PECO Energy Company Statement No. 3R
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Before The

PENNSYLVANIA PUBLIC UTILITY COMMISSION

Maria Povacz

v. **Docket No. C-2015-2475023**

PECO Energy Company

REBUTTAL TESTIMONY OF DR. CHRISTOPHER DAVIS

May 18, 2016

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REBUTTAL TESTIMONY OF DR. CHRISTOPHER DAVIS

I. INTRODUCTION

1. Q. What is your title and name?

A. Dr. Christopher C. Davis.

2. Q. Have you previously submitted testimony in this proceeding?

A. No.

3. Q. What is your business address?

A. Department of Electrical and Computer Engineering, University of Maryland, 2124 Jeong H. Kim Engineering Building, College Park, MD 20742.

II. QUALIFICATIONS

4. Q. What is your position at the University of Maryland?

A. I am the Minta Martin Endowed Professor of Engineering and Professor of Electrical and Computer Engineering.

5. Q. What is your educational background?

A. B.A. with Honors in Natural Sciences, Trinity College, Cambridge University in England; Diploma with Distinction for Advanced Studies in Science (Physics), University of Manchester in England; M.A. in Natural Sciences (Physics), Trinity College, Cambridge University in England; Ph.D. in Physics, University of Manchester in England; and Post-Doctoral Fellow in Applied and Engineering Physics, Cornell University in the United States.

6. Q. What is your professional employment experience?

A. Assistant Professor and Associate Professor of Electrical Engineering at the University of Maryland; Science and Engineering Research Council Senior Visiting Fellow, Department of Physical Chemistry, Cambridge University; Professor of Electrical and Computer Engineering, University of Maryland; and Minta Martin Endowed Professor of Electrical and Computer Engineering, University of Maryland.

7. Q. What type of students do you teach at the University of Maryland?

A. Students seeking Bachelor's degrees, Master's degrees, and Doctor of Philosophy (Ph.D.) degrees.

8. Q. What subjects do you teach to students seeking their Master's degrees and Ph.D. degrees?

A. Many subjects in the fields of Physics and Electrical Engineering, particularly Electromagnetics (which includes radio frequency).

9. Q. Have you supervised any research by students that is required for them to obtain a Ph.D. degree?

A. Yes, I have supervised the research of 68 students who ultimately earned Master of Science or Ph.D. degrees in electrical engineering, physics or biophysics.

9. Q. Have you received any honors or awards for your work?

A. Yes, a number for teaching and research, including being selected as a Fellow of the Institute of Electrical and Electronics Engineers and a Fellow of the Institute of Physics.

10. Q. What type of scientific studies have you conducted?

A. A wide variety in the fields of physics, biophysics, and electrical engineering, and particularly studies on electromagnetics, bioelectromagnetics, and radio frequency electromagnetics and dosimetry.

11. Q. Have you authored any scientific publications in your areas of expertise?

A. Yes, I have authored or co-authored two books, twelve book chapters, 244 articles published in peer-reviewed scientific journals (principally reporting on studies I have conducted) and 313 papers presented at scientific conferences. Among those publications are 2 book chapters on radio frequency fields; 24 articles published in peer-reviewed scientific journals on radio frequency fields. I have also presented 55 papers at scientific conferences on radio frequency fields.

12. Q. Have you done any research on radio frequency fields of the type produced by PECO's AMI meters?

A. Yes, I have conducted a substantial amount of research on radio frequency fields of the type periodically produced by PECO's AMI meters.

13. Q. Have you served on any scientific committees that evaluate research related to electromagnetic fields?

A. Yes, I have served on the Institute of Electrical and Electronic Engineers (IEEE) Committee on Man and Radiation (COMAR) and as chair of the Subcommittee on Radio Frequency Fields, which is comprised of experts who examine the scientific research on them and evaluate the IEEE exposure guidelines.

14. Q. Do you review research papers submitted by other researchers to scientific publishers for publication?

A. Yes, I review papers for a number of scientific publishers, including the American Industrial Hygiene Association Journal, Australian National Health Research Council, Bioelectromagnetics, Cambridge University Press, Radiation Research, Biochimica et Biophysics Acta, Biopolymers, Environmental Biophysics, Applied Physics Letters, The British Council, IEEE Journal of Quantum Electronics, IEEE Journal on Selected Areas in Communication, IEEE Transactions on Biomedical Engineering, International Journal of Modern Physics, Journal of Applied Physics, Journal of Manufacturing Science and Engineering, Microelectronic Engineering, Ohio Board of Regents, Radiation and Environmental Biophysics, Physiological Measurement, Physics in Medicine and Biology, Environmental Biophysics, the National Institutes of Health, and the National Science Foundation.

15. Q. Have you been invited by any institutions to present any scientific talks on electromagnetics and bioelectromagnetics?

A. Yes, I have been invited by several institutions to present talks about the science of electromagnetics and bioelectromagnetics, including: The Johns Hopkins University Applied Physics Laboratory; Stanford University; universities in Canada, Denmark, Korea, Turkey, Taiwan, England, and Australia; the Korean Institute of Science and Technology, the Los Alamos National Laboratory, the National Bureau of Standards, the National Institute of Standards and Technology, the U.S. Food and Drug Administration, and the NASA Goddard Space Flight Center.

16. Q. Have you served as a consultant to any governmental authorities on radio frequency fields?

A. Yes, I have provided expert advice on both power frequency and radio frequency fields, including dosimetry and proposed mechanisms for biological effects other than heating to the United Kingdom Health Protection Agency, the U.S. National Institutes of Health and the U.S. Food and Drug Administration's Center for Devices and Radiological Health.

17. Q. **In light of your education, training and experience that you have described, what are your fields of expertise that relate to your testimony about smart meters in this case?**

A. Physics, Biophysics, Chemistry, Electrical Engineering, Electromagnetics, Bioelectromagnetics, and Radio Frequency Bioelectromagnetics and Dosimetry

III. TERMINOLOGY AND SOME BASIC CONCEPTS

18. Q. **I am going to ask you to define some terms and concepts that have been or may be used in this proceeding. Will you do that in as simplified and non-technical language as possible?**

A. Yes.

19. Q. **What does "EMF" stand for?**

A. "EMF" is used as an abbreviation for several somewhat different terms. Sometimes it is used as an abbreviation for "electric and magnetic fields," particularly those around electrical appliances and powerlines, which can be easily separately measured; sometimes it is used as shorthand to refer to just the "magnetic fields" around electrical appliances and powerlines; and sometimes it is used as an abbreviation for "electromagnetic fields," particularly by physicists and electrical engineers. (I use it as an abbreviation for electromagnetic fields at

frequencies where the electric and magnetic fields are normally measured together rather than separately.)

20. Q. What is a "field" as used in the term "electromagnetic field"?

A. It is an area around an object where an electric and magnetic component can be detected. An easy way to understand what a field is to think about the gravitational field we have on Earth, or the cool temperature field near an open refrigerator.

21. Q. What is electromagnetic "radiation"?

A. "Radiation" is a scientific term that describes how energy travels from a source, i.e., it "radiates" out from the source. An example of radiation is the waves that radiate out in a circle when a stone is tossed into a pond. TV and radio broadcast towers, powerlines, appliances, home wiring, and TV remote controls all produce fields that radiate. NASA has a good and simple statement about radiation on its website: "Radiation is energy that travels and spreads out as it goes – the visible light that comes from a lamp in your house and the radio waves that come from a radio station are two types of electromagnetic radiation." http://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html.

22. Q. Are there different types of electromagnetic radiation?

A. Yes, there are 2 categories based on their fundamental capability and within those categories there are different types of electromagnetic fields that have different properties and thus different uses.

Physicists list sources of electromagnetic radiation on an electromagnetic spectrum in order from the longest wavelength, which has the lowest energy, to

the shortest wavelength, which has the most energy. My exhibit CD1 is a simplified representation of the electromagnetic spectrum. The 2 fundamental categories of the electromagnetic spectrum are Non-ionizing radiation and Ionizing radiation.

The Non-ionizing category of the electromagnetic spectrum consists of waves that do not have enough energy to break any chemical bonds including the chemical bonds in DNA. That category has a number of types of radiation grouped in order starting with lower frequencies: from Extremely Low Frequency (produced from the electricity we use), up to Radio Frequency, and up to Infrared (e.g., used by TV remote controls), none of which has enough energy to break the chemical bonds in DNA and therefore is in the Non-ionizing Radiation category).

The Ionizing radiation category consists of the sources of waves that have enough energy to break chemical bonds in DNA. The Ionizing radiation category includes several types of ionizing radiation, such as Medical X-rays and Radioactive Sources, like the uranium used in bombs. The Ionizing radiation category also includes the Ultraviolet Light from the Sun (which we know can damage our skin).

23. Q. What is a radio frequency field?

A. A radio frequency field is the field produced when an object sends a signal at a frequency in the radio frequency range, most commonly for radio communications.

24. Q. Is it technically accurate to refer to "radiofrequency radiation"?

A. Yes, but as the Health Physics Society says on its website: "Although [people] might be familiar with the use of radiation to diagnose disease and treat cancer, many people, when they hear the terms "radioactive" and "radiation," tend to think of mushroom clouds and the monster mutants that inhabit the world of science fiction movies and comic books."
https://hps.org/publicinformation/ate/faqs/consumerproducts.html
It is *technically* accurate to refer to "radio frequency radiation" but it can sometimes be used to confuse people into thinking about radio signals as though they can be harmful like sources of ionizing radiation.

25. **Q. The terms "radio frequency" and "microwaves" appear to be used by some people interchangeably. Can you explain how those terms relate to each other?**

A. Yes. The radio frequency range is from 3 kHz (kilo Hertz) to 300 GHz (giga Hertz). Microwaves are the part of the radio frequency range between 300 MHz and 3GHz. Therefore, all microwaves are radio frequency waves. When the term "microwaves" is used in communicating about devices with people who are not physicists or electrical engineers, it can incorrectly imply that the device has the same properties as microwave ovens. Microwaves ovens produce a radio frequency wave that is intense enough to quickly heat biological matter (food) to a very high temperature and too high of an exposure to those intense waves is dangerous. All devices that use radio frequency fields in the microwave portion of the radio frequency range, however, do not produce a wave that is intense enough to heat biological matter. Smart meters are a good example of those kinds of

devices. They operate in the microwave frequency range but they do not produce a wave that is intense enough to heat biological matter as a microwave oven does. In communicating with people who are not physicists or electrical engineers, unless I am talking about the properties of a microwave oven, I use the term "radio frequency" to avoid giving a false impression that a particular device produces a wave that is as intense as that of a microwave oven and is therefore dangerous.

26. Q. What is dosimetry?

A. Dosimetry is the measurement and calculation of the level of electromagnetic fields produced from a source. At the low frequencies used by powerlines and appliances, the electric and magnetic fields are sometimes measured and calculated separately. At higher frequencies, such as radio frequency, they are usually measured together and referred to as electromagnetic fields.

27. Q. Ms. Povacz claims that the Smart Meters installed by PECO are conducting excessive RF interference onto the customer's electrical wiring, which she says is called "dirty electricity," and it can be responsible for tripping ground fault interrupters, interfering with home security systems, baby monitors, and other electronic devices on the customer's premises and can cause electrical shock, electrocution, damage to the customer's appliances, and fires. She also claims that the "dirty electricity" is caused by the switching-mode power supply and possibly other components in the Smart Meter and it flows onto the electrical wiring from the customers' premises to neighbors' homes that are served by the same PECO distribution transformer." (page

42). She also claims that PECO's smart meters are adding additional harmonics into the system and that smart meters add harmonics to the environment and homes, and any Switching Power Supply / Switch Mode Power Supply will produce Harmonics. (page 46) As an electrical engineer, what can you tell us about "dirty electricity"?

A. The electricity we use has always been produced by rotating generators at power stations and those generators produce the electricity that is transmitted to us at 60 Hz (in the United States) with harmonic waves at multiples of 60 Hz (120 Hz, 180 Hz, 240 Hz, etc.). Harmonics are a natural byproduct of generating electricity so in electrical engineering we do not use the term "dirty electricity." AMI meters do not generate electrical power; they measure the electrical power flowing into and being used in a house. They do not produce additional harmonics over and above what is coming into the meter. Typical household appliances can generate radio frequency fields that are much larger than those generated by AMR or AMI meters. Switching-mode power supplies generate radio frequency fields at up to about 10 MHz at very low levels. Many modern electrical appliances use switching mode power supplies.

AMI meters do not interfere with the operation of house wiring. In that regard, they behave no differently from old mechanical meters. The very low amplitude radio frequency signals generated by the power supplies in modern electronics are largely filtered out, and are heavily attenuated by resistance when they try to travel along house wiring. That is why, when we want to transmit radio frequency energy for cable TV, we use coaxial cables and not ordinary house wiring.

IV. PECO AMI METERS AND SAFETY

28. Q. Do PECO's AMI meters produce fields that are "ionizing radiation"?

A. No.

29. Q. Does the operation of a PECO AMI meters produce a type of electromagnetic field?

A. Yes, by sending radio signals, it produces a radio frequency field. The field is a natural result of sending radio signals.

30. Q. Do PECO AMI meters produce radio frequency fields all the time?

A. No, only when they are sending a radio signal.

31. Q. Is there anything unusual about the radio frequency fields from PECO's AMI meters?

A. There is nothing unusual about the radio frequency fields from PECO's AMI meters, other than their level is extremely low. The fields from PECO's AMI meters are the same types of fields that are used for radio communications by many common everyday devices, such as radios, garage door openers, baby monitors, portable phones, Wi-Fi, and other wireless communications devices.

32. Q. Is there a scientifically reliable basis for determining whether the radio signals periodically sent by PECO's AMI produce safe levels of radio frequency fields?

A. Yes, by determining whether the radios in PECO's AMI meters exceed or do not exceed the Federal Communications Commission's (FCC) Maximum Permissible Exposure Limits for non-portable devices, including smart meters, which transmit radio frequency signals.

33. Q. What is the basis for the FCC's Exposure Limits for radio frequency fields?

A. The FCC's Maximum Permissible Exposure Limits for non-portable devices that transmit radio frequency signals are based on exposure guidelines issued by two expert organizations: 1) the U.S. National Council on Radiation Protection and Measurements (NCRP) and 2) the American National Standards Institute (ANSI). Based on scientific studies those expert organizations analyzed, both organizations identified the same threshold level (i.e., lowest level) of radio frequency exposure at which a potentially adverse biological effect could occur, which was found to be at a level at where there can be tissue heating. Then they applied safety factors that resulted in lower exposure levels that they adopted as their exposure guidelines. In addition, in adopting its exposure limits, the FCC consulted with the U.S. Food and Drug Administration, the Environmental Protection Agency, the Occupational Safety and Health Administration, and the National Institute of Occupational Safety and Health and each supported the FCC setting its exposure limits based on the exposure guidelines issued by those expert organizations. https://www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety#Q9.

34. Q. Dr. Pall says that the purpose of his testimony is to "discuss the health and safety concerns which have arisen because the Federal Communications Commission (FCC) safety guidelines only take into consideration thermal (that is heating) effects of EMFs" (page 2) and goes on to say that the FCC's limits are "deeply flawed, because they only consider thermal effects." (page 4). Are those statements about the FCC standards by Dr. Pall correct?

A. No. First, the FCC based its exposure standard on exposure guidelines developed by expert scientific organizations, which took into consideration studies of both thermal exposure levels (i.e., those that can produce heating) and non-thermal exposure levels (i.e., those that are lower and cannot produce heating).The expert organizations did not find that the scientific studies showed any adverse biological effects from non-thermal exposures.

Second, the FCC continues to consider whether there are adverse biological effects from non-thermal exposure levels. The FCC states that the scientific evidence for adverse biological effects from non-thermal exposure levels remains "ambiguous and unproven." https://www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety#Q5. I agree with that statement of the FCC.

The FCC explains the reasons for its view on non-thermal effects as follows: "A number of reports have appeared in the scientific literature describing the observation of a range of biological effects resulting from exposure to low levels of RF energy. However, in most cases, further experimental research has been unable to reproduce these effects. Furthermore, since much of the research is not done on whole bodies (in vivo), there has been no determination that such effects constitute a human health hazard." *Id.* The FCC's reasons for its position are scientifically sound and also reflect the consensus of independent scientists who are expert in radio frequency bioelectromagnetics.

It is therefore not correct to say that the FCC's limits are deeply flawed based on the incorrect assertion that the FCC's limits "only take into consideration thermal (that is heating) effects."

In sum, the FCC's limits were set after considering the claim that there are non-thermal effects and the FCC continues to consider that claim. The FCC has found, however, that the claim of non-thermal effects remains scientifically unproven.

35. Q. **Does the FCC have a <u>single</u> Maximum Permissible Exposure Limit for all non-portable devices?**

A. No, the limit varies depending on the frequency range of the radio transmission. The limits for the general population are a 30-minute average exposure of power density for radios, like those in the PECO AMI, that transmit at a frequency that is between 300 and 300,000 mega Hertz (MHz).

36. Q. **Did you determine whether PECO's AMI meters comply with the FCC's Maximum Permissible Exposure Limits?**

A. Yes, my exhibit CD2 shows that PECO's AMI meters comply with the FCC's Maximum Permissible Exposure Limits that apply to both radios in PECO's AMI meters. The radio frequency exposure from PECO's AMI FlexNet radio is **7.8 million times smaller** than the FCC's Maximum Permissible Exposure Limit and the ZigBee radio is **164 million times smaller** than the FCC's Maximum Permissible Exposure Limit.

37. Q. **Did you check the <u>peak</u> exposures from the PECO AMI radios to the FCC limits?**

A. Yes, but first it is important to understand that the FCC limit does not apply to peak exposure; it applies to the 30-minute average exposure. My exhibit CD3 shows that the peak exposure from the AMI FlexNet radio is 37.5 times smaller that the FCC limit for 30-minute average exposure and the peak exposure from the AMI ZigBee radio is 3,800 times smaller than the FCC limit for 30-minute average exposure.

38. Q. Did you compare the exposures from PECO's AMI radios to the exposure guidelines issued by the International Commission on Non-Ionizing Radiation Protection (ICNIRP)?

A. Yes, but first I should point out that the FCC has its own limits and it has not adopted the ICNIRP guidelines. My exhibit CD4 shows that the radio frequency exposure from the PECO AMI FlexNet radio is 5.8 million times smaller than the ICNIRP guideline that applies to it and the ZigBee radio is 164 million times smaller than the ICNIRP guideline that applies to it.

39. Q. Did you compare the level of radio frequency fields from PECO's AMI meters to the level of fields that people are commonly exposed to from other sources?

A. Yes, my exhibit CD5 shows the following: 1) people are and have been commonly exposed to radio frequency fields from a number of sources for many years and they are much higher than the exposure from the PECO AMI radios; 2) compared to the exposure from PECO's AMI radios, exposures from cell phone towers are 14.7 times larger, exposures from radio and TV broadcast transmitters are 18.4 times larger, exposures from standing 30 feet away from a cell phone are

5,700 times larger, exposures from using cell phones can be up to 1.9 million times larger, and exposures from microwave ovens can be up to 6 million times larger. It is notable that the exposure from PECO's AMI radios is 5,700 times smaller than the exposure a person gets standing 30 feet away from somebody talking on a cell phone.

40. Q. **How does the exposure from a PECO AMI compare to the exposure in New Hope, Pennsylvania from UHF television broadcasting?**

A. My exhibit CD6 shows that the radio frequency fields at 1 meter from a PECO AMI are 240 times smaller than the background radio frequency exposure from UHF TV broadcasting in New Hope, Pennsylvania.

41. Q. **Dr. Pall testified (page 21) that "Maria Povacz reports being very health until approximately September 2012 when AMI smart meters were installed at her neighbor's house (10-12 feet away), near her home and throughout her neighborhood" (page 21) and Ms. Povacz says that meter is "located only 10-12 feet away from my bed" (page 18). How does the radio frequency exposure at Ms. Povacz's bed from the PECO AMR that she says has been installed at her house "since February 17, 2001" compare to the radio frequency exposure from the AMI meter that was subsequently installed at her neighbor's house in 2012?**

A. My exhibit CD7 shows that the average exposure 1 meter away from the PECO AMR radio at Ms. Povacz's house is 59 times larger than the exposure from the PECO AMI that was subsequently installed at her neighbor's house.

42. Q. **How do the radio frequency exposures from PECO's old AMR meter and its**

new AMI meter compare?

A. The radio frequency exposure from PECO's new AMI meter is 6.4 times smaller than the radio frequency exposure from PECO's old AMR meter, as shown on my exhibit CD7.

43. Q. **Will the installation of a PECO AMI meter at Ms. Povacz's house increase the radio frequency exposure at her house?**

A. No. In fact, as my exhibit CD8 shows, if the PECO AMR meter at Ms. Povacz's house is replaced with a PECO AMI meter the radio frequency exposure at Ms. Povacz's house will be reduced by 83%.

V. DR. PALL'S THEORY ABOUT A MECHANISM FOR NON-THERMAL RADIO FREQUENCY FIELDS TO PRODUCE BIOLOGICAL EFFECTS AS A BASIS FOR HIS CLAIM THAT THEY RESULT IN HEALTH EFFECTS

44. Q. **Dr. Pall says he has discovered (based on reports of research by others) the mechanism by which non-thermal exposure to electromagnetic fields produces biological effects ("via activation of voltage-gated calcium channels (VGCCs)" in cells) (section E, pages 10-18). He subsequently lists over a dozen of what he calls "reported biological responses" to "low intensity EMFs" generated from VGCC activation (page 15-16) and then refers to them as "health effects" (page 16). Do experts in the field generally accept Dr. Pall's VGCC mechanism theory as showing that non-thermal exposure to radio frequency fields cause biological effects?**

A. No. Dr. Pall's VGCC mechanism theory for how electromagnetic fields produce biological effects (and thus health effects) has not been generally accepted by

experts in the field. I am familiar with mechanism theories like Dr. Pall's because I teach about them - and the lack of consistent and reproducible confirmation of any them - in my Electromagnetics course. (I should note that his VGCC theory reflects a fundamental lack of understanding of basic cell biophysics.)

Since Dr. Pall published his VGCC mechanism theory in 2013, at least 6 expert science panels have conducted careful reviews of radio frequency research. [Health Council of the Netherlands 2014; Australian Radiation Protection and Nuclear Safety Agency 2014; Swedish Radiation Safety Authority 2014; Swedish Radiation Safety Authority 2015; New Zealand Ministry of Health 2015; The Scientific Committee on Emerging and Newly Identified Health Risks of the European Commission 2015. The International Commission on Non-ionizing Radiation Protection (ICNIRP) says no on its website "Acute and long-term effects of HF [high frequency, including radio frequency] exposure below the thermal threshold have been studied extensively without showing any conclusive evidence of adverse health effects." None of those expert authorities accept Dr. Pall's VGCC mechanism theory; in sum it is not generally accepted by experts in the field.

45. Q. **Dr. Pall claims in his testimony that non-thermal radio frequency fields "including EMFs from smart meters" meters can cause "health related effects" including therapeutic "stimulation of bone growth " (pages 2-3) and later refers to the use of "pulsed" fields by bone healing devices. Can the radio frequency fields near PECO's AMIs stimulate bone growth?**

A. No. Bone healing devices use either direct current stimulation or inductive or capacitive coupling of pulses to induce a flow of current in the region of the fracture. They operate either at very low non-radio frequencies or at low radio frequencies up to 27.5 MHz. That frequency is 33 times smaller that the lowest frequency used in PECO's AMI unit. The frequencies used by PECO's AMI units are much too high to produce current flows in the body because of the inertia of the ions in the body.

In addition, the various pulsed field bone healing devices produce magnetic fields of 0.1 Gauss (G) up to 20 G. [Galkowski 2009]. The exposure necessary to produce even 0.1 G is 189 mW/cm^2. That is 11,850 times larger than the peak exposure from a PECO AMI meter.

(I should note that some biophysicists, including myself, have examined the studies of the fields at the levels produced by pulsed field bone healing devices and, because of engineering design weaknesses (flaws) in those studies and the lack of replication of them, we have some doubt about whether the studies demonstrate that the devices actually produce bone healing.)

46. Q. Dr. Pall relied in his testimony on a paper he wrote that was published last year in which he addresses his VGCC mechanism theory and pulsed fields and says "Pulsed fields are, of course, produced by any type of wireless communication device since it is the pattern of pulsations that conveys the information." [Pall 2015] Appendix F of his testimony). Is that correct?

A. No. The only wireless communications devices that use pulses to convey information are laser communication devices. PECO's AMI meters are not laser communications devices.

47. Q. **When asked about whether there are "other types of evidence that should influence our understanding of the health-related impacts of low-intensity microwave frequency EMFs," Dr. Pall says in his testimony that "This whole issue is terribly relevant to smart meters which can be seen to put out very sharply spiked pulses... " (page 20). Is it accurate to say that smart meters put out very sharply spiked pulsed fields?**

A. First, as to the term "pulsed," it depends on how and for what purpose one is using the term and how technically accurate one wants to be. In layman terms, "pulsed" can be used to describe anything that differs in a rhythmic way. In that sense, a device that turns on a lamp each night for a few hours is producing a "pulsed" visible light frequency electromagnetic field.

Second, in communications physics and engineering, "pulsed" means using 1. amplitude modulation and 2. doing so in away that produces a signal that has abrupt changes in the amplitude of the sine wave. PECO's AMI meter radios are not amplitude modulated so they do not produce "pulsed" fields. PECO's AMI meter radios are frequency modulated, specifically "frequency shift keyed," and send out a collection of regular non-pulsed sine waves around the frequencies they use. (AM radio station signals are 1. amplitude modulated, which is what "AM." stands for, but 2. they transmit a sine wave whose frequency is fixed, the so-called "carrier frequency." The amplitude of that sine wave is modulated up

and down in a continuous way to encode the voice or music being transmitted. That is why communications physicists and engineers do not refer to radio station signals as "pulsed" signals.)

In sum, the fields from PECO's AMI meters are not amplitude modulated and thus are not "pulsed" and therefore do not create "pulsed" fields. If Dr. Pall is using the term "pulsed" to suggest that during the time PECO AMIs transmit, they are sending pulses of radio frequency energy then he is incorrect.

48. Q. **Dr. Pall claims in his testimony (pages 2-4) that there is a scientific consensus that radio frequency fields produce various "non-thermal" effects. Do the expert panel reviews of radio frequency field research show such a consensus?**

A. No, they do not. To the contrary, there have been many reports by expert panels advising governments and public health authorities and the consensus is that the scientific research non-thermal (i.e. very low level) radio frequency fields does not provide consistent and reproducible scientific evidence that they cause any biological effects.

For example, the UK government's expert advisory group on radio frequency science found that "[t]here are now several hundred studies in the published literature that have looked for effects on isolated cells or their components when exposed to RF fields. *** [W]here reported effects were investigated by independent replications the effects were not found." [AGNIR 2012, 318]

Similarly, the international expert group ICNIRP has found that "[t]he studies conducted so far have not provided consistent evidence of biological effects under non-thermal RF exposure conditions." [ICNIRP 2009, 155]

A recent review by the New Zealand Ministry of Health concluded "thermal effects are the only ones for which there is clear evidence." [New Zealand 2015, 32]

This view is also shown in the recent finding by the expert committee advising the European Commission on EMF/RF issues that "no interaction mechanism(s) is (are) known regarding potential non-thermal effects of weak fields." [SCENIHR 2015, 24] The expert group further concluded that while mechanisms other than heating have been suggested, "none has been firmly demonstrated in humans and their relevance to health remains unclear." [SCENIHR 2015, 59].

In sum, the scientific consensus is that exposure to non-thermal level radio frequency fields does not produce "non-thermal effects."

V. CONCLUSIONS

49. Q. Have you come to any overall conclusions about the radio frequency fields from PECO's AMI meters?

A. Yes, based on my education, training and experience in Physics, Biophysics, Chemistry, Electrical Engineering, Electromagnetics, Bioelectromagnetics, and Radio Frequency Bioelectromagnetics and Dosimetry, and my calculations, I have come to the following overall conclusions:

The levels of radio frequency fields from PECO's AMI meters are

(1) extremely low, 7.8 to 164 million times lower than the safety limits established by the FCC, and

(2) many times lower than the radio frequency fields people are commonly exposed to from everyday sources.

Based on my education, training and experience in Physics, Biophysics, Chemistry, Electrical Engineering, Electromagnetics, Bioelectromagnetics, and Radio Frequency Bioelectromagnetics and Dosimetry, and on the scientific research on radio frequency fields, it is my opinion that there is no reliable scientific basis to conclude that exposure to radio frequency fields from PECO's AMI meters are capable of causing any adverse biological effects in people, including in Ms. Povacz.

50. Q. Do you make your statements set forth in this testimony to a reasonable degree of Electrical Engineering, Biophysics, Electromagnetics, Bioelectromagnetics, Radio Frequency Bioelectromagnetics, and scientific certainty?

A. Yes.

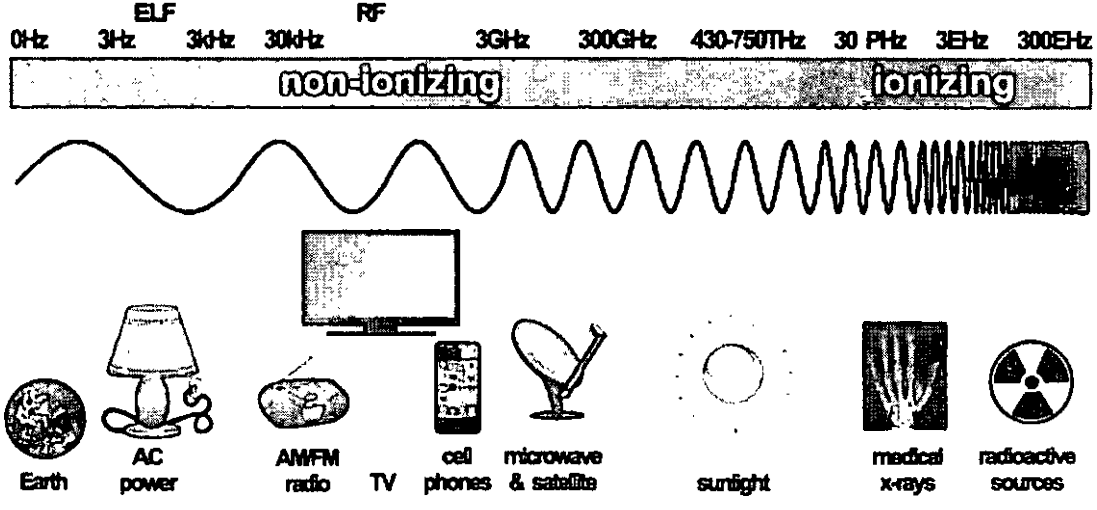
51. Q. Does that conclude your pre-filed rebuttal testimony?

A. Yes

PECO Exhibit CD-1

The Electromagnetic Spectrum

THE ELECTROMAGNETIC SPECTRUM

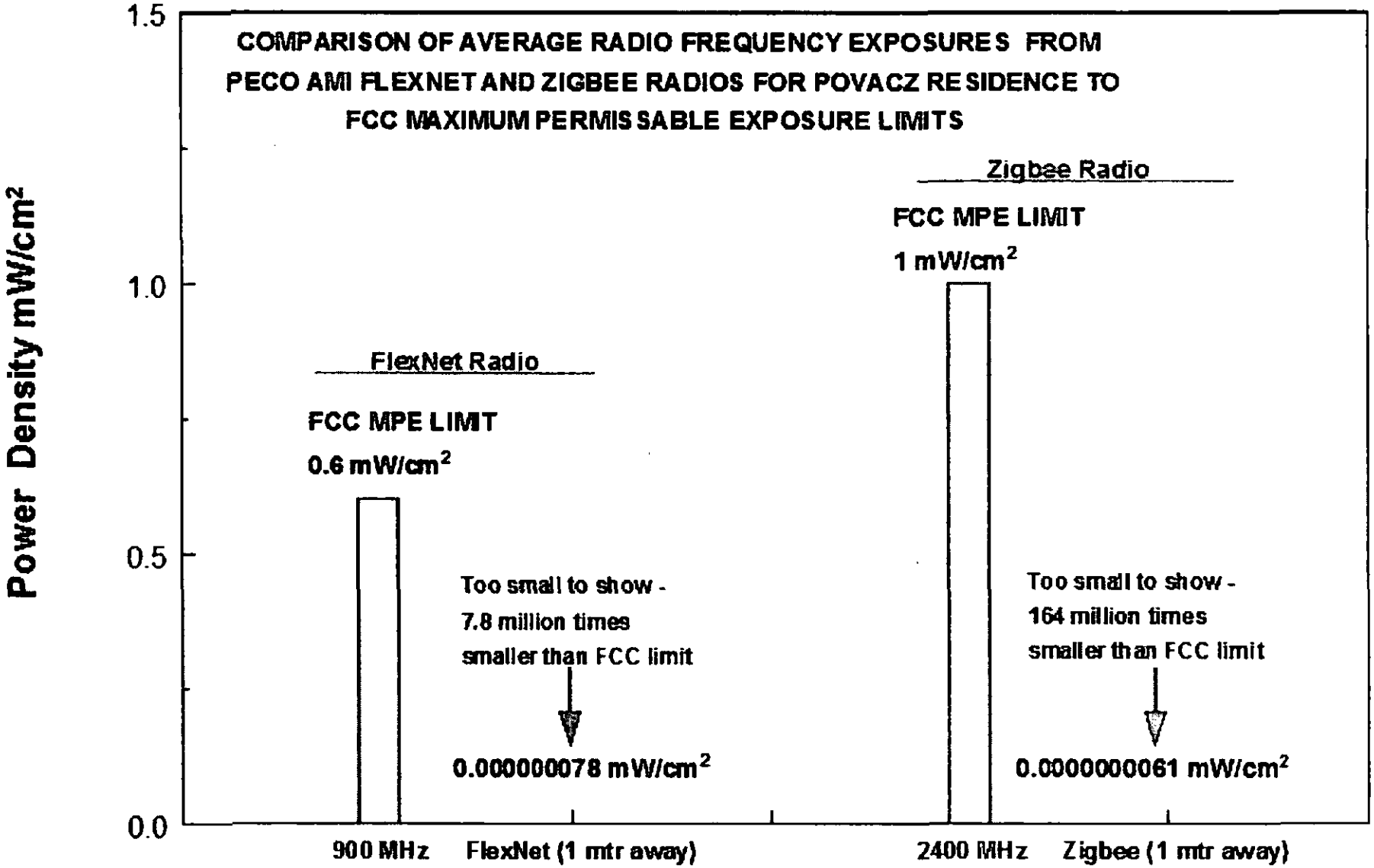


THE ELECTROMAGNETIC SPECTRUM

Exhibit CD1

PECO Exhibit CD-2

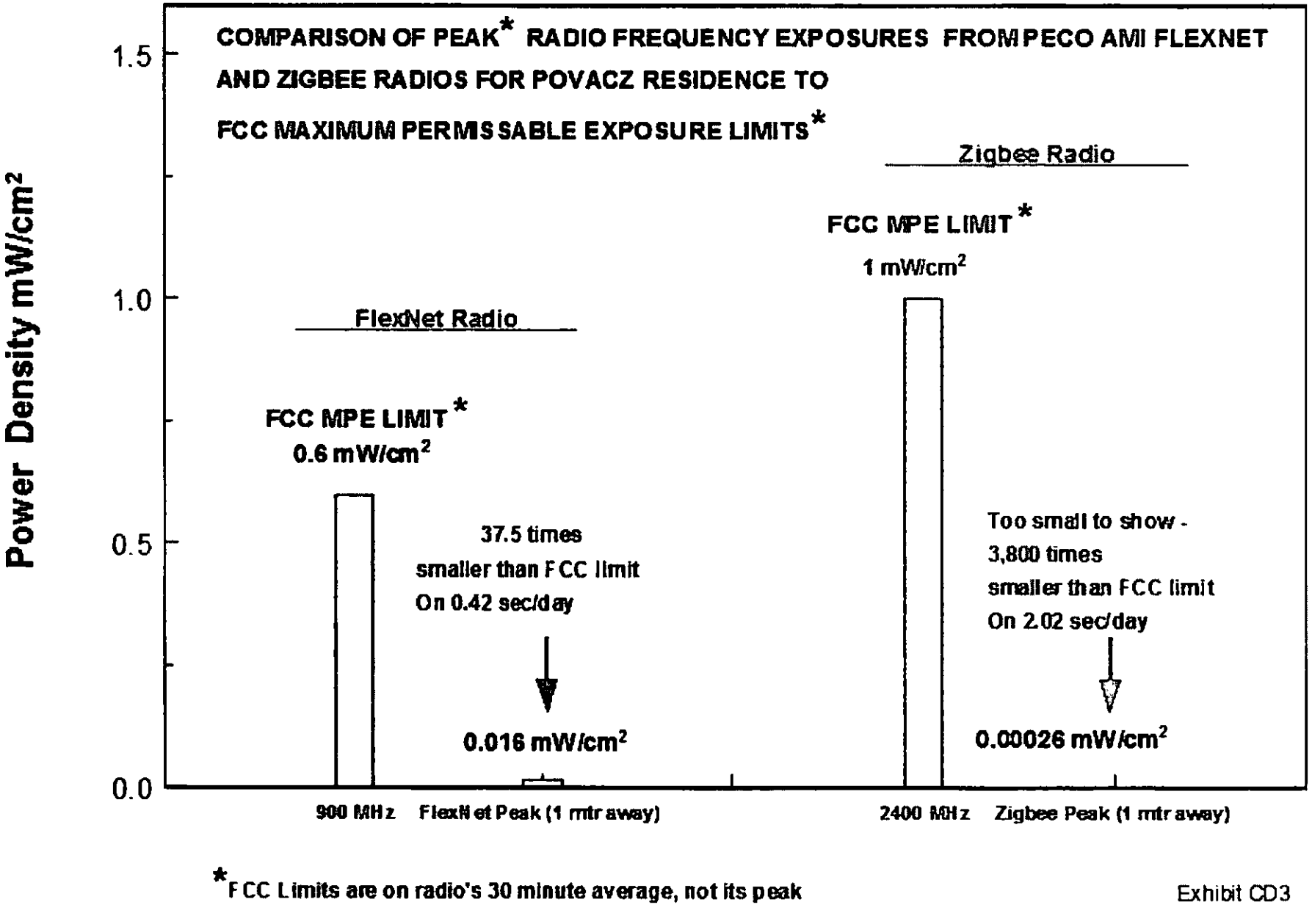
Comparison of Average RF Exposures From PECO AMI FlexNet and ZigBee Radios for Povacz Residence To FCC Maximum Permissible Exposure Limits



PECO Exhibit CD2

PECO Exhibit CD-3

Comparison of Peak RF Exposures From PECO AMI FlexNet and ZigBee Radios for Povacz Residence To FCC Maximum Permissible Exposure Limits

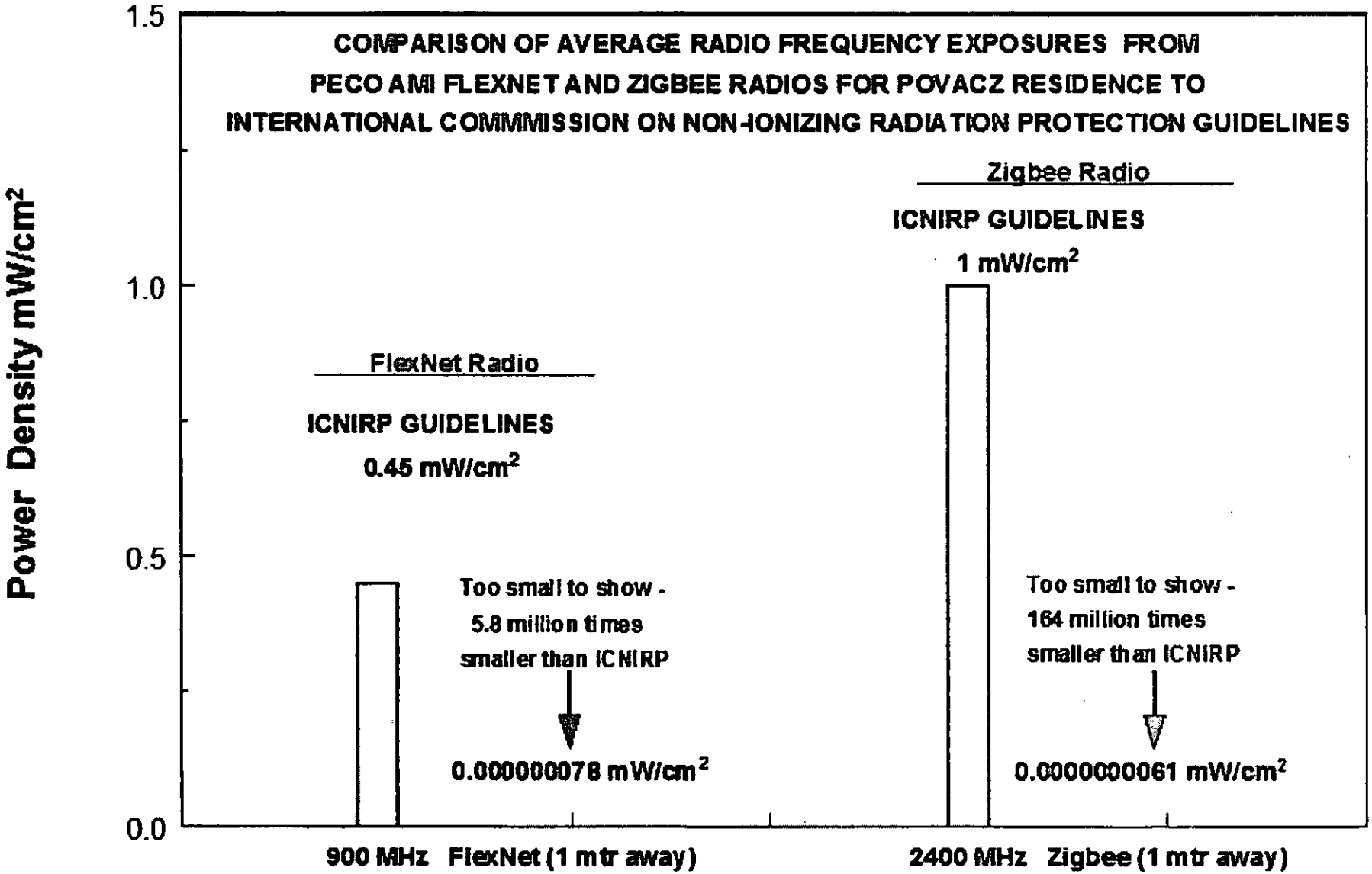


*FCC Limits are on radio's 30 minute average, not its peak

Exhibit CD3

PECO Exhibit CD-4

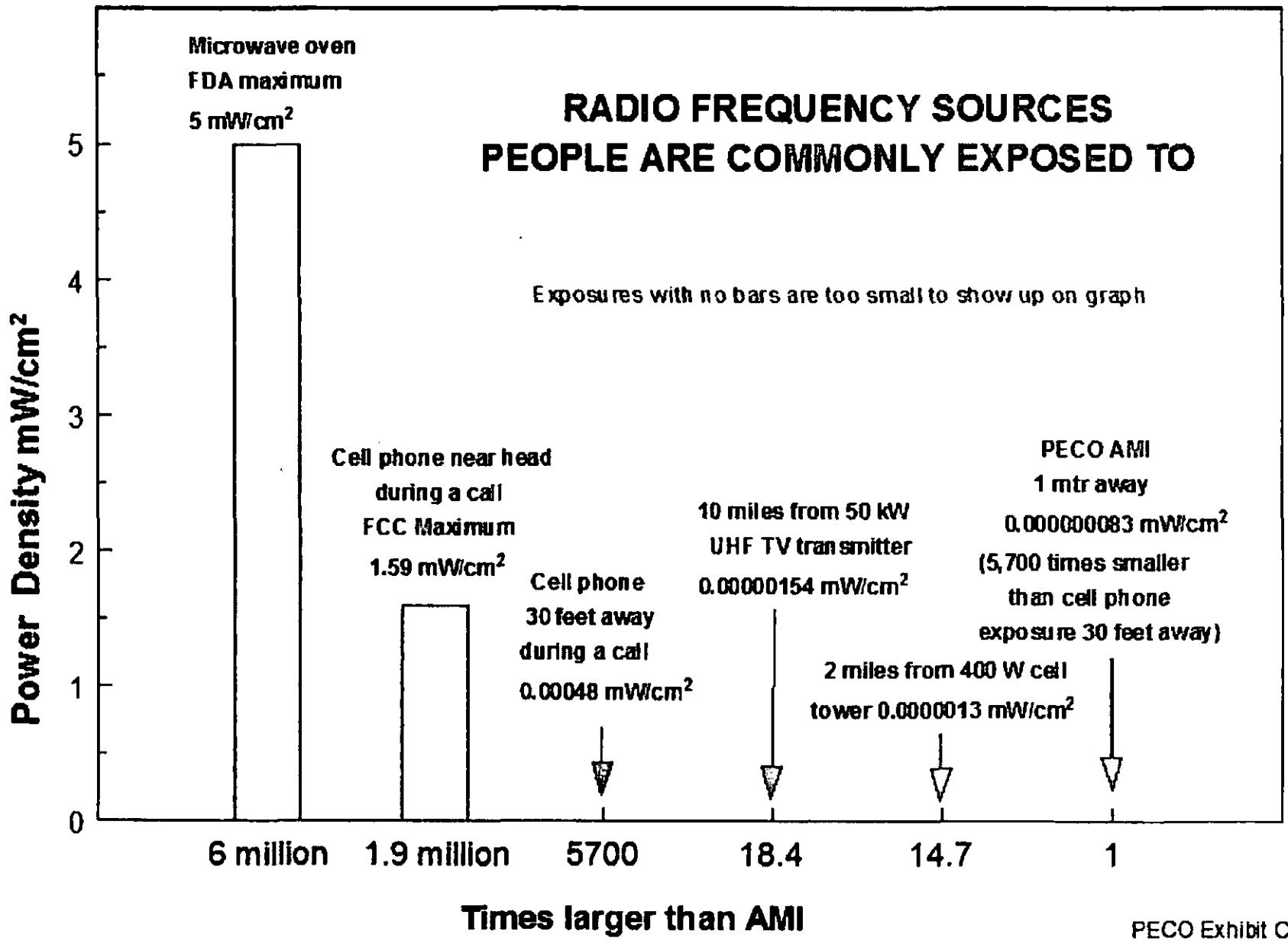
Comparison of Average RF Exposures From PECO AMI FlexNet and ZigBee Radios for Povacz Residence To International Commission on Non-Ionizing Radiation Protection Guidelines



PECO Exhibit CD4

PECO Exhibit CD-5

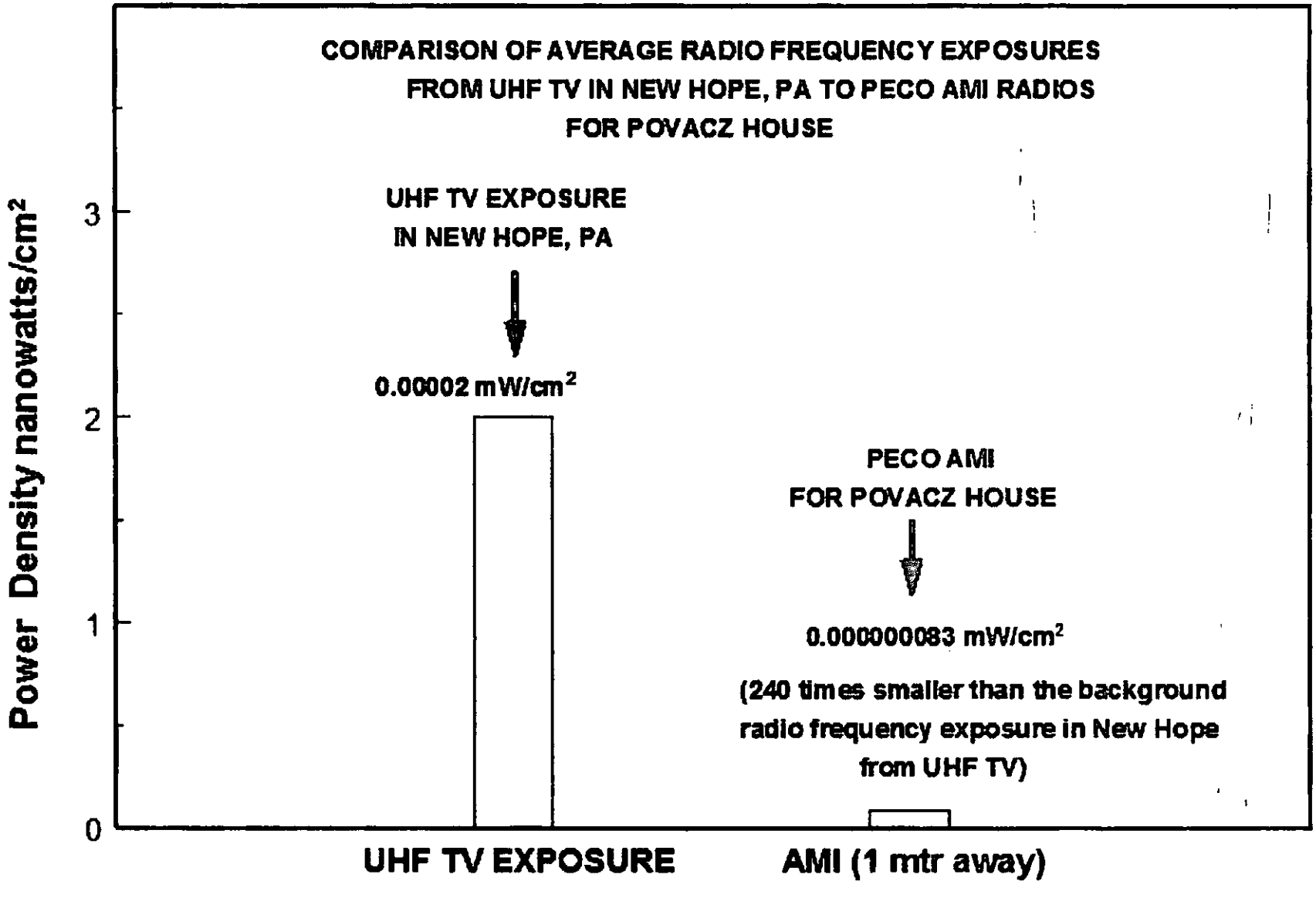
Radio Frequency Sources People Are Commonly Exposed To



PECO Exhibit CD5

PECO Exhibit CD-6

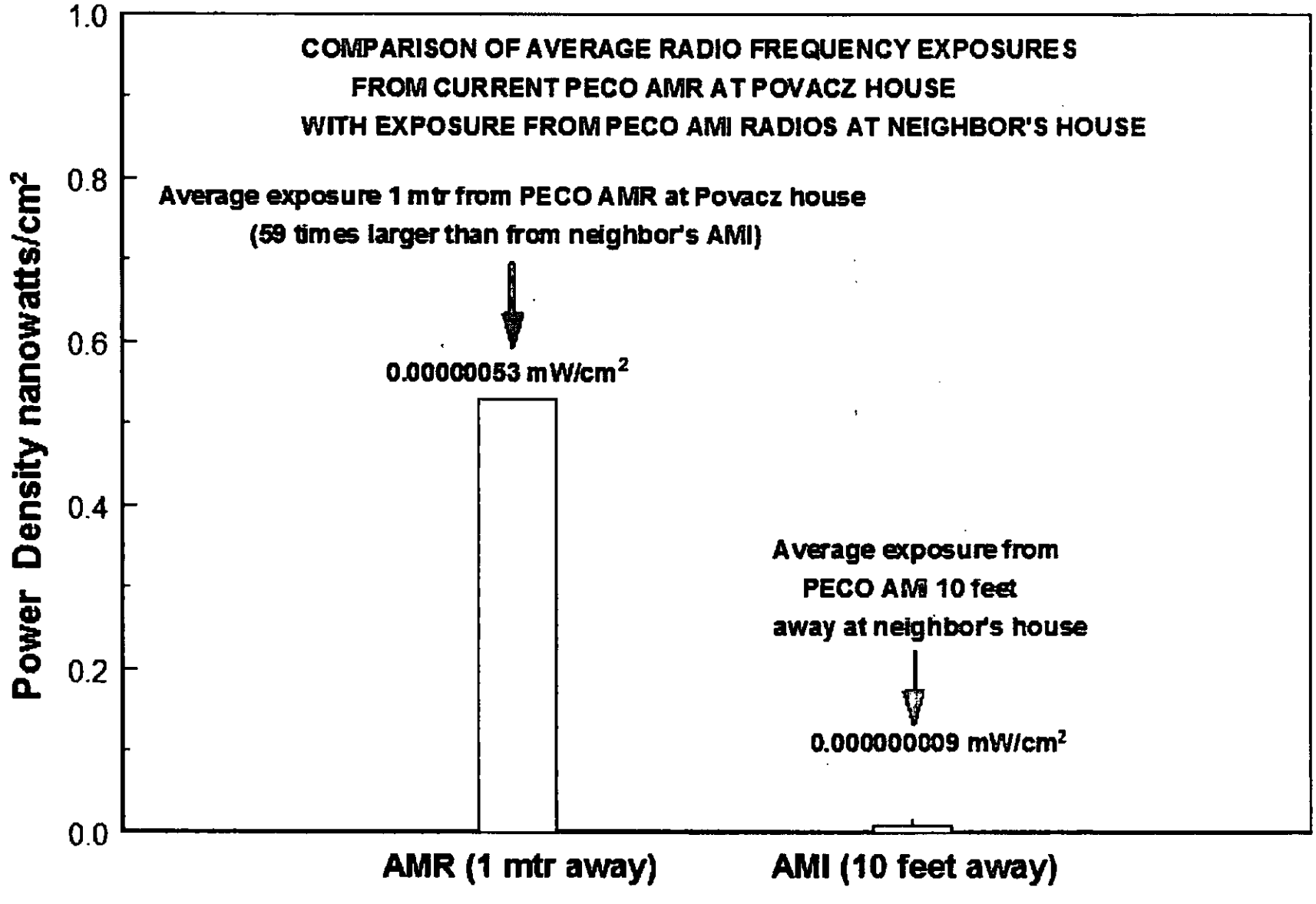
Comparison of Average RF Exposures From UHF TV in New Hope, PA to PECO AMI Radios For Povacz House



PECO Exhibit CD6

PECO Exhibit CD-7

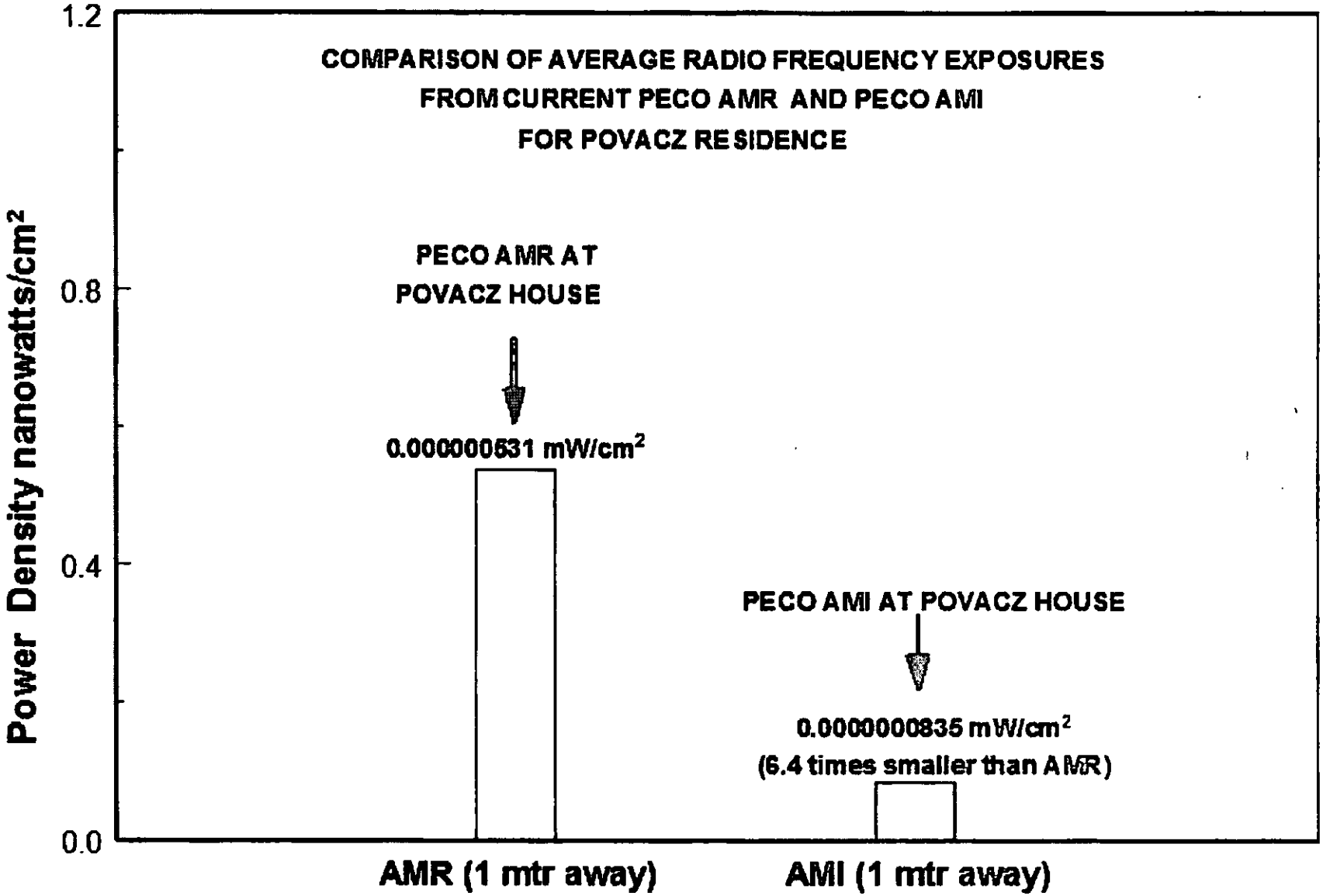
Comparison of Average RF Exposures From Current PECO AMR at Povacz House With Exposure From PECO AMI Radios at Neighbor's House



PECO Exhibit CD7

PECO Exhibit CD-8

Comparison of Average RF Exposures From Current PECO AMR and PECO AMI For Povacz Residence



PECO Exhibit CD8

PECO Energy Company Statement No. 4R
C-2015-2475023
PH 12/8/16 DC

Before The

PENNSYLVANIA PUBLIC UTILITY COMMISSION

Maria Povacz

v. **Docket No. C-2015-2475023**

PECO Energy Company

REBUTTAL TESTIMONY OF DR. MARK ISRAEL

May 18, 2016

REBUTTAL TESTIMONY OF DR. MARK ISRAEL

Table of Contents

REBUTTAL TESTIMONY OF DR. MARK ISRAEL

I. INTRODUCTION

1. Q. What is your name?

A. Dr. Mark A. Israel.

2. Q. Have you previously submitted testimony in this proceeding?

A. No.

3. Q. What is your business address?

A. 1 Medical Center Drive, Lebanon, NH 03756

II. QUALIFICATIONS

4. Q. Are you a medical doctor?

A. Yes.

5. Q. Where did you receive your medical education and training?

A. Albert Einstein College of Medicine in New York City and Harvard Medical School and affiliated hospitals in Boston.

6. Q. Are you licensed to practice medicine?

A. Yes in California and New Hampshire.

7. Q. What types of medical work do you do?

A. I treat patients; teach medical school; supervise medical researchers, physicians, and medical staff; serve as a consultant to other physicians on difficult issues of diagnosis and treatment; and conduct medical research studies.

8. Q. Please summarize your professional employment experience after completing your medical education and training.

A. Research Associate and then Senior Investigator in several laboratories at the National Institute of Allergies and Infectious Diseases and the National Cancer Institute, both of which are parts of the National Institutes of Health (14 years); Kathleen Plant Distinguished Professor and medical researcher at the University of California at San Francisco Medical School (11 years); and Director of the Cancer Center, Professor of Medicine, and medical researcher at Dartmouth College (15 years).

9. Q. How long have you been a teacher and what type of students and subjects have you taught?

A. I have been a teacher for more than 25 years and have taught medical students, interns, residents, and practicing physicians subjects in a number of fields, including endocrinology, immunology, hematology, neurology, cardiology, biochemistry, cell biology, genetics, molecular genetics, medical oncology, and radiation oncology.

10. Q. How long have you been conducting medical research and in what areas?

A. I have been conducting medical research for 40 years. I have done medical research in a wide variety of areas, including systems biology, biochemistry, cell biology, cancer, molecular biology, and molecular genetics.

11. Q. Have you written any papers reporting on your medical research studies that have been published in medical or scientific journals?

A. Yes, over 200 papers reporting on my medical research.

12. Q. Have you supervised research by others?

A. Yes, I have supervised medical research and provided advanced research training for more than 55 (fifty-five) people who had previously received either a Ph. D. degree or an M.D. degree, or both.

13. Q. Have you received any honors for your work?

A. Yes, among others I was elected a Fellow of the American Association for the Advancement of Science, elected to the American Society for Clinical Investigation, elected to the Board of Directors of the Foundation for Advanced Education in the Sciences, received the C. Everett Koop Courage Award for the pursuit of evidence-based medicine, and was awarded the U.S. Public Health Service Commendation Medal.

14. Q. In the course of your work, have you developed medical expertise in whether electromagnetic fields cause, contribute to, or exacerbate diseases or other adverse health effects?

A. Yes.

15. Q. What led you to develop expertise in that topic?

A. After I completed my pediatric training at the Boston Children's Hospital at Harvard Medical School, I pursued medical research at the National Institutes of Health where I became interested in cancer research, particularly molecular genetics and neurooncology. I continued that work in the Pediatric Branch of the National Cancer Institute (NCI), where I later became head of the Molecular Genetics Section. During that time I also continued to see pediatric cancer patients as an officer in the U.S. Public Health Service. The parents of patients occasionally asked me whether exposure to power lines and electric appliances

could be the cause of their child's cancer so I examined the research, informed them, and continued to follow the research. Later, parents of patients began asking me whether using cellphones could cause cancer so again I examined the research, informed them, and continued to follow that research. (The research has examined not only cancer but also many other diseases and conditions and it has involved many of the areas in which I teach or have done medical research.) I have continued to systematically follow the research on those topics for more than 25 years.

16. Q. **Based on your credentials described above, what are your fields of expertise that are relevant to this proceeding?**

A. Medicine and medical research, including particularly related to radio frequency fields and health.

III. MEDICAL EVALUATION OF MS. POVACZ'S REPORTED SYMPTOMS AND CONDITIONS

17. Q. **Did you conduct a medical evaluation of whether radio frequency fields cause, contribute to, or exacerbate the symptoms and conditions that have been reported by Ms. Povacz?**

A. Yes.

1. METHODOLOGY OF MEDICAL EVALUATION

18. Q. **How did you conduct your medical evaluation of the symptoms and conditions reported by Ms. Povacz?**

A. I conducted my medical evaluation of the symptoms and conditions reported by Ms. Povacz using the same methodology I use in the usual course of my medical

work. First, I searched medical and also scientific databases to identify relevant studies. I analyzed any studies I had not previously analyzed. If I had previously analyzed a study but its key elements did not immediately come to mind, I reviewed the study. (Because I systematically follow the research on radio frequency fields and health I was familiar with many of the studies I identified in my searches, and reviewed the others.) I then evaluated as a whole all of the studies I determined were relevant to the symptoms and conditions reported by Ms. Povacz, taking into account a number of factors, including what that type of study can and cannot show and the size of the study population. Then, I made an initial determination of what the studies as a whole show for each particular symptom or condition reported by Ms. Povacz. For each, I considered the studies that (1) report an effect and (2) studies that report no effect because that is necessary for a reliable medical evaluation. Then I considered reliable sources of other information.

19. Q. What other reliable sources of information did you consider?

A. I considered recent reviews of the studies conducted and published by public health agencies and organizations and their expert panels. I looked to see if they provided any insights I missed and to see if they reached any conclusions that were inconsistent with any of my initial determinations. After that, I made my final medical evaluation.

20. Q. **Dr. Pall testified (page 18) that "Smart meters have only been investigated for health effects twice, to my knowledge; once in Australia (Lamech, 2014 in Appendix I) after they were deployed there, and once in the U.S. (Conrad,**

2013 in Appendix I), also after they were deployed here." Did you consider those two papers in the course of conducting your medical evaluation?

A. Yes, I considered the Lamech 2014 and Conrad 2013 materials. The Lamech paper is based on claims made about adverse health symptoms from smart meters that were submitted to an unnamed public website by 91 (ninety-one) unidentified people in the state of Victoria, Australia. (Victoria has a population of approximately 5.7 million people.). The Conrad paper does not appear to have been published in a peer-reviewed scientific journal, and I usually do not rely on papers that are not subjected to peer review; but because Dr. Pall relied on it, I searched and found it on the Internet. It is Exhibit D to the prefiled testimony of Dr. Conrad that was submitted by the Maine Coalition To Stop Smart Meters in a Maine Public Utility Commission proceeding. The Conrad report was based on an invitation to fill out an online survey (utilizing "SurveyGizmo software"), which was distributed to "internet sites and interest groups" over the Internet. A total of 210 (two hundred ten) people responded. The paper also says "The invitation began: 'If you feel your health has been affected by smart meters, we request your immediate help in studying these effects.'" The paper refers readers to a website for additional information about the survey, which says: "Our purpose is to extract in a uniform way, particular types of information which will be useful in a database to be used for research, reporting and testifying on the health safety of smart meters." Appendix 9 of the paper is a copy of the survey itself and at the beginning it informs those who will be submitting their response in hard copy to mail it to the "Maine Coalition to Stop Smart Meters, P.O. Box 43, Richmond,

ME 04357." These two papers only provide data on people's claimed symptoms and their personal belief that they were caused by exposure to smart meters. In addition, the data were not collected from a random sample of people exposed and not exposed to smart meters, but instead were collected from individuals who already identified their symptoms as having been caused by Smart Meters. In essence, these papers are just reports from two self-selected groups identifying symptoms they believe were caused by Smart Meters. It is my medical opinion that the Lamech and Conrad papers do not provide scientifically reliable or useful data upon which to make a determination of causation of any symptom or condition identified in them.

21. Q. **Given your view that the only two papers Dr. Pall identified as having investigated health effects from smart meters "do not provide scientifically reliable or useful data upon which to make a determination of causation of any symptom or condition identified in them," did you limit your medical evaluation to those 2 papers?**

A. No, even though those two papers could not establish whether smart meters cause or do not cause any adverse health effects, there is other relevant information to consider. There have been many studies done over many years on whether radio frequency fields cause or contribute to various health effects and symptoms. Although almost all of those studies used radio frequency field exposures that are much higher, and in many studies multiples higher, than exposures from a smart meter, I considered those studies to see what could be learned from them about whether radio frequency fields from 1) PECO's AMR meter at Ms. Povacz's

house or from PECO's AMI meter at her neighbor's house, or both, caused or contributed to or exacerbated Ms. Povacz's reported symptoms and conditions, and 2) the replacement of the AMR meter at Ms. Povacz's house with an AMI meter would cause or contribute to or exacerbate Ms. Povacz's reported symptoms and conditions.

22. Q. **Before proceeding to your medical evaluation, would you please explain whether there is any difference between a biological effect and a health effect and if there is how you determine which effect is a health effect?**

A. A biological effect is basically any response of the body to any exposure. Many things we experience produce biological effects in the body. A good example is when we are exposed to bright sunlight our eyes squint. A biological effect may or may not result in a health effect.

In medicine we rely on scientific studies to determine whether an exposure causes a health effect. We consider epidemiology studies to identify whether there appears to be an association between an exposure and a health effect that warrants further study. We consider the studies of isolated tissue and cells (called *in vitro* studies, which is taken from the Latin term for "in glass") to see whether there might be relevant biological effects as a means of determining whether an association appears plausible and thus worth pursuing in experiments that can tell us whether an exposure produces a health effect. What happens when isolated tissue and cells are exposed to something does not tell us what will happen when live animals are exposed to the same thing. We do controlled laboratory studies on live animals, and sometimes humans (called *in vivo* studies, which is taken

from the Latin term for "in life"), to see if a health effect is revealed. Then we see if the results can be replicated or confirmed by other researchers.

2. MEDICAL EVALUATION OF MS. POVACZ'S REPORTED SYMPTOMS AND CONDITIONS

a. Electromagnetic hypersensitivity (Idiopathic Environmental Intolerance attributed to electromagnetic fields)

23. Q. **Why do you refer to electromagnetic hypersensitivity as "Idiopathic Environmental Intolerance"?**

A. "Idiopathic Environmental Intolerance" is the term, recommended by a World Health Organization (WHO) working group on the subject, as a better name for the claimed condition. As pointed out in a thorough and careful review of the Idiopathic Environmental Intolerance studies [Rubin 2010]:

> "The aetiology [cause] of 'electromagnetic hypersensitivity' is controversial. While most patients and some scientists believe that the condition is caused by an as yet unrecognised 'bioelectromagnetic' mechanism, most mainstream medical bodies maintain that there is not sufficient evidence to support this theory and that the symptoms experienced by sufferers are unrelated to the presence of electromagnetic fields. Indeed, a working group of the World Health Organisation has recommended that the use of terms like 'electromagnetic hypersensitivity' should be discontinued in favour of the more aetiologically [causalogically] neutral phrase 'idiopathic environmental intolerance attributed to electromagnetic fields... ." (emphasis added)

(The WHO continues to refer to electromagnetic hypersensitivity on its website as it is the term often used by people who report that they have it.) For purposes of a medical evaluation, I believe "Idiopathic Environmental Intolerance" is a more medically neutral term and that is why I use it.

24. Q. **What do the studies show about whether Idiopathic Environmental Intolerance to electromagnetic fields and the variety of symptoms and conditions attributed to it, such as those reported by Ms. Povacz, are caused by, contributed to, or exacerbated by exposure to radio frequency exposure?**

A. There are many reliable studies dating back to at least 2002, and also a significant number of recent reviews of the studies by experts and reviews by expert panels of public health authorities, that have found Idiopathic Environmental Intolerance and the variety of symptoms and conditions attributed to it are not caused by exposure to radio frequency fields. Studies to determine whether reporting of symptoms is related to real exposure are called "provocation studies."

An early and careful study [Hietanen 2002] of people who said they were hypersensitive is revealing. It used a double-blind design (neither the subjects being studied nor the researchers knew when there was or was not a radio frequency exposure). The study used radio frequency fields of 900 and 1800 MHz from cellphones and a sham exposure (i.e., no real exposure). (Dr. Davis informs me that the maximum allowable fields from cellphones are almost 2 million times higher than the fields 1 meter from PECO's AMI meters.) The study found that the number of reported symptoms was higher during sham exposure than during real exposure and none of the test subjects could distinguish actual radio

frequency field exposure from sham exposure. The study concluded that adverse subjective symptoms or sensations perceived by the test subjects were not produced by radio frequency exposure.

A systematic review of the studies of Idiopathic Environmental Intolerance [Rubin 2010] reported:

> "Including studies reported in our earlier review, 46 blind or double-blind provocation studies in all, involving 1175 IEI-EMF [Idiopathic Environmental Intolerance to Electromagnetic fields] volunteers, have tested whether exposure to electromagnetic fields is responsible for triggering symptoms in IEI-EMF. No robust evidence could be found to support this theory. However, the studies included in the review did support the role of the nocebo effect with symptoms in triggering acute symptoms in IEI-EMF sufferers. Despite the conviction of IEI-EMF sufferers that their symptoms are triggered by exposure to electromagnetic fields, repeated experiments have been unable to replicate this phenomenon under controlled conditions. A narrow focus by clinicians or policy makers on bioelectromagnetic mechanisms is therefore, unlikely to help IEI-EMF patients in the long-term."

25. Q. **Is it generally accepted in the scientific or medical communities that Idiopathic Environmental Intolerance and the variety of symptoms and conditions attributed to it, such as those reported by Ms. Povacz, are caused by, contributed to, or exacerbated by exposure to radio frequency exposure?**

A. The United Kingdom Health Protection Agency issued a report in 2012 finding:

"A large body of experimental evidence now exists concerning the impact of RF fields on self-reported symptoms. ... [W]hen taken together the experimental evidence suggests that short-term exposure to RF fields below guideline levels ... does not cause acute symptoms, either in the general public or in people who report being sensitive to electromagnetic fields."

The Royal Society of Canada Expert Panel issued a report in 2013 finding:

"Taken together, research in the past ten years does not provide firm evidence for the hypotheses that people with IEI-EMF can perceive RF energy at levels below the limits in SC6 or that there is a causal link between exposure to RF energy and their symptoms."

The New Zealand Ministry of Health issued a report in 2015 finding:

"Recent reviews of these studies continue to conclude that people who consider themselves unusually sensitive to EMFs are, in fact, unable to detect EMFs, and the occurrence of symptoms appears unrelated to exposures... ."

The Scientific Committee on Emerging and Newly Identified Health Risks of the European Commission issued a report in 2015 finding:

"The symptoms that are attributed by people to RF EMF exposure can sometimes cause serious impairments to a person's wellbeing. However, research conducted since the previous Opinion adds weight to the conclusion that RF EMF exposure is not the cause of these symptoms. This applies to the general public, children and adolescents, and to people with idiopathic environmental intolerance attributed to electromagnetic fields. Recent meta-analyses of observational and provocation data support this conclusion."

In sum, the studies of Idiopathic Environmental Intolerance and public health authority expert panel reports of the studies show that exposure to radio frequency fields does not cause, contribute to, or exacerbate Idiopathic Environmental Intolerance and the various symptoms and conditions attributed to it (reported symptoms of widespread pain, body aches, buzzing in ears, eye floaters, lack of concentration, memory loss and reported symptoms of sleep disturbance, fatigue, and lethargy).

Based on those public health authority expert panel reports, and on the views of many in the medical community I have spoken with about Idiopathic Environmental Intolerance to electromagnetic fields, it is my opinion that it is generally accepted in the scientific or medical communities that exposure to radio frequency fields do not cause, contribute to, or exacerbate Idiopathic Environmental Intolerance or the various symptoms and conditions attributed to it, such as those reported by Ms. Povacz.

26. Q. **Ms. Povacz says that she was healthy "at the beginning of September 2012" (page 11), but after the PECO AMI meters were installed in her neighborhood and at her neighbors house in the "summer months of 2012" (page 8), by "mid-September [2012]" (page 11) she had "a disrupted sleep pattern, frequent headaches and a constant buzzing" (page 13). What does her testimony about her symptoms appearing after the AMI meters were installed tell you about the cause of her symptoms?**

A. I considered the sequence and timing of the events but unfortunately it was of no help in determining the cause of Ms. Povacz s symptoms. When one event occurs

shortly after another, that does not prove that the first event caused the second event. An example of that point is recently, right after I ate breakfast it started raining, but that does not prove that my eating breakfast caused it to rain. In practicing medicine, we often get reports from patients about the sequence and timing of events and the onset of their symptoms. If the symptoms occurred before the event, we can logically rule out the event as the cause of the symptoms. If the symptoms occurred after the event, it would be medically irresponsible to our patient to conclude that the event caused the symptoms because that would lead us to not proceeding with trying to determine the medical cause of the symptoms and thus failing to identify the cause and treat it rather than just the symptoms.

I understand that from Ms. Povacz's perspective she did not have the symptoms she now has, then the AMI meters were installed and shortly after the symptoms appeared so the meters must be the cause of the symptoms. The sequence and timing of those 2 events does not establish that the AMI meters caused her symptoms. To determine the actual or most likely cause of symptoms, in medicine we take a carful medical history, conduct a thorough physical examination, and oftentimes perform relevant imaging and laboratory studies before seeking a unifying diagnosis that accounts for as many of the abnormal findings as possible. Sometimes the identification of a single diagnostic entity is not possible, but in any case, the outcome of this investigation is a differential diagnosis, a list of illnesses prioritized by the likelihood that one (or more) of these disorders are more likely than others on the list to account for the patient's illness. The first step

in forming a differential diagnosis is to consider and rule out things that have not been shown to cause the symptoms and then focus our efforts on plausible causes because, once identified, they can be treated. To do that, we must look at reliable medical and scientific studies. If those studies as a whole do not consistently show that an event, such as exposure radio frequency fields, causes a symptom or symptoms, we proceed to analyze plausible causes.

Many things could have caused Ms. Povacz's symptoms. It could be many things such as 1) other events that occurred about the same time the AMI meters were installed (in medicine when trying to ascertain the cause of symptoms we are sensitive to confounding factors, causes which are unrecognized and sometimes unrecognizable), 2) an ongoing, but undiagnosed medical condition, or 3) the development of symptoms because of a sincere belief that one or another sources of personal concern, like AMI meters, can cause specific symptoms (in medicine we call that the nocebo effect, which is the development of symptoms as the result of a negative perception).

I do not know what caused Ms. Povacz symptoms. But based on the medical and scientific studies and my education, training and experience, I confident they were not caused by radio frequency fields from the AMI meters.

27. Q. **What is your medical opinion about exposure to radio frequency fields and Ms. Povacz's reports of symptoms of widespread pain, body aches, buzzing in the ears, eye floaters, lack of concentration, memory loss?**

A. Based on the studies of Idiopathic Environmental Intolerance and acute reported symptoms and the public health authority expert panel reports, my opinion is that

there is no reliable medical basis for concluding that radio frequency fields from: 1) PECO's AMR meter at Ms. Povacz's house or from PECO's AMI meter at her neighbor's house, or both, caused or contributed to or exacerbated Ms. Povacz's reported widespread pain, body aches, buzzing in ears, eye floaters, lack of concentration, or memory loss, or

2) the replacement of the AMR meter at Ms. Povacz's house with an AMI meter will cause or contribute to or exacerbate, widespread pain, body aches, buzzing in ears, eye floaters, lack of concentration, or memory loss.

28. Q. **Are studies done to address whether exposures have the capability to cause or contribute to adverse health effects?**

A. Yes. The types of studies that I have found to be most helpful in assessing the capability of an exposure to cause health effects are those that address fundamental biological functions in animals that are very sensitive to any disruption. Of course, if you want to know if an exposure causes a specific health effect, you have to look at studies addressing that specific health effect.

29. Q. **What types of studies of fundamental biological functions that are very sensitive to disruption do you find most helpful in assessing the capability of an exposure to cause or contribute to adverse health effect?**

A. I find that the most helpful studies of fundamental biological functions that are very sensitive to disruption for assessing the capability of an exposure to cause or contribute to adverse health effect are those on genetics, reproduction, and growth and development.

30. Q. **Can you give us an example of studies of radio frequency fields and those**

fundamental biological functions that are very sensitive to disruption?

A. Yes. A good example of a well-done study of radio frequency fields and genetics is one titled "Absence of genotoxic potential of 902 MHz (GSM) and 1747 MHz (DCS) wireless communication signals: In vivo two-year bioassay in B6C3F1 mice." [Ziemann 2009]. "Ferris wheels' were used to expose tube-restrained male and female mice to simulated environmental radio frequency signals of the Global System for Mobile Communications (GSM, 902 MHz) and Digital Cellular System (DCS, 1747 MHz). The subjects were exposed to radio frequency fields for 2 hours a day, 5 days a week for 2 years, at maximal whole-body-averaged specific absorption rates of 0.4, 1.3, and 4.0 W/kg body weight. That is very substantial exposure to radio frequency fields given the body size and life span of the subjects. Comparisons of effects were made several control groups (concurrent sham-exposed mice, cage controls, and positive controls). The study found no effects of radio frequency fields on genotoxicity in mice after two years of exposure.

A good example of a well-done study of radio frequency fields and reproduction is one titled "Effects of radiofrequency electromagnetic fields (UMTS) on reproduction and development of mice: a multi-generation study." [Sommer 2009]. Male and female mice were exposed to 1966 MHz radio frequency fields 24 hours a day for their lifetime. The power densities were kept constant for the exposed groups at 1.35, 6.8 and 22 W/cm2 and at 0.0 for W/cm2 the control groups. Their development and fertility were tracked over 4 generations by examining histological, physiological, reproductive, and behavioral functions.

Those examinations were done without knowing which subjects were in the exposed groups and which were in the control groups. The result of this 24 hours a day, lifetime exposure over 4 generations was that the radio frequency had no harmful effects on the fertility and development of the animals.

A good example of a well-done study of radio frequency fields on growth and development is titled "Lack of adverse effects of whole-body exposure to a mobile telecommunication electromagnetic field on the rat fetus. [Takahashi 2010]. The subjects and their offspring were whole-body exposed to 2.14 GHz radio frequency fields for 20 hours a day during gestation and lactation. The study examined the effects of radio frequency fields on growth, gestational condition and organ weights for dams and survival rates, development, physical and functional development, hormonal status, memory function, and reproductive ability of the first generation offspring along with embryotoxicity and teratogenicity in the second generation offspring. The study found that the radio frequency fields had no effects on growth or development.

b. Thyroid gland producing antibodies against itself and Hypothyroidism

31. Q. **Ms. Povacz says that a Dr. Bernstein advised her that her thyroid gland was producing antibodies against itself (page 24) and she was diagnosed with hypothyroidism in 2015 and it persists (Appendix 16). What do the scientific studies show about exposure to radio frequency fields and the thyroid gland producing antibodies against itself and hypothyroidism?**

A. At the outset, it should be understood that the Thyroid gland does not produce antibodies. Antibodies are produced by lymphocytes, which are part of the

immune system. Antibodies that act against the thyroid gland can cause either hyperthyroidism or hypothyroidism.

In Appendix 17, Ms. Povacz provides a copy of a study entitled, "Pulse modulated 900 MHz radiation induces hypothyroidism and apoptosis in thyroid cells: a light, electron microscopy and immunohistochemical study." [Eşmekaya 2010]. The study claims to have found evidence of damaged thyroid tissues in some exposed animals, but it does not provide any data comparing the damage to animals that were not exposed to radio frequency fields. (The study also has other design and reporting flaws.) The cornerstone of diagnosis of hypothyroidism is measurements of thyroid hormones or thyroid stimulating hormones. The study, however, did not report any such measurements. Therefore, despite the reference in the study title to hypothyroidism, it provides no data showing the exposed animals developed hypothyroidism.

A study of human volunteers exposed to 900 MHz radio frequency fields for 2 hours a day, 5 days a week, for a month found no effect on the hormone levels of the anterior pituitary gland in the human volunteers. [deSeze 1998] That is very strong evidence that exposure to radio frequency fields does not cause hypothyroidism in humans.

The studies as a whole do not show that radio frequency fields cause the production of antibodies that act against the Thyroid gland or that they cause, or contribute to hypothyroidism or exacerbate any of its symptoms.

Notably, several of the symptoms Ms. Povacz reports (sleep disturbance, buzzing in the ears, lack of concentration, and headaches) are commonly reported symptoms of hypothyroidism.

32. Q. **What is your medical opinion about exposure to radio frequency fields and the thyroid gland producing antibodies against itself and hypothyroidism?**

A. My opinion is that there is no reliable medical basis for concluding that radio frequency fields from:

1) PECO's AMR meter at Ms. Povacz's house or from PECO's AMI meter at her neighbor's house, or both, caused or contributed to or exacerbated Ms. Povacz's reported production of antibodies against the thyroid gland or hypothyroidism, or 2) the replacement of the AMR meter at Ms. Povacz's house with an AMI meter will cause or contribute to or exacerbate either the production of antibodies against the thyroid gland or hypothyroidism.

c. "Adrenals much stressed and close to burning out"

33. Q. **Ms. Povacz says that a Dr. Bernstein advised her "adrenals were much stressed and close to burning out" (page 24). What do the scientific studies show about exposure to radio frequency fields and the "adrenals ... much stressed or close to burning out"?**

A. The adrenal glands are part of the endocrine system. Some adrenal hormones can be released during acute stress. The studies as a whole show radio frequency fields do not affect adrenal gland function. (See, for example, Djeridane 2008, DeSeze 1998, and Jin 2013). The Djeridane 2008 study was done on humans and found no effect of 900 MHz radio frequency fields on adrenal gland function.

34. Q. What is your medical opinion about exposure to radio frequency fields and Ms. Povacz and, reportedly, her "adrenals were much stressed and close to burning out"?

A. My opinion is that there is no reliable medical basis for concluding that radio frequency fields from:

1) PECO's AMR meter at Ms. Povacz's house or from PECO's AMI meter at her neighbor's house, or both, caused or contributed to or exacerbated Ms. Povacz's reported adrenal stress or "burning out," and

2) the replacement of the AMR meter at Ms. Povacz's house with an AMI meter will cause or contribute to or exacerbate adrenal stress or "burning out."

d. Chest pains, rapid heartbeats, heart arrhythmia, and palpitations

35. Q. Ms. Povacz says that "[i]n the summer of 2013 ... in the middle of the night [she] woke up with chest pains and rapid heartbeats, heart arrhythmia and palpitations" (page 20). What do the scientific studies show about exposure to radio frequency fields and chest pains, rapid heartbeats, heart arrhythmia, and palpitations?

A. There are no studies of humans or other animals that report radio frequency fields cause chest pains. Rapid heartbeats, arrhythmia, and palpitations all involve heartbeat rate variations. There have been 2 studies that measured whether radio frequency fields affected human heart rate variability [Parazzini 2013 and Choi 2014] and both report they do not. In sum, studies of exposure to radio frequency fields in humans do not show that they cause chest pains, rapid heartbeats, arrhythmia, or palpitations.

36. Q. What is your medical opinion about exposure to radio frequency fields and Ms. Povacz's reported chest pains and rapid heartbeats, heart arrhythmia and palpitations?

A. My opinion is that there is no reliable medical basis for concluding that radio frequency fields from:

1) PECO's AMR meter at Ms. Povacz's house or from PECO's AMI meter at her neighbor's house, or both, caused or contributed to or exacerbated Ms. Povacz's reported chest pains and rapid heartbeats, heart arrhythmia or palpitations, and

2) the replacement of the AMR meter at Ms. Povacz's house with an AMI meter will cause or contribute to or exacerbate chest pains and rapid heartbeats, heart arrhythmia or palpitations.

e. Sleep disturbance, fatigue, and lethargy

37. Q. Ms. Povacz says that she has experienced sleep disturbance (pages 10, 11, 12, 13, 20, 27, and Appendix 16), fatigue (page 40 and Appendix 16), and lethargy (Appendix 16). What do the scientific studies show about exposure to radio frequency fields and sleep disturbance, fatigue, and lethargy?

A. There are no controlled laboratory studies of whether exposure to radio frequency fields causes or contributes to fatigue or lethargy in humans or other animals. There are a variety of causes for reported fatigue and lethargy (e.g., medications) but poor sleep quality is one of the principal determinants of reported fatigue and lethargy. Sleep quality has been examined in cohort studies or association studies. [Herr 2005; Mohler 2010; and Mohler 2012]. Each reported no effect of exposure to radio frequency fields on sleep quality. The Mohler 2012 study also included a

nested sleep study with objectively recorded exposure and measured sleep behavior that confirmed their finding that exposure to radio frequency fields has no effect on sleep quality. In sum, studies of exposure to radio frequency fields do not show that they cause, contribute to, or exacerbate fatigue, lethargy, or sleep disturbance.

38. Q. **What is your medical opinion about exposure to radio frequency fields and Ms. Povacz's reported sleep disturbance, fatigue, and lethargy?**

A. Based on the lack of controlled laboratory studies of whether exposure to radio frequency fields causes or contributes to fatigue or lethargy in humans or other animals, the studies of whether exposure to radio frequency fields affect sleep quality, and the public health authority expert panel reports I identified earlier, my opinion is that there is no reliable medical basis for concluding that radio frequency fields from:

1) PECO's AMR meter at Ms. Povacz's house or from PECO's AMI meter at her neighbor's house, or both, caused or contributed to or exacerbated Ms. Povacz's reported sleep disturbance, fatigue, and lethargy, or

2) the replacement of the AMR meter at Ms. Povacz's house with an AMI meter will cause or contribute to or exacerbate sleep disturbance, fatigue, and lethargy.

39. Q. **Dr. Talmor says that "[s]martmeters are known to emit EMF and RF radiation and they would be harmful to my patient's fragile health (page 4). Do you agree?**

A. No, I disagree. My opinion is that there is no reliable medical basis for concluding that radio frequency fields from:

1) PECO's AMR meter at Ms. Povacz's house or from PECO's AMI meter at her neighbor's house, or both, caused or contributed to or exacerbated any adverse health effects for Ms. Povacz's or were harmful to her health, and

2) the replacement of the AMR meter at Ms. Povacz's house with an AMI meter will cause or contribute to or exacerbate any adverse health effects for Ms. Povacz's or would be harmful to her health.

V. CONCLUSION

40. Q. Do you hold each of the medical opinions you provide in this testimony to a reasonable degree of medical certainty?

A. Yes.

41. Q. What is your overall medical opinion?

My overall medical opinion is that exposure to electromagnetic fields from PECO's smartmeters have not been and will not be harmful to Ms. Povacz's health.

42. Q. Does that conclude your testimony?

A. Yes.