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# A Discussion of Smart Meters And RF Exposure Issues

*An EEI-AEIC-UTC White Paper*

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A Joint Project of the EEI and AEIC  
Meter Committees

**March 2011**

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# 1: Introduction

The following industry discussion of Smart Meters and Radio Frequency (RF) Issues was prepared by the member company representatives from the following organizations.

## **Edison Electric Institute (EEI)**

The Edison Electric Institute (EEI) is the association of U.S. Shareholder-Owned Electric Companies. Our members serve 95 percent of the ultimate customers in the shareholder-owned segment of the industry, and represent approximately 70 percent of the U.S. electric power industry. Organized in 1933, EEI works closely with all of its members, representing their interests and advocating equitable policies in legislative and regulatory arenas.

## **The Association of Edison Illuminating Companies (AEIC)**

AEIC was founded by Thomas Edison and his associates in 1885. AEIC encourages research and the exchange of technical information through a committee structure, staffed with experts from management of member companies.

AEIC's members are electric utilities, generating companies, transmitting companies, and distributing companies – including investor-owned, federal, state, cooperative and municipal systems – from within and outside the United States. Associate members include organizations responsible for technical research and for promoting, coordinating and ensuring the reliability and efficient operation of the bulk power supply system.

AEIC's Six Technical Committees are: Load Research, Meter and Service, Power Apparatus, Power Delivery, Power Generation and Cable Engineering. AEIC also provides highly valued literature on load research and underground cable specifications and guidelines.

## **Utilities Telecom Council**

The Utilities Telecom Council (UTC) is a global, full-service trade association dedicated to creating a favorable business, regulatory, and technological environment for members. Founded in 1948, UTC has evolved into a dynamic organization that represents the broad communications interests of electric, gas, and water utilities; natural gas pipelines; other critical infrastructure entities and other industry stakeholders. Visit [www.utc.org](http://www.utc.org) for more information on UTC and its services.





## 2. Executive Summary

Smart Meters and Smart Meter Systems are being deployed throughout North America, and utilities are continuing their efforts to improve grid reliability and promote energy efficiency while providing improved services to their customers. However, concerns have been raised regarding the potential impacts of radio frequency exposure from these meters on the public. The purpose of this paper is to give an overview of the issues raised recently concerning RF exposure due to the deployment of Smart Meter and Smart Meter Systems. The paper provides a basic overview for understanding how the electric utility industry seeks to ensure the appropriate level of accuracy and safety. It also makes evident that before being accepted and deployed Smart Meters must meet a number of national standards and comply with state and local codes designed to ensure proper operation, functionality and safety.

### Radio Frequency (RF) Exposure

Several Smart Meter Systems operate by transmitting information wirelessly. This has raised some concern about the health effects of wireless signals on electric consumers and the general public. Accordingly, this document explains that the RF exposures of Smart Meters are lower compared to other common sources in the home and operate significantly below Federal Communications Commission (FCC) exposure limits.<sup>1</sup> The paper discusses how the location, distance from the transmitter, shielding by meter enclosures, attenuation of building materials, direction of RF emissions, and transmit duty cycle significantly reduce exposure to consumers. It also includes a review of the conclusions of several Smart Meter RF studies and actual measurements of Smart Meter RF emissions to support this conclusion. Other observations include:

- All smart meter radio devices must be certified to the FCC's rules.
- Tests simulating multi-family metering locations containing several meters in close proximity have shown RF exposure levels dramatically less than FCC limits.
- The FCC limits on maximum permissible exposure (MPE) for application to the general public were set using safety factors fifty times lower than the levels of known effects.
- Exposure levels drop significantly (1) with the distance from the transmitter, (2) with spatial averaging, and (3) in living spaces due to the attenuation effects of building materials.
- Due to shielding of the meter enclosure and signal patterns, RF exposure from the rear of a metering location is nominally 10 times less than in front of the meter and dramatically below FCC limits, not including the spatial averaging and building material attenuation reductions.<sup>2</sup>
- For measurement and calculation purposes some studies use a 100% duty cycle parameters. However, the maximum operational Duty Cycle for Smart meter systems is less than 50% to prevent message traffic congestion and collisions. The typical Duty Cycles for Smart Meter Systems is between 1% and 5%.

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<sup>1</sup> See Section 5, RF Exposure in Smart Meter Systems

<sup>2</sup> "An Investigation of Radiofrequency Fields Associated with the Itron Smart Meter", EPRI (2010), December 2010

- An RF exposure comparison of a person talking on a cell phone and a person 3 and 10 feet from a continuously operating Smart Meter would result in Smart Meter RF exposure 125 to 1250 times less than the cell phone.<sup>3</sup>
- In test environments simulating operational conditions, for power (250 mWatt - 2 Watt), duty cycle (2%-5%) at close distance (1 foot) from in front of the transmitter, Smart Meters produce very low RF exposure to the consumer, typically well under 10 % of the FCC exposure regulations.

Additionally, before utilities accept and deploy Smart Meters, these devices must meet a number of national standards and comply with state and local codes designed to ensure proper operation, functionality and safety. In particular, Smart Meter and Smart Meter installations are typically designed to conform with and certified to comply with:<sup>4</sup>

- *ANSI C12 .1, 12.10, and 12.20* standards for accuracy and performance
- *NEMA SG-AMI 1 “Requirements for Smart Meter Upgradeability”*
- FCC standards for intentional and unintentional radio emissions and safety related to RF exposure, *Parts 1 and 2 of the FCC’s Rules and Regulations [47 C.F.R. 1.1307(b), 1.1310, 2.1091, 2.1093]*.
- Local technical codes and requirements
- Utility specific and customer beneficial business and technical requirements

The electric utility industry is continuously developing standards and guidelines to improve the safety, accuracy and operability of meters and associated metering devices. An example of these continuing improvement is *NEMA SG-AMI 1 “Requirements for Smart Meter Upgradeability”* released in September 2009 to support the needs of developing the Smart Grid.

Finally, the paper discusses how manufacturers conduct complete performance and life cycle testing for all meter types and for major design changes to existing meter types, including hardware and firmware. Once the testing is successfully completed, the Smart Meter System components are utility or third party certified for production and purchase. Furthermore, after certification and purchasing, the paper discusses the utility materials acceptance process to evaluate each shipment of equipment for quality and compliance to specification. Completion of this process by utilities allows for receipt of equipment for field installation.

The deployment of a Smart Meter System begins with selection of the technology and the planning for installation, operation and maintenance. Utilities have integrated within the deployment process many elements of management, control and compliance to support successful project implementation.

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<sup>3</sup> “*Health Impacts of Radio Frequency (RF) from Smart Meters*”; California Council on Science and Technology (CCST); January 2011; page 20

<sup>4</sup> This list is not exhaustive, and there may be other sets of rules/standards/requirements not reflected but applicable.

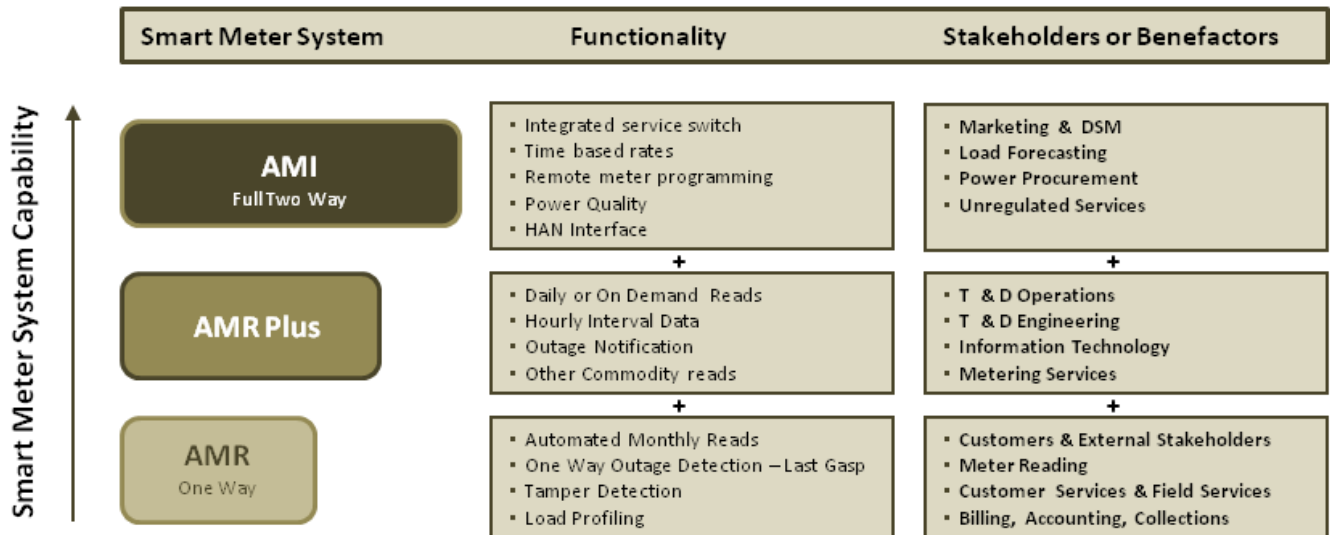
### 3. An Overview of Smart Meters and Smart Meter Systems

#### 3.1 Definition of Smart Meter and Smart Meter Systems

Smart Meters are electronic measurement devices used by utilities to remotely communicate information for billing customers and operating their electric systems. For over fifteen years electronic meters have been used effectively by utilities in delivering accurate billing data for at least a portion of their customer base. Initially, the use of this technology was applied to commercial and industrial customers due to the need for more sophisticated rates and more granular billing data requirements. The use of electronic meters came into service to the largest customers of the utility and over time gradually expanded to all customer classes. This migration was made possible by decreasing cost of the technology and advanced billing requirements for all customer classes.

The combination of the electronic meters with two-way communications technology for information, monitor and control is commonly referred to as Advanced Metering Infrastructure (AMI). Previous systems which utilized one way communication and were referred to as AMR (Automated Meter Reading) Systems. AMI has developed over time, from its roots as a meter reading substitute (AMR) to today’s two-way communication and data system. The evolution from AMR to AMI is shown in Figure 1 with lists of stakeholders and benefactors for each step in the Smart Meter evolution.<sup>5</sup>

Figure 1 – Smart Meter Technology Evolution



<sup>5</sup> Note: All functionality and stakeholder interests are additive, progressing up the chart

Not until the Smart Grid initiatives were established did AMI meters and systems become referred to as “Smart Meters and Smart Meter Systems”. Thus, the present state of these technologies should be more appropriately referred to as “an evolution, not a revolution” because of the development and use of Smart Meter technology and communications over the last fifteen years. The combined technologies are also required to meet national standards for accuracy and operability essential in the industry.

Although the Smart Meters are relatively new to the utility industry, they have still been treated with the same due diligence and scrutiny associated with the older electro- mechanical counterparts. These meters have always met or exceeded national standards such as American National Standards Institute (ANSI) C12.1 for meter accuracy and performance. Another quality control is that equipment used to certify meter performance must be traceable to the National Institute of Standards and Technology (NIST), a federal technology agency that works with industry to properly apply technology and measurements.

Other standards in use for the Smart Meter installations include National Electric Code (NEC) for home electrical wiring, National Electrical Manufacturers Association (NEMA) and Underwriters Laboratories (UL) for meters, enclosures and devices, and National Electric Safety Code (NESC) for utility wiring. Through the leadership of utility metering professionals and metering manufacturers, the meticulous and deliberate development of these solid state electronic measurement devices has resulted in meter products that have advanced functionality, are stable and have tighter accuracy tolerances, and are more cost effective for advanced features than the legacy mechanical technologies.

### 3.2 Smart Meter System Benefits

The benefits of Smart Metering installations are numerous for many different Stakeholders of the systems. The table below lists some of the major benefits for utility stakeholders.

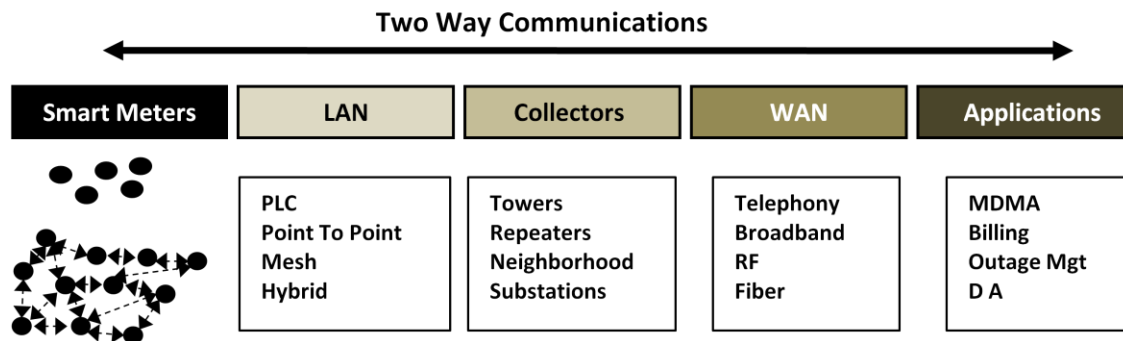
Stakeholder	Benefits
<b>Utility Customers</b>	<ul style="list-style-type: none"> <li>• Better access and data to manage energy use</li> <li>• More accurate and timely billing</li> <li>• Improved rate options</li> <li>• Improved outage restoration</li> <li>• Power quality data</li> </ul>
<b>Customer Service &amp; Field Operations</b>	<ul style="list-style-type: none"> <li>• Reduced cost of Meter reading</li> <li>• Reduced trips for off-cycle reads</li> <li>• Eliminates handheld meter reading equipment</li> <li>• Reduced call center transactions</li> <li>• Reduced collections and connects/disconnects</li> </ul>
<b>Revenue Cycle Services - Billing, Accounting, Revenue Protection</b>	<ul style="list-style-type: none"> <li>• Reduced back office rebilling</li> <li>• Early detection of meter tampering and theft</li> <li>• Reduced estimated billing and billing errors</li> </ul>
<b>Transmission and Distribution</b>	<ul style="list-style-type: none"> <li>• Improved transformer load management</li> <li>• Improved capacitor bank switching</li> <li>• Data for improved efficiency, reliability of service, losses, and loading</li> <li>• Improved data for efficient grid system design</li> <li>• Power quality data for the service areas</li> </ul>
<b>Marketing &amp; Load Forecasting</b>	<ul style="list-style-type: none"> <li>• Reduced costs for collecting load research data</li> </ul>

Stakeholder	Benefits
Utility General	<ul style="list-style-type: none"> <li>• Reduced regulatory complaints</li> <li>• Improved customer premise safety &amp; risk profile</li> <li>• Reduced employee safety incidents</li> </ul>
External Stakeholders	<ul style="list-style-type: none"> <li>• Improved environmental benefits</li> <li>• Support for the Smart Grid initiatives</li> </ul>

### 3.3 Smart Meter Technologies

Smart Meter Systems are varied in technology and design but operate through a simple overall process. The Smart Meters collect data locally and transmit via a Local Area Network (LAN) to a data collector. This transmission can occur as often as 15 minutes or as infrequently as daily according to the use of the data. The collector retrieves the data and may process it or simply pass it on for processing upstream. Data is transmitted via a Wide Area Network (WAN) to the utility central collection point for processing and use by business applications. Since the communications path is two way, signals or commands can be sent directly to the meters, customer premise or distribution device. The utility selects the best technology to meet its demographic and business needs. Figure 3 shows the basic architecture of Smart Meter System operations.

Figure 3: Smart Meter System Basic Architecture





## 4. Deployment of Smart Meter Systems

### 4.1 Meter and System Certification & Acceptance

A plan to certify the meters and other system components for purchase and installation is essential to the deployment of the Smart Meter System. The technical requirements developed by the utility will include the Smart Meter equipment specifications for meeting national standards for safety, accuracy, compliance, and functionality criterion.

Smart Meter hardware to be certified must be production units and must conform to or exceed:<sup>6</sup>

- Federal Communications Commission (FCC) standards for intentional and unintentional radio emissions, and safety related to RF exposure, *parts 1 and 2 of the FCC's Rules and Regulations [47 C.F.R. 1.1307(b), 1.1310, 2.1091, 2.1093.*
- *ANSI C12 .1, 12.10, and 12.20* standards for meter accuracy and performance
- Local technical codes and requirements
- A functional test designed to verify the compliance to utilities technical and business requirements
- Utility specified requirements that are expected to exceed the standards. Examples:
  - Higher surge requirements for areas with lightning issues
  - Stainless steel enclosures for close seaside locations

The electric utility industry is continuously developing standards and guidelines to improve the safety, accuracy and functionality of meters and associated metering devices. An example of these continuing improvements is the release of *NEMA SG-AMI 1 "Requirements for Smart Meter Upgradeability"* published in September 2009 in conjunction with NIST and Smart Grid Interoperability Panel (SGIP).

Complete performance testing is done by manufacturers and utilities for all meter types and for major design changes to existing meter types, including hardware and firmware. Once the testing is completed successfully, the Smart Meter System components are certified for production and purchase.

After certification and purchasing, the utility establishes a materials acceptance process to evaluate each shipment of equipment for quality and compliance with specification. The acceptance plan is usually a combination of vendor manufacturing test data and a sample test plan designed by the utility to meet its risk criteria. In addition to testing items included in the certification phase, other items may be evaluated. These may include items such as binding of the communication module to the meter, accuracy of the face plate data and data format, and quality of the meter data received, etc. Completion of this process allows receipt of equipment for field installation.

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<sup>6</sup> This list is not exhaustive, and there may be other sets of rules/standards/requirements not reflected but applicable.

## 4.2 Smart Meter Installation

The planning for the installation of Smart Meters is just as important as the actual installation itself. This part of the process, if done correctly, can lead to a smooth installation process with a minimum of errors, customer issues or installation delays. The safety aspects of the installation conform to:

- The National Electric Safety Code (NESC) for utility wiring
- The National Electric Code (NEC) for home wiring
- ASNI C12.1 – Code for Electricity Metering
- Local building codes

The customer is notified of the installation if they are present and the installation process begins. The first step in the installation process involves the assessment of access to the meter location and safety of the existing equipment. After proper access has been established, actions include:

- Check meter location for safety issues, damage, and diversion
- Verify meter data for service voltage and meter form type
- Verify premise information for correct address, meter number, GPS Location, etc
- Safely replace old meter with Smart Meter and re-seal
- Update customer premise information for new installation

National demographics show a housing unit split of approximately 74% single family and 26% multi-family homes, with percentages varying from state to state.<sup>7</sup> Therefore, the vast majority of the Smart Meter installations will be to single family homes with single meter base designs. Typically the meter base is mounted to the surface of an exterior wall<sup>8</sup> where the service entrance attaches to the house. Gang meter socket designs are used to consolidate multiple meters to a few locations for the multi-family dwelling units. Generally, these gang sockets are located in designated meter rooms, on the outside wall of apartment buildings, or in the basement of high rise apartment buildings. Both single family and multi-family installation processes are designed to address physical access and safety concerns, to make sure the proper type of Smart Meter is installed safely and correctly, and to ensure the correct information is obtained and delivered for accurate setup of customer billing.

After the Smart Meter is installed, it is usually ready for operation and is automatically registered with the network system. If the customer is not present and the installation cannot be completed, a notification is left detailing the process to schedule the installation for a later date.

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<sup>7</sup> “*Historical Census of Housing Tables, Units in Structure*”; U.S. Census Bureau, Housing and Household Economic Statistics Division; December 16, 2005

<sup>8</sup> See section 4 for further discussion



## 5. RF Exposure in Smart Meter Systems

The implementation of Smart Meter Systems has generated some concerns about RF exposure that the local jurisdictions and serving utilities have addressed or are addressing. In this regard, utilities have used verification, technical data, and numerous third party investigations to address the customer concerns appropriately.

### 5.1 Radio Frequency (RF) Exposure

Various Smart Meter Systems work by transmitting information wirelessly. The Federal Communications Commission (FCC) has jurisdiction over the approval and use of radio frequency devices, whether a license is required for the devices or if unlicensed operation is allowed. The FCC has a twofold role in ensuring safety:

- The FCC has allocated the radio spectrum into a variety of pieces, most of which needs coordination and a license before operation is permitted. At the same time, the FCC has allocated some frequencies for unlicensed operation (e.g., allowing consumers to purchase products at retail outlets and install them in their homes). These devices operate at low power levels, enabling communications but posing no known health effects to humans. Examples include the WiFi routers already discussed, wireless baby monitors and garage door openers. For the most part, Smart Meters fall under this low power, unlicensed criteria.
- The FCC's second role is to approve radio devices for manufacture, import and sale. Regardless of whether the equipment operates on low power unlicensed channels or at higher power levels that require authorization, each device must be tested to meet FCC standards. The sale of untested and unapproved equipment is a serious offense and the FCC aggressively prosecutes violators. FCC Rules governing the approval and sale of radio devices can be found in the Code of Federal Regulations (CFR) title 47, Part 15. These rules govern all aspects of radio emission, including both intentional and unintentional radiators.

Specific to RF safety issues, the FCC is required by the National Environmental Policy Act of 1969, among other things, to evaluate the effect of emissions from FCC-regulated transmitters on the quality of the human environment. Several organizations, such as the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers, Inc. (IEEE), and the National Council on Radiation Protection and Measurements (NCRP) have issued recommendations for human exposure to RF electromagnetic fields.

On August 1, 1996, the Commission adopted the NCRP's recommended Maximum Permissible Exposure (MPE) limits for field strength and power density for the transmitters operating at frequencies of 300 kHz to 100 GHz. The Commission's requirements are detailed in Parts 1 and 2 of the FCC's Rules and Regulations [47 C.F.R. 1.1307(b), 1.1310, 2.1091, 2.1093]. The FCC also presents OET Bulletin 65 on this topic. The revised OET Bulletin 65 has been prepared to provide assistance in determining whether proposed or existing transmitting facilities, operations or devices comply with limits for human exposure to RF fields adopted by the FCC. This bulletin offers guidelines and suggestions for evaluating compliance.

All Smart Meter radio devices must be certified to the FCC's Rules. Vendors develop products based on technical and regulatory specifications. Often, radio transmitters are integral parts of the meter itself;

integrated into the circuit board of the device. The manufacturer tests the devices to FCC specifications and then presents the test results to an independent certification laboratory, or the FCC directly. Only when the FCC reviews the detailed report and certifies the device can the manufacturer market and sell the devices. The same procedures are used for Wi-Fi network equipment in PCs and wireless routers located nearly everywhere in our homes and offices.

There are two types of potential effects due to RF emissions, non-thermal and thermal. To date, there is no conclusive research that confirms negative non-thermal health impacts caused by non-ionizing RF emissions. There is, however, scientific consensus that for certain RF signal strengths there could be negative health effects. Therefore, most health studies have focused solely on the thermal effects of RF.<sup>9,10</sup> Several studies have been prepared to investigate the RF exposures of Smart Meters with relatively consistent conclusions:

- Smart Meter exposures even at close range and with exaggerated duty cycle are many times less than other household devices and are compliant with FCC limitations.
- As an example, an RF exposure comparison of a person talking on a cell phone and a person 3 and 10 feet from a continuously operating smart meter would result in Smart Meter RF exposure of 125 to 1250 times less exposure than the cell phone.<sup>11</sup>

Utility installation and operational practices and the impacts of all equipment used in the premise service location affect the exposure levels of RF greatly. Smart Meters are universally mounted in metal enclosures referred to as sockets or bases. These enclosures are generally mounted outside and facing away from the living space of a home. Single family dwellings typically have one socket located at the point of service. For multi-family housing such as apartments, condominiums, and townhouses, the sockets are a single unit with multiple meters. They are usually located in designated meter rooms, on the outside structure wall, or in the basement of high rise apartment buildings. Most of these typical mounting locations are either facing away from or are not adjacent to living areas. In addition, local fire codes and practical construction techniques limit the number of meters that are typically wall mounted, as described above, for multi-family dwellings and are not usually readily accessible. In larger multi-family buildings, i.e. mid-rise and high-rise units, the meters are typically located in meter rooms or in the basements and are ordinarily secured for limited access.

Even in a meter room or basement with large numbers of meters, it is impossible to obtain peak exposure from every meter. For example, if the meter room is 12 feet wide and the body is 2 foot wide, a person could only be within one foot of 17 % of the meters. Typical exposure to Smart Meter fields is usually at some considerable distance. But for those relatively rare instances that result in close proximity to the meters, measurements have shown exposure well below FCC standard limits. Exposure in living spaces will be even less due to the attenuation of RF signal caused by building materials in the walls and other structures. A typical building wall construction combined with a surface mounted meter base will represent a nominal minimum 10 inch (25 cm) distance between the transmitter and the interior wall surface and

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<sup>9</sup> “*Health Impacts of Radio Frequency (RF) from Smart Meters*”; California Council on Science and Technology (CCST); January 2011

<sup>10</sup> “*Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*”; OET Bulletin 65; Edition 97-01; August; Federal Communications Commission, Office of Engineering & Technology

<sup>11</sup> “*Health Impacts of Radio Frequency (RF) from Smart Meters*”; California Council on Science and Technology (CCST); January 2011; page 20

potential internal dwelling RF exposure to humans. Actual measurements directly behind the meter on the inside of the wall have produced MPE's of 0.01 % of the FCC limits.<sup>12</sup>

At all meter premise locations, the meter socket acts as a barrier for RF emissions entering the home. Manufacturers point out that the area behind the meter socket is virtually a dead spot for RF emissions. In addition, measurements have shown that at 8 inches behind gang meter sockets, the RF exposure is over 10 times less than the same distance in front of the sockets and less than 1% of the FCC exposure limits.<sup>13</sup> The metal meter socket reflects almost all of the RF out of the front of the meter. The only path for RF to get into a building is by first bouncing off the ground or an adjacent house and then back into the building. The distances required for this to happen dramatically reduce the power signal by the time it has traveled a minimum of 4-5 feet to the ground and into the living space.

The following are examples of measured RF exposure level with transmitter at continuous operation (an unrealistic condition) from a gang meter arrangement simulating an apartment metering location.

**Example 1**

Duty Cycle	% FCC Limit @ 1 ft $\mu\text{W}/\text{cm}^2$	% FCC Limit @ 2ft	% FCC Limit @ 3 ft	% FCC Limit @ 5 ft
100%	8.1 %	3.9%	2.5%	1.4%

A 10 meter rack with a 250 mWatt 915 MHz<sup>13</sup> Smart Meter transmitter simulating an apartment wall meter installation demonstrating of exposure variance with distance<sup>14</sup>

**Example 2**

Duty Cycle	Front Exposure @ 1 ft % FCC MPE	Rear Exposure @ 8 in % FCC MPE	Rear Exposure @ 5 ft % FCC MPE
100%	8.1%	0.6%	0.25%

A 10 meter rack with a 250 mWatt 915 MHz Smart Meter transmitter front and rear measurement RF exposure comparison<sup>15</sup>

The FCC limits on maximum permissible exposure (MPE) for application to the general public were set using safety factors fifty times lower than the levels of known effects. The MPE's are those values of RF field strength, or power density that have been averaged over any 30-minute period (time averaging) and

<sup>12</sup> "An Investigation of Radiofrequency Fields Associated with the Itron Smart Meter", EPRI (2010),December 2010

<sup>13</sup> Generally refers to the FCC's "license free" band of 902-928 MHz

<sup>14</sup> "An Investigation of Radiofrequency Fields Associated with the Itron Smart Meter", EPRI (2010),December 2010

<sup>15</sup> "An Investigation of Radiofrequency Fields Associated with the Itron Smart Meter", EPRI (2010),December 2010

averaged over the dimensions of the body (spatial averaging). Discussed below are several basic factors that affect RF exposure:

**RF frequency**

Most Smart Meters use the same frequencies as other RF devices in the home, the 915 MHz band and 2.4 GHz band. The RF exposure limits, MPE, set by the FCC for Smart Meters are rated at the frequencies they use to communicate:

- 915 MHz                                      601  $\mu\text{W}/\text{cm}^2$  avg.
- 2.4 - 100 GHz<sup>16</sup>                              1000  $\mu\text{W}/\text{cm}^2$

**Transmitter Power**

Smart Meters use low power transmitters, generally one watt or less for unlicensed frequency, 2 watts licensed, and produce relatively weak RF signals.

**Distance**

The power density decreases proportional to the square of the distance from the RF source at single meter locations. At multi-meter sites, the power density decreases significantly but at a lesser rate, proportional to the distance.

**Duty Cycle (RF Exposure time)**<sup>17</sup>

The percentage of time an RF device is in operation is called the duty cycle. The actual percent of time the Smart Meter is transmitting, especially in the initial years of operation, is very small, usually less than 1% (less than 15 minutes accumulated total per day). There are several other factors that affect the duty cycle for Smart meter systems.

The first factor of the duty cycle is how many meters communicate at the same time. As a practical design matter, when several Smart Meters are placed in a cluster, they generally have to communicate with a single controller. In order to ensure that the controller receives the information properly, transmitters are typically programmed to communicate with a controller in a random fashion, significantly decreasing the potential for exposure to multiple signals at the same time.

The second factor is the length of the communication. Smart Meter communications are typically less than a second and under normal operations, the programmed interval for randomized transmissions is 4 to 6 hours or longer. Over time, while it is possible that the duty cycle could rise due to additional use of the system for Smart Grid initiatives, the use of higher data transfer rates could, in fact, diminish the duty cycle.<sup>18</sup> All meters transmitting continuously will disrupt the system from functioning properly due to message traffic congestion and collisions. Therefore, the practical operational limit is less than 50%; well below 100% duty cycle sometimes used for comparisons. In spite of this, several RF exposure studies consider 2% -5% duty

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<sup>16</sup> To date there are no known Smart Meter Systems that operate above 6 GHz.

<sup>17</sup> “An Investigation of Radiofrequency Fields Associated with the Itron Smart Meter”, EPRI (2010),December 2010

<sup>18</sup> “Wireless Transmissions: An Examination of OpenWay Smart Meter Transmissions in a 24 hour Duty Cycle”; Itron Inc.; 2011; page 6, note #2.

cycle operational scenarios, and a 100% duty cycle, continuous operation, scenario to establish an absolute maximum exposure value.

### **Spatial Averaging**

MPE values are measured by averaging the exposure value over the dimensions of the body. Since different parts of a person's body are at varying distances from the transmitter, the RF exposure will vary at different parts of the body. At the typical 5 foot mounting height, a person's head may have maximum exposure but the person's knee will receive less exposure. The spatial average MPE is 18% to 24% of the peak value MPE on the body.<sup>19</sup>

In summary, the RF exposure effects of Smart Meters are very small compared to exposure from other sources in the home. Smart Meters operate significantly below FCC exposure limits. In addition, the location, distance from the transmitter, shielding by meter enclosures, attenuation of building materials, direction of RF emissions, and limited duty cycles even further reduce exposure to consumers. A review of the results of several Smart Meter RF studies and actual measurements of Smart Meter RF emissions support these observations. Other summary observations include:

- All smart meter radio devices must be certified to the FCC's rules.
- Exposure levels drop significantly with the distance from the transmitter, with spatial averaging, and in living spaces due to the attenuation effects of building materials.
- The FCC limits on maximum permissible exposure (MPE) for application to the general public were set using safety factors fifty times lower than the levels of known effects.
- Tests simulating multi-family metering locations containing several meters in close proximity have shown RF exposure levels dramatically less than FCC standards.
- Due to shielding of the meter enclosure and signal patterns, RF exposure from the rear of a metering location is nominally 10 times less than in front of the meter and dramatically below FCC limits, not including the spatial averaging and building material attenuation reductions.<sup>20</sup>
- For measurement and calculation purposes some studies use a 100% duty cycle parameter. However, the maximum operational Duty Cycle for Smart meter systems is less than 50% due to message traffic congestion and collisions. The typical Duty Cycles for Smart Meter Systems is between 1% and 5%.
- An RF exposure comparison of a person talking on a cell phone and a person 3 and 10 feet from a continuously operating Smart Meter would result in Smart Meter RF exposure 125 to 1250 times less than the cell phone.<sup>21</sup>
- In test environments simulating operational conditions, for power (250 mWatt - 2 Watt), duty cycle (2%-5%) at close distance (1 foot) from the transmitter, Smart Meters cause very low RF exposure to the consumer, typically well under 10 % of the FCC exposure regulations.

<sup>19</sup> "An Investigation of Radiofrequency Fields Associated with the Itron Smart Meter", EPRI (2010), December 2010

<sup>20</sup> "An Investigation of Radiofrequency Fields Associated with the Itron Smart Meter", EPRI (2010), December 2010

<sup>21</sup> "Health Impacts of Radio Frequency (RF) from Smart Meters"; California Council on Science and Technology (CCST); January 2011; page 20



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