ATTACHMENT 2 – REPORT OF EXPONENT

TESTIMONY OF SHKOLNIKOV AND BAILEY

Q. What is Exponent's role in the December 6, 2011 workshop?

A. NV Energy asked Exponent to be a technical resource to the Commission and to the public on health and safety issues relating to radiofrequency (RF) fields.

Q. What is the purpose of your testimony?

A. The purpose of our testimony is to address issues that have been raised in relation to the operation of smart meters deployed in Nevada by providing: 1) a description of the devices of NV Energy AMI Network that involve communication by means of RF signals; 2) a comparison of these signals with the national standard in the United States for RF emissions as published by the Federal Communications Commission (FCC); 3) documentation of the status of scientific research on potential health risks and safety of RF exposure; and 4) responses to comments submitted to the Commission regarding RF health and safety issues.

WITNESS BACKGROUND AND EXPERIENCE

The witnesses from Exponent are Yakov Shkolnikov, Ph.D. and William H. Bailey, Ph.D. Their background and experience is summarized below.

Dr. Yakov Shkolnikov

Q. Please state your name and business address

A. My name is Yakov Shkolnikov. My business address is 420 Lexington Avenue, Suite 1740, New York, NY 10170.

Q. What is your occupation?

A. I am an Electrical Engineer.

Q. By whom are you employed?

A. I am a Managing Engineer at Exponent, an independent research and consulting company. I work in the Electrical & Semiconductors Practice, which assists clients in designing and evaluating electrically active devices and systems. As a Managing

Engineer, I frequently assist clients in evaluating RF exposure, electromagnetic interference, and the safety of medical and non-medical devices.

Q. What is your education background?

A. I earned my B.S. with *summa cum laude* in engineering physics from Cornell University in 1999. I then continued my studies as Gordon Wu Fellow at Princeton University and subsequently earned my M.A. and Ph.D. in Electrical Engineering from Princeton University in 2004 and 2005, respectively.

Q. Are you a member of any professional organizations?

A. Yes. I am a member of the American Physical Society and the IEEE. I'm also a member of The Institute of Electrical and Electronics Engineers/International Committee on Electromagnetic Safety, Subcommittee 4, Safety Levels with Respect to Human Exposure to Radiofrequency Fields (3 kHz to 300 GHz)

Q. Are you a licensed engineer?

A. Yes. I have passed the Professional Engineering examination, and I am a licensed engineer in the State of New Jersey.

Q. What particular experience do you have regarding the RF signals from the Smart Meter?

A. During my undergraduate internships, I have evaluated the design of RF and optical network components. In my Ph.D. research, I have performed experimental studies on fundamental processes by which electromagnetic fields interact with matter. These research studies have resulted in over 20 peer-reviewed publications in leading physics journals, such as *Physical Review Letters* and *Applied Physics Letters*. A full list is shown on my CV, which is attached as **Exhibit YS-1**.

Since starting at Exponent in 2005, I have designed, evaluated, and tested systems that produce and communicate via RF signals. I have performed multiple evaluations of RF exposure, compatibility, and signal strength from devices as

varied as *ad hoc* networks, radar installations, cell phone and AM radio towers, MRI machines, smart meter networks, consumer electronic devices, and medical device implants. I also evaluated and redesigned network communication installations, and as part of the design team for products to protect U.S. troops from improvised explosive devices, I have developed algorithms to process received RF signals as well as improved RF component designs. Additionally, as a visiting research faculty at the School of Biomedical Engineering at Drexel University, I have researched and published on the topics of electric shock and medical device implants. I have been invited and given guest lectures at Princeton University and Drexel University on the evaluation of risk in medical device design as well as the effect of electricity on the human body.

Dr. William H. Bailey

Q. Please state you name and business address.

A. My name is William H. Bailey, Ph.D. My business address is 17000 Science Drive, Suite 200, Bowie, MD 21705.

Q. What is your occupation?

A. I am a scientist and researcher in the Center for Exposure Assessment and Dose Reconstruction at Exponent. My work involves reviewing, analyzing, and conducting health research. Much of my work over the past 25 years relates to the exposures and potential biological, environmental, and health effects associated with electrical facilities and devices, including electric utility facilities, electrified railroad lines, industrial equipment, appliances, and medical devices that produce electromagnetic fields across a wide range of frequencies.

Q. What is the role of exposure assessment in public health?

A. Exposure assessment is a key element in a) the assessment of potential risks of chemicals and physical agents, and b) environmental epidemiology studies. The

science of exposure assessment encompasses studies based on chemical, biological, and physical principles required to analyze human exposure from single and multiple routes; occupational exposure studies; and population-based studies. These studies are essential for the translation of toxicity data to assess the potential for risk to individuals and populations and to inform public health decisions.

Q. By whom are you employed?

A. I work in the Health Sciences Group within Exponent, an independent research and consulting company.

Q. What is your educational background?

A. I earned a Ph.D. in neuropsychology from the City University of New York. I received two additional years of training in neurochemistry at The Rockefeller University in New York City under a fellowship from the National Institutes of Health. My education includes a B.A. from Dartmouth College in 1966 and an MBA from the University of Chicago, awarded in 1969.

Q. Please briefly describe your professional experience.

A. Since 1986, I have been a visiting research scientist at the Cornell University Weill Medical College. I also have been a visiting lecturer at Rutgers University, the University of Texas (San Antonio), and the Harvard School of Public Health in the field of bioelectromagnetics. From 1983 through 1987, I was head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research. For the seven previous years, I was an Assistant Professor in Neurochemistry at The Rockefeller University.

Q. Are you a member of any professional organizations?

A. I am a member of The Rockefeller University Chapter of Sigma Xi, a national scientific honor society; the Health Physics Society; ICES, Subcommittees 3 and 4 – Safety Levels with Respect to Human Exposure to Fields; the Bioelectromagnetics

Society; the IEEE Engineering in Medicine and Biology Society; the Conseil International des Grands Reseaux Electriques; the American Association for the Advancement of Science; the New York Academy of Sciences; the Society for Neuroscience; the Air & Waste Management Association; the Society for Risk Analysis; and the International Society of Exposure Analysis.

Q. Have you authored any papers or journal articles?

A. I have published or presented more than 50 scientific papers on this and related subjects. My CV is attached as **Exhibit WHB-1**.

Q. What particular experience do you have regarding the RF signals from the Smart Meter and health?

A. I am an Associate Editor of *Health Physics*, with primary responsibility for the peer review of manuscripts describing the results of research on electromagnetic fields including both ELF and RF, a role that I also have filled as a reviewer of grant applications submitted to the National Institutes of Health for funding. I have been involved in performing human health risk assessments of RF exposures from military radar, industrial devices, and a variety of consumer appliances. I am a member of Subcommittee 4, Safety Levels with Respect to Human Exposure to Radiofrequency Fields (3 kHz to 3 GHz) of ICES and served as an elected member of the Committee on Man and Radiation (COMAR) of the IEEE Engineering in Medicine and Biology Society, 1998–2001. In addition, I have served as an advisor to the Irish Government's Department of Communications on health issues relating to RF from mobile-telephone base station antennas. Because of my background and experience I have served as an advisor on risk assessment and public policy to various international scientific and health agencies on topics relating to electromagnetic fields, including RF.

THE NV ENERGY AMI NETWORK

Q. What is the purpose of the NV Energy AMI network?

A. The purpose of the NV Energy AMI network is to automatically transmit electricity and gas use from the customer back to NV Energy. The transmitters on customer's electric meters (smart meters) communicate to NV Energy by sending RF signals with frequencies between 896 megahertz (MHz) to 960 MHz.

Q. Are there other devices in the NV Energy AMI network that communicate by RF signals?

A. Yes. There are Tower Gateway Base (TGB) stations that collect information from the signals sent by smart meters at customers' locations. These TGBs also transmit signals back to the customers' smart meter to maintain accurate communications with customers' smart meters.

Q. **Is the NV Energy AMI network a mesh grid network?**

A. The NV Energy AMI network is a hybrid system. A majority of the smart meters, 99% in the current installation, operate in a point-to-point fashion. A tiny fraction, currently 1%, operate in a mix of a point-to-point and buddy mode (which allows for a single communication between meters on a licensed frequency should it be necessary).

Q. You have identified the devices of the NV Energy AMI network that are sources of RF fields. Are these devices also important sources of other frequencies of electromagnetic fields associated with the operation of other devices?

A. No. Specifically, they would not important sources of electric and magnetic fields (EMF) typically associated with power lines and home and office appliances, which are in the extremely low frequency (ELF) range (i.e., 1 Hertz (Hz) to 3kHz). Neither would they be sources of what has been described as 'dirty electricity.' According to engineers at Health Canada there is no engineering definition for this term. but in their investigation of exposures in homes they referenced voltages on household wiring that could be sources of electric fields in the range of 4 to 100 kHz (Gajda et

al., 2010) as measured by a meter that is claimed to detect electrical transients and harmonics produced by wiring in homes.

NV ENERGY AMI NETWORK RF SIGNALS AND THE FCC NATIONAL STANDARDS

Q. What national standards must the NV Energy AMI network devices comply with to be licensed and deployed in the United States?

A. Devices that emit RF energy must meet levels published by the FCC. As part of its oversight functions, the FCC has published an RF exposure standard and approves devices that emit RF fields for sale after testing to meet FCC standards (FCC 2010a, 2010b, 2010c, 2010d).

Q. What is the history of the FCC exposure standard?

A. Scientists have been reviewing research with the goal of implementing and improving exposure standards for RF energy since the 1950s. A major step towards this goal was the formulation of the American National Standard Institute's (ANSI) Standard C95.1-1982. In parallel, the National Council on Radiation Protection & Measurements (NCRP) initiated a standard setting process that began with a summary of RF exposure parameters and mechanisms of interaction that was published as NCRP Report No. 67 "Radiofrequency Electromagnetic Fields—Properties, Quantities and Units, Biophysical Interaction, and Measurements" (NCRP, 1981). The NCRP is chartered by Congress and operates as a "nongovernmental, not-for-profit, public service organization whose mission is to formulate and widely disseminate information, guidance and recommendations on radiation protection and measurements which represent the consensus of leading scientific thinking."[1] The NCRP's 1981 report was followed in 1986 by a comprehensive review of RF research literature on biological effects and human studies and a proposed standard for RF exposure published in NCRP Report No. 86 "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields." In 1993, a large scientific task group was assembled by the World Health

[1] http://www.ncrponline.org/AboutNCRP/Our_Mission.html

Organization (WHO) to review research on the effects of electromagnetic fields in the frequency range of 300 Hz to 300 gigahertz (GHz) in an evaluation of human health risks (WHO, 1993).

In 1985, the FCC, based on advice from the Institute of Electrical and Electronics Engineers (IEEE) first adopted the ANSI standard (1982). The FCC modified and updated the standard in 1996, based on the ANSI and NCRP standards with input and advice from other agencies including ANSI, NCRP, the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), and IEEE.

Q. What is the purpose of the FCC standard?

A. The purpose of the FCC standard, as for similar standards, is to prevent adverse biological effects from overexposure to RF fields. In the range of frequencies produced by NV Energy AMI network devices, the principal effect of overexposure is heating of tissues, which can accelerate biochemical reactions and affect homeostatic mechanisms. Warming of the body by a degree or so can be uncomfortable and detract from optimum performance, as we all have probably experienced on hot days. At higher temperatures, the effects become more severe, and in the extreme cause tissue damage, e.g., burns. [2] For devices like smart meters that operate at very low power, the RF levels are far too low to produce tissue heating as will be explained below.

Q. How were these adverse effects identified?

A. The steps that scientists follow in identifying adverse effects of RF exposure are the same steps followed to assess the risks of any exposure. Scientific and regulatory agencies worldwide use a standard scientific process for evaluating biomedical

[2] IEEE (1995) elaborates as follows: "At elevated body temperatures, increases in metabolism, heart and respiration rate, and nerve conduction velocity can occur. At temperatures above ~42 °C, central nervous system function can deteriorate and convulsions may occur. At this level protein denaturation may begin and cells may be damaged. Sustained exposure to this level in humans often leads to irreversible neurological and cardiac damage (Mambo et al. [R1011], Britt et al. [B18], and Hales et al. [B51]). Other consequences of severe and prolonged hyperthermia include confusion, unconsciousness, increased heart rate, lowered blood pressure (Gathiram et al. [R1110]), elevated enzyme activity, and damage to the heart and kidneys" (p.41).

research (USEPA, 2003 USEPA, 2005; DHHS, 2004; IARC, 2006) and this process has been recognized as applicable to the evaluation of exposures to RF fields. This process is called a weight-of-evidence review and entails looking at *all* the evidence on a particular issue in a systematic and thorough manner to see if the overall data presents a logically coherent and consistent picture. A weight-of-evidence review consists of three broad steps as follows.

1. **Conduct a systematic search of the scientific literature, typically using computer-based searches of biomedical research databases of published reports, to identify research studies.** This search of the international research literature should retrieve studies regarding RF exposure in relation to various health endpoints in the relevant lines of evidence, including:

   - epidemiologic studies of humans in their natural environment,
   - experimental studies in humans (usually short-term for minor effects) or in animals (*in vivo*), and
   - experimental studies in isolated cells and tissues (*in vitro*).

   The overall pattern of results from epidemiology and *in vivo* studies needs to be considered, because the information provided by these two study types is complementary; *in vivo* studies address the inherent limitations of epidemiology studies and *vice versa*. Epidemiology studies are non-experimental, meaning that researchers do not have precise control over the things to which people are exposed in the study. On the other hand, scientists tightly control all aspects of experimental studies in humans and animals and, therefore, have greater certainty that an observed effect is due to the exposure being studied and not some other factor. Experimental studies in animals have some limitations, however, because of the uncertainty of extrapolating findings in animals to humans. When we consider both of these study types together (in addition to *in vitro* studies), we get a better picture of the possible relationship between the exposure and the disease.

In vitro studies are widely used to investigate the mechanisms for effects that are observed in living organisms. The relative value of *in vitro* studies to a human health risk assessment, however, is much less than that of *in vivo* and epidemiology studies. Responses of cells and tissues outside the body may not reflect the response of those same cells if maintained in a living system, so their relevance cannot be assumed (IARC, 1992). It may, therefore, be difficult to extrapolate from simple cellular systems to complex, higher organisms to predict risk to health. In addition, the results of *in vitro* studies cannot be interpreted in terms of potential human health risks unless they are performed in a well-studied and validated test system. For these reasons, the IARC and other agencies treat data from *in vitro* studies as supplementary to data obtained from *in vivo* and epidemiology studies.

2. **Evaluate each study to determine its strengths and weaknesses, so that more weight can be given to studies of higher quality.** Epidemiology studies must be designed, conducted, and evaluated carefully to prevent bias and ensure validity—the more closely the study's results are believed to reflect the true association between the exposure and the disease under investigation, the more valid the study is and the more weight that is assigned to its findings in a weight-of-evidence evaluation.

3. **Use standard guidance to evaluate the entire body of evidence for the plausibility of a cause-and-effect relationship between a particular exposure and biological effect.** This guidance is usually patterned after Hill's criteria, an analytic framework used in the weight-of-evidence review process for epidemiologic studies (e.g., Hill, 1965; ICNIRP, 2002; DHHS, 2004). The criteria include strength of associations, evidence for a dose-response relationship, consistency within and across studies, and biological plausibility of the hypothesized causal link, among others. The more firmly the data are judged to meet these criteria, the more convincing the evidence for a causal relationship. Similar guidance that is more oriented towards

experimental studies is also applied in assessing potential risks (Repacholi and Cardis, 1997).

It should be clear from this process that all types of studies and all types of effects are evaluated in standard setting. After completing a weight-of-evidence review, the consensus of scientists assembled by national and international health and scientific agencies will determine the lowest level of exposure that produces adverse effects (i.e., the lowest observed adverse effect level [LOAEL]). In the case of exposure to RF fields, the LOAEL is exposure level in which a behavioral disruption occurs with a increase in body temperature. The FCC (1996), NCRP (1986), IEEE (1995), and ICNIRP (1998) all agree that this response occurs at a whole body dose identified as a specific absorption rate (SAR) of 4 Watts per kilogram (W/kg).

Q. How does the FCC standard protect public health?

A. The FCC standard does this by limiting the intensity and duration of exposure such that adverse effects are not expected even when taking into account variation in environmental conditions, e.g., higher ambient temperatures or sensitive populations such as children and the elderly. As illustrated in Figure 1, the FCC SAR limit for the exposure of workers is 10-fold lower than the LOAEL, i.e. 0.4 W/kg, and a further 5-fold reduction in the SAR limit is made for the general public. The same approach is followed by IEEE and ICNIRP. Thus, the exposure limits (i.e., the maximum permissible exposure [MPE]) for the general public is 50-fold lower (10 x 5) than an exposure level associated with an uncomfortable rise in body temperature. [3]

[3] The limits developed are based on the RF dose, also known as the SAR, which varies by frequency. The SAR, however, is not easy to estimate directly, so the standard provides limits on the RF levels in the environment that can be measured or calculated, as power density (power in watts per unit area). To assess compliance, power density is measured or predicted by engineering calculations for areas where people may come in contact with RF fields.

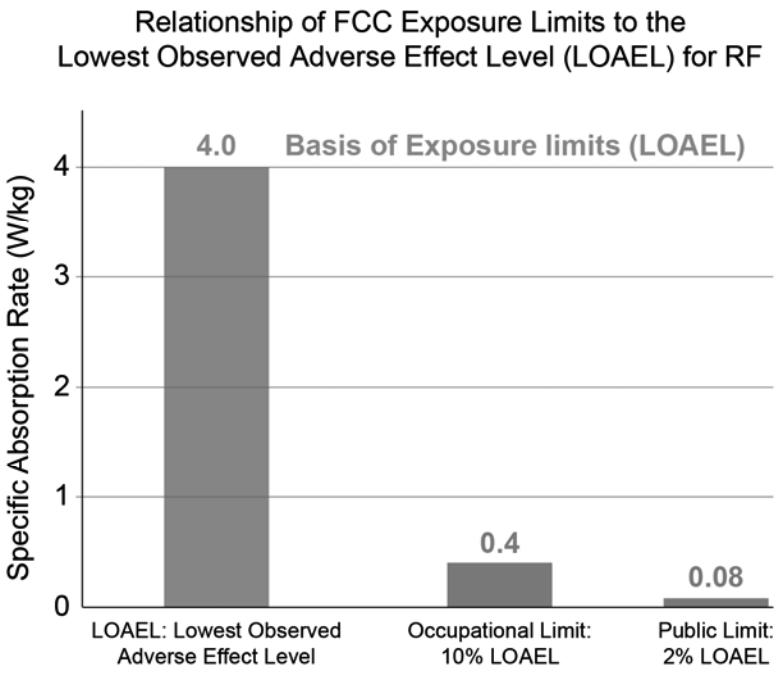

Figure 1. A representation of how biologically-based limits on the RF doses to tissue have been derived by the FCC, IEEE, and ICNIRP standards for persons in occupational environments and members of the general public.

Q. What are the exposure limits set by the FCC for the frequencies produced by components of smart meters?

A. The FCC's RF standard provides MPEs for different sub-ranges within the RF frequency band. The standard has different MPEs for the general public than for those occupations where workers are trained to work in an RF environment. The MPEs for the general public are lower than those for occupational environments. To assess compliance, the MPE is measured (or predicted based on engineering calculations) for areas where people come in contact with RF fields, and averaged over 30 minutes. The MPE is expressed as RF strength, or "power density," which is power in watts over a specified area (i.e., watts per meter [W/m]).

Power density is analogous to the concentration of a chemical dissolved in water or to the brightness of a light focused on an area. Imagine a flashlight shining on a piece of paper held 1 foot away, compared to the dimmer light on a paper from a

flashlight held 10 feet away. For practical purposes, the MPE is estimated at the closest point where a person could be exposed to the fields, because this would be the location of the highest exposure given that the strength, or power density, decreases with distance from the source. The MPE for the frequency of RF signals transmitted by a smart meter is 10 watts per square meter (W/m^2), or its equivalent, 1 milliwatt per square centimeter (mW/cm^2) at 2.45 GHz and 0.6 mW/cm^2 at 900 MHz for members of the public, averaged over 30 minutes (47CFR1.1310). For some RF devices the transmitter is not on continuously, but may transmit for shorter periods at levels above the MPE. The 30 minute averaging time[4] is included in the standard because the body can compensate for shorter high exposures to prevent any changes from occurring (homeostatic mechanisms). Smart meters and similar devices including wireless technology, however, can never reach the MPE, so averaging is not needed or applicable.

Q. You have mentioned RF exposure standards other than the FCC standard that applies within the United States. What are the other well-regarded national or international standards?

A. The main national and international scientific organizations that have recommended RF exposure limits include ICNIRP (ICNIRP, 2009) and the International Committee on Electromagnetic Safety (ICES) (IEEE, 2005). ICNIRP is a committee of independent scientific experts that disseminates information and advice on the potential health hazards of exposure to non-ionizing radiation. ICES is a committee within the IEEE; it is responsible for development of standards for the safe use of electromagnetic energy, including RF energy. While IEEE refers to its recommended exposure limits as standards, these and ICNIRP's exposure limit guidelines are recommendations that do not have the force of law unless adopted by a country, state, or other political entity. The World Health Organization (WHO)

[4] The FCC defines averaging time as the "appropriate time period over which exposure is averaged for purposes of determining compliance with RF exposure limits" (FCC Office of Engineering and Technology, Bulletin OET65).

recommends that countries adopt the ICNIRP guidelines.[5] Both these organizations have reviewed research published after the 1996 FCC regulation was enacted.

Q. Are the ICNIRP and ICES exposure limits similar to those of the FCC standard?

A. Yes. The exposure limits set by the FCC, ICNIRP, and ICES are similar in the frequency range applicable to the smart meter. Each recommends that exposure of the general public be limited to 10 watts per square meter, equivalent to 1 mW/cm^2 at 2.45 GHz. At 900 MHz, the ICNIRP limits the exposure to 0.45 mW/cm^2 while FCC limits the exposure to 0.6 mW/cm^2. There is also difference in averaging time for the FCC and IEEE standards is 30 minutes, and for the ICNIRP standard, the averaging time is 6 minutes.

Q. Have federal, state, and scientific agencies had the occasion to review RF health and safety issues as they pertain specifically to smart meters?

A. Yes, we are aware of reports issued by the FCC (Knapp, 2010) as well as the Monterey County Health Department (MCHD, 2011), the Maine Center for Disease Control and Prevention (MCDC), the Public Service Commission of California (PUCC, 2010), and the California Council on Science and Technology (CCST, 2011) that were prompted by the roll out of smart meters in different parts of the country. All of these agencies indicated from their expertise and research that the RF exposures from smart meters were exceeding low, compliant with FCC and other standards, and unlikely to pose any public health or safety risks.

[5] http://www.who.int/peh-emf/en

Q. What is the difference between exposure and the exposure limit?

A. Exposure is a measurement of how much RF signal arrives at the body. Average power density is an example of exposure measure.

The dose is the rate at which the RF signal is absorbed by the body. The SAR is an example of dose measurement.

The exposure limit is the value, based on the governing standard, of how much exposure is permitted that does not cause the dose limit to the body to be exceeded.

As an analogy, exposure is the equivalent to measuring how fast the car is going and the exposure limit is equivalent to the speed limit (and, in this example, this limit is set below the speed at which accident and loss of vehicle control is likely to occur).

Q. How is the RF exposure measured/defined?

The exposure/dosage value can be further specified as local (affecting only part of the body) or whole body (assuming the whole body is exposed). Additionally, spatial averaging (over 10 grams of tissue, 1 gram of tissue) or time averaging (none, 6 minutes, 30 minutes, 24 hours) may be specified.

The specific exposure and dosage metric that is used depends on the standard adopted by the country and typically varies depending on the frequency of the RF signal, the distance of the transmitter to the body, and the hazard being evaluated.

Table 1: Typical Exposure and Dosage units

Typical exposure measure	Typical dosage measure
Power density: power received per unit area. Typical units of W/m^2, mW/cm^2, $\mu W/cm^2$ $10\ W/m^2 = 1\ mW/cm^2 = 1{,}000\ \mu W/cm^2$	Specific Absorption Rate (SAR), power absorbed per unit volume. Typical units of W/kg

Q. Is there relationship between exposure and dosage?

The relationship between exposure and dosage (SAR) is quite complicated and depends on the geometry, frequency, and multitude of other factors. There is no straightforward conversion between SAR and power density as they measure different quantities (incident versus absorbed power); however, exposure of 0.45

mW/cm^2 at 900 MHz and 1 mW/cm^2 at 2.45 GHz would ensure that the whole-body SAR is below 0.08 W/kg (IEEE C95.1-2005, p. 24).

Q. What are some examples of RF exposure standards in other countries?

Most of the RF safety standards in the world fall into two categories: In the United States, as well as many other countries (such as Japan), the standard is based on IEEE Standard C95.1. In Europe, the primary standard is based on ICNIRP's 1998 guideline (at lower frequencies below 100 kHz, other standards may apply). There are some countries whose national standards deviate from the ICNIRP 1998 standard and IEEE Standard C95.6, such as China, Russia, and other former eastern block countries such as Poland. For convenience, these standards at 900 MHz and 2.45 GHz are summarized in Table 2.

Table 2: National Exposure Standards[a]

Standard	Exposure limit	Notes
FCC 47CFR1.1310	0.6 mW/cm^2 at 900 MHz 1 mW/cm^2 at 2.45 GHz	Source-based (duty cycle) averaging over 30 minutes
ICNIRP 1998	0.45 mW/cm^2 at 900 MHz 1 mW/cm^2 at 2.45 GHz	Time averaging over 6 minutes, peak power density not to exceed 1,000 times the exposure limit
Russia (СанПиН 2.2.4/2.1.8.055-96)	0.01 mW/cm^2 at 900 MHz 0.01 mW/cm^2 at 2.45 GHz Note that the WHO database incorrectly lists the Russian exposure limit as 10 mW/cm^2	Average transmitter power (long duration averaging)
China (GB9175-88)	0.01 mW/cm^2 at 900 MHz 0.01 mW/cm^2 at 2.45 GHz	Average transmitter power

[a] For a summary of national standards, see http://www.who.int/docstore/peh-emf/EMFStandards/who-0102/Worldmap5.htm

Q. Do the RF signals from devices of NV Energy AMI network comply with the FCC standard?

A. The NV Energy AMI network devices that are sources of RF fields are listed in Table 3. These devices received a grant of equipment authorization from the FCC. The FCC ID for the grant of equipment authorization is also listed next to each

device. As part of the grant process, these smart meters underwent an evaluation of their RF fields as they compare to MPE values.[6] The result of this evaluation is a guideline for installing this equipment such that the produced RF signal would not exceed these MPE values during deployment.

Table 3: Devices that are part of the NV Energy AMI network

Device	Location	FCC ID
Tower Gateway Base Station (TGB)	Outside	SDBTGB20
Electrical smart meter (ICON)	On the exterior of the building	SDBIDTB001
Electrical smart meter (Elster)	On the exterior of the building	SDBELS
Electrical smart meter (L & G)	On the exterior of the building	SDBFLEXLG100
Electrical smart meter ZigBee module	Inside the electrical smart meter	SDBZIGMOD10
Electrical smart meter ZigBee module	Inside the electrical smart meter	SDBZIGMOD20
Gas meter module	Inside the gas meter, exterior of the building	SDBGFL2
Gas meter module	Inside the gas meter, exterior of the building	SDBGFL2CI
Thermostat	Interior (optional device)	R33H1
Home energy interface device	Interior (optional device)	R33D1

Q. Some of the equipment installation guidelines require a minimum distance of 20 centimeters (cm). Does this mean that the FCC exposure limit will be exceeded at closer distances?

A. The 20 cm rule is a threshold for performing an SAR-based compliance assessment. As long as the equipment is intended to be used at a distance of greater than 20 cm to the user, this more detailed SAR-based exposure (47CFR2.1091 (c)) is not required. "This does not imply that FCC exposure will be exceeded at distances less than 20 cm" (Knapp , 2010).

[6] Devices currently in development will obtain the grant of equipment authorization prior to deployment.

Q. ZigBee modules operate in an unlicensed frequency band. Does that mean that the FCC does not regulate their exposure?

A. As indicated above, all NV Energy AMI network devices received a grant of equipment authorization from the FCC and underwent an evaluation of their RF exposure.

Licensed versus unlicensed frequency refers to the requirement that all RF installations operating outside a specific frequency range (unlicensed ISM bands) receive a license grant that preserves transmitter equipment exclusive (or sometimes semi-exclusive) access to a licensed frequency band.

Q. Why do published values for smart meters' exposure vary so much and why don't the exposures in this testimony match previously available numbers?

It is inappropriate to use the exposure values calculated for a specific smart meter network as an estimate for an exposure for another network. Other smart meter networks may result in RF exposures that are above or below exposure levels of the NV Energy AMI network. There are many different smart meter network designs; a single exposure value is not applicable to all of them. The exposure from the network may depend on the configuration of the network, frequency of readouts, housing density, total size of the network, frequency of operation, and a multitude of other factors.

In addition, many of these reports incorrectly summarize and combine measurements, or perform theoretical calculations to derive exposures that are not only wrong, but also patently absurd. Some exposure measurements reported on the Internet use measurement devices with dubious specifications, calibration factors, and averaging time constants, and frequently do not perform the analysis to isolate the signal from the smart meter from that caused by other RF generating devices.

There is also a variation in the published reports of how conservative the exposure estimates are. In this analysis, we have utilized a very conservative approach; the

exposure values in this testimony very likely greatly overestimate the actual exposure.

Q. Will accounting for the reflection of RF signals, i.e., the reflection factor, increase the estimate of the exposure?

A reflection factor of 2.56 recommended in the FCC publication OET 65 was used for all the calculations to account for the effects of local enhancement of RF exposure (hot-spots) due to reflections from the ground, walls, wires, and other objects in the environment. There are theoretical papers that suggest much higher reflection factors may occur in a highly reflective environment such as a completely enclosed metal wall elevator. This research, however, neglects to take into account the absorption of the RF signal by a human body. Research that correctly takes this effect into account shows that even for a person inside an almost completely enclosed reflective room, the FCC reflection factor of 2.56 would overestimate the increase in absorbed RF power (Simba et al., 2009).

An additional factor to consider is that in the planned deployment, the smart meters are located outside the residence. A room fully enclosed by a very reflective metal would not permit the RF signal to even enter the residential area; it would reflect almost the entire RF signal back. So a very high reflection factor in a residential area would actually result in a reduction of the exposure.

Q. What information did you rely on to calculate RF exposures from the NV Energy AMI network ?

Exponent utilized the following information to perform the exposure calculation:

- Test reports filed for the equipment listed in Table 3[7]
- Number of messages per day and message length for different devices of the NV Energy AMI network provided by NV Energy
- TGB locations as provided by NV Energy

[7] Retrieved from the FCC database accessible at https://apps.fcc.gov/oetcf/eas/reports/GenericSearch.cfm

- Antenna patterns provided by NV Energy
- Typical installation scenarios as specified by NV energy
- Standard models for the RF signal propagation

Q. What typical smart meter installation did you consider?

A. A typical smart meter installation is shown in Figure 2. The electrical smart meter is installed on a panel that typically is recessed into the exterior wall of the residence (preferably garage walls). Gas smart meters are usually installed several inches away from the exterior wall. If such a gas smart meter is installed, a minimum separation of 18 inches is maintained between it and the electrical smart meter.

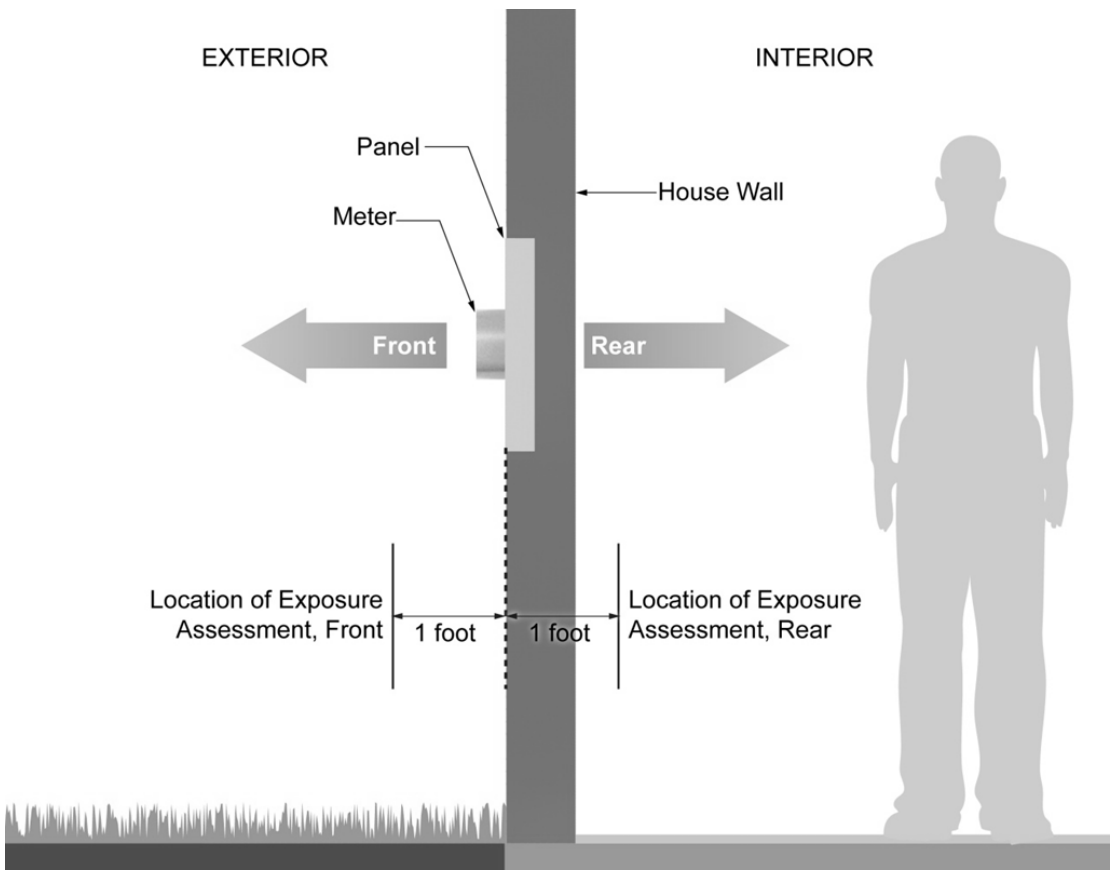

Figure 2. Typical Smart Meter Installation

Q. At what locations did you calculate the exposure?

A. We calculated the exposure at a distance of 1 foot away from the metering panel.

Q. What are the typical exposures from the electrical and gas smart meters?

A. The exposures from the smart meters are summarized below in Table 4.

Table 4: Smart Meter Exposure[a]

Device	Location	Exposure (mW/cm^2)	FCC MPE (mW/cm^2)
Electrical smart meter	1 foot front	0.000026	0.6
Electrical smart meter	1 foot rear	0.00000041	0.6
Gas meter	1 foot front	0.0000072	0.6
Gas meter	1 foot rear	0.00000041	0.6
ZigBee module in the electrical smart meter[b]	1 foot front	0.0000052	1.0
ZigBee module in the electrical smart meter[b]	1 foot rear	0.00000052	1.0

[a] Typically 1 foot rear of the smart meter is on the inside of the house, and 1 foot front of the smart meter is on the outside of the house.

[b] Without the customer-optional home area network (HAN). Since HAN will not be available for the majority of installations, and when available, will still be optional for the customer, it was not considered a typical exposure scenario.

Q. How were these exposures calculated?

A. These exposures were calculated from the product of the peak power density level and the duty cycle.

Table 5. Typical peak power densites and duty cycles[a]

Device	Location	Peak power density (mW/cm^2)	Fraction of time transmitting	Duty cycle based on 30 minute period
Electrical smart meter[b]	1 foot front	0.44	0.000035	0.000060
Electrical smart meter[b]	1 foot rear	0.0069	0.000035	0.000060
Gas smart meter[c]	1 foot front	0.12	0.0000087	0.000060
Gas smart meter[c]	1 foot rear	0.0069	0.0000087	0.000060
ZigBee module in the electrical smart meter	1 foot front	0.026	0.0002	0.0002
ZigBee module in the electrical smart meter	1 foot rear	0.0026	0.0002	0.0002

[a] Typically 1 foot rear of the smart meter is on the inside of the house, and 1 foot front of the smart meter is on the outside of the house.
[b] 95% of the electric meters currently installed operate at or less than 0.000035 of the time (0.0035% of the time). 100% of the electric meters currently installed operate at or less than 0.00048 of the time (0.048% of the time).
[c] 100% of the gas smart meters are expected to operate at or less than 0.0000087 of the time (0.00087% of the time).

On average, typically the smart meter (gas or electric) in the NE Energy AMI network sends less than one message per 30-minute period (averaging time per 47CFR1.1310). Because we performed a conservative exposure estimate, we assumed that at least one message was transmitted per 30 minutes. This resulted in a duty cycle that is greater than or equal to the fraction of time transmitting.

Q. Is it appropriate to utilize the duty cycle in exposure assessment?

A. Yes. FCC exposure limits are based on "source-based" (also known as duty-cycle) time-averaged values (Knopp letter, 2010).

Q. Why is there such a big exposure difference between the front and rear locations?

A. The metal panel (housing) on which the meter is mounted stops most of the RF signal from entering the interior of the house.

Q. How will exposure change at greater distances?

A. At a distance of 1 yard, the calculated exposure values (and peak power density) will drop by a factor of 9 compared to a 1-foot distance. It will continue to drop rapidly as the distance is increased.

Q. Did you consider the effect of the wall material on the exposure?

A. Since we performed a conservative estimate of exposure, we did not take into the account the reduction of the exposure that would result from the absorption of the RF signal by the wall materials and the household furnishings.

Q. If customer utilizes the optional home area network (HAN), will the exposure increase?

A. When the customer chooses to utilize the optional HAN, there will be other devices (see Table 3) that will be provided to the customer by NV Energy. In this case, the RF exposure in the residence will increase, but if the guidelines for installing these devices are followed, the RF signal should not exceed MPE values during the optional HAN use.

Q. What is the typical RF exposure and peak power density from the TGB?

A. Typical RF exposure from the TGB is 0.00000000012 mW/cm^2 and the peak power density 0.000000000594 mW/cm^2. Since we performed a conservative estimate of exposure, we did not take into the account the reduction of the exposure that would result from the absorption of the RF signal by the wall materials and the household furnishings. By comparison, the MPE values at TGB frequencies of 896-960 MHz is 0.6 mW/cm^2.

Q. At what distance was the TGB exposure was calculated?

A. Most houses will be 1 km (0.62 miles) or greater from the TGB. This is the distance at which the TGB exposure was calculated.[8]

Q. Is the exposure from the NV Energy AMI network below the FCC MPE limits?

A. As part of the FCC equipment authorization grant process, FCC required that NV Energy AMI network devices comply with FCC MPE limits. Moreover, our

[8] Standard medium-size city Hata signal propagation model was utilized to calculate the signal drop as a function of distance. (for details of the model see Lee SJ and Miller LE. CDMA Systems Engineering Handbook. Boston: Artech House, 1998, pp. 188-189.)

exposure estimates show that typical exposure will actually be more than a factor of 15,000 below this limit.

Q. How does the exposure from the NV Energy AMI network compare to natural sources of RF exposure?

A. Both the Earth and the human body are sources of a natural RF signal. While the natural RF signal and the AMI network RF signals are not the same (most of the natural RF signals are between 80 GHz and 300 GHz compared to 900 MHz and 2.45 GHz from the AMI network), it is still informative to compare their exposures to gain understanding of their relative values. Figure 3 below illustrates these natural sources.

The whole-spectrum EMF exposure from the ground is 28 mW/cm^2.[9] The RF signal from the Earth is 0.00013 mW/cm^2 (ICNIRP, 2009a). The whole-spectrum EMF exposure from the body is 50 mW/cm^2 (Rogalski, 2000). The RF signal from the human body is 0.0003 mW/cm^2 (ICNIRP, 2009a).

[9] See e.g. http://0-climate.gsfc.nasa.gov.iii-server.ualr.edu/static/cahalan/Radiation/EarthRadVblackbody.html

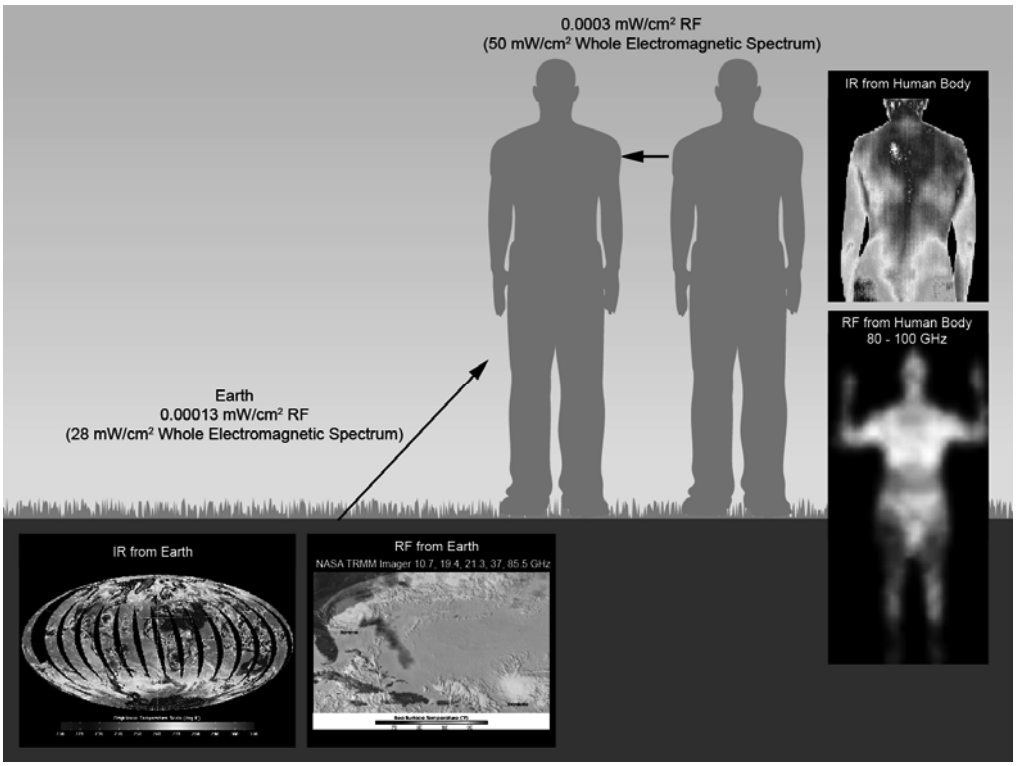

Figure 3. Whole electromagnetic spectrum exposure and RF signal exposure (3 kHz to 300 GHz) from natural sources. Maximum exposure frequency from natural sources is in the infrared (IR) frequency range, well above the RF, but there is still an exposure in the RF frequency band, predominantly in the 80 GHz and 100 GHz range.[10]

Typical exposures from the NV Energy AMI network in the house residential area will be more than a factor of 100 below the RF exposure from the Earth. The network exposure outside the residential areas exposure may be higher, but will still be a factor of 3 lower than the RF exposure from Earth even at 1 foot (and will rapidly drop as the distance increases.

Q. Are there other typical sources of RF exposure?

[10] Image sources: Earth Images: NASA (http://disc.sci.gsfc.nasa.gov/AIRS/additional/gallery/airs_isabel.shtml, http://trmm.gsfc.nasa.gov/overview_dir/tmi.html (technical details), and http://earthobservatory.nasa.gov/Features/HurricaneHeart/heart_5.php); Human Body images: technical details at (http://www.brijot.com/technology/our-technology), http://brijot.com/products/gen2, http://rst.gsfc.nasa.gov/Sect9/Sect9_9.html

A. There are several other sources common sources of RF background. Their exposure values are summarized in Table 6.

Table 6: Other Sources of RF Exposure under Typical Use.

Technology	Peak Power Density (mW/cm^2)	Exposure (mW/cm^2), based on 47CFR1.1310 averaging	Frequency
Mobile phone next to the head (1.81 minute call)[a]	1.5 – 12	0.09 – 0.19	450 MHz, 480 MHz, 850 MHz, 900 MHz, 1800 MHz, 1900 MHz,
Cordless phone next to the head (3 minute call)[b]	0.05 – 1.2	0.005 – 0.12	900 MHz, 1.9 GHz, 2.4 GHz
TV, Radio, Cell phone towers (urban environment)[c]		0.000045 - 0.00015	0.3 MHz to 3 GHz
Microwave oven (1 foot away, 1 minute heating at 100% setting every half hour)[d]	0.14	0.0047	2.4 GHz
WiFi (at least a yard away from transmitter)[e]	0.002	0.000000010 - 0.0010	2.4 GHz

[a] http://news.yahoo.com/s/ytech_gadg/20101007/tc_ytech_gadg/ytech_gadg_tc3837

[b] Based on Table 1-8 in Rohde UL and Newkirk DP. RF/microwave circuit design for wireless applications. John Wiley & Sons, 2000, p. 56; duration of call estimated based on VOIP call length in Guha S and Daswani N. An Experimental Study of the Skype Peer-to-Peer VoIP System (located at http://saikat.guha.cc/pub/iptps06-skype/)

[c] Based on field values in Valberg PA, Van Deventer TE, Repacholi MH. Workgroup report: base stations and wireless networks—radiofrequency (RF) exposures and health consequences. Environ Health Perspect 115:416, 2007.

[d] The FDA's Bureau of Radiological Health has set a limit of 5 mW/cm^2 for leakage from microwave ovens during normal use (21 CFR 1030.10). At 1 foot, the peak power density will drop to 0.14 mW/cm^2.

[e] Based on Foster KR. Radiofrequency exposure from wireless LANs utilizing Wi-Fi technology. Health Physics 92: 280-289, 2007.

A mobile phone produces both local and whole body exposure. Since a mobile phone is held so close to the body, it is the dominating local exposure that is estimated, but there is also whole body exposure for mobile phones, which includes a combination of local head/neck exposure and the exposure when the phone is near the rest of the body).

Q. How does the exposure from the NV Energy AMI network devices compare to the common RF exposure sources.

A. Figure 4 illustrates the relative exposure values:

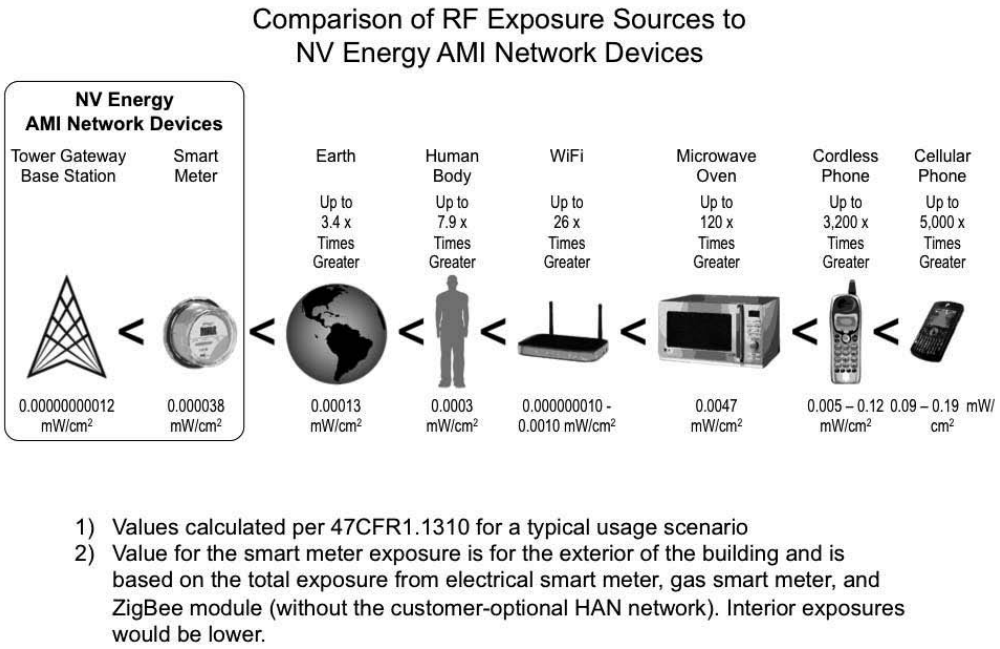

Figure 4: Comparison of common RF Exposure Sources to NV Energy AMI Network Devices

The NV Energy AMI network devices produce RF exposures that are lower than other common RF sources shown in Figure 4.

Q. With all this natural and man-made RF background, how can smart meters and the TGB detect the RF signals?

A. An individual smart meter and its corresponding TGB agree beforehand on what sequence of frequencies (in the 896 to 960 MHz range) they will communicate over. This allows them to track each other's transmission and reject the other sources of RF signal.

As an analogy, consider the task of meeting a friend in a very busy airport terminal. With thousands of people circulating in the terminal, it could be impossible to find your friend. If, however, you agree beforehand that you are going to meet at a specific location and then walk together through the terminal, thousands of people in the airport terminal are no longer interfering with your task.

Q. Will exposure be higher in the multi-tenant buildings where the meters are grouped and may even be located inside the building in electrical rooms?

A. Directly near the meter bank, the average power density will increase by approximately the amount that is equal to the number of meters in the bank. But typically, such installations will be located at a greater distance from the residential areas than a single meter installation. Since the exposure drops rapidly as a function of distance, it is unlikely that the exposure inside the building will exceed the values in Table 4**Error! Reference source not found.**. Moreover, all installations, including multiple units or banks of meters in the same location, must be compliant with public exposure limits (Knapp, 2010).

In addition, the need for orderly communication between multiple devices and TGBs impose practical limits on the number of smart meters that are sending messages at any given time. Finally, the distance between meters (as dictated by the size of the meter) effectively reduces exposure at a given point because exposure decreases significantly in relationship to the distance from the meter. Consequently, as Knapp notes, "Irrespective of duty cycle, based on the practical separation distance and the need for orderly communications among several devices, even multiple units or "banks" of meters in the same location will be compliant with the public exposure limits."

Q. If all the neighboring houses have smart meters, does that increase the exposure inside my residence?

A. Since the exposure drops rapidly as a function of distance from a transmitter, the smart meters mounted on neighboring houses do not add appreciably to the exposure values listed in Table 4.

Q. Do smart meters communicate using pulsed or pulse modulated RF signals?

A. Smart meters that are part of the NV Energy AMI network do not use pulsed or pulsed modulated signals. To transmit the utility-use information to NV Energy, the

smart meter uses a message of approximately 107 milliseconds[11] (1 millisecond is 1/1,000 of a second). Electrical meters will typically transmit 28 messages a day.[12] Gas meters will typically transmit six messages a day.[13] This message is transmitted using a constant amplitude modulation method. That is, during the transmission, the RF signal oscillations have constant amplitude. When the message is completely transmitted, the RF signal oscillations cease. The smart meter's RF transmitter is turned off until the next message needs to be sent out. This type of transmission is considered to be a burst rather than a pulsed or pulse modulated communication.[14] The RF signal from transmitting smart meters, however, is always oscillating,[15] i.e., not generating pulses.[16]

This is exactly the same way that a microwave oven operates when set at less than 100%. For example, when set at 10%, a microwave oven will first use 100% power output, then switch to 0% output, then use 100% power output, and 0% again (and so on) maintaining an average output of 10%. These periodic changes as the microwave changes power output during cooking. While cooking, the power output varies between 100% power output and 0% power output. Thus, like the NV Energy AMI smart meter, it turns on and off.

Q. How many seconds total a day does the NV Energy AMI network smart meters transmit a day?

A. The NV Energy AMI network's electrical smart meter typically transmits a total of 3 seconds per day. Gas smart meters typically transmit a total of less than 1 second

[11] Maximum message length in the current installation is 215 milliseconds. 99% of the meters use message length that is less than or equal to 107.40 milliseconds.

[12] 95% of currently installed electrical smart meters send 28 or less messages a day. The maximum number of messages a day sent in the current installation is 194.

[13] All gas meters are expected to send less than seven messages a day.

[14] A burst is defined as a wave or waveform composed of a pulse train or repetitive waveform that starts as a prescribed time and/or amplitude, continues for a relatively short duration and / or number of cycles, and upon completion returns to the starting amplitude (IEEE:Standard Dictionary of Electrical and Electronics Terms 100. IEEE, 1988).

[15] Oscillation is defined as a Fluctuation or vibration on each side of a mean value or position (http://www.hq.nasa.gov/office/hqlibrary/aerospacedictionary/508/o.html)

[16] Pulse is defined as a variation of a quantity whose value is normally constant; this variation is characterized by a rise and a decay, and has a finite duration. http://www.hq.nasa.gov/office/hqlibrary/aerospacedictionary/508/p.html

per day. The ZigBee module inside the electric smart meter typically transmits less than 18 seconds a day.

Q. Do RF signals from Smart Meters pose a risk for people who have implanted medical devices such as pacemakers?

Medical device users should always follow the device manufacturer's and doctor's recommendations when they are in a vicinity of an RF transmitter, regardless of whether that transmitter is a smart meter, WiFi, cell phone, or cordless phone, or other device the emits RF fields (Knapp, 2010).

Typically, manufacturers of implanted cardiac devices and pacemakers and will recommend that a distance of 6 inches be maintained to a transmitter.[17]

For other medical devices, the information provided by the manufacturer should be the guideline. For example, Medtronic's InterStim Model 3023 Neurostimulator is accompanied by specific instructions (Figure 5)[18]

The following devices should **not** interfere with your InterStim System:

- Microwave ovens
- Televisions, AM/FM radios, stereos, cellular phones
- Tabletop appliances, such as toasters, blenders, electric can openers, food processors
- Hand-held items, such as hair dryers, shavers
- Appliances, such as washers, dryers, electric stoves
- Electric blankets and heating pads
- Vacuum cleaners, electric brooms
- Personal computers, electric typewriters, copiers, and fax machines

Figure 5. Example of medical device manufacturer's instructions

Q. Can RF signals from smart meters and NV Energy AMI network heat up medical implants?

[17] For a detailed discussion see OET 56-1999.
[18] Medtronic Inc., IntelliStim Therapy for Urinary Control Patient Manual, 1999.

A. The typical exposure from the smart meter is more than a factor of a 15,000 below the level that would be required to produce whole-body averaged SAR of 0.08 W/kg. By comparison, a typical limit on RF SAR recommended by medical device manufacturers is between 0.1 and 2 W/kg. [19]

Q. Do smart meters introduce noise into the power lines?

A. All smart meters listed in Table 3 passed a power line conducted emissions test (47CFR15.107) as part of the equipment authorization process. This test verifies compliance with a limit of the signal that a smart meter can introduce into the power lines. The detailed results for each meter can be located on the FCC website.

PERSPECTIVE ON GENERAL HEALTH CONCERNS

Q. Concerns have been raised in comments about a variety of symptoms and nervous system responses either experienced by a few commenters in the vicinity of smart meters or from information obtained from postings on internet websites. Is there a good scientific basis for the idea that RF fields from the NV Energy AMI network would be capable of eliciting such effects?

A. There has been a long history of biomedical research that has observed human and animal subjects as well as the responses of cells and tissues for varying periods of time, ranging from a few minutes or for most of a lifetime that provides us with considerable data to evaluate the possible scientific basis for such assertions.

Our response to comments filed with the Commission on this topic (Exponent, 2011) summarized the conclusions of five national and international health and scientific agencies. It is clear from the consistency of their conclusions that the weight of the evidence fails to support the assertions in the comments. The research supports the absence of adverse effects on the subjects of these studies over a wide range of RF exposure intensities. The very weak RF signals from the NV Energy AMI network further underscores the implausibility that any responses observed are due to exposure to RF signals.

[19] http://www.mrisafety.com/safety_article.asp?subject=139

Q. The topic of electromagnetic hypersensitivity was also raised by some persons who believe that health conditions or hypersensitivity to RF fields might make them especially vulnerable to aggravating influence of signals from the NV Energy AMI network. What can one conclude from scientific research on this topic?

A. This notion has gained the attention of persons who are seeking an explanation for their symptoms or who are trying to avoid exposures that appear to be coincidental with symptoms. Our review of the research literature failed to provide persuasive support for a causal relationship between exposure to weak RF fields and a variety of subjective symptoms. This view is shared by the WHO and other agencies who recommend that such symptoms be termed idiopathic environmental intolerance (IEI) because there is no confirmed link to RF fields or other types of EMF.

We summarized the assessments of research by five national and international agencies in our response to comments filed with the Commission on this topic (Exponent, 2011). Altogether, all of these agencies concluded that the scientific evidence failed to support the existence of an effect of RF fields on self-reported symptoms. That does not mean that there is not some basis for the symptoms that some people experience; it just means that exposure to RF fields is not at all likely to be the cause.

This topic was also addressed by Dr. James Kornberg, M.D. and his report concludes that there is no convincing evidence for human hypersensitivity to electromagnetic fields in general and in particular to the RF fields with power densities and frequencies associated with NV Energy's AMI network (Kornberg, 2011). In addition, there is no recognized medical diagnostic category for a link to effects pf RF or EMF exposure.

QUALITY OF EVIDENCE SUPPORTING ASSERTIONS IN COMMENTS

Q. Would you please comment on the quality of the evidence that some commenters have relied upon as support for their assertions of likely harm from exposure to RF signals from the NV Energy AMI network?

A. Almost the entirety of the evidence provided in submissions relevant to RF health and safety issues consists of anecdotal observations, postings on internet sites, and opinions offered by a small group of scientists. Such data are wholly inadequate for assessing potential health risks of RF exposure. As mentioned above, the requirement for a scientific assessment of health risks that scientific and health agencies perform requires an examination of all the available high-quality data and an objective review process.

Q. Can you single out a source of information that informed a good number of comments filed with the Commission that does not pass scientific muster?

A. Many of the assertions and opinions relevant to the assessment of biological effects of RF fields cite a small group of scientists whose opinions have not been accepted by most experts. The wellspring for these opinions is an unpublished document that has been posted on the internet by its authors (the BioInitiative Report), which has not been peer reviewed by a scientific journal. The authors of the report most widely cited in comments include Cindy Sage, Dr. Johansson, Dr. Carpenter, and Martin Blank, Ph.D. Cindy Sage is also the author of a critique of RF health and safety issues that is posted on the Internet and also referenced in comments. The main conclusion of the BioInitiative Report is that existing standards for exposure to RF fields are insufficient because "effects are now widely reported to occur at exposure levels significantly below most current national and international limits."

Based on our own review of the scientific research on RF and the many reviews of that research conducted by credible scientific panels, the Bioinitiative Report is not an objective or reliable source for information about RF exposure. To be persuaded that any effect occurred below exposure limits, the research would need to show two things: 1) that the effects reported in well-designed single studies were replicated,

and 2) that the reported effects were reliable indicators of adverse effects on the health or functional ability of an intact living organism. These requirements have not been fulfilled. Reviews from public health agencies and national and international scientific organizations in the United States, United Kingdom, and Europe offer conclusions that contrast starkly with the alarmist statements in the Bioinitiative Report about health risks of RF fields and the need for lower exposure limits.

Q. Yet some articles have appeared in a peer-reviewed journal by some of the authors of the Bioinitiative Report and others that do suggest that some laboratory and epidemiologic studies indicated that the risk to human health of exposure to RF fields is significant. What is your comment?

A. Based on our review of the papers in that issue of *Pathophysiology*, we have not found the material to be persuasive. These papers resemble that of the BioInitiative report; they essentially repeat the conclusions of that report, and still rely upon flawed methods for drawing conclusions. It should be noted that the Editor for the special issue of the journal *Pathophysiology* that published these papers was Dr. Blank, a contributor to the BioInitiative Report. As Editor of this special issue, he would have solicited authors to submit manuscripts, selected reviewers of the manuscripts, and signed off and approved all manuscripts.

Q. What are the flaws that affect the conclusions of the BioInitiative Report?

A. The authors of the BioInitiative Report have not followed the standard, scientific methods for developing exposure limits. Other organizations that have reviewed the RF research, or the research for many other exposures, follow a procedure that includes a systematic evaluation of the entire body of scientific evidence. This includes three areas of research: epidemiology studies, *in vivo* studies, and *in vitro* studies. After evaluating the quality of individual studies and consistency of results, exposure limits are developed to prevent exposures at intensities of RF fields where adverse health effects have been reliably reported.

In contrast, the conclusions in the BioInitiative Report are not based on this weight-of-evidence, multidisciplinary approach. The authors of the BioInitiative Report argue that this systematic approach should be replaced by a process that sets guidelines at exposure levels where biological effects have been reported in some studies, even if they have not been substantiated or linked to adverse health effects. Instead of a comprehensive review, the BioInitiative Report cites results from specific studies, but provides no rationale for their inclusion or an explanation why many other relevant, published studies were not considered. One striking omission is that the BioInitiative Report does not discuss the results from whole animal (*in vivo)* studies, which are considered an important indicator of the potential hazard from any exposure. Instead, the BioInitiative Report's approach gives disproportionate weight to the results of *in vitro* studies that report biological effects in isolated cells or tissues that have been selectively 'cherry-picked' from a much larger literature.

Q. Has the larger scientific community considered the BioInitiative Report?

A. Yes and their comments are not favorable. The scientific agencies that have prepared written reviews of the report commented that the BioInitiative Report did not follow the methods of a standard weight-of-evidence review and, for this reason, its conclusions and recommendations were not convincing (EC, 2007; HCN, 2008; ACRBR, 2009; COMAR, 2009). EMF-NET, a project funded by the European Commission[20] wrote, "There is a lack of balance in the report; no mention is made in fact of reports that do not concur with authors' statements and conclusions. The results and conclusions are very different from those of recent national and international reviews on this topic" (EC, 2007).[21] The Australian Centre for RF Bioeffects Research (ACRBR) wrote, "As it stands it merely provides a set of views that are not consistent with the consensus of science, and it does not provide an

[20] EMF-NET is a Coordination Action that aims to provide a framework for the coordination of the results of the research activities related to the biological effects of electromagnetic fields, considering also the potential risks related to exposure in the working environment (occupational exposure). http://web.jrc.ec.europa.eu/emf-net/aims.cfm

[21] http://emf-net.isib.cnr.it

analysis that is rigorous-enough to raise doubts about the scientific consensus" (ACRBR, 2009)

Q. The BioInitiative Report suggests that there are adverse biological effects at levels below current RF exposure limits set by national and international agencies. Such effects are alleged to occur at exposure levels that do not cause tissue heating, i.e., athermal effects.

. Yes. But to date, evaluations of the scientific evidence for biological effects at levels below those attributable to heating have not concluded that the data supporting such effects is persuasive, given the limited quantity, quality, and inconsistencies of the data, e.g., ICNIRP (2009), SCENIHR (2009). However, studies continue to be performed to test for possible effects at lower levels of exposure, and are periodically evaluated by agencies, given that the common exposures to RF fields all occur at levels well below recommended limits for public exposure. As part of the work towards evaluating and updating the ICNIRP standard, this agency invited scientists from around the world to participate in an international seminar on the topic of non-thermal RF electromagnetic fields (ICNIRP, 1997)

Evaluations of the scientific evidence for biological effects at levels below those attributable to heating, however, have not concluded that the data supporting such effects is persuasive, given the limited quality of some of the data, and inconsistencies within the data (e.g., ICNIRP, 2009; SCENIHR, 2009). But studies continue to be performed to test for possible effects at lower levels of exposure and are periodically evaluated by agencies because *the common public exposures to RF fields all occur at levels well below recommended limits for public exposure*. The International Commission for Non-Ionizing Radiation Protection (ICNIRP), for example, in its review of the research literature in 2009 concluded:

> It is the opinion of ICNIRP that the scientific literature published since the 1998 guidelines has provided no evidence of any adverse effects below the basic restrictions and does not necessitate an immediate revision of its guidance on limiting exposure to high

> frequency electromagnetic fields. The biological basis of such guidance remains the avoidance of adverse effects such as "work stoppage" caused by mild wholebody heat stress and/or tissue damage caused by excessive localized heating (D'Andrea et al. 2007). With regard to non-thermal interactions, it is in principle impossible to disprove their possible existence but the plausibility of the various non-thermal mechanisms that have been proposed is very low. In addition, the recent in vitro and animal genotoxicity and carcinogenicity studies are rather consistent overall and indicate that such effects are unlikely at low levels of exposure. Therefore, ICNIRP reconfirms the 1998 basic restrictions in the frequency range 100 kHz–300 GHz until further notice (p. 257).

Q. Do these standard-setting organizations deny that there are any athermal biological effects?

A. No, there are a variety of mechanisms by which RF fields have been demonstrated to affect components of biological tissues other than by frank heating. These include induced charge and dipole relaxation, pearl-chain formation (the linear rearrangement of molecules and cells into chains), changes in the shape and permeability of cells, and the "microwave hearing effect." All of these interactions can occur without appreciable tissue heating and so are athermal mechanisms (ICNIRP, 2009a). The latter is interesting because it occurs due to a rapid pressure wave within the inner ear which, like sound, moves hair cells to stimulate the perception of sound. The peak power density required to elicit this perception in the frequency range of signals transmitted by a smart meter is estimated to be 5-20 kilowatts per square meter (kW/m^2) (ICNIRP, 2009a), some 10,000,000 times greater than the typical exposure (and 1,000 times greater than even peak power density) produced by the NV Energy AMI network.

Thus, despite the athermal nature of these effects, they occur to a significant extent only at exposure intensities greater than those that produce tissue heating. Hence,

there are confirmed athermal effects, but none that would be relevant to an explanation for biological responses at levels below that associated with adverse effects of RF heating, i.e., LOAEL.

Q. If the authors of the BioInitiative Report are not correct, then why is WHO still investigating RF? Doesn't this mean the public should be concerned?

A. No. The public should appreciate that the ongoing role of the WHO in "investigating" or monitoring and reviewing the research is a cautionary measure. The results of their activities can be found at the website of the International EMF Project that includes fact sheets for the public on RF andEMF.[22] Other WHO actions include the recommendation that all countries worldwide consider adopting the ICNIRP guidelines and their scheduled written review of the research to update their 1993 Environmental Criteria Document monograph (WHO, 1993). Because virtually everyone in developed countries has exposures to RF fields from different sources, it is important to make sure that even the slightest possibility of a risk has not been overlooked.

PERSPECTIVE ON HEALTH CONCERNS RAISED ABOUT CANCER

Q. Are you aware that the most common concern expressed in public comments about the smart meter was cancer and the press release by the WHO[23] about a report from the International Agency for Research on Cancer (IARC) that RF fields would fall into the category of a possible human carcinogen (2 B)?

A. Yes, we read of this concern in the comments submitted to the Commission and have provided the perspective of four international health and scientific agencies to address this concern. The consensus expressed in these reviews and evaluations of the scientific evidence in areas of human epidemiology, as well as experimental laboratory studies, is that evidence is limited that cancer develops from exposures to RF fields, and the indications of potential risk derive almost entirely from statistical

[22] http://www.who.int/peh-emf/en/

[23] The WHO is commonly cited in the media as the author of the report, but it was authored by the IARC. The WHO commissioned the IARC to evaluate the potential carcinogenic hazard of exposure to RF fields. So the report here is referred to as the IARC report and a summary of the report by Robert Baan and his colleagues at IARC written on behalf of the WHO is indicated by reference to Baan et al., 2011.

associations in some studies between the use of mobile phones and certain types of cancer. These associations are generally regarded as not being supported by the results of experimental laboratory studies of animals and cells.

In light of the comments to the Commission arising from the IARC's classification, it is important to give this special attention. Therefore, the following Q & A discussion will focus on the recent comprehensive review by ICNIRP (2009) and the IARC report in four specific areas:

1. Studies of cancer from RF sources other than mobile phones.

2. Studies of brain tumors and mobile phone use.

3. Studies addressing other cancers and mobile phoneuse.

4. A discussion of the IARC classification.

This summary of the IARC and ICNIRP reports together with the other current reviews of RF exposure and cancer and other potential effects provides a broad survey of current knowledge about RF exposure and health. In the case of the IARC report, the details supporting the main conclusions and evaluation have yet to be published, which is a limitation to the summary below.

Q. What research did the IARC review that may be most relevant to smart meters?

A. The studies described below cover a broad range of exposure levels. The highest exposures are typically found in experimental studies of laboratory animals; chronic bioassays expose animals at various RF levels (some at or above the effect level) for nearly their entire lifespan. Some laboratory studies look for effects in cells at low RF levels, as well. The highest RF exposure levels in human studies are those in epidemiology studies of either occupational exposure or mobile phone exposure. The lowest RF exposure levels are those epidemiology studies of community

exposures to RF fields from radio and other transmitter antennas. Such studies involve exposures that are closer to that of smart meters than mobile phones

Data on laboratory animals has been reviewed by ICNIRP (2009) and most recently by the IARC (Baan et al., 2011). The 2009 ICNIRP review focused on papers published after 1993. Several cancers have been studied including brain tumors, lymphoma, mammary tumors, skin tumors, and colon tumors in a number of experimental models including rodent bioassays, studies using genetically predisposed animals, and co-carcinogenicity studies. ICNIRP concluded that the cellular and animal genotoxicity and carcinogenicity studies are consistent and indicate that cancer-related effects are unlikely at SAR levels up to 4 W/kg. The IARC summary report (Baan, et al., 2011) noted that none of the seven chronic bioassays showed an increased incidence of any tumor type in tissues and organs in animals exposed to RF-electric and magnetic fields (RF-EMF) for 2 years (Baan et al., 2011). In addition, increased cancer incidence in exposed animals was observed in 2 of 12 studies with tumor-prone animals and in 1 of 18 studies using initiation-promotion protocols.[24] Based on these data, the IARC concluded that there was "limited evidence" in experimental animals for the carcinogenicity of RF-EMF (Baan et al., 2011).

Data on occupational exposure and cancer has been reviewed by ICNIRP (2009) and also by the IARC (Baan et al., 2011). In most of the studies, exposure was assessed by using occupation or job title as a proxy for exposure. ICNIRP concluded that there was no cancer site for which there was consistent evidence that occupational exposure to RF fields affects the risk of cancer. The IARC summary report (Baan et al., 2011) noted that studies of occupational exposure have investigated brain tumors, leukemia, lymphoma, and other types of malignancy including uveal

[24] Initiation is the first stage in the development of cancer; initiation typically results from exposure to an agent that can cause mutations in a cell. Promotion is a later stage in cancer development, following initiation. If there is sufficient exposure to the agent, promoters increase the frequency of tumor formation that occurs after initiation.

melanoma and testicular, breast, lung, and skin cancers. The IARC noted that these studies had methodological limitations and the results were inconsistent (Baan et al., 2011).

Data on exposure from transmitters, including towers that transmit radio, television, microwave, and cellular telephone signals, were reviewed by ICNIRP (2009) and the IARC (Baan et al., 2011). Most of the studies reviewed have been geographic correlation studies with no individual exposure assessment, with the exception of two studies of childhood leukemia that assessed individual exposure using information from radio transmitters (ICNIRP 2009). ICNIRP concluded that the results of these studies based on community exposure have been inconsistent both within and between studies and do not show a relationship with RF exposure. The IARC Working Group reviewed studies that addressed environmental exposure to RF-EMF and cancer, but found the available evidence insufficient for any conclusion (Baan et al., 2011).

Q. Over more than a decade the media has reported on epidemiology studies of cancer in human populations in relation to the use of mobile phones. What do these studies report?

Numerous case-control studies and one cohort study have been conducted to investigate the risk of brain tumors from mobile phone use, including the large multi-site, multi-national project coordinated by the IARC. This project, referred to as the INTERPHONE study involves 13 case-control studies conducted in European countries, Japan, Israel, Canada, New Zealand, and Australia (Cardis et al., 2007). It includes epidemiologic studies on malignant brain tumors, focusing on glioma, and non-malignant brain tumors including meningioma and acoustic neuroma, as well as other cancer outcomes (e.g. salivary and parotid gland tumors) from a few of the studies. A majority of the published epidemiologic studies to date from the INTERPHONE study have not reported an increased risk of mobile phone use and brain tumors; however positive associations have been reported for some tumor types in several studies in subgroups defined by latency period or ipsilateral use (the side of head where the mobile phone is predominantly used, compared with the

location of the tumor). Other than a recent Japanese study (Takebayashi et al., 2008), which incorporated estimates of SAR in their exposure protocols, all published epidemiologic studies to date have relied solely on self-reported estimates of the amount of time the mobile phone was used. A recent pooled analysis that included all glioma and meningioma cases reported an odds ratio (OR) below 1.0,[25] indicating no positive association, and also did not indicate an increase in risk for longer duration of phone use including duration of over 10 years (INTERPHONE, 2010). The only positive association was observed for the highest category of cumulative call time. The authors reported that limitations, including recall and selection bias, may have influence over the results. Recall bias was possible because the exposure to mobile phone use was self-reported and recall may have been more difficult for long duration users or use in the distant past. Nonparticipation was also suggested as a source of selection bias since participating controls had a higher percentage of mobile phone use compared to non-participating controls.

Several studies have also been published based on data from a Swedish case-control study population (Hardell et al., 2002a, 2002b, 2004b, 2005a, 2006a, 2006b, Mild et al., 2007; Hardell et al., 2011). Briefly, the study population included cases of malignant and benign brain tumors diagnosed between 1997 and 2003 from selected (not all) Swedish regional cancer registries matched to one control based on age, sex, and residence identified from the Swedish population registry. Use of mobile phones was obtained from a questionnaire with follow-up by telephone interview. The results from all the Swedish (non-INTERPHONE)[26] studies suggest an association of brain tumors with use of mobile phones, particularly among those in the longer latency groups. The authors noted that they have controlled for, or have no evidence of, recall bias given that they have observed various associations across

[25] A pooled analysis combines individual-level data across many studies and analyzes the data together to get a summary estimate of the association between a particular exposure and disease. An odds ratio is a measure of association that describes the ratio of the odds of exposure among persons with a disease to the odds of exposure among persons without a disease.

[26] These studies were not included data used in the INTERPHONE Group's studies.

different tumor types. This observation, however, is not sufficient to rule out the possibility of recall bias, and given the case-control study design and methods used for collecting exposure information, recall and reporting bias may still influence the results of these studies. These studies include multiple comparisons among the numerous variables, such that the elevated ORs must be considered in the context of extensive exploratory analyses. The results of these studies, which used a different methodology than the INTERPHONE study protocols, reported the highest ORs, and generally are not consistent with all other epidemiologic studies. It is important to note that other Swedish studies that have relied on standard scientific procedures to identify cases from Swedish cancer registry data have not reported such associations.

To date there has only been one cohort study that has reported results of cancer risks among mobile phone users (Schuz et al., 2006). Most recently, results from this cohort have been published extending the follow-up period to 2007 (Frei et al., 2011). The authors analyzed the records of 420,095 mobile phone subscriptions in Denmark and compared them to the Danish Cancer Registry. In the most recent publication, the authors also linked their subscription and cancer data with a cohort study that included socioeconomic data such as education and income. Since this study was looking at subscriptions to mobile phone service as the indicator of mobile phone use exposure, it is not prone to recall bias that is potentially present in the case-control studies, which were based on self-reported exposure. Exposure could be misclassified, however, if the subscriber was not the primary user of the mobile phone or if there is substantial variation of phone use across the group labeled as subscribers. For example, users of mobile phones that were not listed as subscribers would not be identified and would be classified as unexposed in this cohort design. Overall, the authors concluded that no increased risk of brain tumors, acoustic neuromas, salivary gland tumors, eye tumors, leukemias, or overall cancer was observed in their large cohort study (Frei et al., 2011).

Another line of evidence should be considered. The incidence of brain tumors in the United States has appeared to stabilize or even decrease over time since the 1980s

(Deorah et al., 2006), and similarly Denmark, Finland, Norway, Sweden (Lonn et al., 2004; Deltour et al., 2009), Switzerland (Roosli et al., 2007), and New Zealand (Cook et al., 2003), during a period of substantially increased mobile phone use. If the increased risks suggested by the INTERPHONE Study and the Swedish case-control studies conducted by Hardell and associates were correct, we would expect to see an increase in the annual rates of brain cancer, particularly over the period of 10 years or more after mobile phone use became widespread. The data do not indicate that the occurrence of brain cancer has increased over time.

The majority of estimates of relative risk[27] results reported to date for mobile phone use and brain cancer are near 1.0 (i.e., no association) or lower. Based on the epidemiologic literature to date, these epidemiologic data have not established any consistent or strong association between mobile phone use and cancer.

Q. What is the evidence from epidemiology studies for a relationship between mobile phone use and other cancers?

A. The results of mobile phone use and risk of cancers other than brain tumors do not suggest a causal association. Conclusions based on the studies investigating other tumor sites such as parotid and salivary gland tumors (Hardell et al. 2004a; Lonn et al., 200; Sadetzki et al., 2008), non-Hodgkin's lymphoma (Hardell et al., 2005b; Linet et al., 2006), uveal melanoma (Stang et al., 2009), testicular cancer (Hardell et al., 2006c; 2007), and intratemporal facial nerve tumors (Warren et al., 2003) are limited by the small number of studies published, however, a majority indicate no associations with use of mobile phones. The study of parotid gland tumors in Israel (Sadetzki et al., 2008) reported increased risk with heavy and longer term use of mobile phones that was not consistent with the other two studies reporting no associations (citation).

[27] Similar to an odds ratio, a relative risk is an estimate that compares the risk of disease among persons who are exposed to the risk of disease among persons who are unexposed. Relative risk estimates are reported in cohort studies, while odds ratios are reported in case-control studies.

In their assessment of EMF exposure, the European Health Risk Assessment Network on Electromagnetic Field Exposure (EFHRAN) concluded there was inadequate evidence to demonstrate risk of gliomas and meningiomas from mobile phone use (EFHRAN, 2010a). Their review included the recent pooled INTERPHONE study of gliomas and meningiomas (. There was not sufficient evidence for a causal association between exposure and the risk of disease for any of the diseases they reviewed. Based on a review of the epidemiological data available, ICNRIP concluded that despite the methodologic shortcomings and limited data on latency and long-term use, the available data do not suggest a causal association between mobile phone use and gliomas (ICNIRP, 2009).

Q. The status of research as summarized by the IARC panel of scientists seems rather consistent with that summarized by other panels of scientists, so please explain how the research was classified by IARC.

A. According to the preamble for IARC Monographs, the IARC Working Group gathers evidence from epidemiology, *in vivo*, and *in vitro* studies and evaluates the strength of the evidence for carcinogenicity. Based on their conclusions from the strength of the evidence, the Working Group assigns the agent, in this case RF energy, to a category ranging from 1 to 4, with 1 as the category for an agent classified as "carcinogenic to humans" and 4 as the category for an agent classified as "probably not carcinogenic to humans." A 2B classification of "possibly carcinogenic to humans" is defined by the IARC, as follows:

> This category is used for agents for which there is *limited evidence of carcinogenicity* in humans and less than *sufficient evidence of carcinogenicity* in experimental animals. It may also be used when there is *inadequate evidence of carcinogenicity* in humans but there is *sufficient evidence of carcinogenicity* in experimental animals. In some instances an agent for which there is *inadequate evidence of*

> *carcinogenicity* in humans and less than *sufficient evidence of carcinogenicity* in experimental animals together with supporting evidence from mechanistic and other relevant data may be placed in this group. An agent may be classified in this category solely on the basis of strong evidence from mechanistic and other relevant data (emphasis added).

In a publication summarizing the classification of RF energy as 2B, Baan et al. (2011) indicate that the Working Group considered one cohort study and five case-control studies that were judged to provide useful information regarding gliomas and mobile phone use. Ultimately, the Working Group considered the recent results of the pooled INTERPHONE study (2010) and a recent analysis by the Swedish research group (Hardell et al 2011). The Working Group concluded that although both studies were susceptible to biases, the results suggesting the risk of gliomas after exposure for 7 or more years prior to diagnosis "could not be dismissed" and that a causal interpretation was possible (Baan et al 2011). The details of the review and conclusions by the Working Group are to be provided in a future Monograph by the IARC, yet to be published.

In a response to the classification of RF energy as 2B, the members ICNRIP again reviewed the epidemiologic data on brain tumors, gliomas and meningiomas, and the use of mobile phones (Swerdlow et al., 2011). Particular limitations noted by the authors were that the participation rates of INTERPHONE were low, suggesting the possibility of selection bias. In addition, the INTERPHONE study group has identified evidence of recall bias that has an influence over the results of the study. The authors note that the methodological deficits of the INTERPHONE study limit the conclusions that are drawn from the results. When the results of the INTERPHONE study are placed in the context of other epidemiologic, biological, and animal studies, this review concludes that there is unlikely to be an increase in the risk of brain tumors in adults from cell phones.

Q. How does this research affect our perspective on the very low exposures to RF signals that occur from the NV Energy AMI network?

A. While the results of two studies (pooled INTERPHONE 2010 and Hardell et al 2011) suggest a possible increased risk of gliomas with high mobile phone use, the epidemiologic data does not support the presence of a causal association between brain and other tumors and use of mobile phones, which is consistent with available evidence from animal and mechanistic research. Based on epidemiology studies in people who use mobile phones, that provided "limited evidence of carcinogenicity," the IARC Working Group classified RF energy in the category of "possibly carcinogenic to humans" (Group 2b) (Baan 2011). Other groups reviewing the same information have concluded that RF energy is not likely to cause cancer and that the addition of new data from INTERPHONE does not change their conclusion (EFHRAN 2010, ICNIRP 2009).

Q. What is your opinion regarding the health effects of the Smart Meter?

A. Our opinion is that to a reasonable degree of scientific certainty here is not a reliable scientific basis to conclude that the RF signals that are used to communicate between devices on the NV Energy AMI network will cause or contribute to adverse health effects in the population.

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Yakov P. Shkolnikov, Ph.D., P.E.

Managing Engineer

Professional Profile

Dr. Yakov Shkolnikov has expertise in the development and analysis of high performance electronic devices and systems. With this expertise, he is able to advise clients on matters related to reliability and intellectual property issues.

As the head of the software task force at Exponent, Dr. Shkolnikov has assisted clients in software and algorithm development, software reliability analysis, and intellectual property evaluations. Dr. Shkolnikov has extensive experience in algorithm design and has developed methods and software in such diverse areas as analysis of radiological imaging data, computer vision and learning, statistical data processing, mechanical testing of medical implants, instrumentation of diagnostic systems, internet-protocol (IP) based communication, and analysis of ground penetrating radar data.

He has performed reliability and functional analysis of software used in medical, automotive, desktop, and embedded applications, and has experience with C, LabVIEW, MATLAB, and several other script, and controller languages, as well as with auto-documenting software and static verifiers such as PolySpace.

Dr. Shkolnikov has assisted clients in technical analyses supporting complex litigation cases such as class action lawsuits, and patent and trade secret litigation. He has performed infringement, obviousness, and validity analysis of patents for consumer electronic devices and software; assisted clients in locating prior-art and prior-use examples; and overseen large document reviews inherent to such cases.

His medical-devices project and research experience include the technical analysis of implantable cardioverter defibrillators (ICD), pacemakers, implantable pulse generators (IPGs), orthopedic implants, blood flow meters, electrosurgical and robotic equipment used in electro stimulation, and electro pathology. He also has experience in electromagnetic finite element analysis (AC/DC and RF), low electrical noise systems, cryogenic and high magnetic field measurements, data acquisition analysis and visualization, fiber optic systems, and electronic-device packaging.

Dr. Shkolnikov has published over 25 peer-reviewed papers on electrical engineering topics such as semiconductor physics and electrical-safety and has participated in numerous technical conferences on medical device analysis and semiconductors. He has a patent on the security of RFID cards, and has filed several provisional patents filings on cell phone power management, RFID technology, and mechanical strain sensing. Dr. Shkolnikov holds a research faculty appointment at School of Biomedical Engineering, Science and Health Systems at Drexel University, and is a guest lecturer at Princeton University, Department of Mechanical & Aerospace Engineering. He was also a referee for *Physical Review Letters* from 2006–2011 and is currently a referee for Health Physics.

Academic Credentials and Professional Honors

Ph.D., Electrical Engineering (minor in Mechanical Engineering), Princeton University, 2005
M.A., Electrical Engineering, Princeton University, 2004
B.S., Engineering Physics, Cornell University (*summa cum laude*), 1999

Graduated ranked 1st in School of Engineering, Summa Cum Laude, Cornell University; Gordon Wu Fellow, Princeton University; Merrill Presidential Scholar, Cornell University; Tau Beta Pi

2010 IEEE Region 1 Award, Category 3B : Technological Innovation (Industry or Government), For the Development of Mathematical Methods for Computing Ground-Penetrating Radar to Detect Land Mines

The Institute of Electrical and Electronics Engineers/International Committee on Electromagnetic Safety, Subcommittee 4, Safety Levels with Respect to Human Exposure to Radiofrequency Fields (3 kHz to 3 GHz)

Licenses and Registrations

Licensed Professional Engineer, New Jersey, #GE47825

Patents

US Patent No. 7,936,274: Shield for Radio Frequency ID Tag or Contactless Smart Card, filed May 3, 2011 (Shkolnikov Y, Du Y, McGoran B).

Publications

Shkolnikov YP, Bowden A, MacDonald D, Kurtz SM. Wear pattern observations from TDR retrievals using autoregistration of voxel data. J Biomedical Mater Res Part B: Appl Biomaterials, 2010, in press. Epub ahead of print.

Kurtz SM, Ochoa JA, Lau E, Shkolnikov Y, Pavri BB, Frisch D, Greenspon AJ. Implantation trends and patient profiles for pacemakers and implantable cardioverter defibrillators in the United States: 1993–2006. PACE 2009. doi: 10.1111/j.1540-8159.2009.02670.

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Selected Conference Presentations

Shkolnikov YP, Bailey WH. Electromagnetic interference and exposure from household wireless. IEEE Symposium on Product Compliance Engineering, San Diego, CA, October 11, 2011.

Swart J, Shkolnikov YP. Electrical shock and the electric powered vehicles – An introduction forensics. IEEE Symposium on Product Compliance Engineering, San Diego, CA, October 11, 2011.

Hanzlik JA, Patel JD, JA Ochoa, Shkolnikov YP, Horn QC, Pavri BB, Greenspon AJ, Kurtz SM. Why are implantable cardioverter-defibrillators and pacemakers being revised today? Materials and Processes for Medical Devices Conference and Exposition, Minneapolis, MN, August 8–10, 2011.

Shkolnikov Y, Restrepo C, Parvizi J, Hozack W, Garino J, Suggs J, Kurtz S. Clinical validation of a squeakometer for characterization of acoustic emissions in arthroplasty patients. ORS 55th Annual Meeting, Las Vegas, NV, February 23, 2009.

McGowan JC, Shkolnikov YP, Sala JB, Ray RM. Diffuse electrical injury: Questioning the scientific basis. IEEE Canadian Conference on Electrical and Computer Engineering, Niagara Falls, Ontario, Canada, May 6, 2008.

McGowan JC, Shkolnikov YP, Sala JB, Ray RM. Diffuse electrical injury: A questionable phenomenon. 24th Southern Biomedical Engineering Conference, El Paso, TX, April 19, 2008.

Bowden AE, Shkolnikov YP, MacDonald D, Kurtz SM. Automated microCT-based damage maps of explanted polymeric TDR components. North American Spine Society 22nd Annual Meeting, Austin, TX, October 22–27, 2007.

Bowden AE, Shkolnikov YP, MacDonald D, Kurtz S. Development and validation of an automated MicroCT-based technique for mapping damage of explanted polymeric components for TDR. Spine Arthroplasty Society, Berlin, Germany, 2007.

Padmanabhan M, Bishop N, Shkolnikov YP, De Poortere EP, Shayegan M. Gap and mass measurements of composite fermions at nu=5/3 in a 2D electron system with tunable valley occupation. APS March Meeting, Denver, CO, 2007.

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Vakili K, Y. Shkolnikov, Tutuc E, Bishop N, De Poortere EP, Shayegan M. Spin-dependent resistivity at transitions between integer quantum Hall states. APS March Meeting, Los Angeles, CA, 2006.

Vakili K, De Poortere EP, Shayegan M. Spin susceptibility of two-dimensional electrons in AlAs. PCCM Workshop on Correlated Electronic Materials, Princeton, NJ, 2005.

Shkolnikov YP, Vakili K, De Poortere EP, Shayegan M. Dependence of spin susceptibility of a two-dimensional electron system on valley degree of freedom. 16th International Conference on High Magnetic Fields in Semiconductor Physics, Tallahassee, FL, 2004.

Shkolnikov YP, Tutuc E, Vakili K, Gunawan O, Shayegan M. Physics and technology of AlAs semiconductor devices. Corporate Affiliates Program Meeting, Princeton NJ, 2004.

Shkolnikov YP, Vakili K, Shayegan M. Strain dependence of spin and valley polarization in AlAs 2D electrons. APS March Meeting, Montreal, Canada, 2004.

Gunawan O, Shkolnikov YP, Tutuc E, Shayegan M, De Poortere EP. Valley-resolved ballistic transport in a two-dimensional electron system. APS March Meeting, Montreal, Canada, 2004.

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Shkolnikov YP, De Poortere EP, Vakili K, Tutuc E, Shayegan M, Karrai K, Palm E, Murphy T. stress-induced modification of electronic properties in AlAs 2D electrons. Corporate Affiliates Program Meeting, Princeton, NJ, 2003.

De Poortere EP, Shkolnikov YP, Shayegan M. Field-effect persistent photoconductivity in GaAs/AlAs-based structures. APS March Meeting, Austin, TX, 2003.

Gunawan O, De Poortere EP, Shkolnikov YP, Vakili K, Tutuc E, Shayegan M, Yau JB. Ballistic transport in AlAs 2D electrons. APS March Meeting, Austin, TX, 2003.

Vakili K, Shkolnikov YP, De Poortere EP, Tutuc E, Shayegan M. Magnetoresistance measurements in wide and narrow AlAs quantum wells. APS March Meeting, Austin, TX, 2003.

Shkolnikov YP, De Poortere EP, Vakili K, Tutuc E, Shayegan M. Lifting of the valley degeneracy in AlAs 2D electrons. APS March Meeting, Austin, TX, 2003.

Shkolnikov YP, De Poortere EP, Tutuc E, Shayegan M, Palm E, Murphy T. Magnetic field dependence of valley splitting in AlAs 2D electrons. 15th International Conference on High Magnetic Fields in Semiconductor Physics, Oxford, UK, 2002.

Shkolnikov YP, De Poortere EP, Tutuc E, Shayegan M. Evidence of multi-valley fermi surface in AlAs 2D electrons. APS March meeting, Seattle, WA, 2001.

Skinner CH, Stotler DP, Bell RE, Pitcher CS, Terry JL, Shkolnikov Y. High resolution spectroscopy at Alcator C-mod using a Fabry Perot interferometer. APS, 41st Annual Meeting of the Division of Plasma Physics, Seattle, WA, 1999.

Guest Lectures

Shkolnikov YP. Electricity and the human body. Mechanical Engineering, Princeton University, Princeton, NJ, April 8, 2010.

Shkolnikov YP. Got risk? Managing risk and reliability in modern technology. Cornell Club of Central New Jersey, Princeton, NJ, December 4, 2009.

Villarraga M, Shkolnikov YP. Medical device failure analysis during the design process. Department of Biomedical Engineering, Drexel University, Philadelphia, PA, May 6, 2009.

Shkolnikov YP. Electricity and the human body. Mechanical Engineering, Princeton University, Princeton, NJ, April 9, 2009.

Shkolnikov YP. Medical device design. North Jersey Section Engineering in Medicine and Biology IEEE Chapter, Clifton, NJ, August 4, 2008.

Villarraga M, Shkolnikov M. FMEA: Risk management and prioritization in medical device design. Thompson Interactive, July 17, 2008.

Shkolnikov YP. Failure analysis during the design process of medical devices. Department of Biomedical Engineering, Drexel University, Philadelphia, PA, 2008.

Shkolnikov YP, Villarraga M. Introduction to electrophysiology. Mechanical Engineering, Princeton University, Princeton, NJ, 2007.

Shkolnikov YP, Villarraga M. Failure analysis during the design process of medical devices. Compliance Online, 2007.

Shkolnikov YP. Electricity and the human body. Mechanical Engineering, Princeton University, Princeton, NJ, 2007.

Shkolnikov YP, Villarraga M. Medical device failure analysis during the design process. Department of Biomedical Engineering, Drexel University, Philadelphia, PA, 2007.

Academic Appointments

Visiting Research Professor, School of Biomedical Engineering, Drexel University, 2005–2011

Peer Review

- Referee for *Health Physics*
- Past Referee for *Physical Review Letters*, 2006–2011

Professional Affiliations

- Institute of Electrical and Electronics Engineers
- American Physical Society

Project Experience

Computer Architecture and Networks

- Analysis of computer networks including Internet, WAN, LAN, and smart meter networks
- Analysis of shared memory architecture for mobile computer devices
- Analysis of interrupt handling scheme in mobile processors.
- Software source code analysis (C, C++, Assembly) to identify vulnerabilities and errors in code
- Shielding and interference from RFID and related devices
- Intellectual property/patent investigations semiconductors, software, internet and telephony equipment
- Scalability analysis and improvement of IPTV systems
- Prior art and prior use searches for video game, consumer products, testing equipment and other electronic products
- Patent portfolio review and technical due diligence
- Memory technology analysis and reverse engineering
- Reconstruction of physical geometry and zone mapping of hard drives

Computer Graphics

- Design of 2D/3D image processing and machine learning algorithms
- Detection algorithms

- GPGPU software development
- Computer graphics software use and algorithm development
- Analysis of GPU hardware reliability
- Analysis of patent infringement in computer graphics, image processing, and hardware design

Health, Safety, and Medical Products

- Compliance assessment per 47CFR1.1307, 47CFR1.1310, IEEE C95.1, IEEE C95.6, IEC 60601-1-2, IEC 60479-1, ICNIRP 1998, ICNIRP 2010, and other RF and electrical health and safety standards
- Electric Shock & Electrocution investigations
- Software and methodology development for analysis of FTIR, small punch, tensile testing, tissue property testing, radiological images, and field-testing data
- Assistance in technology transfer product development for biological weapons detection

- Design development, review, and analysis for medic diagnostic equipment companies
- Source code review and modeling to identify failure mode in medical device software
- Failure analysis in medical products including diagnostic equipment, surgical equipment, and implants
- EMI and EMC evaluation of medical products
- Magnetic and electric field exposure and heating from transmission and distribution lines
- Medical products intellectual property analysis
- Risk assessment and FMEA analysis
- Reverse engineering analysis of diagnostic equipment

Computer Forensics and Security

- Verification of integrity of the produced digital images: Metadata analysis, image content analysis, photogrammetric analysis
- Enhancement, recovery, and analysis of video surveillance data
- Recovery and analysis of EPROM memory data relating to construction accident
- Data snooping and interception
- Development of automated text and document analysis tools
- Development of technology to secure contents of smart cards
- Security analysis of payment card shipment method
- Security analysis of a data storage and review facility
- Security product performance evaluation
- Validation of hard-drive data sanitization procedure
- Restoring damaged data
- Analysis of wireless transmission systems including encryption, anti-jamming, and error correction

Reliability

- Hardware in the loop testing and probing of microprocessor to identify malfunction
- Electromagnetic finite element analysis (FEA) of components, products, machines, and installations for RF exposure, electric shock hazard, reliability, electrostatic discharge, and effects of defects in manufacture and materials
- Electromagnetic interference with the function of GPS systems
- Shielding and interference from RFID and related devices
- Analysis of software and hardware component reliability of automotive products
- Analysis of RF emissions for purposes of a recall decision
- Product misuse investigations

Acoustic Analysis

- Forensic analysis of acoustic data, speech enhancement and other audio data processing, audio acquisition system design and evaluation, waveform/spectral based hearing damage assessment

Semiconductors

- Solid-state sensor design
- Semiconductor packaging design, processing, and failure analysis
- Semiconductor physics
- Intellectual property analysis of fabrication processes, semiconductor materials and devices

Cryogenics, Vacuum, and Magnetic Systems

- Operation and design of cryogenic systems
- Operation, control and design of electromagnetic and permanent magnet systems
- Operation and service of high and ultra high vacuum equipment, systems, and pumps

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William H. Bailey, Ph.D.
Principal Scientist

Professional Profile

Dr. William H. Bailey is a Principal Scientist in Exponent's Health Sciences practice. Dr. Bailey specializes in applying state-of-the-art assessment methods to environmental and occupational health issues. His 30 years of training and experience include laboratory and epidemiologic research, health risk assessment, and comprehensive exposure analysis. Dr. Bailey has investigated exposures to alternating current, direct current, and radiofrequency electromagnetic fields, 'stray voltage', and electrical shock, as well as to a variety of chemical agents and air pollutants. He is particularly well known for his research on potential health effects of electromagnetic fields and has served as an advisor to numerous state, federal, and international agencies. Currently, he is involved in research on exposures to marine life from submarine cables and respiratory exposures to ultrafine- and nanoparticles. Dr. Bailey is a visiting scientist at the Cornell University Medical College and has lectured at Rutgers University, the University of Texas (San Antonio), and the Harvard School of Public Health. He was formerly Head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research, Staten Island, New York, and an Assistant Professor and NIH postdoctoral fellow in Neurochemistry at The Rockefeller University in New York.

Academic Credentials and Professional Honors

Ph.D., Neuropsychology, City University of New York, 1975
M.B.A., University of Chicago, 1969
B.A., Dartmouth College, 1966

Sigma Xi; The Institute of Electrical and Electronics Engineers/International Committee on Electromagnetic Safety (Subcommitee 3, Safety Levels with Respect to Human Exposure to Fields (0 to –3 kHz) and Subcommitte 4, Safety Levels with Respect to Human Exposure to Radiofrequency Fields (3 kHz to 3 GHz); Elected member of the Committee on Man and Radiation (COMAR) of the IEEE Engineering in Medicine and Biology Society, 1998–2001

Publications

Bailey WH, Johnson GB, Bishop J, Hetrick T, Su S. Measurements of charged aerosols near ±500 kV DC transmission lines and in other environments. IEEE Transactions on Power Delivery, in press.

Kavet R, Bailey WH, Bracken TD, Patterson RM. Recent advances in research relevant to electric and magnetic field exposure guidelines. Bioelectromagnetics 2008; 29:499–526.

Bailey WH, Wagner M. IARC evaluation of ELF magnetic fields: Public understanding of the 0.4μT exposure metric. Journal of Exposure Science and Environmental Epidemiology 2008; 18:233–235.

Bailey WH, Erdreich L. Accounting for human variability and sensitivity in setting standards for electromagnetic fields. Health Physics 2007; 92:649–657.

Bailey WH, Nyenhuis JA. Thresholds for 60-Hz magnetic field stimulation of peripheral nerves in human subjects. Bioelectromagnetics 2005; 26:462–468.

Bracken TD, Senior RS, Bailey WH. DC electric fields from corona-generated space charge near AC transmission lines. IEEE Transactions on Power Delivery 2005; 20:1692–1702.

Bailey WH. Dealing with uncertainty in formulating occupational and public exposure limits. Health Physics 2002; 83:402–408.

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Kavet R, Stuchly MA, Bailey WH, Bracken TD. Evaluation of biological effects, dosimetric models, and exposure assessment related to ELF electric- and magnetic-field guidelines. Applied Occupational and Environmental Hygiene 2001; 16:1118–1138.

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Bailey WH, Erdreich LS. Human sensitivity and variability in response to electromagnetic fields: Implications for standard setting. International Workshop on EMF Dosimetry and Biophysical Aspects Relevant to Setting Exposure Guidelines. International Commission on Non-Ionizing Radiation Protection, Berlin, March 2006.

Bailey WH. Research-based approach to setting electric and magnetic field exposure guidelines (0-3000 Hz). IEEE Committee on Electromagnetic Safety, December 2005.

Bailey WH. Conference Keynote Presentation. Research supporting 50/60 Hz electric and magnetic field exposure guidelines. Canadian Radiation Protection Association, Annual Conference, Winnipeg, June 2005.

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Prior Experience

President, Bailey Research Associates, Inc., 1991–2000
Vice President, Environmental Research Information, Inc., 1987–1990
Head of Laboratory of Environmental Toxicology and Neuropharmacology, New York State Institute for Basic Research, 1983–1987
Assistant Professor, The Rockefeller University, 1976–1983

Academic Appointment

- Visiting Fellow, Department of Pharmacology, Cornell University Medical College, New York, NY, 1986–present

Prior Academic Appointments

- Visiting Scientist, The Jackson Laboratory, Bar Harbor, ME, 1984–1985
- Head, Laboratory of Neuropharmacology and Environmental Toxicology, NYS Institute for Basic Research in Developmental Disabilities, Staten Island, NY, 1983–1987
- Assistant Professor, The Rockefeller University, New York, NY, 1976–1983
- Postdoctoral Fellow, Neurochemistry, The Rockefeller University, New York, NY, 1974–1976
- Dissertation Research, The Rockefeller University, New York, NY, 1972–1974
- CUNY Research Fellow, Dept. of Psychology, Queens College, City University of New York, Flushing, NY, 1969–1971
- Clinical Research Assistant, Department of Psychiatry, University of Chicago; Psychiatric Psychosomatic Inst., Michael Reese Hospital, and Illinois State Psychiatric Inst, Chicago, IL, 1968–1969

Teaching Appointments

- Lecturer, University of Texas Health Science Center, Center for Environmental Radiation Toxicology, San Antonio, TX, 1998
- Lecturer, Harvard School of Public Health, Office of Continuing Education, Boston, MA, 1995, 1997
- Lecturer, Rutgers University, Office of Continuing Education, New Brunswick, NJ, 1991–1995
- Adjunct Assistant Professor, Queens College, CUNY, Flushing, NY, 1978
- Lecturer, Queens College, CUNY, Flushing, NY, 1969–1974

Editorship

- Associate Editor, Non-Ionizing Radiation, *Health Physics*, 1996–present

Advisory Positions

- US Bureau of Ocean Energy Management, Regulation and Enforcement, 2009–2010
- Canadian National Collaborating Centre for Environmental Health, reviewer of Centre reports, 2008
- Island Regulatory and Appeals Commission, province of Prince Edward Island, Canada, 2008
- ZonMw – Netherlands Organization for Health Research and Development, 2007-2008, reviewer for National Programme on EMF and Health

- National Institute of Environmental Health Sciences/ National Institutes of Health, Review Committee, Neurotoxicology, Superfund Hazardous Substances Basic Research and Training Program, 2004
- National Institute of Environmental Health Sciences, Review Committee Role of Air Pollutants in Cardiovascular Disease, 2004
- Working Group on Non-Ionizing Radiation, Static and Extremely Low-Frequency Electromagnetic Fields, International Agency for Research on Cancer, 2000–2002
- Working Group, EMF Risk Perception and Communication, World Health Organization, 1998–2005
- Member, International Committee on Electromagnetic Safety, Subcommittee 3 - Safety Levels with Respect to Human Exposure to Fields (0 to 3 kHz) and Subcommitee 4 - Safety Levels with Respect to Human Exposure (3kHz to 3GHz) Institute of Electrical and Electronics Engineers (IEEE), 1996–present
- Invited participant, National Institute of Environmental Health Sciences EMF Science Review Symposium: Clinical and In Vivo Laboratory Findings, 1998
- Working Group, EMF Risk Perception and Communication, International Commission on Non-Ionizing Radiation Protection, 1997
- U.S. Department of Energy, RAPID EMF Engineering Review, 1997
- Oak Ridge National Laboratory, 1996
- American Arbitration Association International Center for Dispute Resolution, 1995–1996
- U.S. Department of Energy, 1995
- National Institute for Occupational Safety and Health, 1994–1995
- Federal Rail Administration, 1993–1996
- U.S. Forest Service, 1993
- New York State Department of Environmental Conservation, 1993
- National Science Foundation
- National Institutes of Health, Special Study Section—Electromagnetics, 1991–1993
- Maryland Public Service Commission and Maryland Department of Natural Resources, Scientific Advisor on health issues pertaining to HVAC Transmission Lines, 1988–1989
- Scientific advisor on biological aspects of electromagnetic fields, Electric Power Research Institute, Palo Alto, CA, 1985–1989
- U.S. Public Health Service, NIMH: Psychopharmacology and Neuropsychology Review Committee, 1984
- Consultant on biochemical analysis, Colgan Institute of Nutritional Science, Carlsbad, CA, 1982–1983
- Behavioral Medicine Abstracts, Editor, animal behavior and physiology, 1981–1983
- Consultant on biological and behavioral effects of high-voltage DC transmission lines, Vermont Department of Public Service, Montpelier, VT, 1981–1982

- Scientific advisory committee on health and safety effects of a high-voltage DC transmission line, Minnesota Environmental Quality Board, St. Paul, MN, 1981–1982
- Consultant on biochemical diagnostics, Biokinetix Corp., Stamford, CT, 1978–1980

Professional Affiliations

- The Health Physics Society (Affiliate of the International Radiation Protection Society)
- Society for Risk Analysis
- International Society of Exposure Analysis
- New York Academy of Sciences
- American Association for the Advancement of Science
- Air and Waste Management Association
- Society for Neuroscience/International Brain Research Organization
- Bioelectromagnetics Society
- The Institute of Electrical and Electronics Engineers/Engineering in Medicine and Biology Society
- Conseil International des Grands Reseaux Electriques

REPORT PREPARED BY
JAMES P. KORNBERG, M.D., Sc.D.

for submission by NV Energy, Inc.
to the
Public Utilities Commission of Nevada

in connection with the December 6, 2011 Workshop
in Docket No. 11-10007

December 2, 2011

I have prepared this report for submission by NV Energy, Inc. to the Public Utilities Commission of Nevada ("PUCN") in connection with the December 6, 2011 workshop in Docket No. 11-10007. In particular, the report is responsive to topic 6 in the Procedural Order issued on November 2, 2011 in that proceeding, which seeks the provision of "Documentation regarding the health risks and/or safety of Smart Meters."

Since there are several scientific issues that are germane to topic 6 and to citizens' comments, I have identified three issues that are be addressed. The first two, related to alleged claims of hypersensitivity to electromagnetic fields (sometimes abbreviated as EMF), are related to the third issue, namely, indicating whether the RF fields from components of the NV Energy AMI Network pose human health risks.

My CV and qualifications to address the subject matter of this report are attached as Appendix 1 hereto.

Issue I. The Matter of Claimed Hypersensitivity to RF fields Such As Are Produced in the NV Energy AMI Network.

An evaluation of the weight of scientific evidence regarding the clinical and diagnostic existence of "Electromagnetic Hypersensitivity (EHS)[1]" or, more recently named, "Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF)"[2] will address this issue.

Issue II. The Matter of the Need for "Reasonable Accommodations" under the Americans with Disabilities Act (ADA) for Individuals Who Claim to Be Hypersensitive to RF Fields.

Given the conclusions relating to Issue I, it will become apparent whether there exists a need to provide any "reasonable accommodation," for individuals supposedly suffering from "EHS/IEI-EMF."

Issue III. The Overall Matter of the Scientific Research on RF Fields Related to Deployment of the NV Energy AMI Network from a Human Health Perspective.

Given the conclusions articulated in the completion of I and II, the overall assignment is then to report to the PUCN whether scientific research suggests that radiofrequency fields of the NV Energy AMI would cause and/or aggravate symptoms and/or disease in members of the population.

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[1] Rubin, G. James, "Electromagnetic Hypersensitivity: A Systematic Review of Provocation Studies," Psychosomatic Medicine, 67: 2005, p. 224.

[2] Rubin, G. James, "Idiopathic Environmental Intolerance Attributed to Electromagnetic Fields (Formerly 'Electromagnetic Hypersensitivity'): An Updated Systematic Review of Provocation Studies," Bioelectromagnetics, 31 (1); 2010, p.1

Issue I. The Matter of Claimed Hypersensitivity to RF Fields Such as Those Produced in the NV Energy AMI Network.

Based on the comments reviewed, there appears to be a very small subset of the NV Energy customer base who may be suffering from one or more disorders related to the perception of hypersensitivity to RF fields from a variety of RF sources.

These individuals sometimes claim that they have "Electromagnetic Hypersensitivity (EHS)" or, more recently, what is known as "Idiopathic Environmental Intolerance attributed to Electromagnetic Fields" or "IEI-EMF."

These individuals claim to experience a wide variety of complaints or symptoms[3] when in the presence of RF fields. Sometimes the symptoms are mild and at other times severe, allegedly leading to incapacitation. They include, for example[4], problems ranging from headaches, insomnia, tinnitus (ringing in the ears) and stress to increased blood pressure, heart palpitations, balance problems and allergies.

World Health Organization ("WHO")

In an attempt to provide guidance to the medical community, the World Health Organization convened a working group to address the issue of EHS.

The 2004 World Health Organization (WHO) Working Group Meeting Report[5] (WGMR) indicated:

> The patient's medical history needs to be carefully taken to assess the plausibility of symptoms in relation to EMF exposures (dose-response) and possible alternative diagnoses. Physical examination should be carefully done to assess signs (e.g. skin changes) or alternative diagnoses.[6]

This WGMR discussed the ramifications of using of the term "Electrical Hypersensitivity." The report noted:

> There are individuals that report a wide range of symptoms that they attribute to electromagnetic fields or being close to electrical equipment.[7] To date experimental and epidemiological studies have failed to provide

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[3] "Complaints or symptoms" in this context are broad in scope and enormously varied.

[4] The symptoms and problems listed are for illustration and are not a complete list of all problems reported by all persons who responded to 11-10007. Additional problems that were considered included but were not limited to: nausea, vomiting, skin prickling, muscle spasms, problems concentrating, emotional irritation, body temperature changes, migraine headaches, pain, fever, and aggravation of pre-existing medical problems.

[5] WHO Workshop on Electrical Hypersensitivity, Prague, Czech Republic, October 25-27, 2004, p. l-8

[6] WHO Workshop on Electrical Hypersensitivity, Prague, Czech Republic, October 25-27, 2004, p.3

[7] Footnote 1 from the Working Group Report: "The term "electrical equipment" in this report includes any equipment which emits electric, magnetic or electromagnetic fields 0-300 GHz [a range that includes frequencies associated with Smart Meters and Smart Meter Extender Bridges], e.g. power lines, electric motors, hair dryers, mobile phones and base stations. EMF is used as an abbreviation for these fields."

> clear support for a causal relationship between electromagnetic fields and complaints. The reported symptoms are generally non-specific and no consistent set of symptoms has been identified.[8]

Given its findings, the WGMR recommended that the terms "electromagnetic hypersensitivity, electro-sensitivity, and hypersensitivity to electricity" be replaced by the term "Idiopathic Environmental Intolerance (Electromagnetic field attributable symptoms) " or IEI-EMF. The Group clearly indicated that it was not proposing that any scientifically valid cause and effect relationship existed between the development of IEI-EMF and exposure to any electromagnetic energy at any frequency or at any power density.

In a December 2005 fact sheet, WHO indicated[9]:

> EHS is characterized by a variety of non-specific symptoms, which afflicted individuals attribute to exposure to EMF. The symptoms most commonly experienced include dermatological symptoms (redness, tingling, and burning sensations) as well as neurasthenic and vegetative symptoms (fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitation, and digestive disturbances). The collection of symptoms is not part of any recognized syndrome.
>
> EHS resembles multiple chemical sensitivities (MCS), another disorder associated with low-level environmental exposures to chemicals. Both EHS and MCS are characterized by a range of non-specific symptoms that lack apparent toxicological or physiological basis or independent verification. A more general term for sensitivity to environmental factors is Idiopathic Environmental Intolerance (IEI), which originated from a workshop convened by the International Program on Chemical Safety (IPCS) of the WHO in 1996 in Berlin. IEI is a descriptor without any implication of chemical etiology, immunological sensitivity or EMF susceptibility. IEI incorporates a number of disorders sharing similar non-specific medically unexplained symptoms that adversely affect people. However since the term EHS is in common usage it will continue to be used here.
>
> A number of studies have been conducted where EHS individuals were exposed to EMF similar to those that they attributed to the cause of their symptoms. The aim was to elicit symptoms under controlled laboratory conditions.
>
> The majority of studies indicate that EHS individuals cannot detect EMF exposure any more accurately than non-EHS individuals. Well controlled

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[8] WHO Workshop on Electrical Hypersensitivity, Prague, Czech Republic, October 25-27, 2004, p.1
[9] WHO Fact Sheet No. 296, December 2005.

> and conducted double-blind studies have shown that symptoms were not correlated with EMF exposure.
>
> It has been suggested that symptoms experienced by some EHS individuals might arise from environmental factors unrelated to EMF. Examples may include "flicker" from fluorescent lights, glare and other visual problems with VDUs, and poor ergonomic design of computer workstations. Other factors that may play a role include poor indoor air quality or stress in the workplace or living environment.
>
> There are also some indications that these symptoms may be due to pre-existing psychiatric conditions as well as stress reactions as a result of worrying about EMF health effects, rather than the EMF exposure itself.

As recently as 2010, WHO reported[10]:

> There have been several recent high-quality provocation studies of people reporting health symptoms that they attribute to RF EMF exposure. The results of these studies do not show any relation between the symptoms that these individuals experience and RF EMF exposure.

<u>Scientific Committee on Emerging and Newly Identified Health Risks ("SCENHIR")</u>

In 2009 the European Commission's Scientific Committee on Emerging and Newly Identified Health Risks (SCENHIR)[11] concluded:

> Regarding non-carcinogenic outcomes, several studies were performed on subjects reporting subjective symptoms. In the previous opinion, it was concluded that scientific studies had failed to provide support for a relationship between RF exposure and self reported symptoms. Although an association between RF exposure and single symptoms was indicated in some new studies, taken together, there is a lack of consistency in the findings.
>
> Therefore, the conclusion that scientific studies have failed to provide support for an effect of RF fields on self-reported symptoms still holds. Scientific studies have indicated that a nocebo effect (an adverse non-specific effect that is caused by expectation or belief that something is harmful) may play a role in symptom formation.
>
> As in the previous opinion, there is no evidence supporting that individuals, including those attributing symptoms to RF exposure, are able

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[10] WHO Research Agenda for Radiofrequency Fields, ISBN 978 92 4 159994 8, 2010, page 15. [n.b. in footnote "Sensitivity to EMF has been generally termed electromagnetic hypersensitivity (EHS). A more general term for sensitivity to environmental factors is idiopathic environmental intolerance (IEI) (WHO, 2005), i.e. environmental intolerance of unknown cause."]

[11] SCENHIR, "Health Effects of Exposure to EMF," Brussels, 2009, p 8-9

> to detect RF fields. There is some evidence that RF fields can influence EEG patterns and sleep in humans. However, the health relevance is uncertain and mechanistic explanation is lacking. Further investigation of these effects is needed. Other studies on functions/aspects of the nervous system, such as cognitive functions, sensory functions, structural stability, and cellular responses show no or no consistent effects.

In 2010, Rubin indicated (p. 7)[12]:

> In our original review of 31 provocation studies for IEI-EMF, we reported being unable to find any robust evidence to support the existence of (electromagnetic hypersensitivity) as a biologic entity [Rubin et. al. 2005][13]. Five years and 15 experiments later, this update has failed to uncover any evidence which challenges that conclusion."

Rubin went on to state (p. 9):

> To date, 46 studies involving 1175 volunteers with IEI-EMF have tested whether exposure to electromagnetic fields can trigger the symptoms reported by this group.
>
> These studies have produced little evidence to suggest that this is the case or that individuals with IEI-EMF are particularly adept at detecting the presence of electromagnetic fields. On the other hand, many of these studies have found evidence that the nocebo effect is a sufficient explanation for the acute symptoms reported in IEI-EMF. Thus while continued experimental research in this area will be required to clarify the role of chronic exposures and to test the effects of new varieties of electromagnetic emissions, the best evidence currently available suggests that IEI-EMF should not be viewed as a bioelectromagnetic phenomenon. Despite this, some commentators continue to discuss the condition without sufficient reference to this literature [Carpenter and Sage[14] (2007) Goldacre[15] (2007)]. This is regrettable and suggests that the scientific community should do more to communicate the current state of the art in this area.

Rubin stated further (p. 7):

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[12] Rubin, G. James, "Idiopathic Environmental Intolerance Attributed to Electromagnetic Fields (Formerly 'Electromagnetic Hypersensitivity'): An Updated Systematic Review of Provocation Studies," Bioelectromagnetics, 31 (1); 2010, p.1-11

[13] Rubin, G. James, "Electromagnetic Hypersensitivity: A Systematic Review of Provocation Studies," Psychosomatic Medicine, 67: 2005, p. 224-231

[14] Carpenter, D. Sage, C. "Bioinitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF), 2007. Available from <www.bioinitiative.org>

[15] Goldacre, B., "Why don't journalists mention the data," British Journal of Medicine, 334:1249, 2007

> While this update has provided no support for the theory that bioelectromagnetic mechanisms are responsible for IEI-EMF, additional support was found for the theory that psychological factors have an important role in triggering, maintaining or exacerbating IEI-EMF symptoms [Rubin et al.[16] (2007)]."

With respect to [Carpenter and Sage (2007)], the "BioInitiative Report," Rubin indicated (p. 7):

> Subsection seven of section nine in this report dealt with "human subjective effects" of exposure to mobile phone signals and stated that "none of these effects has been studied under controlled laboratory conditions. Thus, whether they are causally related to (mobile phone) exposure is unknown." Given that seven relevant studies were reported in our original review [Rubin et al.[17] (2005)], 12 further studies were identified in this update (Tables 1, 2 and 4) and at least six additional provocation studies involving only healthy volunteers have also been reported [Roosli[18], (2008)], we are unable to explain how this conclusion was reached.

In 2011, Rubin reported[19]:

> At present, there is no reliable evidence to suggest that people with IEI-EMF experience unusual physiological reactions as a result of exposure to EMF. This supports suggestions that EMF is not the main cause of their ill health.

Given the above references, it is clear that the purported symptoms of EHS or IEI-EMF are ill-defined and have been difficult to interpret within a human clinical context.

The above references also underscore the corollary finding that there is no diagnostic medical recognition for the entity known as "EHS" or "IEI-EMF":

The purported problems listed by the individual claiming EHS/IEI-EMF can not be logically interpreted within the diagnostic framework of disease classification associated with the practice of modern medicine.

The typical conditions described by the individual claiming EHS/IEI-EMF usually are not only presented in an inconsistent and enigmatic manner but are also ineligible for

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[16] Rubin, G. J., et. al., "Psychological factors associated with self-reported sensitivity to mobile phones," J. Psychosom Res, 64: 1-9, 2007.

[17] Rubin, G. James, "Electromagnetic Hypersensitivity: A Systematic Review of Provocation Studies," Psychosomatic Medicine, 67: 2005, p. 224-231

[18] Roosli, M., "Radiofrequency electromagnetic field exposure and non-specific symptoms of ill health: A systematic review, Environ Res 107: 277-287, 2008

[19] Rubin, G. James, "Do People with Idiopathic Environmental Intolerance Attributed to Electromagnetic Fields Display Physiological Effects When Exposed to Electromagnetic Fields? A Systematic Review of Provocation Studies," Bioelectromagnetics, 32 (8), 2011, p. 593-609.

formal diagnostic disease classification in any supposed disease category related to "RF fields exposure."

In this regard, the WGMR indicated:

> Note that IEI is **not** to be used as a diagnostic classification[20] [emphasis added]. "

Instead WGMR recommends that in absence of any identifiable disease, diagnosis should be based upon the most pronounced symptoms, again, without suggesting any valid cause and effect relationship between such symptoms and exposure to EMF.

To underscore its position, the WGMR noted:

> Provocation studies with double blind exposure sessions[21] have failed to verify a causal relationship between electric, magnetic or electromagnetic fields and complaints.[22]

With respect to the possible need for epidemiological studies, the WGMR indicated: "For the time being, epidemiological studies are not considered helpful.[23]" One reason given for this recommendation was "the definition of 'cases' is still lacking.[24]

In 2005, WHO indicated[25]:

> EHS has no clear diagnostic criteria and there is no scientific basis to link EHS symptoms to EMF exposure. Further, EHS is not a medical diagnosis, nor is it clear that it represents a single medical problem.

Diagnosis/ICD issues

All recognized and defined diseases, medical conditions, symptom disorders, and causes of injury, death and disability can be assigned in what is known as an ICD (International Classification of Diseases) code as defined by the World Health Organization[26] (WHO) and as applied to record keeping in the United States by the National Center for Health Statistics (NCHS) within the Centers for Disease Control and Prevention (CDC).

The current version ICD-10 (10th revision to be implemented 10/13/13)[27], like the earlier versions, is copyrighted by WHO and is designed to apply to mortality (death) statistics.

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[20] WHO Workshop on Electrical Hypersensitivity, Prague, Czech Republic, October 25-27, 2004, p.2
[21] "Double blind exposure sessions" are those in which neither the patient nor the examiner knows whether there will be a real forthcoming exposure to EMF. The double blind study is considered the gold standard on determining whether an association exists between an exposure and any reported or measured medical condition.
[22] WHO Workshop on Electrical Hypersensitivity, Prague, Czech Republic, October 25-27, 2004, p.4
[23] WHO Workshop on Electrical Hypersensitivity, Prague, Czech Republic, October 25-27, 2004, p.7
[24] WHO Workshop on Electrical Hypersensitivity, Prague, Czech Republic, October 25-27, 2004, p.7
[25] WHO Fact Sheet No. 296, December 2005, page 2.
[26] www.who.int/classifications/icd/en: www.cdc.gov/nchs/icd/icd10cm.htm
[27] www.cdc.gov/nchs/icd/icd10cm.htm#10update

In cooperation with WHO, NCHS has developed a clinical modification designed to apply to morbidity (disease or illness) statistics, ICD-10-CM.

Currently the U.S. Department of Health and Human Services (HHS) has mandated the use of ICD-9-CM in US clinical practice until 10/13/13. Taken together these two classifications (ICD and ICD-CM) represent all recognizable, reportable, and accepted diagnoses of human symptom constellations, diseases and death. These classification systems have been developed following a thorough evaluation by a formal technical advisory panel from the WHO and with extensive additional consultation from qualified physician groups.

There are no ICD-9, ICD-9-CM. ICD-10 or ICD-10-CM disease codes (diagnoses) for any of the purported medical conditions described by some of the commenters in Docket No. 11-10007. These problems, as described, are not amenable to formal diagnostic disease classification (diagnoses) and, therefore, are not medically actionable within a rational clinical framework, in accordance with reasonable standards of medical care.

Simply stated, any qualified medical practitioner confronted with a patient labeled with a diagnosis of "EHS" or "IEI-EMF" or even "electro-sensitivity," would be hard pressed, not only to figure out what this label means, but would also have even greater problems trying to decide what to offer the patient to improve his or her situation.

Conclusion:

A survey of the scientific literature on the subject of "EHS" or "IEI-EMF" leads to the conclusion that there is no proven human hypersensitivity to EMF categorically and, in particular, at the power densities and frequencies associated with the NV Energy AMI Network.

Persons claiming to suffer from "EHS" or "IEI-EMF" deserve comprehensive medical evaluation by their personal medical providers, with emphasis upon alternative explanations for their symptoms and other complaints.

Issue II. ***The Matter of Claimed Need for "Reasonable Accommodations" under the Americans with Disabilities Act (ADA) for Individuals who Claim to be Hypersensitive***

In my clinical experience in the first decade after the passing of Americans with Disabilities Act (ADA) in 1990, I had the opportunity and the responsibility of writing many "prescriptions for reasonable accommodations (RxRAs)," usually within the context of reconciling the needs of both employer and worker in their mutual quest to define the circumstances under which worker satisfaction and productivity were optimized.

Before I could write any RxRA, I first had to understand the worker's diagnosis, prognosis, limitations, and desires. This information had to be coupled with an

understanding of the employment job description and the physical details of the workplace, along with any ergonomic variables that may impair or facilitate job performance. This database then had to be analyzed and evaluated with the ambition of formulating an accommodation solution was both reasonable and realistic for both worker and employer.

The information provided in the performance of addressing Issue I leads to the overall conclusion that the purported disease entity EHS/IEI-EMF represents a rather nebulous, poorly described constellation of medical complaints that are inconsistent in time and from person to person, under a wide array of both real and not-real exposure circumstances.

The enigmatic and unscientific nature of EHS/IEI-EMF defies diagnostic classification. It is my medical opinion that this flaw disqualifies this entity from consideration in any rational process of proffering a RxRA or formulating a reasonable accommodation solution for anyone claiming this condition.

The preceding opinion is supported by the following information:

In 2004, the WHO provided advice to governments in relationship to the matter of managing the issue of patients claiming to suffer from IEI-EMF.[28]

> Patients have real symptoms, some of which are attributed to EMF, but there is no scientific evidence of causal link, therefore no grounds to use IEI as a diagnostic classification for handicap status. But symptoms could be used as a classification.

Within the framework of this workshop, prior to making the above statement, the WHO had already confirmed the lack of a proven causal relationship between exposure to RF electromagnetic fields and the development of IEI, or namely, "[regarding IEI, there is] no attribution of causality to EMF."

There is an important corollary to the matter of the ineligibility of EHS/IEI-EMF for consideration for reasonable accommodations under the ADA. This corollary relates to the risks that would be associated with accepting the pseudo-scientific reality of this condition and then the adoption of the "Precautionary Principle" or the "Prudent Avoidance Principle," as part of a proposed ADA generated RxRA.

Wiedemann and Schutz[29] studied the implementation of the "Precautionary Principle" in the context of cell phone usage. The authors indicate:

> Possible adverse health effects due to electromagnetic fields (EMFs) from cellular phones and base stations present a major public health issue across

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[28] WHO Workshop on Electrical Hypersensitivity, Prague, Czech Republic, October 25-27, 2004, p. 8

[29] Wiedemann, Peter M. and Schutz, Holger, "The Precautionary Principle and Risk Perception: Experimental Studies in the EMF Area," Environmental Health Perspectives, Volume 113, Number 4, April 2005, p 402-405.

> Europe. Because scientists cannot exclude that EMFs may cause health problems, the application of the precautionary principle is debated heavily.
>
> By considering precautionary measures, political decision makers hope to cope with public fears about EMFs. We present results from two experimental studies [performed by the authors] that indicate that precautionary measures may trigger concerns, amplify EMF-related risk perceptions, and lower trust in public health protection.

Specifically, they note:

> Essentially, the precautionary principle recommends that action should be taken to prevent serious potential harm, regardless of scientific uncertainty as to the likelihood, magnitude, or cause of that harm.
>
> By considering precautionary measures, political decision makers hope to cope with these public fears about EMFs. Various courses of action are taken into consideration, including health related measures such as exposure minimization strategies or stricter exposure limits, process-related measures such as better risk communication and enhancing public participation in [cell phone] base station siting decisions, and research-related measures.

Finally, the authors warn and advise:

> Precautionary measures implemented with the intention of reassuring the public about EMF risk potentials seem to produce the opposite effect. They may amplify EMF-related risk perceptions and trigger concerns. Referring to the WHO definition of health [“a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO 1948)[30]], it seems that precautionary measures themselves can be precarious because they might impair well-being.
>
> The results of the two experiments support the warnings in the WHO background document (WHO 2000)[31] on cautionary policies "that such policies be adopted only under the condition that scientific assessments of risk and science-based exposure limits should not be undermined by the adoption of arbitrary cautionary approaches."
>
> We tend to add that any precautionary policy should consider possible countervailing risks such as increasing fear and unnecessarily spreading

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[30] WHO. 1948. WHO Definition of Health. Preamble to the Constitution of the World Health Organization as Adopted by the International Health Conference, New York, 19–22 June, 1946; signed on 22 July 1946 by the Representatives of 61 States and Entered into Force on 7 April 1948. Geneva: World Health Organization.

[31] WHO. 2000. Electromagnetic Fields and Public Health: Cautionary Policies. Geneva: World Health Organization.

anxieties. These adverse impacts of precaution should be brought to the attention of policy makers.

Given the results and conclusions of the Weidemann study, it is clear that the adoption of the "Precautionary Principle" as an excuse for invoking the need for Smart Meter accommodation under the ADA or, for that matter, in response to any other public directive, could very well have the opposite effect of increasing concerns. Such an adoption will probably not accommodate the condition of EHS/IEI-EMF but instead lead to other nebulous, inconsistent medical complaints.

Conclusion:

From a medical point of view, it is clinically unrealistic to fashion one or more accommodations that would appropriately address symptoms characterized by commenters as EHS/IEI-EMF.

Comments:

Given the above discussion and that presented earlier, one should be reminded that some of commenter's purported disorders are offered as the medical driving factors behind their requests for a series of very significant actions by NV Energy and the PUCN.

Commenters are offering not disease-based but symptom-based problems to promote their requests for actions when the latter symptom-based problems have been specifically disqualified by WHO recommendations as being related to EMF (hence, RF) exposure in a probable cause and effect manner.

Commenters are requesting NV Energy and PUCN flexibility, not only by insisting upon an "opt-out" option for afflicted persons; but also by the establishment of "safe-zones" free of overexposure to RF for those "sensitive" persons who have opted out of the program. Commenters and their "scientific" supporters have not and can not specify the level of RF exposure below which the purportedly afflicted person will be safe.

In fact, within my understanding of the clinical paradigm that often drives claims of "electro-sensitivity," there is a "no-threshold" effect, in which the most sensitive persons afflicted will respond adversely at any level, including those associated with "background" alone. Under these conditions, it can be argued that NV Energy compliance will be impossible unless the entire NV Energy AMI Network program were abandoned in order to eliminate man-made RF exposure altogether.

A medical practitioner or other qualified person who was to evaluate the commenters' complaints would need to operate within the accepted medical standards of care and a rational diagnostic framework. The evaluator would need to prepare a differential diagnosis for the commenter that would etiologically consider both other exposure sources and other medical conditions. Such practitioner would need to consider the

diagnostically confounding influence of RF exposure from sources other than the NV Energy AMI Network.

Any such analysis would identify a panoply of RF sources that permeate commenters' residences at comparable "unacceptable and/or unhealthy" levels. The identification of multiple "harmful" sources of RF to those who are "hypersensitive," should also lead to the theoretical medical recommendation that, in addition to the elimination of RF from the NV Energy AMI Network, all other sources of RF in the home, office and community should be eliminated in perpetuity to prevent RF-induced morbidity. Unfortunately, the afflicted individual would have to be restricted from travel virtually anywhere within modern society.

Issue III. The Overall Matter of the Deployment of the NV Energy AMI Network from a Human Health Perspective

Issue III has been addressed comprehensively by the reply to comments by Exponent and the joint testimony of Dr. Bailey and Dr. Yakov Shkolnikov.

From Dr. Bailey's report, I wish to emphasize the following:

In 1998, the International Committee on Non-Ionizing Radiation Protection (ICNIRP) [32] published a comprehensive statements and guidelines regarding the health and safety of exposure to EMF fields.

The main objective of the ICNIRP publication was:

> .. to establish guidelines for limiting EMF exposure that will provide protection against known adverse health effects."

ICNIRP noted:

> An adverse health effect causes detectable impairment of the health of the exposed individual or of his or her offspring; a biological effect, on the other hand, may or may not result in an adverse health effect.

ICNIRP emphasized:

> Studies on both direct and indirect effects of EMF are described; direct effects result from direct interaction of fields with the body, indirect effects involve interactions with an object at a different electric potential from the body. Results of laboratory and epidemiological studies, basic exposure criteria, and reference levels for practical hazard assessment are

[32] ICNIRP Guidelines, Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields, Health Physics, Volume 74, Number 4, April 1998, p 494-522

> discussed, and the guidelines presented apply to occupational and public exposure.

In 2009, ICNIRP[33] published the results of a massive update of its 2003 review of the biological effects of electromagnetic fields.

The editors indicated:

> This document addresses the current scientific evidence concerning exposure to high frequency electromagnetic fields (EMF) and the resulting consequences for health. The following review was conducted by the ICNIRP Standing Committees in cooperation with its Consulting Members. It covers all scientific aspects relevant in this area which include numerical dosimetry, measurements, biological laboratory investigations in vitro and in vivo, as well as epidemiological findings.
>
> This review was motivated by the needs of the World Health Organization's International EMF Project and ICNIRP's own agenda of reviewing its guidance and advice on the health hazards of EMF exposure. Since the 1998 publication of the ICNIRP guidelines on limiting exposure to electromagnetic fields, there have been important studies published, that need detailed analysis and discussion to determine their implications for health.
>
> This review only addresses high frequency EMFs from 100 kHz to 300 GHz. It aims at providing input to the respective health risk assessment currently undertaken by the World Health Organization (WHO). A similar review of the scientific evidence in the static and low frequency fields was published by ICNIRP in 2003. Both reviews will form the basis for a thorough reevaluation of ICNIRP's science-based guidance on limiting exposure to electromagnetic fields.

In 2009, ICNIRP[34] published a summary statement related to its 2009 update on EMF exposure:

> For frequencies above 100 kHz, including frequencies used for modern wireless communications, several major national and international research programs have been completed recently... [British and German] and others are ongoing. The new data need to be reviewed and assessed

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[33] Vecchia, Paulo, et. al. ed "Exposure to high frequency electromagnetic fields, biological effects and health consequences (100 kHz-300 GHz); Review of the scientific evidence on dosimetry, biological effects, epidemiological observations, and health consequences concerning exposure to high frequency electromagnetic fields (100 kHz to 300 GHz)," ICNIRP 16/2009, ISBN 978-3-934994-10-2, 2009.

[34] ICNIRP STATEMENT ON THE "GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC, ANDELECTROMAGNETIC FIELDS (UP TO 300 GHz)," Health Physics, Volume 97, Number 3, September 2009, p 257-58

> with respect to possible health hazards prior to a revision of ICNIRP's recommendations in this frequency band. This process of review and assessment is currently in progress. However, it is the opinion of ICNIRP that the scientific literature published since the 1998 guidelines has provided no evidence of any adverse effects below the basic restrictions and does not necessitate an immediate revision of its guidance on limiting exposure to high frequency electromagnetic fields.
>
> With regard to non-thermal interactions, it is in principle impossible to disprove their possible existence but the plausibility of the various non-thermal mechanisms that have been proposed is very low. In addition, the recent in vitro and animal genotoxicity and carcinogenicity studies are rather consistent overall and indicate that such effects are unlikely at low levels of exposure. **Therefore, ICNIRP reconfirms the 1998 basic restrictions in the frequency range 100 kHz–300 GHz until further notice [emphasis added]."**

With respect to recent advances in the investigation of dose, ICNIRP indicated (in relationship to exposure in children) that:

> ...from 1 to 4 GHz for bodies shorter than 1.3 m in height (corresponding approximately to children aged 8 y or younger) at the recommended reference level the induced SARs could be up to 40% higher than the current basic restriction under worst-case conditions. However, this is negligible compared with the large reduction factor of 50 (5,000%) for the general public.

Finally ICNIRP indicated:

> Epidemiological data on possible health effects of chronic, low-level, whole-body exposure in the far-field of radiofrequency (RF) transmitters are poor, especially because of lack of satisfactory individual exposure assessment. The few studies with adequate exposure assessment did not reveal any health-related effects. Exposure levels due to cell phone base stations are generally around one-ten-thousandth of the guideline levels.

Conclusion:

In conjunction with the comprehensive evaluation of this subject submitted by Exponent and the testimony of Drs. Shkolnikov and Bailey, the above commentary and analysis support the conclusion that RF fields from the NV Energy AMI Network do not pose any significant human health risks.

LIMITATIONS

The above stated comments and opinions are provided within a reasonable degree of occupational and environmental medical and environmental health sciences and engineering certainty.

This report has been expressed and formulated within the scope of my professional training and expertise and the data researched, generated or provided up until the present time.

Any or all of this report, including comments and opinions is subject to modification and/or withdrawal upon the receipt of new, substantive information.

APPENDIX 1

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CURRICULUM VITAE

June, 2011

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EDUCATION

B.S. **Massachusetts Institute of Technology**, 1969 (awarded as part of double degree honors program in 1970) - Aeronautical and Astronautical Engineering. Senior Space Systems Engineering thesis title: ***"An Analysis of the Maintenance and Logistic Supply for a 24-Man Lunar Industrial Laboratory,"*** - awarded the James Means Memorial Prize, M.I.T., Department of Aeronautics and Astronautics, January 20, 1969.

M.S **Massachusetts Institute of Technology**, 1970 – Aeronautical and Astronautical Engineering. NASA Research Fellowship. Thesis title: ***"The Alleviation of Aerodynamically Generated Noise from Supersonic Jet Exhausts."***

Sc.D. **Harvard University**, 1974 – Environmental Health Science and Engineering. General Electric Research Fellowship. Thesis title: ***"High Temperature Filtration of Submicron Aerosols by Diffusion."***

M.D. **Dartmouth Medical School**, 1976.

Activities

- **11-16-10 -** Expert Witness - State of Maine Utilities Commission, Docket No 2010-345, Elisa Boxer-Cook, et al, "Request for Commission Investigation into Pursuing Smart Meter Initiative," Central Maine Power, Iberdrola USA.

- **1/13-1/14/10 – Invited Guest Observer and Participant, Orange Flame 4**, Israeli military and hospital biological warfare exercise, in both the outpatient and in-hospital setting, featuring clinical care and epidemiological assessment of casualties, exposed to smallpox and viral hemorrhagic fever, Tel Hashomer Medical Center and Magen David Adom (Israel Red Cross) Main Control Center, Tel Aviv, Israel.

- **12/07 – Present Columnist** , ***"Frontier Doc,"*** True West Magazine (Preservation of the American West), Cave Creek (Phoenix), Arizona.

- **11/78 - Present** ***President and Medical Director***, COHBI Physicians, P.C., (Comprehensive Occupational Health for Business and Industry) 466 Sky Trail Road, Boulder, Colorado 80302 and P.O. Box 1210, 12665 Highway 62, Ridgway, Colorado 81432-1210

- ***Consulting and Clinical Medical Director or Advisor*** to a broad spectrum of business, industrial, governmental, legal and insurance clients worldwide. (list available upon request).

- **10/92-10/01** ***Level II Accreditation-Colorado Department of Labor and Employment*** - (re-certified). Level II accreditation permits the state sanctioned performance of impairment ratings in all body systems under AMA Guidelines.

- **12/11-12/13/97** ***5th Annual National Academy of Forensic Examiners Conference***, San Diego, California.

- **9/4-9/7/96** ***3rd Annual Aspen Environmental Medicine Conference***, The Givens Institute, Aspen, Colorado.

- **10/23/95** ***University of Colorado School of Medicine – Medical Treatment Guidelines CME,*** Denver, Colorado.

- **11/19/94** ***COPIC Workshop – "Difficult" Physician Patient Relationships"***

- **10/91** ***Certification of Medical Training in Aviation Medicine*** – Civil Aeromedical Institute, Federal Aviation Administration, continuing medical training in Aviation Medicine, Spokane, Washington (recertified).

- **11/86** ***Certification of Medical Training in Aviation Medicine –*** Civil Aeromedical Institute, Federal Aviation Administration, continuing medical training in Aviation Medicine, Denver, Colorado (recertified).

- **1/82** ***Appointment – Class I Aviation Medical Examiner*** – Federal Aviation Administration, Spokane, Washington.

- **7/81** ***Certification of Medical Training in Aviation Medicine –*** Civil Aeromedical Institute, Federal Aviation Administration, Spokane, Washington.

- **7/77-11/78** ***Senior Staff Consultant -*** Occupational Medicine and Environmental Health, Arthur D. Little, Inc., Acorn Park, Cambridge, Massachusetts 02140

- **11/78** ***Advanced Life Support Certification -*** University of Massachusetts Medical School, American Heart Association.

- **6/78** ***Advanced CME Training in Emergency Medicine -*** American Medical Association Conference, St. Louis, Missouri.

- **6/78** ***Harvard University School of Public Health - Residency in Occupational Medicine, Boston, Massachusetts*** - completion of advanced coursework and clinical training.

- **6/76-6/77** ***Columbia University College of Physicians and Surgeons - Flexible Internship***: Internal Medicine, Ambulatory Care, Intensive Care, Emergency Department – Mary Imogene Bassett Hospital, Cooperstown, New York.

  Columbia University College of Physicians and Surgeons - Visiting Clinical Fellow and Resident in Psychiatry – emphasis – Medical model and psychopharmacology, Mary Imogene Bassett Hospital, Cooperstown, New York.

- **'72-'77** ***Consulting Engineer –*** Environmental Engineering, Air Pollution Control and Environmental Toxicology.

- **'71-'72** ***Harvard University, School of Public Health, Boston, Massachusetts – Faculty Teaching Fellow:***

  Fall course – Environmental Health Sciences – Taught the section on the biological and meteorological effects of air pollution and environmental control engineering to Harvard and Radcliff undergraduate and graduate students.

  Spring course – Taught APEX gaming simulation course to MDs and Environmental Health Science graduate students. The course was directed, by computer simulation and role

playing, at examining the overall effects of air pollution control strategies and land use planning upon the urban community, as a whole.

- **6/70 – 9/70** ***Massachusetts Institute of Technology – Consulting Engineer, Department of Metallurgy and Humanities (Archeology)*** – Performed research on the composition and structural characteristics of Neolithic plasters found in the Middle East (e.g. pre-pottery level Jericho, circa 8000 BCE).

- **7/69** ***NASA invitee to witness launching of Apollo 11***

- **6/69-9/69** ***Computer Sciences Corporation, Marshall Spaceflight Center, Huntsville, Alabama – Consulting Engineer*** – Spaceborne Computer Project – NASA Earth Orbital Shuttle Program

- **5/69** ***Massachusetts Institute of Technology – James Means Prize recipient and student representative, invited to witness launch of Apollo 10.***

- **6/68-9/68** ***McDonnell-Douglas Corporation, St. Louis, Missouri – United States Air Force Gemini B Project– Consulting Engineer*** –Aerodynamics Group – Utilized computer simulation to model launch failure trajectories.

LICENSURE and CERTIFICATION

- Diplomat – National Board of Medical Examiners #177128

- Massachusetts Medical License #41325 (Inactive)

- Colorado Medical License #22648

- American Board of Preventive Medicine - Board Certified - Occupational Medicine December 1980; Certificate #21547

- American Academy of Occupational Medicine, Master; elected November 18, 1980

- Senior Aviation Medical Examiner, Classes I, II, III. #17916-7 - Federal Aviation Administration; retired October 1993

- American Academy of Preventive Medicine, elected member, 1982; elected Fellow, April 1983

- Level II Physician Accreditation Colorado Department of Labor and Employment; Division of Worker's Compensation in conjunction with the University of Colorado School of Medicine: received highest achievable accreditation by the Department of Labor to perform impairment ratings in all body systems under the Colorado

Worker's Compensation Act; October 1992 – re-certified, October, 1995, and October 1998.

CLINICAL ACTIVITIES

- COHBI Physicians, P.C., Boulder, Colorado
- Boulder Community Hospital, Boulder, Colorado
- Mapleton Rehabilitation Center, Boulder, Colorado
- Leominster Hospital, Leominster, Massachusetts (1978-1979)
- Veterans Administration Hospital, Concord, Massachusetts (1978-1979)

EXPERIENCE

- Technical Medical Advisor to the Hebrew University, Medical Disaster Preparedness Unit (School of Public Health and Community Medicine) prior to and during the initial days of the Persian Gulf War (Operation Desert Storm) regarding Israeli civilian and military preparedness for chemical and biological warfare. January - February 1991.
- Technical Reviewer - American Journal of Preventive Medicine, July 1986.
- Board of Advisors - Denver Occupational Health Nursing Association, 1984-1986.
- Board of Directors, Rocky Mountain Academy of Occupational Medicine - Regional Representative to the Journal of Occupational Medicine 1981-1985.
- Expert Witness - Mine Safety and Health Administration Hearing - 1985.
- Expert Witness in Occupational Medicine and Medical Toxicology, United States Federal District Court, Denver, Colorado 1982.
- Board of Advisors, Boulder Memorial Hospital Pain Center, 1981-1983.

- Expert Witness qualified in Occupational Medicine, Occupational Lung Disease and Medical Toxicology, Colorado Division of Labor, State Compensation Judicial hearings, 1981 - Present.

- Medical Advisor, Health and Safety Committee, Colorado Mining Association, 1982 - 1992.

- Chairman, Subcommittee on Occupational Health, Massachusetts Public Health Association, 1979.

MEMBERSHIPS (current and/or historical)

- American College of Occupational and Environmental Medicine (New England and Rocky Mountain Sections)

- American College of Preventive Medicine.

- American Medical Association.

- Colorado Medical Society.

- Boulder County Medical Society.

- Massachusetts Public Health Association.

- Council on Occupational Medicine, Pan American Medical Association, Inc.

- Civilian Aviation Medical Association.

TEACHING ACTIVITIES (abbreviated list)

- Guest Speaker – Israel Center for Disease Control, **"The Recent Anthrax Bioterrorist Attack on the US – Overview of Response and Emerging Methods of Early Detection,"** December 16, 2001, ICDC Headquarters, Tel Hashomer Hospital, Tel Aviv, Israel.

- Guest Speaker – Ben Gurion University, **"Weapons of Mass Destruction and the Events of 9/11,"** December 9, 2001, Negev Desert Research Institute, Sde Boqer Campus, Sde Boqer, Israel.

- Guest Speaker and Table Top Physician Participant – Boulder County Colorado Multi-Agency Counter-Terrorism Training Seminar, **"Weapons of Mass Destruction – Bioterrorism Response,"** November 29, 2001, Boulder, Colorado.

- Guest Speaker – St. Mary's Hospital, **"Weapons of Mass Destruction – A Medical Overview,"** November 25-26, 2001, Grand Junction, Colorado.

- Guest Speaker – Longmont United Hospital, **"Weapons of Mass Destruction – A Medical Overview,"** November 19, 2001, Longmont, Colorado.

- Guest Speaker – San Miguel County Colorado Sheriff's Department, **"Weapons of Mass Destruction Counter-Terrorism Medical Planning and Response,"** October 22, 2001, Telluride, Colorado.

- Guest Speaker – Montrose Memorial Hospital, **"Weapons of Mass Destruction – A Medical Overview,"** October 12, 2001, Montrose, Colorado.

- Guest Speaker – 2000 Mealey MBTE and UST Litigation Conference, **"Gasoline Toxicity Update,"** October 23-24, 2000, Phoenix, Arizona.

- Faculty – 1996 AIHA-RMS Fall Technical Conference, **"Workshop on the Interplay between the Industrial Hygienist and the Occupational Health Physician,**" September 26, 1996, Denver, Colorado.

- Administration and Planning Committee – 2nd Aspen Environmental Conference, September 1995, The Givens Institute, Aspen, Colorado.

- Faculty and Guest Medical Speaker - 1st Aspen Environmental Medicine Conference; Indoor Air Quality section; **"Assessment of the Home and the Workplace: The Role of the Physician,"** September 8-10, 1994, The Givens Institute, Aspen, Colorado.

- Guest Medical Speaker - CASPPR/NARPPS (Colorado Association of Service Providers in Private Rehabilitation/National Association of Rehabilitation Professionals in the Private Sector); conference "Challenges to Rebuilding Lives." Presentation: **"Accommodation Solutions: Occupational Medical and Rehabilitation Teamwork,"** September 18, 1992, Denver/Boulder Ramada Inn, Denver, Colorado.

- Guest Medical Speaker - Workers Compensation Education Association, **"Medical Causality**," May 1992.

- Guest Medical Speaker - Colorado Defense Lawyers, Worker Compensation Division, Americans with Disabilities Act Subcommittee, Denver, Colorado, January 1992.

- Guest Medical Speaker - Fox and Grove Chartered, Chicago, Illinois, **"Understanding the Americans with Disabilities Act,"** October 1991.

- Guest Speaker - Colorado Defense Lawyers Association Annual Seminar, Vail, Colorado, **"Defending Toxic Exposure Cases,"** August 1991.

- Guest Medical Seminar Speaker - Israel Defense Forces (Army and Air Force) Medical Corps, Tel Hashomer Military Medical Center, Tel Aviv, Israel. Topics included PATHMAX methodology, hazardous material medical surveillance, military job fitness (combat and non-combat), chemical and biological warfare exposures and military health prevention programs. August 19-20, 1990.

- Keynote Speaker - Surgical Grand Rounds: St. Joseph Hospital, Denver, Colorado, Department of Surgery, **"Surgical Issues in Occupational Medicine,"** October 27, l987.

- Keynote Speaker - Oil and Gas Safety Committee, Colorado Safety Association: **"Substance Abuse - Safety and Employment Issues,"** June 25, l987.

- Keynote Speaker - **"Emerging Issues in Alcohol and Drug Abuse"** - Mine Health and Safety Session - 88th National Western Mining Conference, February 15, 1985.

- Panel Moderator and Speaker - **"Toxic Materials in the Workplace: Clinical and Preventive Perspectives of Exposure,"** 19th Annual Institute of Occupational Medicine - Rocky Mountain Academy of Occupational Medicine, January 19, 1984.

- Keynote speaker - **"Worker's Health: Some Emerging Issues - I) Genetic Screening; II) Worker Health Risk Appraisals: III) Emergency Medical Systems; IV) Medical Record Privacy"** - Mine Health and Safety Session - 87th National Western Mining Conference, February 9, 1984.

- Keynote Speaker - **"Health and Safety in the Microelectronics Industry."** Rocky Mountain Industrial Hygiene Association Fall Technical Conference, October 2, 1984.

- Faculty Seminar - Occupational Medicine - University of Colorado Health Sciences Center, Department of Family Medicine, 1982.

- Faculty: 3rd Annual Colorado Pain Symposium, **"Dealing with the Pain Patient in Industrial Practice,"** Aspen, Colorado, January 1981.

- Faculty: Poisoning: A Symposium Rocky Mountain Poison Center, Denver, Colorado; March 1981.

  - **"Systematic Approach for Preventive Medical Monitoring in a Complex Work Environment."**

  - **"Correlates of Biological Response to Occupational Stressors (The OSAR Reference Module.)"**

- Faculty: Colorado Association of Occupational Nurses - Occupational Health Workshop, April 1981, Denver, Colorado.

- Faculty - International Environmental Health Symposium, (Occupational Health) Environmental Research and Technology, Inc. (Subsidiary of Comsat General Corporation), Concord, Massachusetts, June 1979.

- Faculty - New England Occupational Health Conference, September 1979, Amherst, Massachusetts.

HONORS

- The City of Boulder Police Department Outstanding Citizen Award, presented by Mark R. Beckner, Chief of Police – ***To Thank you for volunteering your time and knowledge to the Police Department's Weapons of Mass Destruction Project. You were an integral part of this project, which allowed us to develop and implement our response plan."*** May 28, 2002.

- Physician's Recognition Award for Continuing Medical Education, American Medical Association 1982-1985.

- Who's Who in the West, (Marquis) 1982-Present.

- Physician's Recognition Award for Continuing Medical Education, American Medical Association, 1979-1982.

- Outstanding Young Men of America, U.S. Jaycees 1977.

- Fellowship - General Electric Foundation (Harvard University), 1970-1974.

- Sigma Xi Research Honorary Fraternity, M.I.T. Chapter, 1970.

- Phi Eta Sigma, Aeronautics and Astronautics Honorary Fraternity, M.I.T. Chapter, 1969.

- James Means Memorial Prize in Space Systems Engineering (awarded by the M.I.T. Department of Aeronautics and Astronautics) 1969.

PAPERS and PUBLICATIONS

- Kornberg, James P. and King, Stephen, "**Excessive Formaldehyde Exposure to Displaced Persons, Living in Temporary Housing Units Following Hurricane Katrina,**" presented at the IPRED (International Preparedness and Response to Emergencies and Disasters) Conference, Tel Aviv, Israel, January 11-14, 2010.

- Kornberg, James P., "**Gasoline Toxicity Update,"** presented the Mealey MBTE and UST Litigation Conference, Phoenix, Arizona October 23-24, 2000.

- Kornberg, James P., Rosenberg, N. L., Bradley, M.E., Dickerson, O.,B., Coe, J., and Spengler, J.D., **"Objective Evidence of a Relationship between Immunological Dysfunction and Poor Indoor Air Quality,"** Environmental Epidemiology and Toxicology, vol. 1, no. 2, April-June 1999, p 175-182.

- Kornberg, James P., **"Indoor Air Quality Assessment of the Home and the Workplace: The Role of the Physician,"** presented at the 1st Aspen Environmental Medicine Conference, The Givens Institute, Aspen, Colorado, September 8, 1994.

- Kornberg. James P., **Kornberg's Operational Guideline Series in Occupational Medicine; Volume I - The Workplace Walk-Through - Operational Guidelines For The Physician** - including "PATHMAX ™ -Parametric Approach Toward Health Maximization" -The Methodology upon which Medical Surveillance Programs are Designed and Implemented, and Rational Guidelines for Approaching the Occupational Medical Causality Analysis; Lewis Publishers, Inc., (CRC Press), Chelsea, Michigan, 1992.

- Kornberg, James P., **"Review of Chemical and Biological Warfare Disaster Preparedness at Selected Israeli University, Hospital and Private Institutions, along with Related Governmental Policies,"** prepared for The Medical Disaster Unit, School of Public Health and Community Medicine, Hebrew University, Jerusalem, Israel, January 17-24, 1991.

- Kornberg, James P., **"Occupational Medical Causality Analysis,"** Provider Pulse, Colorado Compensation Insurance Authority, Winter 1991.

- Kornberg, James P., **"Site Visit Report : Occupational Medical and Military Fitness Recommendations to the Israel Defense Forces,"** Tel Hashomer Military Medical Center, Tel Aviv, Israel, August 19-20, 1990.

- Kornberg, James P., **"Occupational Stress - A Specialist's Point of View."** Safety Management Executive Briefing, June 1986, The Merritt Company, Santa Monica, California.

- Kornberg, J.P., **"A Supervisory and Managerial Perception Survey Audit Document for A Corporate Substance Abuse Prevention Program (SAPP)"** - internal report to major mining company client, January 1986.

- Kornberg, J.P., **"Comprehensive Guide to the Establishment of a Corporate Narcotic and Alcohol Screening Program"** - internal report to two major mining company clients, August 1984.

- Striplin, M.R., Kornberg, J.P., **"Substance Abuse Screening Program"**, internal report to a high-tech manufacturing client - Boulder, Colorado, COHBI Corporation, April 1986.

- Striplin, M.R., Kornberg, J.P., **"Physical Standards for Public Safety Positions within the City of Longmont"**, internal report to the Department of Risk Management City of Longmont - Longmont, Colorado, COHBI Corporation, June 1984.

- Striplin, M.R., Kornberg, J.P., **"FRM Minerals, Inc. - Medical Program Document - Getchell Project"**, internal report to FRM Minerals, Inc. - Lakewood, Colorado, COHBI Corporation, April 1984.

- Kornberg, J.P., Striplin, M.R., **"Homestake Mining Company Physician's Guidelines"**, internal report to Homestake Mining Company - Golden, Colorado, COHBI Corporation, September 1983.

- Kornberg, James P., **"Surveillance and Compliance System"** presented at the New England Occupational Medical Association Conference, September 28-30, 1979, Amherst, Massachusetts.

- Kornberg, James P., **"Industrial Clinics, State of the Art and Recommended Principles of Operation"**, prepared as a chapter for NIOSH document, **Guidelines to Providers of Occupational Health Care**, May 1979.

- Kornberg, James P. and Hathaway, Barbara K., **"Comprehensive Occupational Safety and Health Services"**, Clinical demonstration grant proposal to U.S. Department of HEW, NIOSH, January 20, 1979.

- Kornberg, James P., Chapman, P.K., and Glaser, P.E., **"Health Maintenance and Health Surveillance Considerations for an SPS Space Construction Community,"** presented at the American Astronautical Society, Space Medicine Symposium, Houston, Texas, October 30 - November 2, 1978.

- Sivak, A., Goyer, M., and Kornberg, J.P., **"Aryl Hydrocarbon Hydroxylase and Polycyclic Aromatic Hydrocarbon Carcinogenesis"**, Interim report to NIOSH #210-78-011, October 11, 1978.

- Miller, I. and Kornberg, J.P., **"Ranking Compounds for Clinical Trials"**, presented at the National Cancer Institute, Division of Cancer Treatment, 8th Joint Working Conference, Lancaster, Pennsylvania, September 23, 1978.

- Stricoff, S. and Kornberg, J.P., **"Hazardous Substance Exposure Forms for the Coal Conversion Industry"**, Interim report to NIOSH #210-78-0100.

- Kornberg, J.P. and Wood, M., **"Acute Care Facilities for Coal Conversion Plants"**, Interim report to NIOSH, July 1, 1978, #210-78-0100.

- Couvillion, L.A., Kornberg, J.P. and Aoki, T., **"Devices for the Improved Management of Diabetes"**, Technical proposal to NIH-NIAMDD-RFP-73-5, June 12, 1978.

- Kornberg, J.P., **"OSAR (Organ/System at Risk) A New Approach to an Old Problem in Occupational Medicine"**, presented at the American Insurance Association Convention, Engineering and Safety Division, St. Petersburg, FL, April 27, 1978.

- Kornberg, J.P., **"Health and Safety: An Overview of BZ (3-Quinuclidinyl Benzilate) Insult and Mechanism of Action"**, contribution to technical proposal to U.S. Army, **"Elimination of BZ Stockpiles in Pine Bluff, Arkansas"**, April 19, 1978, ADL-6919.

- Kornberg, J.P., **"Headaches, A Biochemical Basis for Development"**, internal report, Arthur D. Little, Inc., December 1977.

- Kornberg, J.P., Young, G.S., and Stricoff, S., **"Health Maintenance and Health Surveillance Requirements for the Coal Conversion Industry"**, proposal to NIOSH, August 1977; awarded April, 1978 (Energy Industries Medical Protocol #210-78-0200).

- Kornberg, J.P. and First, M.W., **"High Temperature Filtration of Submicron Aerosols by Diffusion"**, presented at the 13th U.S. Atomic Energy Commission Air Cleaning Conference, San Francisco, August 1974.

- Kornberg, J.P., **"Hypothermia: Methods and Applications"** unpublished paper, Harvard University School of Public Health, January 18, 1971.

- Kornberg, J.P. and Mallove, E.F., **"A Minimum Weight Emergency Lunar Escape Vehicle"**, **Tech Engineering News**, April 1970.

- Kornberg, J.P., **"An Analysis of the Maintenance and Logistic Supply for a 24-Man Lunar Industrial Laboratory, Making Optimal Use of Lunar Resources"**, **James Means Memorial Prize Treatise**, Massachusetts Institute of Technology, Department of Aeronautics and Astronautics, January 20, 1969.

Technical Memorandum

Reply to Written Comments Raised by Customers on NV Energy's Advanced Service Delivery Program

Health and Safety of Exposure to Radiofrequency Signals

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Limitations

The findings presented herein are made to a reasonable degree of engineering and scientific certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available, through any additional work, or review of additional work performed by others.

The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

Reply to Written Comments on Radiofrequency Health and Safety Issues Raised by NV Energy Customers

On October 25, 2011, the Public Utilities Commission of Nevada (Commission) requested that interested persons file written comments on NV Energy's Advanced Service Delivery Program, which includes a 'smart meter' communication system, referred to herein as the "NV Energy AMI Network." These comments were to be filed by November 18, 2011. The Commission also requested that NV Energy file written reply comments by December 2, 2011. The following reply to comments was prepared by Exponent's engineers and scientists specifically to address questions pertaining to health and safety concerns about exposure to radiofrequency (RF) signals that the NV Energy AMI Network uses to communicate information about electric and gas energy use by NV Energy's customers.

Scope of Comments Filed

One hundred forty seven persons or organizations responded to the Commission's request for comments; these comments are available on the Commission's website.[1] The majority of filed comments are the same one-page "Smart Meter Petition to PNUC."[2] The petition's comments are itemized below. In addition, 27 members of the public and staff members of the Commission submitted written comments in which more detailed or extensive issues about RF exposure and health were raised. Generally, these comments were one or two page documents, with the exception of notably large documents filed by Angel De Fazio and Cheryl Wisecup. Finally, 23 additional submissions included comments that did not raise issues about RF exposure and health.

Our reply comments first address the "Smart Meter Petition to the PNUC". Our reply comments about RF safety and health follow, which have been grouped into four main

[1] Note that some persons submitted several comments and some submissions mentioned comments from several persons.

[2] http://lasvegasteaparty.org/tea-party-events-around-the-nation/smart-meter-petition-to-pucn

categories (Smart Meter Exposures and FCC Standards; Symptoms and Nervous System Responses; Electromagnetic Hypersensitivity; Cancer and Related Processes).

Summary of Reply Comments

Contrary to the assertions of several people who filed comments, there has been considerable and varied scientific research regarding the effects of long-term, low-level exposure to RF signals. It has not been established that cancer or other health effects result from long-term, low-level exposures to RF signals (ARPANSA, 2002; IEEE, 2005; ICNIRP, 2009; SSM, 2010; SCENIHR, 2009; EFHRAN, 2010a, 2010b; IARC, 2011)[3] .

Turning to symptoms and nervous system responses, anecdotal reports of isolated complaints and symptoms are notoriously unreliable for establishing cause-and-effect relationships. Anecdotal reports and self-reported allegations are not sufficient evidence to conclude that the exposure causes a given response. Studies of anecdotal reports, in fact, are the least probative evidence in the field of human epidemiologic research. In contrast, randomized clinical trials and cohort and case-control studies provide evidence with the most weight. In this vein, panels of scientists assembled by international health agencies do not report that RF exposure at levels associated with smart meters or even higher exposure levels causes adverse effects on the nervous system of healthy persons or animals. Studies and reviews regarding sleep (Danker-Hoppe et al, 2010; 2011; Mohler et al, 2010; Lowden et al., 2011) and auditory sensory processing published after these reviews continue to report no adverse effect of RF exposure on these parameters in adults or children (Kwon et al, 2010a; 2010b; Kwon and Hämälälen, 2011).

With regard to electromagnetic hypersensitivity, the conclusions of several international agencies do not support the idea that RF fields from the NV Energy AMI Network are the cause of health complaints or symptoms. Nor do subsequent reviews published by other scientists (Barth et al., 2011; Feychting, 2011; Röösli and Hug, 2011; Rubin et al., 2011), including those specifically focused on smart meters (CCST, 2011; MCHD, 2011; MCDC, 2010), support this

[3] Full citations to studies, articles and other documents referred to in the text of this report are provided in the "References" section at the end of this report.

idea. They do suggest, however, that some persons anticipating exposure to RF fields or other electromagnetic field sources can experience symptoms that are not triggered by actual exposure to the fields.

Finally, with respect to cancer and related processes, research reviews by national and international agencies have not concluded that RF fields cause or contribute to cancer. In addressing the implications of this research, the World Health Organization published Fact Sheet N°193, entitled "Electromagnetic fields and public health: mobile phones" (WHO, 2011). The fact sheet states:

> A large number of studies have been performed over the last two decades to assess whether mobile phones pose a potential health risk. To date, no adverse health effects have been established as being caused by mobile phone use … A number of studies have investigated the effects of radiofrequency fields on brain electrical activity, cognitive function, sleep, heart rate and blood pressure in volunteers. To date, research does not suggest any consistent evidence of adverse health effects from exposure to radiofrequency fields at levels below those that cause tissue heating. Further, research has not been able to provide support for a causal relationship between exposure to electromagnetic fields and self-reported symptoms, or "electromagnetic hypersensitivity" (p. 2).

As demonstrated in the analysis described in the testimony of Drs. Shkolnikov and Bailey, the NV Energy AMI Network produces RF exposures at levels at least 15,000-fold lower than the Federal Communications Commission's (FCC) exposure limit.

Smart Meter Petition to the PNUC

This petition expresses concern about a "lack of FCC safety standards for chronic long term exposure to RF" and requests that the Commission apply the "precautionary principle" by taking specific action. The petition requested that the Commission and NV Energy proceed with the following five items:

1. Thoroughly investigate the NV Energy proposal for Smart Meters and potential health risks of these devices by holding public hearings. (Classified a class 2B Carcinogen by WHO).
2. Obtain the Smart Meter health and safety study NV Energy commissioned and make it available to the public.
3. Allow customers to "opt out." NV Energy website states that "all programs are voluntary," but is telling customers they have to have a Smart Meter installed.
4. Thoroughly investigate the safety issues of Smart Meters: are not UL approved, installation not by licensed electricians, and are a fire danger – (http://1hope.org/hopeblog/?p=630).
5. Place a moratorium on all new wireless installations to allow time for a thorough scientific review.

The Commission is already addressing item 1 through planned workshops on the NV Energy proposal for an Advanced Service Delivery program, including RF issues.[4]

Exponent was requested by NV Energy to update the Commission, NV Energy, and its customers on the status of health research on RF fields. These comments and accompanying testimony will be available to the public and will address item 2. Prior to Exponent's retention, NV Energy's vendors submitted NV Energy AMI network devices for RF exposure compliance testing as part of the procedure for obtaining an FCC grant of equipment authorization. Reports demonstrating this compliance are publicly available on the FCC website.

The third item is not related to exposure to RF signals, so is not addressed in our reply to written comments, but will be considered by NV Energy and the Commission. Similarly, the fourth item will be addressed in the Comments of NV Energy. The fifth item is also out of our scope, but within the purview of the Commission.

Thus, Exponent's replies to the Smart Meter Petition to the PUNC and other submissions aim to provide a scientific and engineering perspective to address the potential health risks and safety issues associated with smart meters mentioned in item 1 and item 2, which will fall into the four main categories discussed below.

[4] The classification of RF exposures from cell phones as a 2B carcinogen is discussed in our accompanying testimony.

Smart Meter Exposures and FCC Standards

Written Comments Filed with the Commission

Studies of extremely low frequency (ELF) fields and 'dirty electricity' were referenced in comments.[5] These studies, however, are not relevant to the evaluation of RF signals from smart meters, as explained in our testimony.

Multiple comments expressed the opinion that RF signals from smart meters exceed FCC standards.[6] The opinion that the FCC standards do not address long term chronic exposure was also expressed in comments.[7]

Scientific Assessment and Reply to Comments

All devices comprising the NV Energy AMI Network currently installed or planned for installation have received a grant of equipment authorization from the FCC.[8] As part of this grant process, these devices underwent an evaluation of their RF exposure compared to the Maximum Permissible Exposure (MPE) values. The result of this evaluation is a guideline for installing this equipment such that the produced RF signal would not exceed these MPE values during deployment. In addition, calculations presented in the testimony of Drs. Shkolnikov and Bailey show that the typical RF exposure from the NV Energy AMI network electrical smart meters at 1 foot is $\leq$ 0.000026 milliwatts per centimeter squared (mW/cm^2) and at 1 foot from gas smart meters is $\leq$ 0.0000072 mW/cm^2. Since most of the residences are located more than a 1 km (0.62 miles) from a tower gateway base (TGB) station, the typical exposure from them is 0.00000000012 mW/cm^2.

Despite the considerable and varied scientific research to date and an ongoing monitoring of the research, however, it has not been established that cancer or other health effects result from

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[5] Angel De Fazio; Cheryl Wisecup; J. Johnson.

[6] Angel De Fazio; Camille Brunetta; Carol Fineberg; Cheryl Wisecup; Crystal Smith; George Gardner; Harold Moore; Katrin Ivanoff; J. Johnson; Robert and Kay Frank; Russell Brundige; Teresa Wood.

[7] Cheryl Wisecup; Gail Warthen; Pam Szemanski; Theresa Wood.

[8] Devices currently in development will obtain the grant of equipment authorization prior to deployment.

long-term, low-level exposures to RF signals (ARPANSA, 2002; IEEE, 2005; ICNIRP, 2009; SSM, 2010; SCENIHR, 2009; EFHRAN, 2010a, 2010b).

Symptoms and Nervous System Responses

Written Comments Filed with the Commission

Two commenters reported that "After a Smart Meter was installed on our home in February 2011, we experienced frequent low-level headaches, sleeplessness, tingling in the face and ringing in the ears" and that these symptoms dissipated after the commenters moved their bed farther away from a neighbor's smart meter.[9] Whether these are personal experiences or not is not clear as these comments and the rest of their comments were filed by different persons living at two different locations. After installation of a smart meter one commenter reported higher blood pressure, headaches, and insomnia.[10] Another commenter wrote "Since the installation of smart meters in our neighborhood my family and I have experienced a number of issues including dizziness, skin cancers, headaches, and recently my 90 year old mother had what seems to be a mini stroke."[11] Another commenter reported that tinnitus, a ringing in the ears, developed a month and a half after a smart meter was installed in her house.[12] Two others reported a headache when near a smart meter.[13] "A constant 'ringing' in my ears," sleep difficulties, and pet agitation also has been reported.[14] Another reported headaches, difficulty in sleeping, and agitated dogs after installation of a smart meter.[15] Other commenters reported that smart meters are not good for people because of "Health effects like migraines, nausea, vomiting, muscle spasms, heart palpitations and sleeplessness caused by intense bursts of radiofrequency radiation…"[16] and "there have been multiple customer complaints of headaches and other physical problems that have coincided with the introduction of the meters."[17] Similar comments were submitted by others.[18] Another commenter asserted that smart meters "can cause heart arrhythmia…sever[e] headache and a host of neurological and immune system problems."[19] Questions about damage to the blood vessels of the brain that prevent large

[9] Keith Maris; Mike and Joyce Hazard.
[10] Ingrid Serina.
[11] Penny Hess.
[12] Judith Bindorf.
[13] Karen Smith; Charleston Neighborhood Association (Rick Johnson).
[14] Richard Dooling.
[15] Chris and Mona Cladis.
[16] Ellie Ahern; James Bartel; Sol Lee.
[17] Matthew and Melody Chutter.
[18] Darryl Dorfman; Jaclyn Costello; John Nahler; Juan Vasquez; Karen Steelman; Michael Herz; Sheila Sterling; William and Sherry Moran.
[19] Elizabeth Barris.

molecules from entering, i.e., the blood-brain barrier (BBB), DNA fragmentation, and stress responses were raised.[20] Another commenter cited summaries of two studies from one group of researchers in which RF fields were reported to affect the electrical activity of isolated brain tissue *in vitro* (Blackman et al., 1985; Dutta et al., 1989) and opinions offered by some scientists, which presumably were mentioned to support the general proposition that RF fields (from smart meters or other sources) may cause symptoms that reflect altered function of the nervous system.[21]

Scientific Assessment and Reply to Comments

As can be readily appreciated, anecdotal reports of isolated complaints and symptoms are notoriously unreliable for establishing cause-and-effect relationships, especially when complaints and symptoms such as those reported are common in people anywhere. Similarly, relying on postings on the internet, advocacy websites, and a few scientific reports from the literature to prove such relationships or obtain advice about health concerns is also problematic. In addition, only a few scientific studies were selected and cited and many scientific studies have significant limitations that make it difficult to draw clear or relevant conclusions. That is why, in performing health risk assessments, it is important that health agencies examine the body of evidence as a whole following an evaluation of the methodology, strengths, weaknesses, and consistency of individual studies. In addition, some types of studies, mainly *in vitro* studies of isolated tissues and cells, are not relied upon by regulatory agencies to establish health risks because of the difficulty in extrapolating responses to intact tissues and whole organisms.

For the above reasons, it is instructive to review the conclusions of national and international panels of scientists who have been assembled by scientific and health agencies to review research on this specific topic. ***It is particularly important to note that most experimental studies published have examined levels of RF signals over a wide range of intensities, including those characteristic of mobile phones that can produce higher RF exposures than are produced by the proposed NV Energy AMI Network (See testimony of Drs. Shkolnikov and Bailey).*** The excerpts from reviews below focus on the nervous system because the majority of symptoms and responses reported in comments relate to the nervous system.

[20] Gail Page.
[21] Angel De Fazio.

International Commission on Non-Ionizing Radiation (2009)

The most comprehensive recent review of research studies of RF exposure was published by the International Commission on Non-Ionizing Radiation (ICNIRP) in 2009. The panel evaluated studies of the electrical activity of the brain during waking and sleep states, the auditory and vestibular neurosensory systems, regional blood flow in the brain, and human cognitive performance. Their conclusion was that:

> There is some evidence for effects of exposure to a GSM-type [i.e., cell phone] signal on the spontaneous EEG. … These observations are not corroborated, however, by the results from studies on evoked potentials. Although in some studies some small but inconsistent effects were observed, no effects at all were found when auditory evoked potentials were assessed in the same large study group described above.
>
> A similar conclusion of variable results can be drawn with respect to the effects of exposure to GSM-type signals on sleep, although there is some evidence emerging that suggests there may be an effect on sleep EEG. Some studies, but not all, have indicated effects on EEG power in alpha or beta bands with exposure during sleep. A reported shortening of sleep latency was not subsequently reproduced. Other studies which looked at exposure during 30 min before going to sleep also reported variable results, sometimes reporting increases in alpha and beta band power. In summary, exposure to a GSM-type signal may result in minor effects on brain activity, but it should be stressed that such changes have not been found to relate to any health effects. There are some indications of changes in regional cerebral blood flow during and following RF exposure, but the available data are equivocal. It should be noted that changes in rCBF are not by themselves an indication of health damage. No consistent cognitive performance effects were seen. Studies with larger numbers of subjects generally show no effect. No higher sensitivity was shown in children nor in self-proclaimed electrosensitives compared to healthy adults. If anything, any effect is small and exposure seems to improve performance. It was not possible to derive a dose-response relationship.
>
> The weight of evidence from the studies on auditory and vestibular function indicates that neither hearing nor the sense of balance is influenced by short-term exposure to mobile phone signals (p. 245).

The Health Council of the Netherlands (2009, 2011)

The Health Council of the Netherlands (HCN) issued a special review in 2009 that focused entirely on the effects of electromagnetic fields on the nervous system and included studies of brain electrical activity, hearing and balance, regional cerebral blood flow, and cognitive functioning. For RF fields, the review concluded:

> Exposure to radiofrequency electromagnetic fields produced by mobile phones may lead to subtle changes in brain activity. However, the observed effects are temporary and small and, as far as is known, have no effect on health. The picture that emerges from studies of effects on cognitive functioning is unclear: some studies found minor and reversible effects while others found no effect (p. 97).

In 2011, the HCN updated its assessment of possible effects of RF on the nervous system to focus specifically on children with the following conclusions:

> **Brain Development and Function**
>
> The Committee feels that consistent effects of exposure to radiofrequency electromagnetic fields on brain function in children have not been demonstrated. Insofar as effects were observed, they are temporary and minor and there are no signs that they can influence health. Animal studies also fail to demonstrate effects on brain function (p. 25).
>
> **Experimental Behavior and Cognition**
>
> Exposure to radiofrequency electromagnetic fields appears not to have a clear effect on behaviour and cognition in children. Animal studies only used rats, and are therefore less relevant in the eyes of the Committee. A general problem in both studies with children and animal studies is the limited number of studies and, with one exception the small number of human subjects or animals per study (p. 26).

Scientific Committee on Emerging and Newly Identified Health Risks (2009)

In an update to a 2007 report, the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) evaluated studies focusing on behavior and cognition, electrophysiological measurements, sensory related functions, and studies focusing on cell and tissue integrity, including the BBB. Their conclusion was:

Nervous System Effects

With the exception of a few findings in otherwise negative studies, there is no evidence that acute or long-term RF exposure at SAR levels relevant for mobile telephony can influence cognitive functions in humans or animals. There is some evidence that RF exposure influences brain activity as seen by EEG studies in humans. Human studies also indicate the possibility of effects on sleep and sleep EEG parameters. However, certain findings are contradictory and are furthermore not substantiated by cellular studies into mechanisms. There is a need for further studies into mechanisms that can explain possible effects on sleep and EEG.

There is no evidence that acute exposures to RF fields at the levels relevant for mobile telephony have effects on hearing or vision. Furthermore, there is no evidence that this kind of exposure has direct neurotoxicological effects. Most studies show lack of effects on supporting structures like the blood-brain-barrier. The positive finding is lacking dose-response relationships and needs independent replication in studies with improved methodology. The findings of activated glial cells at relatively high SAR-values could indicate gliosis and thus subsequent neurodegeneration after exposure, although exposures at lower levels did not reveal any such effects (p. 31).

Swedish Radiation Safety Authority's Independent Expert Group on Electromagnetic Fields (2010)

At yearly intervals a panel of independent scientists reviews recent research on electromagnetic fields for the Swedish Radiation Safety Authority (SSM) and evaluates potential health risks of electromagnetic fields. The conclusions of the Seventh Annual Report regarding RF fields and the nervous system and behavior were:

Conclusion on animal studies

Recent studies indicate that in rodents several weeks of daily exposure of 45 min or longer to a mobile telephone signal at a SAR of 1.5 W/kg and higher may result in a response in hippocampal neurons that indicates activation in response to injury. This might have an effect on memory and cognitive functions. In previous SSM reports some behavioural effects have been reported, but a clear dose-response relationship has not been established. It is still unclear whether and to what extent rodent behaviour

> can be influenced by RF exposure. No inferences at all can be made from these studies with respect to any influence on human behaviour (p. 32).
>
> **EEG and Sleep**
>
> As pointed out in the previous report (SSM, 2009;36) the biophysical mechanisms of these alpha changes [in recordings of electrical EEG signals recorded from the scalp of the head] induced by pulsing could be well studied in animal models or in neural tissue *in-vitro* instead of such diverse and complex set-ups like human EEG measurements which themselves are sensitive to numerous other factors (i.e. attention, arousal, age etc.).
>
> Three new reports on sleep and sleep EEG have been published with rather convincing results based on large numbers of participants and well controlled designs. Based on these studies it appears that EMF exposure does not affect the subjective well-being, whereas signs of slight changes in some sleep parameters were found. The sleep EEG study again confirmed the effect of GSM EMF on the EEG alpha band (p. 32).
>
> **Cognition**
>
> To summarize, effects during short exposures are not demonstrable with present cognitive measures either in adults or children. There is a need for studies involving longer exposures, especially in children (p. 33).

European Health Risk Assessment Network on Electromagnetic Fields Exposure (2010a, 2010b)

The European Health Risk Assessment Network (EFHRAN) has published two reports by independent scientists. The first, focused primarily on human studies, concluded:

> Regarding effects of RF fields on the brain and nervous system, several studies using volunteers have not reported any consistent effects on various behaviours or cognitive functions, although sporadic changes were noted in some studies. A large number of studies have reported that exposure is without detectable effect on either the auditory or visual systems. Some, but not all studies have reported effects on sleep and sleep encephalogram (EEG) patterns, and others have reported on specific EEG components during exposure. However, SCENIHR questioned the

> relevance of these subtle changes to health, and noted that no interaction mechanism could be identified (2010a, p. 11).

The second report, also a review, considered previous research and new research on a variety of studies of animals and cells of the nervous system exposed to RF fields including studies of the BBB, stress responses, gene expression, neurologic disease and damage, and behavior. This report stated:

> The most surprising finding is the beneficial effect of RFR [radiofrequency radiation] on cognitive function in Alzheimer disease mice.
>
> The very recent animal studies relevant to mobile telephony show a lack of effect on the BBB, microglial cell activation, and stress response.
>
> There is some evidence that RF exposure influences gene expression, behaviour, and the number of neurons but these studies were done with small number of animals or absence of dosimetry. Some in-vitro studies seem to show an effect of mobile telephony signal on oxidative stress that must be confirmed (2010b, pp. 12-13).

Thus, panels of scientists assembled by international health agencies do not report that exposure to RF fields at levels associated with smart meters or even higher levels causes adverse effects on the nervous system of healthy persons or animals. Studies and reviews regarding sleep (Danker-Hoppe et al, 2010; 2011; Mohler et al, 2010; Lowden et al., 2011) and auditory sensory processing published after these reviews continue to report no adverse effect of RF exposure on these parameters in adults or children (Kwon et al, 2010a; 2010b; Kwon and Hämälälen, 2011).

Electromagnetic Hypersensitivity

Whereas the previous section addressed research on the physiology and behavior of primarily healthy persons, attention here is focused on persons who perceive behavioral or possible health sensitivity to RF fields from smart meters or other sources. There is considerable overlap between nervous system effects just discussed and this topic because the majority of symptoms reported by 'sensitive' persons relate to the nervous system.

Written Comments Filed with the Commission

Among the submissions one person reported, "I am extremely sensitive to RF's. My problems with EMF's and EMR's began about 5 years ago with cell phones, cell towers and especially the

computer and microwave ovens. I suffer pain, aching and a prickling sensation whenever I touch or even go near one of these objects."[22] Another states "I have health conditions that warrant avoidance of any type of devices that emit electromagnetic and/or radio frequencies,"[23] while another stated "I have health issues that would become much worse if I was exposed to the radiation that smart meters produce."[24] Another submission expresses concern about smart meters because of some existing health condition.[25] In two submissions, frequent reference is given to studies that examined sensitivity of a person's health in relation to 50/60 Hz fields (as are produced by powerlines, building wiring, and appliances) and harmonics present on building wiring ('dirty electricity') [26] but these exposures are not relevant to devices in the NV Energy AMI Network. These two submissions also referenced sensitivity to RF as discussed in a few case reports and advocacy and opinion pieces.

Scientific Assessment and Reply to Comments

Since the 1980s, a small but growing percentage of persons have reported feeling bad or exhibiting specific complaints and symptoms in certain environments or in the presence of chemicals, e.g., perfumes, or sometimes electromagnetic fields. For those with a proclaimed sensitivity to electromagnetic fields, the term "electromagnetic hypersensitivity" (EHS) has been applied (WHO, 2005). After a review of the research and evidence, the World Health Organization (WHO) adopted the term "idiopathic environmental intolerance (IEI) with attribution to electric and magnetic fields (EMF)." This term is preferred because these symptoms are not explained by any known medical, psychiatric, or psychological disorder, and there is no confirmed link between EMF or RF and symptoms (WHO, 2007, p. 137).

For the most part, the existence of the IEI phenomenon is based on anecdotal reports and self-reported allegations of responses to electromagnetic fields. Anecdotal reports and self-reported allegations, however, are not sufficient evidence to conclude that the exposure causes the response. Rather, scientists use such reports (referred to as case reports) to generate hypotheses that form the basis of scientific studies to assess whether a real causal relationship exists. Case reports are the weakest type of evidence in the hierarchy of scientific information because, without a control group, they cannot address whether the observation is a result of chance:

> While case reports and case series are very useful for hypothesis formulation, they cannot be used to test for the presence of a valid

[22] Carol Stahivke.
[23] Harold Moore.
[24] Lisa Toulouse.
[25] Jane Lyon; Vincent Ames.
[26] Angel De Fazio; Cheryl Wisecup.

> statistical association. One fundamental limitation of the case report is that it is based on the experience of only one person. The presence of any risk factor, however suggestive, may simply be coincidental. Although case series are frequently sufficiently large to permit quantification of frequency of an exposure, the interpretability of such information is severely limited by the lack of an appropriate comparison group. This lack can either obscure a relationship or suggest an association where none actually exists (Hennekens et al., 1987, p. 107).

Hence, there is need for rigorous scientific studies to evaluate the question of IEI-RF. There are several types of studies that can be conducted. From the most informative to the least, the hierarchy of evidence related to human epidemiologic research is: 1) randomized clinical trials, 2) cohort and case-control studies, 3) other comparative studies, and 4) case reports (Elwood, 1988). Experimental research comparable to a randomized clinical trial has been conducted in the field of electrical hypersensitivity; therefore, there is no reason to focus exclusively on weaker forms of opinion or research such as that referred to in filed comments, when more advanced types of research exist.

The status of research on this issue can be summarized briefly by reference to some recent reviews of RF fields with regard to IEI.

International Commission on Non-Ionizing Radiation (2009)

> A wide range of subjective symptoms including headaches and migraine, fatigue, and skin itches have been attributed to various RF sources both at home and at work. However, in provocation studies a causal relation between EMF exposure and symptoms has never been demonstrated. Possibly the conscious expectation of such symptoms may play a role in the etiology of this condition (p. 245).

The Health Council of the Netherlands (2009)

> The number of people attributing a variety of symptoms to various sources of electromagnetic fields in the home and at work seems to increase. They report for instance headache and migraine, fatigue, sleeplessness, concentration problems, itch and sensations of warmth. The number of people that consider themselves to be electrosensitive on the basis of such symptoms seems to be on the increase as well. People particularly attribute their symptoms to mobile phones, base stations, DECT cordless telephones, and now increasingly also to wireless computer network systems. . . .Both in the living environment and in the laboratory, studies

have been performed into a possible link between exposure to electromagnetic fields and the occurrence of symptoms. Several of these studies were not properly designed and cannot be used for the analysis. From the good quality scientific data emerges the picture that there is no causal relationship between exposure to radiofrequency electromagnetic fields and the occurrence of symptoms. However, there is a relationship between symptoms and the *assumption* of being exposed and therefore most likely with the risk perception. Nevertheless, the symptoms do exist and require a solution (p.73).

Scientific Committee on Emerging and Newly Identified Health Risks (2009)

The evaluation of the scientific data at the time of the 2007 opinion suggested that symptoms are not correlated to RF field exposure, but few studies had addressed this issue directly. The 2007 opinion concluded that scientific studies had failed to provide consistent support for a causal relationship between RF field exposure and self-reported symptoms (e.g. headache, fatigue, dizziness and concentration difficulties or well-being), sometimes referred to as electromagnetic hypersensitivity (p. 26).

In the previous opinion, it was concluded that scientific studies had failed to provide support for a relationship between RF exposure and self-reported symptoms. The 2007 opinion also stated that the knowledge at that time suggested that symptoms are not correlated to RF field exposure. Although an association between RF exposure and single symptoms was indicated in some new studies, taken together, there is a lack of consistency in the findings. Therefore, the conclusion that scientific studies have failed to provide support for an effect of RF on symptoms still holds.

The background for symptoms reported to be triggered by RF fields in everyday life has been discussed. There is a discrepancy between open exposures to RF fields where symptoms are triggered when the subjects are aware of the exposure, and double-blind provocations studies where there is no consistent association between RF and symptoms when subjects do not know if they are exposed to RF or not. These results indicate that a nocebo effect plays a role in symptom formation.[27] This

[27] In this context, the nocebo effect refers to effects or complaints experienced by a person because real or perceived exposures are expected to be harmful despite the absence of demonstrated harm.

> does not exclude the possibility of a RF field effect, but so far the support from scientific studies is stronger for a nocebo effect. With regard to detection of fields, scientific studies have not provided any evidence that either so-called sensitive groups or healthy control groups can detect RF fields better than expected by chance (p. 28).

Swedish Radiation Safety Authority's Independent Expert Group on Electromagnetic Fields (2010)

This group of scientists reviewed four recent RF studies with the following conclusions:

> **Nieto-Hernandez et al., 2010.** None of the symptoms (headache, fatigue, dizziness, nausea, sensations of warmth or burning on skin, skin itching, tingling, stinging or numbness, feeling irritable or anxious or depressed, difficulty concentrating or thinking) was related to exposure except skin itching which was decreased during continuous wave exposure (SSM**,** 2010, p. 33).
>
> **Wallace et al., 2010.** There was no difference in any measures between TETRA [a wireless communication signal] and sham (no signal) for either controls or electrically hypersensitive participants, and neither group could detect the presence of the TETRA signal at rates greater than chance (SSM, 2010, p.33).
>
> **Nam et al., 2009.** Nam and colleagues studied the ability of 18 self-reported electrically hypersensitive and 19 control subjects to perceive the existence of the EMF (CDMA), as well as subjective symptoms (Nam et al., 2009). Also several physiological reactions (heart rate, respiration, heart rate variability) were measured. No effects were found in either of the groups (SSM, 2010, p. 34).
>
> **Landgrebe et al., 2009.** Landgrebe and co-workers studied the prevalence of tinnitus, the "ringing ears" with no known mechanism, in 69 self-reported electrically hypersensitive subjects and 80 controls. 50.7% of the hypersensitive subjects in contrast to only 17.5% of the controls reported to experience tinnitus (Landgrebe et al., 2009). There was no difference between the groups with regard to the severity or duration of tinnitus. The amount of cell phone use did not have any association with the tinnitus. The authors discuss the possibility for an individual

> vulnerability to both self-reported electrical hypersensitivity and tinnitus (SSM, 2010, p. 34).

European Health Risk Assessment Network on Electromagnetic Fields Exposure (2010a)

> On non-cancer outcomes, it was concluded that the available scientific evidence failed to provide support for an effect of RF fields on self-reported symptoms. Although an association between RF exposure and single symptoms was indicated in a few cross-sectional studies, there was a lack of consistency in these findings, and several provocation studies indicated a lack of effect on well-being using handset or base stations signals (SCENIHR, 2009a). Further, there was no evidence from a number of studies that those reporting sensitivity to RF exposure or healthy controls could reliably detect the presence of either GSM or UMTS signals significantly better than chance. The possibility that nocebo effects may play a role in symptom formation was highlighted (2010a, p. 11).

The conclusions of these agency reports do not support the idea that RF fields from the NV Energy AMI Network are the cause of health complaints or symptoms. Nor do subsequent reviews published by other scientists (Barth et al., 2011; Feychting, 2011; Röösli and Hug, 2011; Rubin et al., 2011), including those specifically focused on smart meters (CCST, 2011; MCHD, 2011; MCDC, 2010), support this idea. They do suggest, however, that some persons *anticipating* exposure to RF or other electromagnetic field sources can experience symptoms that are not triggered by *actual* exposure to the fields (see nocebo definition in footnote 27).

Cancer and related processes

Written Comments Filed with the Commission

By far, the greatest number of comments submitted to the Commission mentioned cancer. Most of these simply requested that the Commission "Thoroughly investigate the NV Energy proposal for Smart Meters and potential health risks of these devices by holding public hearings. (Classified a class 2B Carcinogen by WHO)."[28] One comment expressed concern about the development of skin cancer after smart meter installation.[29] Other comments also mentioned cancer or concerns about long term effects on health and children, but did not elaborate

[28] Elizabeth Barris; G. Page; J. Friedrich; Matthew and Melody Chutter.

[29] Pam Hess.

further.[30] Two other submissions cited multiple studies that addressed cancer from sources of electromagnetic fields at frequencies unrelated to RF fields from smart meter networks as well as some published RF studies.[31] For example, one commenter cites over 25 studies that relate to extremely low frequency (ELF) magnetic fields.[32] The other cited more than 12 studies that are related to ELF magnetic fields, almost all of which were also cited in the other submission.[33] The studies cited in submissions from Commission staff included: "Questions and Answers about Biological Effects and Potential Health Hazards of Radiofrequency Electromagnetic Fields" – Attachment B; excerpts from the FCC's website on radiofrequency safety – Attachment C; a fact sheet "Cell Phones and Cancer Risk" prepared by the U.S. National Cancer Institute – Attachment H; a press release from the International Agency for Research on Cancer (IARC) – Attachment G; and the California Council on Science and Technology (CCST) report – Attachment E, which all referenced research on RF fields and cancer.

Scientific Assessment and Reply to Comments

In light of the attention given to this topic in the comments, it is worthwhile to review the conclusions provided by national and international scientific and health agencies on this specific issue. In addition, this topic is reviewed in greater detail in testimony filed by Drs. Shkolnikov and Bailey.

It should be kept in mind that the primary drivers of concern about potential health effects of RF exposure are epidemiology studies of mobile phone use. The exposures to RF signals from the NV Energy AMI Network, however, are far lower than the head and whole body RF exposures associated with making a call from a mobile phone. Hence, even if a small risk of mobile phone exposure were to be confirmed, the potential risks at far lower exposures might be very much smaller.

[30] Crystal Smith; Elizabeth Barris; G. Page; J. Burke; J. Friedrich; K. Wald; Matthew and Melody Chutter.

[31] Angel De Fazio; Cheryl Wisecup.

[32] Angel De Fazio.

[33] Cheryl Wisecup.

International Commission on Non-Ionizing Radiation Protection (2009)

Epidemiology studies

In the last few years the epidemiologic evidence on mobile phone use and risk of brain and other tumors of the head has grown considerably. In our opinion, overall the studies published to date do not demonstrate a raised risk within approximately ten years of use for any tumor of the brain or any other head tumor. However, some key methodologic problems remain - for example, selective non-response and exposure misclassification. Despite these methodologic shortcomings and the still limited data on long latency and long-term use, the available data do not suggest a causal association between mobile phone use and fast-growing tumors such as malignant glioma in adults, at least those tumors with short induction periods. For slow-growing tumors such as meningioma and acoustic neuroma, as well as for glioma among long-term users, the absence of associations reported thus far is less conclusive because the current observation period is still too short. Currently data are completely lacking on the potential carcinogenic effect of exposures in childhood and adolescence (pp. 353-354).

Animal studies

Overall, the results of recent carcinogenicity studies are rather consistent and indicate that carcinogenic effects on rodents are not likely at SAR levels up to 4 W kg^{-1} even for long-term exposure. Genotoxicity studies also generally indicate a lack of effect. A notable positive finding was of a two-fold increase in lymphoma incidence in a strain of lymphoma-prone transgenic mice following exposure at 900 MHz with a signal similar to that used in GSM mobile phones. However, this finding was not confirmed in two subsequent replication and extension studies. In addition, studies report an absence of effects of RF radiation characteristic of mobile phone use on melatonin levels (p. 212).

In vitro

In summary, most studies have failed to convincingly demonstrate any direct genetic effect after exposure of laboratory mammals to RF radiation, in particular when temperatures were maintained within normal physiological limits (p. 150).

Scientific Committee on Emerging and Newly Identified Health Risks (2009)

The evidence from epidemiological studies indicates that the use of mobile phones for less than ten years is not associated with an increased risk of developing a brain tumour. A major limitation of the current studies is that the diagnostic period of the cases ended in 2003 at the latest, hence, only a few long-term mobile phone users were included in those studies. This limitation together with uncertainties in reconstructing past exposures and difficulties in the ascertainment of representative study participants, circumvent firm conclusions related to long-term mobile phone use. Altogether, the data collected until now provide no evidence of an increased brain tumour risk. This is consistent with the observation that no visible increases are seen in the age specific incidence rates of tumours of the central nervous system in the Nordic countries over the last decade (Figure 1, 2) (p. 24).

However, despite new data, the existence of a small risk increase cannot be ruled out and therefore a similar level of uncertainty as in the previous SCENIHR report remains. This assessment may or may not change when the complete Interphone material is published. Prospective long-term follow up studies overcome both the limitations of retrospective exposure assessment and the latency problem and are recommended as a powerful long-term surveillance system for a variety of potential endpoints, including cancer, to fill current gaps in knowledge. Recent well-conducted epidemiological studies provide evidence against an association between RF-EMF exposure from broadcast transmitters and the risk of childhood leukaemia. Although new exposure sources such as mobile phone base stations, cordless phone base stations or wireless networks are relatively recent, exposures from these sources are generally lower than the ones investigated in these studies on broadcast transmitters. Thus, there appears to be no immediate need for further studies related to these sources. However, no studies on mobile and cordless phone use among children and adolescents have been completed so far (p. 25).

Overall, the results of the new studies are consistent with results from previous studies, and add to the evidence that the RF fields such as those emitted by mobile phones are not carcinogenic in laboratory rodents. Some of the new studies have also used exposure levels up to 4 W/kg which is high, compared to most previous studies. Thus, these studies provide additional evidence that carcinogenic effects are not likely even at SAR levels that clearly exceed human exposure from mobile phones. (p. 26)

Inconsistent in vitro findings and a lack of dose response relationships render any mechanistic understanding of potential non-thermal

> interactions between RF and living systems difficult. For RF fields below the recommended limits (2 W/kg) for energy absorption due to mobile phones, in vitro studies have not identified reproducible effects by which carcinogenicity in living systems could be explained. (p. 26).

Swedish Radiation Safety Authority's Independent Expert Group on Electromagnetic Fields (2010)

> Based on the results from the pooled analyses of the INTERPHONE study (INTERPHONE, 2010) and two studies evaluating data from high-quality cancer registries (Deltour et al., 2009; Inskip et al., 2010) a short term risk of mobile phone use can be excluded with a high degree of certainty. If mobile phone use increased the brain tumour risk by 50% or more, one would roughly expect to observe an increase in the brain tumour incidence of 30% or more since the introduction of mobile phones assuming a prevalence of mobile phone use of 60%. Such an increase would be clearly detectable unless compensated by a very strong preventive factor that was introduced at the same time as mobile phones. So far, nobody has suggested such a preventive factor. It is particularly hard to imagine that risk increases of 100% or more that have been reported in some studies for specific age groups would not be detectable in brain cancer incidence data. A potential risk for a specific histological tumour entity would be harder to detect in time trends data as the number of cases is small and thus time trends are more fluctuating. Similarly, identification of a potential long-term effect is more challenging since the prevalence of long-term users is smaller. In particular, no data are available for very long exposure periods of more than 20 years. However, even if induction time is long on average, incident cases with shorter than average induction periods have to be expected as the latency distribution will scatter around the mean induction time. Thus, if use of mobile phones was a substantial long-term risk, incidence data should indicate increasing rates by now. Though, a small risk increase may be still undetectable. (p. 39)

European Health Risk Assessment Network on Electromagnetic Fields Exposure (2010a)

> Inclusion of the recent data has not necessitated any revisions to the existing consensus opinions of EMF-NET (2009) or SCENIHR (2009a). For none of the diseases is there sufficient evidence for a causal association between exposure and the risk of the disease, and the strength of evidence for many outcomes remains as inadequate (Table 5).
>
> Results of the international analyses of glioma and meningioma risk in the Interphone study have been published. While an association between mobile phone use and risk of these diseases has not been demonstrated,

> the study does not either demonstrate an absence of risk. There is at this time inadequate evidence for all endpoints considered. Given that the majority of subjects in Interphone were light users compared to users today, particularly young people, and as the study did not include subjects who used phones for more than 12 years, further research is needed to evaluate the possible association between RF exposure and risk of tumours (p. 21).

International Agency for Research on Cancer (Baan et al., 2011)

A summary of the main conclusions of a review performed by the IARC on the potential carcinogenicity of RF exposures prepared for the WHO has been published (Baan et al., 2011). These conclusions are discussed in detail in the accompanying testimony of Dr. Shkolnikov and Bailey.

The panels of scientists assembled by international health agencies have not concluded that RF fields in general pose any likely cancer risk. The greatest uncertainty arises from epidemiology studies of long-term exposures from the use of mobile phones. Epidemiology studies have not been interpreted to demonstrate a causal relationship for up to 12 years of mobile phone use, but because of limitations in the studies and the absence of data on exposures much greater than 12 years, additional research has been recommended to address these issues. Scientists have considered these data as providing inadequate or limited evidence for an association between mobile phone use and cancer. The degree to which exposures from mobile phones can be extrapolated to the much lower exposures from the NV Energy AMI network is unknown but if a risk were to be confirmed for mobile phones, the risk for exposures to sources at much lower intensities such as the NV Energy AMI Network would be expected to be lower as well.

A recent editorial on a study released after the IARC and earlier reviews found the results of an updated study of Danish mobile phone users (Frei et al., 2011) “reassuring” but recommended continued monitoring of mobile phone cohorts (Ahlbom and Feychting, 2011). Notably, three reviews (Feychting, 2011; Repacholi et al. 2011; Swerdlow et al., 2011) and new epidemiology studies of mobile phone use and brain cancer in adults (Larjavaara et al., 2011) and the first study of children and adolescents (Aydin et al., 2011) also published after the IARC report do not conclude that the scientific evidence supports an association between mobile phone use and cancer.

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