Australian Government
Australian Radiation Protection and Nuclear Safety Agency

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A Guide to the Environmental EME Report

What is an Environmental EME Report?

The Environmental EME Report provides calculations of the maximum levels of radiofrequency (RF) electromagnetic energy (EME) around an existing and/or proposed wireless base station that may include mobile telephony, broadband and data services. The report is generally produced by a network operator (such as a mobile phone company) or consultants working on their behalf.

All deployment of public mobile telecommunications service infrastructure in Australia, which includes wireless base stations, small cells and antennas, must be carried out according to the Industry Code C564:2020 Mobile Phone Base Station Deployment (the Code)[1]. The Code requires the supply of certain information as part of the consultative process with the local community and local government authority. The environmental EME report is part of this process and is produced according to a methodology developed by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)[2]. It provides objective estimates of the maximum levels of EME from a wireless base station or small cell for both existing and proposed upgrades to telecommunications systems at the site. There are two types of environmental EME report, each representing either a wireless base station or a small cell.

Why is there an EME Report?

Wireless base stations and small cells work by sending out RF EME in the form of waves carrying information. When the RF EME reaches objects, including people and animals, some of the energy carried by the waves is deposited in the object[3]. This can lead to heating of the object and, if levels are too high, can cause harmful effects. The ARPANSA RF Standard[4] provides limits of exposure which must be complied with by all radio installations, including wireless base stations and small cells. The limits for EME exposure given in the ARPANSA Standard are intended to provide protection for people of all ages and medical conditions when exposed 24 hours per day, 7 days per week. The EME Report shows the maximum

[1] The Communications Alliance Ltd Industry Code C564:2011 'Mobile Phone Base Station Deployment' is available from the Communications Alliance Ltd website, http://commsalliance.com.au.

[2] The ARPANSA methodology produces overconservative calculations for multiple-input and multiple-output (MIMO) systems

[3] Information on RF EME and its effects is available from ARPANSA http://www.arpansa.gov.au/RadiationProtection/basics/rf.cfm

[4] The ARPANSA RF Standard is available from http://www.arpansa.gov.au/Publications/Codes/rps3.cfm

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calculated levels for a specific installation and compares them against the exposure limits in the ARPANSA Standard.

What information is on the report?

The report gives the address of the installation, together with a list of the companies using the site and the types of mobile network currently installed and being proposed. It also includes details of calculated levels of RF EME. If the site already has antennas in place, the report includes separate information on the existing and the combined existing and proposed installations. The report estimates RF EME from all of the identified wireless transmitters at this site; it does not estimate RF EME from all surrounding sites. The calculated levels do not include RF EME from other types of radio transmitters (that are not subject to the industry Code) which may be installed on the same structure, e.g. AM and FM radio, TV etc.

EME Levels

The tables of calculated EME levels on the report provide maximum levels of EME found at various distances from the base of the tower or supporting structure for wireless base stations. Within each range of distances, the highest value is given regardless of direction. For small cells mounted on light and power poles or other structures, the report shows the maximum EME level and the distance where this occurs. This provides more relevant exposure information to account for the lower overall power and the much shorter range of the transmitted radio signals from small cells.

For wireless base stations the values of EME are presented in 3 different units:

- volts per metre (V/m) – the electric field component of the RF wave
- milliwatts per square metre (mW/m²) – the power density (or rate of flow of RF energy per unit area)[5]
- percentage (%) of the ARPANSA Standard

In reports for small cells the EME levels are only presented as a percentage of the ARPANSA Standard.

When expressed as a percentage, a value of 100% corresponds to the general public exposure limit. For example, a typical highest value of 1% means that the total EME level from all wireless network transmitters on the site, all operating at their maximum power, will be no more than one hundredth (1/100) of the limit set by the ARPANSA Standard for members of the public.

The table below shows the actual EME limits in the ARPANSA RF Standard used for the frequency bands representing different types of mobile network. At frequencies below 2000 megahertz (MHz) the limits vary across the band and the limit values shown in the table have been determined at the Assessment Frequency indicated. The table shows the three equivalent exposure limit figures in V/m, mW/m^2 and % ARPANSA Standard.

[5] Power density is often expressed in units other than mW/m², other common units are watts per square metre (W/m²) and microwatts per square centimetre (μW/cm²). Where conversion is required: 1 watt per square metre (W/m²) = 100 microwatts per square centimetre (μW/cm²) = 1000 milliwatts per square metre (mW/m²).

Radio Systems	Frequency Band	Assessment Frequency	ARPANSA Standard public exposure limits at the Assessment Frequency		
			Electric Field V/m	Power Density mW/m²	% of ARPANSA exposure limits
LTE700	758 – 803 MHz	750 MHz	37.5 V/m	3750 mW/m²	100%
WCDMA850	870 – 890 MHz	900 MHz	41.1 V/m	4500 mW/m²	100%
GSM900, LTE900, WCDMA900	935 – 960 MHz	900 MHz	41.1 V/m	4500 mW/m²	100%
GSM1800, LTE1800	1805 – 1880 MHz	1800 MHz	58.1 V/m	9000 mW/m²	100%
LTE2100, WCDMA2100	2110 – 2170 MHz	2100 MHz	61.4 V/m	10000 mW/m²	100%
LTE2300	2302 – 2400 MHz	2300 MHz	61.4 V/m	10000 mW/m²	100%
LTE2600	2620 – 2690 MHz	2600 MHz	61.4 V/m	10000 mW/m²	100%
LTE3500	3425 – 3575 MHz	3500 MHz	61.4 V/m	10000 mW/m²	100%

Effect of Landscape (topography)

The tables of calculated EME levels provide values at 1.5 m above a flat landscape. Commonly, wireless base stations and small cells are located on a high point and the assumption of flat ground provides a worst-case estimate for these situations. Sometimes, however, the ground may slope upwards away from the installation and this can cause concern that levels may be higher than calculated. In these cases the 'Calculated EME levels at other areas of interest' table should include the levels of EME at a selection of heights where maximum levels are expected.

Generally, locations very close to the base of the antenna will experience very low levels of EME compared to the surrounding areas. This may not be true if a location is both close, say within 100 m, and elevated above the height of the base of the antenna structure. This may occur because a building is located nearby or the ground rises sharply. In either of these circumstances, EME levels may actually be higher than found at the height of flat ground or a community member may have reasonable concerns that this is so. If such locations exist, carefully calculated estimates in a representative sample of such situations should be provided in the 'Calculated EME levels at other areas of interest' table. It is important to note that in many cases the location may not be in the direction of significant radiated EME and the EME levels may be very low.

Other Areas of Interest

The Code requires the mobile network companies to take account of Community Sensitive Locations. The Code defines Community Sensitive Location to include land uses such as residential areas, childcare centres, schools, aged care centres, hospitals and regional icons which may be considered as sensitive uses in some communities. It is acknowledged that each location should be evaluated on a site by site basis to determine community sensitive locations.

The table 'Calculated EME levels at other areas of interest' on the report provides additional estimates of EME levels at a small number of such locations. These locations may be identified as being of particular concern to the community during the consultation process required by the Code. Typically, levels may be given for the closest point of a children's facility, or for a small number of other locations. It is expected that for an average report, there may be 3 to 5 additional areas of interest calculations. These should be chosen to be representative of both community concern and locations where higher levels of EME may actually be expected on technical grounds. Community Sensitive Locations would be expected to include a small number of floors of a multistorey building if it is close to the antennas and in the direction of significant radiated EME. For some sites there may be no indication for other areas of interest, such as where there is flat ground, no elevated buildings and no locations identified as being of particular community concern. In these cases, after checking:

- the Code's community consultation plan
- topography or buildings near the antennas
- other locations, such as those identified as being of significant previous community concern

no other areas of interest will have been identified. In this case, the EME Report should include the statement 'No locations identified' in the 'Calculated EME levels at other areas of interest' table.

Can I expect to have an EME calculation done for my house?

Whilst the Environmental EME report is a basic report, members of the public are free to request (in writing) a Carrier to provide additional information under section 3.3 of the Code

The Carrier will choose how best to service that request, but it will not be considered as part of the ARPANSA EME report.

Why do the EME levels vary with distance?

The calculations of the maximum EME levels are based on well understood principles of physics that deal with how electromagnetic waves travel and spread out. The total amount of energy emitted from the antenna is limited by the power of the amplifier used to drive the antenna. As the energy leaves the antenna, it spreads out to cover bigger and bigger areas and so gets less intense the further away it gets, this is illustrated in Figure 1 which shows a basic 2-dimensional view of what happens to the EME around a real base station.

The antenna is usually designed to direct most of the energy out towards the horizon, or a few degrees below, so that most of the energy goes where it is needed to communicate with the mobile phone handsets or other user equipment. As one moves away from a base station at ground level, the levels first increase before reaching a maximum and then get less as you move still further away. Typically, the maximum EME level at ground level will occur between 75 m and 200 m from the base of the antenna.

The mobile network companies sometimes need to adjust the angle of the antennas to obtain the best coverage and this can alter slightly the distance at which the maximum occurs and exactly what EME level is found there. Often, the ARPANSA EME Report will take likely alterations into account and include the

highest levels that might occur if the antenna is moved in the future. Some antennas use self-tilt and pan to dynamically change direction; in these situations the orientation that produces the highest maximum EME level is used for the calculation.

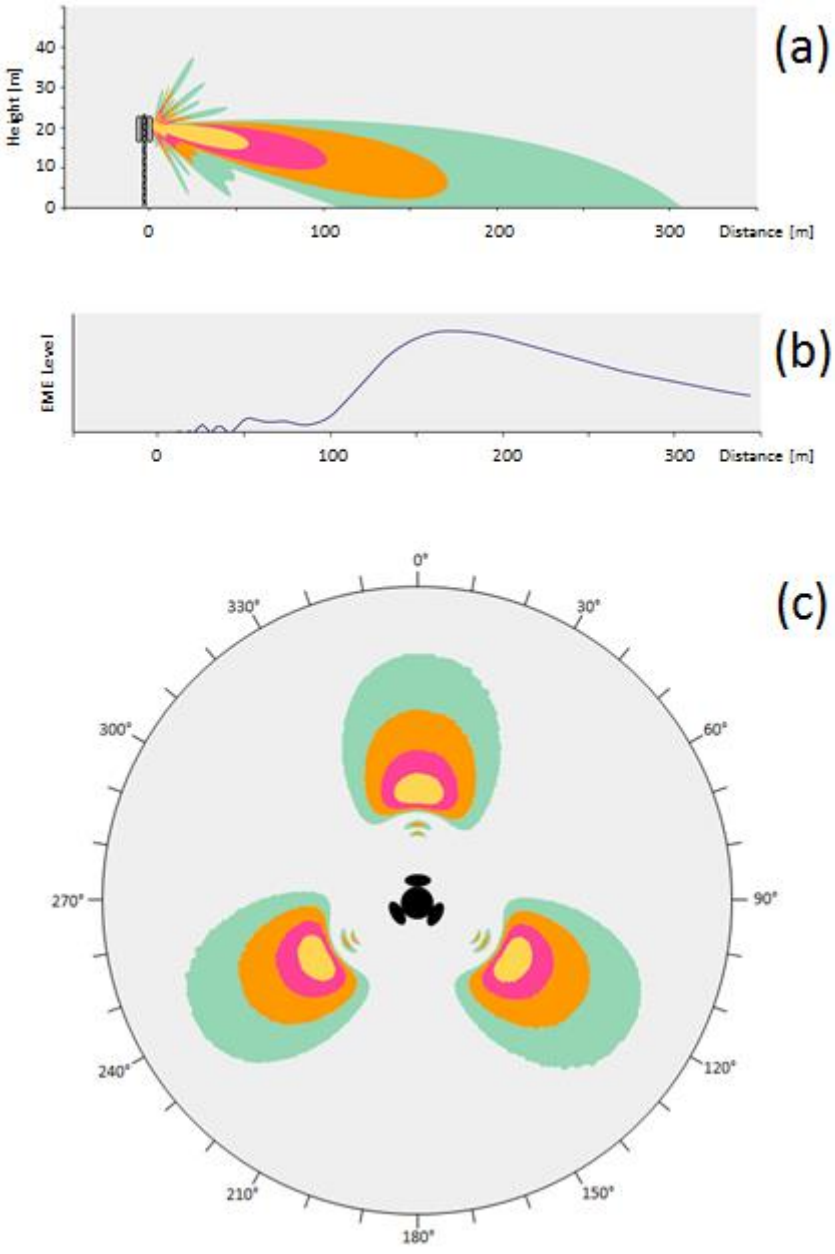

Figure 1. How the EME levels vary as you move away from a base station tower.
(a) Side view of a single antenna pattern. (b) EME level at 1.5 m above ground.
(c) Aerial view of three sector antenna pattern

The EME transmitted from small cells is more localised and, depending on its configuration, may not follow the same emission profile as a larger base station. Typically, the EME levels are very low and they decrease rapidly with distance away from the source much like the larger base stations.

How Accurate are the Calculated Values?

The values of EME provided in the report are intended to be maximum levels that can almost never be exceeded when the base station is operating. The values assume, for example, that all the planned transmitters are installed and are all operating at maximum power. Some of the transmitters at a base station are only used when there are a certain number of telephone calls or data transmissions actually in progress; otherwise they are turned off. Even when a call is in progress, the power transmitted is adjusted to be only as high as necessary to communicate with the handset. If the handset is close, or in a good signal area, the base station transmitter will reduce its power automatically.

The calculations do not take into account trees, vegetation or buildings which may alter the EME levels, generally decreasing them. Some of the EME is reflected from buildings and the ground and often this signal is used by a handset when the direct signal is blocked by a building. When the reflected signal and direct signal combine the overall level can be lower or higher than the direct signal alone depending on the exact location.

Measurements around base stations have shown actual values of EME are usually less than calculation by factors of 10 to 1000 or even more. Values of EME indoors will typically be even lower as walls, windows and roofs absorb or reflect the energy.

A similar situation applies to the emissions from small cells. The EME emissions from small cells follow the same physical process and are similarly affected by surrounding objects.

Example Snapshot of Calculated EME Levels

The maximum EME level calculated for the **existing** systems at this site is

0.46%

out of 100% of the public exposure limit, 161.98 m from the location.

The maximum EME level calculated for the **proposed** changes at this site is

1.0%

out of 100% of the public exposure limit, 161.10 m from the location.

EME levels with the proposed changes

Distance from the site	Percentage of the public exposure limit
0–50 m	0.09%
50–100 m	0.16%
100–200 m	1.0%
200–300 m	0.88%
300–400 m	0.43%
400–500 m	0.24%

The example snapshot above applies to the calculated EME levels around a typical base station and provides the following information:

- The highest calculated level of RF EME coming from the existing equipment at this base station is found at a distance of approximately 161.98 m and is 0.46% or less than 1/200 of the ARPANSA Standard exposure limit.
- Subsequent to the proposed alterations to the equipment at this site, the highest calculated level of RF EME rises to 1.04%, which is found at a distance of 161.10 m from the base of the tower.

The information detailing EME levels at radial distances from the installation is not included in EME reports for small cells due to the more localised emission of the antennas. In this case, information about the highest calculated EME level at the corresponding distance associated with the small cell is included. This is reported for both existing and proposed systems at the site in the same way as wireless base stations.

Example Table of an In-depth Look at Calculated EME Levels

	Existing configuration			Proposed configuration		
Distance from the site	Electric field (V/m)	Power density (mW/m²)	Percentage of the public exposure limit	Electric field (V/m)	Power density (mW/m²)	Percentage of the public exposure limit
0–50 m	0.57	0.87	0.01%	1.7	7.2	0.09%
50–100 m	0.96	2.5	0.04%	1.9	9.2	0.16%
100–200 m	3.4	31	0.46%	5.0	66	1.0%
200–300 m	3.2	27	0.40%	4.6	56	0.88%
300–400 m	2.3	13	0.20%	3.2	28	0.43%
400–500 m	1.7	7.7	0.11%	2.4	16	0.24%

The example table above provides the following information:

- At any location on level ground within 50 m of the base of the tower, the highest calculated level of RF EME coming from the existing equipment at this base station is 0.01% or approximately 1/10000 of the ARPANSA Standard exposure limit. In physical units this is a power density of 0.87 milliwatts per metre squared (mW/m²), equivalent to an electric field strength of 0.57 volts per metre (V/m).
- Subsequent to the proposed alterations to the equipment at this site, at any location on level ground within 50 m of the base of the tower, the highest calculated level of RF EME rises to a power density of 7.18 mW/m² or an electric field strength of 1.65 V/m which is equivalent to 0.09% of the ARPANSA Standard exposure limit (or less than 1/1000 of the limit).
- The values reported here are only expected to occur when the transmitters are all operating at full power and where there is clear line-of-sight to all antennas. Levels indoors will be lower.
- At any distance within 500 m of the tower the table can be used to determine the maximum level. For example at a location 330 m from the tower, that is between 300 m and 400 m, the calculated level will be less than 0.2% of the ARPANSA Standard exposure limit for the existing equipment and 0.43% of the ARPANSA Standard exposure limit for the existing and proposed equipment. In many directions, and at most times, the actual level will be much lower than this calculated level.
- For a new wireless base station where there are no antennas already installed, the above table will only contain data under the 'Proposed Configuration' columns. Similarly, for a wireless base station that is not being upgraded, the table will only contain data under the 'Existing Configuration' columns.

This table is not included in EME reports for small cells due to the more localised emission from these installations.

It should be noted that all values quoted in the above two tables are calculated at 1.5 m above ground level in a flat landscape. As stated in the section “Effects of Landscape (topography)”, If the ground height changes enough to cause significant under estimation of the worst case environmental levels, further calculations shall be reported in the “Other Areas Of Interest” section.

Example Table of Calculated EME levels at Other Areas of Interest

Location	Height range	Electric field (V/m)	Power density (mW/m^2)	Percentage of the public exposure limit
ABC Primary School	0–6 m	2.6	18	0.29%
123 Sports Centre	0–6 m	2.4	15	0.23%
XYZ Community Centre	0–6 m	2.6	18	0.29%

The 'Calculated EME levels at other areas of interest' table provides calculated levels of RF EME at locations considered to be of special community interest or at elevated locations where there may be concern about higher levels of EME. The calculations are performed over the indicated height range and include all existing and any proposed radio systems for this site This table is included in reports for both wireless base stations and small cells. In reports for small cells the EME levels are only presented as a percentage of the ARPANSA Standard.

Further Information

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is a Federal Government agency incorporated under the Health portfolio. ARPANSA is charged with responsibility for protecting the health and safety of people, and the environment, from the harmful effects of radiation (ionising and non-ionising).

Information about RF EME can be accessed at the ARPANSA website, http://www.arpansa.gov.au, including:

- The procedure used for the calculations in this report is documented in the ARPANSA Technical Report; “Radio Frequency EME Exposure Levels - Prediction Methodologies” [2]
- The ARPANSA RF Standard[4]

The Australian Communications and Media Authority (ACMA) is responsible for the regulation of broadcasting, radiocommunications, telecommunications and online content. Information on EME is available at https://www.acma.gov.au/our-rules-eme.

The Communications Alliance Ltd Industry Code C564:2020 Mobile Phone Base Station Deployment is available from the Communications Alliance Ltd website, http://commsalliance.com.au.

Contact details for the Carriers (mobile network companies) operating in Australia and the most recent version of each site’s Environmental EME Report are available online at the Radio Frequency National Site Archive, http://www.rfnsa.com.au.

1. The Communications Alliance Ltd Industry Code C564:2020 Mobile Phone Base Station Deployment is available from the Communications Alliance Ltd website, https://www.commsalliance.com.au/Documents/all/codes/c564

2. The ARPANSA methodology produces overconservative calculations for multiple-input and multiple-output (MIMO) systems. (Radio frequency EME exposure levels - prediction methodologies technical report.)

3. Information on RF and its effects is available from ARPANSA https://www.arpansa.gov.au/understanding-radiation/what-is-radiation/non...

4. The ARPANSA RF Standard is available from https://www.arpansa.gov.au/regulation-and-licensing/regulatory-publications/radiation-protection-series/codes-and-standards/rpss-1

5. Power density is often expressed in units other than mW/m^2, other common units are watts per square meter (W/m^2) and microwatts per square centimetre ($\mu W/cm^2$). Where conversion is required: 1 watt per square metre (W/m^2) = 100 microwatts per square centimetre ($\mu W/cm^2$) = 1000 milliwats per square metre (mW/m^2).