Green Technologies in ICT Sector for Development: A Path to Environmental Sustainability

Om Pal Singh[1] and **Pratibha Singh**[2]
[1]Advanced Level Telecom Training Centre, BSNL, Ghaziabad 201002 UP India
[2]Environmentalist, Former Faculty for B.Tech and MBA
raviom30@gmail.com, singh.pr14@gmail.com

Abstract - **Information and Communication Technologies (ICTs), such as satellites, mobile phones or the Internet, are capable of playing a key role in addressing the global challenges of climate change and sustainable development. There is a strong need to develop a viable independent power industry that serves the ICT equipments by providing cost-effective electricity through the environmentally responsible and efficient development of the available energy resources. By raising awareness of ICT's role in tackling environmental challenges including climate change, various international agencies are promoting innovative ICT solutions to environmental questions and developing green ICT standards to support a sustainable future. The energy industry must be involved by switching generation sources to more sustainable sources and working with customers to help them use energy more efficiently.**

In terms of growing awareness about environmental impact of computing, green technology is gaining increasing importance. With rising energy consumption, global warming and e-waste, the idea of green computing is widely taken into serious consideration by both the government agencies and private companies, as their contribution in good practices for sustainable development.

This paper discusses different ICTs with present main approaches and assumptions of green ICTs by showing the latest solutions and energy efficient practices in ICT industry. Authors made a systematic study on several strategies and developments in context to the ICT sustainability as a future asset of growth for modern society. The main focus is on the practices like use, disposal, design and manufacturing as well as on technology based-solutions like electronic products and services *e.g.* green cloud.

Climate Questions/areas under study by different agencies are Environmental impact reduction including e-waste, Setting up a low cost sustainable telecommunication infrastructure for rural communications in developing countries, ICTs and adaptation to the effects of climate change, Leveraging and enhancing the ICT environmental sustainability, Energy efficiency for the ICT sector and harmonization of environmental standards, Methodologies for the assessment of environmental impact of ICT and Power feeding systems. The outlook for greener ICT should include using Internet for promotion and education for environmentally aware behavior and as a useful tool for creating eco-friendly technology.

Keywords: Green computing, Sustainability, Eco-friendly technology, Green cloud, Green Energy Technology, Clean Energy Technology, Renewable Energy Technology, Green Telecom, Green Power, Green House effect, Green House Gases.

I. INTRODUCTION

INFORMATION AND Communication Technologies (ICTs), such as satellites, mobile phones or the Internet require electrical power for their operation. The expense on energy accounts for a significant share of the operational cost of these networks. This is particularly so in rural areas where availability of power is uncertain. Energy industry must be involved in a big way in any sustainable initiatives, since it is also a major source of CO_2 emissions today. Use of diesel generators to ensure continuous power supply has the disadvantage of increasing the greenhouse gas emission and consequent enlargement of the carbon footprint which has a deleterious impact on environment.

A milestone in international efforts to address the anthropogenic causes of climate change was the "Kyoto Protocol" to the United Nations Framework Convention on Climate Change" (UNFCC), 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% below 2005 levels by the year 2020.

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

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

India is 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.

Green computing is the term referring to efficient use of resources in computing and IT/IS infrastructure. Efficiency of green computing lays emphasis on minimizing hazardous environmental impact in conjunction with achieving economic viability and improved system performance. The field of "green technology" covers a broad spectrum of subjects – from alternative energy-generation and electricity consumption techniques and use of eco-friendly, recyclable materials to implementing sustainable digital services.

Technical issues of green technology include: **green infrastructure** (energy-efficient buildings, intelligent cooling systems, renewable power sources), **green hardware** (multicore computing systems, energy efficient server design and solid-state storage) and **green software and applications** - parallelizing computational science algorithms to run on modern energy efficient multi-core clusters, intelligent load distribution and CPU switch-off (Snell, Weinberg, Katz, Yun, Wilson, Narayanan, Mo, Calzetti, Moss, Shenoy, Weems, p. 1).

II. INFORMATION AND COMMUNICATION TECHNOLOGY AND GREEN ICT

ICT (information and communications technology - or technologies) is an umbrella term that includes any communication device or application, encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as videoconferencing and distance learning.

Growing telecommunications infrastructure requires increasing amount of electricity to power it. Part of the electricity comes from the grid and remaining through burning of fossil fuel like diesel. Both of these sources contribute to emission of greenhouse gases (GHG) with the attendant negative environmental effects. Reduction of the GHG produced or caused to be produced by the telecom sector is referred to as greening of telecom.

ICT processes and practices with the principles of sustainability and finding innovative, alternative ways to use ICT across the enterprise and beyond, to deliver environmental benefits are:

Green Manufacturing: To achieve goals set by the idea of ICT sustainability whole process of creating ICT infrastructure should be taken into account. Minimal impact on the environment should be one of the key assumptions for IT manufacturers during the process of design and production of all ICT components.

Main areas in green manufacturing of computers are:
*Eco-friendly design**:** the design of computing resources that meet the stringent restriction of *e.g*. Energy Star enabling further utilization with determined power supply and power management requirements (including special modes and allowances). "The Energy Star devices can be programmed to power-down to a low electric state when they are not in use, helping to save energy and run cooler which helps them last even longer" (Kiruthiga & Vinoth Kumar, 2014, p. 6319).
*Use of bio-products: Biodegradable and renewable materials often requires less energy to produce in comparison to traditional toxic materials. Manufacturers use many different types of plastic in computers, which makes it very challenging to recycle. What is more computers contain hazardous contaminants for environment like: cadmium, lead, mercury or chromium. Use of harmful power-demanding materials can be replaced by efficient and recyclable elements *e.g*. displays made of OLED's (Organic Light-Emitting Diode) - in manufacturing mercury is not used, making them more environmentally friendly.

Green Use: It is important to understand the full life cycle of computing resources, while applying the idea of green computing. Following are the areas and practices that users can implement for maximizing usefulness and minimalizing negative consequences for environment:

*PC power management techniques**:** set of actions and mechanisms for controlling the power use of personal computer hardware mainly turning off the power or switching the system to the low-power state when inactive. In computing this kind of power management is built around the specification called The Advanced Configuration and Power Interface (ACPI), an open industrial standard that

allows direct control, management savings energy by the operating system - automatic switch off your monitor, go to stand-by mode, etc.

*Virtualization: In the traditional IT infrastructure servers are dedicated to specific computing functions like storage, communication, database and so on. Virtualization eliminates the need for a dedicated server to run applications – it enables at the same time to run multiple operating systems on the same hardware platform and the system at maximum possible performance (Grzadziel, Kosek, p. 4). It is based on a launching the operating system in virtual machine, abandoning the universality of emulation many computer architectures. Limitation only to the hardware platform used to perform a certain number of guest operating system processes (emulated system) directly on the hardware of computer. Only when such operations are not directly performed, virtualizer emulates them. Virtualization contributes in green technology on the one hand by reducing: number of servers, power and disposal requirements of desktops and limiting costly business travels of staff, customers and suppliers as well as replacing paper systems with on-line communication platforms (Warnaweera, 2012, p.45).

Green Disposal: Approach of green technology disposal include refurbishing and reusing old existing computing equipment and proper recycling of obsolete, unwanted or broken computers and its subsystems. Due to strength of negative effects on environment arising from improper approach to disposal, this aspect of green computing is among one of the most important:

Reuse**:** Even old computer should continue to be used as long as it meets the requirements of user. Computer systems which basic functions are obsolete and fail to meet the holder's need can be given to someone who want to use it or need it for its functional components. Many charities and non-profit organizations are willing to receive old equipment through donation to re-purpose or utilize its particular function. Prolonged use of a computer system significantly contributes to the reduction of negative environmental effects.

Refurbish**:** By reconditioning and replacing IT hardware parts user can prolong its utilization. Old equipment can be restored in order to maintain its functions, it also can be up graded for obtaining new serviceableness. Reasons of such actions can be motivated by lower cost of refurbished equipment – nowadays more enterprisers are willing to buy restored hardware, and such market is growing (Saha, 2014, p. 48). Refurbished hardware provide a cost-effective alternative. Another incentive may be maintaining corporate standards by ensuring that all employees use the same equipment. Such action significantly reduce e-waste.

Recycle: Recycling is one of the most complex methods of environmental protection. Its aim is to reduce the consumption of natural resources and reduce waste. The principle of recycling is to maximize re-use of materials, taking into account minimizing the expenditures for their processing. Recycling takes place in two areas: the production of products and the subsequent wastes formation of these goods. E-waste from computer and associated equipment contains different substances, many of which are hazardous, such as mercury, cadmium, lead, arsenic and chromium. The health effects of these toxins on humans include birth defects, brain, heart, liver, kidney, skeletal, reproductive and nervous system damage (Agarwal, Basu, Nath, 2013, p. 297).

Green ICT: Currently, the ICT sector globally accounts for 0.9 metric giga-tons 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.

TABLE 1–GLOBAL CO_2 EMISSIONS

Global	Gigatons CO_2e (2002)	Gigatons CO_2e (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 (0.35from embodied and 1.08 from Network use)
% of Global emissions	1.3%	2.8%

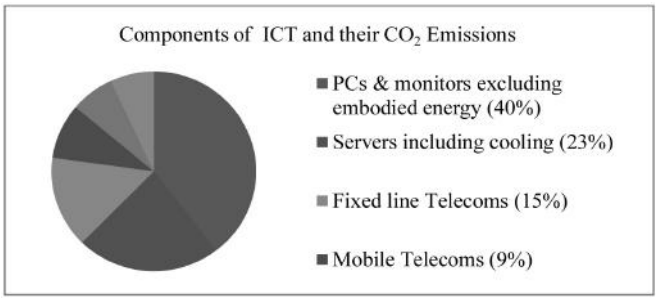
*% of Global emissions (2007): 2%
Source: http://www.smart2020.org

Total emissions of the ICT industry emanate mainly from three different sectors –Telecommunications, Data centers and PCs, peripherals and printers. 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.

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.

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.

Various components of ICT and their CO_2 emissions in the ICT sector and their footprints are shown in Fig.1. Around 25% of the emissions are from the telecom sector.

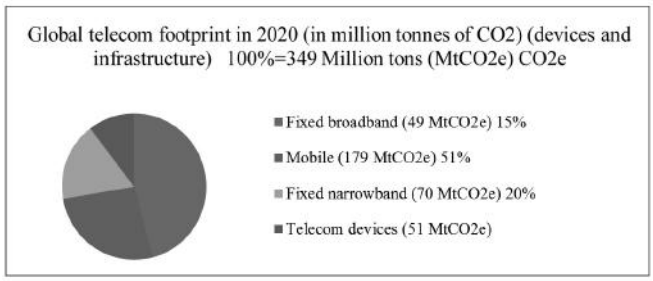


Source: Gartner Group (2007)

Figure 1. ICT emissions.

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.

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.



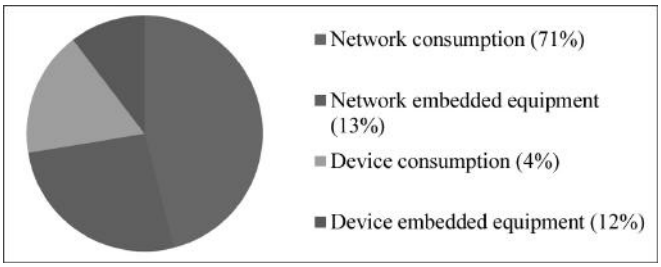
Source: http://www.smart2020.org

Figure 2. Global telecom footprint.

The carbon footprint 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.

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

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 3. Break-up of energy consumption.

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.

Lately, people have become more conscious and concerned about the ills of climate change. Newspapers and TV are regularly carrying features about rising temperature, melting glaciers, rising sea levels, natural disasters and general deterioration of the ecosystem; all presumably because of green house effect created by emissions produced by burning fossil fuel for energy. Among the various sectors, the service industries have been less visible pollutants. A number of factors have led to heightened interest in greening of service sector industries.

In case of telecommunications the factors that are leading to enhanced action on greening are as follows:

- Need to reduce the cost of operations of the telecom network by reducing energy cost.
- Need to expand network into rural areas where power availability is poor.
- Renewable energy technology becoming available at increasingly reducing cost.
- Confluence of socio-political trends towards environmental responsibility, pressure groups against global warming.
- Creating sustainable businesses has become important where the objective is not only to create products and services through ethical means but also minimize environmental impact and improve communities.
- International treaties like Kyoto Protocol.

The Telecom Sector witnessed substantial growth in the number of subscribers during the year 2015-16 and up to September 2016 also the subscriber base was 1123.95 million, out of which 900 million were wireless subscribers. During the year 2015- subscriber base recorded an increase from 969.89 million to 1033.63 while the overall teledensity increased from 79.38 to 83.36. The year also saw density from 48.37 to 51.37 while the urban teledensity increased from 148.61 to 154.01. The Internet subscriber base in the country, as on September 2016, stood at 367.48 million as compared to 324.95 million as on September 2015.

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

With 3G becoming pervasive, the energy demand is likely to increase by two three folds at least because data transfer would consume more energy and the introduction of 4G, with a speed transfer rate 10 times higher than the 3G, will further substantially increase the energy consumption patterns of the telecom sector. The foremost share of the CO_2 emission in the ICT infrastructure is during the actual use of the network equipment and devices. In the telecommunication network, the components that contribute to carbon emission footprint includes the Radio Access Network (RAN), Data Centers, fixed-line network, the Core network, aggregator, transmission system and Fiber to the network (mainly in Access network) etc. Therefore, use of new and innovative technology in these areas can help in reduction of harmful emissions.

To get stakeholders' views on greening the telecom sector, TRAI issued consultation paper on "Approach towards Sustainable Telecommunications" on 16 January, 2017. Also, in an endeavor to get stakeholders' views on greening the telecom sector, TRAI issued a consultation paper on "Green Telecommunications" on 3rd February, 2011. An Open House

Discussion on these issues was held at Delhi on 18th March, 2011. Based on the comments received during the public consultation, the recommendations on "Approach towards Green Telecommunications" were issued on 12th April, 2011 by TRAI.

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

III. ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

If you plan for a year think to plant rice. If you plan for 10 years then think to plant a tree. But if you plan for 100 years then definitely think about the achievement of intergenerational equity (to secure environment for future generation). Environment and development both are very essential elements of one's life. As we know that environment and development both are inversely related so we need to maintain a balanced approach in achieving our needs. We should follow the development in sustainable manner (without harming the environment).

Today we are on the progressive edge of development, somewhere ignoring the importance and requirement of environment. There are so many anthropogenic activities (generation of non decomposable solid wastes, emission of green house gases, release of polluted effluents into water bodies etc.) by us gradually disrupting the compensatory natural cycle of environment and creating a great havoc.

Some devastating problems are increasing at alarming rate like ozone layer depletion, global warming and climate change. Though there are many straight guidelines drafted in various conventions and protocols document (like Kyoto protocol) at global level to conserve the environment, but we are wasting a good time to start doing something in this field. After lot of efforts, still India is ranked 155 out of 178 countries, as per Environmental Performance Index, among the BRICS countries (Brazil – 77, Russia – 73, China – 118, South Africa – 72 and India - 155). India is far away from the aim of conserving environment.

IV. TOOLKIT ON ENVIRONMENTAL SUSTAINABILITY FOR THE ICT SECTOR

Companies in the ICT sector are increasingly being asked by customers, investors, governments and other stakeholders to report on sustainability performance. However, as yet, there is no globally agreed or standardized method to simplify, guide and streamline this type of reporting. Such reporting is essential in that measuring and reporting on environmental performance frames a company's environmental costs in metrics that enable it to gauge the exact extent of their improvement as they work to reduce their environmental impact.

The Toolkit on environmental sustainability for the ICT sector is an ITU-T initiative providing detailed support to ICT companies seeking to build sustainability into the operations and management of their organizations through the application of international standards and guidelines.

The Toolkit provides ICT companies with a set of internationally agreed sustainability requirements which allow for more objective reporting on sustainability practices in the ICT sector, in terms of the following key areas of focus:

- Sustainable buildings
- Sustainable ICT in corporate organizations
- Sustainable products
- End-of-life management for ICT equipment
- General specifications and KPIs
- Assessment framework for environmental impact of the ICT.

The Toolkit draws together contributions from over 50 ICT companies and universities around the world which have partnered in this effort. In India, The theme of National Science day of the year 2018 is "Science and Technology for a sustainable future."

V. MEASURES FOR REDUCING TELECOM CARBON FOOTPRINT

The measures that can be undertaken to reduce the telecom sector footprint are under the following categories:

- Adoption of energy efficient equipment and innovative technologies
- Use of Renewable sources of energy
- Infrastructure Sharing
- Improvement of grid supply
- Waste Management
- Better network planning: more outdoor BTS, less BTS, less air conditioning requirement to cool sites
- Standardization of equipment, test and certification
- Manufacturing process
- Monitoring and reporting
- Government support – incentives, subsidies, taxes & levies.

VI. LATEST DEVELOPMENTS

Green Cloud Computing: The Gartner report from May 2009 defines cloud concept as "a style of computing where scalable and elastic IT capabilities are provided as a service to multiple customers using Internet technologies". Use of the potential of cloud computing model interacts with the concept of sustainable development, understood in three dimensions:

economic, environmental and social. Clouds consolidate environment, saving power, cooling, space and money. Cost savings and flexibility of operations are among the most frequently mentioned benefits associated with a decision to adopt the cloud computing solution. Fixed costs related to the investment in infrastructure (which in the traditional business model generally increases with time and the need to update the software) are reduced, as well as energy costs feeding the infrastructure. The solution allows to adjust supply to demand, eliminating incurring unnecessary costs associated with the overestimation or underestimation of customer needs. At the same time, it affects the reduction of occurrence of lost sales opportunities risk and cost of incorrect demand forecasting and company's supply planning.

Some aspects of cloud's ICT infrastructure allow to identify the model as the one providing green benefits. The basic features of the model allow you to specify a number of environmental benefits that can be achieved by migrating the IT resources to the cloud. These aspects may include:

Dynamic provisioning and multi tenancy: lower energy consumption and associated carbon emissions than the traditional approach of over-provisioning. Automatic processing of computing environment supports user needs, operating under the cloud may acquire or release the resources (instances) where it is appropriate (according to the demand). Dynamic resource allocation is done automatically, thus data centers maintain active servers according to current demand. With virtualization technology, which allows to connect disparate resources, in one great set of resources it is possible to re-lease them more selectively to all customers at the same time increasing the level of their use.

Optimal server utilization**:** traditionally, many servers remain idle of 85-95% of the time using nearly as much power as they do when they are active. Virtualization technology enables hosting of multiple applications through one server. The number of active servers is reduced and the power consumption is lower.

Energy-efficient client devices: the public cloud model reduces the number of energy consuming clients through small energy-efficient devices (*e.g.* thin clients)

Data Centre Sustainability Improvements: Rising energy costs, desire to make existing investments more and more profitable are making today's cloud providers to implement best practices to make datacenters operation green. To build eco-friendly data center, several best practices in key areas are proposed for improving sustainability are:

- Proper location which allows clean energy consumption through renewable sources (solar energy generation, wind power generation, fuel cells, cogeneration).
- Cooling system (new systems based on liquid cooling, nano-fluid cooling systems, and inserver, in-rack and in-row cooling by companies such as Spray Cool; free cooling, spot cooling, using cable grommets to reduce cool air leakages).
- Building design (heat insulation, optimizing floor layout, recycling water).
- ICT platform (middleware-facility linkage, dedicated racks and servers, virtualization technologies).
- Deployment of newest power efficient servers and processors.
- Energy linking (power sharing between company centers, locating data center near power station).

Solar Computing: Now-a-days solar power in gaining increasing attention throughout the world. Solar energy is power derived from the sun through the use of solar panels. Good example of powering PC's with the sun is Taiwanese manufacturer VIA Technologies Inc. VIA Solar Computing initiative is a part of VIA Green Computing projects. VIA Solar Computing use advanced, cost-effective solar panel technology in cooperation with Motech Industries – one of the largest and leading solar product manufacturers and innovators. Solar cells combined with VIA processor platforms and system technologies developed complete solar-powered computing solutions that are less polluting, more affordable, more reliable and more flexible for a wide variety of new markets, applications and environments. VIA Solar Computing is focusing on photovoltaic (PV) solar power to take advantage of the numerous benefits for both emerging market and urban computing installations:

- Solar power is clean non-polluting energy.
- Once capital costs are covered (like purchasing and installation) solar cells require very little maintenance, hence in further perspective of time, they provide energy at virtually no cost
- Solar panels are silent in operation.
- Solar panels do not require refuelling; they are self-sufficient. Due to the undeniable benefits of renewable energy in the form of solar energy private companies continue to invest in research and development of this kind of power providing.

Telecommuting: Telecommunications-related technologies, such as teleconferencing, also are often implemented in green computing initiative. "Advances with communications devices and with the aid of computer networking systems have made it possible for people to work from remote locations and for telecommuting to become an ever-more feasible option for many companies. With the aid of telecommuting it increased satisfaction between the two parties, reduction of greenhouse gas emissions related to travel, and increased profit margins as a result of lesser costs for workplace space, heat, lighting and many more. Through IT/IS systems telecommuting can also be

used for remote administration, group document management and cooperative knowledge management. It is estimated that one-fifth of all travel is associated with commuting. Thus, the wider use of teleworking would greatly reduce the negative impact on the environment. Unified Communications leads to an increase in the level of cooperation between employees. Video solutions enable real-time collaboration which is one of the most important environmental initiatives in the business environment.

VII. CONCLUSION

India is the second largest and fastest growing mobile telephone market in the world. On an average, more than ten million new subscriptions are added every month, the market grows by 23% each year and has now crossed 800 million. But telecom is also the second largest energy consumer in India after the Railways.

Almost all of this consumption is unseen – small diesel generators running for hours to power transceivers on each Cell phone tower and run air-conditioning units to keep equipment shelters cool. Generators are used because mobile operators are able to meet only 40% of their power requirements from grid electricity.

TRAI suggests that in the next five years, at least 50% of rural towers and 33% of urban towers should be powered by hybrid energy (renewable energy technologies and grid power), while all rural towers and 50% of urban towers are to be powered by hybrid energy by 2020.

Energy efficient equipment: New generation equipment is not only more energy and space efficient but also has features that can cut down energy usage. Uninor's sites, for instance, have advanced functionalities like automatic shutdown of inactive transceivers. This saves energy when there is no activity on the network.

Enhancing infrastructure efficiency: Most measures the industry can undertake today fall in this category. Some of these include:

Infrastructure sharing: Passive sharing involves sharing of towers, shelter cabinets, power supply unit, air-conditioning unit alarm systems etc. Just this can lead to significant energy savings. Active sharing would involve sharing of network infrastructure such as antennae systems, backhaul transmission systems, and base station equipment.

Better cooling solutions: A large part of energy consumption at a tower comes from the use of air-conditioning to cool down shelters that house equipment. A lot can be done here.

*Optimisation on diesel generator operation:*_It involves deployment of fuel catalyst to improve the efficiency of the combustion process.

Substituting conventional diesel generators with DC direct generators sets removes the inefficiencies of converting AC to DC power and hence reduces overall fuel consumption.

Big measure next is to deploy renewable energy: initially to complement conventional diesel, and gradually to become the main power source to run telecom networks.

Solar is one of the most adoptable options. Though it has high investment costs, the energy savings make it a compelling option. From the pilot that Uninor has implemented, it is evident that solar panels reduce fuel costs by almost 30%. For adoption of greener technologies and energy sources, measures such as tax holidays, accelerated depreciation and targetted subsidies will encourage early adoption and scale.

Challenges of sustainable development met by today's businesses operators at the same time forcing their activeness not only in economic, but above all, environmental aspect.

Computers and related infrastructure (*e.g*. data centre) are not only costly to maintain, but also harmful to the environment due to the carbon emission. Nowadays, with a greater concern for the environment, green computing reduces the negative effects of ICT on sustainability. The solution protects the environment by dealing with the power management techniques, saving electricity and reducing e-waste.

Cloud providers need to reduce the electricity demand of clouds and take major steps in using renewable energy sources rather than just looking for economic incentives like cost minimization.

Green ICT sustainability addresses issues such as: using renewable energy sources to power data centres, reducing e-waste, designing energy efficient hardware, middleware and software, running multiple operating systems via virtualization, providing information to customers in order to encourage them make green choices, reducing transportation cost and emissions by telecommuting (Kevin, Muketha, Kamau, Wanyembi, Titus, 2014, p. 200).

We should remember one thing if man disturbs Nature consistently then definitely one day Nature will destroy the man. So, "Go green, Go indigenous, Save Humanity, Save environment and ultimately save 'LIFE'".

REFERENCES

[1] Consultation Paper On Approach towards Sustainable Telecommunications, Telecom Regulatory Authority of India , Government of India, 16 Jan. 2017.

[2] Consultation Paper on Green Telecommunications by Telecom Regulatory Authority of India , Government of India, Feb. 2011.
[3] INCCA Indian Network for Climate Change Assessment, India: "Greenhouse Gas Emissions" 2007.
[4] "SMART 2020: Enabling the low carbon economy in the information age", A report by The Climate Group on behalf of the Global eSustainability Initiative (GeSI).
[5] White Paper Green ICT. "The way to green business", By T-Systems Enterprise Services GmbH Mainzer Landstrasse 50 D-60325 Frankfurt am Main, Germany.
[6] "Recommendations on Approach towards Green Telecommunications", by Telecom Regulatory Authority of India , Government of India, Apr. 2011.
[7] ITU Document: "Green ICT Standards- A path to environmental sustainability".
[8] "Eco-friendly design", by Kiruthiga & Vinoth Kumar, 2014, p. 6319.
[9] "Virtualization details" by Grzadziel, Kosek, p. 4 and by Warnaweera, 2012, p.45.
[10] Piotr Pazowski, " Green Computing: Latest practices and technologies for ICT sustainability by, Maria Curie Skłodowska University, Poland, *Proc.t Joint International Conference 2015*, Bari, Italy, 27-29 May, 2015.
[11] Ram Krishna and R. K. Siddhartha, "White paper on Green Energy Technology (GET) for telecom applications ," TEC New Delhi, Website: http://tec.gov.in/pdf/Studypaper/GET%20for%20Telecom%20Applications.pdf.
[12] Snell, Weinberg, Katz, Yun, Wilson, Narayanan, Mo, Calzetti, Moss, Shenoy, Weems, "Green software and applications", Proc. *Joint International Conference 2015,* Bari, Italy, 27-29 May, 2015.
[13] B. Saha, "Green Computing". *International Journal of Computer Trends and Technology*, vol.14, no.2, pp.46-50, Aug. 2014.
[14] S. Agarwal, K. Basu and A. Nath, "Green Computing and Green Technology based teaching learning and administration in Higher Education Institutions", *International Journal of Advanced Computer Research,* vol. 3, no.3, pp.295-303.
[15] N. Kevin, M. Muketha, J. Kamau, G. Wanyembi and W. Titus, "An investigation into the applicability of green IT concepts into green IS, *International Journal of Innovation and Application in Engineering & Management,* vol. 3, no.12, pp.198-204,2014.

Om Pal Singh is working as Sr. Trainer at Advanced Level Telecommunication Training Centre, Ghaziabad for over 12 years. Possesses experience of four years in design, development and imparting training on Switching, NGN and IP Multimedia Subsystems. Involved in planning, installation, operation and maintenance and deployment of IP Multimedia Subsystem based Next Generation Network equipment. He is Commonwealth Telecom Organisations expert trainer and the speaker from ALTTC for IPv6.

Organised ITU-supported program on 'Deployment of Broadband through Next Generation Network', at ALTTC, Ghaziabad in Nov'17. Published paper on 'ICT Regulatory Environment: India and the World Next Generation Technologies & Their Regulations'

Pratibha Singh (b. 14 Oct'81) obtained M Tech. in Environmental Engineering from M.M.M. Engineering College, Gorakhpur in 2006 and MSc from Avadh University in 2016. Was HoD of Applied Sciences at Chaddha Group of Institutes, Ghaziabad during Jun'08 – May'12 and taught Environment & Ecology and Non- Conventional Energy Resources.

Earlier worked with Sahara Group at Lucknow and Noida. Received Gold medal at Post Graduate Level. Her MTech Thesis was on 'Performance Evaluation and Optimum Design of Municipal Wastewater Treatment Plant at Nasik with Different Post-Treatment Options'. Currently pursuing PhD in Environmental Science from Bhagwant University, Ajmer. Published and presented several papers.