7-R Model and Green ICT: Tools promising sustainable future and solutions to climate change

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Abstract: *"The problem of climate change is so large that it can't be solved by voluntary individual responses. It requires an economy-wide solution that limits the total carbon intake of the economy."* - Peter Barnes a sustainable business innovator. This quote epitomizes the imperative to embark upon climate change and environmental degradation caused due to the resource consumption of our modern lives signifying us to preserve and create better environment for next generations. According to the World Meteorological Organization (WMO), last decade (2001-2010) was officially proclaimed as the warmest decade, measuring averaged sea level 20 cm higher and most active decade in terms of tropical cyclone activity alarming the issue of sustainability. On the other dimension, information technologies have become more integral part of our lives than ever. Generations are trying to reach and to process huge size information leading to inventions and evolutions of technologies to increase efficiency of data processing; simultaneously on the other hand, advancements in hardware manufacturing are producing systems that are more powerful with increased performance but this race for data processing and communication is causing larger size carbon footprints on our environment than ever. We are on the edge of sustainability and must take corrective measures to ensure that the carbon footprints will shrink by minimizing Green House Gas (GHG) emission and hence defining new standards of green Information and Communication Technologies (ICTs) by engineers, by academicians and by practitioners in order to meet objectives by practicing green approaches. ICT industry has two major challenges: to minimize its own footprint (2% of global carbon foot print) [1] and to minimize footprint (98%) caused by other units. In this paper I discuss the promising possibilities of use of ICTs to obtain green objectives - by practicing green use (minimizing energy consumption), disposal (reuse, recycle and refurbish), design (energy efficient), and production (with non-hazardous chemicals) of products. ICTs compromises of – end user devices (EUDs), telecommunication networks and data centers accounting for 25% (and growing) of global commercial energy consumption. EUDs has largest footprint with 59

percent of ICT emissions with Personal Computers (PCs) making 60 percent within it. SM represents saving opportunity at $20-$60/PC/year [2]. ICT application areas for achieving green objectives are spread over – industrial process automation, transport optimization, smart buildings/grids/motors/logistics and dematerialization (tele-working) suggesting total savings of 7.82 $GtCO_2e$ in GHG emissions by 2020 [3]. In this paper, I introduce the innovative 7-R model [4] of green practices that is the extension and improvement of traditional 3-R model – Reduce, Reuse and Recycle.

Keywords: Information and Communication Technology (ICT), Green House Gas (GHG), $GtCO_2e$: Giga tones of CO_2 equivalent, 7-R Model.

1. INTRODUCTION

The undesirable appetites for the resources are causing excessive exploitation of resources while its effects on environmental stability remain majorly ignored. The environment includes every living and non-living entities around us and ourselves and attempts to maintain balance through various cycles. But human activities like pollution, population growth, urbanization and industrialization is exceeding the carrying capacity of the environment to repair or replace itself, leading to severe environmental degradation and environmental instability. Environment is continuously giving many warning signs us by means of environmental factors like - floods, droughts, famines, cloudbursts, cyclones, scarcity of natural resources, extinction of some species (are we next?), by means of economical factors like - inflation and recession and social factors like - disruptions to clean water and electricity, transport, communication, mass migration, strikes and wars. While the awareness about environmental issues appears increasing at all the levels of society ranging from governments - non government organizations, policy makers, practitioners, researchers, academicians and even at a laymen level; more actions need to be taken than existing actions. The 7-R model and green ICT prove effective methodologies to take new steps and enhance the steps taken for tackling climate change and for addressing environmental problems posed to us by ourselves.

2. GREEN ICT

Electronic information processing, exchange and communication have turned out to be key necessities of modern life making ICT devices as integral part of our workplaces and homes. ICT has great potential to revolutionaries the focus of serving society and industry in an

efficient and sustainable manner. ICT can reduce its own footprint (green of ICT) and footprint of others which are lingering for solutions (green by ICT). ICT devices include cellular and Public Switch Telephone Network (PSTN), data center/servers, internet and networking devices, infotainment systems, satellite television, mobile devices, PCs etc. As per predictions, energy consumption of ICT will be doubled by 2022 and tripled by 2030 compared to the level in 2010 [5].

In the terminology 'Green ICT' (fig. 1) green imply reduction in energy consumption, GHGs emissions, waste produced and materials used while ICT represents devices and technologies which are responsible for creation, processing, storage, transmission and/or presentation of information in any human or machine readable form.

Fig. 1: The components of green ICT

In this paper I briefly discuss classes of 'Green of ICT' in 2.1 and will discuss more about 'Green by ICT' in 2.2 as that can have its impact on 98% of global carbon footprint.

2.1 Green of ICT

ICT accounts for 25 % of commercial energy consumption for its operation excluding its manufacturing, transportation and disposal. It emphasizes the need of advancements in recent technologies to take up the challenge of greening of ICT services and ICT devices (fig. 2).

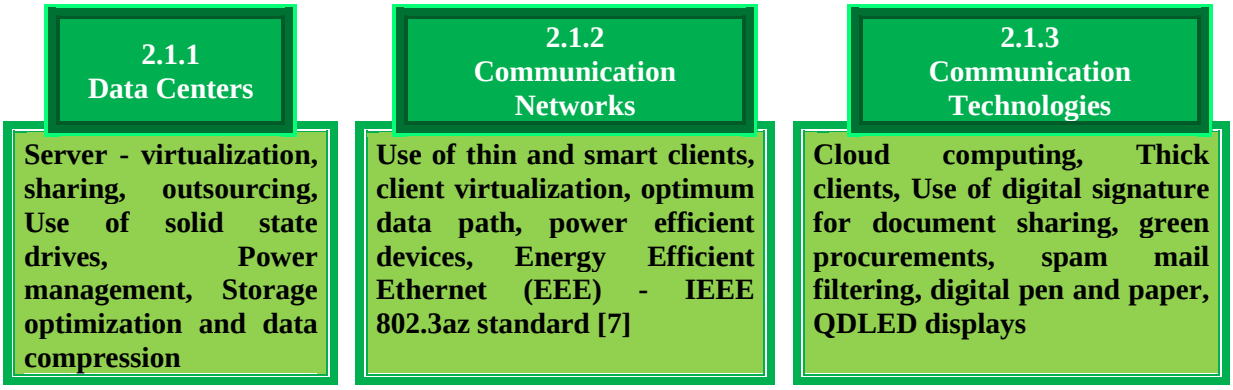

Fig. 2: Showing the components of green of ICT

Digital universe is so vast that it now exceeds available storage space. According to an International Data Corporation (IDC) white paper, the amount of information either created, captured or replicated in the year 2007 was 281 Exabyte. In 2011, the amount of digital

information produced in the year should equal nearly 1,800 Exabyte, or 10 times that produced in 2006. [6] (1 Exabyte = 10^{18} bytes = 2^{60} bytes).

Network devices and network interfaces account for more than 10% of total ICT power usage [7]. This usage can be minimized by techniques listed in 2.1.2. Some behavioral steps towards greening include green procurements, spam mail filtering and minimizing search operations. Average email user is responsible for 28.82 kg with global estimate of 17 million metric tons of CO_2e emission of annually [8]. Google spends about 0.3 Wh of energy translating to roughly 0.2g of CO_2 per search query resulting in 1677423 metric tons of CO_2e emission annually [9]. Use of papers can be minimized by use of digital signature in document sharing and duplex printing (minimizing CO_2e emissions by 1,360 tons/year).

2.2 Green by ICT

Success of using ICT to green the organization depends on 3 factors - ***motivational factors:*** competitiveness, legitimating and social responsibility, ***organizational factors:*** support from senior management for environmentally sustainable initiatives and organization capability and ***technological constraints:*** organization's ability to begin with Green ICT initiatives.

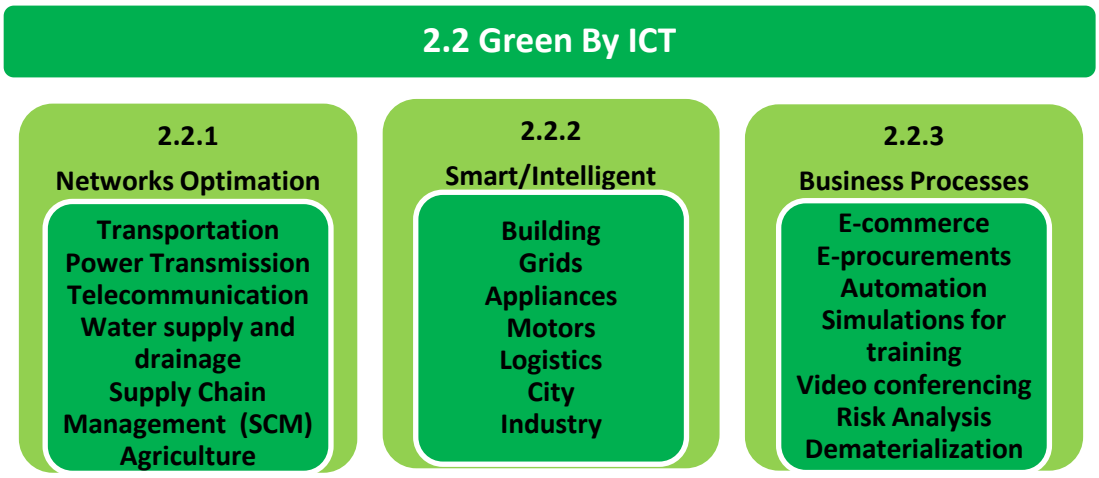

Fig. 3: Showing the components of 'Green by ICT'

2.2.1 Network Optimization:

ICT can optimize all sorts of networks - transportation, power transmission, water, supply chain, telecommunications, etc. by minimizing structural and operational cost and by maximizing the throughput. In agriculture sector [10], data collected at national level with ICTs is applicable to adjust policies, to improve food safety and traceability, to predict food supplies, to strengthen marketing and to select appropriate cropping practices.

2.2.2 SMART (Self-Monitoring, Analysis and Reporting Tool):

Intelligent tools enable better use of energy in buildings, transport, street lighting etc. It can also facilitate the integration of locally generated renewable energy into the main electricity grid [11]. Intelligence can also be used to improve performance of motors, appliances and logistics. These tools need to globally standardized and generate the need to secure concerns of collected data.

2.2.3 Business Processes:

As per eMarketers' forecast, Business-to-consumer (B2C) ecommerce is expected to increase by 20.1% this year to reach $1.500 trillion thereby saving movement of customers and reducing traffic load. Simulators designed using ICT for pilot training save valuable aviation fuel and make the pilot and the plane life risk zero. ICT tools benefit supply chain, manufacturing and packaging processes in minimizing the waste produced and the movement of material in production line.

3. SUSTAINABILITY

Sustainability means the better quality of present and future life in community ensuring that dimensions of sustainability viz. environment, economy and society are healthy, productive and balanced. We need broad vision for understanding of the links (Fig. 4) between these dimensions as tackling problems in isolation can make another problem worsen.

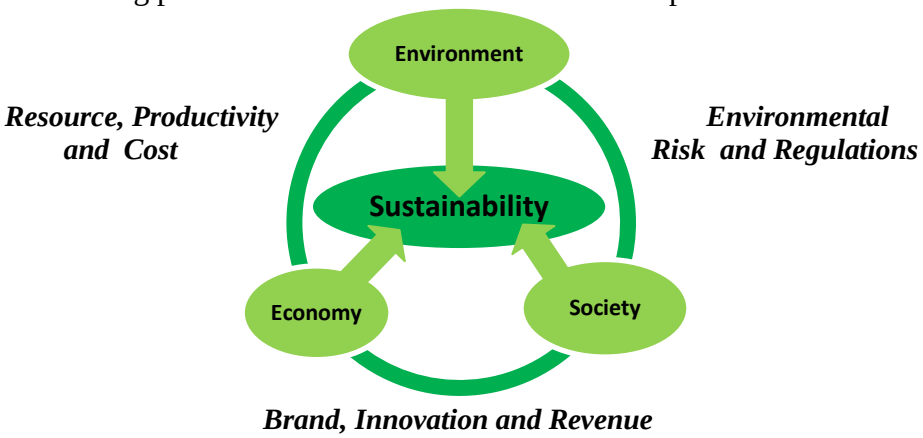

Fig. 4: Three major dimensions of sustainability and mutual relationship between these dimensions

Among many definitions of sustainability available in literature those are given by practitioners, organizations like United Nations, Department of Commerce, etc. We try to define sustainability as "*Use of innovative engineering, technology, design solutions and rational approach that establish harmony and balance between environmental, social and*

economic practices and benefits ecosystem as a whole by meeting present needs of all in manner to retain the ability to meet future needs of all."

4. SUSTAINABILITY AND ICT

Sustainability and ICT are two sides of same coin having tremendous potential to improve each other mutually in cyclic fashion (fig. 5). Four key factors with largest ICT impact are energy, carbon, e-waste and water [12].

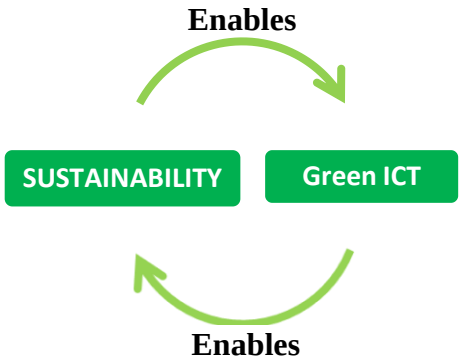

Fig. 5: Cyclic relationship between Sustainability and Green ICT

4.1 Sustainability in ICT

Higher environmental impacts (almost 80%) often occur before and after the use phase of ICT products. Hence it is essential to understand manufacturing and disposal of ICT products and to structure policies and programs. Toxic chemicals are often produced in mining of ores, extraction of metals and recycling of products. In the first stage, company must recycle and select material in way to minimize the impact of all stages. In PC and integrated circuit (IC) manufacturing industries, hundreds of hazardous chemicals are used causing death of thousands while others are dying or diseased [13]. Empirical research has shown that the production of each PC uses 22 kg of toxic chemicals, 240 kg of fossil fuels and 1,500 kg of water [14].

4.2 ICT in Sustainability

Manufacturing is significant producer of GHGs at 14.8 $GtCO_2e$ making 31.4 % of global emission. ICTs that playing fundamental role in dynamic growth by enabling trade, global connectivity, productivity and value creation gives future hopes in betterment of manufacturing process. Research shows that with automation of industrial processes and optimization of variable speed motor systems abatement potential of ICT in manufacturing is 1.25 $GtCO_2e$ [2]. Some effective technologies are Computer Integrated Manufacturing,

wireless monitoring, sensing and remote controlling, computer vision, data mining and data warehousing for predictive analysis and decision support system, simulation and modeling.

5. 7-R MODEL

More often we encounter the old dictum: "3R's: Reduce, Reuse and Recycle." I believe the need for extension of this 3R model. I have proposed 7-R model (fig.6) and all steps of it can directly be applied in industries and even everyday life of an all individuals.

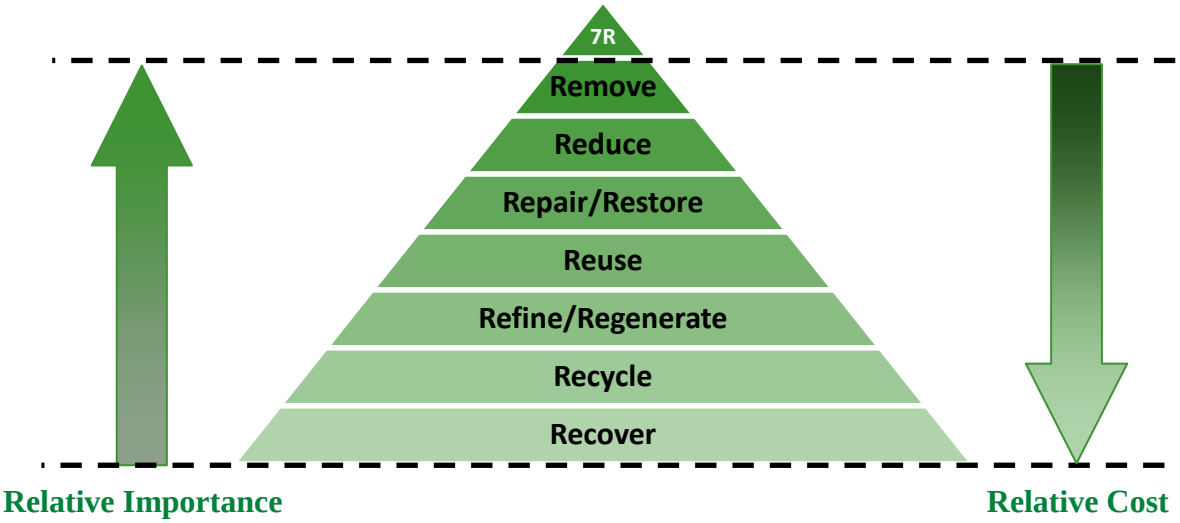

Fig. 6: 7 R's model: Relative importance and implementation cost increasing in direction of arrow

These 7 R's described in general are:

1. **Remove:** Abolish the use of helpful but harmful chemicals and practices
2. **Reduce:** Optimize the use of resources – use only if essential
3. **Repair/Restore:** Fix problems and broken items instead of throwing.
4. **Reuse:** Do not apply "use and throw" methodology directly. Try to find alternate uses of products and use those again.
5. **Regenerate/ Refining:** Best from the waste i.e. remove impurities and enhance collected waste like waste oil.
6. **Recycle:** Extraction of core elements of waste products to use as raw materials in manufacturing of new goods.
7. **Recover:** Explicitly, this step signifies the recovery of energy and toxic chemicals before and/or after disposal. For example, around 76% of waste sector emissions are caused by methane released from solid waste in landfills; can we capture and use this

methane! Implicitly it signifies to help to recover the environment to its original state by planting trees, harvesting rain water, protecting flora and fauna.

5. CHALLENGES AND HOPES: CHALLENGING BUT FEASIBLE TARGETS

While the opportunities and hopes are abundant, yet we have to travel a challenging path to achieve the sustainability and path that has many obstacles and barriers. Some of the major technical challenges are inadequate ICT-based informed decision- making, least awareness about Green ICT, lack of matured inter/multi-disciplinary software tools and issues related to availability and reliability of data. Some more challenges include contradictory standards, government apathy and lack of incentives for green practices. To achieve success on this path we need universal agreement on what sustainable means? Impact of ICT in mitigation of the climate change is estimated the reduction of 7.82 $GtCO_2e$ by the year 2020, equivalent to 5 times the ICT's and to 15% of global footprint [2]. European commission proposed a 10 year 'Europe 2020' strategy aiming at minimum 20% reduction in GHGs emission and energy consumption while making renewable energy share 20% of total energy consumption [15]. Initiatives by industries (like TI, HP and Fujitsu) towards sustainability are brightening the hopes towards achieving these green targets - some green initiatives are 'Sustainability Map' by SAP, 'Smart Planet' by IBM, 'Environmental Vision' by Hitachi and 'Google Green'.

6. CONCLUSION

We wish to end our work with an optimistic note. We can firmly believe that (Green) ICT promises plenty of opportunities towards better world of tomorrow by enabling us to shrink our ever larger carbon footprint. Green ICT practices not only favor the environment but also boost the economy and industries by means of automation and optimization. It is fortunate that many governments and businesses view sustainability as means to enhance competitiveness and human well-being by reducing costs and long-term risks. Looking at phenomenal growth of industries; we need to scale up existing innovative approaches and manufacturing models in order to sustain competitiveness with no harm to environment. The contradictory economic, social and environmental requirements, constraints and criteria often lead to difficulties in optimal decision making in implementation of policies. The effectiveness of decision making can be improvised with statistical models that makes decision making formulized and standardized than being done heuristically. Global awareness about environmental issues, green economy practices and initiatives taken by few

governments gives positive hope and presents opportunities for accelerated eco-friendly progress. We request everyone to play significant role in increasing awareness among society towards environmental issue and long term sustainability. We can contribute at individual or at organizational level applying 7-R model in every possible micro to mega activity of our life. We conclude our paper with quote by famous scientist, Albert Einstein, "*Problems cannot be solved at the same level of awareness that created them.*"

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