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Telecom Regulatory Authority of India

सत्यमेव जयते

Consultation Paper

On

Approach towards Sustainable Telecommunications

16 January, 2017

Mahanagar Doorsanchar Bhawan

Jawahar Lal Nehru Marg,

New Delhi – 110002

Stakeholders are requested to furnish their comments to the Principal Advisor (Network, Spectrum & Licensing), TRAI by 13th February 2017. Counter comments, if any, may be sent by 27th February, 2017. Comments and Counter Comments would be posted on TRAI's website www.trai.gov.in. The comments in electronic form may be sent by e-mail to fn@trai.gov.in, trai.ifn@gmail.com or ja3nsl@trai.gov.in. For any clarification/ information, Shri UK Srivastava, Principal Advisor (NSL) may be contacted at Tel. No. +91-11-23233291 Fax: +91-11-23230056.

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INTRODUCTION

1. Climate change is now being recognized as a prime concern facing the human race by countries across the globe. One of the main reasons for this climate change is the enhanced emissions of heat trapping or Green House Gases (GHGs) arising from the activities of humankind in an increasingly industrialized and globalizing world. Way back in 1992, 'Rio Convention' set out a UN framework for action aimed at stabilizing atmospheric concentrations of GHGs to avoid "dangerous anthropogenic interference with the climate system."

2. A substantial portion of these GHG emissions have their origin in the combustion of fossil fuels. As the world's need for energy-based services increases, the impact is expected to become increasingly pronounced. Recognizing this fact, the United Nations has adopted "Take urgent action to combat climate change and its impacts" as its one of the Sustainable Development Goals (SDGs).

3. A step towards combating climate change was the recent Paris Climate Conference held in December 2015 where 196 countries adopted the first-ever universal, legally-binding global climate deal. The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C. Ensuring less than 2°C warming would require countries around the world to take action to limit or reduce their GHG emissions. India has pledged to reduce the emissions intensity by 33 to 35 percent by 2030 from 2005 level and to achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF).

4. It is estimated that the ICT sector worldwide is responsible for around 2% of global GHG emissions and for around 0.7% of global CO_2 emissions.[1] While contribution of the ICT (Information & Communication Technology) sector to

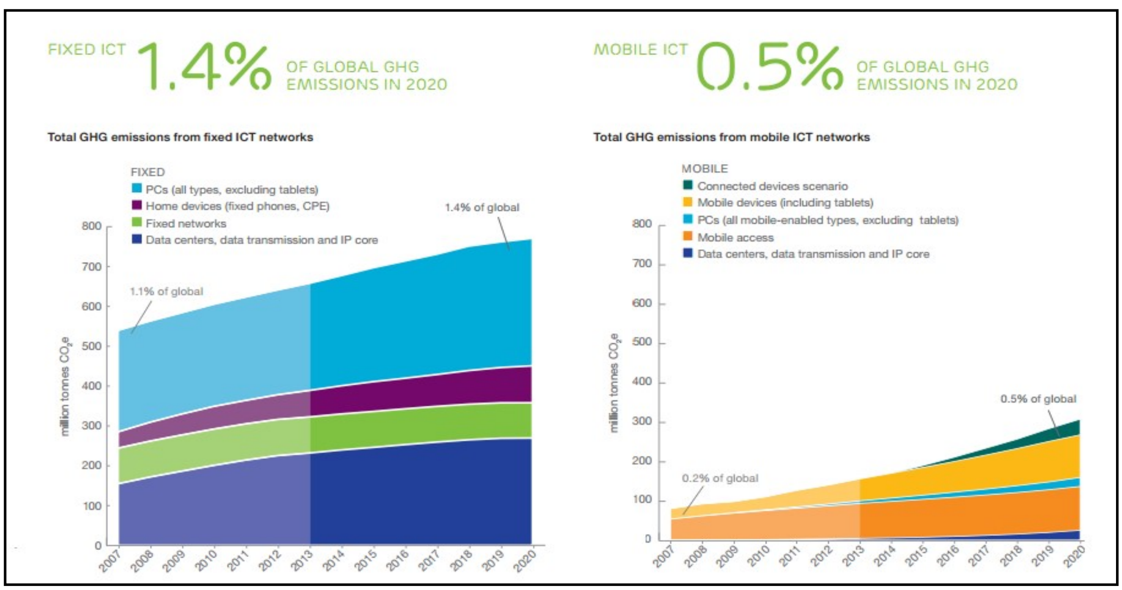
[1] "Green ICT: India and the World Future Information & Communication Technology" by Om Pal Singh and Pratibha Singh, International journal of emerging Research in Management and Technology, Dec 2015.

the global carbon footprint is low compared to other sectors like transportation and construction, it nevertheless contributes a noteworthy share and increasingly so with growing reach of the telecommunications network. Efforts are afoot, all over the world, to find measures to deal with this issue.

5. The world's increasing need for computation, data storage, and communication is driving the rapid growth in telecommunication and enhancing the emissions associated with such technologies. By 2020, ICT is expected to account for about 3% of global GHG emissions worldwide.

6. ICT sector can be segregated into two segments : Fixed ICT network and Mobile ICT network. For fixed ICT networks, it is estimated that the share of GHG emissions will be around 1.4% in 2020, as shown in the left-hand side of Figure 1. Although GHG emissions due to mobile ICT networks are continuously increasing, they remain significantly smaller than those attributable to fixed ICT networks. It is estimated that mobile networks will grow somewhat faster than fixed networks and will contribute about 0.5% of the global GHG emissions by 2020, as shown in the right-hand side of Figure 1.[2]

Figure 1: Graph showing trend in increase of GHG emissions from Fixed and Mobile ICT networks.

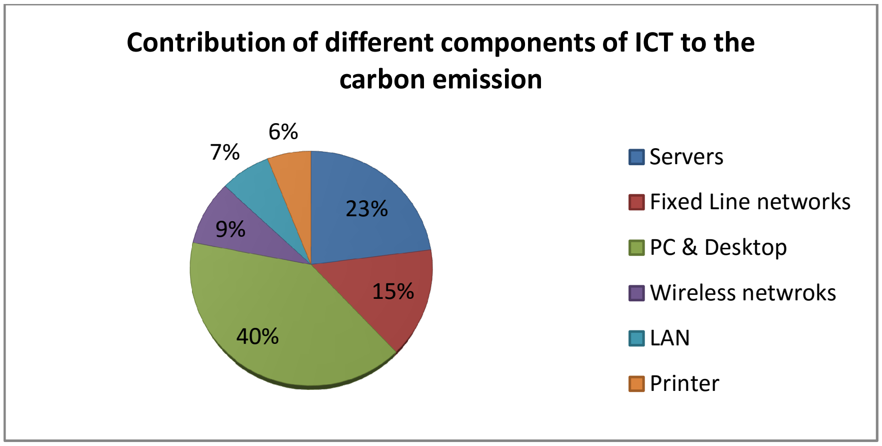


7. The main contributing sectors within the ICT industry include the energy requirements of PCs and monitors (40%), data centers (23%), and fixed &

[2] https://www.ericsson.com/res/docs/2014/ericsson-energy-and-carbon-report.pdf

mobile telecommunications that contribute 24% of the total emissions. This is shown in Figure 2.[3]

Figure 2: Contribution of different components of ICT to the carbon emission



8. India has the second largest and fastest growing mobile telephone market in the world. Power and energy consumption for telecom network operations is by far the most important significant contributor of carbon emissions in the telecom industry. Hence, it is important for the telecom operators to shift to energy efficient technologies and alternate sources of energy. Moreover, Going Green has also become a business necessity for telecom operators with energy costs becoming as large as 25% of total network operations costs. A typical communications company spends nearly 1% of its revenues on energy which for large operators may amount to hundreds of crores of rupees.[4]

9. The Telecom Sector witnessed substantial growth in the number of subscribers during the year 2015-16 and up to September 2016 also. As of November 2016, the subscriber base was 1123.95 million, out of which 1099.51 million were wireless subscribers. During the year 2015-16, wireless subscriber base recorded an increase from 969.89 million to 1033.63 million, while the overall teledensity increased from 79.38 to 83.36. The year also saw increase in rural teledensity from 48.37 to 51.37 while the urban teledensity increased from 148.61 to 154.01. The Internet subscriber base in the country,

[3] "A Review of Energy Efficiency in Telecommunication Networks" by George Koutitas, Member, IEEE, and Panagiotis Demestichas, Member, IEEE.
[4] SATRC Report on green telecommunications, Prepared by SATRC Working Group on Policy and Regulation

as on September 2016, stood at 367.48 million as compared to 324.95 million as on September 2015.

10. The CO_2 emission level from the Indian mobile telecom sector jumped by more than 70% over the past two-three years and in 2014-2015, it accounted for 58.3 million tonnes and a total of approx 836 giga joules of primary energy was consumed during the specified period, which is equivalent to 73 billion units.[5] These numbers indicate that it is imperative to adopt new technologies to reduce the energy consumption and the corresponding CO_2 emissions of the growing Indian mobile telecom industry.

11. With 3G becoming pervasive, the energy demand is likely to increase by two-three folds[5] at least because data transfer would consume more energy and the introduction of 4G, with a speed transfer rate 10 times higher than the 3G, will further substantially increase the energy consumption patterns of the telecom sector.

12. The foremost share of the CO_2 emission in the ICT infrastructure is during the actual use of the network equipment and devices. In the telecommunication network, the components that contribute to carbon emission footprint includes the Radio Access Network (RAN), Data Centers, fixed-line network, the Core network, aggregator, transmission system and Fiber to the network (mainly in Access network) etc. Therefore, use of new and innovative technology in these areas can help in reduction of harmful emissions.

13. In an endeavor to get stakeholders' views on greening the telecom sector, TRAI had issued a consultation paper on "Green Telecommunications" on 3rd February, 2011. An Open House Discussion on these issues was held at Delhi on 18th March, 2011. Based on the comments received during the public consultation, the recommendations on "Approach towards Green Telecommunications" were issued on 12th April, 2011 by TRAI.

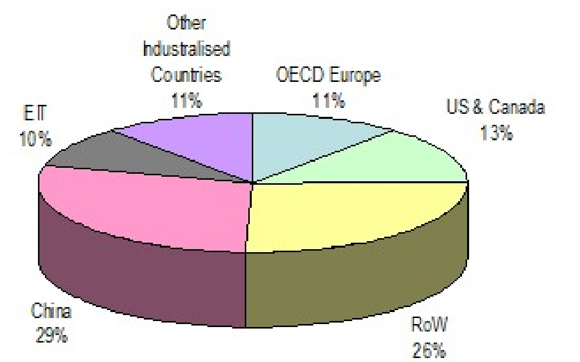
14. Based on the recommendations of TRAI, DoT on 04.01.2012 issued directions for the Telecom industry. Following the direction, the telecom service providers are submitting carbon footprint reports of their respective networks bi-annually : first term spanning from April to September and the second term

[5] "Green Telecom -long way to go? ", a Cybermedia Publication,voicendata.com,October 2015

from October to March. A carbon footprint report, as submitted by the service providers, for the term-October'15 to March'16 is also attached in Annexure I.

15. India is one of the few countries which have adopted a green policy for achieving energy efficiency in the Telecom Sector globally, though the share of carbon footprint from ICT sector in India is negligible as compared to other countries. Share of various countries in global ICT footprint is shown in Figure 3. India is included in **RoW** (Rest of World). India's share is just 1.43% of the 27% share of RoW in global carbon footprint which amounts to just 0.38% of the global carbon footprint.

Figure 3: Global ICT footprint



RoW = Rest of World (includes, India Brazil, South Africa, Indonesia and Egypt
EiT = Economies in transition. (includes Russia and non-OECD Eastern Europe countries

Source: SMART 2020; Report by The Climate Group

16. To develop the roadmap, comprehensive program and viability gap funding for mobilizing the renewable energy technology deployment in telecom sector, DoT constituted a Renewable Energy Technology (RET) committee which submitted its report on 01.08.2014. The recommendations of RET committee were further examined by a departmental committee which has submitted its report in May 2015. In light of the above mentioned reports of the Committee and deliberation thereof, DoT has sought recommendations of TRAI on the following issues:

   i. Methodology of measuring Carbon Emission.
   ii. Calibration of Directives issued by DoT in 2012 & approach for implementation (Target on the implementation of RETs).

17. This consultation paper outlines the significance of energy efficiency in modern telecommunication networks and suggests directions for optimizing network performance in terms of energy demands. Chapter 1 discusses in detail the methodology which may be adopted for calculation of carbon footprint of the network and Chapter 2 discusses about various aspects of energy efficiency in telecom networks and how to achieve the renewable energy targets in telecom sector. At the last, chapter 3 summarizes the issues of consultation.

CHAPTER - I

Methodology for Calculation of Carbon Foot Print

A. What are carbon foot print and various types of greenhouse gas emissions?

1.1. The term carbon footprint is commonly used to describe the total amount of CO_2 and other GHG emissions for which an individual or organisation is responsible. It is expressed in equivalent tonnes of carbon dioxide abbreviated as CO_2e. As an example, on driving a car, the engine burns fuel which creates a certain amount of CO_2, depending on its fuel consumption and the driving distance. Similarly, when a house is heated with oil, gas or coal, CO_2 is generated. Even if a house or organization is heated with electricity, the generation of the electrical power may also have emitted a certain amount of CO_2. The production of the food and goods also emits some quantity of CO_2. Therefore, carbon footprint is the sum of all emissions of CO_2 (carbon dioxide), which was induced by an individual's or organization's activities in a given time frame. Usually a carbon footprint is calculated for the time period of a year.

1.2. In order to produce a reliable footprint, it is important to follow a structured process and to classify all the possible sources of emissions thoroughly. A common classification is to group and report on emissions by the level of control which an organisation has over them. On this basis, GHG emissions can be classified into three main types:

1.2.1. <u>Direct emissions that result from activities that the organization controls.</u>

Most commonly, direct emissions will result from combustion of fuels which produce CO_2 emissions like combustion of diesel in DG sets. Such emissions are also called 'Scope 1' emissions and are defined as 'emissions from sources that are owned or controlled by the organization', such as:

1. Stationary Combustion: from the combustion of fossil fuels (e.g. natural gas, fuel oil, propane, etc.) for comfort heating or other industrial applications.
2. Mobile Combustion: from the combustion of fossil fuels (e.g. gasoline, diesel) used in the operation of vehicles or other forms of mobile transportation.
3. Process Emissions: emissions released during the manufacturing process in specific industry sectors (e.g. cement, iron and steel, ammonia).
4. Fugitive Emissions: unintentional release of GHG from sources including refrigerant systems and natural gas distribution.

1.2.2. Emissions from the use of electricity.

Emissions from the use of purchased electricity for operation of telecom equipments fall under this category. Such emissions are also called as 'Scope 2' emissions. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated.

1.2.3. Indirect emissions from products and services

Such emissions are also called as 'Scope 3' emissions and are defined as 'emissions that are a consequence of the operations of an organization, but are not directly owned or controlled by the organization'. Scope 3 includes a number of different sources of GHG including employee commuting, business travel, third-party distribution and logistics, production of purchased goods, emissions from the use of sold products, and several more. Each product or service that is purchased by an organization is responsible for emissions. So the way the organization uses products and services affects its carbon footprint. For example, a company that manufactures a product is indirectly responsible for the carbon that is emitted in the preparation and transport of the raw materials. Downstream emissions from the use and disposal of products can also be indirectly attributed to the organization.

B. Need to measure the carbon footprint

The growing telecom infrastructure requires an increasing amount of electricity to power it, which increases the energy consumption base of the telecom industry. Hence, it becomes indispensable to develop energy-efficient telecom solutions. It is necessary for the TSPs to identify all potential areas for energy efficiency optimization in every part of the telecom network such that all parts of the telecom networks are addressed to achieve significant reduction in carbon emissions. There are typically two main reasons to calculate a carbon footprint for telecom industry as explained in the following section.

1.3. Footprinting for management of emissions

Calculating a telecom network's carbon footprint and quantifying key emissions is an effective tool for ongoing energy, environmental and cost management. This approach is relatively quick and straightforward. Having quantified the emissions, opportunities for reduction can be identified and prioritized, focusing on the areas of greatest savings potential.

1.4. Footprinting for accurate reporting to a third party

The calculations done in the process of carbon footprinting should be independently verified to ensure that the methodology has been correctly used and the results hence obtained are accurate.
Organizations increasingly want to calculate their carbon footprint in detail for public disclosure in a variety of contexts:

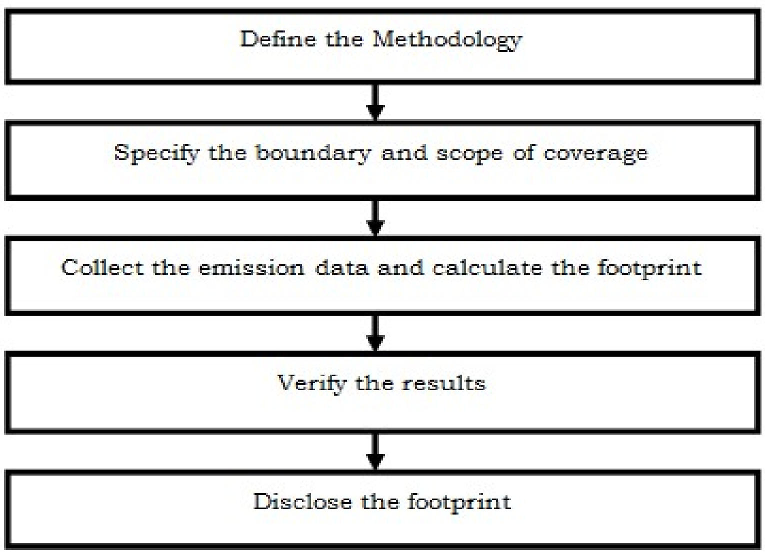
- For Corporate Social Responsibility (CSR) or marketing purposes.
- To fulfill requests from business or retail customers, or from investors.
- To ascertain what level of emissions they need to offset in order to become 'carbon neutral'.
- On directives from the Government.

For these reasons, a more robust approach is needed, covering the full range of emissions for which the organization is responsible. It may also be appropriate for the telecom service providers to report their carbon foot prints in order to ascertain what level of emissions they need to offset in order to become 'carbon neutral'.

C. Approach for calculating carbon footprint[6]

1.5. Accurate calculation of carbon footprint requires a detailed approach. Figure 1.1 displays a systematic approach suitable for producing an accurate carbon footprint. Each step of the proposed methodology has been explained in the following section.

Figure 1.1: Systematic Approach to calculate Carbon footprint



1.6. <u>Define the methodology for calculating Carbon Footprint</u>

For a footprint to be accurate, there must be a consistent approach which makes it important to define a methodology from the outset, especially in scenarios where there is a large telecom network with many telecom service providers operating and competing with each other. Where there is a common methodology, the results are more credible and the reports of a telecom operator may be easily compared with that of the other operator.

[6] "Carbon footprinting- An introduction for organizations" by Carbon Trust

Hence, a consistent and accurate methodology for calculating the carbon footprint is required.

1.7. Specify the boundary and scope of coverage

There should be a clear defined boundary as to which set of emissions emanating from the telecom network can be practically quantified. Common issues include:

- Treatment of emissions from wholly or partially owned subsidiaries of telecom operators.
- Treatment of emissions from leased assets of telecom operators.

It is usual to define the boundary to include the full range of emissions that the telecom service provider controls directly and this is likely to include subsidiaries and leased assets. Having defined the boundary, the next question is related to the types of emissions which will be included. The emissions may be broadly grouped as given below:

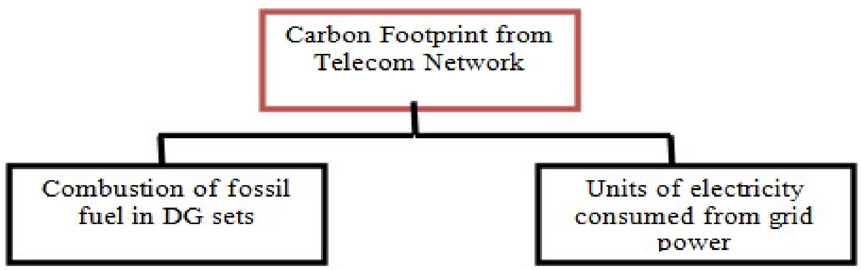
- Direct emissions from the combustion of fossil fuels.
- Emissions from the electricity purchased (Grid Power).
- Emissions from manufacturing of telecom equipments and their disposal. (Indirect emissions from Life Cycle Assessment process).

The emissions emanating during Life Cycle Assessment (LCA) process i.e. from extraction of raw materials, manufacture of finished telecom equipment, their usage by consumers and their ultimate disposal etc. are not under the direct control of telecom operators. Hence, such emissions do not lie in the domain of the service providers. Making the equipments energy efficient can be possible by following energy efficient techniques, lesser usage of harmful chemicals, recycling electronic waste etc. during the manufacturing process.

1.8. Hence, for calculating carbon footprint, only the emissions from combustion of fossil fuels and usage of purchased electricity should be taken in account while calculating the carbon footprint of a telecom network. Moreover, emissions from usage of renewable energy like solar energy, wind energy etc. can be taken as zero because whatever emissions happen at component level are taken care of during the manufacturing stage of such sources.

Hence, the carbon footprint of the telecom network may constitute the emissions from consumption of Grid power and Diesel Power (DG sets) as shown in Figure 1.2.

Figure 1.2: Carbon footprint of Telecom Network



1.9. <u>Collect emissions data and calculate the footprint</u>

The accuracy of the footprint relies on correct data and may include collecting information on:

- Amount of fuel consumed in DG sets.
- Running hours of the telecom equipment.
- Number of units of electricity consumed by telecom equipment from grid power supply.

Moreover, before collecting the data, it is important to decide the level of accuracy which is required and the margin for error which may be acceptable.

A possible option for meeting the above mentioned requirement will be to set a threshold value for the accuracy level which may be used by incumbent telecom service providers while collecting the emission data so as to keep the uncertainties in calculations at the lowest possible level.

Question 1: What accuracy level may be set for collecting the data and also, what should be the basis for arriving at this threshold level? Please comment with justification.

1.10. Verification of Results

Having the carbon footprint verified by a third party shall lend credibility to the operators' claims of carbon footprint. Verification typically involves analysis of the methodology, data collection techniques and the calculation process that was used.

Question 2: Is there a need for auditing the carbon footprint of a telecom network by a third party auditor? If yes, what is the mechanism proposed? Please comment with justification.

1.11. Disclose the footprint

The carbon footprint calculated by the telecom operators should be presented to TRAI and the public to ensure that the data is presented transparently, providing full information about the process followed and what the information implies. The following information may be made available in the reports:

- Methodology.
- Boundary conditions which were set and types of emissions included and excluded.
- Data collection techniques, including level of accuracy achieved and any assumptions or estimations that were required.
- Level of verification of the results provided by independent third party.

Question 3: Do you agree with the approach for calculating the carbon footprint? If so, please comment with justification.

D. Understanding various blocks of telecom industry contributing to carbon emissions

1.12. The telecom network can be broadly divided into four vital blocks which contribute significantly to the carbon emissions. These are elaborately explained in the Authority's Recommendation "Approach towards green telecommunications dated 12th April 2011". The various blocks have been tabulated in Table 1.

Table 1: Various blocks of the telecom network

Blocks of the Telecom network	Carbon Footprint denoted by
Access network	C_{AN}
Core network (which includes edge / core routers / NGN / softswitches / IP cores / all core items / data centers / all centralised sub systems peripherals)	C_{CN}
Aggregators (or Backhaul)	C_{A}
Transmission Network	C_{TN}

1.13. The Carbon footprint of the <u>Access network</u> can be further divided into four categories namely; Landline network, Mobile network, Fixed Broadband network and Fibre to the X network. The various blocks of access network have been tabulated in Table 2.

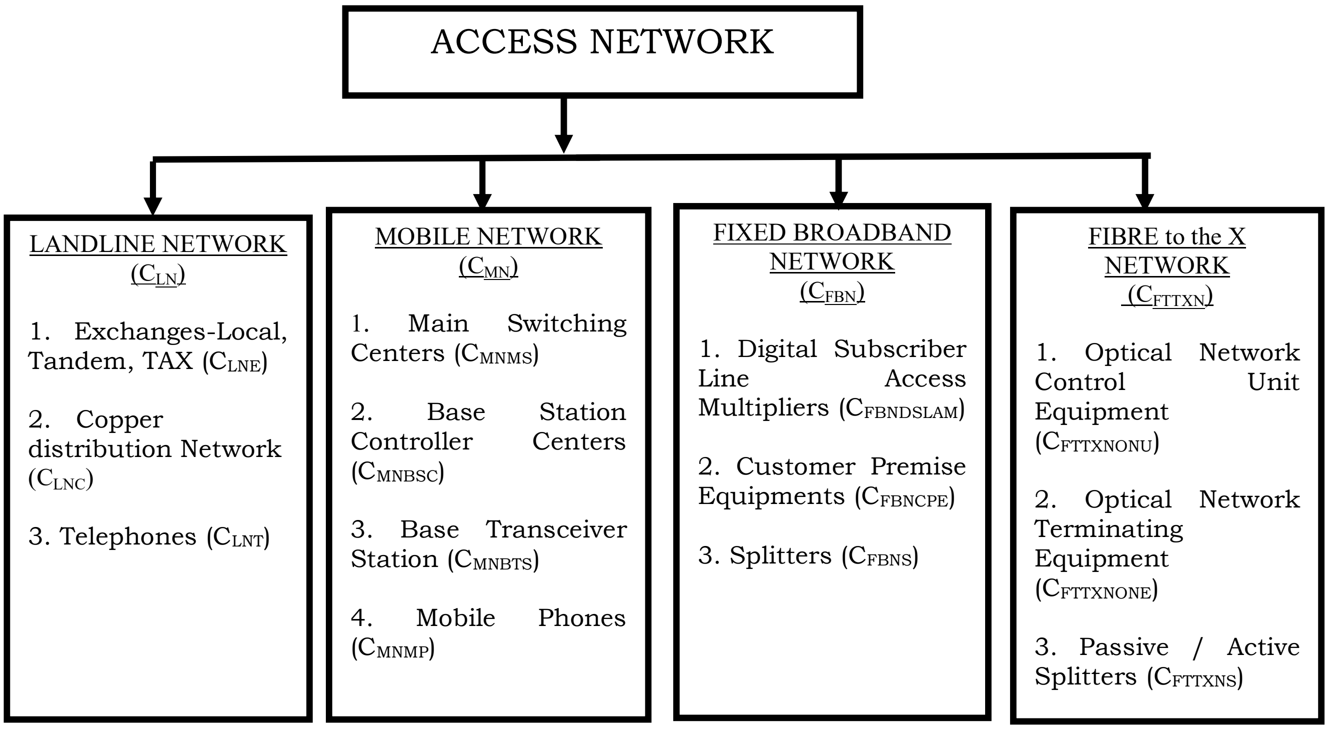
Table 2: Various blocks of Access network

Blocks of the Access network	Carbon Footprint denoted by
Landline Network	C_{LN}
Mobile Network	C_{MN}
Fixed Broadband Network	C_{FBN}
Fibre to the X Network	C_{FTTXN}

1.14. The next stage of classification will involve the various blocks under each category of Access Network which is done as shown in Figure 1.3.

There will be carbon emissions emanating from each block of Access network. There are certain emissions which will be a part of the manufacturing process or under the control of users. The emissions emanating during Life Cycle Assessment (LCA) process i.e. from extraction of raw materials, manufacture of finished telecom equipment, their usage by consumers and their ultimate disposal etc. are not under the direct control of telecom operators. Therefore, such emissions cannot be considered for calculating the carbon footprint of telecom networks.

Figure1.3. Classification of various blocks of Access network



In the following section, the emissions which need to be considered for calculating the carbon footprint of Access network are elaborated.

a) Landline Network: The carbon emissions due to copper distribution network and telephone sets are neglected since such emissions fall under the manufacturing part. Hence, C_{LNC} and C_{LNT} are zero.

Thus, $\mathbf{C_{LN} = C_{LNE}}$

b) Mobile Network: The carbon emissions due to mobile phones is neglected as the type of handset, a customer uses, is not under the control of service providers. Moreover these are already covered in the LCA as part of the manufacturing process. Hence, C_{MNMP} is zero.

Thus, $\mathbf{C_{MN} = C_{MNMS} + C_{MNBSC} + C_{MNBTS}}$

c) Broadband network: The carbon emissions due to Customer Premise Equipments (CPE) and Splitters are neglected. Emissions from Splitters and CPEs fall under the manufacturing part which is already covered under the LCA. Hence, C_{FBNCPE} and C_{FBNS} are zero.

Thus, $\mathbf{C_{FBN} = C_{FBNDSLAM}}$

d) Fibre to the X network: The carbon emissions from optical network terminating equipments and splitters fall under the manufacturing part and therefore they are neglected. Hence, $C_{FTTXNONE}$ and C_{FTTXNS} are zero.

Thus, $\mathbf{C_{FTTXN} = C_{FTTXNONU}}$

The total carbon footprint of the Access part of the telecom network can be summed up as below:

$$\mathbf{C_{AN} = C_{LN} + C_{MN} + C_{FBN} + C_{FTTXN}}$$

Where, $C_{LN} = C_{LNE}$

$C_{MN} = C_{MNMS} + C_{MNBSC} + C_{MNBTS}$

$C_{FBN} = C_{FBNDSLAM}$

$C_{FTTXN} = C_{FTTXNONU}$

1.15. The total carbon footprint of the telecom network can be expressed as a sum of carbon footprints from Access network, Core network, Aggregators and transmission network; This can be put in the form of an equation as given below:

$$\mathbf{C_{TOTAL} = C_{AN} + C_{CN} + C_{A} + C_{TN}}$$

Where, $\mathbf{C_{CN}}$ = Carbon footprint of Core network

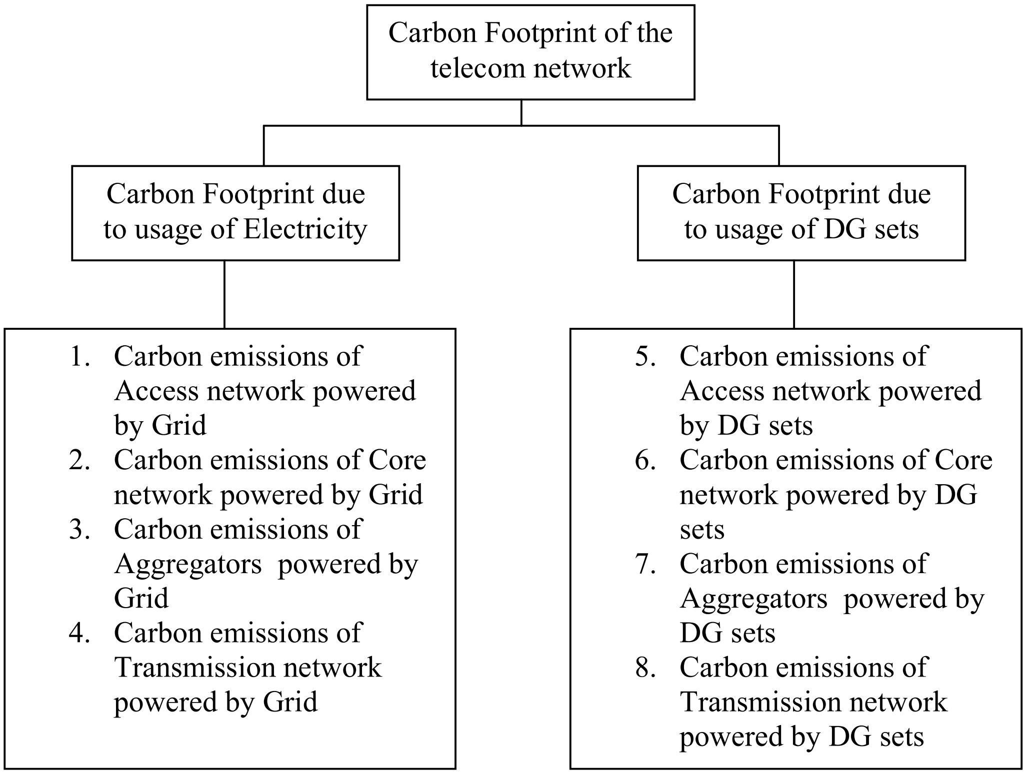
$\mathbf{C_{A}}$ = Carbon footprint of Aggregators

$\mathbf{C_{TN}}$ = Carbon foot print of Transmission network

$\mathbf{C_{AN}}$ = Carbon foot print of Access network

Further, the total carbon footprint will be calculated by summing up the carbon emissions from combustion of diesel in DG sets and usage of purchased electricity in each of the sub-networks mentioned above. This illustrated in the following Figure 1.4.

Figure1.4. Total carbon footprint of the telecom network



E. TRAI's recommendations, "Approach towards green telecommunications dated 12th April 2011" in line with ITU-T L.1420 recommendation

1.16. ITU-T L.1420 recommendation titled '*Methodology for energy consumption and greenhouse gas emissions impact assessment of information and communication technologies in organizations*' assists ICT organizations in assessing the energy consumption and GHG emissions related to their operations. The key points of the ITU-T recommendations and TRAI's compliance with them are explained in the following section.

i. Identification of GHG sources for calculation of carbon footprint: The GHG sources must be classified as two types: Direct & Indirect sources. In TRAI's recommendation (dated 12th April, 2011), the sources had been classified as direct & indirect sources and accordingly a methodology was developed for calculation of carbon footprint.

ii. Specification of the boundary and scope of coverage: This involves defining the boundary for emissions which are under the direct control of the telecom service provider. Such emissions include emissions from combustion of fossil fuels and usage of electricity. Emissions from life cycle assessment (LCA) of products like manufacturing, eventual breakdown etc. are not taken into consideration for calculation carbon footprint as these are not under the direct control of the operators.

In TRAI recommendation (dated 12th April, 2011), only the emissions from fossil fuels and electricity were considered for calculating the carbon footprint of the telecom network.

iii. Selection of an appropriate quantification methodology: This involves developing an appropriate formula for calculation of carbon footprint which is accurate and consistent taking into account all the emissions. An appropriate methodology was developed and presented in the earlier TRAI's Recommendations dated 12th April, 2011 wherein two formulae were developed for quantifying the emissions from both DG sets and grid supply.

iv. Selecting a Base year and reporting year: The organization should mention the base and the reporting years for reporting the carbon footprints.

The Authority had, in its previous recommendation, set the base year to 2011 and reporting year as 2012. Based on recommendations by TRAI, DoT on 4.01.2012 issued directions for the telecom industry to submit the carbon footprint reports of their respective networks bi-annually by keeping the base year as 2011 and reporting year as 2012. Following the direction, the telecom service providers have been submitting the carbon footprint reports of their respective network twice a year.

v. Disclosing the footprints: The organization shall prescribe a particular format for disclosing the carbon footprints of the operator's network.

TRAI also ensures that the service providers disclose their carbon footprints twice a year in a particular format prescribed by the Authority (The format in which carbon footprints are collected are given in Annexure I).

F. Existing Formula of TRAI for calculating the carbon footprint

1.17. TRAI in its recommendation, "Approach towards Green Telecommunications" had come up with the following formula for calculation of carbon footprint:

$$\mathbf{C_{TOTAL} = C_{GRIDPOWER} + C_{DGSET}} \quad \text{in tonnes of } CO_2\text{e per year}$$

Where, $\mathbf{C_{GRIDPOWER=} = 0.365(0.84*P*X)}$ **in tonnes per year,**

$\mathbf{C_{DGSET} = 0.365\ [(0.528*Y*Z)/\eta]}$ **in tonnes per year**

Also,

P = Power consumption in kWh

X= Average hrs with grid supply per day

Z = Power capacity of DG set in kVA

Y = Running time of the DG set in hours per day

η = efficiency of the generator

1.18. In this formula, the carbon emission from grid power is calculated based on the assumption that the CO_2 emission from the electricity grid will be 0.84 tonnes of CO_2e/MWh. In case of carbon emission from DG sets, the same was calculated after taking into account the fact that a 15 KVA DG set consumes 3 litres of diesel per hour and 1 litre of diesel emits 2.629 kgs of CO_2 emissions.

1.19. Further, average carbon foot print is calculated in two ways:

I. <u>Carbon footprint per subscriber:</u> Dividing the total carbon footprint by the total number of subscribers gives average carbon footprint of the telecom network per subscriber. If N_{SUB} is the total number of subscribers in the telecom network, then the average carbon footprint per subscriber is given as:

$$C_{TOTAL\_PER\ subscriber} = \frac{CTOTAL}{NSUB}$$ in tonnes of CO_2e /subscriber /year

II. Carbon footprint per unique user: Dividing the total carbon footprint by the total number of subscribers gives average carbon footprint of the telecom network per unique user. If N_{USER} is the total number of unique users in the telecom network, then the average carbon footprint per unique user is given as:

$$C_{TOTAL\_PER\ USER} = \frac{CTOTAL}{NUSER}$$ in tonnes of CO_2e /user /year

G. Modified Formula for calculating carbon footprint from DG sets and Grid power

1.20. New formulae have been devised and presented in the following section to calculate the carbon footprint of the telecom network. The formulae so developed broadly have two stages:

STAGE 1: The first stage consists of calculating the carbon footprint per year i.e. calculating tonnes of CO_2e produced per year. Separate formulae have been developed for calculating carbon footprint due to usage of electricity and for calculating carbon footprint due to DG sets.

STAGE 2: The second stage consists of calculating the average carbon footprint of the telecom network. There are various options for the choice of entity across with which the averaging may be done in a telecom network:

i. Total number of mobile subscribers in the network
ii. Total number of unique users in the network
iii. Total amount of traffic carried by the network in exabytes.

The following sections present the formulae devised for quantifying carbon emissions from telecom network.

1.21. Calculation of carbon footprint of the Telecom network due to usage of Grid Supply

Emissions from the use of electricity for operation of telecom equipments fall under 'Scope 2' emissions. A formula to quantify such emissions has been explained in this section.

The formula for quantifying the emissions from electricity grid involves calculating a suitable value of the "Emission factor" which is defined as the average emission rate of a given GHG for a given source, relative to units of activity.[7]

The emission factor proposed in the following section has been proposed with respect to the methodology proposed by United Nations Framework Convention on Climate Change (UNFCC).[8]

The Indian power system is divided into two grids:

1. NEWNE grid: Comprises of Northern, Eastern, Western and North Eastern grids.
2. South grid: Covers Southern India.

The geographical scope of the two electricity grids is defined in Table 1.1

Table 1.1: Geographical scope of Electricity grid in India

NEWNE Grid				Southern Grid
Northern	**Eastern**	**Western**	**North-Eastern**	**Southern**
Chandigarh	Bihar	Chhattisgarh	Arunachal Pradesh	Andhra Pradesh
Delhi	Jharkhand	Gujarat	Assam	Karnataka
Haryana	Orissa	Daman & Diu	Manipur	Kerala
Himachal Pradesh	West Bengal	Dadar & Nagar Haveli	Meghalaya	Tamil Nadu
Jammu & Kashmir	Sikkim	Madhya Pradesh	Mizoram	Puducherry
Punjab	Andaman-Nicobar	Maharashtra	Nagaland	Lakshadweep
Rajasthan		Goa	Tripura	
Uttar Pradesh				
Uttarakhand				

Each electricity grid has an emission factor associated with it. The emission factor is defined as a measure of CO_2 emissions intensity per unit of electricity generation in the grid system. (Units of Emission factor is "tonnes of CO_2e/MWh").

[7] http://unfccc.int/ghg_data/online_help/definitions/items/3817.php
[8] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v1.1.pdf

As per the CO_2 Baseline data base published by Central electricity board, the emission factor (EF) of Grids (in tonnes of CO_2e /MWh) has been given in Table 1.2:[9]

Table 1.2: Emission factor of electricity grids (in tonnes CO_2e/ MWh)

GRID	Average	OM	BM	CM
NEWNE	0.82	1.00	0.95	0.97
South	0.82	1.02	0.96	0.99

Where,

Average is the average emission of all stations in the grid, weighted by net generation.

OM (Simple operating margin) is the average emission from all stations excluding the low cost/must run sources.

BM (Build Margin) is the average emission of the 20% (by net generation) most recent capacity addition in the grid.

CM (Combined Margin) is a weighted average of the OM and BM (here weighted 50: 50).

Based on the selection of an appropriate margin, a particular emission factor for the grid may be obtained. Also, the telecom service areas powered by NEWNE grid and south Grid shall use the Emission factor of the corresponding grids for a particular choice of margin.

Question 4: Whether the existing formulae for calculation of Carbon footprints from Grid (given in paras 1.16, 1.17 and 1.18) need to be modified? If so, please comment with justification.

Question 5: Which emission factors as mentioned in Table 1.2 need to be used for the calculation (Average/OM/BM/CM)? Is there any other factor(s) needs to be considered in the calculation? Please comment with justification.

1.22. If the emission factor of the grid is 'EF' (in tonnes of CO_2e/MWh),consumption of power from the grid by the telecom network is 'A

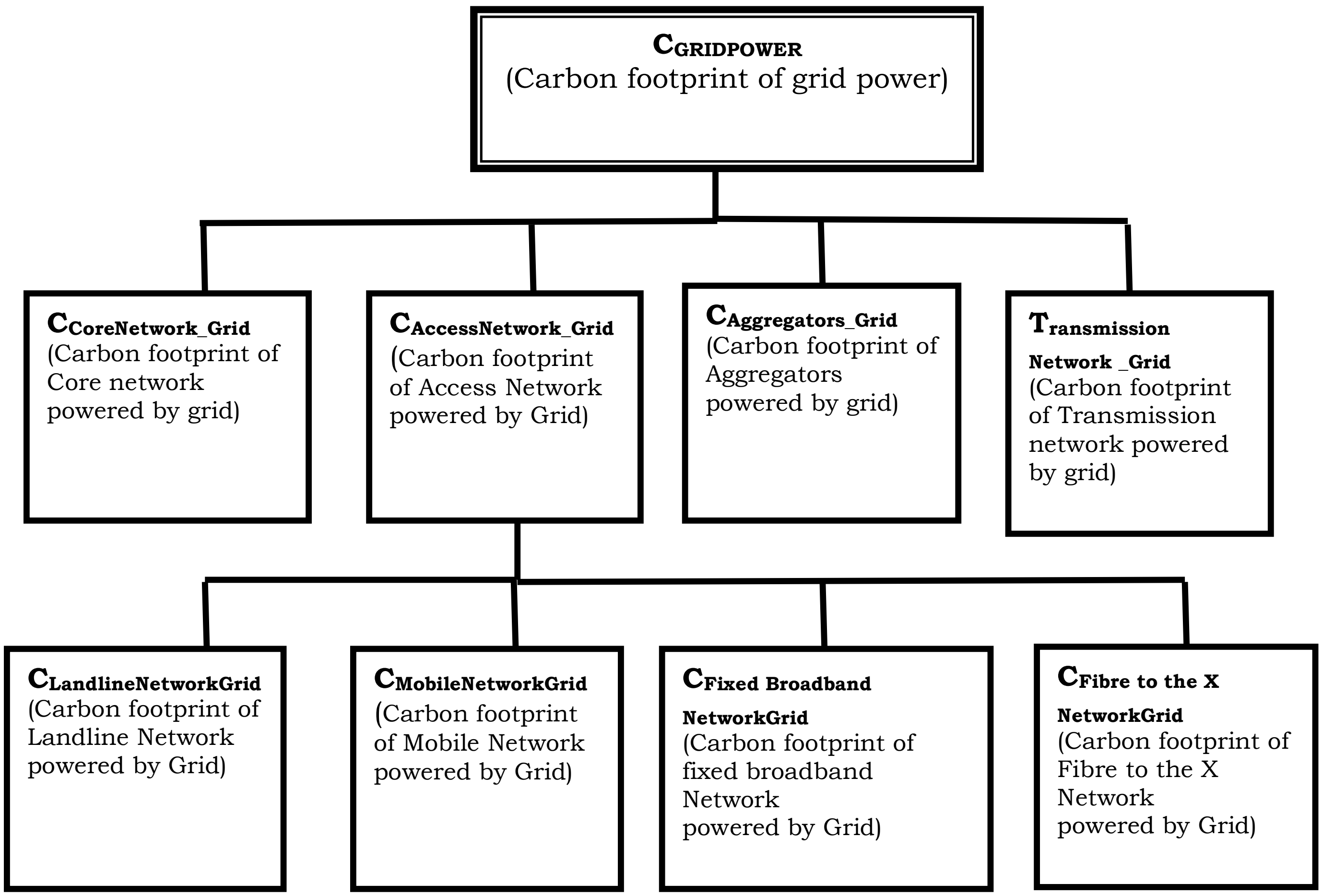
[9] CO2 Baseline Database for the Indian Power Sector ,User Guide Version 10.0 , December 2014 by Central Electricity Authority , Ministry of Power , Government of India

MWh' per year, then the carbon footprint per year due to grid power is calculated as:

$$\mathbf{C_{GRIDPOWER} = (EF * A)} \quad \text{tonnes of } CO_2\text{e per year}$$

Therefore, the composition of carbon emissions due to grid supply (**$C_{GRIDPOWER}$**) emanating from the telecom network can be shown in Figure 1.5.

Figure 1.5: Composition of Carbon foot print due to Grid supply



Question 6: Is the formula mentioned in para 1.22 suitable for calculation of Carbon footprints from Grid supply? Please comment with justification.

1.23. <u>Calculation of carbon footprint of the Telecom network due to Diesel Generator (DG) sets</u>

Carbon emissions due to usage of diesel in powering the telecom equipments fall under Scope 1 emissions. This section proposes formulae which may be used to calculate such carbon emissions.

The carbon footprint due to DG sets can be calculated using two formulae given below:

i. Based on Diesel Consumption of DG set: This formula utilizes the carbon equivalents emitted per litre of diesel.
ii. Based on Capacity of Generator used: This formula is based on the Capacity of the DG set used to power the telecom tower.

Each of these formulas has been defined and explained in the following section.

1. Formula based on the diesel consumption of the DG set

In this formula the total diesel consumed in a year is used directly for calculation of the emissions from DG sets.

One litre of diesel produces 2.629 Kilograms of CO_2e or 0.002629 tonnes of COe. (1 tonne= 1000 kilograms)

Hence, the total carbon footprint is obtained by multiplying the number of litres consumed by the DG set (in one year) and 0.002629 tonnes of CO_2e. This can be expressed in the following equation:

$$\mathbf{C_{DGSET\_A} = 0.002629 * N} \quad \text{tonnes of } CO_2\text{e per year}$$

Where "N" is the total Diesel consumption of the diesel generator in litre in a year.

2. Formula based on the Capacity of the generator used[10]

In this formula the capacity, efficiency and power factor of the DG set, are used for calculation of the emissions from DG sets.

The net calorific value of diesel fuel is 43.33 Mega joules per kilograms[11] or 36.59 Mega joules per litre (1 kilogram of diesel=1.184 litres of diesel) which

[10] "Green Telecom Layered Framework For Calculating Carbon Footprint Of Telecom Network" by Himanshu Makkar, IJRET Journal
[11] http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_1_CO2_Stationary_Combustion.pdf

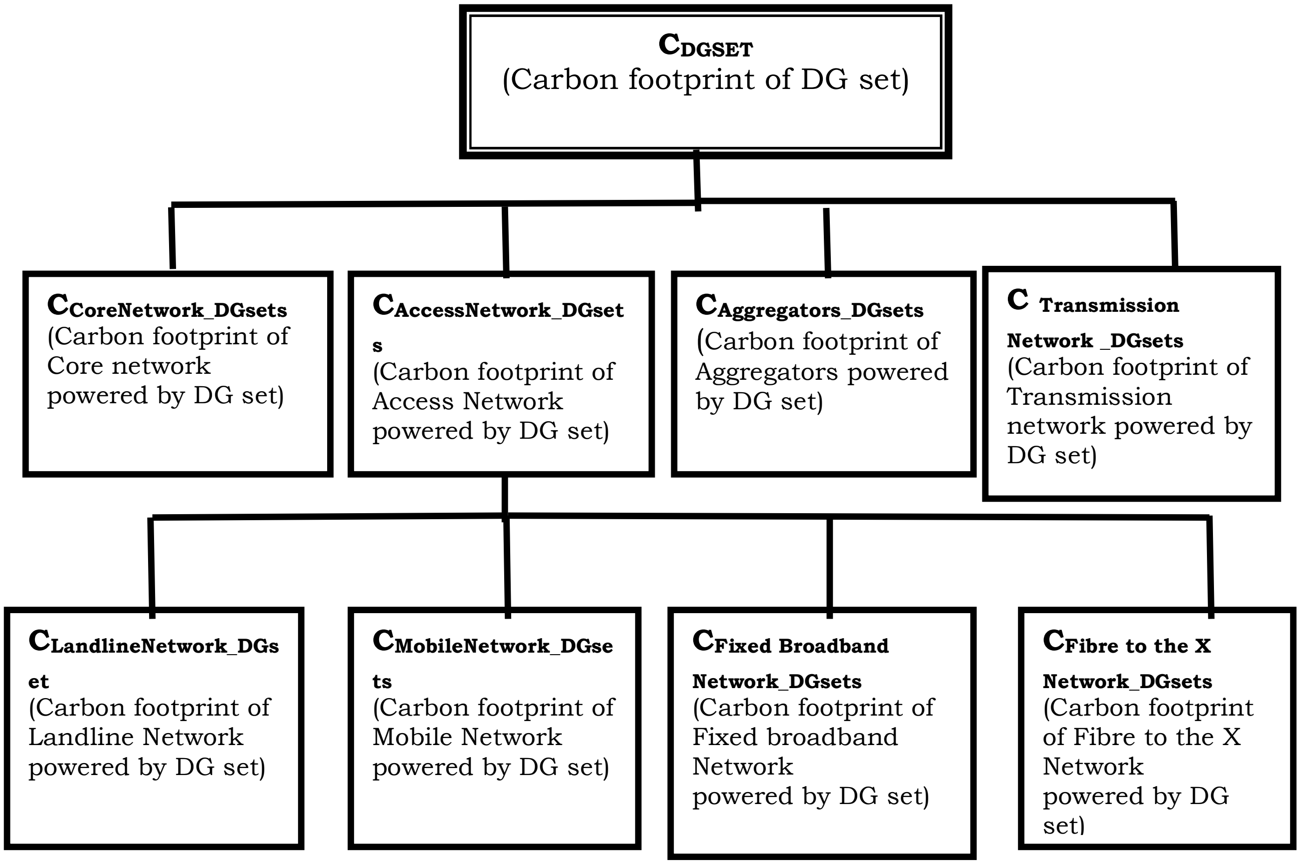
means 10.16 Kilowatt hours of energy (1 kWh=3.6MJ) is generated for one litre of diesel. Also, one litre of diesel produces 2.629 Kilograms of CO_2. This means that 0.2587 kilograms of CO_2 is produced per kilowatt hour per litre of diesel.

If 'X Kilowatt-amperes (KVA)' is the capacity of DG set, 'φ' be the power factor of DG set, 'Y hours' is the number of hours the network element is in use per year and 'η' be the efficiency of the DG set, then the carbon foot print in tonnes per year is given by:

$$\mathbf{C_{DGSET\_B}} = \frac{\mathbf{0.2587 * X * \varphi * Y}}{\mathbf{\eta * 1000}} \quad \textbf{tonnes of } \mathbf{CO_2}\textbf{e per year}$$

Therefore, the composition of Carbon emissions due to DG sets emanating from telecom network ($\mathbf{C_{DGSET}}$) can be shown in Figure 1.6.

Figure 1.6: Composition of carbon footprint due to DG sets



Question 7: Which of the formulas, (i) or (ii), in para 1.23 is to be used for the calculation of carbon footprints from the Diesel generator along with views on possible values of φ and η? Please comment with justification.

1.24. Total Carbon footprint of the telecom network

The total carbon foot print of the telecom network will be the sum total of carbon footprints of Grid power and DG sets. This is presented in the form of an equation as below:

$$C_{TOTAL} = C_{GRIDPOWER} + C_{DGSET} \quad \text{in tonnes } CO_2e \text{ per year}$$

Where, $C_{GRIDPOWER}$ = **[EF * A] tonnes of CO_2e per year**

$C_{DGSET} = C_{DGSET\_A}$ **or** C_{DGSET_B}

1.25. Calculation of average carbon footprint of the Telecom Network

Next stage of methodology involves calculating the average carbon footprint of the telecom network. Three options may be considered for averaging the total carbon footprint of the telecom network. These are given as below:

i. OPTION 1: Averaging across total number of subscribers

If the total number of subscribers in the network is N_{SUB}, then the average carbon footprint per unit subscriber is:

$$C_{TOTAL\_PER\ UNIT\ SUBSCRIBER} = \frac{CTOTAL}{NSUB}$$ in tonnes per unit subscriber

ii. OPTION 2: Averaging across total number of unique users

If the total number of unique users in the network is N_{USERS}, then the average carbon footprint per unit subscriber is:

$$C_{TOTAL\_PER\ UNIT\ USER} = \frac{CTOTAL}{NUSERS}$$ in tonnes per unit unique user

(*Subscriber is the term used to refer to a person that has an account with a mobile network carrier. Unique user refers to a single individual that has subscribed to a mobile service and that person can hold multiple mobile connections (i.e. SIM cards). If an individual 'A' has two mobile connections subscribed to operator 'X, then the mobile network of X has two mobile subscriptions but the user is one (i.e. A)*)

iii. OPTION 3: Averaging across total amount of traffic carried

If the traffic carried by the telecom network is 'T Exabytes' then the total carbon footprint per unit traffic is given by:

$$C_{TOTAL\_PER\ UNIT\ TRAFFIC} = \frac{CTOTAL}{T}$$ in tonnes CO_2e per unit Exabyte

Question 8: For calculation of average carbon footprint, which of the options mentioned in para 1.25 is to be used? Please comment with justification.

CHAPTER II

Energy Efficiency in Telecom networks and Renewable energy targets

A. Drivers for designing energy efficient Telecom networks

Green Telecommunication challenges the norms of the design and construction industry. Design teams must actively search for better alternatives to conventional models to successfully reduce the environmental impact related to telecommunication construction and uses. Telecom network operators and their equipment vendors have begun to take new initiatives to improve the energy efficiency of telecom networks and reduce their associated carbon emissions. These efforts include reductions in the electricity required to power network elements, integration of renewable energy sources such as solar and wind, more energy efficient practices for network operations and a greater focus on recycling and reuse of network equipment.

The key drivers for designing energy efficient networks are summarized as below:

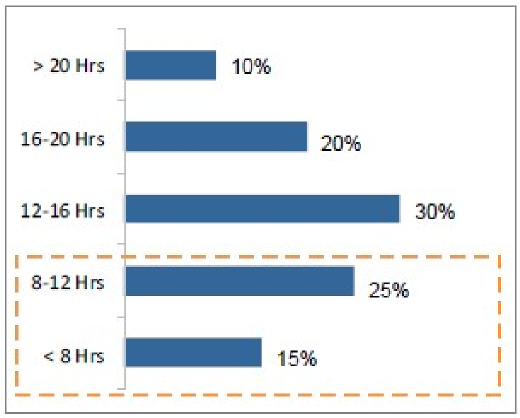
2.1. Growing Telecom Market in India **:** Telecommunications has been recognized as one of the prime support services needed for rapid growth and modernization of various sectors of economy. India is now the second largest and fastest growing mobile telephone market in the world and its increasing penetration is rapidly transforming communication in generating new economic opportunities. It has been observed that teledensity is lower in rural areas than that in urban areas. Areas with low teledensity could offer potential for future growth but have limitations in terms of power and other infrastructure availability. It is estimated that total number of telecom towers would reach ~1,000,000 by FY17 primarily driven by increasing penetration in rural areas.[12] There are 4,50,000 telecom towers in the country.[13]Moreover, with 3G becoming pervasive and the increasing roll out

[12] "Green Telecom Towers – an attractive option for sustainable tomorrow" TATA Strategic management group.
[13]"Green Telecom -long way to go? ", a Cyber media Publication,voicendata.com,October 2015

of 4G networks, the energy demand will further substantially increase the energy consumption patterns of the telecom sector.

2.2. Uncertain power scenario in the Telecom Industry: Power deficit in India is a continuing problem. Due to the precarious power scenario ~40% of the telecom towers face load shedding for more than 12 hours per day. All India Power availability (in hours) at various cell sites is shown in Figure 2.1.

Figure 2.1: All India Power Availability at various cell sites



Because of limited availability of power and an uncertain grid power situation, telecom tower companies are increasingly relying on diesel generators, batteries and a variety of power management equipment to back-up the grid and ensure network availability. Presently ~40% power requirements are met by grid power and 60% by diesel generators.[14] It is seen that energy costs account for ~30%-34% of total operational expenditure for a telecom tower company.[15]

2.3. Larger carbon emissions: The ever-increasing demands for telecommunication services has not only increased the energy consumption significantly and poses an environmental challenge in terms of larger carbon emission footprint of the telecommunication industry, but also presses telecom operators and vendors to spend less on energy and extract more efficiency out of their systems. Consequently, telecom vendors will need to take the decision of investing millions in new energy optimization

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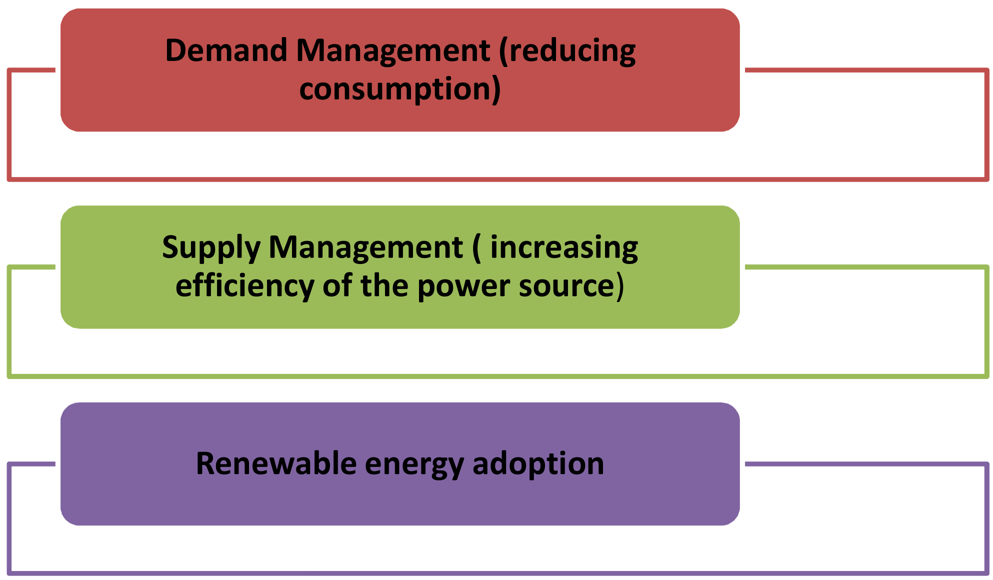
[14] "Green Telecom Towers – an attractive option for sustainable tomorrow" TATA Strategic management group.
[15] "Green Telecom Towers – an attractive option for sustainable tomorrow" TATA Strategic management group.

technologies and offering enough innovations to satisfy not only their customers, but also to improve their own bottom lines.

B. Aspects of Energy efficiency in telecom network [16][17]

Telecom service providers and tower infrastructure companies are turning to 'green' power management solutions which can be broadly classified into three categories as shown in Figure 2.2.

Figure 2.2: Aspects of Energy efficiency in Telecom networks



The various aspects of energy efficiency in telecom networks are explained in the following section:

2.4. **Demand management (reducing consumption):** This includes a wide range of actions and practices to reduce demand for electricity (or for hydrocarbons) and/or to attempt switching demand from peak to off-peak hours.

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[16] Energy efficiency :Green telecom by PwC
[17] "Green Solutions for Telecom Towers: Part I" by Intelligent Energy Limited, 2013

Activities like passive infrastructure sharing, replacement of old Base Transceiver Stations (BTSs) with new generation BTSs, usage of outdoor BTS, optimized cooling at shelter, usage of intelligent transceivers (TRXs), reduction of air conditioner load by using cold ambient air for shelter cooling and operating air conditioners using stored energy in the batteries to reduce diesel consumption and carbon emission are some of the initiatives that have been implemented so far.

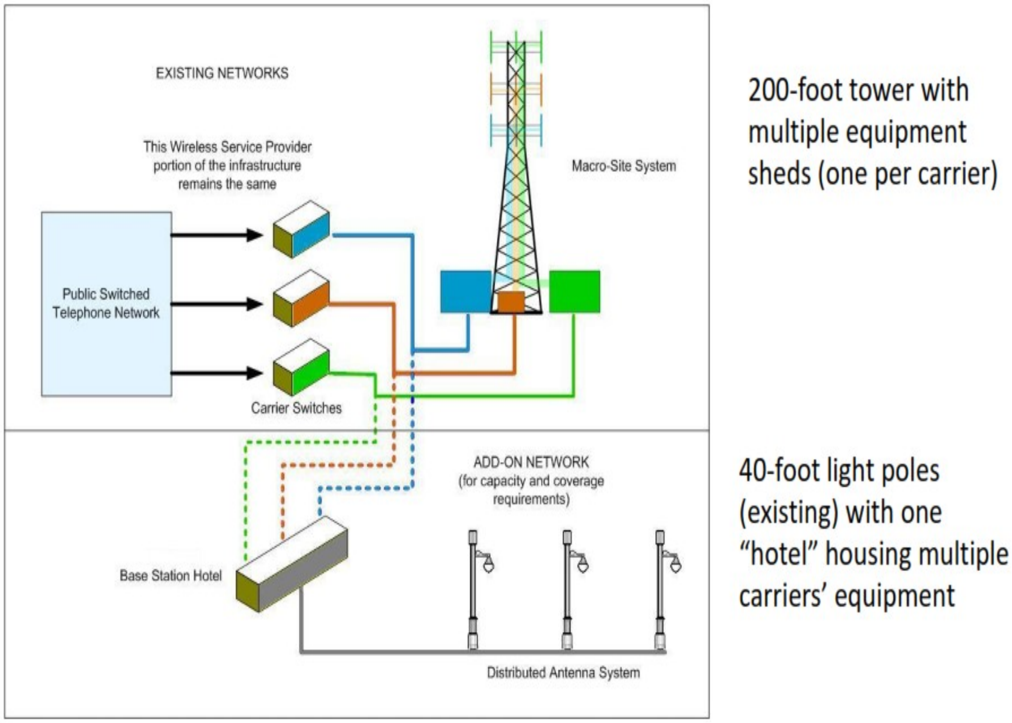
Some key energy efficient technologies which may be adopted to reduce the energy consumption at tower site are given below:

i. Active Distributed Antenna System (DAS)[18]

DAS is a network of spatially separated antenna nodes connected to a common source via a transport medium (like optical fibres, coaxial cables etc.) that provides wireless service within a geographic area or structure. A single antenna radiating at high power is replaced by a group of low-power antennas to cover the same area. The idea works because less power is wasted in overcoming penetration and shadowing losses and also because a line-of-sight channel is present more frequently, leading to reduced fade depths and reduced delay spread. Figure 2.3 compares a macro site with DAS.

[18] www.thedasforum.org

Figure 2.3: Comparing Macro sites with DAS



ii. <u>Sleep mode Base Transceiver Stations.</u>[19]

Sleep mode BTS can turn power off when the call traffic is low. This capability can be simply added to the site with minor software modifications in BTS technology. This technology has the potential to reduce power consumption by more than 40% under low traffic conditions and more than 10-15% on an overall level. In order for the sleep mode techniques to function, Base Stations (BS) usually need to cooperate with each other. A BS controller (BSC) facilitates exchange of traffic information between BSs. If certain BSs are selected to sleep, the sleeping BSs release their channel resources to active neighbours, while active BSs make use of obtained resources to cooperatively provide extensive coverage to the mobile users located in the service areas of nearby sleeping BSs. A technique called S*elf-Organizing Network* (SON), introduced in the 3GPP standard is intended to be gradually implemented in BSs along with the 4G standards including LTE and WiMAX. It adds automatic network management and intelligence features to the system and thus reduces costs, improves performance and increases flexibility of the

[19]" Energy-Efficient Base-Stations Sleep-Mode Techniques in Green Cellular Networks: A Survey " byJingjin Wu, Yujing Zhang, Moshe Zukerman, Fellow, IEEE, and Edward Kai-Ning Yung, Fellow, IEEE, IEEE COMMUNICATION SURVEYS & TUTORIALS, VOL. 17, NO. 2, SECOND QUARTER2015

cellular system through network optimization and reconfiguration processes. Sleep mode in BSs is one of the various applications of SON, where BSs are enabled to act collectively to save energy by redistributing traffic and sharing traffic information among BSs.

iii. DC Free air cooling units (DCFCUs)[20]: The power consumed by a DC Free Cooling Unit (DCFCU) is only 208 watts as against 1350 watts consumed by a 0.9 ton air-conditioner. Further, a DCFCU operates on DC power whereas an Air-conditioner requires a 230 V AC supply. So, in case of a grid power failure, a DCFCU can run on power available in the battery, and reduce the usage of DG by maintaining the temperature.

iv. HVAC (Heating, ventilating and air conditioning) systems along with hot aisle/cold aisle configuration and management of air flow in data centre can reduce the energy by 25%.

v. Tower Remote Monitoring Solutions: Tower Remote Monitoring Solution can achieve remote monitoring & control of onsite equipments and energy on a 24x7 basis. Business analytics on this data enables to drive further excellence towards operational efficiency.

2.5. **Supply management (increasing efficiency of the power source):**

This refers to a set of actions adopted to ensure efficiency through the electricity supply chain. Telecom Service Providers look at means to make rational use of their least efficient generating equipment. The objective is to improve the operation and maintenance of existing equipment or upgrade it with energy-efficient technologies. Network optimization and operations management will play a key role in supply side energy efficiency management. Some key energy efficient technologies which may be adopted to increase the energy efficiency of power source are given below:

i. Integrated Power Management System (IPMS)[21] :

IPMS is targeted for all sites having poor grid availability where low voltage and single phasing are pertinent problems. This results in maximizing usage

[20] Green Networks: Transforming Telecommunications on Sustainable Energy Alternatives, a whitepaper by Bharti Infratel Limited

[21] Green Networks: Transforming Telecommunications on Sustainable Energy Alternatives, a whitepaper by Bharti Infratel Limited

of grid power and reducing DG run-hours at cell sites. IPMS helps improve the combined efficiency of the equipment by as much as 3-5%. IPMS also intelligently integrates various components like LCU (Local Control Unit), NMS (Network Management System), RTU Metering (Remote Terminal Unit), SMPS(Switch Mode Power System), distribution and wiring into one unit thus saving space, cost and improving quality.

ii. Variable Speed DC DG:

Telecom loads are highly variable depending on traffic and temperature. Depending on the number of tenants, diesel consumption varies and may go up with the requisite increase in tenancies. Average DG run-hours for such sites hovers up to 16 hours/day. Since the load at cell sites is highly variable, constant speed AC DGs become inefficient under low-load conditions. Variable speed DC DGs have a relatively flat efficiency curve and are a better solution for cell sites even if we consider the efficiency loss incurred in AC to DC conversion. Fuel consumption for similar load applications in case of DC DGs is up to 30% lesser than AC DGs, thus significantly saving on diesel consumption.

iii. GenX:[22]

GenX is a product, which converts DC power to AC power, and has the functionality of a soft starter. These are being installed at all those indoor cell sites where ambient temperature remains predominantly above 25 degree Celsius. The product would enable running of air-conditioner from battery source during grid unavailability thus avoiding DG usage.

2.6. **Renewable energy solutions:** Renewable energy solutions like using solar energy, wind energy, fuel cells, batteries etc can be deployed to power the telecom towers to achieve energy efficiency in the telecom networks leading to less carbon emissions and less operational costs. Various options available for RET solutions and the current status of RET installation in India are discussed in the following sections of this chapter.

[22] Green Networks: Transforming Telecommunications on Sustainable Energy Alternatives, a whitepaper by Bharti Infratel Limited

C. **Renewable Energy Technology (RET) for Telecom Sector**

RET solutions like solar photovoltaic, wind power, biomass and fuel cells are the technologies of choice for alternative solutions at telecom towers today. Hybrid solutions that combine diesel generators with RETs and batteries are being customized. Fuel cells are being installed as a standalone solution replacing the existing diesel generator to power the telecom sites.

It is seen that customization of the RET solution for a particular site requires a thorough understanding of each technology and its relevant economics. The comparative characteristics, advantages and limitations of solar photovoltaic, wind power, battery and fuel cell technologies are discussed in this section to understand the viability and importance of each RET solution.

2.7. Solar Photovoltaic[23]

India receives abundant sunshine for about three hundred days a year. The daily average solar energy incident across India varies from 4-7 kWh/sq.m.This translates to 4-6 hours of sunshine per day that can be used by a Solar Photovoltaic (SPV) installation.

Since a photovoltaic system can only generate power during sunshine hours, it is not feasible to create a standalone solution using this system. Generally, a solar photovoltaic backup power system is:

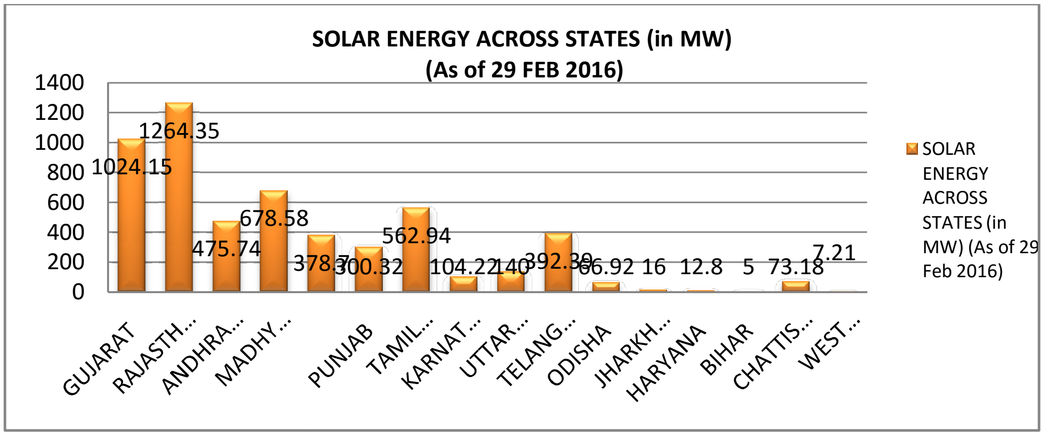
- Designed in combination with the appropriately sized battery bank, or
- Used to offset the operation of a backup power system like a diesel generator for the approximately four hours per day when sunlight is available.

The Ministry of New and Renewable Energy (MNRE) is supporting off-grid solar photovoltaic telecom applications efficiency, charge controller efficiency, power loss due to dust accumulation and available area for installation by providing a capital subsidy of 30%.

[23] "Green Solutions for Telecom Towers: Part I" by Intelligent Energy Limited, 2013

Figure 2.4 shows the deployment of solar energy across various Indian states.

Figure 2.4: Solar Power installed capacity across various states



Solar power is currently the most commercialised technology amongst RETs used to power towers. The technology is best suited for rural areas, which offer a vast expanse of land for panel installation. In urban areas, solar panels mounted on rooftops are gaining acceptance. Further, with the price of panels declining substantially in recent years, solar is becoming a more feasible option financially besides being the most easily deployable technology amongst RETs. The number of solar sites, however, continues to constitute less than 10 per cent of tower companies' portfolio.

2.8. Wind Power[24]

Viability of wind power technology is dependent on the duration of useful wind speed and quality of wind. The wind speed profile varies throughout the year. During January and February, the wind speed is at its lowest and peaks through September. The speed reduces from October again. In India quality wind speed is available in states of Maharashtra, Tamil Nadu, Gujarat, Karnataka and in parts of Orissa, Andhra Pradesh and Madhya Pradesh. With an annual national average of 5-6 m/s wind speed and an average duration of 4 hours/day, the wind power turbine solution for telecom towers cannot form a standalone solution. The dependency on availability of high quality wind speed has made the technology unreliable for less windy sites.

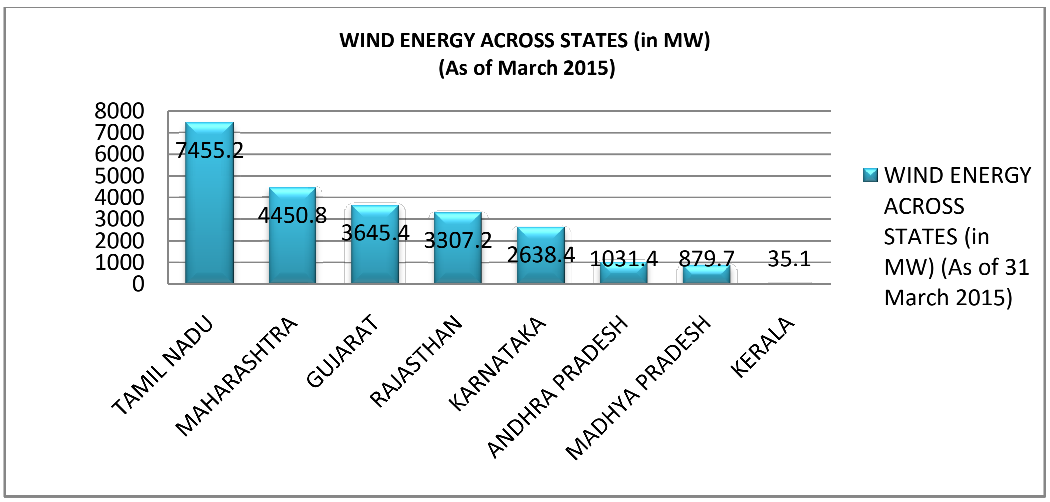
[24] "Green Solutions for Telecom Towers: Part I" by Intelligent Energy Limited, 2013

Wind generators can even be installed on telecom towers at a height of 15-20 meters with suitable modification in tower design, taking into account tower strength.

The southern and western coastal areas are the ideal locations for wind generators. For the telecommunication network in rural areas in states like Tamil Nadu, Karnataka, Gujarat, Maharashtra and parts of Orissa, Andhra Pradesh, Madhya Pradesh where annual average wind speeds of 5-6 m/s are available, installation of wind power systems can be an attractive option to supplement the energy supply.

Figure 2.5 shows the deployment of wind power across various Indian states as of 31 March 2015.

Figure 2.5: Wind Power installed capacity across various states



2.9. Fuel Cells[25]

A fuel cell is a device that converts the chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent. Hydrogen is the most common fuel, but hydrocarbons such as natural gas and alcohols like methanol are sometimes used. A fuel cell is different

[25] "Green Solutions for Telecom Towers: Part I" by Intelligent Energy Limited, 2013

from a battery in the sense that reactants are constantly supplied to a fuel cell making it an open system whereas a battery cell is a closed system that stores the reactants within it. A fuel cell works as long as fuel is supplied to it whereas a battery cell requires regular replacements. The various types of fuel cells that can be used for telecom towers are Proton Exchange Membrane (PEM), Solid Oxide Fuel Cell (SOFC) and Molten Carbon Fuel Cell (MCFC). These fuel cells use fuels like hydrogen, methanol, natural gas and other hydro carbons.

Fuel cell based systems can be designed to be modular allowing a close match of the installed capacity to the power demand of the site. Additionally, any increase in the demand at the site due to increased tenancy can be met by simple addition of capacity to the fuel cell system. Fuel cells have higher efficiency when compared to other RET solutions. Owing to significantly better efficiency versus load characteristics, fuel cell systems can be used in reduction of the energy requirement of the telecom site in comparison to diesel generators.

Compared to other technologies, fuel cell based solution for telecom towers are relatively new in India. Some trial projects have been undertaken by telecom companies like Idea Cellular and Indus Towers and a few others. While the technology has proven itself through these trials to provide power, the availability and the price of the fuel remains a challenge that needs to be overcome for large scale adoption.

2.10. Hybrid Power Systems[26]

Hybrid systems Grid–DG-Battery-Solar/Wind/Biofuels/Biomass for the rural exchanges can make alternative power solutions to power the telecom towers and optimize the power requirement fed through different energy sources. The hybrid combination uses the best of energy sources and can provide quality, stable power supply for sustainable development in rural areas. The system does require availability of diesel generator, though for much reduced duration of operation. It is also designed to give priority to RET power so that

[26] Report Implementation of Renewable Energy Technology in Telecom Sector by Department of Telecommunications,2014

operation of generators can be minimized to the extent possible. The limitation of this approach is the high initial capital investment required.

2.11. Battery Technologies for RET solution[27]

Batteries are used to store and supply electricity to telecom towers when grid power fails. When battery life is longer, the need for towers to depend on costly diesel-fuelled generators (DG) during grid supply failures, becomes lesser. Presently, there are a large number of options in battery technology for a TSP to choose from depending upon the place of installation, average hours of usage etc. Some of the available options are Lead acid battery, Tubular GEL VRLA, Nickel based battery, Lithium – Ion battery etc.

Question 9: What are the options available for renewable energy solutions which may be harnessed to their maximum potential to power the telecom sector? Please comment with justification.

D. Status of RET Installations in Telecom Sector[28][29]

2.12. This section discusses about sites, powered by RET solutions, installed by various service providers across the country. Also it discusses about the recommendations given by the committee constituted by DoT for implementation of RET in Telecom sector.

2.13. Out of the 4,50,000 telecom towers in the country, only 90,000 are diesel free sites as on Dec 16.

2.14. Out of 1,50,030 towers, 37,262 Airtel towers now run on less or optimized diesel consumption which includes 3,501 sites powered by solar. This implies about 2.3% of towers are powered by 100% renewable energy.

2.15. Indus towers, the joint venture between Bharti Airtel, Vodafone and Idea Cellular, supposedly the largest telecom tower company in the world is all set

[27] Report Implementation of Renewable Energy Technology in Telecom Sector by Department of Telecommunications,2014

[28] Report Implementation of Renewable Energy Technology in Telecom Sector by Department of Telecommunications,2014

[29] “Green Telecom -long way to go? “, a Cybermedia Publication,voicendata.com,October 2015

to invest over Rs 500 crore on green initiatives. This joint venture already manages about 1.23 lakhs towers out of which approx 60,000 sites are diesel free and approx 1,000 sites run on solar as on Dec 16.

2.16. In order to examine the technical feasibility and financial viability of RET in Telecom sector, DoT undertook 20 RET pilot projects in USOF Phase-I sites through BSNL with subsidy support from Universal Service Obligation Fund (USOF) and MNRE. These sites are tabulated in Table 2.2.

Table 2.2: RET projects undertaken by DoT through BSNL

S. No.	Place	State	RET Solution
1	Dabil	Bihar	10KWp Solar
2	Kaliya	Chhattisgarh	10KWp Solar
3	ChannaJattan	Haryana	10KWp Solar
4	Award	Himachal Pradesh	10KWp Solar
5	Surjan	J&K	10KWp Solar
6	Dehkala	Jharkhand	10KWp Solar
7	Burj	Punjab	10KWp Solar
8	Khidarpur (DisttDholpur)	Rajasthan	10KWp Solar
9	Manduwala (Distt Dehradun)	Uttarakhand	10KWp Solar
10	PaschimSripatinagar	West Bengal	10KWp Solar
11	Hezamara	Tripura	10KWp Solar
12	Jaluki	Nagaland	10KWp Solar
13	Keinou	Manipur	10KWp Solar
14	Namliang	Arunachal Pradesh	10KWp Solar
15	Motaratadia	Gujrat	10KWp Solar & 5KWp Wind
16	Shivrampur (Tumkur)	Karnataka	10KWp Solar & 5KWp Wind
17	Garpathar	Madhya Pradesh	10KWp Solar & 5KWp Wind
18	Titane	Maharashtra	10KWp Solar & 5KWp Wind
19	Barkolikhala	Orissa	10KWp Solar & 5KWp Wind
20	Madavakurichi	Tamil Nadu	10KWp Solar & 5KWp Wind

2.17. According to the RET Committee report, 400 RET projects were taken up by various TSPs with support from MNRE. The Telecom Industry has also executed around 3400 RET projects on RESCO (Renewable Energy Service Company) model. Based on the pilot projects, it was found that solar power system for mobile BTS is technically feasible and the payback period in an off-grid site based on savings in diesel consumption alone is about 4 to 5 years.

Question 10: If electricity generated by a RET project (funded/ maintained by TSP) is also used for community, should it be subtracted from overall carbon emission of a TSP? Please comment with justification.

Question 11: If the RET project is funded/ maintained by other agency, should that emission be counted? Please comment with justification.

2.18. The following are the recommendations of the RET Committee constituted by DoT for implementation of Renewable Energy Technology in the telecom sector.

1. The overall objective of a green telecom policy should aim towards reducing the diesel consumption of the telecom networks and achieving the overall carbon reduction targets for the mobile network at 8% by the year 2014-15 and 17% by the year 2018-19 from base year 2011-12.

2. The methodologies for measuring carbon emission should be aligned with international practices.

3. The directives issued by DoT in 2012 may be calibrated taking into account current status of RET deployment & learnings and significant changes in technologies including optimum energy solutions now available for telecom networks.

4. <u>APPROACH:</u>

The approach suggested by the RET committee for incorporating RET in telecom networks include the following key points:

- In new mobile tower installations, the backup power to grid shall be based on Energy Efficient solutions/ RET power to the extent feasible such as to make the site diesel free.
- In urban areas, the outdoor BTS installations should be made diesel free to the extent feasible with required capacity of efficient storage battery backup and RET systems.
- In the first phase, the Non-EB (Non- Electricity Board) sites & the sites having grid power availability up to 8 hours and DG set more than 5 years old may be converted to RET by 2015-16.

- The diesel free sites that contribute to the overall objective of reducing diesel consumption in telecom networks may be recognized as contributing towards the overall objective of the policy.

5. ENERGY EFFICIENCY:

   Several methods have been suggested by the RET committee for making the telecom networks energy efficient. They are given as below:

- Telecom Service Providers (TSP) and Internet Service Providers (ISP) may optimize their power requirements by adopting more energy efficient strategies in the BTSs and ensure that the total power consumption of each BTS does not exceed 500 W by the year 2020 for 2+2+2 configuration of BTS.
- In line with the objective of National Telecom Policy 2012, use of outdoor DAS (Distributed Antenna Systems) in uncovered, isolated, scattered and small locations including buildings is recommended.
- Active sharing of network infrastructure, which involves the sharing of antennae systems, backhaul transmission systems and base station equipment, is recommended as this will allow operators to save an additional 40% beyond available savings from passive infrastructure sharing.

6. All projects being implemented with funding from USOF should be powered by Grid/RET only.

7. MONITORING:

   The Committee has highlighted the need to monitor the cell sites and has suggested the following to achieve the same:

- The industry may compile the location of all tower sites with Latitude/ Longitude. Other details, such as electrification status of the site, broad data of the cluster i.e. diesel consumption, RET power generated, if any etc. may be collected and this information may be provided to DoT TERM for creating a database within six months.

- The industry shall develop a monitoring & management system for efficient monitoring, controlling and optimizing the use of power consumption in to the network.
- A web based Centralized Energy monitoring system needs to be developed in DoT for monitoring of various parameters and generation of reports.
- TERM cells need to monitor compliance of RET objectives of DOT.
- The committee is, however, of the view that the penalty should not be linked to achievement of RET target at present.

8. In order to ensure that RET adoption in telecom networks is viable and sustainable, the service providers may adopt cluster based, long term agreements indexed to Total Cost of Operation (TCO) where-ever implementation of RET is through Renewable Energy Service Companies (RESCOs) or power management companies.

9. SUPPORT TO INDUSTRY:

- In order to enable industry to access resources for deployment of RET power solutions, DoT should facilitate in processing the industry's proposals for financial assistance, if required under various government schemes such as MNRE cluster based scheme for providing micro-grids and mini-grids with telecom as anchor load and Ministry of Power capital subsidy scheme under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY).
- In the event of a proposal being received from industry, the Government may consider support through (National Clean Energy Fund) NCEF or bilateral financing agencies like World Bank or (Asian Development Bank) ADB to fund capital requirements for green telecom initiatives.
- For realizing the impact of inclusion of Telecom as an Infrastructure sub-sector in the harmonised master list, the benefits for accelerated depreciation and concessional loans with longer tenure may be extended to telecom companies, so that the Service Providers qualify

for claiming depreciation on the capital cost of PV system with associated tax benefits. This would support in faster deployment of RET in telecom sector.

10. INCENTIVES TO INDUSTRY:

The Committee while taking into consideration the objectives of NTP-2012 (National Telecom Policy) which inter-alia includes enhanced and continued adoption of green policy in telecom and incentivization of the use of renewable resources for sustainability, recommends that performance based incentives be provided to telecom licensee/ operators who deploy RET solutions in their networks.

The Committee recommends a rebate of 1%, 2% and 3% in license fees in the financial year subsequent to installation to licensees (TSPs) which deploy RET solutions in 20%, 35% & 50% of their total BTS's in India respectively.

Question 12: Please comment with justification on the approach suggested by the DoT committee.

Question 13: For effective implementation of RET/Energy efficient solutions in telecom sector, how can the industry be supported? Should incentives be provided to licensees (TSPs)? If yes, what should be the milestone? Please comment with justification.

Question 14: What methodology can be proposed for setting new Renewable energy targets in the telecom sector? What should be the timeframe for achieving these targets? Please comment with justification.

Chapter III

ISSUES FOR CONSULTATION

Methodology for calculation of Carbon footprint

3.1. What accuracy level may be set for collecting the data and also, what should be the basis for arriving at this threshold level? Please comment with justification.

3.2. Is there a need for auditing the carbon footprint of a telecom network by a third party auditor? If yes what is the mechanism proposed? Please comment with justification.

3.3. Do you agree with the given approach for calculating the carbon footprint? If not, then please comment with justification.

New Formulae for calculation of Carbon footprint of Telecom network

3.4. Whether the existing formulae for calculation of Carbon footprints from Grid (given in paras 1.16, 1.17 and 1.1.8) of Chapter I need to be modified? If so, please comment with justification.

3.5. Which emission factors as mentioned in Table 1.2 of Chapter I need to be used for the calculation (Average/OM/BM/CM)? Is there any other factor(s) needs to be considered in the calculation? Please comment with justification.

3.6. Is the formula mentioned in para 1.22 of Chapter I suitable for calculation of Carbon footprints from Grid supply? Please comment with justification.

3.7. Which of the formula, (i) or (ii) as given in para 1.23. of Chapter I is to be used for the calculation of carbon footprints from the Diesel

generator along with views on possible values of φ and η? Please comment with justification.

3.8. For calculation of average carbon footprint, which of the options mentioned in para 1.25 of Chapter I is to be used? Please comment with justification.

<u>Energy efficiency in Telecom networks</u>

3.9. What are the options available for renewable energy solutions which may be harnessed to their maximum potential to power the telecom sector? Please comment with justification.

<u>Renewable Energy targets for Telecom networks</u>

3.10. If electricity generated by a RET project (funded/ maintained by TSP) is also used for community, should it be subtracted from overall carbon emission of a TSP? Please comment with justification.

3.11. If the RET project is funded/ maintained by other agency, should that emission be counted? Please comment with justification.

3.12. Please comment with justification on the approach suggested by the DoT committee.

3.13. For effective implementation of RET/Energy efficient solutions in telecom sector, how can the industry be supported? Should incentives be provided to licensees (TSPs)? If yes, what should be the milestone? Please comment with justification.

3.14. What methodology can be proposed for setting new Renewable energy targets in the telecom sector? What should be the timeframe for achieving these targets? Please comment with justification.

Annexure - I

A. Directions of DoT on 4.01.2012 based on the recommendations of TRAI

(DoT has issued separate directions to ISPs, NLDs and CMTS/UASL/Basic Service Licensees on this matter)

1. At least 50% of all rural towers and 20% of the urban towers are to be powered by hybrid power (Renewable Energy Technologies (RET) + Grid power) by 2015, while 75% of rural towers and 33% of urban towers are to be hybrid powered by 2020.
2. All telecom products, equipments and services in the telecom network should be Energy and performance assessed and certified "Green Passport [GP]" utilizing the ECR's Rating and the Energy 'passport' determined by the year 2015.
3. TEC shall be the nodal centre that will certify telecom products, equipments and services on the basis of ECR ratings. TEC may either appoint independent certifying agencies under its guidance or shall certify the same through their Quality Assurance teams. TEC shall prepare and bring out the 'ECR Document' delineating the specifics of the test procedures and the measurement methodology utilized.
4. All service providers should declare to TRAI, the carbon footprint of their network operations in the format prescribed by TRAI. This declaration should be undertaken after adopting the formulae and procedures prescribed by TRAI. The Declaration of the carbon footprints should be done twice in a year i.e. half yearly report for the period ending September to be submitted by 15th of November and the succeeding half yearly report for the period ending March to be submitted by 15th of May each year.
5. All service providers should adopt a Voluntary Code of Practice encompassing energy efficient Network Planning, infra-sharing, deployment of energy efficient technologies and adoption of Renewable Energy Technology (RET) including the following elements:

a. The network operators should progressively induct carefully designed and optimized energy efficient radio networks that reduce overall power and energy consumption.

b. Service providers should endeavor to ensure that the total power consumption of each BTS will not exceed 500W by the year 2020 for 2+2+2 configuration of BTS. TEC shall regularly standardize and prescribe specifications for Telecom equipments of different technologies with respect to power consumption levels. Service providers should adhere to the TEC specifications in order to reduce the total power consumption of BTS.

c. A phased programme should be put in place by the telecom service providers to have their cell sites, particularly in the rural areas, powered by hybrid renewable sources including wind energy, solar energy, fuel cells or a combination thereof. The eventual goal under this phased programme is to ensure that around 50% of all towers in the rural areas are powered by hybrid renewable sources by the year 2015.

d. Service providers through their associations should consensually evolve the voluntary code of practice and submit the same to TRAI within three months from the date of issue of the direction.

6. Service providers should evolve a 'Carbon Credit Policy' in line with carbon credits norms with the ultimate objective of achieving a maximum of 50% over the carbon footprint levels of the base year in rural areas and achieving a maximum of 66% over the carbon footprint levels of the base year by the year 2020. The base year for calculating all existing carbon footprints would be 2011, with an implementation period of one year. Hence the first year of carbon reduction would be the year 2012.

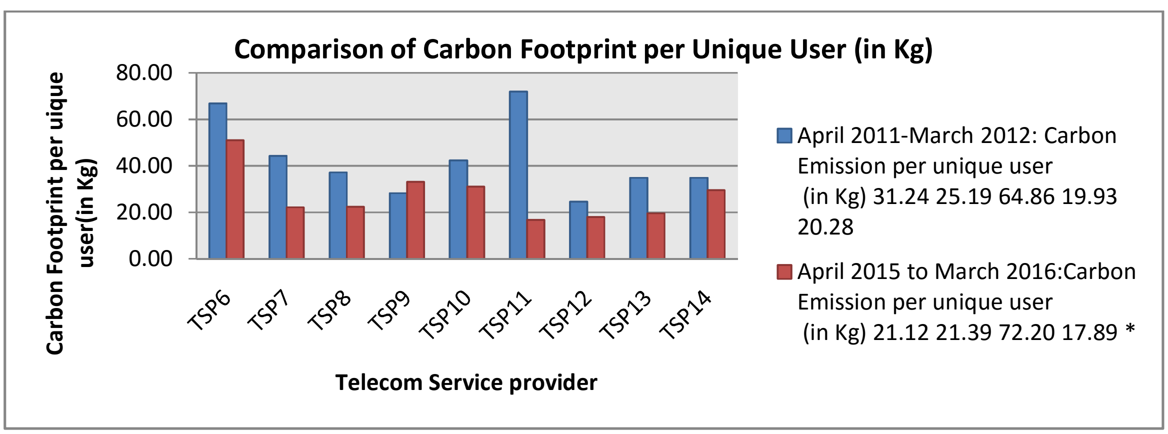
7. Based on the details of footprints declared by all service providers, service providers should aim at Carbon emission reduction targets for the mobile network at 5% by the year 2012-2013, 8% by the year 2014-2015, 12% by the year 2016-2017 and 17% by the year 2018-2019.

B. Carbon Footprint reports for the term: October'15 to March'16

Carbon Footprint Report (Access Providers)						
	Name of the Service Provider	Report Submitted for	Total of Consolidated Report for the period October 2015 - March 2016			
			Total Carbon Emission (in Tonnes)	Total No. of Subscribers	Carbon Emission per subscriber (in Tonnes)	Carbon Emission per subscriber (in Kg)
	TSP1	Access/NLD/ILD/ISP	612677	85848457	0.007	7.14
	TSP2	Mobile network	1906925	239744758	0.008	7.95
		Fixed Line+Broadband	70708	3541071	0.020	19.97
	TSP3	Access/NLD/ILD/ISP	2361957	99635176	0.024	23.71
	TSP4	Access/NLD/ILD/ISP	1278487	175074042	0.007	7.30
	TSP5	Access/NLD/ILD/ISP (Delhi)	60893	3933893	0.015	15.48
		Access/NLD/ILD/ISP (Mumbai)	40058	4929366	0.008	8.13
	TSP6	Access (GSM, CDMA & Wireline)	19237	3415455	0.006	5.63
	TSP7	Access/NLD/ILD	618703	109472475	0.006	5.65
	TSP8	Access Service Provider/ISP	54191	4795227	0.011	11.30
	TSP9	Access Service Provider	489816	47768854	0.010	10.25
	TSP10	Access/NLD/ILD	236783	52454949	0.005	4.51
	TSP11	Access Service Provider	37352	6563762	0.006	5.69
	TSP12	Access/NLD/ILD/ISP	1513334	197946755	0.008	7.65

S.No.	Name of the Service Provider	April:-2011 to March:-2012		April:-2015 to March:-2016	
		Carbon Emission per subscriber (in Kg)	Carbon Emission per unique user (in Kg)	Carbon Emission per subscriber (in Kg)	Carbon Emission per unique user (in Kg)
1	TSP1	20.95	31.24	14.09	21.12
2	TSP2	17.63	25.19	15.96	21.39
3	TSP3	41.58	64.86	45.44	72.20
4	TSP4	16.60	19.93	13.90	17.89
5	TSP5	9.94	20.28	Services discontinued	Services discontinued
6	TSP6	32.75	66.82	24.97	50.94
7	TSP7	22.45	44.28	11.29	22.12
8	TSP8	24.63	37.20	13.60	22.36
9	TSP9	20.83	28.19	23.18	33.18
10	TSP10	28.79	42.37	20.48	31.02
11	TSP11	45.79	72.02	10.80	16.74
12	TSP12	21.21	24.57	11.43	17.94
13	TSP13	17.31	34.79	14.94	19.58
14	TSP14	24.47	34.79	18.56	29.55

The base year for calculation of carbon footprints is 2011. Latest Carbon footprint per unique user (in Kg) has been compared with that in the base year for each service provider in the graph shown below.



List of Acronyms

S.NO	Acronyms	Expansion
1	3G	3rd Generation
2	4G	4th Generation
3	ADB	Asian Development Bank
4	ATM	Asynchronous Transmission Mode
5	BTS	Base Transceiver Station
6	CAPEX	Capital Expenditure
7	CO_2	Carbon Dioxide
8	CSR	Corporate Social Responsibility
9	DAS	Distributed Antenna System
10	DC	Direct Current
11	DCFCU	DC Free air Cooling Units
12	DG	Diesel Generator
13	DoD	Depth of Discharge
14	DoT	Department of Telecommunication
15	ECR	Energy Consumption Rating
16	GCF	Green Climate Fund
17	GDP	Gross Domestic Product
18	GHG	Green House Gases
19	GP	Green Passport
20	HVAC	Heating, Ventilation and Air Conditioning
21	ICT	Information and Communications Technology
22	IPMS	Integrated Power Management System
23	INDC	Intended Nationally Determined Contributions
24	IT	Information Technology

25	KW	Kilo Watts
26	LAN	Local Area Network
27	LCA	Life Cycle Assessment
28	Li-Ion	Lithium Ion
29	LCU	Local Control Unit
30	MCFC	Molten Carbon Fuel Cell
31	MNRE	Ministry of New and Renewable Energy
32	MTTR	Mean Time To Repair
33	MW	Mega Watt
34	NCEF	National Clean Energy Fund
35	NiCd	Nickel-Cadmium
36	Ni-Fe	Nickel-Iron
37	NiMeH	Nickel Metal Hydride
38	NiZn	Nickel-Zinc
39	NMS	Network Management System
40	NTP	National Telecom Policy
41	OPEX	Operating Expenditure
42	PC	Personal Computer
43	PEM	Proton Exchange Membrane
44	PV	Photo -Voltaic
45	RAN	Random Access Network
46	RESCO	Renewable Energy Service Company
47	RETs	Renewable Energy Technologies
48	RF	Radio Frequency
49	RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
50	RTU	Remote Terminal Unit

51	SDH	Synchronous Digital Hierarchy
52	SMPS	Switch Mode Power Supply
53	SOFC	Solid Oxide Fuel Cells
54	SON	Self-Organizing Networks
55	SONET	Synchronous Optical Network
56	TCO	Total Cost of Operations
57	TDM	Time Division Multiplexing
58	TEC	Telecommunication Engineering Center
59	TERM	Telecom Enforcement Resource and Monitoring
60	TRAI	Telecom Regulatory Authority of India
61	TRX	Transceiver
62	TSP	Telecom Service Provider
63	UNFCCC	United Nations Framework Convention on Climate Change
64	USOF	Universal Service Obligation Fund
65	VRLA	Valve Regulated Lead Acid
66	WDM	Wavelength Division Multiplexing
67	WiMAX	Worldwide Interoperability for Microwave Access
68	WLAN	Wireless Local Area Network