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The Challenge of ICT Long-Term Sustainability

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Abstract
The long-term sustainability of Information and Communication Technologies (ICT) requires a new design paradigm based on the recyclable-by-design, repairability-by-design approach, the minimization of material and power consumption, and a zero-waste goal. Nevertheless the growing speed of electronics devices replacement is not compatible with the limits of the planet Earth. A new design, development, manufacturing, and use of ICT, based on the Slow Tech concept, is required: technologies that are socially desirable, environmentally sustainable, and ethically acceptable.

Key words: Information and Communication Technologies (ICT), long-term sustainability, rare-earths, cloud computing, Slow Tech

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***Perspective**: Theoretical visions*

***Fields**: Technology, Economy and Social Sciences*

***Issues**: Sustainable ICT production and consumption*

Introduction

This paper proposes to look at Information Communication Technology (ICT) from the point of view of the relationship with the environment and sustainability in the long-term. Up to the year 2013, very few researchers were investigating the "*uncomfortable truth*" related to the production, use and disposal of modern ICT. Several works have investigated this area (Fairweather, 2011; Whitehouse et al., 2011; Hilty et al., 2011; Patrignani and Kavathatzopoulos, 2012) and, since 2013, with the first Conference ICT4S, *ICT for Sustainability*, in Zurich, an important community of scholars is investigating with a wider view on this fundamental issue at the core of critical infrastructures of society (ICT4S, 2013). The main questions are "*is it possible to close the production-use-disposal cycle for ICT? And for how long will this cycle be sustainable?*". In the following a closer and systemic view is proposed at these three phases - production, use, and disposal - applied at the ICT world in order to highlight the relationships with material consumption, climate change, and dangerous pollution.

Production

The famous expression "*matter matters too*" (Georgescu-Roegen, 1979) recalls the importance of taking into account the long-term consequences of the continuous materials extraction. These activities imply irreversible processes, decreasing quantities and increasing extraction costs (Bardi, 2014). For producing ICT a long list of materials is needed and, unfortunately, ICT use rare metals for manufacturing microprocessors and integrated circuits in general. As described in a recent study from Yale University: "*... the increasingly use and mining of rare metals can have devastating environmental consequences as well as serious geo-political concerns*" (Schmitz and Graedel, 2010). The famous case of Coltan (Columbium-Tantalum mineral) disclosed this grey area of ICT, where most of these materials (also called "*conflict minerals*") are extracted in conditions of illegality, including child labour and slavery (Nimbalker et al., 2014; Vazquez-Figueroa, 2010).

Electronic devices contain *conflict minerals* like Tantalum, Tungsten, Gold, Tin; *substances of concern* like Litium, Beryllium, Chromium, Fluorine, Chlorine, Arsenic, Bromine, Cadmium, Antimony, Mercury and Lead; *rare earths* like (Yttrium etc.); and many other scarce elements like Indium, Palladium, Cobalt, Platinum, etc. For example, the reserves of supply remaining of Indium, used for screens and displays, are estimated to be just 14 years. Inside all of ICT, just the smartphones account for 7.1 Billion devices produced and distributed since their introduction in 2007. The energy needed just for manufacturing them have been around 700 TWh (Greenpeace, 2017). Just for reference, in 2016 Italy consumed 310 TWh (Terna, 2017).

A serious reflection on this side of ICT long-term sustainability is now mandatory. Designers, computer professionals, vendors, the main drivers of ICT development, should seriously reconsider the entire life-cycle of electronic devices in order to minimize their impact on the planet.

Use

Of course, ICT can be used for de-materialising processes and reducing energy consumption by moving bits instead of atoms, accelerating the transition to a less material-intensive economy (Hilty, 2008). But moving and processing bits does not come for free and, since the 1980s, the debate about the side effects of ICT on the environment has emerged (Benson, 1985; SVTC, 2007). It is very complex to balance these two aspects but manufacturing, using, and disposal ICT is requiring a growing amount of energy and this risks compromising the benefits coming from dematerialization.

End users' mobile devices, computers and servers are the most visible areas of ICT and, considering their growth speed, their total power consumption is growing: a smartphone, for example, requires about 5 KWh per year for its use (EPRI, 2017). But nowadays they are completely useless without connecting them to a network.

Looking at the power consumption of a typical telecommunication network one can divide it in four different components: data centers, network, mobile access and fixed access.

The gigantic data centers of the cloud computing represents about 10% of the total power consumption and it is increasing by 25% every year. In 2016 the world's data centers total power consumption has been around 416.2 TWh (Ericsson, 2015).

The network in itself (data transmission, routers, channels, IP networks, etc.) consumes about 20% of the total, while the fixed access (ADSL, fiber, etc.) consumes about 45% of the total. The mobile access network areas (2G, 3G, 4G, etc.) get 25% of the total.

Looking at the total CO_2 generated by data centers (0,36 $GtCO_2$), voice and data networks (0,30 $GtCO_2$), and end-users-devices (0.59 $GtCO_2$) (GESI, 2015) we have a total of 1.25 $GtCO_2$ that can be attributed to ICT. On the positive side, it is estimated that by 2030, if appropriately developed and applied in manufacturing, buildings, agriculture, transportation, and power, ICT could save 12.1 $GtCO_2$. Even if the ICT energy balance looks positive, a number of issues need further research: what is the amount of energy (and related CO_2) needed to build ICT and to manage e-waste?

Welcome to the wireless world

Another area of concern is the growing use of wireless channels for accessing ICT. Electromagnetic spectrum is a commons now put on sale by many countries. It is considered a "limited commons" since: a) the available frequencies are limited (radio waves, microwaves, infrared up to 428 THz, the upper frequency limit where humans start seeing red light), and b) beyond some limits, one cannot use two frequencies that are too close each other without risking interferences. The new exponential growth of wireless connectivity of mobile devices to the Internet have introduced immense market opportunities and a pervasive penetration of these waves carrying energy (Cachard, 2017). The World Health Organization (WHO), via its International Agency for Research on Cancer (IARC), has classified the waves used in ICT, like WiFi, Bluetooth, UMTS, LTE, etc., in the category B2 "*potentially carcinogenic for human beings*" (IARC, 2013). While waiting for more precise results coming from many ongoing research studies in this direction, a precautionary approach is recommended in particular for long-time expositions.

Disposal

Since in all ICT devices many hazardous substances are contained, the related environmental risk of disposal is very high. The United Nations University estimated that in 2014 roughly 42 million tons of e-waste was generated despite the value and the risk of related materials. Smartphones contributed for 3 million tons to this mountain of e-waste. And the mountain is growing: it will reach 50 million metric tons in 2017 (Baldé et al., 2014). It is now mandatory to investigate the destination of these devices at the end of their life, since the precise location of their disposal in mostly unknown, or they are sent to destinations where their management is very dangerous. According to Blacksmith Institute and Green Cross Switzerland the most polluted place in the world is Agbogbloshie, Accra in Ghana. This dumpsite is an immense area full of electronic devices coming from Western countries and it grows at a rate of 215,000 tons per year (Bernhardt and Gysi, 2013).

The entire ICT community should immediately start to face this challenge to long-term sustainability.

One first possible action is of course to introduce the recycling of ICT devices as mandatory. Several studies have demonstrated, for example, that the cost of recycling gold from old computers is in the same order of the cost of mining the mineral (Step, 2013).

A second action is to address the problem at design stage: all ICT devices should be required a recyclable-by-design approach that will simplify the e-waste management.

A third possible action is to introduce a repairable-by-design approach: by easily repairing these devices their lives will be lengthened. By changing only the broken components that will be easily substituted, provided that the interfaces by all modules are interoperable and open, like in open software and open hardware (Arduino, 2017).

A fourth more radical action is to introduce comprehensive industrial design and developments (e.g. "*cradle-to-cradle*" or "*regenerative design*") that learn from natural cycles; the industrial products should start to be seen as organisms with circulating materials creating waste-free systems (Lovins, 2008).

Slow Tech

Slow Tech concept, a quest for a good, clean, and fair ICT has been recently introduced: "*... a new starting point for systems design: ... based on a long-term view of the desirability and social importance of technologies, their environmental impact and sustainability, and the fairness and equity of the conditions of workers*" (Patrignani and Whitehouse, 2014). Slow Tech approach starts from taking into account the limits of the planet and the limits of human beings. In particular the "*clean side of Slow Tech*" is introducing the reflection into the ICT community: how should designers, computer professionals, ICT companies, policy makers, and end-users collaborate for directing ICT towards a long-term sustainability? (Patrignani and Whitehouse, 2015). A very good case study of Slow Tech approach is provided by Fairphone, a smartphone that is seriously taking into account the problem of recyclability and repairability (Raoul, 2017).

Conclusions

The ICT community of designers, computer professionals and vendors have to seriously reconsider ICT consumption cycles and their speed with repairable and upgradable by-design projects. Also from the end users' point of view a serious reflection is urgent: in some countries 50% of people change their mobile device every twelve months. It is a speed that the Earth cannot afford and a slow replacement approach is one of the key actions.

Even in the economists' community the concept of limit to growth is now starting to be accepted: the new concept of a "*circular economy*" is very promising (Stahel and Reday-Mulvey, 1981; EMAF, 2013).

A more systemic view of nature including our industrial processes is needed. Even if ICT could and should be mainly used for saving energy and cleaning our activities, the increasing speed of human beings' processes is not sustainable in the long term. If human beings seriously appreciate the limits of the planet, closing the cycles is no more enough: a reflection on the *speed* of these cycles is becoming mandatory. According to German sociologist Rosa the curious paradox of contemporary society is that "*we don't have any time although we've gained far more than we've needed before*" (Rosa, 2013). Since this acceleration is mainly due to ICT, facing this paradox of modern times requires the wise production, use, and disposal of ICT.

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