ICTs, the Environment and Climate Changes

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Abstract—Even if Information and communication technologies constitute one of the sources of climate degradation, this sector can now provide a plethora of solutions to mitigate and adapt to this adverse impact Indeed, ICTs have a major role in improving environmental performance and addressing climate change across all sectors of the economy. ICTs can help reduce energy consumption and manage scarce resources. High-impact areas include urban infrastructures, buildings and the energy sector. ICT applications also enable monitoring and responding to pollution, biodiversity loss, land use patterns, desertification, etc... Today, many governments have established policies and programmes on ICT covering increasing Green ICTs applications and promoting environment related. The purpose of our paper is to expose the potential role that Information and Communication Technologies (ICTs) play at different stages of the process of climate change, from contributing to global warming to mitigating its impact on environment and developing solutions either in other sectors like energy, transport and buildings.

Keywords — Climate Changes, Green House Gases, Global warming, Information and Communication Technologies (ICTs),

1 ICTs AND ENVIRONMENT

ICTs play both positive and negative roles for environment. Positive impacts concern dematerialization and online delivery, transport and travel substitution, a host of monitoring and management applications, greater energy efficiency in production and use, and products reuse and recycling. Negative impacts are those coming from energy consumption and the materials used in the production and distribution of ICT equipment, energy consumption in use directly and for cooling, short product life cycles, greenhouse gas emissions and e-waste, and exploitative applications The impacts of ICT on the environment can be direct (*such* as energy consumption and e-waste), indirect (the impacts of ICTs applications, such as intelligent transport systems, buildings and smart grids). Today, ICTs impacts on environment are widely discussed in developed and developing countries. Nevertheless, the indirect enabling impacts of ICTs are greater, and a number of studies have identified potentially significant net positive impacts from ICTs.

In this paper, we will present the two roles played by ICTs in environment: the negative and the positive. After that we surround policies putted on by governments to improve green ICTs and to promote the good role that can play ICTs to limit climate change and preserve environment.

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2 ICTs NEGATIVE EFFECTS ON ENVIRONMENT

The relationship among ICTs and the environment is often examined in terms of three distinct kinds of effects [1, 2, 3]:

- First-order or direct effects, which arise from the design, production, distribution, maintenance and disposal of ICT goods and services by the ICT industry.
- Second-order or indirect effects, which arise from the application and use of ICTs throughout the economy and society, in government and public institutions, and in the research and academic communities.
- Third-order or systemic effects, which arise from changes in economic and social structures and behaviour enabled by the availability, accessibility, application and use of ICT goods and services.

And in term of used indicators to measure ICTs effects on environments we have the followings:

2.1 Resources consumption

Consumption of paper is continuously increasing by the world. In the same time however, the capacity for electronic information storage is developing widely. According to [4], in the United States annual paper consumption rose from 7 to 22 million tonnes between 1956

and 1986. If there is indeed a replacement effect, for example when documents are sent electronically rather than by traditional postal services, the increase in paper consumption is explained the increased possibilities for printing offered by using ICT.
A study conducted by Ispos Global4 thus estimates that 43% of French people print up to 50 pages a day thanks to easy access to information, 20% admit to printing out all the documents they receive so as to be able to read it on paper. In the private sector, the prize for paper wasting is given to the supermarket sector, with 40% of pages printed out unnecessarily.

2.2 Transports

Due to ICTs there is a certain amount of energy saving by suppressing the need to displace to get information, but these savings are very much compensated for by the transportation of the books and revues. It is thus the transportation of merchandise that makes the energy bill higher.

2.3 Energies consumption

ICTs represent only about 3% of total electricity consumption [1]. Nevertheless, the electricity consumption needed to supply and cool the data centres in the world represented almost a quarter of all the CO2 emissions generated by the IT industry. It thus seems difficult, at the present time, to establish a clear review of electricity consumption as the various sources give contrasting responses. The idea of minimal consumption nevertheless does not seem very probable.

2.4 Greenhouse gas emissions

Estimates of the direct impacts of the ICT industries vary with the definition of the industry and coverage of ICT-related energy uses, but the production and use of ICT equipment is estimated to be equivalent to 1% to 3% of global CO_2 emissions (including embedded energy) and a higher and growing share of electricity use [3]. This corresponds to the level of emissions of one of the most pollutant sectors : air transport. In 2006, it was estimated that ICT equipment (excluding broadcasting) contributed around 2 to 3% of worldwide Greenhouse Gas (GHG) emissions – 40% of this was reported to be due to the energy requirements of PCs and monitors, 23% to data centres, 24% to fixed and mobile telecommunications, and 6% to printers [1]. More recent life cycle assessments produce broadly similar results [2, 4]. Data centres are a particular focus, and the worldwide electricity use for servers is increasing very highly year by year

2.4 Waste production

In the life cycle of ICT, several stages result in pollution. The first is the production stage, followed by the usage stage and finally that of the end of life stage. If we look at the production phase, we can see that this activity is highly polluting, given that only 2% of the raw materials used in the production of ICT can be found in the finished product, with the remaining transformed into waste. A computer contains 1,000 different materials from all over the world, including lead, cadmium, barium, beryllium... If the life expectancy of a computer in 1997 was 6 ans, it was only two years in 2005, and it is calculated that there will be 1.3 billion computers in the world by 2013 [5,6]. It has been observed that moore than 50% of the waste obtained from electrical or electronic equipment is either incinerated or covered without any form of pre-treatment. Many of the pollutants found in municipal dumps come from electrical or electronic equipment, and more than 10% from this WEE comes from ICTs. According to Consumer Reports, only 10% of the computers thrown away are recycled "in a responsible manner". Roughly 80% of the electronic objects thrown away are currently sent to developing countries [7]

3 ICTs SOLUTIONS FOR BETTER ENVIRONMENT

3.1 ICTs "good" role for environment

Besides their negative impacts on environment and climate, ICTs play an important role in mitigating global warming and it's effect on environment.In addition to the fact that ICTs are helping dematerialization and de-carbonisation of the economy, we can say that

- ICTs are reducing travel, through providing services such as:

tele-and video-conferences
teleworking/telecommuting
Internet services such as e-commerce, e-government and distance learning
coming up with new ways, as yet undreamed of, to help other sectors minimise climate
change emissions

- The move from narrowband to mass market broadband gives the Internet levels of diffusion, acceptance and functionality that will enable it to be potentially disruptive.

- Two developments, both still ongoing, have accelerated this tendency:

for corporate users, IP in the enterprise
for domestic users, broadband becomes a mass market service

3.2 ICTs solutions for environment and climate change

Three principal themes illustrates how ICT can make a big impact on energy efficiency and there so on environment preserving. The three themes are detailed by examples and case studies in [9].

Smart buildings

Buildings represent nearly 40% of primary energy used on average globally, and between 25% and 40% of energy demand in OECD countries2. Including the energy consumed in building construction, this number grows to more than 50% and is rising fast thanks to economic development and a construction boom in countries like China and India. The Intergovernmental Panel on Climate Change (IPCC) has estimated that CO2 emissions from building energy use could be reduced by 29% by 2020 at no net cost. Other studies have indicated that demand reduction measures could almost halve the expected growth in global electricity demand.

The four measures that can have the biggest impact on the energy efficiency of buildings are: insulation; heating, ventilation and cooling (HVAC); appliances (including lighting); and behavior of occupants8. Energy efficient roofs and walls can prevent air leakage, reducing the load of HVAC systems by as much as 50%. Building automation systems aim to optimize efficiency in HVAC and appliances, while enabling occupants to have more direct impact on energy use. These systems rely on information and communications technology as the network backbone, as well as for two-way communication of data that impacts energy distribution with buildings |9].

Smart grid

The generation of electricity is responsible for about 40% of global CO2 emissions, presenting an enormous opportunity for savings due to smart grid/metering technologies.10 Improving the efficiency of the U.S. electricity grid by 5% would alone be the equivalent of eliminating the fuel use and carbon emissions of 53 million cars.

Information and communications technology plays a significant role in enabling the transformation to the smart grid. A 2008 study from the Electric Power Research Institute (EPRI) calculated that ICT could reduce America's electricity usage by 200 billion kilowatt-hours, or 4.3% by 2030.11 That could prevent the release of more than 200 million metric tons of carbon dioxide emissions by 2030 [8,9].

Just the communications portion of the global smart grid deployment is expected to be worth $20 billion a year over the next five years, according to Cisco12. That includes functions such as integrated communications among components of the grid, sensing and measurement technologies, and improved interfaces and decision support for grid operators.

Information and communications equipment and software is poised to help the electricity industry make the transformation from a centralized, producer-controlled network to one that enables visibility into generation, transmission and usage. Essential (but sometimes less visible) infrastructure projects are underway, including transmission upgrades, substation automation, and distribution automation.

The technology area that show the greatest potential for energy savings in the near-term, are in-unit displays that let users view real-time energy use and pricing. Utilities across the globe have pledged to deploy extensive smart meter installations during the next decade, using devices from companies Also in use today are demand and response systems, which control the use of power to avoid blackouts and reduce peak-time consumption. Enhanced demand response systems are still being developed that use two-way communication to power down equipment to avoid blackouts or reduce the amount of power consumed at peak load times [9, 10].

Smart logistics

Recent studies have been aplenty on the savings that can be achieved through technologies for smart buildings and smart metering/grid. There are fewer on logistics. ICT-driven applications across logistics could achieve an important reduction in total global emissions of CO2, by improving the efficiency of logistics operations in a number of ways. These include —software to improve the design of transport networks, allow the running of centralized distribution networks and run management systems that can facilitate flexible home delivery services. Specific levers include intermodal shift, or moving to the most efficient type of transport, eco-driving, route optimization and inventory reduction [2,9]. Import and export trade relies on cost-efficient supply chain management, including freight and distribution. Those costs are directly correlated to the consumption of natural resources such as oil and gas, meaning that efficiency of spending frequently results in energy efficiency.

The boom in manufacturing and consumption in developing nations will lead to increased market opportunities for third party logistics providers. Information technology holds promise to address these challenges but has not been widely deployed.

4 GREEN ICTS STRATEGIES

4.1 Objectives

ICTs are transformative technologies which put intelligence at the edges of networks, thereby maximizing users capacity to create and adapt. Examples of such transformation include using ICTs to improve practices in agriculture and forestry; monitor air and water pollution and prevent by the way the climate change; improve disaster warning and relief; improve the efficiency of the energy, transportation, and goods and services sectors; and harness social networking for transformative change.

For all these reasons, governments and business associations have introduced a range of programs and initiatives on ICTs and the environment to address environmental challenges, particularly global warming and energy use.

Reducing the *direct* environmental impacts of ICTs (energy consumption and CO2 emissions during *ICTs use*)is the most frequent objective of governments and businesses. Over two thirds of governments programs focus on greening ICTs. The high concentration of programmes and initiatives targeting energy consumption shows that many of them have both economic and environmental rationales Other environmental impact categories such as biodiversity, water or land use are rarely targeted, despite ICTs impacts (*e.g.* water consumption in ICTs production, or the impact of dematerialisation on land use) [10, 11]

Government programmes cover the domains of R&D, ICTs diffusion. The objectives are multiple:

-Stimulating R&D and innovation: R&D programs are the most common and focus on developing resource-efficient ICTs

-Increasing Green ICTs diffusion and ICT applications: the largest group including green ICTs diffusion to businesses.

-Promoting environmental-related ICTs skills and awareness: Measures including increasing awareness and knowledge of consumers and users of the environmental impact of ICTs as well as the advantages in using ICTs applications.

4.2 Governments Strategies and policies

An increasing number of governments are seeing ICTs as an important part of their strategies for tackling environmental problems and have established policies and programmes on ICT and the environment. These policies, cover R&D and innovation, Green ICT diffusion and ICT application and usage, and education on ICT and the environment and promoting environmental related ICTs skills and awarness. Some governments focus on a single policy such as Australia's *Minimum Energy Performance Scheme,* which includes mandatory eco standards enforced by the Australian government legislation. Others, such as Denmark's *Action Plan for Green IT* sumarized as fellows, include several policies

Denmark's *Action Plan for Green IT [1]*

Focus area 1, "Greener IT use", includes four initiatives aiming at reducing the environmental impact of ICTs:

- The first aims at reducing the environmental impact of ICT usage within companies, mainly by promoting green ICTs to businesses.
- The second focuses on promoting greener ICT usage by children and young people through an information campaign.
- The third focuses on Green ICT guidelines for public authorities.
- The last initiative in focus area 1 aims at providing a —knowledge base for energy and CO2 calculation.

Focus area 2, "IT solutions for a sustainable future", includes three initiatives aiming at reducing society's impact on the environment.

- The first aims at R&D on Green ICT, pervasive computing and e-Government.
- The second focuses on the export of Green ICTs know-how and technology.
- The last initiative concerns international conferences on Green ICT hosted by Denmark.

Japan's Green IT project [1]

This project which constitutes a part of the *Green IT Initiative,* is promoting high energy efficient ICTs (with an annual budget of JPY 3 billion in fiscal year 2008). The *Green IT Project* especially focuses on three main fields:

Networks: the objective is to reduce energy consumption of network components by more than 30%. Technologies for optimising router power consumption and traffic volume are promoted

Data centres: The project also aims at reducing the energy consumption of data centres, especially of servers and storage devices, by more than 30%, by promoting technologies like ultra-high density Hard Disk Drives (HDD) and high-efficiency cooling systems.

Displays: The objective of the third research field is to reduce the power consumption of displays by 50%. Organic Light Emitting Diodes (OLED) are one of the technologies that will be promoted.

5 CONCLUSION

ICT has played a significant role in the last decades of improving economic productivity. It now has the opportunity to enable us to make further significant productivity improvements, helping us transform the world to a more sustainable, lower carbon and more resource-efficient future in the process. Perhaps that ICTs contribute in climate changes and global warming but they more contribute in mitigating their impacts on environment and in developing solutions either in other economics and industrial sectors.

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