Deriving a Sustainability Index for EF Emissions and Carbon Footprint for the Telecom Industry

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Abstract
This research examines the evolving emission standards for 5G base stations compared to their 4G counterparts, focusing on the imminent implementation of massive Multiple-Input-Multiple-Output (MIMO) 5G base stations over the next two years. As 5G technologies have become integral to global connectivity, concerns regarding hazard levels, primarily from the exponential growth of 5G handsets and base stations, prompt a critical examination of emission standards. ***The study Investigates whether the emission standards for 4G base stations, particularly the public exposure requirement of 0.45 W/m², will be maintained with the introduction of massive MIMO 5G technologies.*** Considering the expansion of milli-level antennas and power-intensive 5G devices, the research extrapolates industry trends to predict emission standards in 2025. India, currently in a 5-7 year 5G rollout plan expected to conclude by 2028, faces the challenge of upholding emission standards amid increasing technological demands. The results contribute to an overall sustainability index, providing a holistic perspective on the environmental impact of 5G base stations. The findings are crucial for policymakers, industry stakeholders, and the public, aiding informed decision-making.

Keywords Audits, Carbon Footprint, Electromagnetic Emissions, Sustainability, Telecom Towers

Introduction

Although empirical evidence supporting the theory of health hazards associated with cell phone towers is limited, concerns persist. Reports, such as those from the International Agency for Research on Cancer (IARC), highlight the classification of radiofrequency (RF) fields as "possibly carcinogenic to humans," citing limited evidence linking cell phone usage to an elevated risk of brain tumours[1]. While exposure from cell phone towers is typically lower than that from cell phones, the potential impact on public health remains a subject of on-going scrutiny. The research methodology involves comprehensive testing of existing base stations across both rural and urban areas, focusing on evaluating carbon footprints.

This report explores the environmental dimensions of the Information and Communication Technology (ICT) sector, focusing on reducing emissions and enhancing energy efficiency. Emissions in the industry predominantly emanate from the Telecommunications, Data Centers and PCs, and Peripherals and Printers sectors. With the expanding global reliance on ICT, this analysis aims to identify sustainable practices and technological innovations to address the sector's environmental impact.

The term "EMF" refers to electromagnetic fields, universal in our environment, from natural sources like the earth, sun, and ionosphere, and human-generated electric power charges.[2] These fields contain two key types: electric fields, arising from charge strength (voltage), and magnetic fields, emerging from charge motion (amperage). Only an electric field manifests when a charge is stationary; however, a magnetic field is also produced if it is in motion. The synergy of these electric and magnetic fields gives rise to the encompassing electromagnetic field.
Notably, numerous electrical appliances generate EM fields and depend on them for functionality. Devices such as televisions, radios, mobile phones, and emergency service communication systems employ Radio Frequency EM fields for seamless operation. Similarly, wireless technologies like WiFi, integral to computer networks connecting to the Internet, operate through the transmission of EM fields. In contemporary society, radio communications have become an integral part of daily life, utilizing EMF in the electromagnetic spectrum's radiofrequency (RF) segment[3].

Figure1 Ionizing and Non Ionizing Radiations

Despite the prevalence of such technologies, typical background EMF levels from radio communication systems remain considerably low, well below established safety guidelines.
In the broader context of Information and Communication Technology (ICT), the sector contributes approximately 4% of the entire global greenhouse gas emissions annually[4]. This includes emissions from the manufacturing and using devices and components within the ICT realm, encompassing personal computers, servers, cooling equipment, telephony infrastructure, local area networks (LAN), and printers. As the demand for information traffic rises, so does the power consumption required for telecom sector. However, ICT also plays a transformative role, altering processes and reducing carbon footprints by minimizing the need for travel and face-to-face interactions over the long term. This research dives into the intricate dynamics of EMFs, their role in communication technologies, and the environmental implications of the expanding ICT sector.
Emissions in the Telecommunications sector are rising due to the widespread adoption of telecom services globally. The Data Centers and PCs segment experiences increased greenhouse gas emissions driven by the growth in servers and data storage. Moreover, the Peripherals and Printers sector significantly contributes to the overall carbon footprint. Despite these challenges, the report underscores the potential for positive change through technological advancements leading to efficiency gains. The report aims to provide valuable insights for shaping a more sustainable future within the ICT industry by examining each sector.

2. Materials and Methods

The green role of ICT is the emission reduction and energy savings within the ICT sector. The total emissions of the ICT industry emanate mainly from three different sectors

1. Telecommunications,
2. Data centers and PCs,
3. Peripherals and printers.

The Telecom sector comprises of telecom devices and telecom infrastructure, and emissions from this sector are rising on account of the increasing global permeation of telecom. In data centers, the increase in the number of servers, cooling equipment and data storage are the reasons for increased GHG emission. With the growth in purchasing power in countries like India and China, PC dissemination is expected to sharply in-crease. However, due to technological innovations, the efficiency of ICT devices and systems is also expected to increase, leading to consequential attenuations in emissions.[5]

WHO and DOT Standards

- **WHO:-World Health Organization**
- **DOT:-Department of Telecom**

DOT has adopted strict norms for safety from EMF radiation that are emitted from mobile towers and mobile handsets. Government of India has been taking due precautions and necessary actions in respect of EMF radiation emitted from mobile towers and mobile handsets by issuing various guidelines and norms taking into account the inter-national standards/norms prescribed by International Commission on Non Ionizing Radiation Protection **(ICNIRP)** as recommended by World Health Organizational Base Transceiver Stations (BTSs) are to be safe-limits compliant and certification to this effect is submitted to respective Telecom Enforcement Resource and Monitoring (TERM) Cells of DoT on launch, whenever a change occurs and also on a biennial basis. All new BTS sites start radiating commercially only after such certification is submitted to relevant TERM Cells. Format for Certification of BTS for compliance of EMF levels are provided by DoT/TEC in line with international norms of (International Telecommunication Union) ITU- K.52 and ITU- K.100 providing details of site data, photographs, technical parameters, frequency, power density etc. Extensive Audit of Compliance of Self-Certificates being submitted by Telecom service Providers is regularly being carried out by TERM field units. Further, every year up to 10% of the total BTSs are also tested by TERM Cells where physical measurements are conducted. Additionally, BTSs against which there are public complaints are also tested by TERM Cells. [6, 7]

The testing is done as per detailed test procedure published by Telecom Engineering Centre (TEC).In case a BTS site is found violating the prescribed EMF norms, actions are taken to impose a penalty of up to Rs 20 lakh per BTS on defaulting Telecom Service Providers (TSPs) whose BTSs are found exceeding the prescribed EMF emission limits, and shutting down of BTS, as per procedure, if the violation persists. The present EMF emissions limits/levels for BTSs for general public exposure are as below (These are 1/10th of limits prescribed by ICNIRP and recommended by WHO for general public exposure).[8]

A cellphone handset contains a radio transmitter and receiver, for sending and receiving radio signals from other phones. The radio transmitter and receiver are low-powered, which means cellphones cannot send signals very far. This is a deliberate feature of their design, since all that a cellphone has to do is communicate with its nearest mast and base station (BTS) often also called a “cell”. The base station has to pick up faint signals from many cellphones and route them onward to their destination, which is why the masts have antennas (often mounted on a tower or tall building). A cellphone automatically communicates with the nearest cell and calls can be transferred from one base station to another. A mobile phone needs to have ‘sight’ of a mobile phone base station. In other words, the radio signal from the phone to the base station needs to be of adequate quality and should be uninterrupted to enable making calls.

India followed the safety guidelines prescribed by the International Commission on Non-Ionizing Radiation Protection (IC-NIRP) for exposure to electromagnetic fields (EMF) from mobile towers. According to these guidelines, the recommended safe distance between a house and a mobile tower is typically about 1.5 meters to 2 meters. The antenna arrays are formed with two main configurations viz. horizontal separation and vertical separation. Microwave circular horn antennas are used for terrestrial microwave link between the cell towers. The antenna can function as transmit, receive or transmit/receive both. In order to use antenna as both transmitter and receiver, duplexer is used. There should be 10*λ distances between the two transmit or receive antennas. Radio signals at any frequency travel at the same speed and they all travel the same infinite distance unless something stops them. Also, the signal power received by a given antenna will fall off with the inverse square of distance and this is also independent of frequency. At the same time however lower frequencies will tend to be received with higher signal levels and so the useful range of a system is often longer when lower radio bands are used.

This is due to a number of factors:

- Normal antenna dimensions scale with wavelength and so lower bands use larger antenna leading to a larger “effective aperture”. This means that a lower band receive more of the radiating signal than a higher band.
- Lower bands tend to diffract better than higher bands and so they are better at delivering useful signal in behind buildings and indoors which improves coverage. This is very useful in cellular mobile systems where direct line of sight paths are often not available
- Base stations are often easier to build for higher bands and so more complex antenna systems may be used. This tends to mean that antenna patterns may be made more directives and so more power is directed towards the devices. This has not be a significant issue in previous generations of cellular mobile but we should expect 5G to exploit this using a technique called beam steering

Net effect is that bands like 800 MHz will offer better coverage than say 1800 MHz. We use this to offer both longer range, and hence support wider separation between cell towers in rural areas, and to offer higher percentage of coverage in urban areas. Bands below 1GHz “coverage bands” and higher bands which often have more spectrums are “capacity bands”. A good mobile network will use both types of bands.

Power and energy consumption for telecom network operations is by far the most important significant contributor of carbon emissions in the telecom industry. However large parts of the India are power deficient and with increasing coverage of mobile services in off grid areas, network operations will increasingly have to rely on alternative sources of energy until the rural electrification process is complete. **India has presently around 10.4 Lakh telecom towers, with average power consumption per tower ranging between being 3 to 10 kW as per the technology**.

3. Results

3.1. Observed Antenna Types in India,Technology,Range

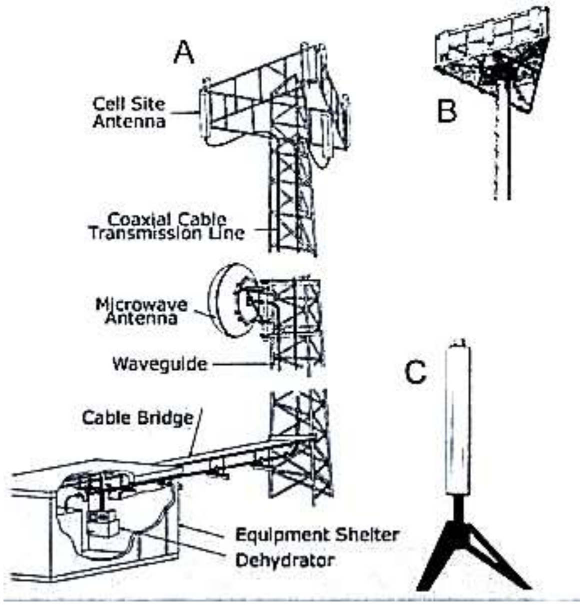

Figure 2:Observed Antenna Patterns in India

- Rural up to 3.2 to 9.6 Km
- Suburban till 3.2 Km
- Urban 100m to 500m

High powered systems are used for television and radio broadcast, usually from a single transmitting tower in an elevated location.Medium powered systems are used for two-way communications typically from a repeater tower to vehicle radio systems like emergency services.Low powered systems are used for mobile communications and rely on a network of transmitting sites like mobile phone base stations.

3.2. RF Exposures and Carbonfootprint

DOT BTS Audits have shown that the RF exposures from base stations range from 0.002% to 2% of the levels of international exposure guidelines, depending on a variety of factors such as the proximity to the antenna and the surrounding environment. This is lower or comparable to RF exposures from radio or television broadcast transmitters. RF exposures from base stations and wireless technologies in publicly accessible areas (including schools and hospitals) are normally thousands of times below international standards.

Local Service Area LSA	Intensity Watt/M^2	Prescribed Limit	Measured Value	WHO STD	%	Category	Number of DOT Audits 2023	10 year Ave	Audit Efficiency %
Andhra Pradesh	0.006	0.450	0.457	4.5	10.15	A	736	1360	54
Gujarat	0.005	0.450	0.459	4.5	10.2	A	959	1483	65
Karnataka	0.004	0.450	.451	4.5	10	A	294	1286	23

Rajasthan	0.007	0.450	.445	4.5	9.9	A	780	946	82
Tamil Nadu	0.030	0.450	.506	4.5	11.2	A	847	2214	38

Table 1.1 EM Exposures in India[1, 2]

Telecom Component	Carbon Footprint MT
BTS	18.50
BSC	1.85
MSC	0.14
Exchanges	8.54
Network Controllers	0.11
Network Core and Server	.07
Total	29.22

Table 1.2 Carbon Footprints of various Telecom Components[2,3]

3.3. Carbon footprint due to Grid Electricity

Component	Value
Telecom Towers	**10.4 Lakhs**
Power Consumption Per Tower	**3.5 kW**
Total Power Consumption	**36.4 Lakh kW**

Table 2: GRID POWER

Calculations

- IF we assume 16 hours of Grid Power=**582.4 Lakh KWH**
- One KWH of grid electricity consumed emits around **0.84 Kgs of carbon dioxide.**
- So total carbon footprint due to Grid use approx. **50 MT (Million Tons)**

4. Discussion-Sustainability index

This is an assumed derived index that gives the multiply ratio of Carbon emission to EM Exposure.

Sustainability Factor =Carbon Foot Print per Subscriber *EM Exposure (Watt/M^2)

Player	Carbon Emission (MT)	Subscribers (Mn)	Carbon Emission Per Subscriber (Kg)
Jio	24.82	401	61.90
Airtel	23.47	367	63.95
BSNL	12.73	115	47.72
IDEA	12.60	264	110.66
		Average	71.06

Table 3: Sustainability Factor

India

SF=71*0.46=32.66

Global

SF=31*4.5=139.5

Our EM Exposures are approximately at 10% (**Ref Table 1.1**) of Global level but Carbon foot print is 229% of the Global level. SF is still very commendable compared to the Global level

5. Conclusions

The Following will be a guideline to improve the carbon footprint of Telecom industry. They are only indicative and not necessarily comprehensive.

- Better network planning
- Infrastructure Sharing
- Adoption of Energy Efficient Equipment's
- Improvement in supply of Grid Power
- Use of Renewable sources of energy
- Deployment of Tower Tubes

Appendix A

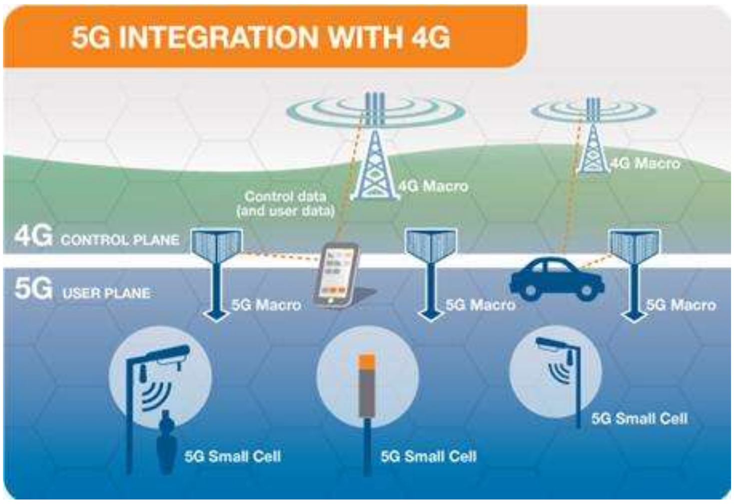

Figure A1

Mobile Service Provider	No. of BTS	Average Power Consumption (P) (in KW)	Avg. Grid Supply (in hrs.) 'x'	DG Capacity (in KVA) 'y'	Avg. DG Supply (in hrs.) 'z'	η of DG Set η'	A 0.84Px	B 0.528yz/'η'	Carbon Emission per BTS (in Tonnes) C = 0.365[0.84 Px+(0.528 yz/η)]	Total Carbon Emission (in Mn Tonnes)
4G	**4G**	**4G**	**4G**	**4G**	**4G**	**4G**	**4G**	**4G**	**4G**	**4G**
BA	503000.00	5.90	21.00	15.00	3.00	1.00	104.08	23.76	46.66	23.47
RJ	532000.00	5.90	21.00	15.00	3.00	1.00	104.08	23.76	46.66	24.82
BL	335000.00	5.90	21.00	15.00		1.00	104.08	0.00	37.99	12.73
VI	270000.00	5.90	21.00	15.00	3.00	1.00	104.08	23.76	46.66	12.60
Total										**73.62**
5G	**5G**	**5G**	**5G**	**5G**	**5G**	**5G**	**5G**	**5G**	**5G**	**5G**
BA	53223.00	9.80	21.00	15.00	3.00	1.00	172.87	23.76	71.77	3.82
RJ	228689.00	9.80	21.00	15.00	3.00	1.00	172.87	23.76	71.77	16.41
BL	0.00	9.80	0.00	15.00		1.00	0.00	0.00	0.00	0.00
VI	36.00	9.80	21.00	15.00	3.00	1.00	172.87	23.76	71.77	0.00
Total										**20.24**

Table A1

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