Smart meters:
Compliance with radio frequency exposure standards

Summary

Smart meters use low power radio frequency signals to collect and transmit information about use of services such as electricity, water and gas. The meter reading data is collected and collated at access points and forwarded to the power company over the existing mobile networks in the same way as a call or text is sent. The radio frequencies and nominal powers transmitted are similar to those used for mobile phones and home wireless internet connections. However, as smart meters transmit for very short intervals and infrequently, the average transmitted powers are very low. A number of studies have concluded that the duty cycle (the percentage of time the signal is transmitted) is very small, typically less than 5% for most of the time (even for heavily loaded access points) and far less than 1% for most meters for the majority of the time.

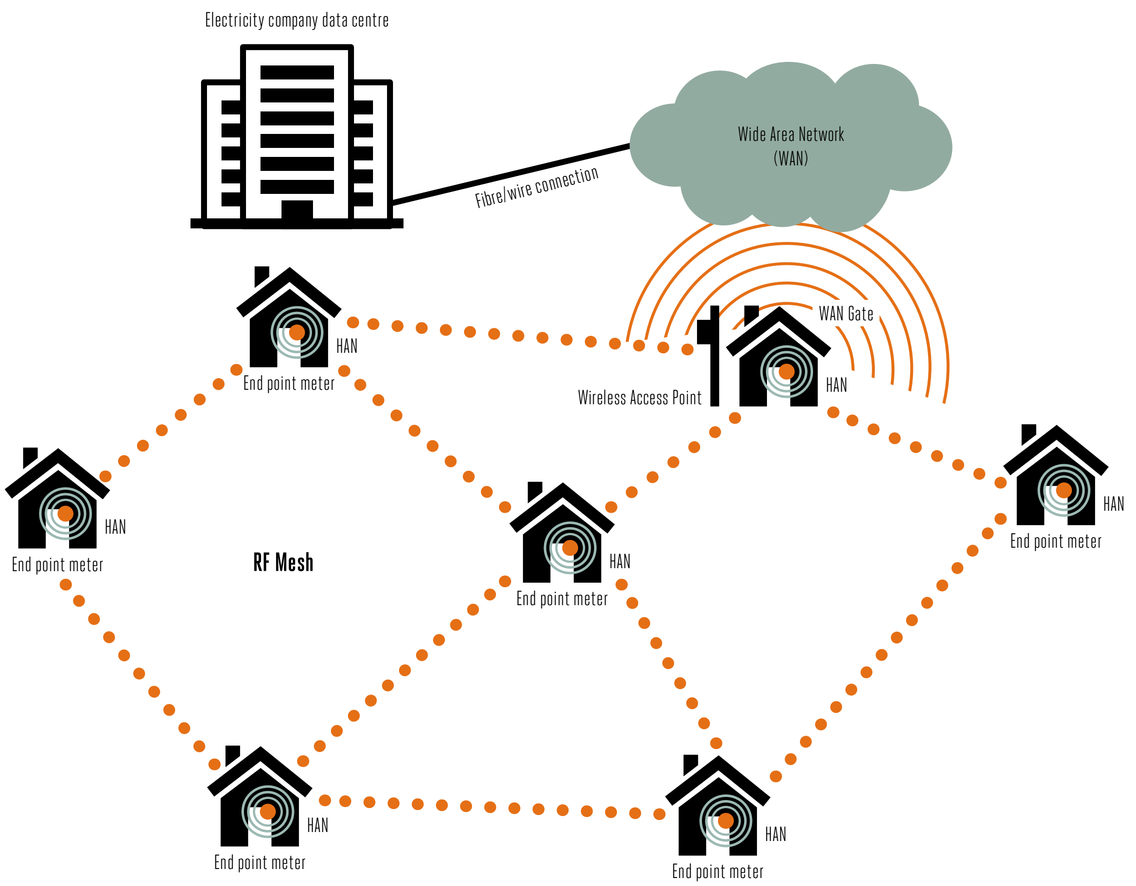
Measurements of both single and banks of smart meters have been made by organisations in many different countries. The results are broadly similar from all the surveys. The exposure levels are similar to many common devices and transmission services including home Wi-Fi, laptops, mobile phone base stations and TV/FM broadcast services.

The possible health hazards of radio-frequency energy have been studied for many years. The consensus of expert groups and health agencies is that there are no established health effects below recommended exposure limits. Numerous national public health agencies have concluded that the radio signals used by smart meters do not pose a health risk and that there is no scientific basis to decline having a smart meter installed.

Introduction

Advance Metering Infrastructure (AMI), commonly known as smart meters, use low power radio frequency signals to collect and transmit information about use of services such as electricity, water and gas. Whilst different utility companies may configure their smart meter networks slightly differently, all networks contain radio transceivers (transmitters and receivers) located at the customer premises that transmit information about the service usage to wireless access points. The radio transceivers are similar to the wireless routers many people have installed in their homes and offices to communicate within a computer network and ultimately with the Internet via a wireless access point. Similarly, the wireless access points within the smart meter network collect and transmit usage data to the utility company via a cellular mobile type network or wide area network (WAN). Some meters support a Home Area Network (HAN) that allows monitoring and control activities within the residence. Figure 1 illustrates the main radio links of a smart meter system.

Mesh network of smart meters also equipped with Home Area Network (HAN).



(adapted from EPECentre, 2012)

Figure 1

The radio transceivers at the customer premises and the access points may be organised into a mesh network where they can both transmit data and communicate with each other. Radio transceivers can be installed as single units in individual dwellings or in banks to serve blocks of dwellings. Wireless access points are typically located in an elevated position to ensure a satisfactory radio communication with each of the transceivers it receives data from. Individual transceivers can also be configured to operate as wireless access points depending on the quality of the received radio signal which is primarily impacted by separation distance, local geography and building structure. Smart meters are fitted with an internal antenna which can be replaced by an external antenna fitted to the outside of the cabinet or further away to improve reception and transmission.

The individual transceivers typically operate in the 902–928 MHz and 2.4-2.48 GHz bands, utilising both frequency-hopping and spread spectrum techniques which are controlled by a wireless mesh network overlay.

Some meters use cellular data modems at 900 MHz, 1.8 GHz or 2.1 GHz, the same technology used in mobile phones. The meter reading data is carried over the existing mobile networks in the same way as a call or text is sent.

Depending on the radio technology used the transceivers operate at a nominal peak power of up to 1 W. However, as they transmit for very short intervals and infrequently, the average transmitted powers are very low.

Smart meter data transmission and duty cycles

The communication between smart meters includes the service use data, as well as information to and from other smart meters within the mesh network, to maintain the hierarchy of each of the meters within the network. The transmissions within the network are characterized by very short pulses sometimes referred to as chirping and the numbers of pulses vary throughout the day and with the level of the meter within the network. Smart meters which are configured as access points transmit a higher number of pulses. The wireless access point that finally communicates to the WAN and ultimately the utility company transmits the highest number of pulses.

Illustration of smart meter duty cycle

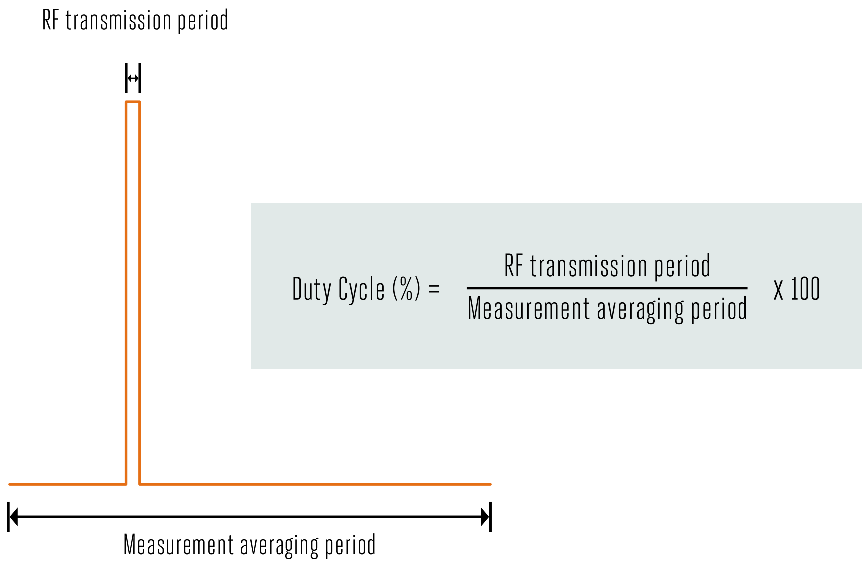


Figure 2

Tell et al. (2012a) and EMC Technologies (2011) have extensively investigated the characteristics of the data transmission and duty cycles (the percentage of time the signal is transmitted – see Figure 2) in operational smart meter networks with different smart meter brands and different power utility networks. Tell et al. (2012a) analysed data from 46,698 meters over an 89 day period. Based on more than four million data points, they conservatively estimated the maximum duty cycle as 4.74% and that this occurred in 0.1% of values. For 99% of values, the duty cycle was only about 0.1%. EMC Technologies (2011) investigated actual byte count data from over 2,000 meters, including a highly loaded access point. They concluded that the majority of the meters had a duty cycle of between 0.3% – 0.4% and that 99.9% of the meters were transmitting below a duty cycle of 2.5%. Based on this data, it can be concluded that the duty cycle is very small, typically less than 5% even for heavily loaded access points and far less than 1% for most meters.

SMART METERS TYPICALLY TRANSMIT LESS THAN 1% OF THE TIME.

Results of measurements of smart meters

International radio frequency (RF) exposure guidelines have been developed to provide protection against established effects from RF fields by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998) and the Institute of Electrical and Electronic Engineers (IEEE, 2005). In the United States, the Federal Communications Commission (FCC) has adopted limits that are similar to those of ICNIRP and the IEEE (FCC, 1997).[1]

Measurements of both single and banks of smart meters have been made by organisations in many different countries. The results are broadly similar from all the surveys. Some important features are summarised in Table 1 and Table 2 based on measurements conducted in Australia and the United States.

Peak measured levels

The peak levels represent maximum values during the short transmission periods. These need to be multiplied by the duty cycle to arrive at the time averaged exposure levels (see Table 2).

Reference	Measurements	Peak levels (W/m²)
Tell et al 2012(a) (Itron Meters) (902 – 928 MHz)	Banks of 10 meters at 0.2 m	0.35 mean
Tell et al 2012(b) (GE and Landis Meters) (902 – 928 MHz)	Lab test at 0.3 m	<0.6
	Outside residences at 0.3 m	0.27 – 0.9
	Inside 6 residences	6.6×10^{-05} median / 0.051 max
	Bank of 112 meters	0.27 at 0.6 m / 0.043 at 3.0 m
Foster & Tell (2013) (Trilliant Meters) (2.4 – 2.48 GHz)	Single isolated meter at 0.3 m	0.62
	Single meter on house at 1.0 m	1.0×10^{-03} – 1.0×10^{-02}
	Inside house at 5 – 10 m	1.0×10^{-03} – 1.0×10^{-02}*
ARPANSA (2013) (915 – 928 MHz)	Single meter at 0.5 m	7.0×10^{-03}
	Inside residence behind meter	3.5×10^{-04}

*These measurements were affected by more dominant Wi-Fi signals from within the house.

Note: Tell et al 2012 (a) and (b) reported their measured peak values as a percent of the FCC limits. In Table 1, the peak levels have been calculated assuming an FCC general public of 6 W/m² at 900 MHz. The ARPANSA measurements were done in Australia, the others in the USA.

Table 1

1. The public exposure limit varies with frequency. At 900 MHz it is 4.5 W/m2 in the ICNIRP guidelines and 6 W/m² in the FCC requirements.

Time averaged levels

These levels are determined using the highest value duty cycles based on measurements and/or conservative estimations and calculated using the appropriate measurement averaging period (ICNIRP or FCC)[2] to allow comparison with the allowable limit values for the public.

Reference	Measurements	Time-Averaged Levels (W/m²)
EMC Technologies (2011)	Bank of 13 meters, inside dwelling at 0.3 m from meters	5.09×10^{-04}
	Bank of 11 meters 0.3 m from meters	3.70×10^{-02}
Tell et al 2012 (a) (Itron Meters) (902 – 928 MHz)	Front of single at 0.3 m	$<4.80 \times 10^{-02}$
	Front of single meter acting as wireless access point at 0.3 m	6.00×10^{-02}
	Front of single meter at 3.05 m	$<4.80 \times 10^{-04}$
ARPANSA (2013)	Single meter at 0.5 m	2.1×10^{-03}

Note: EMC Technologies (2011) and ARPANSA (2013) generally reported the time-average values as a percent of the Australian limits (ARPANSA, 2002) which are almost identical to ICNIRP. Where stated in the reference, the actual field strength values have been cited. If they were not available they have been calculated assuming a general public limit of 4.5 W/m² at 900 MHz.

Table 2

2. The measurement averaging period in ICNIRP is 6 minutes and for the FCC it is 30 minutes.

Comparison of the measurements with other common RF sources

Table 3 presents typical values of measured RF exposures from other common sources of radio signals.

Measured results of exposures from other common RF sources

The measurements are reported as time-averaged levels, using the appropriate measurement averaging period (ICNIRP or FCC), when the service is operating, for example, when a laptop is uploading a file over Wi-Fi.

Reference	Measurements	Time-Averaged Levels (W/m^2)
Foster (2007)	Wi-Fi devices in offices, shops, healthcare, educational institutions at 1 m	median range 1.0×10^{-06} to 1.0×10^{-05}
Peyman et al (2011)	Max from laptops at 0.5 m	2.2×10^{-02}
	Max from laptops at 1 m	8.7×10^{-02}
	Max from access points at 0.5 m	4.0×10^{-03}
	Max from access points at 1 m	1.8×10^{-02}
Foster & Moulder (2013) based on Joseph et al (2010)	Mobile phone (downlink)	2.0×10^{-05} to 2.0×10^{-04}
	Mobile phone (uplink) – exposure to bystanders, not the user	5.0×10^{-05} to 9.0×10^{-04}
	DECT cordless phone	1.0×10^{-06} to 5.0×10^{-05}

Table 3

Conclusions about RF Health Effects

The possible health hazards of exposure to RF energy have been studied for many years and the overwhelming consensus of expert groups and health agencies is that there are no established health effects below recommended safety limits.

The ICNIRP[3] states:

> ***Acute and long-term effects of HF [high frequency] exposure below the thermal threshold have been studied extensively without showing any conclusive evidence of adverse health effects.***

The World Health Organization (WHO)[4] states:

> ***Based on mixed epidemiological evidence on humans regarding an association between exposure to RF radiation from wireless phones and head cancers (glioma and acoustic neuroma), RF fields have been classified by the International Agency for Research on Cancer [IARC] as possibly carcinogenic to humans (Group 2B). Studies to date provide no indication that environmental exposure to RF fields, such as from base stations, increases the risk of cancer or any other disease.***

The WHO[5] explains that the IARC classification Group 2B is a category used when a causal association is considered credible, but when chance, bias or confounding cannot be ruled out with reasonable confidence. The WHO continues to promote research related to mobile phone use and brain cancer risk and several studies are underway. The IARC task group concluded that the scientific evidence in respect of environmental RF exposures (from sources like smart meters) was insufficient for any conclusion.

Conclusions specific to smart meters

Some agencies have specifically addressed questions regarding the compliance of smart meters and the possibility of health risks. Australian Radiation Protection and Nuclear Safety Agency:[6]

> ***'Smart meters measure electricity usage and communicate this information back to the supplier using short bursts of radio waves or low level radiofrequency (RF) electromagnetic radiation (EMR). The scientific evidence does not support that the low level RF EMR emitted from smart meters causes any health effects.'***

Health Canada:[7]

> ***'...Health Canada has concluded that exposure to RF energy from smart meters does not pose a public health risk. Since RF energy exposure levels are far below Canadian and international safety limits, Health Canada does not consider that any precautionary measures are needed to reduce RF energy exposure from smart meters.'***

Health Protection Agency, United Kingdom:[8]

> ***'...The evidence to date suggests exposures to the radio waves produced by smart meters do not pose a risk to health. Assessments made in other countries that use smart meters have found exposures that are low in relation to internationally agreed guidelines. Public Health England (PHE) will be carrying out research to assess exposures from the devices as the technology is rolled out. PHE considers exposure to radio waves does not provide a basis to decline having a smart meter.'***

These public health agencies have concluded that there are no health risks from the installation of smart meters and no scientific basis to decline having a smart meter installed.

---

3. http://www.icnirp.org/en/frequencies/high-frequency/index.html
4. http://www.who.int/features/qa/30/en/
5. http://www.who.int/mediacentre/factsheets/fs193/en/
6. http://www.arpansa.gov.au/radiationprotection/Factsheets/is_smartmeters.cfm. Last updated: February 2014.
7. http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/prod/meters-compteurs-eng.php. Last updated 13 February 2012.
8. https://www.gov.uk/government/publications/smart-meters-radio-waves-and-health/smart-meters-radio-waves-and-health. Published 31 December 2012.

Where to go for further information:

ICNIRP http://www.icnirp.org/
WHO http://www.who.int/peh-emf/en/

References:

ARPANSA, Australian Radiation Protection and Nuclear Safety Agency, *Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields - 3 kHz to 300 GHz*, Radiation Protection Series, No. 3, 2002.

ARPANSA, Australian Radiation Protection and Nuclear Safety Agency, Preliminary Measurements of Radiofrequency Transmissions from a Mesh Radio Smart Meter, Technical Report 163, ISSN 0157-1400, 9 December 2013.

EMC Technologies, *AMI Meter Electromagnetic Field Survey – Final Report*. Prepared for Victorian Department of Primary Industries, Doc. No. M110736, October 2011.
http://www.smartmeters.vic.gov.au/__data/assets/pdf_file/0011/138926/AMI-Meter-EM-Field-Survey-Report-Final-Rev-1.0.pdf

EPECentre (Electric Power Engineering Centre), College of Engineering, University of Canterbury, Christchurch, Health and Safety Aspects of Electricity Smart Meters: A Study into the Potential Health Effects of Radio Frequency Emissions From Smart Meters, May 2012. http://www.epecentre.ac.nz/media/smartmeter.shtml

FCC, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, Edition 97-01*. Federal Communications Commission Office of Engineering & Technology Washington, DC, 1997.

Foster KR, *Radiofrequency Exposure from Wireless LANS Utilizing Wi-Fi Technology*. Health Physics, 92:280-289; 2007.

Foster KR & Moulder JE, *Wi-Fi and Health: Review of Current Status of Research*. Health Physics, 105:561-575; 2013.

Foster KR and Tell RA. *Radiofrequency energy exposure from the Trilliant smart meter*. Health Physics, 105:177-186; 2013.

Joseph W, Frei P, Röösli, M, Thuroćzy G, Gajsek P, Trcek T, Bolte J, Vermeeren G, Mohler E, Juhasz P, Finta V, Martens L. *Comparison of personal radio frequency electromagnetic field exposure in different urban areas across Europe.* Environmental Research, 110:658-663; 2010.

ICNIRP, *Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz).* International Commission on Non-Ionizing Radiation Protection. Health Physics, 74:494–522; 1998.

IEEE, *Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.* Institute of Electrical and Electronic Engineers (2005). IEEE Std. C95.1-2005.

Peyman A, Khalid M, Calderon C, Addison D, Mee T, Maslanyj M, Mann S. *Assessment of Exposure to Electromagnetic Fields from Wireless Computer Networks (Wi-Fi) in Schools; Results of Laboratory Measurements*. Health Physics, 100:594-612; 2011.

Tell RA, Sias GG, Vazquez A, Sahl J, Turman JP, Kavet RI, Mezei G. *Radiofrequency fields associated with the Itron smart meter.* Radiation Protection Dosimetry 151:17-29; 2012a.

Tell RA, Kavet RI, and Mezei G. *Characterization of radiofrequency field emissions from Smart Meters.* Journal of Exposure Science and Environmental Epidemiology, 23: 549-553; September/October 2013.

About the GSMA

The GSMA represents the interests of mobile operators worldwide, uniting nearly 800 operators with more than 250 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and Internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces industry-leading events such as Mobile World Congress, Mobile World Congress Shanghai and the Mobile 360 Series conferences.

For more information, please visit the GSMA corporate website at **www.gsma.com**. Follow the GSMA on Twitter: **@GSMA**.

www.gsma.com/health/
www.gsma.com/connectedliving

GSMA Head Office
Level 2, 25 Walbrook
London, EC4N 8AF,
United Kingdom
Tel: +44 (0)207 356 0600

www.gsma.com