



Telecom Regulatory Authority of India

Recommendations
on
Approach towards Green Telecommunications

April 12, 2011

Mahanagar Door Sanchar Bhawan
Jawahar Lal Nehru Marg,
New Delhi- 110 002

PREFACE

Spread of technology use in quotidian life of humanity brings with it certain challenges, including challenges to the environment. Ecological concerns are universally shared, with the international community dedicating itself to several measures to preserve the planet. Telecommunications, as part of Information and Communication Technology simultaneously contributes to, as well as mitigates environmental pollution. Currently, it contributes to 0.7% of the Global CO₂ emissions; in India, the corresponding figure is 1%. While this figure might appear to be not significant, the rapid growth of telecommunications envisaged over the next decade calls for an effort to contain and reduce the carbon footprint. The measures should not only result in reduction of environmental pollution but also improve the economics for the industry, also delivering advantage to consumers.

This domain has so far not been explored and is therefore a new initiative, atleast in so far as TRAI is concerned. An attempt has been made to identify the issues involved in promoting Green Telecommunications and suggest ways to address them. We are thankful to the stakeholders who have participated in the consultation process and helped TRAI in arriving at conclusions. Some of these conclusions are in the nature of recommendations, while others are in the nature of an advisory to the industry.

This document is therefore to be treated as the first in a series. TRAI will continue work in this field to enhance the awareness of Green Telecommunications and improve the package of practices.


Dr. J. S. Sarma
Chairman, TRAI

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INTRODUCTION

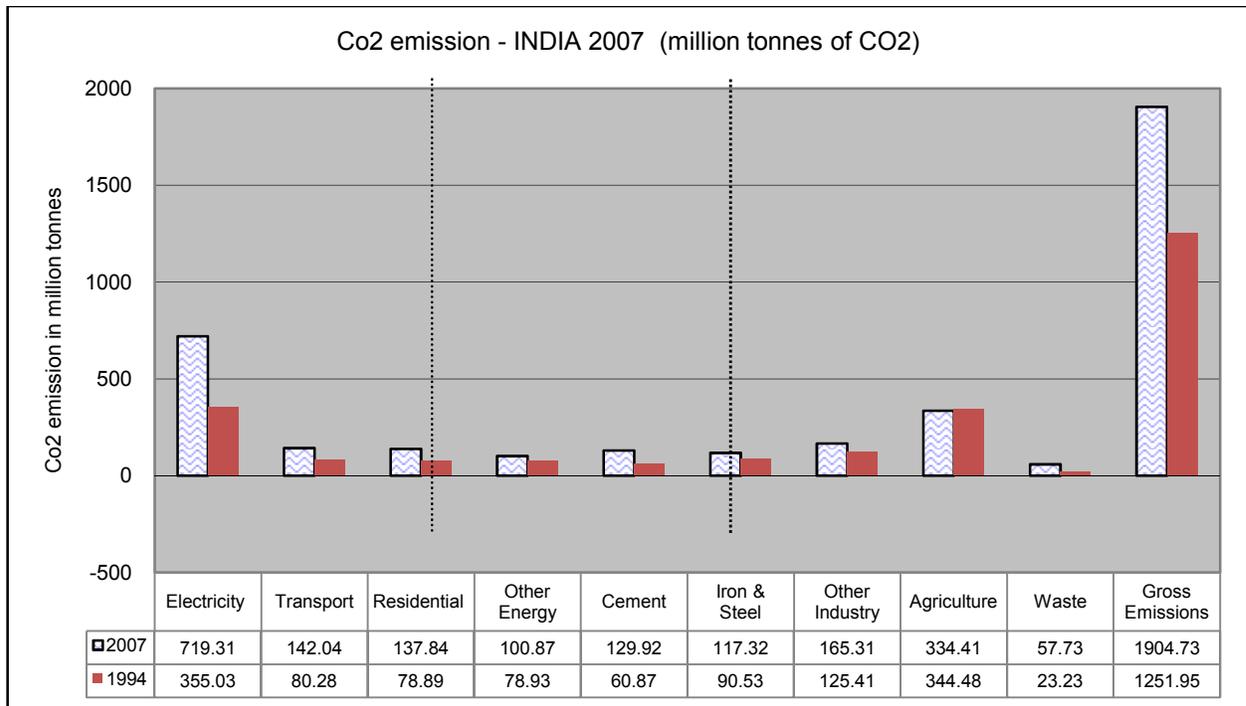
- (i) In recent years, the rise in the world's average ambient temperature has become a matter of global concern, and is now recognised as one of the key challenges facing humanity. "Global warming", "Climate Change", "Greenhouse Effect" etc are common expressions used to describe the threat to human and natural ecosystems resulting from enhanced emissions of heat trapping or greenhouse gases (GHGs) arising from the activities of humankind in an increasingly industrialized and globalizing world. These emissions are changing the composition of the atmosphere at an unprecedented rate. While the complexity of the global climate system makes it difficult to accurately predict the impact of these changes, the evidence from modeling studies as interpreted by the world's leading scientists assembled by the Intergovernmental Panel On Climate Change (IPCC), indicates that global mean temperature may increase by 1.4°C to 5.8°C, with a doubling of carbon dioxide concentrations, relative to pre-industrial levels; over the next 40 to 100 years. The magnitude of the predicted climate change, as well as the anticipated rate of this change, poses serious risks for human lifestyles as well as the global ecosystem. Global warming is expected to lead to numerous secondary effects such as the melting of the polar ice cap, changes in precipitation patterns, changes in vegetation as well as in the composition of the atmosphere.

- (ii) Climate change and global warming is a phenomenon largely attributed to anthropogenic (human-caused) emissions of pollutants; particularly carbon-di-oxide (CO₂) that traps heat within the Earth's atmosphere. A substantial portion of these pollutant emissions have their origin in the combustion of fossil fuels. As the world's need for energy-based services increases, and in the absence of a significant transition to non-fossil

energy sources, global temperature rises and its attendant impacts are expected to become increasingly pronounced over the coming decades.

- (iii) A milestone in the international efforts to address the anthropogenic causes of climate change was the "Kyoto Protocol" to the United Nations Framework Convention on Climate Change" (UNFCCC), an agreement among the nations of the world to reduce emissions of six greenhouse gases over specified timelines. This protocol adopted at Kyoto, Japan in 1997, requires that industrialized countries cut their greenhouse gas emissions by an average of 5.2% relative to 1990 levels over target years ranging from 2008 to 2012. As an extension of the Kyoto protocol, the 2009 United Nations Climate Change Conference, commonly known as the Copenhagen Summit, was held in Denmark. The Copenhagen Accord recognized that climate change is one of the greatest global challenges of the present day and that actions should be taken to keep further ambient temperature increases to below 2°C. Consequently, India has agreed to cut carbon emissions intensity by 20–25%¹ below 2005 levels by the year 2020.
- (iv) The sector wise distribution of the CO₂ emissions in India for 2007 is given below. It may be noted that the CO₂ emissions have increased by 52% from 1994.

¹ MOEF's report on India's Greenhouse Gas Emissions 2007



Source: INCCA-India GHG Emission, 2007 – MOEF

- (v) It is estimated that the ICT sector worldwide is responsible for around 2% of global CO₂ emissions. This includes the impact of personal computers, servers, cooling equipment, fixed and mobile telephone instruments and networks, local area networks, office communications and printers. The world's increasing need for the 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 emissions worldwide. Of the current CO₂ emissions, the contribution from the global telecommunication systems – mobile, fixed and communication devices- is estimated to be around 230 million tones of CO₂, or approximately 0.7% of global emissions. The worldwide growth in the use of mobile phones as well as the multiplication of data centres are expected to contribute to this trend. However the pervasive use of ICT is expected to simultaneously lead to significant positive net externalities on account of what are called the second order and third order effects of the use of ICT's worldwide. Second order effects are the immediate

consequences of the use of ICT is in terms of changing processes like reducing travel for business reasons and for social interactions, while third order effects are the expected changes in the organisational structures and modalities of transacting business and social interactions over the longer-term, which would reduce the need for travel and face-to-face interactions.

- (vi) 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. However large parts of the country 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 400,000 telecom towers, with average power consumption per tower being 3 to 4 kW. Assuming 8 hours of operation by DG sets, an average fuel consumption of 8760 liters of diesel every year per tower, total carbon emission on account of diesel use by telecom towers is estimated to be around 10mt of CO₂, while the emissions on account of power drawal from the grid by towers is estimated to be around 6mt of CO₂. The total emission of the Indian telecom industry is expected to be around 1% percent of the country's total CO₂ emissions.

It can thus be seen that the contribution of the Indian telecommunication industry to the total CO₂ emissions is worse than the world average in percentage terms. The greening of the telecom sector assumes significance in this context as well as the need to effect economy in operations.

- (vii) Greening the telecom sector is an endeavour that would require the active participation of all three sets of stakeholders – the government, the telecom industry and the citizenry. Accordingly, TRAI had issued a consultation paper on “Green Telecommunications” on 3rd February,

2011. Comments regarding the various issues raised in the consultation paper were invited from stakeholders by 7th March, 2011. An Open House Discussion on these issues was held at Delhi on 18th March, 2011. These recommendations have been formulated based on the consultation process. They broadly follow an approach whereby the telecom industry would take the initiative in measuring their emissions following standardised procedures as well as by fostering the adoption of environmentally friendly practices that would result in sustainable benefits to the industry, the consumer as well as to the total ecosystem.

(viii) A necessary first step for greening the sector is to measure emission quanta from telecom networks and devices, encompassing the entire cycle from manufacturing to waste disposal. The approach adopted in this paper is to prescribe broad and robust emission measurement parameters that can be adopted by the telecom industry to measure the emissions from telecom equipment as well as telecom operations. This measure would not only foster normative and objective comparison of the emission reduction efforts by the telecom industry, but also spread awareness among the public at large regarding the 'green quotient' of the telecom sector. Thus the carbon footprint, of all Telecom Service Providers, is proposed to be estimated and a comprehensive carbon credit policy defined. Specific emission reduction procedures and approaches have also been suggested for adoption by the industry, and standardization metrics for certifying telecom products and equipment to be deployed in the green telecom Network discussed.

(ix) Chapter I sets out the overall scenario, relative to Green Telecommunications and establishes the need to develop a strategy to improve the situation over the next few years. The Green telecom strategy for India would need to encompass the following aspects: green telecom networks, green manufacturing, waste Management and green buildings.

The components of green telecom networks, estimating carbon footprints, reporting metrics and various methods of reducing carbon footprints are discussed in Chapter 2. The greening process in manufacturing, standardization of equipment and R &D are discussed in Chapter 3. Various elements of waste management such as waste collection, waste disposal and waste recycling are discussed in Chapter 4.

- (x) The conclusions arrived at in this document are expected to be the first in a series of iterative measures to be put in place for transforming the Indian telecom industry into a global model of green telecommunications. The enumeration, quantification and dissemination of the green quotient and the metrics behind telecom operations, telecom manufacturing as well as telecom waste disposal would be a necessary first step in building environmental awareness in this sector, which would be a necessary precondition for finalising strategies for mitigating their environmental impacts. Certain indicative measures have also been suggested for reducing the carbon footprint of various elements in the telecom space.
- (xi) The Government has announced their intention to announce a New Telecom Policy this year. It is hoped that the recommendations and suggestions made in this paper would be relevant and useful in this context, since experience worldwide has proven that adoption of certain green practices like Life Cycle Assessment, green rating etc. would not only lead to better efficiencies for the telecom industry but also reduce environmental impact and improve customer experience.
- (xii) It is hoped that all the stakeholders in the telecom sector will come forward in a collaborative spirit to implement these measures, as part of a common national endeavour to green the telecom sector.

CHAPTER I: GREEN TELECOM –THE SCENARIO

A - The Global Scenario

1.1 Currently, the ICT sector globally accounts for 0.9 metric gigatons of GHG emissions annually, or about 2% of total global emissions; which includes personal computers, servers, cooling equipment, fixed and mobile telephony, local area networks (LAN) and printers. The world’s increasing need for computation, data storage, communications and entertainment is rapidly growing and at the same time there is an increase in the emissions associated with such technologies. By the year 2020, total emissions globally from the ICT sector is expected to be around 1.43 metric gigatons, accounting for around 3% of total global emissions of greenhouse gases. These emissions include emissions from both the embodied devices and components during manufacturing, as well as from the use of devices and equipment.

Global	Gigatons CO₂e 2002	Gigatons CO₂e 2020
Global CO ₂ emissions	40	51.9
Total ICT footprint	0.540 (0.11 from embodied and 0.43 from Network use)	1.430 (0.35 from embodied and 1.08 from Network use)
% of Global emissions	1.3%	2.8%

*% of Global emissions (2007): 2%

Table 1.1 : % Global CO₂ emissions

Source: <http://www.smart2020.org>

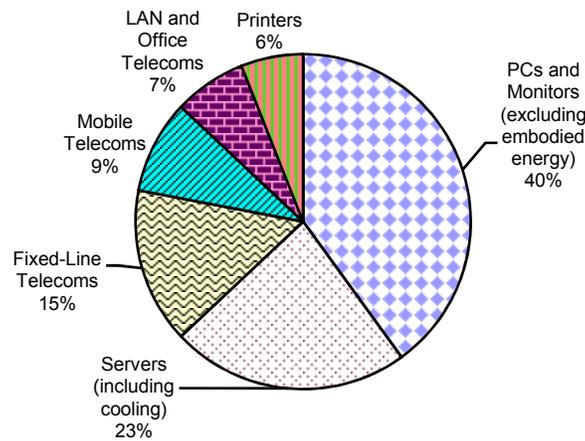
1.2 The total emissions of the ICT industry emanate mainly from three different sectors –Telecommunications, Data centers and PCs,

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 increase. However, due to technological innovations, the efficiency of ICT devices and systems is also expected to increase, leading to consequential attenuations in emissions.

- 1.3 By the year 2020, almost a third of the global population is expected to own a PC, while 80% are expected to own mobile phones and one in 20 households to have broadband connections. By 2020, when a large part of the populations of developing countries are expected to be able to afford ICT devices, they are expected to account for more than 60% of the carbon emissions from ICT's compared to less than half today. The demand for energy for ICT is expected to increase by 70% by the year 2020, driven by the demand for broadband, customer premises equipment and power hungry devices like HDTV services.
- 1.4 The enhancement of the data center carbon footprint is due to the increased numbers of servers, network equipment, power supplies, fans and other cooling equipment. Only about half of the energy used by data centers powers the servers and storage, the rest is needed to run back-up, uninterruptible power supplies (5%) and cooling systems (45%). It is expected that there will be 122 million servers in use by 2020. A major trend driving down the overall growth in the footprint of data centers is 'virtualisation'. By allowing the temperature of the data centre to fluctuate along a broader operating temperature range, a 24% reduction in energy consumption from cooling is also possible. Cloud computing is

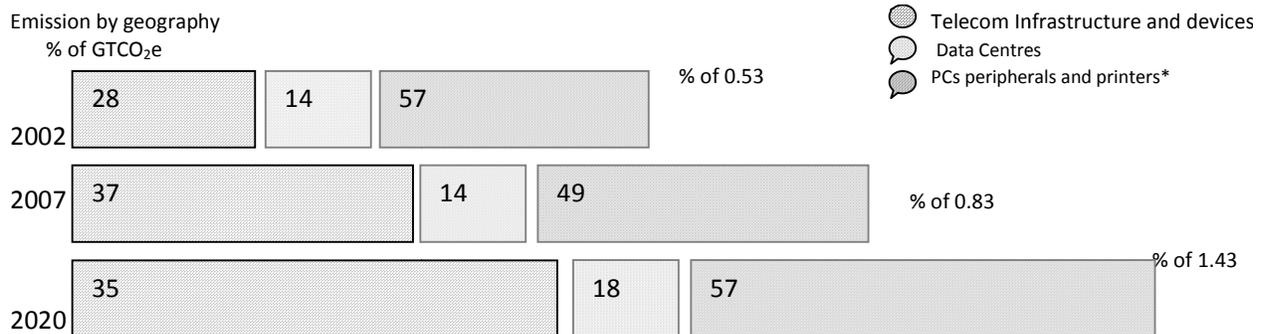
also expected to play a major role in reducing the carbon footprint of data centers.

1.5 The various components of ICT and their CO₂ emissions in the ICT sector and their footprints are shown below and around 25% of the emissions are from the telecom sector.



Source: Gartner Group (2007)

Figure 1.1 : Components of ICT and their CO₂ emissions

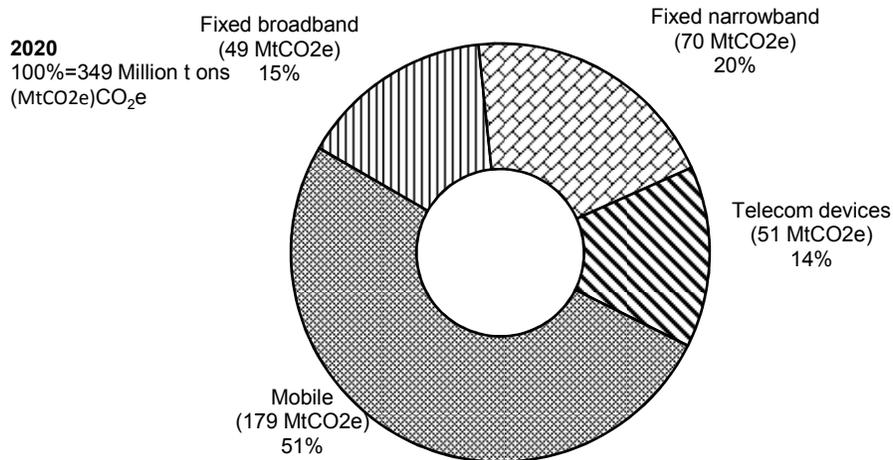


Source: <http://www.smart2020.org>

Figure 1.2 : Global Footprint by sectors in gigatons of CO₂(GtCO₂)

1.6 From 2002, the growth in global telecoms emissions has risen from 150 MtCO_{2e} in 2002 to 300 MtCO_{2e} in 2007 and is expected to reach 350

MtCO₂e in 2020. In this period, the number of fixed-line, narrowband and voice telephony accounts is expected to remain fairly constant overall, but the number of broadband accounts – operated by both telecoms and cable operators, as well as mobile accounts is expected to more than double.



Source: <http://www.smart2020.org>

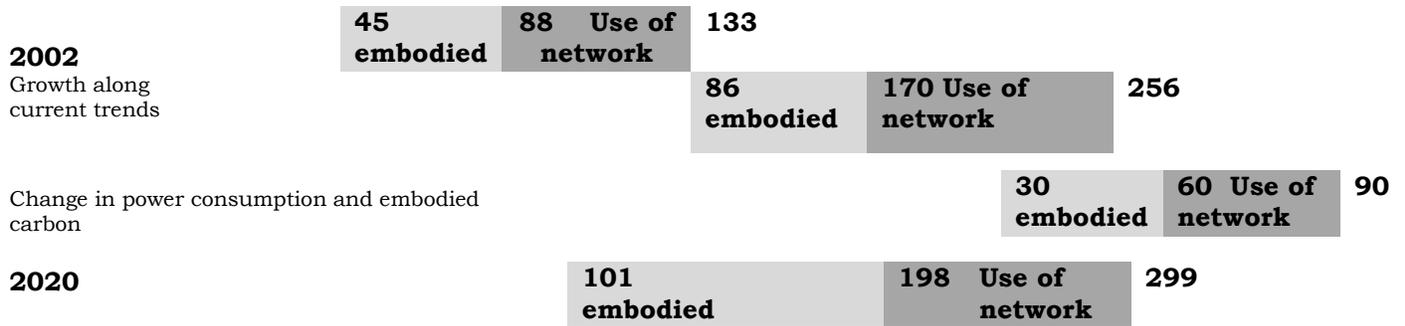
Figure 1.3: Global telecom footprint in 2020 (in million tonnes of CO₂) (devices and infrastructure)

1.7 Carbon footprint due to telecom infrastructure is expected to increase from 25% of total ICT emissions to 30% of total ICT emissions by the year 2020. It is also estimated that 51% of the emissions in telecom will be from the mobile segment. The mobile industry is forecast to invest \$800 billion during the next five years; \$550 billion of this is earmarked for mobile broadband, potentially connecting 2.4 billion people to the Internet.

1.8 The telecom devices' global footprint was 18 MtCO₂e in 2002 and is expected to increase almost threefold to 51 MtCO₂e by 2020. The number of mobiles is expected to increase from 1.1 billion to 4.8 billion, routers

from 67 million to 898 million and IPTV boxes from 0 to 385 million. The main increment in telecom devices emission is attributed to routers, IPTV boxes and modems, while the increase in the carbon footprint of telecom infrastructure would mainly be due to increases in base stations and mobile switching centers. As the demand for telecoms services and devices grow, the need for infrastructure that supports it will also grow. This growth is due not only because of the increase in the number of broadband and mobile accounts in emerging economies, but also because of emerging new applications like sharing of videos and games and other peer-to-peer content exchange. One of the main reasons for the increase in the carbon footprint in telecom infrastructure is expected to be the increase in the number of telecom accounts from the present level of 6 billion to 50 billion (fixed, mobile and broadband) by the year 2020.

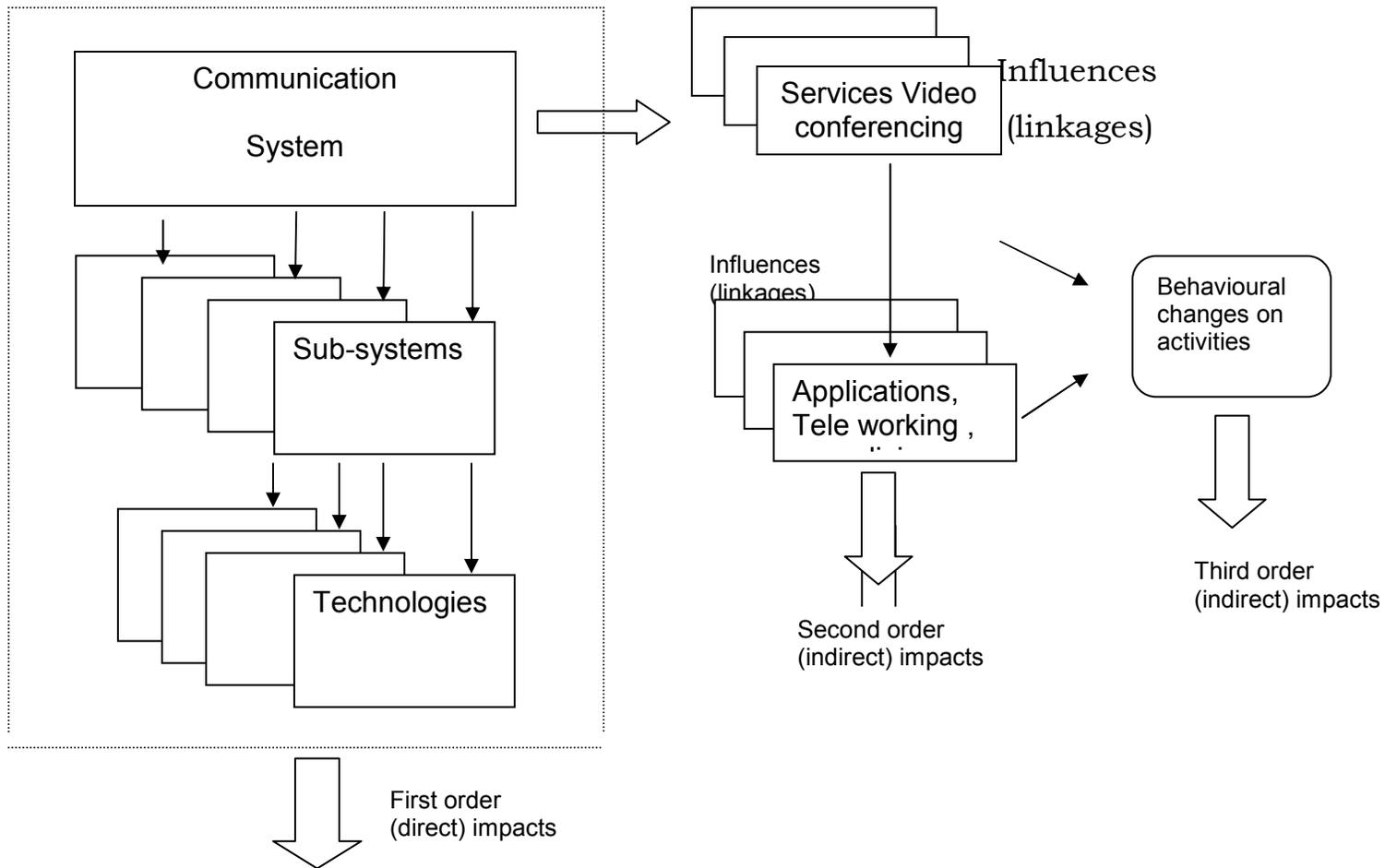
- 1.9 The telecom infrastructure carbon footprint, including energy use and carbon embodied in the infrastructure, was 133 MtCO_{2e} in 2002. This is expected to more than double to 299 MtCO_{2e} by 2020, at a growth rate of 5% pa. However, electricity use per information unit decreased between 2003 and 2005 by 39% annually, but this has been more than negated by an increase in bandwidth requirements of 50% annually. In the figure 1.4 below, without any effort in reduction of CO₂ emission the telecom infrastructure emissions would have grown from 133 MtCO_{2e} in 2002 to 389 MtCO_{2e} (133 + 256) by 2020, but because of various CO₂ emission control measures, it is estimated that 90MtCO_{2e} will be saved by 2020. Hence the net increase in the foot print is expected to be 166 MtCO_{2e} by 2020.



Source: <http://www.smart2020.org>

Figure 1.4 : The global telecom infrastructure footprint in million tones of CO₂ (MtCO₂e)

1.10 The carbon footprint mentioned above would cause direct emission impacts, called first order effects of carbon emission in the network. There are also indirect positive impacts called second order and third order effects; which can reduce carbon emissions of the other sectors by increasing the use of ICT. These second order and third order effects of the pervasive use of ICT could increasingly lead to the sector becoming a key player in global efforts to contain carbon emissions. Human behaviour as well as organisational structures and interaction protocols are rapidly changing on account of the pervasive adoption of ICT in almost every sphere of human endeavour, reducing the need for physical face-to-face interactions and long-distance travel, especially by air.



Source: <http://www.smart2020.org>

Figure 1.5: Second order and third order impacts of ICTs

1.11 Across the world, several initiatives have been launched to green the telecom sector. A few such initiatives are listed below:

- (i) The 'Green Touch²' is a global consortium organised by Bell Labs whose goal is to create the technologies needed to make communications networks 1000 times more energy efficient than they are today.[AT&T, CEA-LETI, China Mobile, Freescale Semiconductor, Imec, The French National Institute for Research in Computer Science and Control (INRIA),The Research Laboratory for Electronics (RLE) at Massachusetts Institute of Technology (MIT), Portugal Telecom ("PT"), Samsung Advanced Institute of Technology (SAIT), Swisscom, The

² www.greentouch.org

Wireless Systems Lab (WSL), Stanford University, Telefonica, The Institute for a Broadband-Enabled Society (IBES), University of Melbourne, Alcatel-Lucent Bell Labs are consortium partners in this initiative]

- (ii) British Telecom have indicated that they have reduced carbon emissions by 60% compared to 1996, and plan to reduce the same by 80% by the year 2020.
- (iii) GeSI³ (Global e-Sustainability Initiative) based in Belgium, with 30 members, brings together leading ICT companies – including telecommunications service providers and manufacturers as well as industry associations – and non-governmental organisations committed to achieving sustainability objectives through innovative technology.
- (iv) The Green Grid⁴ is a non-profit open industry consortium of end-users policymakers, technology providers, facility architects and utility companies collaborating to improve the resource efficiency of data centers and computing ecosystems. With more than 175 member companies around the world, the Green Grid initiative based in Oregon, USA seeks to unite global industry efforts, create a common set of metrics and to develop technical resources and educational tools in quest of its goals.
- (v) The European Commission's Code of Conduct on Data Centres' Energy Efficiency comprises a series of voluntary, light-touch measures, expected to form the basis of more stringent legislation in the future, laying out a set of minimum standards for compliance. The move to introduce the code of conduct at the end of last year was a recognition by the EC that

³ <http://www.gesi.org/>

⁴ www.thegreengrid.org

datacentres are heavy and often inefficient consumers of energy.

(vi) Telefonica, having presence in 25 countries, has created a climate change office and is committed to reducing its consumption of network electricity by 30% by the year 2015.

B. The Indian Scenario

1.12 In India around 4% of the GHG emissions are from the ICT sector which is around 80 million tonnes of CO₂ emission every year. And around 25% of this emission i.e. 1% of the GHG emissions is from the telecom sector which is around 20 million tonnes of CO₂.

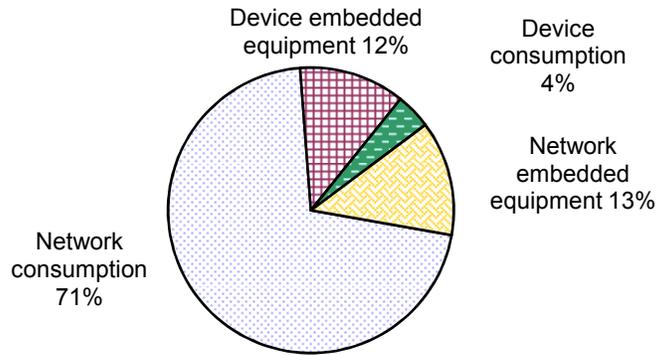
S. No.	Network Elements	Total Carbon Emission (in Tonnes)	Total Carbon Emission (in Tonnes)
1	BTS	13 million	
2	BSC	1.3 million	
3	MSC	0.1 million	
4	Exchanges	6 million	
5	Network Controllers + Transmission	.08 million	
6	Core & Servers	.05 million	
	Total	20.5 million	1904 million
	% CO₂ emission of the total	1%	

Table 1.2 : % CO₂ emissions from the telecom Sector

1.13 Of the 100 million tonnes of carbon dioxide emission reduction target by 2015, set by the NMEEE [National Mission on Enhanced Energy Efficiency], ICT adoption in buildings, transport and nine other sectors under the PAT (perform, achieve and trade) scheme could contribute about 31 million tonnes — approximately 30% of the 2015 target.

- 1.14 In June 2008, the National Action Plan on Climate Change (NAPCC) was launched, outlining the nation's strategy to manage greenhouse gas (GHG) emissions. India has announced the goal of reducing the emissions intensity of its GDP by 20-25% by the year 2020 compared to 2005. The Planning Commission is also in the process of defining a low-carbon growth map for the country. The GHG reduction opportunities via ICT (Information & Communication Technology) solutions mainly focus on the three mitigation-related missions of NAPCC - National Mission on Enhanced Energy Efficiency (NMEEE), National Mission on Sustainable Habitat (NMSH) and National Solar Mission (NSM).
- 1.15 While NMEEE and NMSH focus on reducing energy consumption and improving energy efficiency, NSM seeks to increase India's solar energy generation. Identified ICT solutions can potentially lead to GHG emission savings of up to 450 million tonnes CO₂ per annum in 2030, which is approximately 10% of estimated GHG emissions in 2030 for the different sectors. ICT solutions can potentially lead to energy cost savings of around INR137,000 crore per annum in 2030 - approximately 2.5% of India's current GDP.
- 1.16 Targets for ICT solutions in key sectors could also be identified, such as Railways, Power Transmission and Iron & Steel. These three have more than 90% GHG emission savings potential in NMEEE mission sectors. Projected GHG emissions from NMEEE mission sectors would be about 1.55 billion tonnes CO₂ in 2020 and 3.2 billion tonnes CO₂ in 2030. The electricity saved by ICT adoption in the power sector in 2030 can help electrify more than 14,000 villages with an average population of 2,000-3,000. Implementation of ICT measures in the paper sector in 2030 can reduce emissions by an amount equivalent to that sequestered by 3 million trees.

- 1.17 Savings achieved via video-conferencing and tele-commuting with moderate ICT penetration in 2030 can offset GHG emissions more than 70 times the current GHG emissions due to the annual air traffic between Delhi and Mumbai. At multi-location and disintegrated consumption points such as telecom towers, ATMs and retail outlets, Remote Management Systems (RMS) can deliver up to 10% energy savings and their faster implementation is recommended. For instance, with each of the 400,000 telecom towers in India consuming 3 kW of power, the total electricity consumed is around 11169 million kWh annually. With RMS, around 10% energy consumption can be reduced, leading to savings of 1116.9 million kWh, equivalent to GHG emission reductions of more than 938 000 tonnes of CO₂.
- 1.18 The total cost of ICT usage in NMEEE mission sectors - considering moderate penetration of ICT solutions in 2020 and 2030 - is estimated at Rs.49,700 crore and Rs.156,100 crore. These investments correspond to cost savings of around Rs.7,300 crore per annum and Rs.29,200 crore per annum respectively. Similarly, the deployment of ICT technologies in Transport, Buildings and Solid Waste Management sectors can lead to cost savings of Rs. 26,300 crore in 2020 under a moderate scenario.
- 1.19 Around 71% of the carbon emissions in the Indian telecom sector are on account of network power consumption and hence containing power utilization in telecom networks would be the cornerstone of any green telecom strategy. Carbon emissions by network and device embedded equipment contributed 25%. Thus, green manufacturing and waste disposal is also an important element of the Green telecom strategy.



Source : <http://www.gsmworld.com>

Figure 1.6: Energy Consumption distribution in Telecom

1.20 Presently of the power consumed by the network, around 67% is met by the contribution of diesel power, while around 33% is met by recourse to grid power in rural areas, while Renewable Energy Technologies (RETs) are deployed, at a few locations purely on a pilot basis. In urban areas, while the contribution of diesel power is around 33% and around 67% is met by the grid power. However, in backward areas the situation is alarming, where around 87% is met by contribution of diesel power and only around 13% is met by grid power. The objective of the green telecom endeavour in India would be to ensure that the consumption of diesel for powering telecom network is substantially reduced to a level of 33% by the year 2020 resulting in diesel to grid power ratio of 1 to 3, in both rural and backward areas. The RETs use for powering network operations is also to be ramped significantly to a level of around 25% by 2020.

1.21 In India too, various service providers have made numerous efforts towards green initiative. Some of their recent efforts to reduce the carbon footprint of the Indian telecom industry are as follows:

- (i) The launch of the "green shelter" concept to save energy consumption by a telecom service provider. This is expected to reduce air conditioning costs at BTS locations.
- (ii) The use of renewable energy and bio diesel for running cellular sites by some service providers.
- (iii) The initiation of pilot projects for solar/ fuel powered cell sites at selected locals by some service providers.
- (iv) The installation of fuel catalyts in the fuel pipeline of Diesel Generators sets.
- (v) The installation of Free Cooling Units (FCU) at some BTS sites by certain service providers.
- (vi) The initiation of pilot projects for bio-diesel powered cell sites at a few locals.

1.22 Key aspects of a Green telecom strategy for India would include the following:

- (i) **Green telecom networks:** The primary aspect would be the estimation of carbon footprints, minimization of energy consumption in telecom networks through use of energy-efficient technologies and protocols, transitioning to renewable energy sources, eco-friendly consumables and evolving a carbon credit policy.
- (ii) **Green Manufacturing:** The greening process would involve using eco-friendly components, energy-efficient manufacturing equipment, standardization of equipments, reduction in use of hazardous substances like chromium, lead and mercury and reduction of harmful radio emissions. The adoption of the life cycle assessment (LCA) approach should ideally form the base of any strategy to reduce the environmental impact of telecom products.

(iii) **Waste disposal:** This initiative would include the disposal of mobile phones, network equipment and other material in an environmentally friendly manner for ensuring that the toxic material does not get absorbed into the atmosphere, the water or the ground. This would also include efficient ways of electronic and mechanical waste recycling and disposal.

(iv) **Design of green buildings:** This would involve the optimization of energy, power consumption, thermal emission and minimization of greenhouse gas emissions. The Energy and Resource Institute (TERI) has developed a rating system called GRIHA (Green Rating for Integrated Habitat Assessment) which has been adopted by the Government of India as the National Green building rating system for the country. It will be in the interest of the service providers to ensure that their buildings are green, for reducing energy consumption levels.

1.23 Specific strategies and measures to green these components of Indian telecom are outlined in subsequent chapters.

1.24 The New Telecom Policy is expected to be announced by the Government this year. It would be desirable to include measures for greening the telecom sector in this policy, including steps to reduce the carbon footprint of the telecom industry as well as measures to reduce noise pollution and adverse environmental impacts of running diesel generators at cell sites. The proposed NTP should identify the Green Telecom as an area for specific action.

1.25 The Authority recommends that measures to green the telecommunication sector should be an integral part of the proposed National Telecom Policy. The policy should underline the need to Green Telecommunications and set the broad direction and goals.

CHAPTER II: GREEN TELECOM NETWORKS

- 2.1 The telecom network consists of three major components – the Access network, the Core Network and the Backhaul / aggregators. The CO₂ emission from these telecom networks are from embodied devices as well as the use of the equipment in actual operations. CO₂ emission caused by network embodied elements during the manufacturing process is discussed in the succeeding chapter. The predominant constituent of CO₂ emission in the telecom network is during the actual use of the network equipment. The utilisation of the network leads to power consumption, which is the prime factor for emission of CO₂ in the network. Hence, strategies for reducing the CO₂ footprint will necessarily have to primarily focus on decreasing power consumption in the network, or alternatively on using clean energy by renewable energy sources. The reduction in power consumption could be effected by better network planning, effective infrasharing, adaptation of energy efficient technologies, use of renewable energy sources and effective use of available power. Methods for reducing power consumption and consequently CO₂ emissions are discussed in this chapter.
- 2.2 In the telecom network, the components that contribute to carbon emissions include the RAN (Radio Access Network), Fixed Line Network, Fibre to the x(FTTx) networks in the access networks, the Core, Aggregators(backhauls) and the Transmission systems in the central core network. The distribution of power consumption across these networks is indicated in Figure 2.1. Hence, detailed CO₂ footprint of these networks will have to be estimated and methods of reporting evolved. Once the CO₂ footprint of the networks are established and methods for reduction of

CO₂ emission attempted, a carbon credit policy for the same could be delineated.

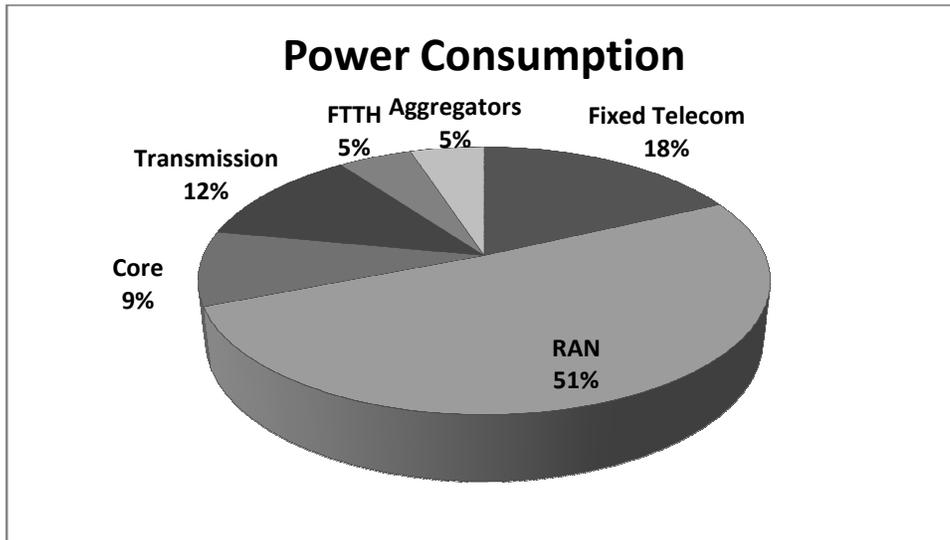


Figure 2.1: The distribution of power consumption across the telecom access network

- 2.3 The mobile subscriber base in India crossed the 790 million mark in February 2011 and is expected to reach the 1 billion mark shortly. This would imply an additional requirement of around 250,000 more mobile towers with a projected total annual emission of nearly 30mt of CO₂.
- 2.4 Among the components of the mobile network, the base station alone consumes around 59% of the power in the network while the mobile switching centers constitute around 21% and the core transmission around 18% of the power consumed.
- 2.5 As the data transmission requirements in the networks continue to double every five years, a desirable objective would be to ensure that the

energy required per delivered bit falls at a corresponding rate, so that the total carbon emission quantum does not increase.

A. Estimating the Carbon Footprint and reporting structure

2.6 Any strategy for greening telecom networks would essentially involve minimizing the consumption of energy through utilization of energy-efficient technology, effective network planning, using renewable energy sources and eco-friendly consumables. An essential starting point for these efforts is to clearly define and estimate the carbon footprint in the telecom network.

2.7 After estimating the carbon footprint, the next step would be to put in place a robust carbon emission measurement and reporting system.

2.8 In the consultation paper, aspects relating to the estimation of the carbon footprint of fixed mobile and broadband networks were raised. Also, the issues relating to the monitoring and reporting mechanism for these carbon footprints in the telecom network were raised and the following questions posed:-

- a. How should the carbon footprint of Indian telecom industry be estimated?
- b. What is your estimate of the carbon foot print of the fixed, mobile and broadband networks?
- c. In case of mobile what would be the individual footprints of the radio access network and the core network? How are these likely to change with 3G and 4G technologies?
- d. What should be the rating standards for measuring the energy efficiency in telecom sector?

- e. Please give suggestions on feasibility of having energy audit in the telecom sector on the lines of energy audit of buildings.
 - f. What should be the monitoring mechanism for implementation of green telecom?
 - g. Who should be the monitoring agency?
 - h. What type of reports can be mandated and what should be the frequency of such reports?
- 2.9 Some of the stakeholders suggested that the carbon footprint of a telecom operator be estimated based on the amount of power and fuel consumed over a period of one year. Some stakeholders have suggested the estimation and verification of carbon emission figures by third parties. The number of BTS towers, the average availability of grid power, the average power consumption per indoor and outdoor BTS diesel generator running at the site should be taken into account for measuring carbon footprints of wireless networks. One of the stakeholders opined that the carbon footprint of Indian telecom Industry can be estimated after considering all the technological deployments in the Indian Telecom sector employing different equipments and technologies, old & new. For example; power consumed by equipment deployed in various technologies like Fixed line, Broadband, GSM, 3G, CDMA, WiMax, LTE, etc. may be considered as a whole for accounting the carbon footprint of the Indian Telecom Industry. The power consumption on various associated equipments, servers, etc. should also be taken into account. Another stakeholder suggested that all the various Telecom networks elements could be taken into account for calculating the carbon estimates.
- 2.10 A stakeholder held the view that the carbon footprint of the Indian telecom industry be estimated in accordance with ISO 14065, PAS 2050

& GHG Protocol for carbon accounting. The second step should be verification and assurance of “carbon emission figures” by a third party i.e. an accredited energy accounting agency under the United Nations Framework Convention on Climate Change (UNFCCC). For transparency and effective monitoring, the carbon emission figures and corresponding reduction under the set target should be reported regularly to the compliance authority. Also these figures should also be unconditionally disclosed in the public domain through each company’s sustainability reporting. One of the stakeholders had suggested that the industry should adopt a model similar to the Carbon Disclosure Project CDP, which collects, analyzes and reports on companies and industry sector emissions.

2.11 Some of the stakeholders had commented that with the onset of 3G, there would be a huge transition from voice to data applications and increased NGN services. Using 3G technology, operators are likely to step up the peak data transfer offered to consumers, which will necessitate more cell sites for 3G coverage, with energy use and emission consequences.

2.12 Some of the stakeholders opined that instead of relying on estimates, all players must declare, using well defined guidelines, what their energy consumption is, using all sources and all heads and this could be in the form of formal reports that are in the public domain. Some of the stakeholders stressed that it is essential for all industries to evaluate their performance on their own and be able to show that they are making cost effective and proportionate contributions to the reduction in the emissions of Green House Gases. Metrics such as declining energy costs, improved remote collaboration, regulatory compliance and improved resource utilisation can be some of the factors to be considered when measuring success.

- 2.13 Some stakeholders suggested that in the initial stage, broad guidelines for energy audit for telecom can be drawn up by TRAI while the onus of measuring the same may lie with the operator itself. Such “self-assessment” may be undertaken on a voluntary basis by operators themselves to assess their energy efficiency. Others pointed out that mandatory energy audit may be feasible in telecom sector also. To ensure use of power efficient telecom equipment, energy audit may be made mandatory by TRAI to be conducted at regular intervals. It may give good results in terms of reduction in power consumption/ carbon footprint of any operator. Audits for assessing the energy efficiency of telecom networks is a viable mechanism and has been employed voluntarily by equipment makers for their customers i.e. service providers.
- 2.14 Some stakeholders felt that from a regulatory perspective, it is advisable that specific norms be set in place and communicated to the operators through mutual discussions. These can be subjected to periodic audits by TRAI / other Government agencies and the results published. Telecom operators should be asked to provide returns/quarterly reports and steps taken by them to reduce the carbon footprint; and this could be monitored by TRAI regularly. While most of the stakeholders suggested that quarterly reports be taken, one stakeholder has opined that the reports could be collected once in six months.
- 2.15 While most of the stakeholders stressed that the carbon footprints for the networks should be calculated taking all network elements into account, no specific methodology for calculating these footprints was delineated. Hence TRAI has attempted to develop a formula for measuring the carbon footprint of the telecom network which could be declared by the telecom service provider twice a year. In the first instance, it may be appropriate

if the telecom service provider was entrusted with the responsibility of measuring the carbon footprint of his network utilizing this formula. It is expected that this measure would spur enthusiasm and innovative energies amongst all the actors in the telecom space to reduce the size of their carbon footprints.

2.16 The Carbon footprints in the telecom industry (C_T) could be broadly divided into four categories in the Access network:-

- (i) Carbon footprint from Landline (C_L)
- (ii) Carbon footprint from Mobile (C_M)
- (iii) Carbon footprint from Fixed Broadband (C_{FB})
- (iv) Carbon footprint from FTTx (C_{FT})

2.17 The other THREE vital blocks that add to the Carbon footprints of the telecom network are:-

- (i) Carbon footprint from Core Network (which includes edge / core Routers / NGN / softswitches / IP Cores / all core items / data centers / all centralized sub systems / peripherals) (C_C)
- (ii) Carbon footprint from Aggregators or Backhaul (C_A)
- (iii) Carbon footprint from Transmission Networks (C_{TX})

2.18 There are also various other factors of the Life Cycle Assessment LCA – from the extraction of raw materials, the manufacture of finished goods, and their use by consumers or for the provision of services, recycling, energy recovery, to ultimate disposal- involved in the emission of carbon content. These constitute around 13% of the actual Carbon emission in the Telecom sector and efforts to reduce the same are discussed in the next chapter. However, these need to be factored in during the manufacturing process where a process of standardization of the green quotient for telecom equipment would be in place. The carbon content in

the customer end equipment is also not taken into account, as this will be covered under the green certification for the manufactured equipment.

2.19 Similarly in the Carbon footprint of the Core Network (C_C), Aggregators (C_A) and Transmission System Networks (C_{Tx}), the component level / PCB level of carbon content have not been considered. Hence, the Carbon footprint of these networks is assumed to be the emission of carbon content because of the consumption of grid power and the diesel power (DG sets) only. The carbon footprints of these networks powered by Solar or wind, if any, could be taken as zero, as the component level emissions are taken care of during the manufacturing stage. It is to be noted that a litre of diesel produces 2.6391 kgs of carbon dioxide and one KWH of grid electricity consumed emits around 0.84 Kgs of carbon dioxide.

2.20 If the consumption of power of the Network element, in KW (including Air Conditioning etc) is P , the Grid power is for 'x' hrs, the power from 'z' KVA DG is for 'y' hrs and the efficiency of the generator is ' η ' then

$$C = 0.365 [0.84Px + (0.528 yz / \eta)] \text{ in Tonnes}$$

Similarly carbon footprints for each of the network elements are to be calculated. The detailed calculation of footprints of various network elements is at [Annexure -I](#).

2.21 The Radio Access Network / BSS are geographically spread out in a mix of urban, semi-urban, rural and highway sites. Source of power in the given geography, BTS frequency of operation, RF power output and TRX configurations are important parameters for estimating carbon footprints. The core networks are strategically installed at locations of reliable power (e.g. district HQ or major cities). 3G, 4G BSS are operating in 2.1 or 2.3 GHz bands which have higher free space loss (attenuation) compared to 900 MHz band. Therefore 3G and 4G BTS draw higher

energy for RF propagation. This is also likely to increase the share of BSS footprint compared to the core network's footprint. When the radio equipment is located in shelters, the combination of free cooling boxes and the enhanced maximum operating temperature can bring about more than 10% of energy savings per site.

- 2.22 The total carbon footprint contribution is calculated from the sum of the carbon footprint for each network elements and of the carbon footprint of various stages to provide the final result.

Total Carbon footprint (C_T) = Carbon footprint of Landline networks (C_L) + Carbon footprint of Mobile networks (C_M) + Carbon footprint of Fixed Broadband networks (C_{FB}) + Carbon footprint of FTTx networks (C_{FT}) + Carbon footprint of core networks (C_C) + Carbon footprint of Aggregators networks (C_A) + Carbon footprint of Transmission networks (C_{TX}) + Carbon footprint of Infrastructure providers network (C_{IP}) expressed in Tonnes.

The Service providers could utilise this calculation methodology for calculating their footprint.

- 2.23 Sample calculations of the carbon footprint of 5 different mobile operators were calculated and they are reproduced below. It is found that the average per subscriber CO₂ emission is around 21 Kg when compared to the international average of 8Kgs of CO₂ emission per subscriber. The CO₂ emission per subscriber from the rural sector is around 40 Kg and the CO₂ emission per subscriber from the Urban sector is around 13 Kg. Hence efforts are required to be taken for reduction of carbon footprints in the telecom industry, especially when the rural sector is going to account for more than 70% of the new towers planned.

Mobile Service Provider	No. of BTS	Average Power Consumption (P) (in KW)	Avg. Grid Supply (in hrs.)	DG Capacity (in KVA)	Avg. DG Supply (in hrs.)	η of DG Set	Carbon Emission per BTS (in Tonnes)	Total Carbon Emission (in Tonnes)	Total No. of Subscribers	Carbon Emission per subscriber (in Tonnes)	Carbon Emission per subscriber (in Kg)
			'x'	'y'	'z'	' η '	$C = 0.365[0.84 Px + (0.528 yz/\eta)]$				
Rural											
A	70000	1.32	12	15	12	1	39.546144	2768230.08	64119630	0.0432	43.1729
B	25734	1.76	13	15	11	1	38.8138	998834.5351	18620834	0.0536	53.6407
C	48875	1.76	16	15	8	1	31.760256	1552282.512	50237766	0.0309	30.8987
D	36241	1.65	16	15	8	1	31.22064	1131467.214	28500765	0.0397	39.6995
E	25846	2.3	16	15	8	1	34.4093	889342.2509	32115835	0.277	27.6917
Total							175.7501	7340156.5922			39.0207
Urban											
A	45000	1.75	21	15	3	1	19.9400	897297.75	94879239	0.0095	9.4573
B	30238	2.375	21	15	3	1	23.964075	724625.6999	69033638	0.0105	10.4967
C	50500	3.125	21	15	3	1	28.793025	1454047.763	80682966	0.0180	18.0217
D	35745	3.125	21	15	3	1	28.793025	1029206.679	103676149	0.0099	9.9271
E	38769	3	21	15	3	1	27.9882	1085074.5258	58193579	0.0186	18.64
Total	406948						129.4783	5190252.4168			13.3098

Table 2.1: Sample Calculations for estimating Carbon Footprint

2.24 Calculation of carbon footprints towards the conclusion of the peak season – of winter and summer – may be desirable. Hence the telecom service providers can declare their Carbon footprints twice in a year.

2.25 All service providers should declare to TRAI, the carbon footprint of their network operations in the format provided in Annexure -II. This declaration should be undertaken after adopting the formulae and procedures mentioned under para 2.20 and at Annexure -I. 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.

B Methods for reducing Carbon Footprints

2.26 International experience shows that there can be considerable reduction in the telecom carbon footprint through a number of activities of the telecom value chain. The service providers can take several steps to reduce their carbon footprint e.g. proper radio planning to reduce number of BTSs, sharing of passive and active infrastructure, sharing of backhaul, adoption of green shelters, replacing air-conditioners with forced air cooling, HFC free cooling systems, precision air-conditioning, intelligent remote air-conditioning control, installing outdoor base-stations, adoption of energy efficient technology and renewable energy sources.

2.27 Some of the measures that could be followed by the service providers for reducing the telecom sector footprint could be broadly classified as:

1. Better network planning
2. Infrastructure Sharing
3. Adoption of energy efficient equipment and innovative technologies
4. Improvement in supply of Grid Power
5. Use of Renewable sources of energy

1. Network Planning

2.28 With the advent of 3G technologies, there would be associated innovations in the BTS deployment which would increase the power amplifier efficiency, raise the capability of the base station to work at higher temperatures to reduce air-conditioning requirements, adopt distributed and integrated central office approach and use intelligent shutdown technology. These new technologies can host BTS that could be actively shared by different operators which would reduce the overall power consumption levels. A single unified core can serve all the present

technologies, 3G, LTE and beyond architectures, which will help in reducing carbon emissions substantially. Due to energy efficient technologies, network elements will require much lesser power consumption for 3G and future technologies. Hence, a carefully designed optimized energy efficient radio network will reduce the overall power consumption and significantly minimize the site cost. Planners can also serve the cause of green telecom and bring savings to their companies by judiciously using a mix of micro and macro sites and also home-based femto cells, which will lower the power consumption levels by more than a factor of seven when compared to the macro base stations.

2.29 In the consultation paper, issues relating to Better Network planning to reduce the carbon footprints in the network were raised and the following question was posed:

- a. What steps can be taken by the service providers in planning green networks?

2.30 In response, some of the stakeholders suggested that a significant step for greening networks would be by the use of energy efficient core equipments wherever possible, working mostly on a resource-sharing, integrated all-IP communications platform. Such equipments could be part of a streamlined, optimized system that would meet environmental standards, and also reduces OPEX and CAPEX. One stakeholder suggested that by co-location of RAN equipments by more than one service provider, they can save on air-conditioning costs. By using environment friendly shelters and structures for housing of BTS / BSC equipments and by increased use of outdoor BTS mounted at the tower top, adjacent to the antenna array the networks, could be greened. Some stakeholders opined that by upgrading equipment firmware to introduce new power saving features, by remotely monitoring diesel generator runtime and fuel consumption and by the use of energy efficient technologies, a greener network could be planned. One of the

stakeholders held the view that the use of eco-friendly renewable energy sources, efficient power management and proper active infrastructure sharing may be mandated to the service providers.

2.31 Another suggestion was that the computing power of the mobile devices is increasing exponentially. MANETs (Mobile Adhoc NETWORKS) are in experimental stages as of now; but the future developments in this area have the potential to cut down infrastructure requirements substantially. A stakeholder opined that with the advent of technologies, new infrastructure products and solutions are available in the global markets which are power efficient. Using alternate deployment architectures using these products, significant power efficiencies can be attained in the networks. Operators could be encouraged to use such solutions for network roll out. Rural Telecoms have peculiar traffic requirements and traditional architectures are not optimized for it. Using new solutions and architecture rural telecom can be run solely on solar and other renewable energy sources. The indoor coverage requirements can be managed with small capacity and highly energy efficient solutions within the buildings to save power and for better spectrum utilization.

2.32 It was suggested by some stakeholders that the operators should plan a network architecture in which systems operate either on solar energy or hybrid with grid power as back up. In rural & remote areas, the population clusters are scattered. Operators should plan judiciously for adequate capacity and coverage in rural areas. Since the capacity requirement in rural areas is much less than the urban areas, small capacity and low power systems should be planned which operate on non-conventional energy sources, preferably solar power. The operators should use energy efficient equipments which operate in non air-conditioned environment and should be compact to be installed on low height towers / poles. Power efficient low power BTSs operable on solar

power are available in the market which can be easily installed on small height poles to extend the coverage within villages.

- 2.33 A suggestion was made that for urban areas, the operators should install the equipment in the green buildings designed for such purposes to avoid use of air-conditioners. They should plan to power the equipments through hybrid power plants with solar power backed up by grid power supply. Only the outdoor coverage is to be provided by high capacity BTS installations as is the practice now, but these must be energy efficient and could operate on nonconventional sources of energy. The indoor coverage requirements can be managed with small capacity and highly energy efficient solutions within the buildings to save power and for better spectrum utilization.
- 2.34 There are a number of measures taken by service providers and vendors internationally to increase the efficiency and to reduce carbon emission of telecom infrastructure. Service providers should plan to adopt such measures that reduce the power consumption of equipment and in turn paves the way for reducing the carbon emissions. One such key measure would be to reduce the number of separate hardware components involved in the network which would lead to reduction in energy utilization.
- 2.35 Service providers could also plan to deploy “intelligent” antennas, which draw less power by monitoring customers’ bandwidth requirements and using this information, allocate only the required transmission capacity. Deploying BTS power savings features as a Self Organizing Networks, (SON), in which unused resources are put on stand-by, saving up to 25% of the power in the radio access network, could be planned. Relying on dynamic energy management control and monitoring the solutions could reduce energy consumption by putting on stand-by the power amplifiers

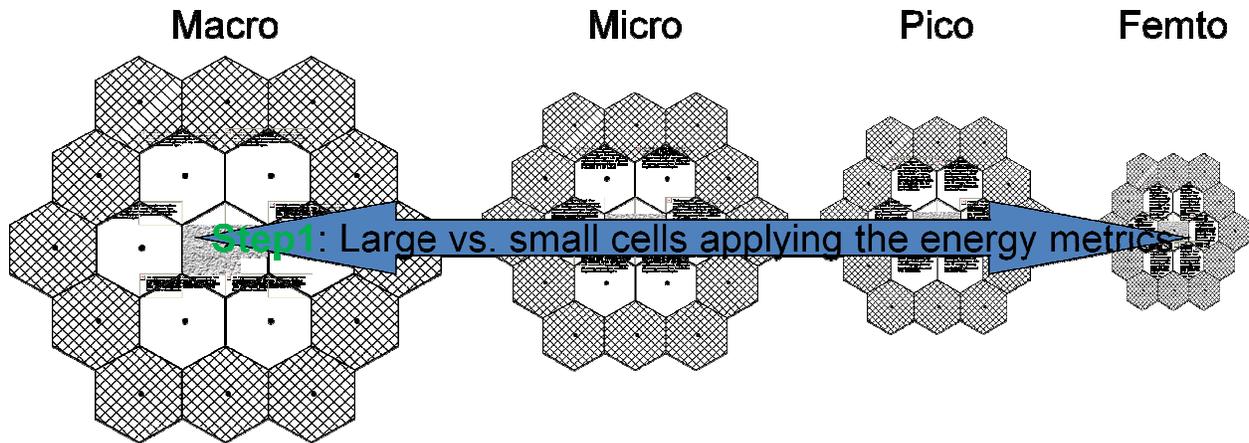
not required for operations. In addition, site energy management software could allow operators to pre-configure specific site energy profile for extraordinary conditions such as local events increasing traffic and, in turn, minimize energy consumption at other times.

- 2.36 Deploying software-defined base-stations (SDRs) which can quickly adapt to support different mobile network technologies or even several such technologies at the same time would be another option. This solution can reduce the power consumption of base-stations by 50% and the volume of equipment needed by 70%.
- 2.37 Using remote radio heads, where the BTS is mounted on the tower next to the antenna, reduces the energy loss associated with the feeder cable connecting the radio to the antenna. By using “active antenna arrays”, energy in wireless base stations could be saved by integrating power-hungry radio frequency equipment within each antenna element, thus reducing power losses.
- 2.38 Switching off network components required for excess capacity at times of low traffic could also save power consumption. By implementing “Mistral-Mobile” cooling system (a tubular tower approach) the energy needed for cooling mobile network equipment could be reduced by 85%. Also, instead of conventional cooling, Tower Tubes can be developed, which use natural convection cooling, to greatly reduce feeder loss, resulting in a reduction of nearly 40% in power consumption. Furthermore, the Tower Tube is designed so that backup-batteries can be placed below ground, thus lowering their operating temperature and increasing their lifetimes significantly.
- 2.39 Novel thermal solutions can be developed, such as three-dimensional heat sinks and thermal interface materials which could more efficiently

conduct heat at the electronic component level, as well as modular liquid cooling solutions that reduce the power required to cool electronics at the racks and data centre level.

2.40 Overall Base Station Efficiency could be improved by deploying techniques required to deliver significant improvements in overall efficiency for base stations, measured as RF power out to total input power. Care should be taken to ensure that the Quality of Service is ensured during such power optimization techniques, for which the QoS/RF Power Ratio has to be improved. These are techniques that will reduce the required RF output power required from the base station whilst still maintaining the required QoS.

2.41 The Energy Efficiency Analysis Process could ensure efficient Base station operation. The first step in the process will be to apply the energy metrics from a large cell to a femto cell. The second step will be to overlay the Source and Network Coding for effective Cooperative Networking of base stations. The third step involves evaluation from the perspective of packet scheduling, handover, power control, load control, differentiated QoS, fast fading effects, UE speed and MIMO. The Energy consumption is also proportional to the distance, which is also to be taken into account. The service providers should select equipments with the best Energy Consumption ratings (ECR), as well as resort to techniques like adaptive network management.



Source: www.mobilevce.com

Figure 2.2: Energy Efficiency Analysis Process

2.42 If some of these strategies that minimize power consumption are followed, then this will help in the reduction of carbon footprint of the telecom network.

2. Adoption of Energy Efficient Technologies

2.43 Intelligent Network Planning can help reduce the carbon footprint in a number of ways. New network design methodologies, radio techniques and site technologies have been developed to reduce energy consumption across the board - from radio equipment, through climate and power systems to radio access networks with the focus on improving both new network roll-out, as well as the operation of existing networks. Energy consumption can be reduced if network solutions and services can be designed to use fewer sites. Energy demand and therefore the carbon footprint can be reduced if planners use energy efficient equipment that need less energy to work and also dissipate lesser power as heat. Energy efficient technologies need to be adopted in all components of the network chain including rollout of telecom equipment, air conditioners, and secondary power sources.

2.44 In the consultation paper, issues relating to the adoption of energy efficient technologies for reducing the carbon footprints in the network as well as cost aspects relative to legacy equipment were raised and the following questions were posed:-

a. As a manufacturer/service provider, have you started producing/using energy efficient telecom equipments? How is energy efficiency achieved? Please explain.

b. How does the cost of energy efficient and the normal equipment compare?

2.45 It was suggested by some stakeholders that some of the vendors have developed innovative technologies to significantly reduce energy consumption and emission of base stations. These technologies involve improving the power amplifier efficiency, raising the base station working temperature and using intelligent shutdown technology.

2.46 A suggestion has been made regarding a Single RAN solution based on the software-defined radio (SDR) system which could truly integrate multiple networks. Single RAN is one of the solutions in the industry to simplify energy-using nodes and saves energy by way of network convergence. This solution effectively reduces the number of sites and is deployed on a commercial basis successfully in many parts of the world. Two or more operators could share their network.

2.47 Some Stakeholders suggested that the use of a high performance, advanced and unified hardware platform should be provided for reducing average power consumption. Platforms like ATCA (Advanced Telecom Computing Architecture) for core network can act as a unified platform for most of the core elements. The applications cover SGSN, SG, HLR, MSC server both in mobile and fixed area and IMS. Use of device pool solutions, such as MSC pool, SGSN pool, etc will not only increase the network reliability, but also increase the usage rate of equipment, and

therefore reduce the overall energy consumption. One of the stakeholders suggested that there are also a series of hybrid power solutions with MPPT (Maximum power point tracker) based charge controller unit, tailored to the base station sites.

- 2.48 Alternating mode of technology such as the alternating diesel battery hybrid mode that helps to reduce the diesel consumption by using batteries managed by smart controllers at the main power source is increasingly being utilised by some of the operators.
- 2.49 Some of the stakeholders have suggested using energy efficient cooling solutions such as free cooling that uses fresh air to cool equipment. They have also suggested deploying equipment that has higher operational temperature. Both these methods have reduced the need for air-conditioning and have resulted in huge savings in terms of power consumed. It was suggested that it is a well known fact that renewable energy is most successful at lower loads and that associated costs are relatively low. This is a blessing in the Indian case, because the bulk of the investments in rural networks are yet to be made and distributed systems with low power requirement can easily be mass deployed. Some of the stakeholders had the concern that the CAPEX of green products could be higher than normal products in some cases. This is attributable to the extra R&D efforts requiring manufacture control, and supply chain control.
- 2.50 Service providers could plan to modify networks so as to enable turning off extra TRXs of BTS during off-peak periods or night hours of low traffic, since 59% of the power consumed in the mobile network is consumed by the BTS. Since the actual signal burst power is never greater than 15%, introduction of sleep mode technologies will drastically reduce the power requirement at BTS sites.

- 2.51 The maximum consumption of energy is on account of cooling. By modifying, BTS as outdoor unit in place of Indoor BTS, substantial savings could be achieved in cooling. Therefore, this single innovation can help reduce cost relating to cooling by more than half. There are new low power outdoor mountable BTS/BSS and transmission equipments which are highly power efficient and run on alternate energy sources such as solar power. These systems do not require air-conditioning. These have contributed towards better energy efficiency due to power efficient BSS design, reduction in losses in feeder, power plant, and power requirement of air-conditioner and transmission system integration. Low power base stations running on non-conventional energy resources, specifically for rural & remote areas could be deployed. There are also new GSM infrastructure solutions, which run entirely on solar power, which do not require grid supply or power backup using diesel gensets.
- 2.52 An Integrated BTS with transmission backhaul system could be planned in future networks. An integrated, backhaul-free base station solution delivers the power of a macro cell—in a micro cell size. These BTS eliminates the costly backhaul barrier to service expansion. They will help in optimizing backhaul while they are still easy to deploy for highway, suburban, or rural coverage. Besides, with a planned shift to the all IP scenario (routing/switching) there could be a 25% reduction in the power consumption levels at the core also.
- 2.53 The above measures could contribute towards better energy efficiency due to power efficient BSS design, reduction in losses in feeder, power plant, power requirements of air-conditioner and transmission system integration. These techniques could help in decrease of the power consumption as per the following table.

	GSM
Mast sharing	5%
Power-down in quiet periods	25%
Base station efficiency improvements (mainly PA efficiency gains)	20%
Mast head amplification	30%
Higher temperature operation	25%
Equipment cooling	15%

Table 2.2: Decrease in the power consumption

2.54 Though most stakeholders provided different solutions for adopting of energy efficient technologies, the exact methodology for calculating optimal cost of energy efficient equipment did not evoke any specific response. TRAI has worked out a sample estimate for calculation of Energy Bill estimates. Also some of the additional measures that could be added to for energy efficient network planning are explained.

2.55 The Energy Bill Estimation methodology will help the service provider in choosing the best cost energy efficient systems. Service providers could also factor in this criterion during the procurement of the equipments. It would be useful for the service providers to have an estimate of energy consumption over a projected lifetime (total cost of operation). Using these calculations, the service providers could find equipment that is most cost effective in the long run, over the lifetime of their networks.

For a reference system described by a vector of variable-load measurements (E_{100} , E_{50} , E_{30} , E_{10} , E_i), building such an estimate is trivial and can be expressed by the following equation:

The total Cost of Operation estimated for the energy consumption over a projected life time =

$$C = \sum_{j=1}^N (\alpha * E_{100} + \beta * E_{50} + \gamma * E_{30} + \delta * E_{10} + \varepsilon * E_i) / 1000 * 8765.25 * C_{kwh j}$$

Weights (α , β , γ , δ , ε) are network utilization weights [$\alpha + \beta + \gamma + \delta + \varepsilon = 1$] specific to a customer's network, N is a projected lifetime (in years) and $C_{kwh j}$ represents the cost of kilowatt hours in a year of operation. The E_{100} is the energy consumption under highest load (watts), E_{50} is the energy consumption under half load (watts), E_{30} is the energy consumption under thirty percent load (watts) and the E_{10} is the energy consumption under ten percent load (watts).

2.56 Therefore, it could be concluded that if the above mentioned energy efficient technologies are adopted, they will minimise the power consumption, which will help in the reduction of carbon footprints of the telecom network. A tentative method of finding out the best cost energy efficient systems in the network could be used by the service providers to deploy the best possible equipment.

3. Infrastructure Sharing

2.57 Passive site sharing involves components such as the ground based or rooftop tower, cables, shelter cabinets, power supply, air-conditioning, alarm systems, etc. In addition to OPEX saving, tower sharing saves utilization of various natural resources like steel, cement, concrete, zinc and land, besides optimizing the use of power. In addition, active sharing of network infrastructure, which involves the sharing of antennae systems, backhaul transmission systems and base station equipment, will allow operators to save an additional 40% on top of available savings from passive infrastructure sharing. Sharing also results in reduction of

number of generator sets and telecom masts installed, which lead to reduction in noise, air and visual pollution. Infrastructure sharing curtails duplication of resources and leads to less deployment of cell sites. Access network costs typically represent between one sixth and one third of mobile network operators costs. Analysis shows that operators who have jointly rolled out around 2500 sites in a developed economy could typically achieve a 30% CAPEX saving accumulated over five years. They would also reduce OPEX by 15% per year by the fifth year.

2.58 In the consultation paper, issues relating to the potential of Infrastructure Sharing for reducing the carbon footprints on account of reduction in power consumption in the network were raised and the following questions were posed:-

a. What is the potential of infrastructure sharing in reduction of energy consumption?

2.59 Most of the stakeholders were of the opinion that there could be a reduction in the energy consumption levels by upto 40% by active infra sharing. They opined that infrastructure sharing can substantially lower costs of network deployment. This does reduce energy costs, including those for creating and setting up infrastructure. However, given that cost is the chief barrier to the use of renewable energy, the cost savings due to infrastructure saving can significantly improve the economics of deploying renewable energy solutions.

2.60 Most of the stakeholders were of the view that Active infrastructure sharing (such as Antennae systems, Backhaul transmissions systems, Base Station, BSC, RNC, e-NodeB) would allow operators to save an additional 40% on top of available savings from passive infrastructure. Operational expenses can also be reduced through sharing. Doubling the tenancy on sites does not linearly increase the operational expenses and there are also additional common operational services that will not be

proportional to the tenancy, such as security, lighting and cooling. They also opined that certain percentage of towers must be supported with 100% subsidy under various schemes for using non-conventional energy. Infrastructure sharing curtails duplication of resources and leads to less deployment of cell sites. Access network costs typically represent between one sixth and one third of mobile network operators costs.

2.61 Currently, telecom infrastructure sharing takes place on an ad-hoc basis as it takes place only voluntarily. Though most stakeholders encourage infrastructure sharing, making the same mandatory was opposed except in sensitive areas like Cantonment areas, Central Government and State Government office buildings, Forest or Green Belt areas and Government Residential colonies, etc., where installation of cell sites by individual operators is either difficult or is not permissible due to lack of policy, security or aesthetic concerns. Most stakeholders explained the potential of infrasharing and suggested that there definitely exists a power saving potential of 30% from active infra sharing. Apart from these advantages, one single network will have less than 25% fewer radio nodes and less than 40% fewer site locations as compared to the standalone scenario. This leads to large and readily achievable synergies in both network & IT that saves costs as well as power consumption.

2.62 The passive RAN network sharing among operators could be shared at 2G and 3G site locations, including masts and possible backhaul. The Traffic could also be managed independently of each other. By this arrangement the Customers expect to benefit from improved coverage, especially for mobile broadband (i.e., HSPA and later LTE). Also the best sites could be retained for improved coverage and quality of service. A Progressive sharing of backhaul, backbone and core could be planned.

2.63 A typical active infra-sharing between three operators X1, X2 and X3 is attempted below which could lead to a more optimized network. By infrastructure Sharing there could be maximum addressable cost, in which savings can be expected between 30% (passive) to 60%(active) of the technology costs. There could be a maximum operational cost savings where the annual saving on relevant cost could be between 20% to 40%. The termination cost (in network consolidation) could also be achieved which could be between 1.5 to 3.0 times that of the annual steady state savings. There could be integration and migration cost (i.e., CAPEX) depending upon the size, the scope of sharing, the supplier match and the age of infrastructure, etc.

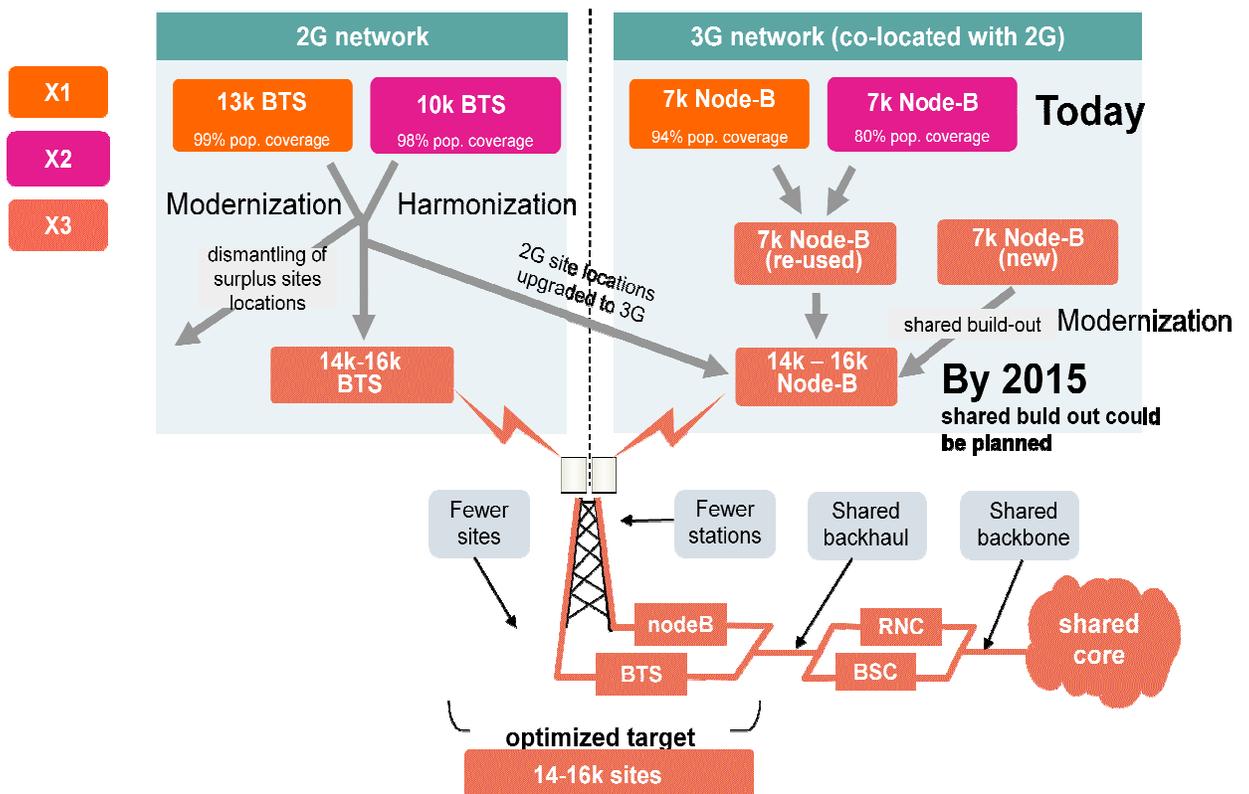


Figure 2.3: A conceptual view of 3 operators sharing an active infra structure

2.64 Therefore, it could be concluded that if the infrasharing is resorted to then there is a huge potential savings in the power consumption levels,

which will help in the reduction of carbon footprints of the telecom network.

4. Improvement in Supply of Grid Power

- 2.65 Today, India with an installed capacity of around 170000 MW has around 12% power shortage. While 80 percent of Indian villages have at least an electricity line, less than 52.5% of rural households have access to electricity. In urban areas, the access to electricity was 93.1% in 2009. The overall electrification rate in India is 64.5% while 403.7 million people live without access to electricity. Due to the precarious power situation, about 70% of the telecom towers have grid/Electricity Board power availability of less than 12 hours.
- 2.66 Deficient grid power makes it imperative to use non-grid sources, the most common being diesel gensets. Since growth is expected to come mainly from rural areas in the coming years where the grid power supply is already very low, the use of diesel generators for uninterrupted power supply will give rise to more diesel consumption. In future, emission from BTS sites will increase more rapidly and the network cost will also increase. As the price of oil is on an increasing trend, consumption of diesel will only add more costs towards maintenance of infrastructure. The consumption of diesel would increase as more new operators roll out their services, while existing operators expand their network further and launch 3G service or BWA services.
- 2.67 In the consultation paper, the issues relating to the proportion of tower infrastructure in the rural areas and the availability of grid/electricity board power to these towers were raised and the following questions were posed:-

- a. What proportion of tower infrastructure is in rural areas? Please comment on the grid/electricity board power availability to these towers.
- b. To what extent can active sharing reduce the carbon footprint and operational expenses?

2.68 Some of the stakeholders opined that 70% of tower infrastructure is in semi-urban & rural areas with a grid power outage of 8 hrs and above at present. Almost 80-90% of the power requirements for these rural towers are met by diesel gensets. Stakeholders also opined that the other part of the opportunity is to reach uncovered rural markets is through sustainable green infrastructure. Since the rural teledensity has a long way to go, it would be correct to assume that the maximum investments in infrastructure would be in those areas.

2.69 Some stakeholders also opined that the use of alternative and non-conventional energy sources like solar/wind/fuel cells forms an important source of energy for powering base stations, which may not altogether remove the requirement of DG sets, but would definitely reduce dependence on them. The operators in spite of their efforts and best intentions have not been able to deploy such alternative energy sources as solar/wind/fuel cells on a large scale as these are very costly and are economically unviable. On a national level, the BTSs avail an average grid power availability of 13.5 hours per day only.

2.70 In metro circles, grid power is available for more than over 20 hours per day. In some of the northern states power availability is 10 to 16 hours per day. The grid power availability pattern also changes with seasonal variations in demand. Table 2.1 shows availability of power in different types of cell site locations.

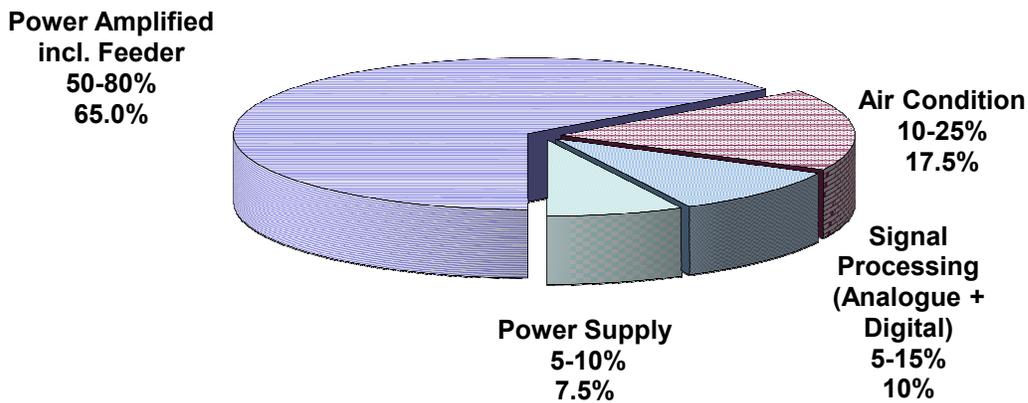
Cell Sites	EB Availability	Description
10%	>20 hrs	Mainly metro cities of Mumbai, Kolkota, Chennai, some cities of Gujarat, State of Chattisgarh, some cities of Punjab
20%	16-20 hrs	Covers most other major cities and towns in the rest of the country
30%	12-16 hrs	All semi-urban and small urban towns in all states
25%	8-12 hrs	Mostly rural areas
15%	<8 hrs Off grid	Mostly parts of Bihar and some towns of Assam, NE states, UP and J&K

Source: Intelligent Energy Limited

Table 2.3 Power Availability for Tower Sites

2.71 But due to non availability of grid power, load shedding or voltage irregularities, most of the cellular operators and independent telecom infrastructure providers pre-dominantly use standby Diesel Generator Sets at their cell sites in order to provide 24X7 uninterrupted cellular mobile services to the end users resulting in GHG emission. Consumption of diesel is more at those places where grid power supply is poor. In some areas due to severe power shortage, diesel generators are the only medium to run BTS sites. As diesel is more easily available as compared to any other fuels and the initial cost is low as compared to others sources, diesel generators are preferred to run BTS sites.

2.72 Energy related expenditure accounts for nearly 67% of total operating cost per cell site in the rural areas. At present the energy expenses (OPEX) is nearly 30% of the total network operating costs. The power requirement of a BTS currently varies from 1300 – 2500 watts. A large percentage of these deployments are still indoor type needing air conditioning. In any BTS, The Average Power Consumption towards Air conditioning is 17.5% and over 65 % is because of power amplification including the feeder.



Source: <http://www.gsmworld.com/>

Figure 2.4 : BTS Power Consumption.

2.73 Without cooling, telecom equipment is likely to overheat and fail or suffer a greatly shortened life. Most of the instruments need temperature less than 25 Degree Celsius. However today, outdoor BTS are available that does not require cooling. Power consumption of BTS is about 1.5KW-2KW right now but this is also reducing with the advancement of technology. New BTS with power consumption levels of only 500 W are already available. The detailed (RoM) Power consumption estimates of a sample GSM BTS is given below:

Sl. No	Status	6/6/6 config in W	2/2/2 config in W
1	AC Units only ON	1720.8	999
2	Power Plant Only ON	1631.25	1305
3	Media Equipment only ON (CPE)	1631.25	1305
4	BTS ON but TRXs OFF, Media OFF	1648.53	1310
5	BTS ON, Media OFF	1706.4	1325
6	BTS Power Consumption	2664.45	1647
7	All the Equipments ON	4385.25	2646

Table 2.4: GSM BTS Macro-site Power Consumption Estimates – Current Technology

Total BTS Sites (September, 2010)			
	GSM-only	CDMA-only	
Total BTS Sites	470969	89307	560276

Table 2.5 : Total BTS Sites

Assuming on an average the urban sites use a 6/6/6 config, the approximate total consumption of one BTS will be 2.6 KW, which will contribute to around 19 mt of CO₂. It could also be seen that AC units and the TRX units contribute sizably to power consumption and subsequently the carbon emission.

- 2.74 If the improvement in grid supply is enhanced, then the CO₂ emissions levels are reduced, as grid power is less CO₂ emitting than diesel gensets. Hence it should be a key objective of the Government, on priority basis, provide grid power to rural sites so that dependency on diesel power is reduced to a large extent.

5. Use of Renewable Sources of Energy

- 2.75 India's current renewable energy base is 18455 MW (11% of total installed base). The Indian Wind Energy Association has estimated the 'on-shore' potential for utilization of wind energy for electricity generation is of the order of 65,000 MW. In wind power, India's total installed capacity is planned to at least double by 2022 and the nation is emerging as an important manufacturing base for the global wind industry. As of June 2010, wind energy alone contributed 12009 MW. In July 2009, India unveiled a \$19 billion plan, the Jawaharlal Nehru National Solar Mission, to produce 20,000 MW of solar power by 2020. India's National Solar Mission aims to see solar energy achieve grid parity with the cheapest coal fired capacity by 2030 and establish the country as a global leader in the field. Other major renewable technologies are on the anvil too, making India one of the world's most important markets for the Renewable Energy Technology (RET) Sector.
- 2.76 Where sites are beyond the reach of an electricity grid or where the electricity supply is unreliable, and are remote enough to make regular maintenance and refueling of diesel generators prohibitive, there are several cost-effective alternative energy sources available. The importance of these alternative energy sources is increasing, as the costs of expanding into remote areas grow. As radio sites have become more energy-efficient, it has become more economically and technically feasible to use alternative energy sources.
- 2.77 The question of utilizing eco-friendly energy sources has been under intense consideration by telecom operators. Apart from the development of energy-efficient technology, power has been a major problem for rural telecommunications in India. Another area of concern is the use of the diesel engine-alternator sets for running mobile systems, particularly in

rural areas where commercial power is available only for a part of the day. This naturally causes an enormous degradation of the environment.

2.78 In the consultation paper, the issues relating to use of renewable energy technologies for reducing the carbon footprint – proportion of the non grid power supply in rural powered by RET, the savings that will accrue per tower if supply is through RET instead of DG sets, expedition of migration to RETs, as service providers steps taken towards RET, were raised and the following questions were posed:-

- a. What proportion of non-grid power supply to towers in rural areas can be anticipated to be through renewable sources of energy in India in the next 5 years?
- b. How much saving accrues per tower if supply is through a renewable source instead of diesel for towers that do not get grid power for 12 hours or more?
- c. How can migration to renewable sources be expedited?
- d. If you are a service provider what steps has your company taken towards use of renewable sources of energy? Have the gains from this move been quantified?
- e. What are the most promising renewable energy sources for powering telecom network in India? How can their production and use be encouraged?

2.79 Some of the stakeholders opined that India has abundance of sunshine and wind energy; so these two sources are the obvious choices for renewable energy sources. Apart from these, remote hilly areas in the North, North East and Central India, there is a huge potential for Mini and Micro Hydel Power Plants, in the North and North Eastern states. Other sources which can prove useful are the Tidal Energy in the coastal areas, and blending of the diesel and petrol with bio fuel. Some

stakeholders were also of the view that since India has abundant gas reserves provisioning of piped natural gas to tower sites could be a viable solution to start distributed power generation. The piped gas can be used for natural gas based generation sets and subsequently fuel cells. One of the stakeholders stressed that fuel cell technology provides one of the cleanest sources of power. Though proven technology is available, high CAPEX of Fuel cells and lack of distribution network for hydrogen are the bottlenecks for large scale deployment.

- 2.80 Several stakeholders were of the view that because of the technological conditions of renewable sources, the initial cost of installing the equipment is significantly high and considering the severe competition in the telecom sector, there is little willingness to spend resources/finances on renewable sources of energy. They opined that if adequate subsidy/incentive schemes are given for migration to renewable energy sources, then 100% sites having grid power of less than 12 hours can be covered in next five years.
- 2.81 Some of the stakeholders were of the view that large scale deployments could depend on various factors like the cost of renewable sources of energy & Government subsidy/incentives for deployment of renewable sources of energy. There should be solar solutions made available at affordable cost through CAPEX subsidization.
- 2.82 One of the stakeholders commented that in India, no new tower in rural part should be allowed to be run on fossil fuel and that a time frame should be fixed for conversion of existing towers. Some wanted the USOF to be utilised for fostering Renewable Energy Technologies (RETs), and at least 25% of the existing off grid sites should be considered over the next five years, as the CAPEX of renewable energy resource is relatively high. Some of the stakeholders also commented that a significant saving of

diesel could be achieved on account of extending power supply through solar powered systems.

- 2.83 Others suggested that to expedite the migration to renewable sources, there could be an enhancement of number of telecom sites being granted subsidy under JNNSM or any other scheme like USO fund / clean energy fund. Indigenization of systems / technology should be encouraged so that there will be a reduction in the initial investment. One of the stakeholders suggested that to avoid mushrooming of small capacity of power generators based on renewable sources, feasibility of bridging / supplementing the shortfall in grid capacity through larger capacity Power Plants based renewable sources should be preferred.
- 2.84 Some of the stakeholders opined that the Government may it mandatory to use only renewable energy sources for network deployment in rural and remote areas.
- 2.85 Some stakeholders suggested that Hybrid powered BTS could be powered using a combination of Grid + Wind or Solar or biomass or fuel cells. In exceptional cases, batteries could be charged using DG sets, but the usage of DG sets should not exceed 5 hrs in a day.

Wind and Solar Energy Utilisation

- 2.86 Solar and wind power have progressed in recent years with costs steadily falling. A point is being reached where they can be considered as supplementary or even the primary power source for cell sites in difficult locations. As the cost of wind and solar technology continues to fall, and the cost and scarcity of fossil fuels increase, solar and other renewable energies will become increasingly cost effective compared with more conventional power sources. Solar power is generated using the

photovoltaic properties of semi-conductors to convert light energy into electricity. Manufacturing costs for solar cells have been declining by 3-5% per year in recent years, leading to growth capped only by silicon supply issues. However this year the cost of the solar panel has gone down from 170 Rs/W to 70 Rs/W. Another advantage that solar has over many other technologies is its scalability. Solar photovoltaic (PV) panels are modular and the size of a PV array can be increased easily and in small steps.

2.87 For wind power, a wind turbine attached to an electrical generator converts wind power to electrical energy. The global adoption of wind and solar as commercially viable technologies, together with the falling costs and growing reliability of the technologies, make them cost effective technologies to adapt to a telecommunications environment.

Fuel Cells

2.88 Fuel cells are emerging as a strong alternative power source. The technology has matured in recent years and has many benefits compared to generators, such as fuel efficiency, climate resistance, reliable start-up, and being very compact (e.g. fitting in a 19" rack). Their silent operation means there will be no indication that a power source is operating on the cell site, reducing the likelihood of theft. Having reached volume manufacturing and with prices falling, they would challenge conventional engine driven generators in terms of cost and reliability.

Fuel cells operate by converting a fuel, such as hydrogen, into electricity without combustion. There are several types of fuel cells, of which the most promising for telecommunications is the Proton Exchange Membrane Fuel Cell (PEMFC). The PEMFC operates at low temperatures, and runs at 40-60% efficiency. New Technologies are evolving such as hybrid fuel cell technologies for radios, a hydrogen generator used as a

miniature fuel-cell power source, improving fuel cell performance, durability and manufacturability using single wall carbon- nanotubes (SWNTs); which could further improve performance efficiency levels.

Biomass Energy

- 2.89 Biomass power is obtained from the energy in plants and plant-derived materials, such as food crops, grassy and woody plants, residues from agriculture or forestry and the organic component of municipal and industrial wastes. Biomass power is not only a source of renewable energy but also helps in waste management. Electricity generated from biomass is also called biopower. Biopower facilities use many different technologies; the most common is burning of wood or other biomass feedstock to produce steam which then is used to drive turbines and produce electricity. Biomass power is close to a carbon-neutral electric power generation option, as biomass absorbs carbon dioxide from the atmosphere during its growth and then emits an equal amount of carbon dioxide when it is processed to generate electricity. Thus, biomass fuels “recycle” atmospheric carbon, and may reduce global warming impacts. The DG which is part of the hybrid solution can be made to use biomass instead of costly and polluting fossil fuel. In India, some operators are deploying base stations powered by biofuels in rural areas that have not previously had access to a mobile network and are located in areas with unreliable power supply. In the long term, it is expected that locally produced jatropha oil could be used, as soon as this is available in sufficient quantities.

Pico Hydro

- 2.90 The term pico hydro refers to very small hydro systems. Pico-hydro refers to very small hydroelectric power generators that typically produce up to 10kW from the energy of streams and rivers. It is a mature technology for

other applications such as rural electrification and has one of the lowest capital investment requirements of all. But again, it is applicable only in a limited number of places. There is a large potential market for pico hydro due to the fact that only small water flows are required, small communities in the developing world are often not linked to a power grid and that locally manufactured pico hydro systems have lower long term costs per kilowatt than solar, wind, or diesel systems. Hydro systems provide constant energy during times of normal rainfall. Areas with high rainfall, steep flowing streams and rivers provide an ideal source of power for wireless communication network base stations, allowing the low cost, low maintenance deployment of wireless communications to emerging markets.

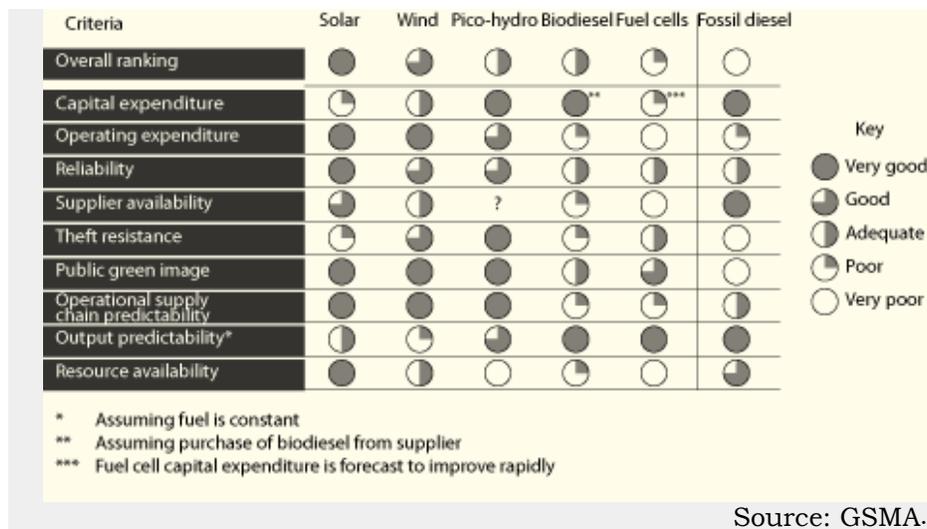
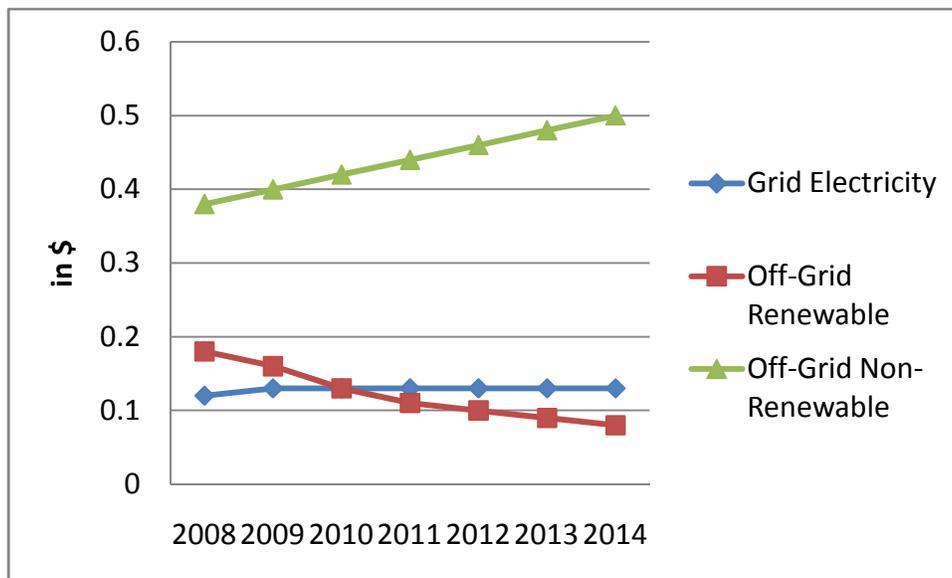


Figure 2.5: Viability of green power solutions

2.91 In the figure 2.5 above, the viability of the different Renewable Energy technologies (RETs) for mobile base stations is compared. It could be seen though it is comparatively inexpensive to install a diesel-powered generator for a mobile base station, the operating costs in fuel and maintenance are high and extremely vulnerable to market conditions. At present, solar and wind power solutions require about 50 per cent more capital investment, but they have much lower running costs. They

more quickly pay for themselves in cases where the site load is below 2 kW. For a 10KW load the payback period is less than 5 years for a solar powered system. In other situations, hybrid systems can be valuable, combining diesel with green power solutions to reduce operational costs along with the environmental impact. As per a report made by the firm, Juniper Research, (Figure: 2.6) the implied costs of renewable energy are already less than half of non-renewable energy. By the end of 2014, as renewable costs fall and diesel rises, they are expected to be just 16% of diesel costs.



Source: Juniper Research

Figure 2.6: Global average Implied Cost of Base Stations Electricity Split by Source, 2008-2014

2.92 Globally, if operators look for a three-year payback on investment, then 9 per cent of mobile base stations could be powered by green energy sources, saving 3 million tonnes of CO₂ emissions each year and USD 1.3 billion in fuel costs (see Table 2.6). With a five-year payback period, the figures rise to 30 per cent of base stations using green power and thereby saving 10 million tonnes of greenhouse-gas emissions — as well as USD 4.4 billion in fuel costs. In India also if operators plan for hybrid powered towers, then they could plan for conversion of 30% of the

towers with a 5 year payback period. Hence operators should plan for at least 50% of the rural towers to be powered by hybrid power in the next five years. (30% of the existing towers and all new towers, planned to be hybrid powered). In Urban areas, with more deployment of Directional Antenna System (DAS), hybrid powered towers could be commissioned. Operators should plan for conversion of about 1/3rd of the towers under urban areas into hybrid powered sites.

	3-year payback period	4-year payback period	5-year payback period
Percentage of off-grid BTS sites viable for green power	9%	20%	30%
Reduction of diesel per year	1.1 billion litres	2.5 billion litres	3.5 billion litres
Fuel cost savings per year	USD 1.3 billion	USD 2.9 billion	USD 4.4 billion
CO ₂ emission reduction per year	3 million tonnes	6.8 million tonnes	10 million tonnes
Source: GSMA.			

Table 2.6: Global projection of off-grid green power base transceiver stations (for specific payback periods)

2.93 The Government has introduced policies and regulatory measures for renewable energy development, such as financial incentives, capital subsidy and customs duties. The Government has imposed preferential tariff for renewable power in strategic areas under its National Electricity Policy 2005 and in national tariff policies. In 2003, the Government has set a fixed minimum percentage for renewable electricity purchase through electricity legislation. Further government efforts include generation-based incentives scheme for wind power, which prescribes 0.50 rupee per unit incentive for electricity fed into the grid.

2.94 The Jawaharlal Nehru National Solar Mission is currently the centerpiece of India's renewable energy development. The

program, launched in November 2010, will boost deployment of solar energy systems and install 20,000 MW solar capacities by 2022. The first phase of the mission targets grid connected solar power plants with a combined capacity of 1,100 MW; equivalent off-grid solar applications of 200 MW; and solar thermal collectors that will cover an area of 7 million square meters. Currently, the government is trying to spread public awareness regarding necessity of generating power from renewable energy sources.

2.95 Thus by the effective deployment of Renewable Energy technologies in the network, the dependence on grid power could be decreased considerably and the use of DG sets could be minimized by use of hybrid power plants (Solar+wind) or (Solar +DG) systems . This will reduce the CO₂ emissions levels. The service providers could also think of deploying hybrid power systems in all rural sites and 50% of the urban towers by 2020. The OPEX cost of running DG sets will offset the cost of installation of a hybrid system within 3 years. In the course of the next five years , efforts to be made to ideally move 100% of all the towers to be powered by hybrid power. But a clear plan to be immediately evolved so that at least 50 % of all rural towers and 33% of the urban towers should be hybrid powered by 2015. It is to be noted that under infrasharing policy, it is proposed that more number of DAS could be deployed in the urban areas. These DAS since they require less power could be powered by hybrid power (Grid + RETs) which could also reduce the dependency of DG sets.

Incentives for Deploying Renewable Energy Sources

2.96 Adoption of green telecom has its own costs and offsets. R&D of energy efficient equipment or those that work on alternate sources of energy requires funds. There is a general impression that the alternate sources

of energy are more expensive as compared to the grid electricity or even that obtained through diesel gensets.

2.97 Hence in the consultation paper issues relating to the incentives for Green telecom were raised and the questions posed were:-

a. What financial and non-financial incentives can be useful in supporting the manufacturers and service providers in reducing the carbon footprint?

2.98 Some of the stakeholders commented that at present renewable energy sources measures are initially capital intensive and thereafter its maintenance costs are also quite substantial. Hence adequate subsidies/incentives could be given for at least all BTS sites where grid power availability is upto 12 hrs. a day only. They also insisted that Tax rebates for organizations who have been able to reduce their carbon footprint more than a predefined threshold be extended.

2.99 One of them opined that an higher rate of depreciation for green telecom equipment be offered, or an option for subsidized / lower revenue share for license and spectrum fees could be extended. The Department of Non-conventional Energy Resources has devised a scheme for operators to promote the use of solar power and alternative fuel sources specifically for use by the Telecom sector. These schemes should provide Viability Gap funding and not just part of the CAPEX and OPEX requirements.

2.100 Some stakeholders requested that incentives for the telecom equipment manufacturers and service providers be provided in the form of Tax holidays and as a Free or subsidized tariff for use of grid power to the extent power generated by them through alternate energy sources.

2.101 Some requested that incentives be provided to replace existing energy inefficient BTS powered by Diesel gen-sets in rural areas by the solar powered highly energy efficient BTS infrastructure. They also requested complete import duty & tax exemption.

2.102 The incentives proposed by the stakeholders were on the following lines:-

- (i) Tax holiday: The GoI provides a tax holiday under section 80IA of the Income Tax Act, 1961 to infrastructure companies such as those in the power sector, ports, natural gas distribution etc. A similar tax holiday could be extended to tower companies, which are seen as critical infrastructure. Such a step is expected to encourage the overall development of the Renewable energy solutions in telecom sector, and help foster the green and clean environment in the country. In order to incentivize private sector participation in infrastructure projects, State Governments could extend the exemption from state levies like VAT, Entry Tax and Stamp Duty etc. for these projects.
- (ii) Accelerated depreciation: Renewable energy solutions for telecom infrastructure being highly capital intensive, benefits of accelerated depreciation would encourage further investments in expanding renewable energy solutions in rural areas. As an incentive to the industry to adopt such newer technologies, one possibility was to provide accelerated depreciation of equipment to tower companies. The accelerated depreciation of Renewable energy equipment scheme could address the current infrastructure deficiency such as low rural tele-density and foster adoption of newer technology.
- (iii) Subsidies: Subsidies can have a major impact in augmenting the growth of the telecom sector, especially to promote rural coverage

through use of green energy. They are expected to significantly boost the overall growth of the sector, and provide an impetus to the GDP growth. Dependence on diesel can be reduced by promoting use of renewable sources of energy such as solar, fuel-cells, wind, etc. Besides the environmental objectives, if the government wishes to save on long-term subsidy burden on diesel, it could think of an innovative approach towards use of alternative energy for telecom infrastructure, by introducing various incentives under the National Action Plan on Climate Change (NACC). Such initiatives would establish sustainable business models, beneficial to all in line with the GoI's stated policy objective of the Ministry of New Renewable Energy (MNRE).

2.103 The Government has already been promoting private investment in setting up of projects for power generation from renewable energy sources through a mix of fiscal and financial incentives, in addition to the preferential tariffs being provided at the States level. These include capital/ interest subsidy, accelerated depreciation and concessional excise and customs duties. In addition, generation based Incentives have also been introduced recently for Wind Power to attract private investment by Independent Power Producers not availing Accelerated Depreciation benefit and feed- in tariff for solar power.

2.104 There is already Subsidy support from MNRE and USOF towards solar/solar-wind hybrid power installations. The Government has also been promoting private investment in setting up of projects for power generation from renewable energy sources through an attractive mix of fiscal and financial incentives, in addition to the preferential tariffs being provided at the States level. These include capital/ interest subsidy, accelerated depreciation and nil/ concessional excise and customs duties. These incentives should be properly utilized for deploying renewable energy sources for 'greener' telecom.

2.105 All service providers, through their Service associations, should adopt a Voluntary Code of Practice encompassing energy efficient Network Planning, active infra-sharing, deployment of energy efficient technologies and adoption of Renewable Energy Technology (RET) including the following elements:

- 1) The network operators should progressively induct carefully designed and optimized energy efficient radio networks that reduce overall power and energy consumption.**
- 2) Service providers should endeavour to ensure that the total power consumption of each BTS will not exceed 500W by the year 2020.**
- 3) Sharing of the infrastructure using passive as well active methodologies should be done to minimize the eventuality of locating new sites within the vicinity of existing towers. [say within 200m, in Urban areas & within 2 Km, in Rural areas]. Service providers should plan to have at least 10% of their sites actively shared by the year 2014.**
- 4) 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.**
- 5) Service providers through their associations should consensually evolve the voluntary code of practice and submit the same to TRAI before the end of July 2011.**

2.106 The Authority recommends that in the next five years, at least 50% of all rural towers and 33% of the urban towers are to be powered by hybrid power (Renewable Energy Technologies (RET) + Grid power) by 2015, while all rural towers and 50% of urban towers are to be hybrid powered by 2020.

C - CARBON CREDIT POLICY

2.107 Once the carbon footprint is calculated and reported, the methods of reducing the carbon footprint needs to be considered by the service providers. The next step will be to evolve a carbon credit policy and protocol that would have to be in place to facilitate the greening process.

2.108 One carbon credit has been defined as being the equivalent to one tonne of carbon dioxide emission, or in some markets, carbon dioxide equivalent gases saved. A carbon credit is a generic term meaning that a value has been assigned to a reduction or offset of greenhouse gas emissions. Carbon credits and markets are key components of national and international attempts to mitigate the growth in concentrations of Green House Gases (GHGs). Greenhouse gas emissions are declared and capped, later the markets are then used to allocate the emissions among the group of regulated sources. The goal is then to allow market mechanisms to drive industrial and commercial processes in the direction of low emissions or less carbon intensive approaches than those used when there is no cost to emitting carbon dioxide and other GHGs into the atmosphere.

2.109 The service providers would get an indication of products that use more, less or no carbon during the manufacturing process so that firms can go for low carbon emission based inputs. Specifications based on the ECR/EER ratings will help in selecting products that emit lesser CO₂. This would also lead to market incentives for inventors and innovators to

develop and introduce low-carbon products and processes that can replace the current generation of technologies. A carbon credit policy for the telecom sector would be an incentive for operators choosing to minimize carbon emissions.

2.110 In the consultation paper the issues relating to the evolution of a carbon credit policy, the time frame for implementation, framework and the metrics of such a policy were raised and the following questions posed:-

- a. How should the carbon credit policy for Indian telecom sector be evolved? What should be the timeframe for implementing such a policy?
- b. What should be the framework for the carbon credit policy?
- c. What should be the metric to ensure success of the carbon credit policy in reducing the carbon footprint of the telecom industry?

2.111 Some of the stakeholders had the view that most of the green telecom efforts are being taken voluntarily either as a cost saving initiative or part of a larger CSR framework of an organization. There is an urgent need for drafting a comprehensive carbon credit policy which will not only incentivize operators to invest more in green technologies but also provide sufficient opportunity to augment their revenues through carbon trading.

2.112 One of the stakeholders felt that Carbon credit policy for Indian telecom sector can be evolved by vigorous promotion of renewable energy by government agencies, corporate, public sector, and academic institutions. A stakeholder suggested that a typical financial incentive would be a rebate on the license revenue share for the operator who deploys solar or wind energy for powering remote BTSs. One of the stakeholders opined that there should be a surcharge on the excessive usage of grid power & total diesel used by the mobile operators and

infrastructure providers. Government could levy a surcharge of about Rs 7.0 per liter on diesel consumption by telecom operators /infrastructure providers. This may be termed as “Pollution Surcharge”.

2.113 Stakeholders also opined that a carbon credit policy should quickly be in place, encompassing identification of major sectors of industries contributing to GHG emissions, recording and compiling sector wise baseline GHG emissions on priority, identification of growing sectors (e.g. Telecom), setting up sector-wise targets of GHG emission for short term and long term after factoring anticipated growth and formulation of processes for registration and periodic certification of carbon credits. It was suggested that the “Carbon Credit Policy” for the Telecom industry should attempt to/reduce capital and energy costs, manage risks, increase revenues by deploying new technologies, and respond to new market opportunities.

2.114 One of the stakeholders strongly felt that there is no need for any special carbon credit policy and that Green Telecom could be attained by licensing and regulatory incentives, levies and penalties. Another commented that metrics can include carbon reduction goals compared to a specific base-year. The telecom industry can then offer a voluntary code of conduct that individual entities can endorse. Their products, services and network solutions can then demonstrate energy efficiencies and resulting carbon reductions that can be applied towards these reduction goals. Gold/Silver/Bronze status for companies & Star Labeling/rating system for equipments will help in this regard.

2.115 In line with the stakeholder suggestions a clear carbon credit policy has been defined. The Service providers will have to frame an internal comprehensive Green Policy that offers a voluntary code of conduct. The products, services and network solutions of service providers

demonstrate energy efficiencies and resulting carbon reductions that can be applied towards carbon reduction goals, which will form the basis for carbon credit policy and claim Carbon Credits.

2.116 A sample protocol for evolving a carbon credit policy is discussed below.

One unit of Carbon Credit equals one tonne of Carbon Di Oxide not emitted. In other words, a carbon credit refers to one tonne of carbon dioxide emissions avoided by the adoption of a certain practice when compared with a business-as-usual scenario. Carbon Credit could be maintained in the form of a Electronic Certificate, similar to that of a De-Materialized (Demat) Share Certificate.

2.117 Carbon credits and carbon markets are components to mitigate the growth in concentrations of greenhouse gases (GHGs). The GHGs consists of different gases like methane, perfluorocarbons and nitrous oxide, and these together are termed as Carbon di oxide equivalent CO₂e, in the telecom sector the measure of one unit of carbon credit can be restricted to only one tonne of CO₂ not emitted. Carbon credits are created when GHG emissions are reduced below the 'business-as-usual'(BAU) baseline.

2.118 Since all the mobile operators would have declared their carbon footprint by November 2011, a basic idea of the extent of the carbon footprint in the telecom sector would be in place by them. Service providers could then start taking initiatives to reduce carbon credits with 2011 as the base year, with the implementation of the policy to commence in the year 2012. This year 2011 will become the carbon BAU(business-as-usual) baseline. The baseline allowance is set by the target for reduction of CO₂ emissions from the estimated Carbon footprint. Year-on-Year (YoY) reduction of the carbon footprint could then be achieved by the service providers. The basic requirements are that emission reductions are measurable and that these reductions are capped for a period of at least

five years. These credits are only for the carbon content / emission on account of power consumption either through grid or DG sets. All other credits in use for other manufacturing process, equipment, packaging, transportation, would be claimed under the CDM scheme of the Government of India and would have to be accounted here.

2.119 There are two necessary steps for carbon emissions and reductions to be certified. Certification is needed so that the resulting credits are recognized and may be legitimately traded. The value of this intangible asset exists because of trust that buyers place in the system. The success and survival of the system is thus predicated on the credit-worthiness of emissions reductions. This problem is addressed through the mandatory use of independent third parties to verify that emission reductions are real. An independent third party carries out the function of verifying, monitoring, and certifying emission reductions. The oversight body would only recognize emissions reductions as certified by one of its accredited auditors. These auditing parties must demonstrate technical expertise of certification criteria, possess strong internal systems and controls, and have the financial resources and liability insurance in place to carry out its duties. Periodic spot checks of the auditors are routinely carried out by the accreditation body in order to ensure ongoing compliance with existing standards.

2.120 The carbon credits so calculated could be traded over the MCX (multi Commodity Exchange of India Ltd) and also could be exchanged between the operators. The value of these carbon credits are already traded at the multi Commodity Exchange of India Ltd (MCX), which could be used as a base for credit transfer amongst operators. The ultimate goal for all service providers is to become carbon-neutral. The most effective way to achieve a neutral carbon footprint is through the mechanism of carbon

offsets, which are essentially financial representations of a reduction in carbon emissions.

2.121 All Service providers should evolve a ‘Carbon Credit Policy’ in line with carbon credits norms with the ultimate objective of attaining full carbon neutral footprints in rural areas and with 50% carbon neutral footprint in urban areas 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.

2.122 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 8% by the year 2012-2013, 12% by the year 2014-2015, 17% by the year 2016-2017 and 25% by the year 2018-2019.

CHAPTER III: GREEN TELECOM MANUFACTURING

A - MANUFACTURING PROCESS

- 3.1 There is increasing market interest and consumer demand for environmentally friendly products. For telecom equipment manufacturers the case is no different. The value of a green product for these companies is not just about environmental goodwill. It is often also about the lowered operating costs, arising from improved energy efficiency. Developing these products often come with high investment and research costs, but finding ways to overcome these challenges is crucial for manufacturers intent on transforming market differentiation into product profitability.
- 3.2 Certain global telecom equipment manufacturers have claimed to have attained substantial cost reduction by inducting green manufacturing process and green supply chains. Greening of the manufacturing and supply chain would involve reducing onsite inventories, optimising power consumption during manufacturing, transportation, usage and disposal, packaging, inventories and capacity building. Hence there is likely to be substantive economic benefits to the manufacturers by adaptation of green processes; quite apart from the aspect of improving consumer acceptability on account of the greenness of the product. With regard to mobile handsets, vendors and operators must analyze emissions across the life cycle of the handset from raw material extraction to end-of-life and then put in place policies to reduce direct and indirect emission.
- 3.3 In the consultation paper, the issues relating to reduction of GHG across the complete product life cycle were raised and the following where the questions posed:-

- a. How can manufacturers help in reducing GHG across the complete product life-cycle?
- 3.4 Some of the stakeholders were of the view that almost all mobile operators are taking initiatives to improve their sustainability and reduce Green House Gases emissions. They opined that manufacturers can reduce their GHG by adopting practices that could increase the energy efficiency of handsets, Increase the energy efficiency of chargers or by utilizing solar-power handsets or solar-powered chargers. They could also reduce their emissions by ensuring that the handsets are manufactured using materials sourced from companies with green credentials.
- 3.5 Some of the stakeholders also commented that the Telecom equipment manufacturers need to carry out research and development of environment friendly equipment which minimize emissions from conceptualization to product delivery. The design should promote environmental conservation, quality enhancement and efficient use of resources. The equipment should be designed to lower operational costs by effectively reducing the cost of leasing, electricity, air-conditioning, and manpower. The manufacturer should use renewable materials to manufacture products and recycled materials for packaging, as far as possible. Telecom equipment should conform to global standards for green telecom. The impact on the environment will be considered at every stage of the product life cycle and assessed in the aspects of resource and energy consumption, waste, recycling, etc., so as to ensure product quality
- 3.6 Some stakeholders opined that operators are using various technologies and operating in a number of different spectrum bands. CDMA and GSM technologies are operating in 800, 900 and 1800 MHz spectrum bands but 3G and BWA technologies are being deployed in 2.1 GHz and 2.3

GHz spectrum bands. Each spectrum band has different number of tower sites requirement to provide the desirable quality of services.

- 3.7 It was suggested that after completion of the product life cycle, the option of buy back needs to be institutionalized. Some parts and component of the product may be reused before disposing off the complete product. The product may be also recycled after completion of its life cycle.
- 3.8 It was opined that vendors are adapting their strategy today to reduce GHG across their supply chain and to provide end users with eco-efficient products, but also ensuring persons living in off grid areas have access to more reliable and sustainable products.

Life cycle assessment (LCA)

- 3.9 The complexity of measurement, variety of business models and sector growth has led to different approaches to estimate carbon footprint. Life cycle assessment (LCA) is a tool for estimating the total environmental impact of a given product or service throughout its lifespan, from cradle to grave. The term 'life cycle' reflects the assessment of production, manufacture, distribution, use and disposal, including all raw materials and intervening transportation steps necessary or caused by the product's existence. However, accurate LCA is complex and time consuming, and heavily dependent on various assumptions. In case of network and the handsets, the overall life cycle environmental impact comprises of:
- (i) Less use of raw materials
 - (ii) Less Energy consumption of manufacturing process
 - (iii) Less Energy consumption during transportation and distribution

(iv) Less Energy consumption during usage

(v) Less Energy consumption during disposal, and the physical disposal of waste.

(vi) Land usage for BTS

3.10 The majority of the power consumed during charging of mobiles is mainly due to the standby power of chargers which are not unplugged when not in use. The standby power is significant for older transformer-based chargers, but these are being superseded by latest generation switch-mode and 'smart charger' technologies (which adopt more intelligent charge sensing and standby functions).

3.11 Thorough and systematic use of life-cycle assessment (LCA) forms the foundation of manufacturer's efforts to reduce the environmental impact of our products and networks. By evaluating the impact of each product, including its sub-assemblies, the manufacturer can continually improve design, material selection and such operating characteristics as energy efficiency. Life-cycle assessment enables us to identify environmental issues at multiple levels and to track eco-sustainable evolution over time. There are three levels of LCA – the Network or system-level LCA that evaluates new architecture features to conserve energy use and promote increased functionality, Product assembly level LCA that sets targets for future new products and the Component-level LCA that helps in selection of materials.

3.12 Life-cycle assessment (LCA) is becoming a fundamental methodology within the broader sustainability management framework for businesses to assess and take action on the environmental impact of their products, solutions and processes. Until now, the time and volume of information needed to perform a LCA has discouraged more wide-spread adoption of this extremely useful technique.

Reducing environmental impact throughout product life cycle



Source : <http://www.huawei.com/>

Figure 3.1 Reducing environmental impact throughout product life cycle

3.13 Manufacturers have started to actively participate in various industry standards: ITU-T, ATIS, ETSI, JRC, Energy Star and CCSA for meeting these standards in their equipment. They are also setting up internal eco-design certification standards and energy-saving targets within their company. Some of the manufacturers have designed smaller products and lower energy-consumption network solutions by innovations such as smart power management policy and technology, high efficiency power suppliers, power amplifiers and radio technology etc.

3.14 Some of the manufacturers have also started 'Green Supply Chain Certification Programmes' which ensure a reduction of 30% CO₂ emissions over two years. They also plan to use reusable green packages. They are designing BTSs which are designed and manufactured with more than 20% energy saving. Some of the manufacturers also intend to manufacture Green broadband networks. Some manufacturers are

planning to create a global recycling platform in partnership with local professional recycling companies and organizations. To accurately assess the impact of products on the environment at each phase of their lifecycle, manufacturers use the lifecycle assessment (LCA) technique to evaluate products, including raw material procurement, part and component manufacturing, product processing, transport, use, waste treatment, and recycling. Through this process, products and their lifecycle phases that have a great impact on the environment can be clearly identified, key impact factors can be defined and green solutions developed for reducing environmental impacts.

3.15 Through LCA analysis, the impact of products on the environment with regard to climate change, carcinogens, long term or non-biodegradable materials, radioactivity, ozone depletion, ecology toxicity, acidification, land occupation, and mineral consumption can be evaluated. Among these issues, climate change is of the utmost concern. The evaluation results of the index pertain to the total carbon emissions of the product throughout its lifecycle.

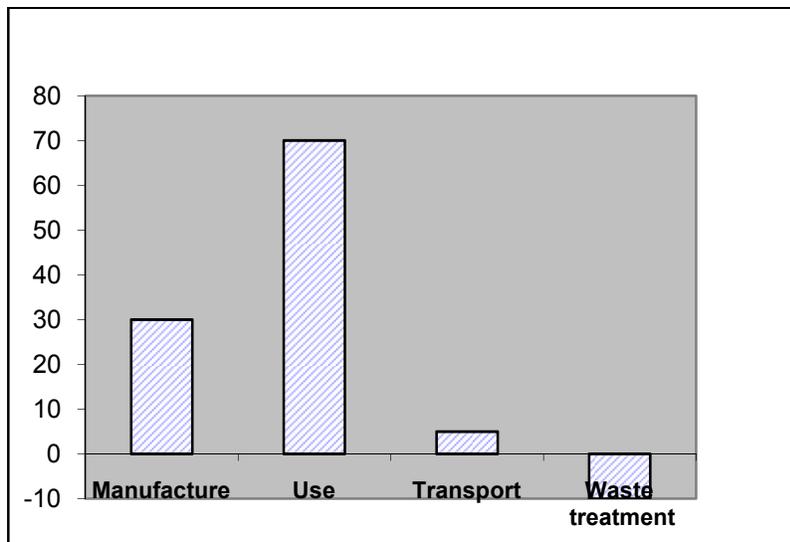
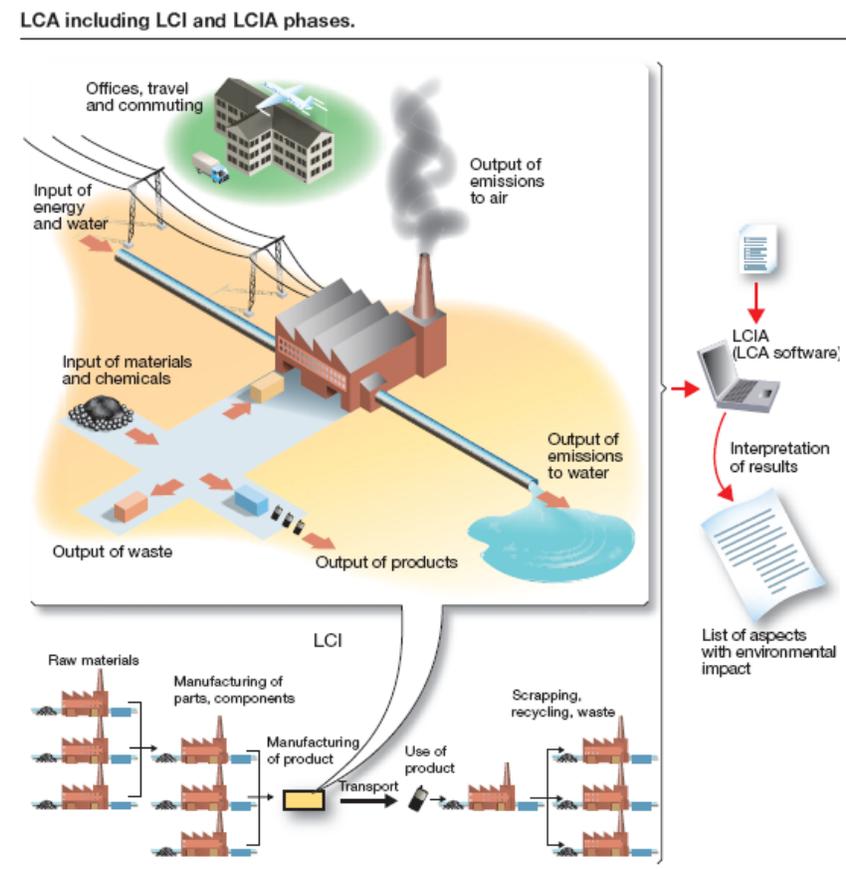


Table 3.1: Carbon emissions ratio throughout the product lifecycle

3.16 During product design and manufacturing, manufacturers always regard “reducing products’ impact on the environment” as one of the most important indices for product quality evaluation.

3.17 Some of the manufacturers have developed certification standards for “green products”, covering all regulations, directives, standards, and requirements in energy saving, emissions reduction, and environmental protection factors such as energy efficiency, use of renewable energy sources, weight, package, harmful substance, retrieval, noise, and electromagnetic radiation safety. The Life cycle Assessment of a product life cycle could be explained using the diagram shown below:-



Source : <http://www.ericson.com/>

Figure 3.2: Life cycle Assessment of a product

3.18 Hence the telecom equipment manufacturers may calculate their LCA for each of their products, using a clearly defined algorithm that primarily focuses on GHGs in the form of CO₂ equivalents and help in the reduction of embedded CO₂ emissions.

B - STANDARDIZATION OF TELECOM EQUIPMENTS

3.19 There are some existing global standards for green telecom that telecom equipment should conform to, such as ISO 14001:2004, OHSAS 18001:1999 and EuP. The EuP is a new regulation that sets eco-design requirements for energy-using products. The international standards WRI/WBCSD GHG Protocol and the ISO 14067 standard “Carbon Footprint of Products” are moving closer to full adoption. Furthermore, significant developments are taking place in different countries that will shape the practical implementation of product carbon foot printing in the future.

3.20 In the consultation paper, the issues relating to standardization and metrics for certification of Products and Services of the Equipment – standards / metrics proposed, and the agency to handle the standardization - were raised and the following where the questions posed:-

- a. What should be the metric for certifying a product green?
- b. Who should be the metric for certifying a network or service as green?
- c. What standards do you propose to be followed in Indian telecom network for reducing the carbon footprint?

d. Who should handle the testing and certification of green equipment and networks?

3.21 Some Stakeholders expressed the view that standardization of green equipment should be done, so that it can be taken into consideration along with other parameters like technology, cost etc. while procurement decisions are taken. The Energy saving Index (EI) may be fixed by the government, which may be used to evaluate an operator in terms of its carbon footprint. Some others opined that The Indian telecom industry must comply with the international standards i.e. ISO 14001 and ISO 50001. ISO 14001 is designed to assist companies in reducing their negative impact on the environment. ISO 50001 which is expected to be introduced in 4th quarter of 2011 will deal with effective Management System for Energy (MSE).

3.22 Many stakeholders were of the view that with the advent of technologies, new infrastructure products and solutions are available in the global markets which are power efficient. Using alternate deployment architectures, significant power efficiencies can be attained in the networks. Operators should be encouraged to use such solutions for network roll out. Rural telecom has peculiar traffic requirements and traditional architecture is not optimized for it. Using new solutions and architecture, rural telecom can be run primarily on the Solar / Renewable energy sources. Indoor coverage requirements can be managed with the small capacity and highly energy efficient solutions within buildings to save power and for better spectrum utilization.

3.23 Most of the stakeholders were of the view that there is a strong case that certification metric of telecom equipments be framed in the Indian context. Such a metric would readily identify telecom equipments against a standard and well defined energy efficiency scale. However, such a metric system will require test and certification labs

to be set up. Standards if defined can help green telecom efforts. International standards stimulate large production of standard equipment and help vendors to exploit economies of scale. Standards if adopted internationally can help larger adoption of green technologies.

- 3.24 One of the stakeholders opined that the Network infrastructure products such as radio access and core network products could employ standardized metrics that measure energy efficiency and carbon emissions. For example, network energy efficiency standards have been developed by ETSI, ATIS and IEC standards development organizations (SDOs). For carbon foot printing within the full lifecycle stages of network equipment, WRI / WBCSD has provided high level carbon accounting / reporting handbooks, and is currently developing the guidelines for ICT products including Telecom Network Equipment. For consumer premises equipment (terminal devices, PCs, phones, etc.) energy efficiency metrics and threshold criteria has been developed by the International Energy Star specifications and labeling standards.
- 3.25 One of the stakeholders felt that it is comparatively much simpler and cost effective to implement energy efficient solutions during the green field project planning phase as compared to the same task in a live operational network because there arises several difficulties along with additional CAPEX in retrofitting existing networks with more recent, environment friendly mechanisms.
- 3.26 Regarding the agency for handling the testing and certification of green equipment and networks, some of the stakeholders opined that a designated expert organization under the supervision of TRAI could handle the testing or the Bureau of Energy Efficiency (BEE) or any other

suitable agency may be given the task of handling the testing and certification of green equipments.

- 3.27 Some of the stakeholders also opined that the Certified Lead Auditors by TRAI / Ministry of Communication and IT could certify green equipment and the networks. It was also suggested that the Telecom Engineering Centre (TEC), could handle the testing and certification of the equipment and networks for such purposes.
- 3.28 One of the stakeholders opined that for network equipment, the standards development organizations (e.g. ISO, WRI / WBCSD) should provide testing/reporting measures for assuring specification conformance, with information that can be submitted to end customers (e.g., Carbon Disclosure Project). TEC in consultation with BEE and MNRE who will provide the guidelines.
- 3.29 Some of the stakeholders also felt that self-certification is the most practical approach in this case. Manufacturers could be involved through voluntary agreements that encourage reducing the amount of packaging, packaging take-back schemes and greater recyclability of packaging.

Energy Consumption Rating Analysis

- 3.30 Most of the stakeholders were of the view that standardization of the equipment is required to evolve a green quotient in the network. But no clear standardization procedures were expressed. Though some of the stakeholders has expressed ISO standards 50001 etc , these are primarily energy management standards and not standards for equipments.
- 3.31 Hence TRAI has attempted to introduce a new concept of metrics for standardization of the equipment, based on the “Network and Telecom

Equipment—Energy and Performance Assessment document” of the USA, in which the energy efficiency is reported by a factor called Energy Consumption Rating [ECR] (W/Gbps). It is calculated as energy consumption normalized to effective throughput. In other words, it is assumed that the more energy-efficient network system to be the one that can transport more data (in bits) using the same energy budget (in Joules).

[$ECR = E / T$], where E denotes the maximum energy consumption (in watts) and T denotes the effective system throughput (in bits per second)

3.32 Packet-based systems offer a slightly greater challenge for this approach. Because the amount of data the system can transport is equal to or lower than the theoretically possible load, system performance should be subjected to measurement alongside energy consumption, which constitutes a basic energy efficiency test. Hence additional tests will be added for comprehensive evaluation of other energy related properties, such idle (static) energy management, energy management for connected (cascaded) devices and embedded energy monitoring capabilities.

The tests should cover all the following scenarios:-

- (i) Energy Consumption in relation to dynamically changing load
- (ii) Energy Consumption in relation to Statically changing load
- (iii) Component level energy footprint.
- (iv) Embedded energy monitoring capabilities.
- (v) Collateral Energy Management.

3.33 The results obtained from the tests Nos. (i) to (iv) above forms the energy “passport” of the product under test, which can be used directly by consumers for evaluation and energy planning purposes. Comparing

product metrics will allow the service providers to add energy efficiency to purchase criteria.

- 3.34 ECR relates to the maximum throughput vs. the energy consumed, but the throughput may not always be maximum. Hence middle level energy consumption is required to be estimated in the calculation of ECR. Hence the weighted, variable load metric ECR-VL, if required, should also be calculated and defined accordingly; taking appropriate weight coefficients.
- 3.35 Energy billing estimates over a period of time (Operational Cost) 'C' would also have to be determined. This will help the service provider to estimate the most energy efficient product over a period of time.
- 3.36 The ECR of the different products and equipments of various manufacturers can be calculated and a normalized value on a 0 to 1 scale obtained for comparison. For example, the ECR of the BTS (2/2/2 config) for various manufacturers can be calculated. The highest valued ECR would then be normalized to 1 and the ECR value of all other manufacturers can be accordingly normalized on a 0 to 1 scale. The service providers will have the option of selecting the best ECR rated equipment.
- 3.37 The Authority recommends that all telecom products, equipments and services in the telecom network should be Energy and performance assessed and certified "Green Passport [GP]" utilising the ECR's Rating and the Energy 'passport' determined by the year 2015.**

3.38 The Authority recommends that TEC⁵ should be the nodal centre that will certify telecom products, equipments and services on the basis of ECR ratings. TEC could either appoint independent certifying agencies under its guidance or will certify the same through their Quality Assurance teams. TEC should also prepare and bring out the ‘ECR Document’ delineating the specifics of the test procedures and the measurement methodology utilised.

C - R&D FOR GREEN TELECOM

3.39 Globally, a number of manufacturers of telecom equipment have committed funds to R&D in green telecom equipment. The ‘Green Touch’ initiative incubated by Bell Lab is a global R & D project for enhancing energy efficiency in telecom networks.

3.40 In India by and large, telecom equipment is imported. Many of the IPRs of even those that are manufactured in India are held by foreign companies. This results in the financial benefit of the growth of infrastructure accruing largely to foreign companies. In the domain of green telecom there have only been some dispersed efforts for carrying out R&D in green telecommunications equipment. Some private operators in India have developed microcellular systems run by solar power. There are also reports of energy-efficient engine alternators being developed for rural areas. Lightweight base station arrays have been designed for rural applications.

3.41 In the consultation paper the issues relating to promoting R&D for Green Telecom – what are the efforts underway and the promotion of IPR generation was raised were raised and the following where the questions posed:-

⁵ TEC is being separately proposed to be converted into an autonomous ‘Testing and Certification Organisation’

- a. What R&D efforts are currently underway for energy efficient and renewable energy telecom equipment?
 - b. How can domestic R&D and IPR generation be promoted?
- 3.42 Some stakeholders commented that there are a number of R &D efforts in the private sector and some private operators in India have developed microcellular systems run by solar power. Governments should support such efforts so that India can become an exporter of clean technologies. Some stakeholders requested that to support new green technology technologies development through (R&D and commercialization) pilots, governments should use grants, soft loans and other incentives.
- 3.43 Some stakeholders stressed that the Government has already created Centres of Excellence in addition to other research institutes like C-DoT which are doing research on telecom. Such institutions should be encouraged to carry out dedicated research on Green Telecom. The government should create dedicated fund for funding these institutions.
- 3.44 It was mentioned by some stakeholders that the GSMA (Global System for Mobile Communications Association) and the IFC (International Finance Corporation) have announced their partnership in a program called “Green Power for Mobile” (GPM). The objective of this program is to support investments on research and development of clean power sources for base stations and mobile phones. Telecom equipment manufacturers, infrastructure providers are working on Green telecom solutions.
- 3.45 One of the stakeholders stressed that the R&D efforts emphasize the development of new generation Distributed Antenna Systems (DAS) and in-building solutions, which are deployment alternates to the conventional network roll out and ensure significant energy savings of the network deployment.

3.46 A concerted effort to bring energy efficiency closer to theoretically possible limits would shrink the estimated 2% of the world's carbon emissions directly contributed by ICT. Some of the key areas of R & D for developing new technologies that reduce the power consumption by telecom equipment would include the following:-

- (i) Innovations in technologies that will have specially designed rectifiers and software that increases the efficiency of the AC/DC conversion process to up to 97%, thus reducing power consumption.
- (ii) Chip-Level and Automated Power Management
- (iii) Dynamic Energy Consumption Management in Network Devices
- (iv) Data Storage Technologies
- (v) Utilizing Hardened ICT Equipment
- (vi) New Computer Architectures
- (vii) Use of Nano electronic Circuitry
- (viii) Deployment of All-Optical Networks
- (ix) Use of Superconductive Components
- (x) Elimination of Conversion Steps/Losses AC/DC
- (xi) Induction of High-Efficiency Power Conversion Circuits
- (xii) Using Efficiency-Optimized Control Systems
- (xiii) Transition to DC, DG sets
- (xiv) On-Site DC Generation and Micro-Grid
- (xv) Deployment of integrated alternatively powered wireless base stations

- (xvi) Research in power amplifiers which consume 70% of the
- (xvii) BTS power Innovations in heating / cooling of BTS
- (xviii) Femto cells induction
- (xix) Enhanced efficiency of solar PV module

3.47 The government is already providing a number of incentives in the R & D sector. The Department of Scientific & Industrial Research (DSIR), a part of Ministry of Science & Technology, provides various fiscal incentives for scientific research. The following are some of the incentives for promoting R & D (from Ministry of Non Renewable Energy sources⁶ & Department of Scientific & Industrial Research⁷):

- (i) Customs/central excise duty on imports/domestic purchases for research purposes
- (ii) 125 % weighted tax deduction on R&D expenditure in certain areas
- (iii) Depreciation allowance on plant & machinery set up based on indigenous technology
- (iv) 3 years excise duty waiver on patented products.
- (v) A profit making industry registered with Department of Scientific & Industrial Research for in-house R&D may get support upto 50% of the cost of the project
- (vi) A consortium of industry, academic institutions, research laboratory and R&D institution etc., could be formed to undertake a R&D project. Consortium members will be required to share at least 50% of the cost of the project. The balance will

⁶ <http://www.mnre.gov.in/r&d/rd&d-industrial.htm>

⁷ <http://www.dsir.gov.in/tpdup/irdpp/irdpp.htm>, <http://www.dsir.gov.in/tpdup/irdpp/fisr.htm>

be released from MNRE funds to the implementing institution in the consortium selected by consortium members.

(vii) An industry may join hands with the Ministry to entrust an R&D project to an R&D institution/research laboratory or an academic institution. MNRE support up to 50% of the cost of the project will be available. For some proposal from Universities, Government research institutions etc. Ministry may provide upto 100% funding, depending on project priority.

3.48 There is a need to ramp up R & D efforts for greening the telecom industry, and the stakeholders viz. the telecom industry, the research institutions as well as the Government need to work together to strengthen the R&D efforts in this area.

CHAPTER IV: WASTE MANAGEMENT

A - WASTE MANAGEMENT

- 4.1 It needs to be acknowledged that e-waste in the telecom sector is a growing problem. Efforts must be made to dispose of mobile phones, old telecom equipment, other network elements etc., in an environment-friendly manner and to reduce and eventually eliminate the use of toxic materials in telecom equipment at the production stage. The re-use of equipment also needs to be encouraged. Some manufacturers have started inviting their consumers to deposit discarded products at specified locations, for eventual reuse or environmentally friendly internment.
- 4.2 Telecom waste contains toxic elements and the decomposition of solid waste in landfills produces methane, which is a green house gas that is 21 times more potent than CO₂. While the quantum of emissions from telecom waste may not be significant in absolute terms, in comparison with emissions from waste in the other sectors , the recycling and reuse of telecom waste is a practice that needs to be integrated into the telecom sector. Moreover recycling of telecom products and the practice of sustainable manufacturing will also save on energy costs during manufacture. The hazardous waste generated in the country per annum is estimated to be around 4.4 million tonnes. Out of this, 38.3% is recyclable, 4.3% is incinerable and the remaining 57.4% is to be disposed in secured landfills. Some countries are imposing strict regulations on disposal of electronic waste, consisting of network equipment as well as handsets.
- 4.3 In the consultation paper, the issues relating to Waste Management- were raised and the following where the questions posed:-

- a. What is the current procedure for storing, disposing and recycling telecom waste by the service providers and manufacturers?
 - b. How can waste management be made more green?
- 4.4 Some of the stakeholders stressed that since the telecom items are only part of the large quantity of electronic and electrical goods that are disposed off annually, a holistic approach addressing all electronic and electrical waste needs to be formulated. One of the stakeholders opined that the mobile phone recycling mechanisms will not only reduce CO₂ emissions, but also limit the release of toxic elements into the environment. End-of-life batteries and any associated circuit boards or electronic assemblies containing lead-based solders could be disposed-off in an environmentally sound manner.
- 4.5 One of the stakeholders also opined that recycling is on the increase globally, driven by increasingly strict regulations. One example is the Waste Electrical and Electronic Equipment Directive (WEEE Directive) of the European Community imposing responsibility for the disposal of waste electrical and electronic equipment on the manufacturers of such equipment; which became European law in February 2003. This has substantially changed the way equipment recycling is handled, mainly by equipment vendors but also by telecom operators. Mobile phone recycling is reducing the environmental impact of the telecom industry not only by reducing CO₂ emissions, but also by limiting the release of toxic elements into the environment. With more than 5 billion mobile phone users globally, it is estimated that over 500 million tonnes of mobile phones have been retired worldwide so far. These devices contain numerous toxic elements, like arsenic, beryllium and lead, which are hazardous if interred in landfills.

- 4.6 Some stakeholders cited initiatives, like the Nokia who has 1,300 bins spread across the country, where consumers can drop their old phones and accessories, irrespective of the brand. It was mentioned that three tonnes of e-waste have been collected in the first forty-five days of the initiative. It was mentioned that new Nokia devices are made free of PVC, lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE).
- 4.7 One of the stakeholders opined that the overall objective of electrical and electronic waste management is to contain hazardous substances like lead, cadmium, beryllium, mercury etc. If these substances are not refurbished, recycled or disposed off in an environmentally sound manner, this may harm human health and impact the environment. It was emphasized that telecom items are only part of the large quantity of electronic and electrical goods disposed off annually.
- 4.8 It was mentioned that some of equipment manufacturers have offered to service providers that all types of network equipment could be uninstalled and shipped to approved recyclers located throughout the world. These selected recyclers provide proper dismantling, scrapping and recycling facilities that go back into the supply chain. Additional options include remanufacturing, whereby selected products are processed and resold for extended use within various global markets.
- 4.9 Some manufacturers have effectively saved energy in the area of packaging and logistics under a "6Rs" (Right, Reduce, Returnable, Reuse, Recovery and Recycle") philosophy. Under the "6Rs" policy, they have developed a "transportation cabinet + visualized packaging" product, in order to develop a green industry chain of mobile communications. This solution is based on recycled wood materials, visualized packaging

technology, assembly technology, standardization, and appropriate design.

- 4.10 Efficient and environmentally sound treatment of end-of-life mobile phones and other electronic equipment require sophisticated facilities that would not need to be duplicated in every country. Therefore, end-of-life electronic equipment may need to be exported, under appropriate authorisations, to the few suitable plants at appropriate locations worldwide.
- 4.11 Plastics provide problems at end of their life due to their flame retardants. There is a small percentage of reuse in primary and secondary markets for recycled plastic materials. This is one key area where ICT/Telecom manufacturers working together with plastic / polymer resin manufacturers are beginning to develop long term solutions. Currently most plastics at the end of their life are incinerated or disposed in landfills. Uncontrolled incineration can produce harmful emissions. The goal is to further develop reusable plastic resins that can be re-introduced into the raw material end of the supply chain. Where ever organic waste is easily available, small biomass plants can be deployed.
- 4.12 Intelligent shut down features at operational level, reuse of legacy equipment and components and software upgradable for future technologies are some of the strategies for enabling reduction of e-waste.
- 4.13 The product manufacturing phase consumes a great deal of materials, natural resources and energy. Manufacturers are dedicated to reducing resource consumption during the design and manufacturing processes. Manufacturing and the production of raw materials such as metal and plastic, requires consumption of vast amounts of natural resources, and

this has a significant impact on the environment. Manufacturers have significantly reduced the consumption of spray materials and energy sources through various optimized measures to reduce or remove spray. They can reduce the consumption of water through design improvements, thus saving 90,000 tons of water annually.

4.14 Manufacturers can also promote environmental protection measures internally, whereby energy saving and environmental protection are integrated into corporate operations and employee activities. For example, since air-conditioning power consumption accounts for approximately 40% of total power consumption in summer, by setting the air-conditioning ambient temperature to above 26 Celsius degrees, nearly 4 million kilowatts/ hours (kWh) annually could be saved in the telecom sector worldwide.

4.15 Waste management is the collection, transport, processing, recycling or disposal, and monitoring of waste materials. Telecom equipment manufacturers however have sufficient ground to take disposal of E-Waste seriously. Already some mobile handset manufacturers have started the process of re-cycling of old and discarded handsets which have met with adequate response. The Ministry of Environment & Forests has released the draft regulations for management of e-wastes which are proposed to be made effective from 1-1-2012. Some of the key provisions of these rules relating to e-waste are mentioned below:-

4.16 *Responsibilities of The Producer In Terms Of The Draft Regulations*

The producer shall be responsible for:-

- (i) collection of e-waste generated during the manufacture of electrical and electronic equipment and channelizing the same for recycling or disposal.

- (ii) collection of e-waste generated from the 'end of life' of their products in line with the principle of 'Extended Producer Responsibility' (EPR), and to ensure that such e-wastes are channelized to registered refurbisher or dismantler or recycler.
- (iii) setting up collection centers or take back system either individually or collectively for all electrical and electronic equipment at the end of their life.
- (iv) financing, and organizing a system to meet the costs involved in the environmentally sound management of e-waste generated from the 'end of life' of its own products and historical waste available on the date from which these rules come in to force. Such financing system shall be transparent. The producer may choose to establish such financial system either individually or by joining a collective scheme.
- (v) providing contact details such as address, telephone numbers/helpline number and e-mail of distributors and authorized collection centers to consumer(s) or bulk consumer(s) so as to facilitate return of used electrical and electronic equipment.
- (vi) creating awareness through publications, advertisements, posters, or by any other means of communication and information booklets accompanying the equipment, with regard to information on hazardous constituents in e-waste electrical and electronic equipment, information on hazards of improper handling, accidental breakage, damage and/or improper recycling of e-waste, instructions for handling the equipment after its use, along with the Do's and Don'ts and affixing the symbol on the products to prevent e-waste from being dropped in garbage bins containing waste destined for disposal.
- (vii) obtaining an authorization from the concerned State Pollution Control Board or Pollution Control Committee in accordance with the procedure prescribed under rule-11.

- (viii) maintaining records in Form 2 of the e-waste handled. Such records should be available for scrutiny by the appropriate authority.
- (ix) filing annual returns in Form 3, to the concerned State Pollution Control Board or Pollution Control Committee, on or before the 30th day of June following to the financial year to which that return relates

Procedure for Storage of E-Waste in terms of the Draft Regulations

Every producer, distributor, collection centre, refurbisher, dismantler or recycler may store the e-waste for a period not exceeding one hundred and twenty days and shall maintain a record of collection, sale, transfer, storage and segregation of wastes and make these records available for inspection:

All telecom manufacturers should comply with the guidelines towards; Rule 15. Reduction in the use of hazardous materials in the manufacture of telecom equipment.-

- (i) Every producer of electrical and electronic equipment shall ensure that, new electrical and electronic equipment does not contain Lead, Mercury, Cadmium, Hexavalent Chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE).
- (ii) The rule 15(i) shall not apply to applications listed in Schedule-II (of the draft regulations). Such reduction in use of hazardous substances in electrical and electronic equipment shall be achieved within a period of three years from the date of commencement of these rules.
- (iii) In the event of such reduction in the hazardous materials used in the electrical and electronic equipment, the detailed information on the constituents of the equipment shall be provided in the product information booklet.

(iv) Imports or placement in the market for electrical and electronic equipment shall only be permitted for those which are RoHS (restriction of Hazardous Substances) compliant.

4.17 The collection, storage, transportation, segregation, refurbishment, dismantling recycling and disposal of e-waste is clearly defined by the guidelines issued by the Central Pollution Control.

4.18 The Authority recommends that by 2015, all mobile phones should be free of brominates and chlorinated compounds and antimony trioxide in accordance with the e-waste (Management and Handling) Rules 2010, proposed by the Ministry of Environment and Forests to be followed by all telecom manufacturers, as and when notified.

4.19 The Authority also recommends that all mobile manufacturers/ distributors should be required to place collection bins at appropriate places for collection of e-waste - mobile phones, batteries, chargers etc. The e-waste should be safely disposed or recycled as per the prevailing standards. The collection, storage, transportation, segregation, refurbishment, dismantling recycling and disposal of all e-waste shall be in accordance with the procedures prescribed in the guidelines by the Pollution Control Boards from time to time.

CHAPTER V: SUMMARY OF RECOMMENDATIONS

A. Recommendations to the Government.

- 5.1 Measures to green the telecommunication sector should be an integral part of the proposed National Telecom Policy. The policy should underline the need to Green Telecommunications and set the broad direction and goals. (Para: 1.25)**
- 5.2 In the next five years, at least 50% of all rural towers and 33% of the urban towers are to be powered by hybrid power (Renewable Energy Technologies (RET) + Grid power) by 2015, while all rural towers and 50% of urban towers are to be hybrid powered by 2020. (Para: 2.106)**
- 5.3 All telecom products, equipments and services in the telecom network should be Energy and performance assessed and certified “Green Passport [GP]” utilising the ECR’s Rating and the Energy ‘passport’ determined by the year 2015. (Para: 3.37)**
- 5.4 TEC should be the nodal centre that will certify telecom products, equipments and services on the basis of ECR ratings. TEC could either appoint independent certifying agencies under its guidance or will certify the same through their Quality Assurance teams. TEC should also prepare and bring out the ‘ECR Document’ delineating the specifics of the test procedures and the measurement methodology utilised. (Para: 3.38)**
- 5.5 By 2015, all mobile phones should be free of brominates and chlorinated compounds and antimony trioxide in accordance with the e-waste (Management and Handling) Rules 2010, proposed by**

the Ministry of Environment and Forests to be followed by all telecom manufacturers, as and when notified. (Para: 4.18)

5.6 All mobile manufacturers/ distributors should be required to place collection bins at appropriate places for collection of e-waste – mobile phones, batteries, chargers etc. The e-waste should be safely disposed or recycled as per the prevailing standards. The collection, storage, transportation, segregation, refurbishment, dismantling recycling and disposal of all e-waste shall be in accordance with the procedures prescribed in the guidelines by the Pollution Control Boards from time to time. (Para: 4.19)

B. Other measures proposed for Green Telecom.

5.7 All service providers should declare to TRAI, the carbon footprint of their network operations in the format provided in Annexure -II. This declaration should be undertaken after adopting the formulae and procedures mentioned under para 2.20 and at Annexure -I. 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. (Para: 2.25)

5.8 All service providers, through their Service associations, should adopt a Voluntary Code of Practice encompassing energy efficient Network Planning, active infra-sharing, deployment of energy efficient technologies and adoption of Renewable Energy Technology (RET) including the following elements: (Para 2.105)

- 1) **The network operators should progressively induct carefully designed and optimized energy efficient radio networks that reduce overall power and energy consumption.**
- 2) **Service providers should endeavour to ensure that the total power consumption of each BTS will not exceed 500W by the year 2020.**
- 3) **Sharing of the infrastructure using passive as well active methodologies should be done to minimize the eventuality of locating new sites within the vicinity of existing towers. [say within 200m, in Urban areas & within 2 Km, in Rural areas]. Service providers should plan to have at least 10% of their sites actively shared by the year 2014.**
- 4) **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.**
- 5) **Service providers through their associations should consensually evolve the voluntary code of practice and submit the same to TRAI before the end of July 2011.**

5.9 All Service providers should evolve a ‘Carbon Credit Policy’ in line with carbon credits norms with the ultimate objective of attaining full carbon neutral footprints in rural areas and with 50% carbon neutral footprint in urban areas 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. (Para: 2.121)

5.10 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 8% by the year 2012-2013, 12% by the year 2014-2015, 17% by the year 2016-2017 and 25% by the year 2018-2019. (Para: 2.122)

METRICS FOR ESTIMATING THE CARBON FOOTPRINT OF TELECOM NETWORKS AND REPORTING STRUCTURE

TRAI has attempted to develop a formula for measuring the carbon footprint of the telecom network which could be declared by the telecom service provider twice a year. In the first instance, it may be appropriate if the telecom service provider was entrusted with the responsibility of measuring the carbon footprint of his network utilizing this formula.

The Carbon footprints in the telecom industry (C_T) could be broadly divided into four categories in the Access network :-

- a) Landline (C_L)
- b) Mobile (C_M)
- c) Fixed Broadband (C_{FB})
- d) FTTx (C_{FT})

The other THREE vital blocks that add to the telecom network are:-

- a) Core Network (which includes edge / core Routers / NGN / softswitches / IP Cores / all core items / data centers / all centralized sub systems / peripherals) (C_C)
- b) Aggregators or Backhaul (C_A)
- c) Transmission Networks (C_{TX})

There are also various other factors of the Life Cycle Assessment LCA – from the extraction of raw materials, the manufacture of finished goods, and their use by consumers or for the provision of a service, recycling, energy recovery, and ultimate disposal- involved in the emission of carbon content . But these constitute around 13% of the actual Carbon emission in the Telecom sector and the efforts to reduce the same are discussed in the subsequent chapters. However these factors are to be factored during the manufacturing process where a process of standardization of the green quotient for telecom equipment would be in place. The carbon content in the customer end equipment is also not

taken into account, as this will be covered under the green certification for the manufactured equipments.

Similarly in the Carbon footprint of the Core Network (C_c) , Aggregators (C_A) and Transmission System Networks (C_{TX}) , the component level / PCB level of carbon content are neglected.

Hence, the Carbon footprint of these networks will be the emission of carbon content because of the consumption of Grid power and the diesel power (DG sets) only. The carbon footprints of these networks powered by Solar or wind , if any, could be taken as Zero, as the component level emissions are taken care of during the manufacturing stage. It is to be noted that a litre of diesel will produce 2.6391 kgs of carbon dioxide and one 1KWH of GRID electricity consumed will emit 0.84 Kgs of carbon dioxide.

If the consumption of power for Core Network, in KW, (including Air Conditioning etc) is P_c , the Grid power is for ' x_c ' hrs , the power from ' z_c ' KVA DG is for ' y_c ' hrs and the efficiency of the generator is ' η ' then

$$C_c = 0.365 [0.84x_cP_c + (0.528 y_cz_c / \eta)] \text{ in Tonnes}$$

Similarly carbon footprint for Access networks and Transmission networks will be ,

$$C_A = 0.365 [0.84x_{AP}P_A + (0.528 y_{AZ}z_A / \eta)] \text{ in Tonnes}$$

$$C_{TX} = 0.365 [0.84x_{TX}P_{TX} + (0.528 y_{TXZ}z_{TX} / \eta)] \text{ in Tonnes}$$

The transmission network should include all Microwave back hauls , VSAT etc also to calculate the carbon footprint.

LANDLINE NETWORK (C_L)

The carbon content in the Landline network (C_L) consists mainly of the following building blocks:-

- a) Exchanges –Local,Tandem,TAX (C_{Le})
- b) Copper distribution Network (C_{Lc})
- c) Telephones (C_{Lt})

Since the component level / PCB level of the carbon emission is negligible (and accounted differently under Manufactured Goods sector) , C_{Lc} & C_{Lt} will tend to Zero.

In the Carbon footprint of the Exchanges (C_{Le}) again the component level / PCB level of carbon content is neglected. Hence, the Carbon footprint of this network will be the emission of carbon content because of the consumption of Grid power and the diesel power (DG sets) only.

If the consumption of power for exchanges, in KW, (including Air Conditioning etc) is P_L , the Grid power is for ' x_L ' hrs and the power from ' z_L ' KVA DG is for ' y_L ' hrs , then

$$C_L = C_{Le} = 0.365 [0.84x_L P_L + (0.528 y_L z_L / \eta)] \text{ in Tonnes}$$

MOBILE NETWORK (C_M)

The carbon content in the Mobile network (C_M) consists mainly of the following building blocks:-

- a) Main Switching Centers (C_{MS}) (includes all centralized control sub systems including GGSN ,SGSN,etc)
- b) Base Station Controller Centers (C_{BSC})
- c) Base Transceiver Station (BTS) (C_{BTS})
- d) Mobile Phones (C_{BS})

In the Carbon footprint of the Mobile Network (C_M) again the component level / PCB level of carbon content are neglected. Also as mentioned earlier the carbon footprint of Mobile phones (C_{BS}), is also not included since these are covered under different green programs . This also depends upon the type of the handset the customer uses which is not within the control of the service providers. Hence (C_{BS}) will be Zero.

Hence, the Carbon footprint of this network will be the emission of carbon content because of the consumption of Grid power and the diesel power (DG sets) only.

If the consumption of power for MSC , in KW , (including Air Conditioning etc) is P_{MMS} , the Grid power is for ' x_{MMS} ' hrs and the power from ' z_{MMS} ' KVA DG is for ' y_{MMS} ' hrs , then

$$C_{MS} = 0.365 [0.84x_{MMS}P_{MMS} + (0.528 y_{MMS}Z_{MMS} / \eta)] \text{ in Tonnes}$$

Similarly,

$$C_{BSC} = 0.365 [0.84x_{MBSC}P_L + (0.528 y_{MBSC}Z_{MBSC} / \eta)] \text{ in Tonnes}$$

$$C_{BTS} = 0.365 [0.84x_{MBSC}P_{MBSC} + (0.528 y_{MBSC}Z_{MBSC} / \eta)] \text{ in Tonnes}$$

Hence , $C_M = C_{MS} + C_{BSC} + C_{BTS}$ in Tonnes

The Radio Access Network / BSS are geographically spread out with mix of urban, semi-urban, rural and highway sites. Source of power in the given geography, BTS frequency of operation, RF power output and TRX configurations are important parameters for carbon footprints. The core networks are strategically installed at locations of reliable power (eg district HQ or major cities). 3G , 4G BSS are operating in 2.1 or 2.3 GHz which have higher free space loss (attenuation) compared to 900 MHz. Therefore 3G and 4G BTS draw higher energy for RF propagation. This will also likely to increase the share of BSS footprint compared to core network's footprint. When the Radio Equipment are located in shelters the combination of Free Cooling Boxes and the Increased Max Operating Temperature can bring more than 10% of energy savings per site.

FIXED BROADBAND (C_{FB})

The carbon content in the Fixed Broadband (C_{FB}) consists mainly of the following building blocks:-

- a) Digital Subscriber Line Access Multiplers (DSLAM) (C_{FBD})
- b) Customer premise Equipments (CPE) (C_{FBE})
- c) Splitters (C_{FBS})

In the Carbon footprint of the Fixed Broadband Network (C_{FB}), again the component level / PCB level of carbon content is neglected. Also as mentioned earlier the carbon footprint of Customer premise Equipment (C_{FBE}) and the Splitters (C_{FBS}) , are also not included since these are covered under different green programs . Moreover they, also depend

upon the type of the CPEs the customer uses , which may not be within the control of the service providers. Hence (C_{FBS}) & (C_{FBE}) will be Zero.

Hence, the Carbon footprint of this network will only be the emission of carbon content because of the consumption of Grid power and the diesel power (DG sets) only.

If the consumption of power for DSLAMs, in KW, (including Air Conditioning etc) is P_{FB} , the Grid power is for ' x_{FB} ' hrs and the power from ' z_{FB} ' KVA DG is for ' y_{FB} ' hrs , then

Hence, $C_{FB} = C_{FBD} = 0.365 [0.84x_{FB}P_{FB} + (0.528 y_{FB}z_{FB} / \eta)]$ in Tonnes

Fibre to the X (C_{FT})

The carbon content in the **Fibre to the X** {FTTx (C_{FT})} consists mainly of the following building blocks:-

- a) Optical Network Control Unit Equipment (ONU) (C_{FTU})
- b) Optical Network Terminating Equipment (C_{FTT})
- c) Passive / Active Splitters (C_{FTS})

In the Carbon footprint of the FTTx (C_{FT}), again the component level / PCB level of carbon content are neglected. Also as mentioned earlier the carbon footprints of Optical Network Terminating Equipment (C_{FTT}) and the Splitters (C_{FTS}), are also not included since these are covered under different green programs . Moreover they depend upon the type of the ONTs the customer uses, which may not be within the control of the service providers. Hence (C_{FTT}) & (C_{FTS}) will be zero.

Hence, the Carbon footprint of this network will only be the emission of carbon content because of the consumption of grid power and the diesel power (DG sets) only.

If the consumption of power for DSLAMs, in KW, (including Air Conditioning etc) is P_{FT} , the grid power is for ' x_{FT} ' hrs and the power from ' z_{FT} ' KVA DG is for ' y_{FT} ' hrs, then

Hence, $C_{FT} = C_{FTU} = 0.365 [0.84x_{FT}P_{FT} + (0.528 y_{FT}z_{FT} / \eta)]$ in Tonnes

Telecom Infra Providers (C_{IP})

Some of the service providers do not install separate power plant/DG for their BTS. The Telecom Infra Providers provide all infra – like power plant, battery and DG sets to cater the requirement of various service providers at their locations.

Hence, the Carbon footprint of this infrastructure will be the emission of carbon content because of the consumption of grid power and the diesel power (DG sets) only at various IP locations.

If the consumption of power for each IP site in KW, (including Air Conditioning etc) is P_{IP} , the grid power is for ' x_{IP} ' hrs and the power from ' z_{IP} ' KVA DG is for ' y_{IP} ' hrs , then

$$C_{IP} = 0.365 [0.84x_{IP}P_{IP} + (0.528 y_{IP}z_{IP}/\eta)] \text{ in Tonnes}$$

For BTS housed at these infra providers site, the power consumption individually for these BTS by the service providers should not be considered and calculated as part of C_M , since the same will be calculated from C_{IP} .

TOTAL CARBON FOOTPRINT

The total carbon footprint contribution is calculated from the sum of the carbon footprint for each part and of the carbon footprint of various stages to provide the final result.

$$C_T = C_L + C_M + C_{FB} + C_{FT} + C_C + C_A + C_{TX} + C_{IP} + \text{error in Tonnes}$$

The Service providers could opt to use these calculation techniques for calculating their footprint.

Name of the Service Provider :

Fixed Line Network (C_L)

S. No.	Name of Exchange	Total Power Consumption (P) (in KW)	Avg. Grid Supply (in hrs.)	DG Capacity (in KVA)	Avg. DG Supply (in hrs.)	η of DG Set	Carbon Emission	Total Carbon Emission (in Tonnes)	Total No. of Subscribers	Carbon Emission per subscriber (in Tonnes)	Carbon Emission per subscriber (in Kg)	
			'x'	'y'	'z'	'η'	$C = 0.365[0.84 Px + (0.528 yz/\eta)]$					
								Total				

Name of the Service Provider :

Fixed Broadband - (C_{FB})

S. No.	DSLAM Locations	Total Power Consumption (P) (in KW)	Avg. Grid Supply (in hrs.)	DG Capacity (in KVA)	Avg. DG Supply (in hrs.)	η of DG Set	Carbon Emission	Total Carbon Emission (in Tonnes)	Total No. of Subscribers	Carbon Emission per subscriber (in Tonnes)	Carbon Emission per subscriber (in Kg)
			'x'	'y'	'z'	'η'	$C = 0.365[0.84 Px + (0.528 yz/\eta)]$				
Total											

Name of the Service Provider :

Fiber to the X - (C_{FT})

S. No.	ONU Locations	Total Power Consumption (P) (in KW)	Avg. Grid Supply (in hrs.)	DG Capacity (in KVA)	Avg. DG Supply (in hrs.)	η of DG Set	Carbon Emission	Total Carbon Emission (in Tonnes)	Total No. of Subscribers	Carbon Emission per subscriber (in Tonnes)	Carbon Emission per subscriber (in Kg)	
			'x'	'y'	'z'	'η'	$C = 0.365[0.84 Px + (0.528 yz/\eta)]$					
								Total				

Name of the Service Provider :

Core Network (Edge/ core Routers/ NGN/ Softswitches/ IP cores/ all core items/ data centers/ all centralized sub systems/ peripherals) - Core (C_c)

S. No.	Core Network Locations	Total Power Consumption (P) (in KW)	Avg. Grid Supply (in hrs.)	DG Capacity (in KVA)	Avg. DG Supply (in hrs.)	η of DG Set	Carbon Emission	Total Carbon Emission (in Tonnes)	Total No. of Subscribers	Carbon Emission per subscriber (in Tonnes)	Carbon Emission per subscriber (in Kg)	
			'x'	'y'	'z'	'η'	$C = 0.365[0.84 Px + (0.528 yz/\eta)]$					
								Total				

Transmission Network (includes Microwave, OFC, VSAT, etc.)- (C_{TX})

S. No .	Tx Locations	Total Power Consumption (P) (in KW)	Avg. Grid Supply (in hrs.)	DG Capacity (in KVA)	Avg. DG Supply (in hrs.)	η of DG Set	Carbon Emission	Total Carbon Emission (in Tonnes)	Total No. of Subscribers	Carbon Emission per subscriber (in Tonnes)	Carbon Emission per subscriber (in Kg)
			'x'	'y'	'z'	'η'	$C = 0.365[0.84 Px + (0.528 yz/\eta)]$				
							Total				

Name of the Service Provider :

Infra Providers- I.P (C_{IP})

S. No.	IP No.	Total Power Consumption (P)	Avg. Grid Supply (in hrs.)	DG Capacity	Avg. DG Supply (in hrs.)	η of DG Set	Carbon Emission	Total Carbon Emission (in Tonnes)	Total No.of Subscribers	Carbon Emission per subscriber (in Tonnes)	Carbon Emission per subscriber (in Tonnes)
			'X'	'Y'	'Z'	'η'	$C = 0.365[0.84Px + (0.528 YZ/\eta)]$				
Total											

GLOSSARY OF ABBREVIATIONS

1	ATCA	Advanced Telecom Computing Architecture
2	BEE	Bureau of Energy Efficiency
3	BSC	Base Station Controller
4	BTS	Base Transceiver Stations
5	BWA	Broadband Wireless Access
6	C _A	Carbon footprint from Aggregators or Backhaul
7	C _C	Carbon footprint from Core Network
8	C _{DP}	Carbon Disclosure Project
9	C _{FB}	Carbon footprint from Fixed Broadband
10	C _{FT}	Carbon footprint from FTTx
11	C _{IP}	Carbon footprint from Infra providers network
12	C _L	Carbon footprint from Landline
13	C _M	Carbon footprint from Mobile
14	CO ₂	Carbon-di-oxide
15	CPE	Customer premise Equipments
16	CSR	Corporate Social Responsibility
17	C _{TX}	Carbon footprint from Transmission Networks
18	DAS	Distributed Antenna System
19	DSIR	Department of Scientific Industrial Research
20	DSLAM	Digital Subscriber Line Access Multiplers
21	ECR	Energy Consumption Rating
22	EER	Energy Efficiency Rating
23	EPR	Extended Producer Responsibility
24	FCU	Free Cooling Units
25	FTTx	Fibre to the x
26	GeSI	Global e-Sustainability Initiative
27	GGSN	Gateway GPRS Support Node
28	GHG	Green House Gases
29	GPM	Green Power for mobile
30	GRIHA	Green Rating for Integrated Habitat Assessment
31	GSMA	Global System for Mobile Communication Association
32	GtCO _{2e}	Gigaton of Carbon Dioxide Equivalent
33	ICT	Information and Communications Technology
34	IFC	International Finance corporation
35	IPCC	Intergovernmental Panel on Climate Change

36	IPTV	Internet Protocol Television
37	LCA	Life Cycle Assessment
38	MNRE	Ministry of New Renewable Energy
39	MPPT	Maximum Power Point Tracker
40	MSE	Management System for Energy
41	MtCO _{2e}	Million Tons of Carbon Dioxide Equivalent
42	NAPCC	National Action Plan on Climate Change
43	NGN	Next Generation Network
44	NMEEE	National Mission on Enhanced Energy Efficiency
45	NMSH	National Mission on Sustainable Habitat
46	NSM	National Solar Mission
47	OEM	Original Equipment Manufacturer
48	ONU	Optical Network Control Unit Equipment
49	PBB	Polybrominated biphenyls
50	PBDE	Polybrominated diphenyls ethers
51	PEMFC	Proton Exchange Membrane Fuel Cell
52	RAN	Radio Access Network
53	RET	Renewable Energy Technology
54	RMS	Remote Management Systems
55	SGSN	Serving GPRS Support Node
56	SWNTs	Single Wall carbon-Nano Tubes
57	TERI	The Energy and Resources Institute
58	UNFCCC	United Nations Framework Convention on Climate Change
59	USOF	Universal Service Obligation Fund
60	WBCSD	World Business Council for Sustainable Development
61	WEEE	Waste Electrical and Electronic Equipment Directive
62	WRI	World Resources Institute
63	YoY	Year on Year