Radiofrequency (RF) Safety Overview
Massachusetts Environmental Health Association

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Agenda

1) RF-EME 101
   a) What is RF energy?
   b) Antenna Basics
   c) Documented Health Impacts

2) FCC Regulatory Limits

3) RF Health Impacts
Electromagnetic Spectrum

<table>
<thead>
<tr>
<th>Source</th>
<th>Frequency in hertz (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-rays</td>
<td>10^22</td>
</tr>
<tr>
<td>Ionizing radiation</td>
<td>10^20</td>
</tr>
<tr>
<td>Ultraviolet radiation</td>
<td>10^18</td>
</tr>
<tr>
<td>Gamma rays</td>
<td>10^16</td>
</tr>
<tr>
<td>Visible light</td>
<td>10^14</td>
</tr>
<tr>
<td>Infrared radiation</td>
<td>10^12</td>
</tr>
<tr>
<td>Microwaves</td>
<td>10^10</td>
</tr>
<tr>
<td>Non-ionizing radiation</td>
<td>10^8</td>
</tr>
<tr>
<td>Radiowaves</td>
<td>10^6</td>
</tr>
<tr>
<td>Very low frequency (VLF)</td>
<td>10^4</td>
</tr>
<tr>
<td>3000–30,000 Hz</td>
<td>10^2</td>
</tr>
<tr>
<td>Extremely low frequency (ELF)</td>
<td>60 Hz</td>
</tr>
<tr>
<td>3–3000 Hz</td>
<td></td>
</tr>
<tr>
<td>Direct current</td>
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X-rays, about 1 billion billion Hz, can penetrate the body and damage internal organs and tissues by damaging important molecules such as DNA. This process is called "ionization."

Microwaves, several billion Hz, can have "thermal" or heating effects on body tissues.

Power-frequency EMF, 50 or 60 Hz, carries very little energy, has no ionizing effects and usually no thermal effects. It can, however, cause very weak electric currents to flow in the body.
Everyday Exposure of RF Energy

- Cell Tower (inside): 0.06 µW/cm²
- Cell Tower (outside): 0.6 µW/cm²
- WiFi Router 1.0: 1.0 µW/cm²
- Baby Monitor 2.0: 3.5 µW/cm²
- Cell Phone In Call, poor signal: 10.0 µW/cm²

SOURCE: Sitesafe (www.sitesafe.com)
Typical Microcell Tower Installation

Utility Pole

Antenna

very low power

Main Antenna Beam

Strength of RF signal decreases rapidly with distance

ground level
Effect of Distance on RF Energy Levels

Comparable Radio Frequency (RF) Emissions Levels
- Cell Phone (hold to ear) 1-5 mW/sq. cm
- Microwave Oven (at 2-inch distance) 5 mW/sq. cm

RF Emissions Area Guide
No prolonged or stationary activities while antennas are active

Main Antenna Beam/Pattern

Values in the above graphic are expressed in milliwatts/square centimeter for a person standing on the roof surface (FCC's regulatory limit is 1 mW/sq. cm)
Example Data from Recent MA Microcell Site Review

Predicted RF Exposure Levels (as a % of the FCC’s Most Stringent (General Population) Limit

<table>
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<tr>
<th>Modeled Height</th>
<th>Maximum</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
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<tr>
<td>Antenna Face (29’ AGL)</td>
<td>313.00%</td>
<td>44.69%</td>
<td>11.17%</td>
<td>2.79%</td>
<td>0.70%</td>
<td>0.31%</td>
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Directional (Panel) vs. Omni Antennas

- Antennas shape and project RF energy waves in a specific direction
- Panel antennas produce more focused signal (higher gain) than an omnidirectional antenna
- Analogy: A flashlight (vs. a light bulb)
Some Facts About RF Energy To Keep In Mind

- RF energy levels decline significantly as one moves away from an RF source (in much the same way that visible light sources decrease in intensity with distance)

- Wireless antennas are designed and installed to send RF signals towards the horizon, away from the building or tower; antennas are designed to direct very little power downward (toward the ground or roof surfaces)
Within buildings, the weak RF emissions at the roof surface level are further reduced by the intervening roof materials. In many cases, roof surfaces reduce RF signals by 90% or more.

All cell carriers operating antennas are required by state and Federal regulations to meet specified emission limits and provide safety measures to prevent harmful RF exposures.
FCC’s Maximum Permissible Exposure Limits for Licensed RF Transmitters

- The *occupational or controlled MPE* limit applies to individuals who may come into contact with RF EME as a consequence of employment, but have been made fully aware of the potential for exposure and have the ability to exercise control over the exposure.

- The *general population or uncontrolled MPE* limit applies to the exposure the general public may experience, and they are generally unaware of the potential for exposure.
In the Typical Wireless Carrier Range (>1800 MHz)

Controlled Exposure: 5 mW/cm² (6-minute avg)

Uncontrolled Exposure: 1 mW/cm² (30-minute avg)
Commonly-used Frequencies

- AM Radio: 520 KHz-1610 KHz (commercial)
- FM Radio: 87.5 MHz-108 MHz (commercial)
- Cellular Phones: 850 MHz-2300 MHz
- Television:
  - VHF: 51 MHz-201 MHz
  - UHF: 471 MHz-801 MHz
- Microwave Oven: 2450 MHz
Why Do We Care About RF-EME Hazards?

- Moving charge causes stationary charge to move
- Water molecules are polarized
- Water molecules move when an E-M wave passes
- Increased motion leads to increased body temperature (humans are made up of ~60% water)
- RF heating effects are temporary and are reduced with distance
Injuries resulting from RF exposure incidents

- Thermal effects caused by excessive RF energy include:
  - Cataract formation
  - Keratitis (eye cornea infection/inflammation)
  - Testicular degeneration
  - Decreased sperm count
  - “Microwave Hearing”
RF fields at frequencies between 1 MHz and 10 GHz penetrate bodily tissue and heat it due to the absorbed energy.

The depth of penetration decreases at higher frequencies.

Heating occurs from the inside; it is not perceived (or it is perceived too late) because our receptors are situated near the skin surface.

The body handles heating as a result of small amounts of RF energy through its normal thermoregulation processes.
RF and Health Impacts

- World Health Organization: “Studies… have not provided evidence that RF exposure from the transmitters increases the risk of cancer. Likewise, long-term animal studies have not established an increased risk of cancer from exposure to RF fields, even at levels that are much higher than produced by base stations and wireless networks.”

- BCCDC (2016); “Ongoing research regarding the potential health effects of RF has not demonstrated clear evidence of impacts on cancer, reproduction, and development…”
RF and Health Impacts

- FCC: “Radiofrequency emissions from antennas used for cellular and PCS transmissions result in exposure levels on the ground that are typically thousands of times below safety limits. There is no reason to believe that such towers could constitute a potential health hazard to nearby residents or students.”

- To date, no U.S. public health agencies have identified any RF health impacts beyond thermal effects (e.g. body heating)
Some Recent Summary Documents on RF Health

NIH National Cancer Institute “Cell Phones and Cancer Risk”

NIH National Cancer Institute “Electromagnetic Fields and Cancer”

American Cancer Society “Cellular Phone Towers”

British Columbia Centre for Disease Control “2016 Review: Radiofrequency and Health”
Environmental Noise Sources?

- Typical Microcell Equipment list:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Manufacturer</th>
<th>Model Number</th>
<th>Sound Pressure Level (dBA)</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Antenna</td>
<td>Amphenol</td>
<td>CUUX063X06F</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>2</td>
<td>Remote Radio Head</td>
<td>Ericsson</td>
<td>RRUS 11</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>1</td>
<td>Remote Optical System</td>
<td>Commscope</td>
<td>ION-M-17 HP</td>
<td>0</td>
<td>n/a</td>
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<td>Commscope</td>
<td>ION-M7HP/85HP EU</td>
<td>0</td>
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- Some RRU units may be fan-cooled; need to check specification sheets