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Green Information and Communication Technology

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Abstract- **This research explores how ICT is used to combat GHG emissions. Green Information and Communication technology benefits the environment by improving energy efficiency, lowering greenhouse gas emissions, using less harmful materials, and encouraging reuse and recycling.**

Keywords- Green ICT(GICT), Greenhouse gases (GHG), Carbon footprint, Information and Communication Technology (ICT), Sustainable Environment

I. INTRODUCTION

Green ICT refers to manufacturing, using, and recycling environmentally friendly and energy-efficient ICT products. These products should pose minimal or no risk to the user or the environment regarding the earth's normal cycles. It also involves using ICT to reduce the environmental impact of human activities and combat greenhouse gas (GHG) emissions in other sectors. [1][2]. Green ICT is "a pioneering approach of using ICT related to the environment protection and sustainability of ICT in the future as well as consists of practices to achieve corporate social responsibility by minimizing carbon footprint, ICT waste and conserving energy [3]. On the other hand, [4] defines green ICT as "the systematic application of ecological-sustainability criteria to the design, production, sourcing, use, and disposal of ICT technical infrastructure as well as within the ICT personnel to reduce ICT, business process and supply chain related emissions, waste and water use; improving efficiency and generate green economic rent."

[5] found that green ICT positively affect sustainability by "lessening direct effects on the environment of the manufacturing, distribution, operation and discarding of ICTs equipment through enhanced energy and resources efficiency, increased use of renewable energy sources, reduced use of toxic materials and improved recycling and end-of-life disposal of ICTs". It also "increase the enabling effects of ICTs on sustainability by reducing energy consumption and demand of materials through the whole or partial substitution of virtual goods and services for their physical equivalents and through the dematerialization of human activities and interactions; by supporting systemic effects it results in the change of behavior, attitudes and values of individuals as citizens and consumers; economic and social structures; and governance processes". Green ICTs is an "organization's capability to analytically apply environmental sustainability criterion (such as pollution prevention, product stewardship, use of clean technologies) to the design, production, sourcing, use and disposal of the ICT technical infrastructure as well as within the human and decision-making components of the ICT infrastructure" [6].

ICTs play an essential role in the economic transformation process, and in addition, they are a vital source of competitiveness for enterprises. However, despite ICTs' benefits, they also contribute to environmental problems, consuming significant electricity and generating carbon dioxide emissions. According to the literature concerning the environmental impact of ICTs, ICT is considered part of the global environmental problem and the solution. It is accepted that ICTs can promote sustainable development [7]. Green ICT or ICT sustainability refers to the efficient and effective design, manufacturing, use, and disposal of computers, servers, and associated sub-systems to reduce energy, emissions, and consumption of resources [8]. Furthermore, green ICT indicates ICT applications that optimize energy usage and create a more sustainable environment. It promotes economic viability and cost-effective management, including the cost of disposal and recycling, while complying with social and ethical constraints. Green ICT has attracted significant interest and has been considered an important issue for several years. It has taken to such an extent that companies are striving to compete with each other in how much "green" they will be. The words "green" and "sustainable" are sometimes used in the literature without discrimination. However, the term "sustainable development" includes not only environmental impacts but also economic and social aspects. Therefore, it can be mentioned that sustainable ICT provides a broader view than green ICT.

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II. CLIMATE CHANGE

Climate change is fast becoming a big concern to both government and industry due to its impact on various aspects of life on the planet. The debate about climate change and its causes is ongoing, and many questions remain to be answered. Some schools of thought suggest that climate change is a natural part of the Earth's evolutionary life cycle; after all, there was no industrial pollution during the formation of the ice ages and other major global climate shifts in the past. They suggest nothing can be done about it; you only have to prepare for it [9] [10]. However, a more popular theory is that man's activities and industrialization cause, or at least hasten global climate change, and it is predicted to get catastrophically worse if immediate actions are not taken. [1] [2] [11]. In recent years, many alarming statistics about the planet's condition and resources have become increasingly available.

Global warming and unpredictable weather are already affecting food production and water supply in some areas; the United Nations Environment Programme (UNEP) has raised some concerns about the continued availability of food and fresh water in some communities due to the effects of global warming and poor management and response to the situation [12]. GHG emission is increasing, and the rising CO_2 levels in the atmosphere are raising the earth's average temperature, resulting in drought and shifting rain patterns in Southeast Asia and Africa [13]. The earth's climate is changing rapidly. An accepted theory for global climate change is that it occurs when there is an imbalance between the energy input to the Earth and the energy output for various reasons. Some known causes of this phenomenon include the effects of CO_2, solar activities, orbital variations, volcanism, etc., [2]. Among these causes is the CO2 level that we can control, which appears to be a major factor in the increasing global warming in recent years. The Effects of global warming can be felt in various aspects of life. For instance, there have been diverse adverse weather conditions in recent times. Incidences of severe flooding are now prevalent; a recent example is the disastrous flooding in Australia and Sri Lanka, where whole towns were completely submerged under seawater, killing many people, destroying homes and businesses, and costing billions of dollars in damage to crops and coal exploration. [14] Europe experienced the coldest December since records began over one hundred years ago [15]. It was probably caused by high temperatures that allowed unusually high air pressure to build up and block the mild westerly winds, which brought in frigid air from the Arctic. This event disrupted many businesses, travel, and general economic activities, slowing the recovery in many European countries and other parts of the world. The global average temperature is rising, forecasted to rise by up to 6.4^{o}C by the end of the century. This rising temperature continues to drive more bad weather phenomena like typhoons, tornadoes, and tsunamis in many parts of the globe [1] [2]. Sea levels will continue to rise as more polar ice melts due to rising temperatures at the poles, resulting in more flooding in lowland and coastal areas. The Emission of greenhouse gases (GHG), the gases driving this global warming, is increasing worldwide. It is estimated that GHG Emissions have risen by more than 70% since 1970 (IPCC) [2], as shown in Fig.1, and it is expected to rise more as heavily populated economies like China and India become more industrialized with their increasing energy demand, while their emission and environmental laws remain porous. A major contributor to CO2 emissions is the consumption of fossil fuels for personal and industrial use. The United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) has given comprehensive evidence that human activities contribute immensely to global warming [16]. These activities include burning fossil fuels to generate energy for growing and sustaining our GDP. The present global contribution of ICT to GHG emissions has been estimated at 2-3% [1] [3]. Still, it is expected to rise as the popularity of ICT grows and its use proliferates in more businesses worldwide for efficiency and convenience. Although ICT devices and activities generally don't emit GHGs directly, their Carbon footprint contribution streams from the massive amount of electrical energy used to keep them running and cool. This electrical energy is produced in plants that burn fossil fuels like coal and natural gas that release much CO2 into the atmosphere [9]. This is called Secondary or indirect emission, as shown in Fig.2 (Indirect effects refer to reducing GHG emissions in other sectors, e.g., transportation, power, buildings, industry, agriculture, forestry, and land use, by delivering so-called smart solutions). Estimating how much they contribute to the global average GHG emissions is sometimes difficult. So, the more electrical energy a facility or device needs to run, the more carbon footprint it is said to contribute to the GHG equation. Some reports suggest that CO_2 emissions may double every five years [17] as more ICT activities, especially data centers, are established and require huge amounts of energy to keep them running and cool. For instance, it is estimated that data organizations like Google may require as much electricity to run and cool it as the electricity required by a small city [18]. The energy consumed by ICT can sometimes be enormous, like the millions of PCs, servers, and mobile phones being manufactured and used (powered) every day worldwide. ICT Equipment like PCs and mobile phones are continuously discarded after just a few years of use. About 100 million Europeans discard their phones after just about one year of use [11], in addition to the 16 - 50 megatons of waste PCs and monitors disposed of annually worldwide. This could pose problems with proper disposal and how to prevent hazardous contaminants from this end-of-life equipment from being introduced into the environment.

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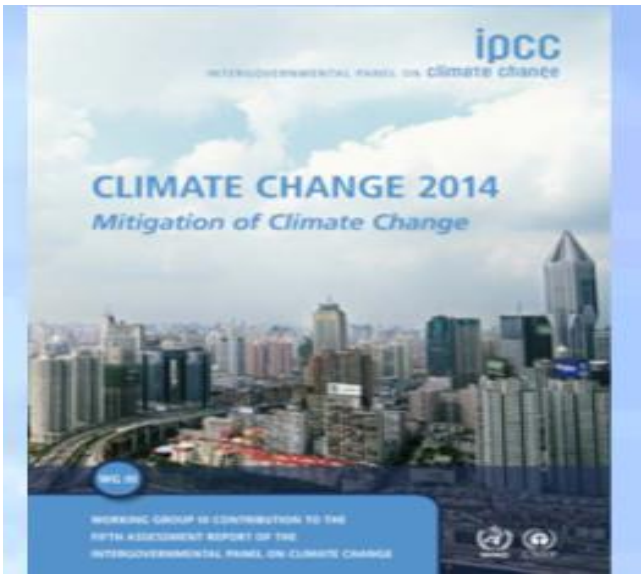
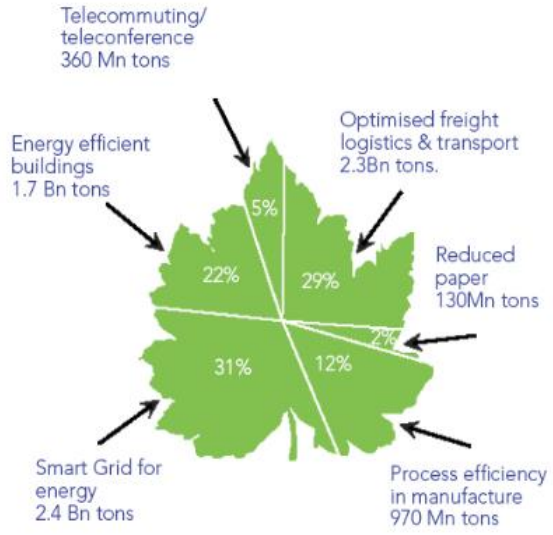


Fig. 1. Climate Change



By 2020, GeSI forecasts a 15% global reduction. in emissions by applying ICTs, some 7.8 Bn tons

Fig. 2. Impacts of using ICT on greenhouse gas emissions

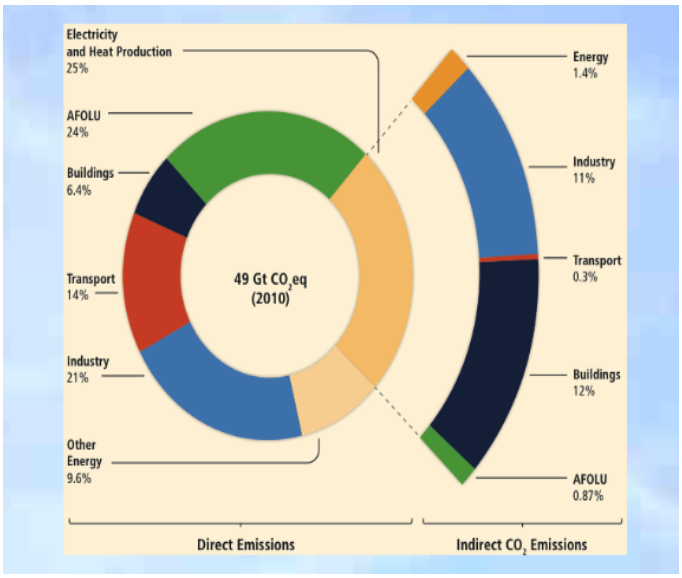


Fig. 3. GHG Emissions by Economic Sector

III. ICT FOR GREEN AND SUSTAINABILITY

Using green ICT initiatives, we solve environmental problems and ensure sustainability. The environmental management with ecological data". Green ICTs is a specific process that focuses on the greening of ICT this involves making the ICT sector green and greening by ICT consists in using of ICTs to transform socioeconomic sectors [21] as shown in Fig.3. Greening of ICT involves "Power management solutions are focused on reducing the energy consumption of ICT resources and using alternative environment-friendly energy sources; Software and deployment optimization solutions concentrate on reducing the number of ICT hardware components and increasing the products' lifespan and material recycling initiatives take care of environmentally friendly utilization of used ICT equipment and establish standards for hardware products' manufacturing". According [22] report defined greening by ICT according to [23] categorization such as the use of "Smart motors technologies shown in Fig.4 and Fig.5 to reduce the energy consumed by industrial motors, or support industrial process' automation; smart logistics technologies that enable fuel reduction and energy efficiency through improved route and load planning" i.e., the application of information technology to improve the efficiency of the transportation infrastructure; deployment of advanced sensors, analytical models and ubiquitous communications enable: less polluting forms of transport, reduced congestions, fewer and shorter delays, enhance operating capacity, improve safety e.g. bus lane management and transport smart cards make public transport more attractive, road charging reduces congestion and fleet logistics, tracking and telematics optimize vehicle efficiency, freight logistics, and air traffic control management. Mobile-

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enabled initiatives such as fleet tracking systems, load optimization, onboard telematics, and synchronized traffic and notification systems can facilitate better communication and trip planning and drive a reduction in GHG emissions; " Fig. 6 shows smart buildings solutions that maximize energy efficiency in buildings, such as building management systems that run heating and cooling systems according to occupants' needs," i.e., building optimization and energy management systems - use of sensors and controls including smart meters, smart appliance, and low energy lighting in buildings to improve efficiency. It is estimated that more than 40% of the energy consumption in Europe is building-related (residential, public, commercial, and industrial). The Action Plan for Energy Efficiency estimates that the most significant cost-effective energy savings potential lies in the residential (around 27%) and commercial buildings (about 30%); "smart grids digital technologies that allow greater visibility of energy use and power flows and dematerialization where substitution of high-carbon products and activities with low-carbon alternatives, such as replacing paper bills with e-billing." This provides numerous opportunities to replace existing processes and technologies with software solutions and e-services. [24] argues that green ICTs support "the construction and improvement of the natural environment and resources surveillance systems, as a means to protect and restore natural ecosystems, i.e., deploying smart meters and communication technologies within the electricity sector, implementing integrated renewable solutions - use of simulation analytical and management tools to enable wide deployment of renewable energy. As the smart grid shown in Fig.7 is in the process of radical change, ICTs will play a major role in reducing losses and increasing efficiency as well as in managing and controlling the distributed power grid to ensure stability and reinforce security as well as in supporting the establishment of a well-functioning electricity retail market. The multiplication of local energy networks, the integration of renewable energy sources (RES), the spread of co- and micro-generation (micro-grids, virtual power plants), and new user demands require the use of the most advanced technologies for monitoring and control as well as for electronic trading of electricity. The Power Management System (PMS) balances energy demands with the available energy supply, preventing operational disturbances or blackouts. Furthermore, it enables a company to control its energy costs and enhance safety. PMS can monitor and control electrical devices. Smart meters will allow consumers to better manage their energy usage by providing more detailed information about their consumption, allowing them to save money on their power bills and reduce greenhouse gas emissions. Further, regarding climate change management, "ICT-enabled optimization can provide great savings in production through tailored mass production, the utilization of production lines, the optimization of raw material usage, and preventive maintenance." "Recycling is seen as a source of raw material and in terms of energy production, the use of renewable energy sources is increasing, mainly due to the politics of global warming."

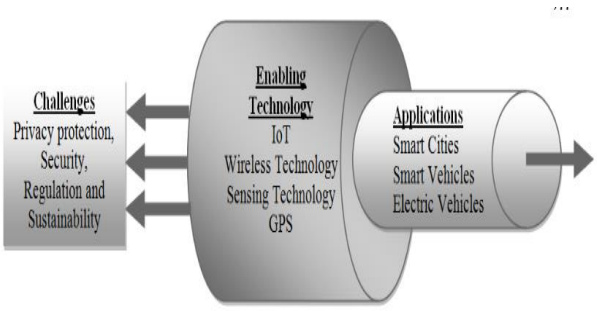

Fig. 4. Smart Transportation's enabling technology, applications, and challenges [25]

Fig. 5. Smart Logistics [26]

Fig. 6. Integrated Building Management System [27]

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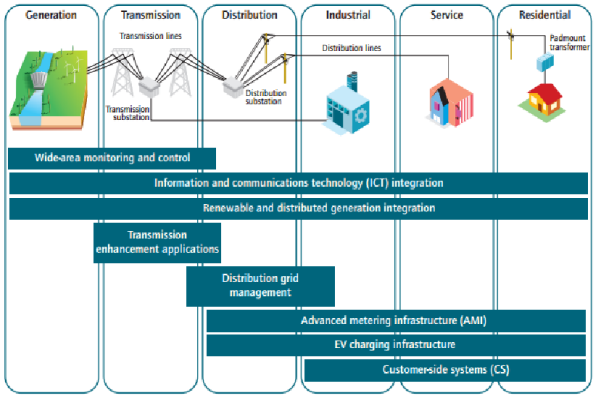

Fig. 7. Evolution to the Smart Grid [28]

IV. CONCLUSION

Green ICT is a broad and evolving subject, and the debate continues. Still, the beauty is that everyone agrees that being green will eventually mean saving money for everyone, which is a good incentive for everyone to get involved in energy efficiency. The potential for ICT to be green while helping other sectors to be greener is enormous. Many people are already taking advantage of this, which will likely increase as ICT becomes faster, more reliable, and cheaper.

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