EFFICIENT AND EFFECTIVE
Toward a Strategy that Works 'Forever'

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Abstract: This paper takes the position that the ICT-sector would do well to embrace an efficiency strategy but argues that a sole focus on efficiency is insufficient. Eco-effective strategies are introduced and it is argued that they presuppose each other.

1 INTRODUCTION

The past 40 years we have witnessed the coming about of a totally new industry and services sector; the Information and Communication Technology sector, colloquially referred to as the ICT-sector. During those decades we have become highly dependent on ICT to coordinate stocks and flows of people, goods, materials and services around the world. This growth has been healthy from an economic perspective, creating and replacing many jobs that were lost in other parts of industry. The coming decades we are in for a far more deep restructuring in the way we produce and distribute things. Increases in population and dwindling resource bases force us to be innovative, but the pay-offs economically, ecologically and socially are potentially enormous.

It is to be expected that more people will want to use more computers and computing power while resources are dwindling on a global scale. The goal of this paper is therefore to sketch an outline for a transition-path for the ICT-industry toward a non-harmful profitable industry that is able to generate a wide enough range of services and products to include all people.

In order to be able to do so it is important to determine how much of the materials and energy is used to produce a computer in order to come up with suggestions how to improve design, production and recycling phases. Energy-usage and E-waste are the two topics we focus on because energy use and E-waste taken together are a good indicator of the relative Ecological Footprint of the production of most goods. (See Huibregts, et.al. 2008, 2010)

We will sketch why it is urgent to try to become a more ‘green’ sector in the background section, where we also elaborate on two approaches that are emblematic for a eco-efficiency and eco-effectiveness approach. We show that a focus on energy-efficiency is promising but insufficient if we look further than 2 decades or so. We will touch upon the implications and come to the conclusions that the current efforts of the industry leaders are primarily aimed at becoming more efficient; a laudable goal but insufficient in the long run and suggest a route to go from eco-efficient to eco-effective solutions.

2 BACKGROUND: SUSTAINABILITY APPROACHES

In this section we sketch some global trends that elucidate that it is timely to think about alternative ways of producing and we introduce two approaches to sustainability that exemplify two generic strategies that promise to deliver a sustainable ICT-sector. Then we follow with a more detailed account of the current use of materials and energy in the global ICT-sector. This will, just as in subsection 1, be an exemplary account because there is a vast world of research behind the multitude of topics. We

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unite the sustainability subsection and the ICT-subsection in the subsequent conclusions where we outline a strategy, applicable at all levels and therefore necessarily rather abstract, that can make the ICT industry ‘last forever’.

The first decade of this new millennium is marked, even taking the economic crisis into account, by an extraordinary economic productivity and an alarming decline in the viability of eco-systems that are the foundation of our prosperity and survival.

The simple truth is that we as a species are able to destroy our own conditions for prosperity. Since 1987, industry and end-consumers use more resources than the earth can produce and if we do not find alternatives and the current growth-rates of our economies continues we will be out of Zinc, Copper and a few other materials within 30 to 50 years.

There are, essentially, two ways to contribute to a more sustainable computing industry. The first is labelled eco-efficiency and is a ‘do more with less’ strategy. When we give an overview of the activities of the global ICT sector we will see that industry and governments currently put great emphasis on this strategy. The other strategy aims to design/develop products and production platforms that are inherently good, That is to say beneficial to the natural environment, inclusive at the social level, through an emphasis on diversity, and financially profitable in the economic realm. But we start now with an introduction of an approach that is emblematic for an eco-efficient approach.

Eco-efficiency

The ecological footprint concept and calculation method was developed by Wackernagel and Rees (1992, 1996). Ecological footprint analysis compares all human demand on nature with the capacity of the biosphere to regenerate resources and provide services. This resource accounting is similar to life cycle analysis wherein the consumption of energy, biomass (food, fiber), building material, water and other resources are converted into a normalized measure. The Ecological converst all inputs to so-called 'global hectares'. The method does, however have a ‘blind spot’, it is myopic with respect to the relative toxicity of substances released in nature, while: “Air, water, and soil do not safely absorb our wastes unless the wastes themselves are completely healthy and biodegradable” (McDonough & Braungart, 2002). A barrel of dioxin can a have a similar footprint as a barrel of a less toxic chemical or maybe even harmless chemical substance that required a similar amount of energy and resources to produce. But apart from this remark it is a comprehensive method that enables measurement and comparison (bench-marking).

Per capita ecological footprint (EF) is a means of comparing consumption and lifestyles, and checking this against nature's ability to provide. Consumption should be read here as input or demand. Just as human consumers, industries and factories also consume or demand large amounts of energy and resources. It totally depends at what level you analyze a system. The footprint can also be a useful tool to educate people about carrying capacity and over-consumption, with the aim of altering personal behaviour. That is how the footprint was originally used but EF can accommodate and measure footprints at different levels. The smallest unit is the individual but via aggregation higher levels can easily be compounded and analyzed. Ecological footprints show that many current lifestyles and ways of producing goods and services to support such life-styles are not sustainable. Comparison at the nation-state or regional level clearly shows the inequalities of resource use on this planet at the beginning of the twenty-first century. As such, although it is essentially an accounting method, the truth it reveals about how we deal with our planet and fellow human beings immediately gives rise to ethical and political considerations. The approach can inform policy by examining to what extent a nation, region or municipality uses more (or less) than is available within its territory, it clearly shows limits. It does not provide much information on how to transform production to a nourishing instead of destroying activity, which stimulates diversity and is profitable. The main prescription is to do more with less to fight the twin-problem of dwindling resources and growing populations. So, EF is ‘naturally’ inclined to focus on efficiency strategies because of the way in which the problem is framed. Essentially, the strategy chosen is a watered down version of the business as usual scenario. We will elaborate on the use of the foot print and the strategy of eco-efficiency when we sketch the current state of affairs in the ICT-industry. Now we turn to the introduction of approaches that try to come up with solutions to the ecological problems, and therewith, economic and social, that will redefine what business as usual is.

Eco-effectiveness

These approaches are labeled as eco-effective because they try to support a transition to an economy and society that is not harmful, excluding and economically unfeasible in the long run. Positively framed these approaches aim to deliver designs that are nourishing, inclusive and profitable. A number of ecologically intelligent design approaches to architecture, industry and architectures that involves materials, buildings and patterns of settlement have been formulated and developed over the past two decades. Elements of C2C are also found in industrial ecology (Ehrenfeld, 1997, 2000) and bio mimicry (Benyus, 2002) both approaches were formulated from an engineering perspective. In the agricultural field deep ecology, as a philosophy, spawned a new radical way of re-designing agriculture, permaculture, in such a way that it functions once again as a CO2 sink, contributes to instead of destroys (bio-)diversity and is more productive per acre. All these approaches aim to come to designs that last ‘forever’, that is, as long as the sun shines.

Cradle-to-cradle is an eloquent and outspoken version of this approach. It frames (human) systems as nutrient cycles. Materials designed as biological nutrients provide nourishment for nature after use; technical nutrients circulate through industrial systems in closed-loop cycles of production, recovery and remanufacture. Following a science-based protocol for selecting safe, healthful ingredients, cradle-to-cradle design maximizes the utility of material assets. Responding to physical, cultural and climate-related settings, it creates buildings and community plans that generate a diverse range of economic, social and ecological value in industrialized and developing countries (McDonough, W., Braungart, M., 2002b).

The keyword is the generation of value: eco-effective systems tend to generate value in more than one domain and once installed for a long period of time. The aim is to maximize profit, people and planet.

The design precepts that demarcate a solution space are:

- Use only renewable energy sources such as solar power, hydropower and wind power.
- Eliminate the concept of waste.
- Outputs of any component in the system should provide nutrients for the biosphere or the technosphere.
- No loss of quality should occur (upgrading of materials instead of the current downgrading)
- Respect and cherish diversity. This includes diversity of life, culture, place, needs and uniqueness of people.
- Promote the rights of people and nature to coexist in a healthy, mutually supporting diverse and sustainable situation.

The last two points indicate, just as with the Ecological Footprint, that the solutions that need to be found will require more than becoming even more efficient. Systemic change also requires change at the institutional level, usually the domain of politics in a co-production with regulators. However, even if the political field would do nothing industry will need to alter the ways in which they design and produce in order to remain flourishing as a sector, exactly because some raw materials are increasingly getting scarce.

3 STATE OF THE ART: THE ICT SECTOR

In this section we start with an impression of the economic performance of the industry and continue with energy-use and e-waste to sketch the ecological performance of the sector. Then we report on the initiatives undertaken by the ICT-sector itself to decrease its impact on the environment while remaining profitable.

Economic Growth

The Information Communications Technology (ICT) Industry has experienced impressive growth figures over the past 30 years. The sector contributed 16% of global GDP growth from 2002 to 2007 and the sector itself has increased its share of GDP worldwide from 5.8 to 7.3% and it is expected to jump further to 8.7% of GDP growth worldwide in 2020.

Economy-wise the ICT sector is performing above average and the trend is, under similar circumstances, that this growth pattern will be maintained for the next decade. Initially the ICT-sector has had a relatively green image, due to the promises it potentially delivers in the area of tele-working or distributed ways of working and critical studies in the 70’s already showed that vast improvements could be made in the area of design and production of hardware.

In low income countries, an average of 10 more mobile phone users per 100 people was found to stimulate a per capita GDP growth of 0.59%. (The Climate Group, 2008). The report further suggests that a third of the economic growth in the Organization for Economic Cooperation and Development (OECD) countries between 1970 and 1990 was due to access to fixed-line telecoms networks alone, which lowered transaction costs and helped firms to access new markets.[1]

Energy Efficiency in Manufacturing

The energy consumed by a manufacturing process is a major direct measure of its impact on the environment. The energy consumed usually translates to the amount of energy that has been produced from fossil fuel-fired plants or captive generators. The energy consumed thus has a strong link with the amount of fossil fuels consumed and contributes therefore to the depletion and degradation of the environment (soil, air and water). The sustainability benefits are further magnified because a unit of energy consumption on the demand side has a multiplier effect. It results in savings of about five to ten units of raw energy input on the supply side.

A typical desktop pc with a 17” flat panel LCD monitor requires about 100 watts. Not much? Left on 24/7 for one year, the system will consume a whopping 874 kWh electricity. That’s enough to release 750 lbs. of carbon dioxide into the atmosphere—the equivalent of driving 820 miles in an average car (NASSCOM, 2009).

The ICT sector’s own emissions are expected to increase, in a business as usual (BAU) scenario, from 0.53 billion tonnes (Gt) carbon dioxide equivalent (CO2e) in 2002 to 1.43 GtCO2e in 2020 The ICT-enabled solutions would deliver savings of 1 tonne per capita in 2020, a significant step in the right direction.

In 2007, the total Carbon footprint of the ICT sector – including personal computers (PCs) and peripherals, telecom networks and devices and data centres – was 830 MtCO2e, about 2% of the estimated total emissions from human activity released that year. *Even if the efficient technology developments outlined in the rest of the chapter are implemented, this figure looks set to grow at 6% each year until 2020.* The carbon generated from materials and manufacture is about one quarter of the overall ICT footprint, the rest coming from its use (The Climate Group, 2008).

[1] Section 2 has largely been based on a report composed by one of the authors for the Government of India, Bureau of Energy Efficiency.

By 2020, when a large fraction of developing countries’ populations (up to 70% in China) will be able to afford ICT devices and will have caught up with developed countries’ ownership levels, they will account for more than 60% of ICT’s carbon emissions (compared to less than half today), driven largely by growth in mobile networks and PCs. But these are not the fastest growing elements of the footprint. Despite first-generation virtualization and other efficiency measures, data centers will grow faster than any other ICT technology, driven by the need for storage, computing and other information technology (IT) services. Though the telecoms footprint continues to grow, it represents a smaller share of the total ICT carbon footprint in 2020 as efficiency measures balance growth (The Climate Group, 2008).

E-waste

E-scrap is one of the fastest growing components of the global waste stream and, arguably, one of the most troublesome. The European Environmental Agency calculates that the volume of e-scrap is now rising roughly three times faster than other forms of municipal waste. The total annual global volume of e-scrap is soon expected to reach roughly 40 million metric tons — enough to fill a line of dump trucks stretching half way around the world. Rapid product innovations and replacement, especially in ICT and office equipment — the migration from analog to digital technologies and to flat-screen TVs and monitors, for example — is fueling an increase of e-waste. (UNUniversity, 2007). For manufacturers, improving the e-scrap recycling process is essential to continuity in business one or 2 decades from now. Unqualified or unscrupulous treatment of e-scrap is still usual in many emerging economies and a lot of the problems are exported by more developed nation states to developing countries.

The inappropriate handling of E-waste leads, amongst others, to:

1. Emissions of highly toxic dioxins, furans and polycyclic aromatic hydrocarbons (PAHs).

2. Soil and water contamination from chemicals such as: brominated flame retardants (used in circuit boards and plastic computer cases, connectors and cables); PCBs (in transformers and capacitors); and lead, mercury, cadmium, zinc, chromium and other heavy metals (in monitors and other devices). Studies show rapidly increasing concentrations of these heavy metals in humans; in sufficient dosages, they can cause neuro-developmental disorders and possibly cancer.

3. Waste of valuable resources that could be efficiently recovered for a new product lifecycle. In many industrializing and developing countries, growing numbers of people earn a living from recycling and salvaging electronic waste. In most cases, though, this is done through so called "backyard practices," often taking place under the most primitive circumstances, exposing workers to extensive health dangers. (UNUniversity, 2007) But what kind and what quantities of valuable resources are we talking about are we talking about?

One metric ton (t) of electronic scrap from personal computers (PC's) contains more gold than that recovered from 17 t of gold ore. In 1998, the amount of gold recovered from electronic scrap in the United States was equivalent to that recovered from more than 2 million metric tons (Mt) of gold ore and waste. A ton of used mobile phones, for example – or approximately 6,000 handsets (a tiny fraction of today's 1 billion annual production) contains about 3.5 kilograms of silver, 340 grams of gold, 140 grams of palladium, and 130 kg of copper, according to StEP. The average mobile phone battery contains another 3.5 grams of copper. Combined value: over US $15,000 at today's prices.

Another example: recovering 10 kilograms of aluminum via recycling, for example, uses no more than 10% of the energy required for primary production, preventing the creation of 13 kilograms of bauxite residue, 20 kilograms of CO_2, and 0.11 kilograms of sulphur dioxide emissions, and causes many other emissions and impacts. Compared to disposal, computer reuse creates 296 more jobs per for every 10,000 tons of material disposed each year (Electronics Takeback Coalition, 2010).

In addition to well-known precious metals such as gold, palladium and silver, unique and indispensable metals have become increasingly important in electronics. Among them: Indium, a by-product of zinc mining used in more than 1 billion products per year, including flat-screen monitors and mobile phones. In the last five years, indium's price has increased six-fold, making it more expensive than silver. Though known mine reserves are limited, indium recycling is so far taking place in only a few plants in Belgium, Japan and the U.S. Japan recovers roughly half its indium needs through recycling.

The market value of other important minor metals used in electronics such as bismuth (used in lead-free solders) has doubled since 2005 while ruthenium (used in resistors and hard disk drives) has increased by a factor of seven since early 2006. The large price spikes for all these special elements that rely on production of metals like zinc, copper, lead or platinum underline that supply security at affordable prices cannot be guaranteed indefinitely unless efficient recycling loops are established to recover them from old products (UNUniversity, 2007). Now, what is already done by the industry at this point in time?

The global ICT industry has chosen an eco-efficient strategy. Standardizing recycling processes globally to harvest valuable components in electrical and electronic scrap (E-scrap), extending the life of products and markets for their reuse, and harmonizing world legislative and policy approaches to e-scrap are prime goals of a new global public-private initiative called: Solving the E-waste Problem (StEP). Major high-tech manufacturers, including Hewlett-Packard, Microsoft, Dell, Ericsson, Philips and Cisco Systems, join UN, governmental, NGO and academic institutions, along with recycling / refurbishing companies as charter members of the initiative. (UNuniversity, 2007) In which reduction in the form of dematerialization, recycling and re-use to recoup precious resources and regulation to induce compliance with standards are the main foci of attention. That will sometimes be quite a challenge, because alloys cannot be separated anymore and, sometimes, the different metals cannot be separated which delivers an alloy when melted. The quality of the materials used is downgraded in this way and cannot be restored and recycled for the same purpose. It will serve a lower function because the properties of the materials have been lost, a classical example of down-cycling.

Valuable resources in every scrapped product with a battery or plug — computers, TVs, radios, wired and wireless phones, MP3 players, navigation-systems, microwave ovens, coffee makers, toasters, hair-dryers, to name but a few — are being trashed in rising volumes worldwide. Worse, items charitably sent to developing countries for re-use often ultimately remain unused for a host of reasons, or are shipped by unscrupulous recyclers for illegal disposal. And, e-scrap in developing countries is incinerated, not only wasting needed resources but adding toxic chemicals to the environment, both local and global. (UNUniversity, 2007)

Re-use happens but not systematically and given the short innovation cycles in the industry hybridization of products is a trend that is emerging. To cater to consumer-preferences exteriors can be replaced while the technology driving the device is long-lasting and will be taken back by the producer to retain and re-use the resources embedded in it. The trick is to make the different components easily separable, saving costs and creating conditions to upgrade the resources used. Currently most of what is re-used is donated and in the end thrown away in developing countries that do not tend to have good e-waste recovery infrastructures.

To get things moving forward, the GeSi report launches a new SMART framework, a guide for developing ICT solutions. Through standards, monitoring and accounting (SMA) tools and rethinking (R) and optimizing how we live and work, ICT could be one crucial piece of the overall transformation (T) to a low carbon economy> The sector is supported when moving in this direction by some inherent positive traits of ICT when related to sustainability.

According to an INTEL report on sustainability, the forecasts for energy consumption and emissions of carbon dioxide to 2010 for the North American economy may have to be adjusted down by around 5 percent, due to the rapid impact of the Internet economy. Another study, by the Lawrence Berkeley National Laboratory and cited in the INTEL report, found that the IT-economy could potentially reduce the growth in carbon emissions by 67 percent over what they would otherwise be between 2000 and 2010.

ICT also contributes to dematerialization. Through dematerialization, the same or an increased quality and quantity of goods and/or services are created using fewer natural resources (material or energy). Decreased consumption of paper is a good example and applications like e-readers could contribute to a reduction of energy consumption. Compared to reading a newspaper, receiving the news on a wirless device like a PDA, results in the release of 32 to 140 times less carbon dioxide and several orders of magnitude less nitrogen and sulphur oxides.

For years, the potential for video conferencing has been discussed. Coupled with other soft-ware such as sketching tools, Group Support Systems and design support tools, virtual meetings become eminently possible. Today's bandwidth makes the technology truly viable. Existing video conference solutions indicate that if 5 to 30 percent of business travels in Europe were substituted by video conferencing or virtual meetings, more than 5.59 to 33.53 million tons of CO2 emissions would be saved. Based on German experiences, a 20 percent reduction of business travel in the EU through video conferencing could save 22 million tons of CO2 (INTEL, 2007).

The Climate Group, 2008) analysis did identify some of the biggest and most accessible opportunities for ICT to achieve savings:

1. Smart motor systems: A review of manufacturing in China has identified that without optimization, 10% of China's emissions (2% of global emissions) in 2020 will come from China's motor systems alone and to improve industrial efficiency even by 10% would deliver up to 200 million tonnes (Mt) CO2e savings. Applied globally, optimized motors and industrial automation would reduce 0.97 GtCO2e in 2020, worth Euro68 billion ($107.2 billion).
2. Smart logistics: Through a host of efficiencies in transport and storage, smart logistics in Europe could deliver fuel, electricity and heating savings of 225 MtCO2e. The global emissions savings from smart logistics in 2020 would reach 1.52 GtCO2e, with energy savings worth Euro280 billion ($441.7 billion).
3. Smart buildings: A closer look at buildings in North America indicates that better building design, management and automation could save 15% of North America's buildings emissions. Globally, smart buildings technologies would enable 1.68 GtCO2e of emissions savings, worth Euro216 billion ($340.8 billion).
4. Smart grids: Reducing T&D losses in India's power sector by 30% is possible through better monitoring and management of electricity grids, first with smart meters and then by integrating more advanced ICTs into the so-called energy internet. Smart grid technologies were the largest opportunity found in the study and could globally reduce 2.03 GtCO2e, worth Euro79 billion ($124.6 billion) (the Climate Group, 2008).

An industry led efficiency approach promises to have quite some impact and could help us move globally to a low-carbon economy. The Climate Group report mentions that specific ICT opportunities can lead to emission reductions five times the size of the ICT sector's own footprint, up to 7.8 GtCO2e, or 15% of total BAU (business as usual) emissions by 2020. But is it enough? This is what we provide an answer to in the last section.

4 CONCLUSIONS: EFFICIENCY AND EFFECTIVENESS PRESUPPOSE EACH OTHER

Although one may expect to find that ICT could make our lives ‘greener’ by making them more virtual, the first and most significant role for ICT is enabling efficiency. Consumers and businesses can’t manage what they can’t measure. Efficiency may not sound as inspirational as a CtoC solution but, in the short term, achieving efficiency savings equal to 15% of global emissions. The breadth of solutions will span motor systems, logistics and transport, buildings and electricity grids – across all key economies in the world. Mature economies will be able to upgrade and optimize entrenched systems and infrastructures. Developing countries could ‘leapfrog’ inefficient mechanisms and integrate state-of-the-art solutions into their evolving societies. Companies that implement the solutions will capture part of the potential global savings of Euro600 billion ($946.5 billion).

In the introduction we already hinted at the fact that there are a lot of signals that “Business as Usual” is over. Business as usual ultimately destroys the natural base on which we built all our wealth. We showed that awareness has translated in action and, globally, the ICT industry follows other sectors that put their sustainability bets on an eco-efficiency strategy, exemplified by the Ecological Footprint. Governments and regulators tend to like the Ecological Footprint because they can fulfil their designated role as regulator. Business and government like it because you can measure things; a precondition for regulation, control and prediction. The fact remains however that the Ecological Footprint is unable to factor in toxicity as a measure and the framing of the problem leads to solutions that follow the credo: ‘do more with less resources and energy’.

We strongly support the move the industry world wide is making in the area of (energy)-efficiency, because it gives relief to a host of problems we will face the coming years. But efficiency strategy provides just that, relief. And if we stick to such a strategy as a sector we: “… will in fact achieve the opposite; it will let industry finish off everything, quietly, persistently and completely.” (McDonough& Braungart, 2002a, p.81)

Given this common-sense notion, also echoed by other scholars/researchers, we conclude that eco-efficiency in and by itself is, as a strategy, necessary but insufficient. Eco effective strategies should also be formulated. And the strategies are mutually supportive, almost pre-suppose each other, because eco-efficiency strategies generate funds in the form of cost-savings that should be reinvested in eco-effective design of infrastructures and appliances to ensure a sustainable future for the sector. Efficiency further supports the move to an effectiveness strategy because the more energy-efficient a product is the easier it becomes to design and produce eco-effective computers and auxiliary products. Simply because alternative sources of energy-generation and supply become feasible and the soft-ware and technical support, that help ensure a stable supply of energy are increasingly available. We also put forward that following an eco-efficient strategy with an eco-effective strategy is good business sense because it creates new markets as can currently be witnessed in the energy-sector. Where diversification of supply, based on current technologies, combined with smart-grid technology creates possibilities to reduce carbon emissions drastically. A precondition to come to solutions that are effective and efficient and, therefore will potentially last as long as the sun shines.

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