

PECO Energy Company Statement No. 3^R

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Before The

PENNSYLVANIA PUBLIC UTILITY COMMISSION

Laura Sunstein Murphy

v.

Docket No. C-2015-2475726

PECO Energy Company

REBUTTAL TESTIMONY OF DR. CHRISTOPHER DAVIS

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REBUTTAL TESTIMONY OF DR. CHRISTOPHER DAVIS

I. INTRODUCTION

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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?

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

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

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

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

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

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

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

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

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

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

- 1 A. A wide variety in the fields of physics, biophysics, and electrical engineering, and
2 particularly studies on electromagnetics, bioelectromagnetics, and radio frequency
3 electromagnetics and dosimetry.
- 4 **11. Q. Have you authored any scientific publications in your areas of expertise?**
- 5 A. Yes, I have authored or co-authored two books, twelve book chapters, 244 articles
6 published in peer-reviewed scientific journals (principally reporting on studies I
7 have conducted) and 313 papers presented at scientific conferences. Among those
8 publications are 2 book chapters on radio frequency fields; 24 articles published
9 in peer-reviewed scientific journals on radio frequency fields. I have also
10 presented 55 papers at scientific conferences on radio frequency fields.
- 11 **12. Q. Have you done any research on radio frequency fields of the type produced**
12 **by PECO's AMI meters?**
- 13 A. Yes, I have conducted a substantial amount of research on radio frequency fields
14 of the type periodically produced by PECO's AMI meters.
- 15 **13. Q. Have you served on any scientific committees that evaluate research related**
16 **to electromagnetic fields?**
- 17 A. Yes, I have served on the Institute of Electrical and Electronic Engineers (IEEE)
18 Committee on Man and Radiation (COMAR) and as chair of the Subcommittee
19 on Radio Frequency Fields, which is comprised of experts who examine the
20 scientific research on them and evaluate the IEEE exposure guidelines.
- 21 **14. Q. Do you review research papers submitted by other researchers to scientific**
22 **publishers for publication?**

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

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

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

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

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

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

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

11 **III. TERMINOLOGY AND SOME BASIC CONCEPTS**

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

15 A. Yes.

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

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

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

3 **20. Q. What is a “field” as used in the term “electromagnetic field”?**

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

8 **21. Q. What is electromagnetic “radiation”?**

9 A. “Radiation” is a scientific term that describes how energy travels from a source,
10 i.e., it “radiates” out from the source. An example of radiation is the waves that
11 radiate out in a circle when a stone is tossed into a pond. TV and radio broadcast
12 towers, powerlines, appliances, home wiring, and TV remote controls all produce
13 fields that radiate. NASA has a good and simple statement about radiation on its
14 website: “Radiation is energy that travels and spreads out as it goes – the visible
15 light that comes from a lamp in your house and the radio waves that come from a
16 radio station are two types of electromagnetic radiation.”

17 <http://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html>.

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

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

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

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

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

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

18 **23. Q. What is a radio frequency field?**

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

22 **24. Q. Is it technically accurate to refer to “radiofrequency radiation”?**

1 A. Yes, but as the Health Physics Society says on its website: "Although [people]
2 might be familiar with the use of radiation to diagnose disease and treat cancer,
3 many people, when they hear the terms "radioactive" and "radiation," tend to
4 think of mushroom clouds and the monster mutants that inhabit the world of
5 science fiction movies and comic books."

6 <https://hps.org/publicinformation/ate/faqs/consumerproducts.html>

7 It is *technically* accurate to refer to "radio frequency radiation" but it can
8 sometimes be used to confuse people into thinking about radio signals as though
9 they can be harmful like sources of ionizing radiation.

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

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

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

8 **26. Q. What is dosimetry?**

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

14 **27. Q. Ms. Murphy says that the Switched Mode Power Supply contained in
15 all digital meters creates dirty electricity and harmonics on the whole
16 household current (page 11). As an electrical engineer, what can you tell us
17 about “dirty electricity”?**

18 A. The electricity we use has always been produced by rotating generators at power
19 stations and those generators produce electricity that is transmitted to us at 60 Hz
20 (in the United States) with harmonic waves at multiples of 60 Hz (120 Hz, 180 Hz,
21 240 Hz, etc.). Harmonics are a natural byproduct of generating electricity so in
22 electrical engineering we do not use the term “dirty electricity.” AMI meters do
23 not generate electrical power; they measure the electrical power flowing into and

1 being used in a house. They do not produce additional harmonics over and above
2 what is coming into the meter. Typical household appliances can generate radio
3 frequency fields that are much larger than those generated by AMR or AMI
4 meters. Switching-mode power supplies generate radio frequency fields at up to
5 about 10 MHz at very low levels. Many modern electrical appliances use
6 switching mode power supplies.

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

13 IV. PECO AMI METERS AND SAFETY

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

15 A. No.

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

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

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

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

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

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

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

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

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

14 A. The FCC's Maximum Permissible Exposure Limits for non-portable devices that
15 transmit radio frequency signals are based on exposure guidelines issued by two
16 expert organizations: 1) the U.S. National Council on Radiation Protection and
17 Measurements (NCRP) and 2) the American National Standards Institute (ANSI).
18 Based on scientific studies those expert organizations analyzed, both
19 organizations identified the same threshold level (i.e., lowest level) of radio
20 frequency exposure at which a potentially adverse biological effect could occur,
21 which was found to be at a level at where there can be tissue heating. Then they
22 applied safety factors that resulted in lower exposure levels that they adopted as
23 their exposure guidelines. In addition, in adopting its exposure limits, the FCC

1 consulted with the U.S. Food and Drug Administration, the Environmental
2 Protection Agency, the Occupational Safety and Health Administration, and the
3 National Institute of Occupational Safety and Health and each supported the FCC
4 setting its exposure limits based on the exposure guidelines issued by those expert
5 organizations. [https://www.fcc.gov/engineering-technology/electromagnetic-](https://www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety#Q9)
6 [compatibility-division/radio-frequency-safety/faq/rf-safety#Q9](https://www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety#Q9).

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

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

19 **Second, the FCC continues to consider whether there are adverse biological**
20 **effects from non-thermal exposure levels. The FCC states that the scientific**
21 **evidence for adverse biological effects from non-thermal exposure levels remains**
22 **“ambiguous and unproven.” [Page 14 of 25](https://www.fcc.gov/engineering-</p></div><div data-bbox=)**

1 technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-
2 safety#Q5. I agree with that statement of the FCC.

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

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

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

18 **35. Q. Does the FCC have a single Maximum Permissible Exposure Limit for all
19 non-portable devices?**

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

- 1 36. Q. Did you determine whether PECO's AMI meters comply with the FCC's
2 Maximum Permissible Exposure Limits?
- 3 A. Yes, my exhibit CD2 shows that PECO's AMI meters comply with the FCC's
4 Maximum Permissible Exposure Limits that apply to both radios in PECO's AMI
5 meters. The radio frequency exposure from PECO's AMI FlexNet radio is 7.8
6 million times smaller than the FCC's Maximum Permissible Exposure Limit and
7 the ZigBee radio is 164 million times smaller than the FCC's Maximum
8 Permissible Exposure Limit.
- 9 37. Q. Did you check the peak exposures from the PECO AMI radios to the FCC
10 limits?
- 11 A. Yes, but first it is important to understand that the FCC limit does not apply to
12 peak exposure; it applies to the 30-minute average exposure. My exhibit CD3
13 shows that the peak exposure from the AMI FlexNet radio is 37.5 times smaller
14 than the FCC limit for 30-minute average exposure and the peak exposure from
15 the AMI ZigBee radio is 3,800 times smaller than the FCC limit for 30-minute
16 average exposure.
- 17 38. Q. Did you compare the exposures from PECO's AMI radios to the exposure
18 guidelines issued by the International Commission on Non-Ionizing
19 Radiation Protection (ICNIRP)?
- 20 A. Yes, but first I should point out that the FCC has its own limits and therefore has
21 not adopted the ICNIRP guidelines. My exhibit CD4 shows that the radio
22 frequency exposure from the PECO AMI FlexNet radio is 5.8 million times

1 smaller than the ICNIRP guideline that applies to it and the ZigBee radio is 164
2 million times smaller than the ICNIRP guideline that applies to it.

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

6 A. Yes, my exhibit CD5 shows the following: 1) people are and have been
7 commonly exposed to radio frequency fields from a number of sources for many
8 years and they are much higher than the exposure from the PECO AMI radios; 2)
9 compared to the exposure from PECO's AMI radios, exposures from cell phone
10 towers are 14.7 times larger, exposures 10 miles from a typical radio and TV
11 broadcast transmitter is 18.4 times larger, exposures from standing 30 feet away
12 from a cell phone are 5,700 times larger, exposures from using cell phones can be
13 up to 1.9 million times larger, and exposures from microwave ovens can be up to
14 6 million times larger. It is notable that the exposure from PECO's AMI radios is
15 5,700 times smaller than the exposure a person gets standing 30 feet away from
16 somebody talking on a cell phone.

17 **40. Q. How does the exposure from a PECO AMI compare to the exposure**
18 **in West Chester, Pennsylvania from UHF television broadcasting?**

19 A. My exhibit CD6 shows that the radio frequency fields at 1 meter from a PECO
20 AMI are 282 times smaller than the background radio frequency exposure from
21 UHF TV broadcasting in West Chester, Pennsylvania.

22 **Q. In her answer PECO's Interrogatories and Requests for Production of**
23 **Documents, Set II, Interrogatory 11-1, Ms. Murphy says she has a Samsung**

1 Galaxy Note 4 cell phone and in response to a request for 6 months of phone
2 bills she provided a redacted bill for March/April 2016 showing 7 minutes of
3 usage. How does the 7 minutes of radio frequency field exposure from using
4 that phone compare to exposure from PECO AMR and AMI meters?

5 A. My exhibit CD7 (to which I have attached a copy of Ms. Murphy's interrogatory
6 response) shows that average exposure to radio frequency fields from using a cell
7 phone 7 minutes a month is 188 times greater than the exposure at 1 meter from a
8 PECO AMR meter and 1,200 times greater than the exposure from an AMI meter.
9 Put another way, to reach the same amount of exposure one would get from 7
10 minutes of cell phone use it, would take 15 years of AMR exposure within 1
11 meter of an AMR meter and over 107 years of exposure within 1 meter of an AMI
12 meter.

13 **41. Q. How do the radio frequency exposures from PECO's old AMR meter and its**
14 **new AMI meter compare?**

15 A. The radio frequency exposure from PECO's new AMI meter is 6.4 times smaller
16 than the radio frequency exposure from PECO's old AMR meter, as shown on my
17 exhibit CD8.

18 **42. Q. Will the installation of a PECO AMI meter at Ms. Murphy's house increase**
19 **the radio frequency exposure at her house?**

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

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

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

13 **A. No. Dr. Pall’s VGCC mechanism theory for how electromagnetic fields produce**
14 **biological effects (and thus health effects) has not been generally accepted by**
15 **experts in the field. I am familiar with mechanism theories like Dr. Pall’s because**
16 **I teach about them - and the lack of consistent and reproducible confirmation of**
17 **any them - in my Electromagnetics course. (I should note that his VGCC theory**
18 **reflects a fundamental lack of understanding of basic cell biophysics.)**
19 **Since Dr. Pall published his VGCC mechanism theory in 2013, at least 6 expert**
20 **science panels have conducted careful reviews of radio frequency research.**
21 **[Health Council of the Netherlands 2014; Australian Radiation Protection and**
22 **Nuclear Safety Agency 2014; Swedish Radiation Safety Authority 2014; Swedish**
23 **Radiation Safety Authority 2015; New Zealand Ministry of Health 2015; The**

1 Scientific Committee on Emerging and Newly Identified Health Risks of the
2 European Commission 2015. The International Commission on Non-ionizing
3 Radiation Protection (ICNIRP) says no on its website “Acute and long-term
4 effects of HF [high frequency, including radio frequency] exposure below the
5 thermal threshold have been studied extensively without showing any conclusive
6 evidence of adverse health effects.” None of those expert authorities accept Dr.
7 Pall’s VGCC mechanism theory; in sum it is not generally accepted by experts in
8 the field.

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

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

21 In addition, the various pulsed field bone healing devices produce magnetic fields
22 of 0.1 Gauss (G) up to 20 G. [Galkowski 2009]. The exposure necessary to

1 produce even 0.1 G is 189 mW/cm². That is 11,850 times larger than the peak
2 exposure from a PECO AMI meter.

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

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

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

16 **46. Q. When asked about whether there are “other types of evidence that should**
17 **influence our understanding of the health-related impacts of low-intensity**
18 **microwave frequency EMFs,” Dr. Pall says in his testimony that “This whole**
19 **issue is terribly relevant to smart meters which can be seen to put out very**
20 **sharply spiked pulses... ” (page 8). Is it accurate to say that smart meters put**
21 **out very sharply spiked pulsed fields?**

22 A. First, as to the term “pulsed,” it depends on how and for what purpose one is
23 using the term and how technically accurate one wants to be. In layman terms,

1 “pulsed” can be used to describe anything that differs in a rhythmic way. In that
2 sense, a device that turns on a lamp each night for a few hours is producing a
3 “pulsed” visible light frequency electromagnetic field.

4 Second, in communications physics and engineering, “pulsed” means using 1.
5 amplitude modulation and 2. doing so in away that produces a signal that has
6 abrupt changes in the amplitude of the sine wave. PECO’s AMI meter radios are
7 not amplitude modulated so they do not produce “pulsed” fields. PECO’s AMI
8 meter radios are frequency modulated, specifically “frequency shift keyed,” and
9 send out a collection of regular non-pulsed sine waves around the frequencies
10 they use. (AM radio station signals are 1. amplitude modulated, which is what
11 “AM.” stands for, but 2. they transmit a sine wave whose frequency is fixed, the
12 so-called “carrier frequency.” The amplitude of that sine wave is modulated up
13 and down in a continuous way to encode the voice or music being transmitted.
14 That is why communications physicists and engineers do not refer to radio station
15 signals as “pulsed” signals.)

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

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

1 A. No, they do not. To the contrary, there have been many reports by expert panels
2 advising governments and public health authorities and the consensus is that the
3 scientific research non-thermal (i.e. very low level) radio frequency fields does
4 not provide consistent and reproducible scientific evidence that they cause any
5 biological effects.
6 For example, the UK government's expert advisory group on radio frequency
7 science found that "[t]here are now several hundred studies in the published
8 literature that have looked for effects on isolated cells or their components when
9 exposed to RF fields. *** [W]here reported effects were investigated by
10 independent replications the effects were not found." [AGNIR 2012, 318]
11 Similarly, the international expert group ICNIRP has found that "[t]he studies
12 conducted so far have not provided consistent evidence of biological effects under
13 non-thermal RF exposure conditions." [ICNIRP 2009, 155]
14 A recent review by the New Zealand Ministry of Health concluded "thermal
15 effects are the only ones for which there is clear evidence." [New Zealand 2015,
16 32]
17 This view is also shown in the recent finding by the expert committee advising the
18 European Commission on EMF/RF issues that "no interaction mechanism(s) is
19 (are) known regarding potential non-thermal effects of weak fields." [SCENIHR
20 2015, 24] The expert group further concluded that while mechanisms other than
21 heating have been suggested, "none has been firmly demonstrated in humans and
22 their relevance to health remains unclear." [SCENIHR 2015, 59].

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

3 **V. CONCLUSIONS**

4 **48. Q. Have you come to any overall conclusions about the radio frequency fields**
5 **from PECO’s AMI meters?**

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

10 The levels of radio frequency fields from PECO’s AMI meters are
11 (1) extremely low, 7.8 to 164 million times lower than the safety limits
12 established by the FCC, and
13 (2) many times lower than the radio frequency fields people are commonly
14 exposed to from everyday sources.

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

22 **49. Q. Do you make your statements set forth in this testimony to a reasonable**

1 **degree of Electrical Engineering, Biophysics, Electromagnetics,**
2 **Bioelectromagnetics, Radio Frequency Bioelectromagnetics, and scientific**
3 **certainty?**

4 A. Yes.

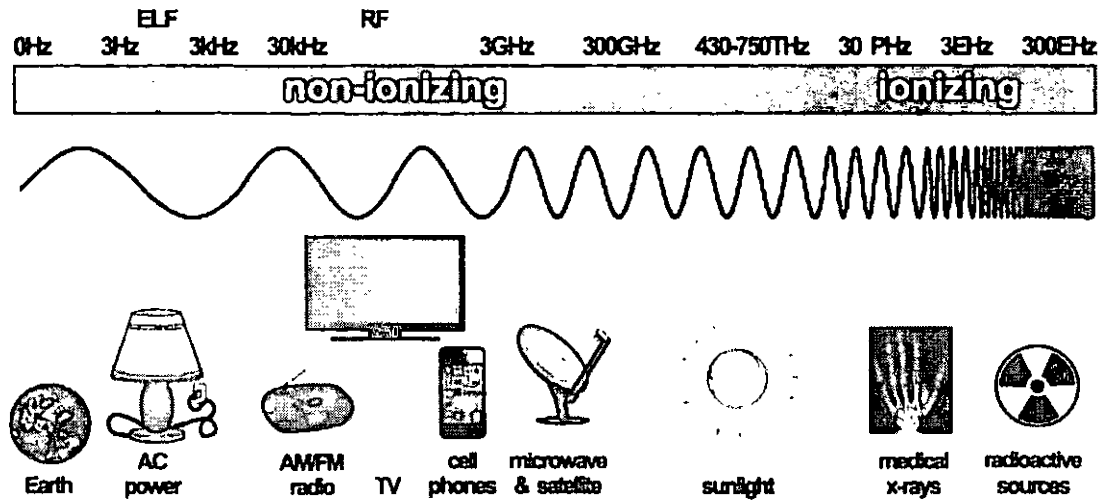
5 50. Q. **Does that conclude your pre-filed rebuttal testimony?**

6 A. Yes

PECO Exhibit CD-1

The Electromagnetic Spectrum

THE ELECTROMAGNETIC SPECTRUM



THE ELECTROMAGNETIC SPECTRUM

Exhibit CD1

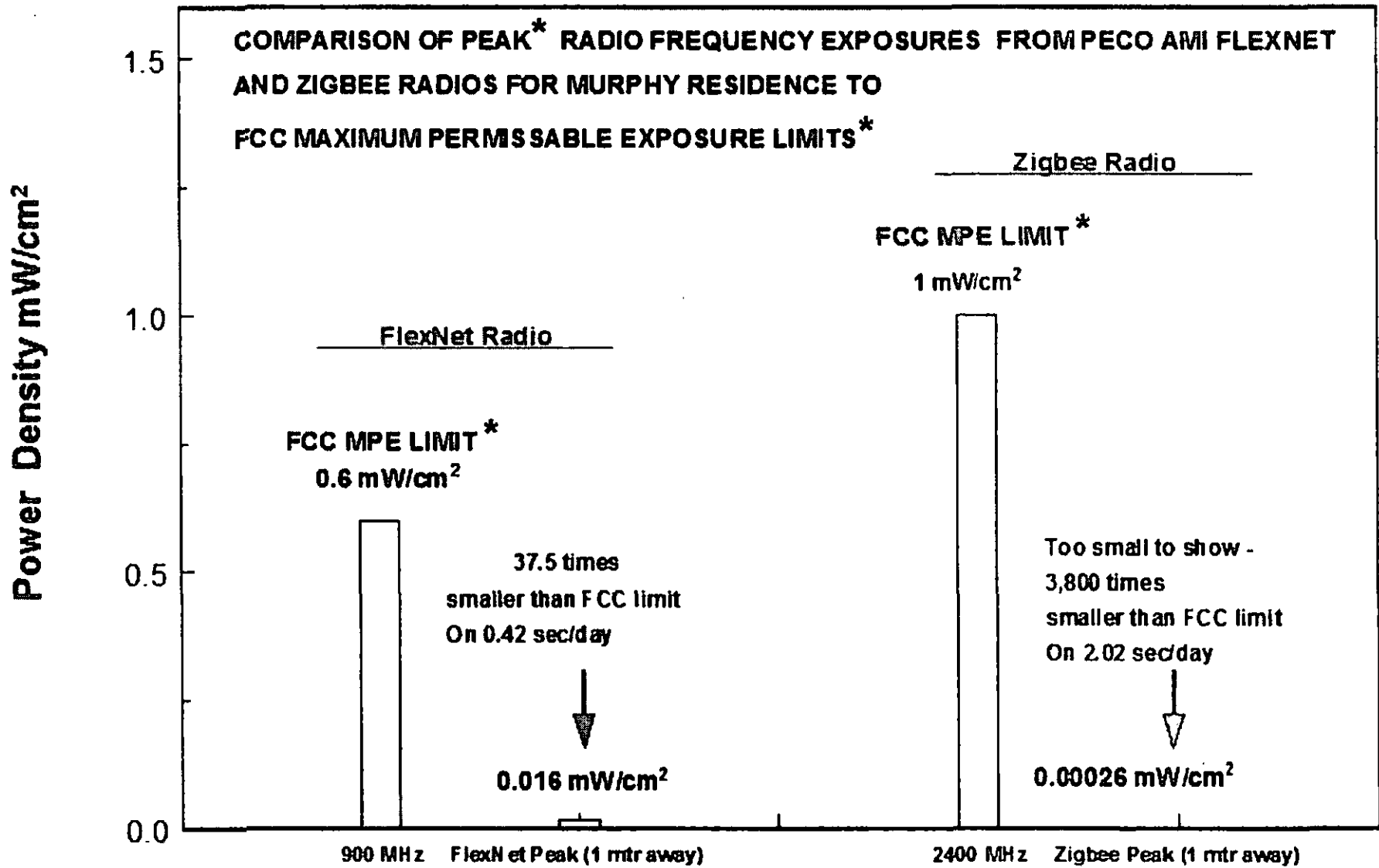
PECO Exhibit CD-2

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



PECO Exhibit CD-3

**Comparison of Peak RF Exposures From PECO AMI FlexNet
and ZigBee Radios for Murphy Residence to FCC Maximum
Permissible Exposure Limits**



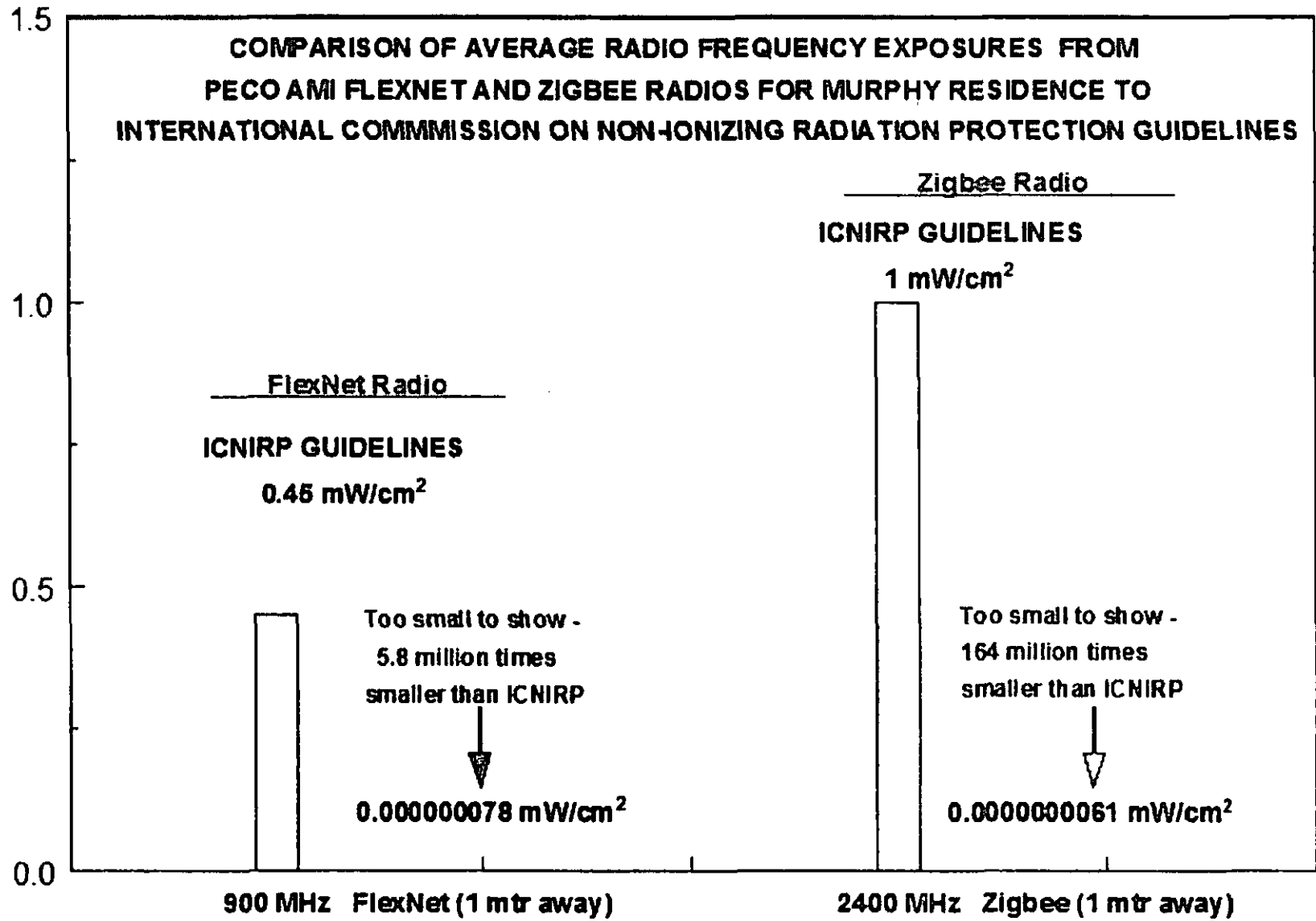
* FCC Limits are on radio's 30 minute average, not its peak

PECO Exhibit CD-4

**Comparison of Average RF Exposures From PECO AMI FlexNet
and ZigBee Radios for Murphy Residence to International
Commission on Non-Ionizing Radiation Guidelines**

**COMPARISON OF AVERAGE RADIO FREQUENCY EXPOSURES FROM
PECO AMI FLEXNET AND ZIGBEE RADIOS FOR MURPHY RESIDENCE TO
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION GUIDELINES**

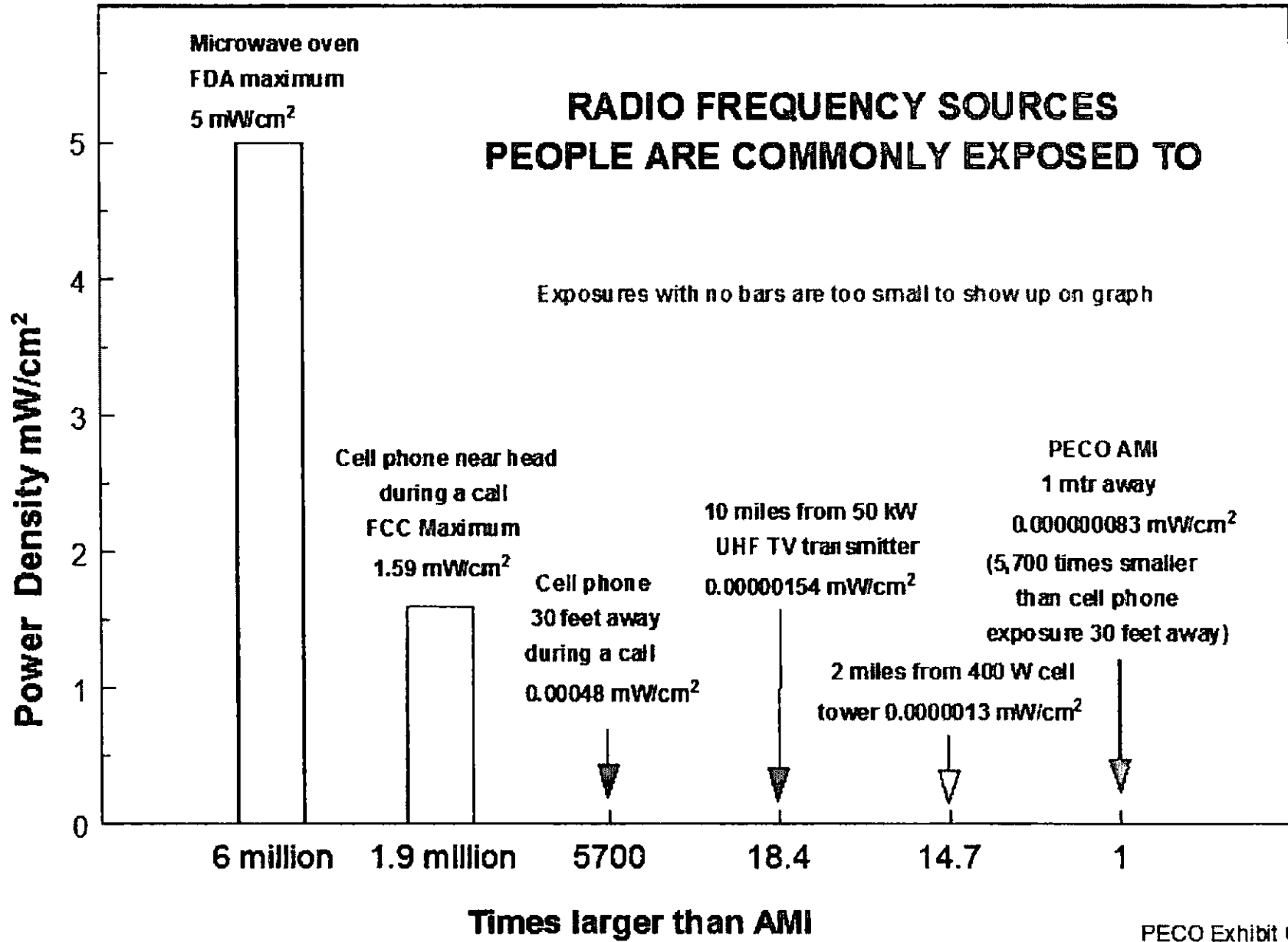
Power Density mW/cm²



PECO Exhibit CD-5

Radio Frequency Sources People Are Commonly Exposed To

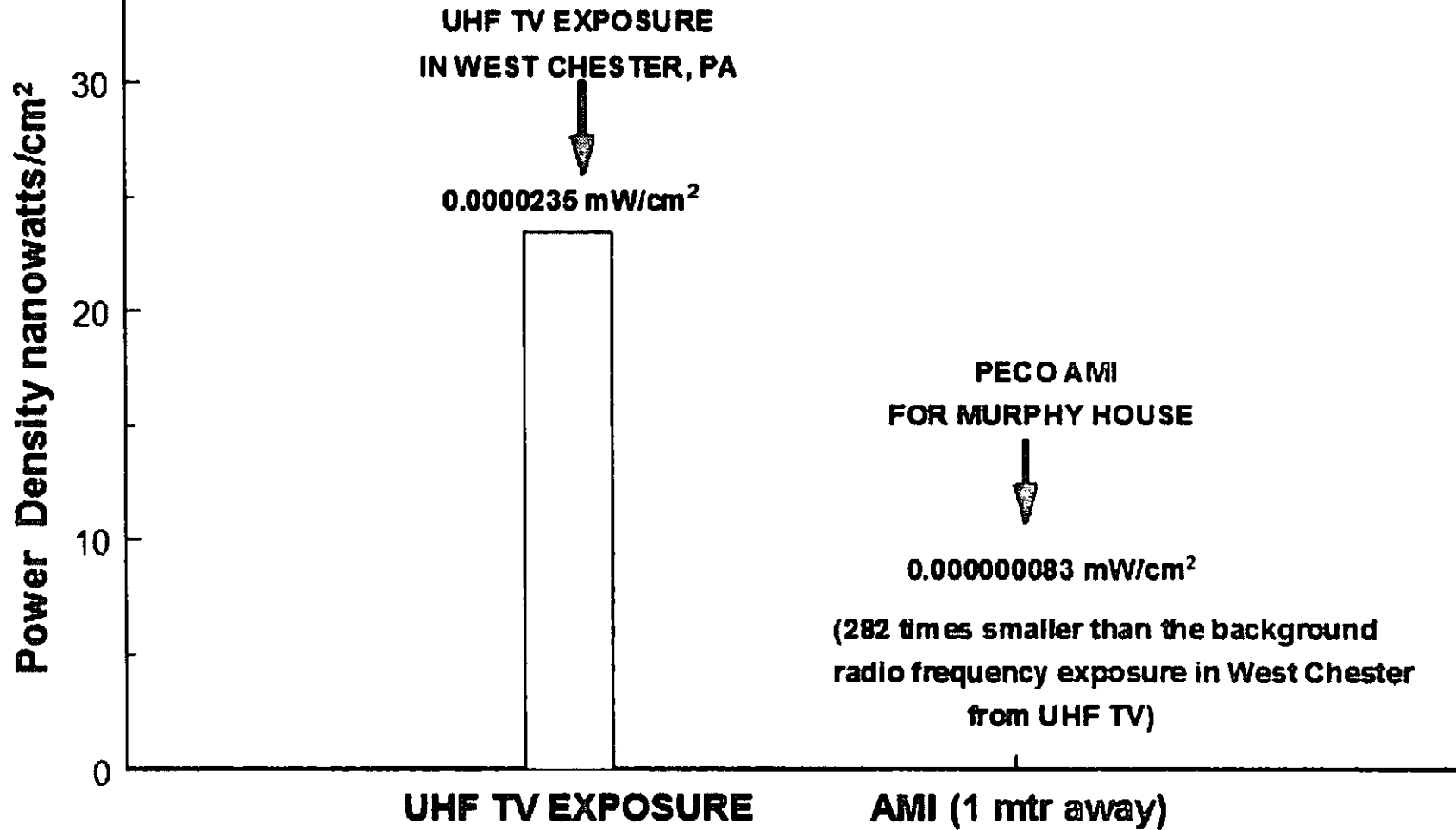
RADIO FREQUENCY SOURCES PEOPLE ARE COMMONLY EXPOSED TO



PECO Exhibit CD-6

**Comparison of Average RF Exposures From UHF TV in West
Chester, PA to PECO AMI For Murphy Residence**

**COMPARISON OF AVERAGE RADIO FREQUENCY EXPOSURES
FROM UHF TV IN WEST CHESTER, PA TO PECO AMI RADIOS
FOR MURPHY HOUSE**



UHF TV Transmitters Causing Exposure in West Chester, PA.

TV Broadcast Transmitters ID, Location and Call Sign	Distance from		Exposure (mW/cm ²)
	W. Chester (mils)	km	
39 DT 446.5 ALLENTOWN PA WLVT-TV 52	52.00	32.10	51.66 1.55055E-07
46 DT 482.0 ALLENTOWN PA WFMZ-TV 800	800.00	32.00	51.50 2.4004E-06
9 DT 452.3 BETHLEHEM PA WBPH-TV 80.6	80.60	32.00	51.50 2.4184E-07
6 DT 394.7 PHILADELPHIA PA WPVI-TV 34	34.00	24.20	38.95 1.78378E-07
14 CA 436.1 PHILADELPHIA PA WTSD-CA 146	146.00	24.30	39.11 7.59684E-07
17 DT 389.0 PHILADELPHIA PA WPHL-TV 645	645.00	24.30	39.11 3.35614E-06
6 DT 440.0 PHILADELPHIA PA KYW-TV 790	790.00	24.30	39.11 4.11062E-06
28 CA 226.0 PHILADELPHIA PA WFGA-CA 10.9	10.90	24.30	39.11 5.67161E-08
32 DT 465.0 PHILADELPHIA PA WPSG 250	250.00	24.30	39.11 1.30083E-06
34 DT 464.3 PHILADELPHIA PA WCAU 700	700.00	24.30	39.11 3.64232E-06
35 DT 441.0 PHILADELPHIA PA WYBE 450	450.00	24.30	39.11 2.34149E-06
38 DC 288.8 PHILADELPHIA PA WPHA-CD 3	3.00	24.30	39.11 1.56099E-08
42 DT 406.6 PHILADELPHIA PA WTXF-TV 260	260.00	24.30	39.11 1.35286E-06
22 DT 294.0 CAMDEN NJ WNJS 197	197.00	39.80	64.05 3.82114E-07
LANCASTER PA WGAL 32.2	32.20	44.90	72.26 4.90745E-08
LANCASTER PA WLYH-TV 500	500.00	44.90	72.26 7.62026E-07
WILMINGTON DE KJWP 9.36	9.36	17.70	28.49 9.17956E-08
WILMINGTON DE WHYI-TV 30	30.00	17.70	28.49 2.94217E-07
WILMINGTON DE WPPX-TV 200	200.00	17.70	28.49 1.96145E-06
Total exposure (mW/cm²)			2.34526E-05

PECO Exhibit CD-7

**Average RF Exposures From PECO AMR and AMI Radios
Compared to Cell Phone Exposures**

**AVERAGE RADIO FREQUENCY EXPOSURES
FROM PECO AMR AND AMI RADIOS
COMPARED TO CELL PHONE EXPOSURE**

Power Density nanowatts/cm²

150

100

50

0

**Average exposure
from cell phone 5 cm from head
used 7 minutes per month**

0.0000998 mW/cm²

**188 times greater than AMR exposure
1,200 times greater than AMI exposure**

**Average exposure from
PECO AMR 1 meter away**

0.00000053 mW/cm²

**Average exposure from
PECO AMI 1 meter away
too small to show on graph**

0.000000083 mW/cm²

Cell Phone (5 cm away)

AMR (1 mtr away)

AMI (1 mtr away)

**Answers of Complainants to
Interrogatories and Requests for Production of Documents
of PECO Energy Company, Set II
Docket No. C-2015-2475726**

PECO Interrogatory 11-1:

PECO Interrogatory Set 1-2 asked the following question: "Please identify the type (with make and model) of all devices, appliances, and equipment used in Complainant's home that produce radiofrequency fields, including cell phones ... "In response, the only phone listed was a Samsung Galaxy Note 4 Cell Phone, with the comment "For emergency only."

(a) Please provide six months of phone bills or other usage records for the Samsung Galaxy Note 4 Cell Phone with sufficient detail to show actual usage for that period.


(b) Does any member of the Murphy household other than Ms. Murphy use a cell phone? If so, please provide the make and model of each cell phone owned or used by any member of the household and, for each such phone identified, provide six months of phone bills or other usage records with sufficient detail to show actual usage for that period.

Answer:

Complainant only has access to her latest cell phone bill (March/April 2016), and a redacted copy of that bill is attached.

Responsible Witness: Laura Sunstein Murphy

Mar 11 - Apr 10

 Print/Save Bill (PDF)

Account Name: LAURA SUNSTEIN MURRELL

SUMMARY

CHARGES

USAGE

CALLS/TEXTS

 450 Anytime Minutes Included



Anytime Minutes (450)

7 / 450

Historical Usage

450

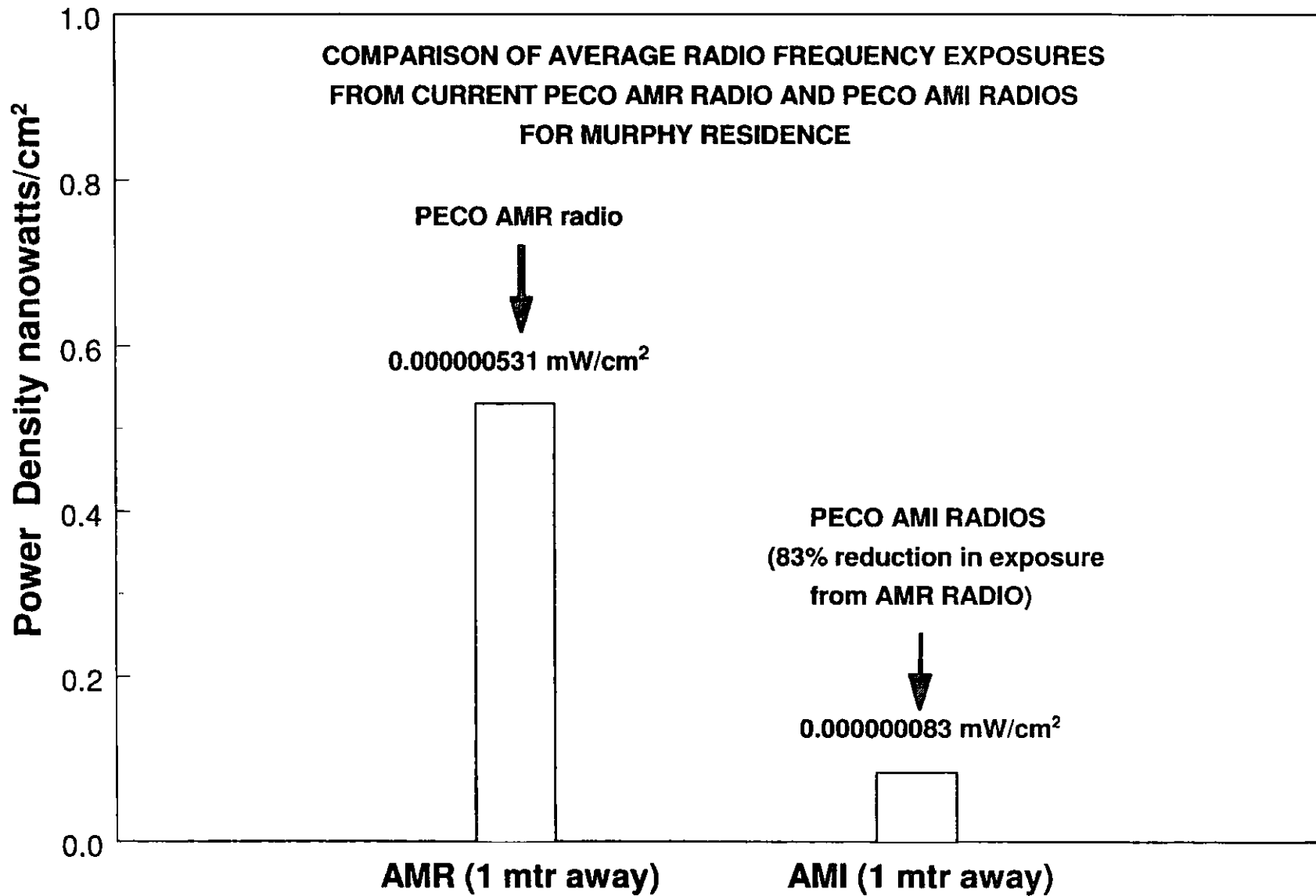
340

142



PECO Exhibit CD-8

**Comparison of Average Radio Frequency Exposures From
Current PECO AMR and PECO AMI For Murphy Residence**



PECO Energy Company Statement No. 4R

C-2015-2475023
Phi 12/8/16 vx

Before The

PENNSYLVANIA PUBLIC UTILITY COMMISSION

Laura Sunstein Murphy

v.

Docket No. C-2015-2475726

PECO Energy Company

REBUTTAL TESTIMONY OF DR. MARK ISRAEL

May 20, 2016

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REBUTTAL TESTIMONY OF DR. MARK ISRAEL

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REBUTTAL TESTIMONY OF DR. MARK ISRAEL

1

I. INTRODUCTION

2 1. Q. What is your name?

3 A. Dr. Mark A. Israel.

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

5 A. No.

6 3. Q. What is your business address?

7 A. 1 Medical Center Drive, Lebanon, NH 03756

8

II. QUALIFICATIONS

9 4. Q. Are you a medical doctor?

10 A. Yes.

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

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

14 6. Q. Are you licensed to practice medicine?

15 A. Yes in California and New Hampshire.

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

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

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

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

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

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

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

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

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

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

22 **12. Q. Have you supervised research by others?**

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

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

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

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

14 A. Yes.

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

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

1 could be the cause of their child's cancer so I examined the research, informed
2 them, and continued to follow the research. Later, parents of patients began
3 asking me whether using cellphones could cause cancer so again I examined the
4 research, informed them, and continued to follow that research. (The research has
5 examined not only cancer but also many other diseases and conditions and it has
6 involved many of the areas in which I teach or have done medical research.) I
7 have continued to systematically follow the research on those topics for more than
8 25 years.

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

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

13 **III. MEDICAL EVALUATION OF MS. MURPHY'S REPORTED**
14 **SYMPTOMS AND CONDITIONS, AND DR. PALL'S OPINIONS**
15 **ABOUT THE MEDICAL CAUSE OF THEM**

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

19 A. Yes.

20 **1. METHODOLOGY OF MEDICAL EVALUATION**

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

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

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

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

23 **20. Q. Dr. Pall testified (page 18) that “Smart meters have only been investigated**

1 for health effects twice, to my knowledge; once in Australia (Lamech 2014 in
2 Appendix I) after they were deployed there, and once in the U.S. (Conrad
3 2013 in Appendix I), also after they were deployed here.” Did you consider
4 those two papers in the course of conducting your medical evaluation?

5 A. Yes, I considered the Lamech 2014 and Conrad 2013 materials. The Lamech
6 paper is based on claims made about adverse health symptoms from smart meters
7 that were submitted to an unnamed public website by 91 (ninety-one) unidentified
8 people in the state of Victoria, Australia. (Victoria has a population of
9 approximately 5.7 million people.) The Conrad paper does not appear to have
10 been published in a peer-reviewed scientific journal, and I usually do not rely on
11 papers that are not subjected to peer review; but because Dr. Pall relied on it, I
12 searched and found it on the Internet. It is Exhibit D to the prefiled testimony of
13 Dr. Conrad that was submitted by the Maine Coalition To Stop Smart Meters in a
14 Maine Public Utility Commission proceeding. The Conrad report was based on an
15 invitation to fill out an online survey (utilizing “SurveyGizmo software”), which
16 was distributed to “internet sites and interest groups” over the Internet. A total of
17 210 (two hundred ten) people responded. The paper also says “The invitation
18 began: ‘If you feel your health has been affected by smart meters, we request your
19 immediate help in studying these effects.’” The paper refers readers to a website
20 for additional information about the survey, which says: “Our purpose is to
21 extract in a uniform way, particular types of information which will be useful in a
22 database to be used for research, reporting and testifying on the health safety of
23 smart meters.” Appendix 9 of the paper is a copy of the survey itself and at the

1 beginning it informs those who will be submitting their response in hard copy to
2 mail it to the "Maine Coalition to Stop Smart Meters, P.O. Box 43, Richmond,
3 ME 04357." These two papers only provide data on people's claimed symptoms
4 and their personal belief that they were caused by exposure to smart meters. In
5 addition, the data were not collected from a random sample of people exposed and
6 not exposed to smart meters, but instead were collected from individuals who
7 already identified their symptoms as having been caused by Smart Meters. In
8 essence, these papers are just reports from two self-selected groups identifying
9 symptoms they believe were caused by Smart Meters. It is my medical opinion
10 that the Lamech and Conrad papers do not provide scientifically reliable or useful
11 data upon which to make a determination of causation of any symptom or
12 condition identified in them.

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

18 **A.** No, even though those two papers could not establish whether smart meters cause
19 or do not cause any adverse health effects, there is other relevant information to
20 consider. There have been many studies done over many years on whether radio
21 frequency fields cause or contribute to various health effects and symptoms.
22 Although almost all of those studies used radio frequency field exposures that are
23 much higher, and in many studies multiples higher, than exposures from a smart

1 meter, I considered those studies to see what could be learned from them about
2 whether radio frequency fields from 1) PECO's AMR meter at Ms. Murphy's
3 house or from PECO's AMI meter at her neighbor's house, or both, caused or
4 contributed to or exacerbated Ms. Murphy's reported symptoms and conditions,
5 and 2) the replacement of the AMR meter at Ms. Murphy's house with an AMI
6 meter would cause or contribute to or exacerbate Ms. Murphy's reported
7 symptoms and conditions.

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

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

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

1 live animals are exposed to the same thing. We do controlled laboratory studies
2 on live animals, and sometimes humans (called *in vivo* studies, which is taken
3 from the Latin term for “in life”), to see if a health effect is revealed. Then we see
4 if the results can be replicated or confirmed by other researchers.

5 **2. MEDICAL EVALUATION OF MS. MURPHY’S REPORTED**
6 **SYMPTOMS AND CONDITIONS**

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

9 **23. Q. Why do you refer to electromagnetic hypersensitivity as “Idiopathic**
10 **Environmental Intolerance”?**

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

15 "The aetiology [cause] of ‘electromagnetic hypersensitivity’ is controversial.
16 While most patients and some scientists believe that the condition is caused
17 by an as yet unrecognised ‘bioelectromagnetic’ mechanism, most mainstream
18 medical bodies maintain that there is not sufficient evidence to support this
19 theory and that the symptoms experienced by sufferers are unrelated to the
20 presence of electromagnetic fields. Indeed, a working group of the World
21 Health Organisation has recommended that the use of terms like
22 ‘electromagnetic hypersensitivity’ should be discontinued in favour of the

1 more aetiologically [causalogically] neutral phrase 'idiopathic environmental
2 intolerance attributed to electromagnetic fields... .' (emphasis added)

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

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

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

18 **An early and careful study [Hietanen 2002] of people who said they were**
19 **hypersensitive is revealing. It used a double-blind design (neither the subjects**
20 **being studied nor the researchers knew when there was or was not a radio**
21 **frequency exposure). The study used radio frequency fields of 900 and 1800 MHz**
22 **from cellphones and a sham exposure (i.e., no real exposure). (Dr. Davis informs**
23 **me that the maximum allowable fields from cellphones are almost 2 million times**

1 higher than the fields 1 meter from PECO's AMI meters.) The study found that
2 the number of reported symptoms was higher during sham exposure than during
3 real exposure and none of the test subjects could distinguish actual radio
4 frequency field exposure from sham exposure. The study concluded that adverse
5 subjective symptoms or sensations perceived by the test subjects were not
6 produced by radio frequency exposure.

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

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

21 **25. Q. Is it generally accepted in the scientific or medical communities that**
22 **Idiopathic Environmental Intolerance and the variety of symptoms and**
23 **conditions attributed to it, such as some of those reported by Ms. Murphy,**

1 **are caused by, contributed to, or exacerbated by exposure to radio frequency**
2 **exposure?**

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

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

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

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

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

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

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

20 “The symptoms that are attributed by people to RF EMF exposure can
21 sometimes cause serious impairments to a person’s wellbeing. However,
22 research conducted since the previous Opinion adds weight to the conclusion
23 that RF EMF exposure is not the cause of these symptoms. This applies to the

1 general public, children and adolescents, and to people with idiopathic
2 environmental intolerance attributed to electromagnetic fields. Recent meta-
3 analyses of observational and provocation data support this conclusion.”

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

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

18 **26. Q. Ms. Murphy says that she developed she “developed bouts of atrial**
19 **fibrillation after the installation of the AMR meter on my home. Before**
20 **installation of the AMR meter, I never experienced any heart irregularities.”**
21 **(page 12). She also says “[b]efore the deployment of the AMR meter, I rarely**
22 **got sick from contagious diseases” and “I was going down the 20**
23 **inflammation path steadily and surely ever since the deployment of the AMR**

1 **21 meter on my house." (page 29) What does her testimony about those**
2 **symptoms appearing after the AMR meter was installed tell you about the**
3 **cause of those conditions?**

4 A. I considered the sequence and timing of the events but unfortunately it was of no
5 help in determining the cause of Ms. Murphy's symptoms. When one event
6 occurs shortly after another, that does not prove that the first event caused the
7 second event. An example of that point is recently, right after I ate breakfast it
8 started raining, but that does not prove that my eating breakfast caused it to rain.
9 In practicing medicine, we often get reports from patients about the sequence and
10 timing of events and the onset of their symptoms. If the symptoms occurred
11 before the event, we can logically rule out the event as the cause of the symptoms.
12 If the symptoms occurred after the event, it would be medically irresponsible to
13 our patient to conclude that the event caused the symptoms because that would
14 lead us to not proceeding with trying to determine the medical cause of the
15 symptoms and thus failing to identify the cause and treat it rather than just the
16 symptoms.

17 I understand that from Ms. Murphy's perspective she did not have the symptoms
18 she now has, then the AMR meter was installed and her symptoms appeared so
19 the AMR meter must be the cause of the symptoms. The sequence and timing of
20 those 2 events does not establish that the AMR meter caused her symptoms. To
21 determine the actual or most likely cause of symptoms, in medicine we take a
22 careful medical history, conduct a thorough physical examination, and oftentimes
23 perform relevant imaging and laboratory studies before seeking a unifying

1 diagnosis that accounts for as many of the abnormal findings as possible.
2 Sometimes the identification of a single diagnostic entity is not possible, but in
3 any case, the outcome of this investigation is a differential diagnosis, a list of
4 illnesses prioritized by the likelihood that one (or more) of these disorders are
5 more likely than others on the list to account for the patient's illness. The first step
6 in forming a differential diagnosis is to consider and rule out things that have not
7 been shown to cause the symptoms and then focus our efforts on plausible causes
8 because, once identified, they can be treated. To do that, we must look at reliable
9 medical and scientific studies. If those studies as a whole do not consistently show
10 that an event, such as exposure radio frequency fields, causes a symptom or
11 symptoms, we proceed to analyze plausible causes.

12 Many things could have caused Ms. Murphy's symptoms, such as 1) other events
13 that occurred about the same time the AMR meter was installed (in medicine
14 when trying to ascertain the cause of symptoms we are sensitive to confounding
15 factors, causes which are unrecognized and sometimes unrecognizable), 2) her
16 general medical condition and what she says are her "genetic medical conditions"
17 (page 4), or 3) the development of symptoms because of a sincere belief that one
18 or another sources of personal concern, like the AMR meter, can cause specific
19 symptoms (in medicine we call that the nocebo effect, which is the development
20 of symptoms as the result of a negative perception).

21 I do not know what caused Ms. Murphy's symptoms. But based on the medical
22 and scientific studies and my education, training and experience, I confident they
23 were not caused by radio frequency fields from the AMR meter.

- 1 27. Q. **Are studies done to address whether exposures have the capability to**
2 **cause or contribute to adverse health effects?**
- 3 A. Yes. The types of studies that I have found to be most helpful in assessing the
4 capability of an exposure to cause health effects are those that address
5 fundamental biological functions in animals that are very sensitive to any
6 disruption. Of course, if you want to know if an exposure causes a specific health
7 effect, you have to look at studies addressing that specific health effect.
- 8 28. Q. **What types of studies of fundamental biological functions that are very**
9 **sensitive to disruption do you find most helpful in assessing the capability of**
10 **an exposure to cause or contribute to adverse health effect?**
- 11 A. I find that the most helpful studies of fundamental biological functions that are
12 very sensitive to disruption for assessing the capability of an exposure to cause or
13 contribute to adverse health effect are those on genetics, reproduction, and growth
14 and development.
- 15 29. Q. **Can you give us an example of studies of radio frequency fields and those**
16 **fundamental biological functions that are very sensitive to disruption?**
- 17 A. Yes. A good example of a well-done study of radio frequency fields and genetics
18 is one titled "Absence of genotoxic potential of 902 MHz (GSM) and 1747 MHz
19 (DCS) wireless communication signals: In vivo two-year bioassay in B6C3F1
20 mice." [Ziemann 2009]. "Ferris wheels' were used to expose tube-restrained male
21 and female mice to simulated environmental radio frequency signals of the Global
22 System for Mobile Communications (GSM, 902 MHz) and Digital Cellular
23 System (DCS, 1747 MHz). The subjects were exposed to radio frequency fields

1 for 2 hours a day, 5 days a week for 2 years, at maximal whole-body-averaged
2 specific absorption rates of 0.4, 1.3, and 4.0 W/kg body weight. That is very
3 substantial exposure to radio frequency fields given the body size and life span of
4 the subjects. Comparisons of effects were made several control groups
5 (concurrent sham-exposed mice, cage controls, and positive controls). The study
6 found no effects of radio frequency fields on genotoxicity in mice after two years
7 of exposure.

8 A good example of a well-done study of radio frequency fields and reproduction
9 is one titled "Effects of radiofrequency electromagnetic fields (UMTS) on
10 reproduction and development of mice: a multi-generation study." [Sommer
11 2009]. Male and female mice were exposed to 1966 MHz radio frequency fields
12 24 hours a day for their lifetime. The power densities were kept constant for the
13 exposed groups at 1.35, 6.8 and 22 W/cm² and at 0.0 for W/cm² the control
14 groups. Their development and fertility were tracked over 4 generations by
15 examining histological, physiological, reproductive, and behavioral functions.
16 Those examinations were done without knowing which subjects were in the
17 exposed groups and which were in the control groups. The result of this 24 hours
18 a day, lifetime exposure over 4 generations was that the radio frequency had no
19 harmful effects on the fertility and development of the animals.

20 A good example of a well-done study of radio frequency fields on growth and
21 development is titled "Lack of adverse effects of whole-body exposure to a
22 mobile telecommunication electromagnetic field on the rat fetus. [Takahashi
23 2010]. The subjects and their offspring were whole-body exposed to 2.14 GHz

1 radio frequency fields for 20 hours a day during gestation and lactation. The study
2 examined the effects of radio frequency fields on growth, gestational condition
3 and organ weights for dams and survival rates, development, physical and
4 functional development, hormonal status, memory function, and reproductive
5 ability of the first generation offspring along with embryotoxicity and
6 teratogenicity in the second generation offspring. The study found that the radio
7 frequency fields had no effects on growth or development.

8 b. Constipation

9 **30. Q. Dr. Pall says “Laura Murphy reports that her chronic constipation started in**
10 **2002 after installation of the AMR meter” and “[g]iven the clear linkage**
11 **between the level of AMR EMF exposure and the chronic constipation, it is**
12 **very highly probable, in my opinion, that the AMR EMFs" caused it. (page**
13 **37) Do studies show that radio frequency fields cause, contribute to, or**
14 **exacerbate constipation?**

15 A. There are no studies that report radio frequency fields cause, contribute to, or
16 exacerbate constipation in humans or other animals, and no collection of studies
17 that as a whole shows that demonstrates that. Long-term bioassay studies of
18 laboratory animals would likely have detected an indicator of constipation [e.g.,
19 Anderson 2004], but none have reported any.

20 **31. Q. What is your medical opinion about exposure to radio frequency**
21 **fields and Ms. Murphy's constipation?**

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

1 1) PECO's AMR meter at Ms. Murphy's house caused, contributed to, or
2 exacerbated her constipation, and

3 2) the replacement of the AMR meter at Ms. Murphy's house with an AMI
4 meter will contribute to or exacerbate either her constipation.

5 c. Hypothyroidism

6 **32. Q. Ms. Murphy says she developed hypothyroidism in 2002 (page 25) and Dr.**
7 **Pall adds it was "diagnosed shortly after the deployment of the AMR meter**
8 **on her home." (page 28). Dr. Pall adds that "[r]epeated exposures to EMFs**
9 **from the AMR meter have led to exhaustion of Laura Murphy's thyroid**
10 **function." (page 37). What do the studies show about exposure to radio**
11 **frequency fields and hypothyroidism?**

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

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

20 **33. Q. What is your medical opinion about exposure to radio frequency fields and**
21 **hypothyroidism?**

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

1 1) PECO's AMR meter at Ms. Murphy's house caused, contributed to, or
2 exacerbated her hypothyroidism, and
3 2) the replacement of the AMR meter at Ms. Murphy's house with an AMI meter
4 will contribute to or exacerbate either her hypothyroidism.

5 d. Excessive peroxynitrite producing pathophysiological effects

6 34. Q. Dr. Pall says that “[b]ecause EMFs act to a great extent via excessive
7 peroxynitrite in producing pathophysiological effects (See Fig. 1), that fact
8 along with Laura Murphy’s genetic polymorphisms make her particularly
9 susceptible to pathophysiological effects of EMFs, such that she should avoid
10 unwarranted exposure to EMFs to achieve, to the extent possible, better
11 health. (page 36). Do studies of radio frequency fields show that they cause
12 excessive peroxynitrite and thereby produce pathophysiological effects, and
13 particularly for those with genetic polymorphisms?

14 A. No. There are no laboratory studies that report, and no collection of studies that as
15 a whole show that, radio frequency fields affect the level of peroxynitrite or
16 produce pathophysiological effects that result from peroxynitrite. In addition,
17 there are no studies that show a polymorphism would make a person particularly
18 susceptible to either peroxynitrite or radio frequency fields.

19 35. Q. What is your medical opinion about exposure to radio frequency fields and
20 causing excessive peroxynitrite and thereby producing pathophysiological
21 effects, and particularly for those with genetic polymorphisms?

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

1 1) PECO's AMR meter at Ms. Murphy's house caused, contributed to, or
2 exacerbated excessive peroxynitrite or produced pathophysiological effects in Ms.
3 Murphy, and
4 2) the replacement of the AMR meter at Ms. Murphy's house with an AMI meter
5 will cause or contribute to or exacerbate excessive peroxynitrite or produced
6 pathophysiological effects in Ms. Murphy.

7 e. Heart Irregularities

8 **36. Q. Ms. Murphy says she developed heart irregularities after the AMR meter**
9 **was installed at her house (page 12-13). Dr. Pall says “Dr. Pall says “It is my**
10 **opinion that EMFs act directly on those pacemaker cells to produce the**
11 **various changes that have been reported – tachycardia, bradycardia,**
12 **arrhythmias and in some conditions, heart palpitations. (page 36) What do**
13 **the scientific studies show about exposure to radio frequency fields and heart**
14 **irregularities?**

15 **A. Heart irregularities all involve heartbeat rate variations. There have been 2 studies**
16 **that measured whether radio frequency fields affected human heart rate variability**
17 **[Parazzini 2013 and Choi 2014] and both report they do not. In sum, studies of**
18 **exposure to radio frequency fields in humans do not show that they cause heart**
19 **irregularities.**

20 **37. Q. Do you agree with Dr. Pall 's opinion and, if not, what is your medical**
21 **opinion about exposure to radio frequency fields and**
22 **Ms. Murphy's reported heart irregularities?**

1 A. I disagree with Dr. Pall's opinion. My opinion is that there is no reliable medical
2 basis for concluding that radio frequency fields from:

3 1) PECO's AMR meter at Ms. Murphy's house caused, contributed to, or
4 exacerbated Ms. Murphy's heart irregularities, and

5 2) the replacement of the AMR meter at Ms. Murphy's house with an AMI meter
6 will cause or contribute to or exacerbate Ms. Murphy's heart irregularities.

7 f. Cataracts

8 **38. Q. Dr. Pall says that non-thermal radio frequency field exposure can cause**
9 **cataracts and "It is my expert opinion, it is more likely than not, that Laura**
10 **Murphy's cataracts were caused by a combination of effects of the EMFs**
11 **produced by the AMR meter, acting via VGCC activation, being exacerbated**
12 **by Laura Murphy's high level of oxidative stress." (page 38)**

13 A. Dr. Pall's VGCC theory for how non-thermal electromagnetic fields can cause
14 health effects is not generally accepted in the medical community. In other words,
15 it is not generally considered to be proven valid. In any event, there are no studies
16 that show non-thermal radio frequency fields cause cataracts. There has been little
17 research on radio frequency fields and cataracts since 2012. In 2012, National
18 Radiological Protection Board of the U.K Health Protection Agency reaffirmed its
19 prior conclusion based on a thorough examination of the study by experts that the
20 incidence of cataracts is not increased as a result of radio frequency field exposure
21 below current exposure guidelines. [NRPB 2012]

22 **39. Q. Do you agree with Dr. Pall's opinion and, if not, what is your medical opinion**
23 **about exposure to radio frequency fields and Ms. Murphy's cataracts?**

1 A. I disagree with Dr. Pall's opinion. My medical opinion is that there is no reliable
2 medical basis for concluding that radio frequency fields from:

3 1) PECO's AMR meter at Ms. Murphy's house caused, contributed to, or
4 exacerbated her cataracts, and

5 2) the replacement of the AMR meter at Ms. Murphy's house with an AMI meter
6 will contribute to or exacerbate to her cataracts.

7 g. Sleep disturbance and lethargy

8 **40. Q. Ms. Murphy's says that she has experienced sleep disturbance (page 47) and**
9 **fatigue (pages 25, 40 and 47). Dr. Pall says, "sleep dysfunction is caused by**
10 **the PECO AMR meter." (page 40) What do the scientific studies show about**
11 **exposure to radio frequency fields and sleep disturbance and fatigue?**

12 A. There are no controlled laboratory studies of whether exposure to radio frequency
13 fields causes or contributes to fatigue in humans or other animals. There are a
14 variety of causes for reported fatigue (e.g., medications) but poor sleep quality is
15 one of the principal determinants of reported fatigue. Sleep quality has been
16 examined in cohort studies or association studies. [Herr 2005; Mohler 2010; and
17 Mohler 2012]. Each reported no effect of exposure to radio frequency fields on
18 sleep quality. The Mohler 2012 study also included a nested sleep study with
19 objectively recorded exposure and measured sleep behavior that confirmed their
20 finding that exposure to radio frequency fields has no effect on sleep quality. In
21 sum, studies of exposure to radio frequency fields do not show that they cause,
22 contribute to, or exacerbate fatigue, lethargy, or sleep disturbance.

23 **41. Q. Do you agree with Dr. Pall, and if not, what is your medical opinion about**

1 exposure to radio frequency fields and Ms. Murphy's reported sleep
2 disturbance and fatigue?

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

9 1) PECO's AMR meter at Ms. Murphy's house caused, contributed to, or
10 exacerbated her reported sleep disturbances or fatigue, and

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

13 h. Post-concussion syndrome

14 **42. Q. Ms. Murphy reports that she was diagnosed with post-concussion syndrome**
15 **after a 2014 car accident (page 39) and Dr. Pall says “Because the impact of**
16 **VGCC activation on the physiology of the brain is very similar to that of the**
17 **NMDA receptor activation involved in causing post-concussion syndrome, it**
18 **is highly probable that EMF exposure does act to substantially prevent**
19 **effective recovery from her symptoms. Furthermore, because the three main**
20 **symptoms that Laura Murphy reports in her post-concussion syndrome:**
21 **cognitive defects, lack of concentration and headaches are also produced by**
22 **smart meter exposure in the U.S. and Australian studies (Table 2). This**
23 **provides still further support that her lack of recovery is likely to be caused,**

1 **at least in part, by the AMR meter EMF exposures that PECO has inflicted**
2 **upon her.” (page 39). Do you agree with what Dr. Pall says quoted above?**

3 A. No, for 3 reasons.

4 First, for the reasons I set forth earlier in answer to question 20 (pages 7-8 above),
5 the U.S. and Australian studies (Table 2) Dr. Pall relies on [Lamech 2014 and
6 Conrad 2013] do not provide scientifically reliable or useful data upon which to
7 make a determination of causation of any symptom or condition identified in them,
8 including cognitive defects, lack of concentration, and headaches. In addition, as I
9 also said earlier, Dr. Pall’s VGCC theory for how non-thermal electromagnetic
10 fields can cause health effects is not generally accepted in the medical community.
11 Second, post-concussive syndrome has been described as including Ms. Murphy’s
12 symptoms of cognitive defects (Edmed, 2015), lack of concentration (Jotwani and
13 Harmon, 2010), and headaches (Moran et al, 2015). But there are no studies that
14 report, and no collection of studies that show, that radio frequency fields impede
15 or inhibit recovery from post-concussion syndrome.

16 Third, it is well documented that the pathological changes underlying of post
17 concussive syndrome are unknown (Jotwani and Harmon, 2010; Tator and Davis,
18 2014, Moran et al 2015), as are the causes of the molecular mechanisms that must
19 mediate these changes. Indeed the inability to identify the medical causes that
20 lead to post-concussion syndrome is an important contributor to the continuing
21 debate as to its pathophysiology. What Jotwani and Harmon said in their 2010
22 review article remains true today: “The confusion about a clear definition for
23 post-concussion syndrome and lack of findings on standard imaging has led to a

1 significant debate in the neuropsychiatry literature, with some authors concluding
2 that the persistence of post concussion symptoms is not a consequence of brain
3 injury but rather is caused by psychological illness.”

4 **43. Q. Do you disagree with Dr. Pall’s opinion and, if so, what is your medical**
5 **opinion about whether exposure to radio frequency fields impedes or inhibits**
6 **recovery from post-concussion syndrome?**

7 A. I disagree with Dr. Pall’s opinion. My medical opinion is that there is no reliable
8 medical basis for concluding that radio frequency fields from:

9 1) PECO’s AMR meter at Ms. Murphy’s house impeded or inhibited her recovery
10 from post-concussion syndrome, and

11 2) the replacement of the AMR meter at Ms. Murphy’s house with an AMI meter
12 will not impede or inhibit her recovery from post-concussion syndrome.

13 i. Osteoarthritis

14 **44. Q. Dr. Pall says “the probable causes of her osteoarthritis, then, include all**
15 **probable causes of the underlying oxidative stress and inflammation. These**
16 **include the genetic predisposition that expresses itself via Ehlers-Danlos**
17 **syndrome and lipedema; the genetic predisposition due to the**
18 **polymorphisms ... the oxidative stress/peroxynitrite elevation caused by low-**
19 **intensity EMFs including the PECO AMR meter; and the oxidative stress**
20 **and inflammation caused by the post-concussion syndrome.” (page 40). Do**
21 **you agree that radio frequency fields from PECO’s AMR meter are one of**
22 **the probable causes of Ms. Murphy’s osteoarthritis?**

23 A. No. But first, it may be helpful to explain what osteoarthritis is and how it comes

1 about. Osteoarthritis is a disease of cartilage, which is found in our joint spaces,
2 typically separating juxtaposed bones, as in the knee. Cartilage is a unique tissue
3 with viscoelastic and compressive properties that are imparted by a proteinaceous
4 matrix (material outside of cells). In osteoarthritis, matrix-degrading enzymes are
5 overexpressed with resultant loss of proteins from the matrix. Osteoarthritis is not
6 considered to be one disease but a final common pathway secondary to many
7 predisposing factors, most notably age, joint trauma, altered biomechanics, and
8 obesity. All the ways in which these predisposing factors lead to overexpression
9 of matrix degradation enzymes are not known, but some scientists believe that
10 inflammation can contribute to it and lead to oxidative stress.

11 There are, however, no studies that report, and no collection of studies that as a
12 whole show, that exposure to radiofrequency fields can lead to inflammation in
13 human or animal joint spaces, or any other tissue. There are some *in vitro* studies
14 (i.e., isolated tissue or cells taken from animals) of the effects of exposure to
15 electromagnetic fields and oxidative stress but the results are contradictory and
16 many of them that report an effect or no effect have flaws or limitations that make
17 them unreliable. As a whole, they do not provide a reliable basis for concluding
18 that the fields cause oxidative stress in isolated tissue or cells, let alone in animals.
19 A good example of a reasonably well-done study of radio frequency fields and
20 macrophages (the specific cell type thought to be responsible for the matrix
21 degradation in cartilage that leads to the signs and symptoms of osteoarthritis)
22 reported no effect of radio frequency fields on oxidative stress (Hook 2004).

23 45. Q. Do you agree with Dr. Pall's opinion, and if not, what is your medical opinion

1 **about whether radio frequency fields from PECO's AMR meter are one of**
2 **the probable causes of Ms. Murphy's osteoarthritis?**

3 A. No, I disagree with Dr. Pall's opinion. My medical opinion is that there is no
4 reliable medical basis for concluding that radio frequency fields from:

5 1) PECO's AMR meter at Ms. Murphy's is not one of the probable causes
6 of Ms. Murphy's osteoarthritis, and

7 2) the replacement of the AMR meter at Ms. Murphy's house with an AMI
8 meter will not contribute to or exacerbate Ms. Murphy's osteoarthritis.

9 j. Retinal detachment

10 46. **Q. Dr. Pall says "Detached retinas are associated with oxidative stress,**
11 **inflammation and apoptosis (programmed cell death) (see below). Each of**
12 **these has been reported to be produced by nonthermal exposures to EMFs,**
13 **and each can also be produced by effects of VGCC activation. It is my**
14 **opinion that Laura Murphy's general high level of oxidative stress and**
15 **inflammation were likely to be involved in causing her detached retinas, but**
16 **there is also a high probability of exacerbation by the additional oxidative**
17 **stress/inflammation effects of the AMR meter EMFs (page 33) and then cites**
18 **3 studies. Do you agree with Dr. Pall that there is a high probability of**
19 **exacerbation by the additional oxidative stress/inflammation effects of the**
20 **AMR meter EMFs?**

21 A. No. First, it may be helpful to explain what retinal detachment is and we know
22 about it. Retinal detachment is the separation of the part of the retina containing
23 the nerves that detect light from the underlying (epithelial) support layer. It is an

1 outcome and there are numerous known causes, such as infection and trauma.
2 There are several different types of retinal detachment and there are different
3 underlying causes, such as pus and traction on the nerves. There are not studies
4 that report, and no collection of studies that as a whole show, exposure to radio
5 frequency fields causes, contributes to, or exacerbates retinal detachment. None of
6 the 3 studies Dr. Pall relies on involves exposure of animals to radio frequency
7 fields to determine if retinal detachment occurs as a result

8 **47. Q. Do you agree with Dr. Pall's opinion that radio frequency fields from**
9 **PECO's AMR meter likely caused her detached retina exacerbated it, and if**
10 **not, what is your medical opinion?**

11 **A.** I do not agree with Dr. Pall's opinion. My medical opinion is that there is no
12 reliable medical basis for concluding that radio frequency fields from:

- 13 1) PECO's AMR meter at Ms. Murphy's caused, contributed to, or
14 exacerbated her detached retina, and
15 2) the replacement of the AMR meter at Ms. Murphy's house with an AMI
16 meter will not contribute to or exacerbate Ms. Murphy's detached retina.

17 **V. CONCLUSION**

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

20 **A.** Yes.

21 **49. Q. What is your overall medical opinion?**

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

4 **50. Q. Does that conclude your testimony?**

5 **A. Yes.**