

# Report to the City of Glendale

## Health Effects of Radio Frequency Energy from Smart Meters and Collection Systems

---

### **Executive Summary**

As utilities seek to modernize their aging infrastructure and upgrade to a “smart” electric grid, wireless communications will play an ever increasingly important role in the facilitating these enhancements. Several consumer groups have raised concerns about the potential health effects of a two way communications device, the next generation electric meter or smart meter, on their homes.

This paper provides a brief review of the safety standards dealing with radio frequency energy and safety and shows that smart utility devices pose no health threat. The report compares other household wireless devices to smart meters to show the energy from a meter is actually less than commonly used devices. Finally, we show the devices proposed by the City of Glendale meet the safety guideline set out by government agencies.

The City’s smart grid deployments use devices that fall into the same category as many wireless devices found in the home, such as wireless routers used for internet connectivity and wireless baby monitors. Unlikely the laptop or WiFi router in the home that are always transmitting, smart meters transmit for only a fraction of the day for short durations.

### **Introduction**

Smart Grid is a transformed electricity transmission and distribution network or "grid" that uses robust two-way communications, advanced sensors, and distributed computers to improve the efficiency, reliability and safety of power delivery and use. Deploying the Smart Grid became the policy of the United States with passage of the Energy Independence and Security Act of 2007 (Title 13). The Smart Grid is also being promoted by the European Union and other nations.

The smart grid will rely on the use of radio frequencies to provide wireless connectivity to the various components of the new grid. Wireless communications technology has become ubiquitous in our lives, enabling mobile connectivity with cell phones, wireless internet services and home area networking with WiFi technology and even cooking our food with microwave ovens. Yet there are unsubstantiated concerns that the smart meters being installed around the country and the world will cause ill health effects to members of the household where the meters are installed.

In this report, we examine the facts about the impact of radio frequency energy on the body, showing that the devices utilities seek to install pose no threat of harm to humans. We show that the type of radio energy used and emitted by smart meters, cell phone, wireless routers and microwave ovens can only damage the body at extremely high levels. While research continues into long term effects, there has been no conclusive evidence that low level RF energy has a long term negative impact. This report concentrates on RF energy and acknowledges that electric meters are connected to the power system and unauthorized tampering or dismantling an electric meter could pose electric shock danger to anyone coming in direct contact with energized electric conductors.

# Report to the City of Glendale

## Health Effects of Radio Frequency Energy from Smart Meters and Collection Systems

---

### **Federal Jurisdiction for Safety of Radio Frequency Devices**

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. FCC regulations are based on standards set by the Institute of Electrical and Electronic Engineers (IEEE) based on years of research by health professionals. The FCC's has a twofold role in ensuring safety. First, the FCC has allocated the radio spectrum into a variety of pieces, most of which need coordination and license before operation is permitted. Examples of this include television, satellite and radio broadcast channels, a variety of cellular and personal communications service frequencies, and microwave frequencies that transmit huge amounts of information from one point to another using dish style antennas. At the same time, the FCC has allocated some frequencies for unlicensed operation, allowing consumers to purchase products at Best Buy or Wal-Mart and install them in their homes. These devices operate at low power levels, enabling communications but posing no threat of health effects to humans. Examples include the WiFi routers already discussed, wireless baby monitors and garage door openers.

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 operations that require an 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 Mandates on RF Exposure and Impact on Humans**

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 limits for field strength and power density for the transmitters operating at frequencies of 300 kHz to 100 GHz. In addition, the Commission adopted the specific absorption rate (SAR) limits for devices operating within close proximity to the body as specified within the ANSI/IEEE C95.1-1992 guidelines. (See Report and Order, FCC 96-326) 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 potential hazards associated with RF electromagnetic fields are discussed in FCC's Office of Engineering and Technology (OET) Bulletin No. 56, "Questions and Answers About the Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields."<sup>1</sup>

---

<sup>1</sup> <http://www.fcc.gov/oet/rfsafety/>

# Report to the City of Glendale

## Health Effects of Radio Frequency Energy from Smart Meters and Collection Systems

---

The FCC also offers OET Bulletin 65 on this topic. This 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 radiofrequency (RF) fields adopted by the Federal Communications Commission (FCC). The bulletin offers guidelines and suggestions for evaluating compliance.

### **Understanding the Impact of RF Energy on Humans**

RF signals are known to propagate as waves, and one of the key characteristics of the wave is its frequency. Frequency is the most significant control factor in radio transmission and impacts how the waves travel through space, whether they pass through walls or bounce off them, the wave's interaction with foliage, etc. Use of the transit frequency is common knowledge in our society, as commercial radio and television stations often use this parameter as part of the public persona.

Frequency also determines the impact of RF energy on the human body. Only very high frequencies, ultraviolet rays and above, have the capability of mutating living cells to cause cancer and similar illness. This frequency range is known as ionizing radiation because the RF energy creates ions out of living cells by removing or adding electrons at the cellular level.

Non-ionizing radio energy fall below this frequency range and the primary interaction with human cells is to heat them. This is the basis for the microwave oven. Non-ionizing energy, at a high enough level, will heat human cells until they die, but non-ionizing energy is simply incapable of mutating cells and causing cancer.

Industry research and standards agencies, such as ANSI and IEEE, have compiled the research associated with human exposure of RF energy and created guidelines that the FCC and the Federal Occupational Safety and Health Administration (OSHA) have adopted. The standards incorporate frequency of the energy to define maximum exposure levels (MPE). The resulting MPE levels incorporated into the requirement include a 10:1 safety ratio to account for variations in size, weight and physical condition of the subject. Therefore exposure even at 100% of the MPE level will not cause physical harm.

In order to further protect the public from exposure to RF energy, the FCC set the MPE discussed above as the "occupational" or "controlled" environment, intended for workers and other professional previously trained in safety related to RF energy. The FCC then created a "general public" or "uncontrolled" environment criteria that added an additional 5:1 safety factor over the occupational level. Thus the FCC's MPE limit for the general public is 50 times less than the level research shows can actually cause harm.

# Report to the City of Glendale

## Health Effects of Radio Frequency Energy from Smart Meters and Collection Systems

---

**Table 1. LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)**

**(A) Limits for Occupational/Controlled Exposure<sup>2</sup>**

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm <sup>2</sup> )	Averaging Time  E  <sup>2</sup> ,  H  <sup>2</sup> or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	(900/f <sup>2</sup> )*	6
30-300	61.4	0.163	1.0	6
300-1500	--	--	f/300	6
1500-100,000	--	--	5	6

**(B) Limits for General Population/Uncontrolled Exposure**

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm <sup>2</sup> )	Averaging Time  E  <sup>2</sup> ,  H  <sup>2</sup> or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f <sup>2</sup> )*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz \*Plane-wave equivalent power density

NOTE 1: **Occupational/controlled** limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2: **General population/uncontrolled** exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

---

<sup>2</sup> Exposure is assumed to be constant.

# Report to the City of Glendale

## Health Effects of Radio Frequency Energy from Smart Meters and Collection Systems

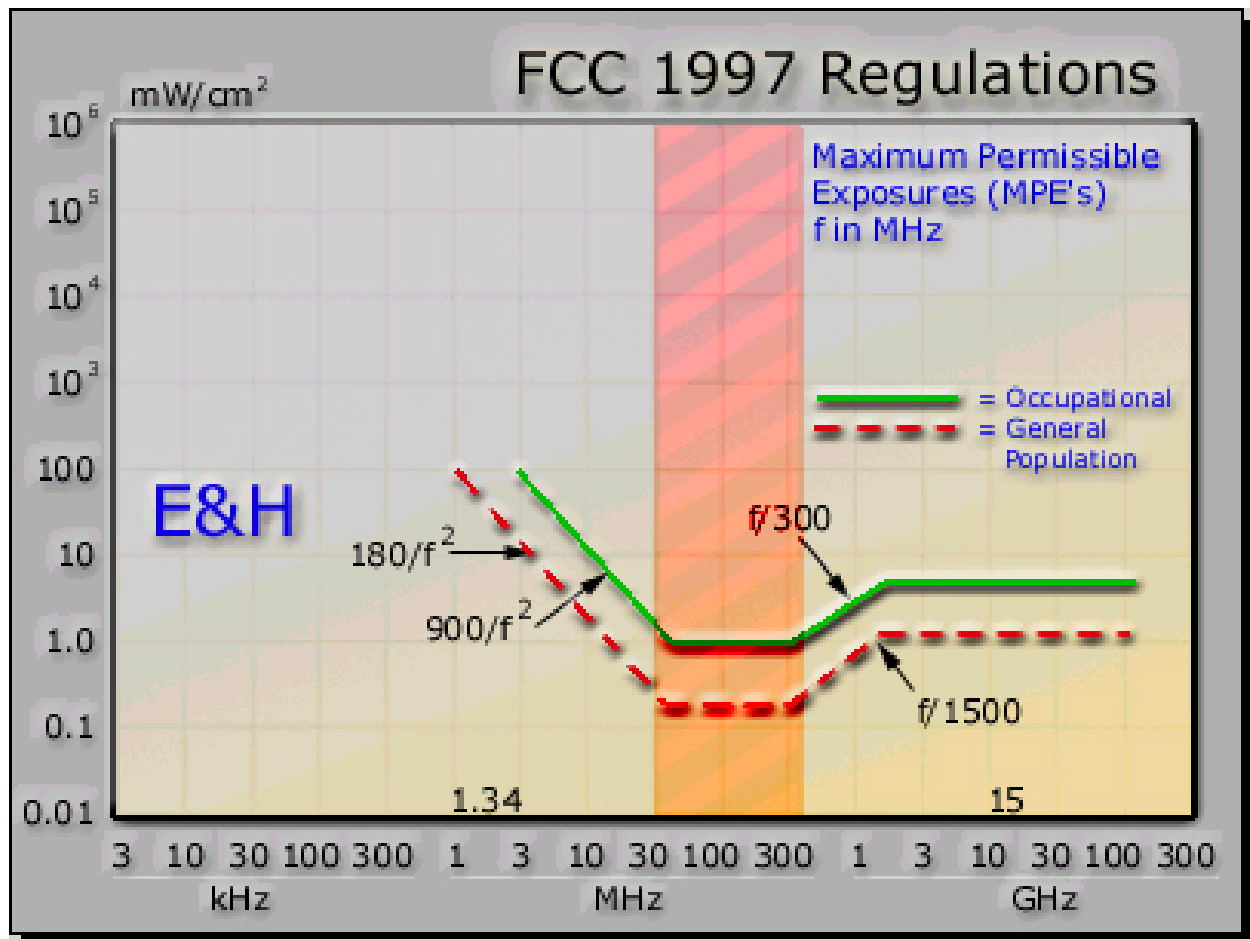


Figure 1. MPE Level by Frequency and Class (Source: Sitesafe, Inc., Arlington VA)

The FCC’s OET 65 document also defines concepts like time averaging. As shown in the tables above, the averaging time for occupational/controlled exposures is 6 minutes, while the averaging time for general population/uncontrolled exposures is 30 minutes. It is important to note that for general population/uncontrolled exposures it is often not possible to control exposures to the extent that averaging times can be applied. In those situations, it is often necessary to assume continuous exposure.<sup>3</sup> Since the known danger in RF energy is tissue heating, if the subject moves out of the area of high RF levels, the cells will return to normal temperature. At 100% or less of MPE, there is no danger in continuous exposure. Time average says that if one is in an area identified as 200% of the occupational MPE, up to three minutes of exposure is safe as long as three minutes elapse in an area at less than 100% MPE.

<sup>3</sup> FCC OET Bulletin 65

# Report to the City of Glendale

## Health Effects of Radio Frequency Energy from Smart Meters and Collection Systems

---

In summary, there is no known long term health effect from exposure to RF energy at levels below those designated by the FCC. This energy is all around and the energy associated with smart meters is far less than those of other common services and equipment

### Comparison of RF Power Density in the Everyday Environment

Device Relative Power Density in microwatts per square centimeter ( $\mu\text{W}/\text{cm}^2$ )

FM radio or TV broadcast station signal	0.005
<b>SmartMeter™ device at 10 feet</b>	<b>0.1</b>
Cyber cafe (Wi-Fi)	10-20
Laptop computer	10-20
Cell phone held up to head	30-10,000
Walkie-Talkie at head	500-42,000
Microwave oven, two inches from door	5,000

Source: Richard Tell Associates, Inc.<sup>4</sup>

### Meter Reading System Configurations

Residential and industrial electric meters allow utilities to accurately bill for the energy consumed. These devices have been used as long as the electric industry has been in place. Early meters required manual reading, with a utility employee writing down the use data and returning to the office to enter that information into the utility billing system. The use of radio frequencies to interrogate meters began in the early 1980's. These systems used an interrogation signal sent from a utility employee either walking or driving through the area of interest. A radio signal "pings" the meters within range and the devices respond with consumption information, also using radio signals.

As previously noted, the electric infrastructure in the US is going through a major transition, replacing equipment that can be 40 to 50 years old. At the same time, renewable energy sources like solar and wind must be integrated into this new grid. Increased communication with consumers that allows customers to adjust their energy usage based on the instant rate is a key component of the smart grid and this capability relies on smart meters.

---

<sup>4</sup> Pacific Gas and Electric: <http://www.pge.com/myhome/edusafety/systemworks/rf/>

# Report to the City of Glendale

## Health Effects of Radio Frequency Energy from Smart Meters and Collection Systems

---

Smart meter systems varying in implementation depending on the utility's needs and the vendor selected. Most utilities are electing to install radio based smart meter systems. Radio based systems also vary in configuration, but each system is made up of the following components:

1. **Meter:** The meter device measures consumption and stores the information for retrieval by the utility.
2. **Meter Transceiver:** The transceiver is a radio that receives instructions from the utility network and transmits necessary information to the utility. The transceiver is often an integral part of the meter, especially in the case of electric meters. Often, water and gas meters' transceivers are mounted near the device. The meter's radio system can also communicate with home energy management systems used by customers to control and monitor appliance power consumption. The meter transceivers operate on low power unlicensed channels, or in some cases, using cellular radio channels.
3. **Data Aggregation Points:** The meter transceiver transmits information to nearby collection devices, often called data aggregation points (DAPs). These devices are often mounted on nearby power poles at heights of 20 to 30 feet above ground. The DAPs collect information and transmit that information to the utility. If the utility has high capacity fiber infrastructure, that resource carries information from the DAPs. Typically, the DAP will communicate with center receive stations on radio frequencies in the unlicensed bands, or using cellular technology.

A common misconception about smart meters is that they are always "on" or transmitting. This is far from the case. Water and gas utilities usually read meters once or twice a month and the time needed to transmit information is less than 1 second. Electric utilities are implementing time-of-use billing structures but rarely need to read the meter more than once every 15 minutes. Again, the time to transmit consumption data is less than 1 second. This means in this scenario, these low power devices are transmitting approximately 0.11% of the day<sup>5</sup>, at short bursts of less than one second. Even if the meter transmits once every 15 seconds, transmission would still only be 6.7% of the day

We know from our discussion of RF exposure, even if the RF levels from these devices would exceed 100% of the FCC MPE, the impact on the body takes time. For the RF signal from a smart meter to be powerful enough to harm the human, that signal would have to be so powerful the transmission would be on the order of TV or radio broadcast stations. This is clearly not the case for smart meters.

### **City of Glendale Smart Grid Configuration**

The smart meter deployment for Glendale uses components from two vendors. Tropos Networks provides a mesh network that relays meter information from regional DAPs to metering headquarters. Itron is the vendor for the electric and water meters, and the pole mounted collection devices. We discuss each of these devices in detail below.

---

<sup>5</sup> Daily exposure percentage =  $[(4 \text{ seconds/hour}) / (24 \text{ hours/day} * 60 \text{ minutes/hour} * 60 \text{ seconds/minute})] * 100$

# Report to the City of Glendale

## Health Effects of Radio Frequency Energy from Smart Meters and Collection Systems

---

### **Open Way Electric Meter**

The electric meter is governed by the unlicensed radio device specifications in FCC Rule 15.247. The meter uses frequency hopping in the 910-920 MHz band to ensure the information is received at the DAP. This configuration limits the power to 0.25 watts. The device also uses a transmitter at 2400 MHz using Zigbee protocol to communicate with in-home energy management systems. The maximum power for this band is 1 watt.

The predicted percentage of the MPE at general population level for the 900 MHz transmitter is 32.6%, measured at 10 cm. If we assume a 1 second transmission every 15 seconds, the resulting duty cycle percentage is 7%. The percentage of MPE is thus 2.2% with duty cycle factor included. This is nearly 50 times below the FCC limit for general population exposure.

The predicted percentage of the MPE at general population level for the 2400 MHz transmitter is 79.6%, measured at 10 cm. If we assume a 1 second transmission every 15 seconds, the resulting duty cycle percentage is 7%. The percentage of MPE is thus 5.3% with duty cycle factor included. This is nearly 20 times below the FCC limit for general population exposure.

### **Water SaveSource Water Module**

The SaveSource module is a stand-alone device that connects to various water meters by cable. The radio in this product uses frequencies in the 1427-1432 MHz band, licensed under FCC Rule 90.259. Maximum output power for devices in residences and other buildings is 0.6 watts.

The predicted percentage of the MPE at general population level for the 1427 MHz transmitter is 50.2%, measured at 10 cm. We note that water meters are often read less frequently than electric meters, so we assume a duty cycle percentage of 1%. The percentage of MPE is 0.5% with duty cycle factor included. This is nearly 200 times below the FCC limit for general population exposure.

### **Cell Control Unit 4**

In electric meter case, the Cell Control Unit is the Data Aggregation Point mounted on utility poles. However, this device does not transmit a radio signal, it merely receives meter data from the devices under its control and processes the information. Output from this device is transferred via cable connection to the WAN portion of the network, discussed below.

The Cell Control Unit also uses a 1427-1432 MHz transceiver that collects meter data from the water meters. FCC Rule 90.259 limits the transmitter power to 10 watts, though Itron licenses the devices for only 2 watts.

At 2 watts, the predicted percentage of the MPE at general population level for the 1427 MHz transmitter is 0.017%, measured at 10 meters, or 30 feet, on a pole. We assume an aggressive duty cycle



# Report to the City of Glendale

## Health Effects of Radio Frequency Energy from Smart Meters and Collection Systems

---

percentage of 50%. The percentage of MPE is 0.008% with duty cycle factor included. This is nearly 12,500 times below the FCC limit for general population exposure.

### **Tropos 7320 Mesh Network Transceiver**

The final layer in the Glendale Smart Grid network is provided by a mesh network of pole top mounted devices that feed electric and water meter data to the Glendale billing centers. The Tropos transceivers also use unlicensed radio spectrum. The technology used is WiFi, the same as residential internet routers, though at a slightly higher power level. The specifications for these devices provides the maximum output power as 36 dBm, or 3.98 watts. The device uses two frequency bands, 2.4 GHz and 5.8 GHz. The FCC MPE level is the same for both bands.

At 4 watts, the predicted percentage of the MPE at general population level for these transmitters is 0.032%, measured at 10 meters, or 30 feet, on a pole. In this case, we assume the devices are always on, an aggressive duty cycle percentage of 100%. The percentage of MPE is 0.032% with duty cycle factor included. This is nearly 3,150 times below the FCC limit for general population exposure.

### **Summary**

In this paper, we defined the concept of the smart grid and the benefits to society. We also highlighted the importance of smart grid radio networks to the successful deployment of the smart grid. This report provides the important concepts of RF energy and the impact on humans. Specifically, there is no demonstrated long term impact of low level non-ionizing energy on humans. Ionizing energy, beginning with the ultraviolet component of sunlight, has been demonstrated to have long term impact, but the frequencies cited in this report are hundreds of orders of magnitude below that of sunlight. Therefore, this shows that the often quoted sources in the media expressing concern about the RF safety from smart meters are shown to be based on faulty logic, or faulty "facts" and misrepresentations.

We show that a specific analysis of the component used in this smart grid deployment are significantly below general population MPE and note, again, that FCC limits for MPE of general population are already at least 50 times lower than levels that can cause tissue heating.

Report to the City of Glendale  
Health Effects of Radio Frequency Energy from Smart Meters and  
Collection Systems

---

Prepared for the City of Glendale, CA by

A handwritten signature in blue ink that reads "Klaus Bender". The signature is fluid and cursive, with a long horizontal stroke at the end.

Klaus Bender, PE  
Directory of Standards and Engineering  
Utilities Telecom Council  
Washington DC

# Report to the City of Glendale Health Effects of Radio Frequency Energy from Smart Meters and Collection Systems

---

## **Appendix – Useful Links**

<http://www.fcc.gov/oet/rfsafety/>

<http://www.fcc.gov/oet/rfsafety/rf-faqs.html>

<http://www.fcc.gov/oet/info/documents/bulletins/Welcome.html#56>

<http://www.fcc.gov/oet/info/documents/bulletins/Welcome.html#65>

Report to the City of Glendale  
Health Effects of Radio Frequency Energy from Smart Meters and Collection Systems

---

**Appendix - Calculations**

<b>Component</b>	<b>Frequency Band</b>	<b>Effective Isotropic Radiated Power (mw)</b>	<b>Distance (cm)</b>	<b>Calculated Power Density</b>	<b>Uncontrolled MPE Limit (mw/cm^2)</b>	<b>MAX % of limit</b>	<b>Duty Cycle %</b>	<b>Average % of MPE</b>
Tropos Outdoor Router	2400 MHz	4000.0	1000.0	0.000318309	1	0.032%	100%	0.032%
Tropos Outdoor Router	5800 MHz	4000.0	1000.0	0.000318309	1	0.032%	100%	0.032%
Water Meter	1428 MHz	600.0	10.0	0.477463713	0.952	50.154%	1%	0.502%
Water Meter CCI	1428 MHz	2000.0	1000.0	0.000159155	0.952	0.017%	50%	0.008%
Electric Smart Meter	915 MHz	250.0	10.0	0.198943214	0.61	32.614%	7%	2.174%
Electric Meter Zibgee	2400 MHz	1000.0	10.0	0.795772855	1	79.577%	7%	5.305%