

# The 2020 ICNIRP RF guidelines

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## Scope

- Limit exposure to radiofrequency EMFs (100 kHz – 300 GHz)
- Provide protection against adverse health effects to humans under realistic conditions
- Consider occupational and general public exposure
- Consider direct and indirect exposure (but only contact with charged objects)
- Not included:
  - Electromagnetic interference
  - Exposure for medical purposes
  - Compliance issues (e.g. measurements)

## Identification of adverse health effect thresholds

- Identification of scientific data on effects of exposure on biological systems
- Determination of effects considered both
  - adverse to humans and
  - scientifically substantiated (independent replication, sufficient quality, scientifically explicable generally)
- Identification of adverse health effect threshold
  - minimum RF EMF exposure level shown to produce harm, or
  - where insufficient RF/biology research, minimum exposure predicted to cause harm from non-RF literature, e.g. heating from other factors
    - *operational* adverse health effect threshold

## Derivation of Basic restrictions (=exposure limits)

- Application of reduction factors to adverse health effect thresholds
  - account for scientific uncertainty, relative importance of the health effect, variation across the population
  - reduction factors may differ based on these parameters
  - consistency of reduction factors across limit types is sought, unless there is *substantive* reason for variation
- Reduction factors for general public are higher than for occupational
  - general public may not be aware of exposure and will not have any training to mitigate harm
  - variation in tolerance (e.g. for heating) may be larger in general public

## Reference levels

- Field strength values derived from basic restrictions, to provide a practical method for determining compliance with basic restrictions
- Conservative for all *realistic* exposure conditions, but not all *possible* exposure conditions

## Scientific basis

- Draft WHO RF EHC, SCENHIR, SSM reports + original papers not included
- Extensive body of relevant literature, ranging from cell studies to cancer epidemiology
- Only evidence of potentially harmful effects from:
  - temperature elevation above thresholds
  - microwave hearing (thermal effect; not considered harmful, no limits)
  - nerve stimulation (described in ICNIRP 2010 ELF Guidelines; not considered separately here)
  - electroporation (no problem in practice; no limits formulated)

## Scientific basis (cont.)

- No evidence that RF EMF causes diseases such as cancer
  - Results of US, Italian studies (animals, lifetime exposure) not convincing (Note with ICNIRP comments published)
- No evidence for other non-thermal effects of RF EMF
- Thermal biology literature also considered

## Interaction mechanisms (temperature elevation)

- Health effects primarily related to absolute body core or local temperature
- Body core / local temperature depend on many factors independent of EMF, e.g. environmental temperature, physical activity
- Therefore: temperature increase used that is indicative of adverse health effects *assuming thermonormal baseline state*
- Distinction between steady-state / brief exposures (no dissipation of heat)



## Body core temperature

- Mean body core temperature (approximately 37 °C) typically varies over the day by 0.5 °C
  - thermoregulatory functions (e.g. vasodilation, sweating) keep body core temperature in thermonormal range
  - most health effects induced by hyperthermia (>38 °C) resolve with no lasting effects, but risk of accident and heat stroke increases (>40 °C)
- Increase >1 °C in body core temperature defined as potentially harmful
  - operational health effect threshold
  - for comparison: ACGIH (American Conference of Governmental Industrial Hygienists) heat stress at work standard:
    - protect against >1 °C core body temperature increase

## SAR and body core temperature

- RF modelling:
  - ~6 W/kg WBA SAR, 1 h, ambient temperature of 28 °C:
    - core body temperature increase ~1 °C (consistent with limited measurements)
  - WBA SAR higher in children (more efficient heat dissipation)
- **ICNIRP: adverse health effect threshold:**  
**WBA SAR of 4 W/kg averaged over 30 min (=time to ~ reach steady state)**
- Very conservative !
- Generation energy in human adult: ~1 W/kg at rest, ~2 W/kg standing, ~12 W/kg running

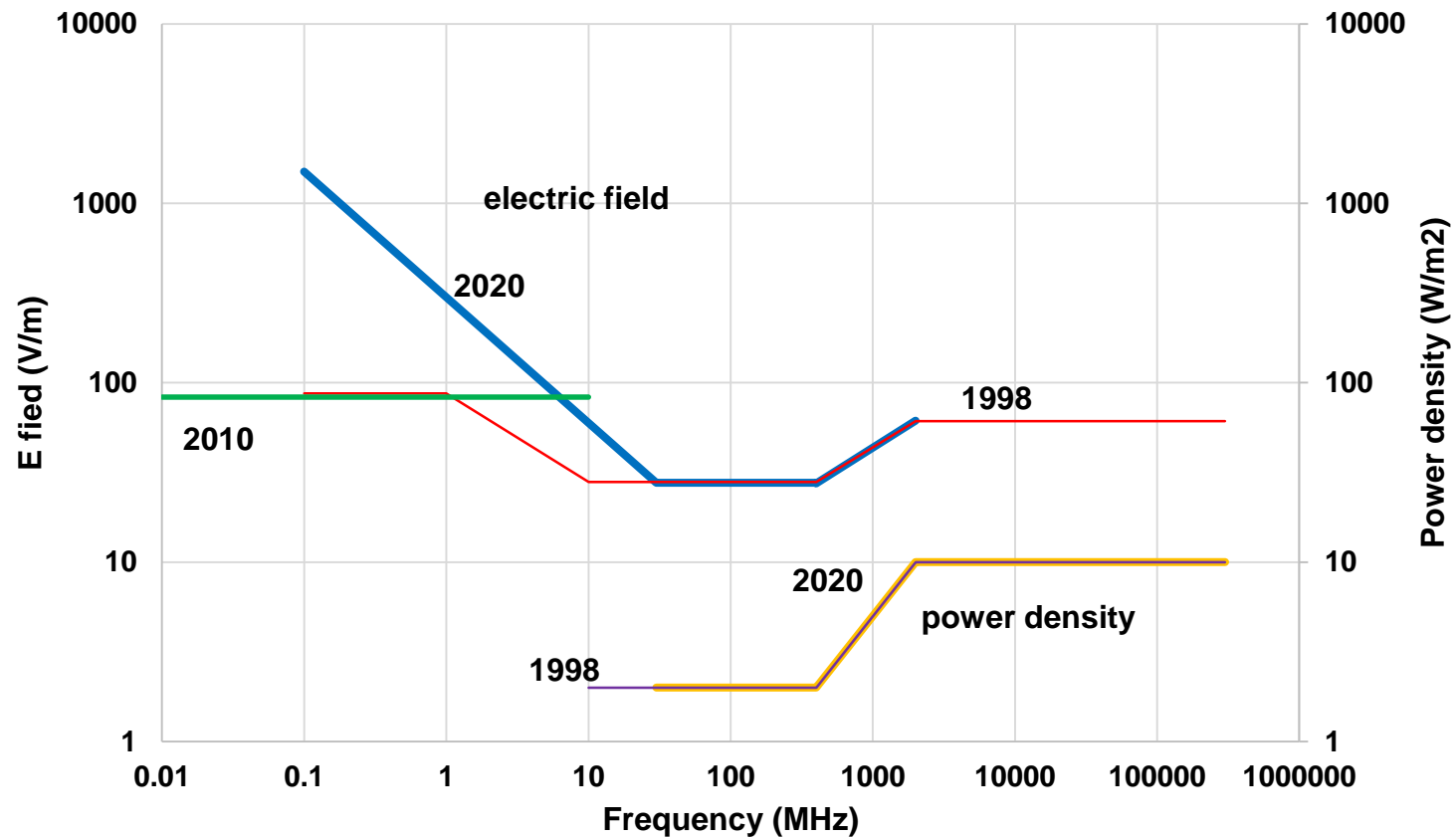
## Basic restrictions and differences with 1998 values

Parameter	Freq. range	$\Delta T$	Spatial	Aver. time	Health effect level	RF	Occup.	RF	General public
Core $\Delta T$	100 kHz-300 GHz	1°C	WBA	30 min 6 min	4 W/kg	10	0.4 W/kg	50	0.08 W/kg
Local $\Delta T$ (Head & Torso)	100 kHz-6 GHz 100 kHz-10 GHz	2°C	10 g	6 min	20 W/kg	2	10 W/kg	10	2 W/kg
Local $\Delta T$ (Limbs)	100 kHz-6 GHz 100 kHz-10 GHz	5°C	10 g	6 min	40 W/kg	2	20 W/kg	10	4 W/kg
Local $\Delta T$ (Head, Torso, Limbs)	>6-300 GHz 30-300 GHz 10-300 GHz	5°C	4 cm <sup>2</sup> 1 cm <sup>2</sup> 20 cm <sup>2</sup>	6 min 6 min 68/f <sup>1.05</sup>	200 W/m <sup>2</sup> (absorbed, incident)	2	100 W/m <sup>2</sup> 200 W/m <sup>2</sup> 50 W/m <sup>2</sup>	10	20 W/m <sup>2</sup> 40 W/m <sup>2</sup> 10 W/m <sup>2</sup>

## Reference levels

- Dependent on:
  - Workers / general public
  - Far field / radiative near field / reactive near field
  - Whole-body / local
    - Local, exposure  $\geq 6$  minutes
    - Local, exposure  $< 6$  minutes
- All reference levels for a given exposure frequency and situation need to be satisfied simultaneously

# Reference levels general public, whole-body $\geq 6$ min



## 5G

- Recent RF guidelines apply to 5G
- Not many differences with 1998 guidelines for lower frequencies (700 MHz, 3.5 GHz)
- Differences for 26 GHz:
  - Whole-body SAR applies
  - Local exposure: absorbed power density, dependence of surface area

Thank you for your attention