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Appraisal of Green Communication Technology Deployment in Nigeria

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ABSTRACT: The idea behind "green" processes and technologies is the use of upgraded, ecologically friendly processes and technologies in a way that preserves natural resources and doesn't disturb the environment. Clean technology and environmental technology are other names for green technology. These days, most governments take steps to promote these technologies because of their value. Governments therefore suggested a number of financial incentives that produce electricity using renewable resources. As its primary objective, green technologies seek to address societal demands while minimizing the use of natural resources and causing no harm to them. The idea is to create materials that are entirely recyclable or reusable. Green technology generates energy through novel and inventive methods. The goal of green communication is to explore sustainability in relation to energy efficiency, the environment, and communication goals. Green communications have an obligation to promote ecological network equipment and systems and to fortify corporate environmental responsibility. The paper presents Nigeria renewable green energy sources, green electronics, recycling, communication technology areas of application. The paper also presents a careful consideration of materials and methods to ensure the chosen deployment are environmentally sustainable. Despite the challenges, utilizing green ICT methods in Nigeria is not just a choice, it is essential for a number of advantageous causes as people throughout the world become more environmentally aware, implementing green ICT practices can improve Nigeria's standing internationally. It will demonstrate the nation's dedication to sustainability.

KEYWORDS: Green communication technology, CO2 emission, Mobile Devices., Environmental pollution, Renewable energy.

1. INTRODUCTION

Green communications have been a major priority for the industrial and communication research communities in recent years. It refers to any method—hardware or software—that the information and communication technology (ICT) industry is permitted to use to lower energy usage. This trend's significance comes back to how it affects financial costs and environmental degradation. In fact, according to recent studies, the ICT accounts for as much as 10% of the world's CO2 emissions, with its contribution more than doubling between 2006 and 2011[1]. A considerable amount of ICT energy is reported to be spent in network components, reaching between 30–37% of Green Houses Gases (GHG) produced by the ICT sector [2]. As a result, lowering networking infrastructures' energy usage will need a significant effort.

As energy use rises, atmospheric carbon dioxide concentrations grow as well. and because there are more and more mobile subscribers, this ratio is growing extremely quickly. The increasing amounts of CO2 in the atmosphere are caused by several mobile communication industries. Fig. 1 shows how the worldwide mobile footprint is expected to develop between 2007 and 2020, taking into account end-user devices, operator business operations, and data traffic. Five key observations are highlighted below.

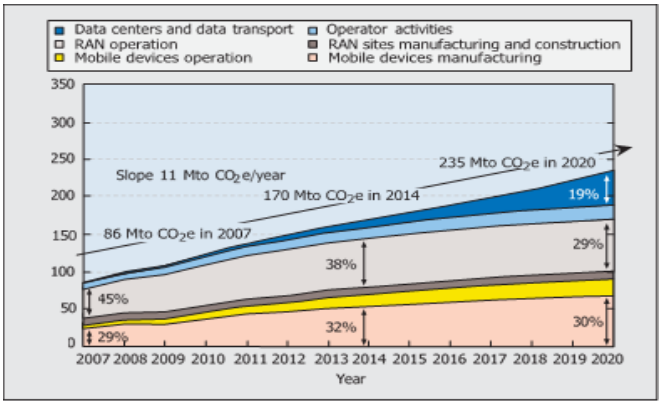

Figure 1: The Mobile Communications' Worldwide Carbon Footprint Estimated Upto 2020 [3].

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The estimate states that until 2020, the total carbon footprint of mobile communications will rise practically linearly, averaging 11 Mto CO2e annually—an amount equal to the annual emissions of 2.5 million EU households or the entirety of Luxembourg. Over 235 million tons of CO2 equivalent emissions will be produced in 2020, more than one-third of the UK's current yearly emissions. The total carbon footprint will rise by a factor of two until 2014 and a factor of 2.7 until 2020 in comparison to 2007. The footprint might potentially rise by more than three times in the unlikely scenario that base station locations and end-user devices only see modest efficiency improvements. On the other hand, over the same 13-year period, the ICT sector's overall footprint is predicted to grow by a factor of just 1.72 [4]. Looking at the manufacturing and construction footprint of RAN sites in Fig. 1, it appears that the contribution from the so-called embedded energy of RANs, which some authors have recently examined, will not be significant in comparison to RAN operation.

A significant portion of the overall carbon footprint is attributed to the fabrication of mobile devices and the operation of RANs. Therefore, efforts to reduce the carbon footprint of the mobile communications sector should focus on these two areas. Even if RAN operation accounted for the majority of the carbon footprint in 2007, the production of mobile devices will contribute significantly more to the total carbon footprint in 2020. The rationale behind this is that a steadily rising portion of the devices connecting to the network are laptops and cell phones. the desire for cutting-edge wireless services and apps, particularly video, is driving this trend. Compared to normal phones, laptops and smartphones have carbon footprints that are around ten times and two times larger, respectively [4]. Due to the huge increase in mobile data traffic volume in the upcoming years, data centres and data transport will expand at the highest rate out of all the contributions made up to 2020. From 2015 to 2020, the high data traffic model considered in this scenario will expand at a compound annual growth rate (CAGR) of 60%. By 2020, data centres and data transportation will emit 33% less CO2e when mobile traffic volume is reduced at a 50% CAGR. By 2020, there will be 50 billion connected devices (More than 50 billion connected devices, 2011), and by 2030, there will be an additional 100 billion [5]. Higher data speeds by 1000 times are required to accommodate this massive number of devices (The data challenge, 1000x). The surge in subscriber demands can be attributed to the intense demand of bandwidth-demanding apps and high data rates [6].

In the UK, a typical mobile phone network uses between 40 and 50 MW. More than a million gallons of diesel are used daily by a service provider like Vodafone to power its networks. This suggests that a sizeable amount of the ICT infrastructure's overall energy usage may be attributed to wireless communications.

Nigerian GSM networks have developed significantly in recent years, as seen by the variety of services offered. Due to this expansion, users continuously experience data traffic, and the number of mobile subscribers has increased dramatically. As a result, in order to meet demand, numerous GSM network providers, including MTN and Globalcom, have been compelled to install additional GSM base stations (BSs) [7][8][9]. Regretfully, power is scarce or nonexistent in both rural and urban regions, especially in developing countries like Nigeria. This can be ascribed to a number of things, such as unfavorable government policies and the GSM operators' unwillingness to explore for feasible alternative power sources elsewhere instead of depending only on low-cost or basic power sources, like diesel generators (DG), to power their base stations. as a result of which their operational expenses (OPEX) rise annually and they do not use electricity sources that are good for the environment [7].

Green communications must take into account two main factors in order to save expenses:

• Reducing energy use in order to lower operational expenditure costs.

• To lower carbon emissions and make the environment a safer place to live.

Wireless communications play a major role in human-to-human, human-to-machine, and machine-to-machine communications in this information age. Such enormous demands will ultimately lead to worldwide environmental problems, with energy consumption being a major concern. As a result, switching to green communications is imperative.

2. LITERATURE REVIEW

The process of choosing networking and communications technologies and solutions that are energy-efficient, or need less resources, is known as "green communication." This approach applies to all types of communication.

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Figure 2. Green Communication (Vinay, 2018) [10]

2.1 Related Works

[7] in 2020 evaluated green communication energy and gave top priority on efficiency, reducing running expenses, and reducing carbon emissions. In line with [7], The globe is not only dealing with issues like the energy crisis and climate change; the GSM industry is also dealing with broader issues that if left unchecked, would continue to have an adverse impact on human life and the environment.

Pure and more reliable green energy sources are needed than the ones now employed in the sector, as greenhouse emissions such as carbon dioxide (CO2) and methane are the cause of global warming, which poses a serious threat to human survival.

According to [11][12] as depicted in figure 3 below, The Base station in telecommunication network architecture, in particular, consumes the most power, and the major reason for this is that the power amplifier was poorly designed. Additionally, consider how energy-efficient each component is. Consequently, the population density should be the primary consideration while selecting a site for a base station. The following stage, if more base stations are needed there, is to decide which hardware will work best there while also taking the components' energy efficiency into consideration.

2.2 Various Environmental Impacts

Discussions revolve around carbon emissions at the moment because of the issue of global warming and the resulting climate change. When selecting an environmentally friendly solution, considerations such as soil quality, ozone layer safeguarding and water pollution, air pollution, use of resources, reducing waste, and others must be made. Telecom equipment often contains significant concentrations of heavy metals and unusual minerals. The primary environmental concern is waste treatment, and the primary issue is the mining for these resources. The issue of energy consumption and the parts of ICT that are associated with carbon emissions should also be taken into consideration.

The Kyoto Protocol addresses greenhouse gas emissions, which include PFCs, nitrous oxide (N2O), carbon dioxide (CO2), and sulfur hexafluoride (SF6). These emissions must be considered. Every one of these greenhouse gases has a unique global warming capability (GWC) when taken into account over a 100-year timeframe. Of these GWCs, the carbon dioxide GWC in CO2 equivalent is the most notable. [10].

We are currently in an era of a smart society thanks to a variety of mobile communication technologies, including wearable technology for personal communication, health care devices, smart watches, smart phones, and smart glasses. Mobile nodes' incapacity to collaborate has a detrimental effect on the quality of communication and results in an uneven resource usage, which raises the high power consumption of mobile gadgets. This is especially true given the rapid advancement of wireless communication technologies. the operation of this smart devices based on charging of battery capacity every day is very high [10].

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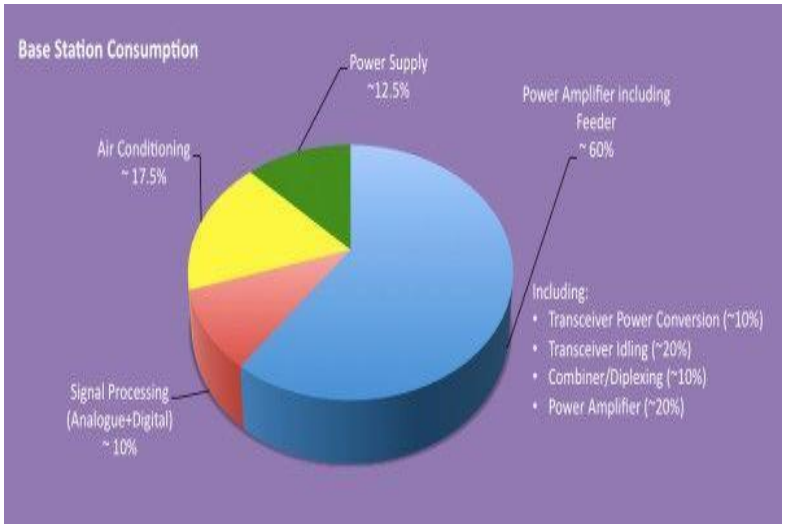

Figure 3: Base Station Power Consumption Distribution [11][12].

Research on green communication has become increasingly important and intriguing for future mobile networks. Green communication among mobile and networks includes information sharing, spectrum of energy awareness, routing adaptation, and data caching. These characteristics make it possible to optimize and balance resource usage and reduce energy consumption across mobile and wireless networks. The purpose of the special issue is to inspire scholars to disseminate their most recent research on issues and challenges that exist in the field of green mobile device communication. [13][14].

It is necessary to address the pertinent areas of wireless architectures that have the potential to dramatically impact power consumption [15]. The retail group, data centers, mobile switches, core transmission, and base stations consume roughly 2%, 6%, 15%, 20%, and 57% of the power in figure 4, according to [11][16].

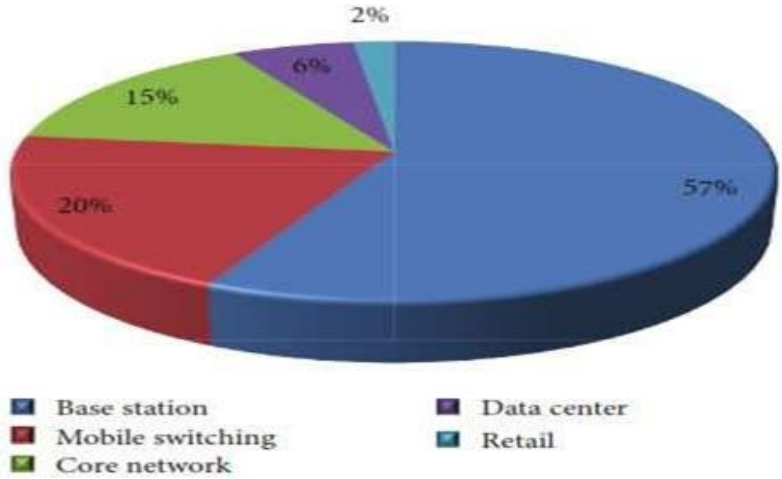

Figure 4: Energy Consumption Composition of a Mobile Operator [11][16].

2.3 Nigeria Renewable Green Energy Sources

Natural resources can be preserved by using abundant renewable energy sources like hydropower, wind, and solar electricity. They contribute to reducing climate change by emitting little or no greenhouse gases. Nigeria may attain a more environmentally friendly and sustainable energy system by switching to renewable energy. Renewable energy sources like light, water, and wind can be transformed into electrical energy. Renewable energy sources include biological fuel, wind, solar, and water energy. Nigeria now uses a relatively little amount of its plentiful renewable energy resources, which are essential for the country's sustainable growth.

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2.4 Green Electronics and Recycling

Legislation is putting increasing pressure on the electronics and electrical businesses to stop using harmful and dangerous ingredients in their products. There is an ongoing global environmental push to produce electronics devices with green method and green materials. The difficulty of developing environmentally friendly electronics is one that faces makers of electronics.

The manufacturing of electronics devices faces a unique challenge in developing environmentally friendly equipment. Reducing the amount of parts in devices, recycling energy and device parts, reusing green materials, and efficiently employing green energy and materials are all important aspects of manufacturing green electronics. In green electronics, the use of toxic elements like lead, plastic, and other hazardous chemicals is either carefully restricted or prohibited in order to facilitate recycling. Recycling is the process of collecting waste and repurposing it into new items instead of throwing it away as garbage. Nowadays, the vast majority of individuals worldwide own smartphones, smart watches, and iPads and other gadgets as a result of the previous 30 years' continuous development of cellular wireless communication technologies. Consequently, the quantity of superfluous electronic gadgets is rapidly rising [17].

Because so many gadgets are being produced and thrown away, a new environmental disaster strikes the world. Landfills are rapidly being overrun by outdated electronics that have been thrown away or produced electronic waste. These electric devices contain hazardous and toxic materials that jeopardize the local communities' health and ecology. The amount of electrical waste increases environmental contamination.

Table 1 lists the most frequent toxic elements discovered in electronic trash and toxicity, while Figure 8 below illustrates undesired electronics.

Figure 5: Electronic waste [18]

Table 1: The Toxic Materials Most Frequently Found in Electronic Waste

Materials	Toxicity
Mercury	Mercury exposure, even at low levels, can harm the brain and kidneys.
Lead	Lead exposure can seriously harm the brain, especially in young infants.
Beryllium	Beryllium, a recognized human carcinogen that affects the lungs when inhaled, is included in many motherboards.
Brominated Flame Retardants (BFRs)	Hormonal functions that are necessary for normal development are negatively impacted by BFRs.
Cadmium	When cadmium builds up in the body, studies have indicated that it can lead to kidney damage and cancer.

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Green technologies reduce environmental pollution. Recycling bottles, plastic waste, outdated batteries, and technological waste helps to reduce pollution. Recyclables help save raw materials. Recycling lessens pollution and waste.

Advantages Recycling:

i. Decreases the quantity of garbage that is burnt and dumped in landfills.
ii. Boosts financial stability by utilizing a homegrown supply of resources.
iii. Preserves natural resources including minerals, water, and wood.
iv. Prevents pollution by lowering the requirement for fresh raw material extraction.
V. Preserves energy.
vi. produces and preserves priceless resources.

2.6 Green Communications and Networking Technology

The development of wearable medical technology, smartphones, smart watches, and other mobile communication devices has ushered in the age of the smart society, enabling reliable information flow from anywhere, at any time. However, the energy that mobile communication devices use that is not necessary has increased. The mobile communications industry sustains the rising data volume at the cost of a significant carbon impact. Governments and users are asking for environmental protection by requesting that ICT decrease CO2 emissions. In the ICT sector, green communications and networking can result in significant energy consumption reductions.

The characteristics of green communication include sustainability, energy efficiency, energy consciousness, and ecological awareness. Furthermore, it is a communication method that is green. Green communication aims to reduce energy consumption in fully wireless and mobile networks by balancing resource utilization. It's expected to cover growing telecommunication costs, their impact on the environment, and CO2 emissions. Energy consumption is rising quickly as a result of the communication and networking technologies' quick development and growth. Thus, the urgent need for green networking and communication [19].

The term "greening of telecommunication" refers to the reduction of greenhouse gases (GHGs) brought on by the telecommunications industry. It can be broadly divided into four categories: equipment manufacture, atmosphere-friendly building design for telecommunications, secure telecommunication waste disposal, and greening of telecommunication networks [20].

The core idea underlying "green communication." Finding a way to influence people's behaviour in order to increase the efficacy of communication systems Lowering energy costs without sacrificing quality of service (QoS) in terms of user needs, coverage requirements, and capacity is the aim of green communication. All building blocks of a communication system, including the baseband, transmitter, receiver, and signal modulation, must be optimized for green communications. Green communication seeks to reduce the energy consumption and carbon impact of communication systems. Using biodiesel, solar, fuel, and fuel-powered cell sites, as well as adding fuel catalysts and cooling units, are some methods for doing this. [19][20]

There are four main trade-offs that have been identified [21]:

i. Spectrum efficiency: the use of energy efficiency to balance energy consumption and the achievable rate.
ii. Deployment efficiency: Using energy efficiency to balance network energy consumption and deployment costs.
iii. Delay power: the capacity to equalize the average power consumed and the average end-to-end service delay.
iv. Bandwidth: the ability to match the amount of bandwidth used with the amount of power needed for transmission.

Green communication meets the same characteristics as green technology [22][23].

i. It reduces the degradation of the environment.
ii. It produces negligible or no greenhouse gases.
iii. It promotes improved living conditions for all organisms.
iv. It reduces the need for energy and natural resources.
v. It promotes the use of sustainable resources.

Cognitive networks, network coding, and smart grid are three of the most important green communication strategies [24]

Cognitive networks: These networks can efficiently increase the efficiency of spectrum resource use and the performance of the network's transmission. For the radio spectrum to be used more effectively, cognitive radio is essential. It is able to take use of the residual bands and open the channel as soon as the primary users need to use it, provided that its licensed customers, also referred to as primary users, are not broadcasting on such frequencies. Network coding is the process of eliminating pointless paths to boost network speed. Technology for network coding lowers network traffic and improves link performance.

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• Smart grid: Improving the dependability, efficiency, adaptability, and resilience of the electrical system is the main goal of the smart grid. By integrating two-way data connectivity into the electrical system, smart grid achieves this. It offers a technological foundation for high-speed, fully integrated, two-way communication with the current electrical system. It makes the processes of keeping an eye on, controlling, gauging, and safeguarding easier.

2.7 Green networking

Green networking, sometimes referred to as energy-efficient networking, is the practice of reducing energy consumption through the use of renewable energy sources, energy-efficient technology, and ecologically friendly consumables. Unnecessary energy consumption in wired and wireless networks is addressed. Historically, wired network architecture has not taken energy efficiency into consideration. Reducing unnecessary energy use, however, is turning into a significant issue for wired and wireless networks alike. Green networking includes all network components, such as computers, switches, routers, communication channels, and other devices connected to the network. Lowering these components' energy usage is the aim of energy-efficient networking. The goals of green networking are numerous, including [21].

i. Reduction in energy usage.
ii. Increasing energy efficiency.
iii. The environmental impact of network components is considered at every stage, from conception to disposal.
iv. Infrastructure and network service integration.
v. Enhancing intelligence within networks.
vi. Compliance with regulatory reporting requirements.
vii. Encouragement of a shift in mindset regarding how we go about reducing carbon emissions.

Green networking is the process of choosing networking tools and systems that are resource- and energy-efficient. Among its methods are [25] virtualization implementation.

i. consolidating servers in practice.
ii. replacing outdated machinery with modern, more energy-efficient models.
iii. system management is used to improve efficiency.
iv. using videoconferencing, remote administration, and telecommuting in place of travel.

The energy efficiency of a communication system is largely determined by how much electricity each component in the system uses. The ensuing tactics [25] can be employed to lower communication networks' energy usage:

i. Network planning should optimize resource placement and provide the option to turn off network hardware.
ii. Introduce low-energy network devices and equipment through equipment reengineering.
iii. Network management: By allocating network resources according to user demand, you can optimize the performance of network hardware as well as network-wide protocols and procedures.
iv. Energy from renewable sources, often known as green energy, such as wind, micro hydro, solar, tidal, and geothermal, can be used to reduce the amount of energy that is used from the power grid.
v. Social awareness: Inform users on how to save energy.

Energy-saving methods will improve network efficiency, save expenses, and have a smaller negative impact on the environment.

3. MATERIALS AND METHODS

When implementing green communication technology, materials and techniques must be carefully considered to guarantee that the solutions selected will not negatively impact the environment. Here are some important things to think about:

3.1 Materials

1. **Energy-Efficient Hardware:** Choose parts and equipment (such as switches, routers, and servers) that are built with high energy efficiency in mind. Seek accreditations such as EPEAT, LEED, or ENERGY STAR. Energy Star establishes energy efficiency guidelines for a range of goods and services and certifies particular goods that satisfy the guidelines. Based on environmental factors, consumers can assess, contrast, and choose desktop, laptop, and monitor models with the aid of the EPEAT (Electronic Product Environmental Assessment Tool) system. The LEED (Leadership in Energy and Environmental Design) rating system is the most widely used green building standard globally. LEED accreditation offers a basis for safe, economical, and highly efficient green buildings that support social, political, and environmental objectives.

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2. **Recycled and Eco-Friendly Materials:** Select goods manufactured using recycled materials. Make sure enclosures and packaging are recyclable and environmentally friendly.
3. **Low-Impact Manufacturing:** Select vendors and producers who follow eco-friendly policies, such as conserving water, cutting back on emissions, and minimizing waste.
4. **Renewable Energy Sources:** energy that comes from renewable natural resources, which are always being created at a faster rate than they can be used. Use renewable energy sources, such as solar, wind, or hydro power, for manufacturing processes, or choose suppliers who share your dedication to sustainable practices.
5. **Minimal Hazardous Materials:** Make certain that no dangerous elements or components—like lead, mercury, or PVC—are utilized that could endanger people directly or indirectly.
6. **Long-Lasting and Durable Components:** Give priority to long-lasting goods and materials to minimize the need for frequent replacements.

3.2 Methods

1. **Lifecycle Assessment:** Examine the chosen communication technology's environmental effects in detail at every stage of its lifecycle, from production to disposal at the end of its useful life.
2. **Energy-Efficient Network Design:** Create and plan networks that use the least amount of energy possible. This can entail employing effective protocols, streamlining routing, and giving devices sleep modes.
3. **Smart Grids and Data Centres:** To optimize resource consumption, deploy smart grids and data centres with server virtualization, intelligent load balancing, and energy-efficient cooling systems. Smart grids combine digital technology, sensors, and software to better match the supply and demand of power in real time, lower costs, and maintain the stability and reliability of the grid.
4. **Virtualization and Cloud Computing:** Reduce the amount of hardware needed by consolidating servers using virtualization technologies. Utilize cloud computing to provide shared and scalable resources. To put it briefly, cloud computing is the practice of providing computer services via the Internet, or "the cloud," including networking, servers, storage, databases, software, analytics, and intelligence, with the goal of enabling economies of scale, flexible resource availability, and faster innovation.
5. **Telecommuting and Remote Work:** Promote telecommuting and other remote work choices to cut down on the demand for actual office premises and commute, which will reduce the amount of energy used. Through the use of green communication technology, connectivity has been made possible in rural and distant places where grid power is frequently unstable or non-existent. In order to guarantee that communities may take advantage of contemporary communication services even in these places, solar-powered base stations and other off-grid alternatives have been implemented.
6. **E-Waste Management and Recycling:** Provide a detailed plan for the ethical recycling and disposal of electronic components when their useful lives are coming to an end. Nigeria has difficulties managing its e-waste. There have been initiatives to encourage the recycling and appropriate disposal of electronic equipment, especially communication devices. When green technologies are adopted, their end-of-life phase is taken into account.
7. **Education and Training:** Educate and train employees and end users on energy-efficient and sustainable technology use best practices. There have been initiatives to inform and involve local populations in sustainable technology practices. This includes educating the public about the advantages of eco-friendly communication technologies and the ways in which each person may support environmental initiatives.
8. **Monitoring and Reporting:** Install systems to track carbon emissions, energy use, and other environmental indicators. Report on the goals of green communication technology on a regular basis.
9. **Regulatory Compliance:** Assure adherence to national and international environmental laws and guidelines that control the ICT industry. Regulation and Policy, through legislative and regulatory frameworks, the Nigerian government has taken action to promote the use of green communication technology. This entails sanctions for failing to adhere to green standards and rewards for businesses that make investments in eco-friendly operations.

Continuous Improvement: Review and update the resources and techniques utilized for the implementation of green communication technologies on a regular basis. Stay up to date on the latest technical developments and sustainable best practices to include into your tactics. The adoption of green communication technology has been aided by cooperation between international

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partners, governmental organizations, non-governmental organizations, and telecommunications businesses. This makes it possible to exchange best practices, resources, and information.

Recall that the effective implementation of green communication technology depends on cooperation with manufacturers, suppliers, and other stakeholders. Additionally, to confirm the environmental performance of your technology deployments, think about pursuing certifications and designations (such Energy Star, LEED, or EPEAT).

3.3 Applications of Green Communication Technology

Energy efficiency in wireless networks, cellular networks, mobile networks, vehicle ad hoc networks (VANETs), and smart grids are common green networking and communication applications.

3.3.1 Green wireless communication

The most popular and contemporary kind of communication is wireless. The goal of green wireless communications is to reduce their detrimental impact on the environment and increase energy efficiency. To do this, one can employ green code, green electronics, green base handover, green manufacturing, green electronics, green power amplification, green antennas, and green energy from renewable sources [18]. Green cellular base stations, energy-efficient mobile terminals, green ad hoc and sensor networks, green cognitive radios, energy-efficient signal processing techniques, electromagnetic pollution mitigation, and more are additional concerns related to green wireless networks [26]. Green wires will enable communication that is energy-efficient. The potential benefits of offering green communication across wireless and mobile networks for energy conservation and resource balancing are made possible.

3.3.2 Cellular Networks

The cellular network is the primary energy-consuming element of the mobile industry. Cellular operators are now increasingly concerned with energy efficiency in cellular networks as a result. A radio network composed of cells, or land-based areas serviced by one or more base stations, is known as a cellular network In a typical cellular network, there are three primary components: mobile terminals that are used to create voice or data connections, base stations that offer radio frequency interface, and a core network that manages switching [27]. Green communication technologies are widely favoured and used to achieve energy efficiency.

3.3.3 Green Mobile Communications

Research indicates that mobile providers rank among the largest users of electricity. There is strong evidence to support reducing electromagnetic pollution given the rapid expansion of mobile communications. The production of mobile devices, radio frequency (RF) transmission, battery charging, base station, data centre, and data transit electricity consumption, office and retail operations, vehicle miles, and business travel are some of the factors that affect the carbon footprint of mobile communications [13]. Reducing greenhouse gas emissions and carbon footprint is in line with the trend toward green mobile communications [28]. When not in use, mobile terminals can choose to run in idle or sleep modes to help save power.

3.4 Why A Green Communication Nation?

Environmental Conservation: One of the main arguments in favour of Green ICT adoption in Nigeria is the need to protect the environment. Like many other nations, Nigeria faces issues with regard to pollution, deforestation, and climate change. It is possible to considerably reduce the damage that the computer sector does to our economy by implementing energy-efficient ICT practices, such as updating data centers with renewable energy sources.

Energy Efficiency: We are aware of the ongoing energy problems that our country faces; putting an emphasis on green ICT will help find solutions. Green ICT encourages the use of energy-saving devices and practices, which helps mitigate the effects of energy scarcity. In addition to helping the environment, this increases the reliability and stability of the electrical supply for residences and businesses. In order to lower energy usage, telecommunications companies in Nigeria have begun employing energy-saving techniques include the use of energy-efficient equipment, cutting-edge cooling systems, and better network planning. This makes the operation more sustainable.

Cost Savings: Using green ICT practices would result in significant cost savings both for enterprises and consumers. Organizations can save operating costs and electricity prices by using technologies that are energy-efficient and optimizing resource use. It is imperative to be frugal in a nation where many enterprises are low-income.

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Sustainable Growth: Everyone is aware of the significant contribution Nigeria's ICT sector makes to the country's economic expansion. Nigeria may make sure that its IT industry grows sustainably without using excessive resources or harming the environment by implementing Green ICT. This strategy shows Nigeria as a responsible member of the international community and is in line with the Sustainable Development Goals (SDGs) of the UN.

Global Reputation: As residents increasingly more aware of environmental problems globally, Nigeria can improve its standing overseas by implementing green ICT practices. It will demonstrate our nation's dedication to sustainability and position it as a desirable location for international cooperation and investment.

Job Creation: Green ICT initiatives will generate employment in fields like renewable energy, environmental consulting, and green education training, where experts will educate and train staff members, students, and clients on the advantages and practical uses of green technology. People will be able to acquire the skills necessary to work as green building architects and construction workers, who will plan, design, construct, and renovate buildings that are energy-efficient, water-efficient, and environmentally friendly, as well as engineers and technicians for renewable energy, who will install, maintain, and operate renewable energy systems. These choices might help lower the unemployment rate in the nation.

Access to International Funding: Projects that support environmental responsibility and sustainability are given priority by a number of international organizations and financial bodies. Nigeria can obtain financial possibilities to advance the technical infrastructure by integrating Green ICT into national projects.

Educational Opportunities: By promoting green ICT, Nigerian schools would be able to provide the youths of the nation with knowledge as well as abilities that are sought after globally. As a result, the ICT sector is experiencing an increase in employable and entrepreneurial potential.

Challenges

Environmental laws and growing energy costs are two of the causes driving the demand for energy-efficient networking. One of the primary barriers to the broad use of energy-efficient techniques in real-world networks is the need for them to be integrated into network protocols. The Internet is using a lot more energy since there are more gadgets that are connected to it. The difficulty lies in getting the Internet's operational efficiency to increase faster than the growth of traffic [25]. It is challenging to classify the many sources of energy consumption because there are no realistic or accurate models to aid in the development of protocols and algorithms. Additional challenges include scalability, dependability, interoperability, and security.

4. CONCLUSION

It is hard to disregard the carbon footprint of mobile and wireless technologies given their exponential expansion. Future mobile and wireless networks need to prioritize green networking and green communication. They want to push technology in the direction of "Going Green." Any new technology must be compatible with the natural world. This suggests that even better environmental effects would come from enhanced fuel economy and procedures.

The need for green networking and communication has become more widely recognized. Green communications are necessary for real smart applications. Green networking and communications will be able to meet the energy-efficiency requirements of the next-generation wired, wireless, smart-grid, and Internet of Things networks. They have become the new focal point for the telecom industry. Their ability to create power-efficient, ecologically friendly networks has drawn a lot of interest from academic institutions, commercial companies, and governmental bodies. It has been discovered that telecommunications applications greatly lower power consumption and greenhouse gas emissions. Consequently, companies are adopting eco-friendly hiring, training, and operational procedures.

Nigeria has had an incredible upsurge in digital development and advancements in technology. The advancement of information and communication technology, or ICT, has had a significant impact on the future and the health of our country's economy. Despite this quick expansion, implementing green ICTs needs to be the main priority. The use of technology in a sustainable and ecologically conscious way is known as "green ICT." Implementing green ICT standards is not only an alternative but a must in Nigeria for a number of grounds.

Components and ways Technologies can benefit from green ICT:

i. Redesign of data centres to be more energy-efficient
ii. Eco-friendly storage of information

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iii. implementing green computing practices in data centers
iv. The use of virtualization and cloud computing technologies
v. Eco-friendly networking.. etc.

Beyond issues with the environment, Nigeria places a high priority on green ICT. It transcends social, economic, and international boundaries, making it a vital part of the nation's technical advancement. Nigeria can lead the way for a more pleasant, more sustainable and more wealthy future by implementing sustainable ICT practices. Prioritizing green ICT has several advantages for the nation and its people.

Recommendation

Notwithstanding advancements, problems still need to be solved. It is advised that the following areas receive special attention:

1. Funding Constraints
2. Technological Limitations
3. Regulatory hurdles.
4. Additionally, ensuring that the benefits of green communication technologies are equitably distributed across the country remains a concern.

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