Can ICTs enable green growth?

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1. Introduction

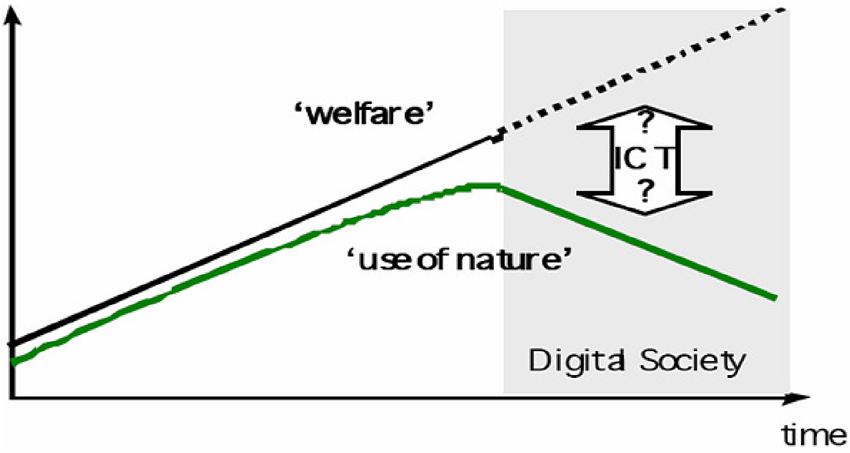
This paper investigates the conditions under which ICTs[1] can contribute to green growth. It draws on an ongoing project funded by the Telecom Institute about the future of green IT. in the current context of economic, social, and environmental crises, the quest for "green growth" has become a priority for many heads of state. Interviewed last week by a French newspaper, the Spanish PM reasserted that his priority was to foster green growth in his country, as did the new US president[2].

Will the current crisis enable to get out of business as usual scenarios? As far as sustainable development is concerned, business as usual means a dominant priority given to its economic dimension, thus at the expense of social and environmental issues. For some people one way to escape from such a destructive lock-in is to support greener technologies, which development forms the basis of a greener economic growth.

The French PM also sees green growth as an opportunity to use sustainable development as a competitive lever rather than seeing it as a constraint[3]. The union of French largest companies (MEDEF) also declares that sustainable development must be made a source of comparative advantage for the French economy[4]. This national dynamic has led to the publication in March 2009 of a report on ICTs and sustainable development[5]. It underlines that ICTs can contribute to save between one to four times the equivalent of their own GHG emissions. It will serve as basis for the national policy on how to use ICTs to foster sustainable development. As argued below, these forecasts are likely to be overestimated, since they do not take into account rebound effects and other side effects of ICTs such as ewaste, but focus on the expected capacity of ICTs to reduce our carbon footprint. At European level, ICTs are also praised for their capacity to decouple economic growth from the consumption of natural resources:

[1] For a definition of the ICT sector, see Appendix 1 of DSTI/ICCP/IIS(2006)2/FINAL, http://www.oecd.org/dataoecd/38/58/38228300.pdf.
[2] See Lean & Doyle (2008); and "Obama's green policy", *The Green IT Review*, 10/11/2008, http://www.thegreenitreview.com/2008/11/obamas-green-policy.html.
[3] See l'article du 18 septembre 2007 paru sur le blog de François Fillon intitulé « Croissance verte », http://www.blog-fillon.com/article-12465769.html.
[4] See http://www.medef.fr/main/core.php?pag_id=129136.
[5] See www.telecom.gouv.fr/fonds_documentaire/rapports/09/090311rapport-ticdd.pdf.

Figure 1: The decoupling between welfare and the use of nature



In 2004, the first version of the European Environmental Technologies Action Plan (ETAP), ICTs are considered as ecoinnovations, since they allow the collection of environmental data and thus avoid wasting natural resources, and allow the diffusion of technologies that will have a positive impact on the environment (smart meters and networks of captors)[6].

What are eco-innovations? The EC has changed its definition several times and it now uses the term "Eco-friendly technologies", which are technologies that stimulate the economy, reduce environmental pressures, and create jobs[7]. The first ETAP defined them as any technology which use generates less environmental impacts than the use of other technologies[8]. Underlines Hilty (2008, p. 32), for the World Business Council for Sustainable Development, an ecoinnovation needs to be both ecologically and economically efficient.

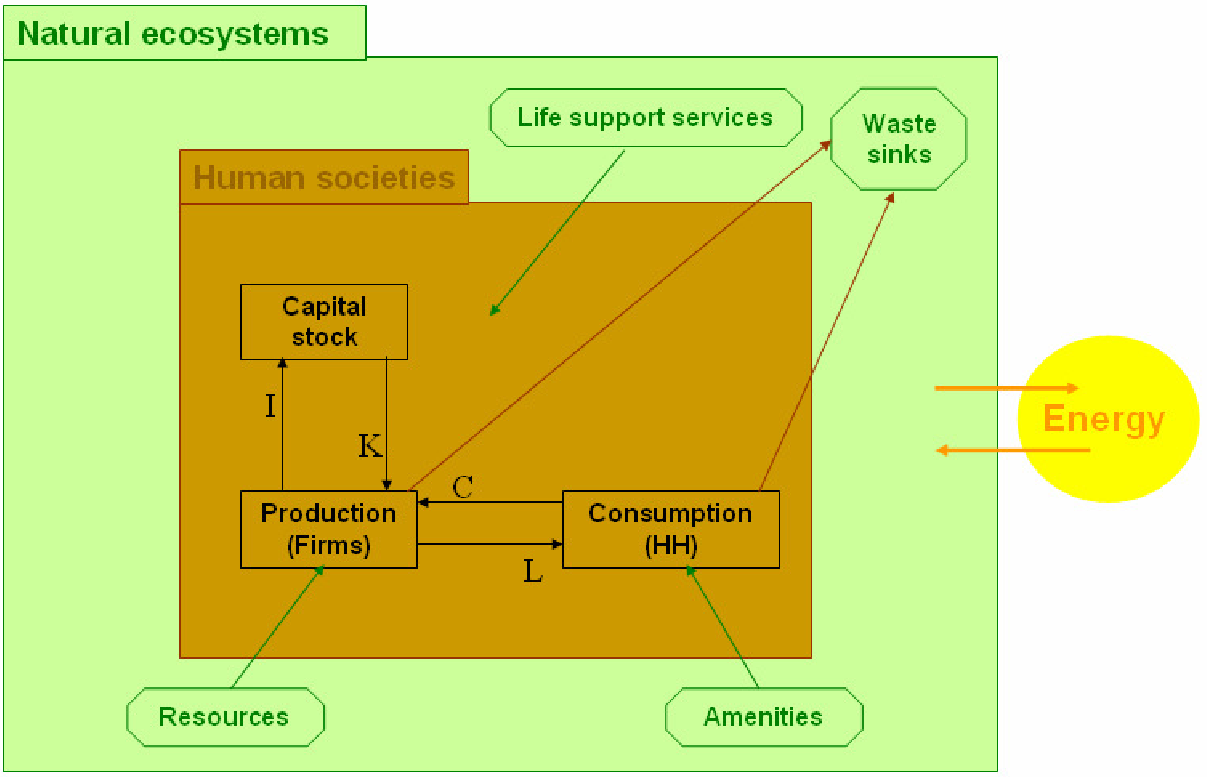
The definition of green growth used in this paper also implies a balanced achievement of economic and environmental objectives. The concept of sustainable development was created because of the lack of concern of business-as-usual scenarios for social and environmental issues. This risk has materialised in the expression "greenwashing", which characterises firms that claim to be environment-friendly but which claims are not grounded. Green growth can result from the diffusion of eco-innovations, but also from other factors fostering the decoupling between a higher HDI and the use of natural ecosystems' services, such as a change of our consumption habits and of our lifestyle. The following figure explains what these services are, and the next one what a sustainable development path looks like.

[6] Source: « Les écotechnologies sont très diverses : l'exemple des TIC », http://eur-lex.europa.eu/LexUriServ/site/fr/com/2004/com2004_0038fr01.pdf, p. 7.

[7] Source: http://ec.europa.eu/environment/etap/index_en.html.

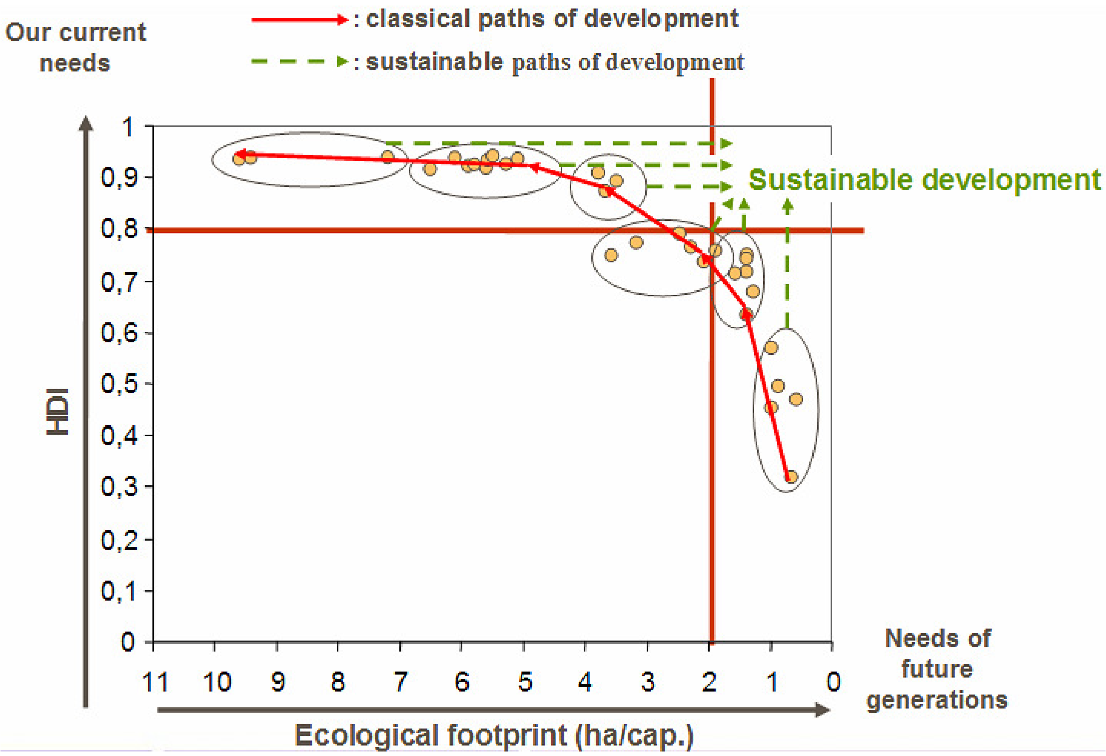
[8] The chapter 34 of the Agenda 21 ….###

Figure 2: The relationships between human societies and natural ecosystems



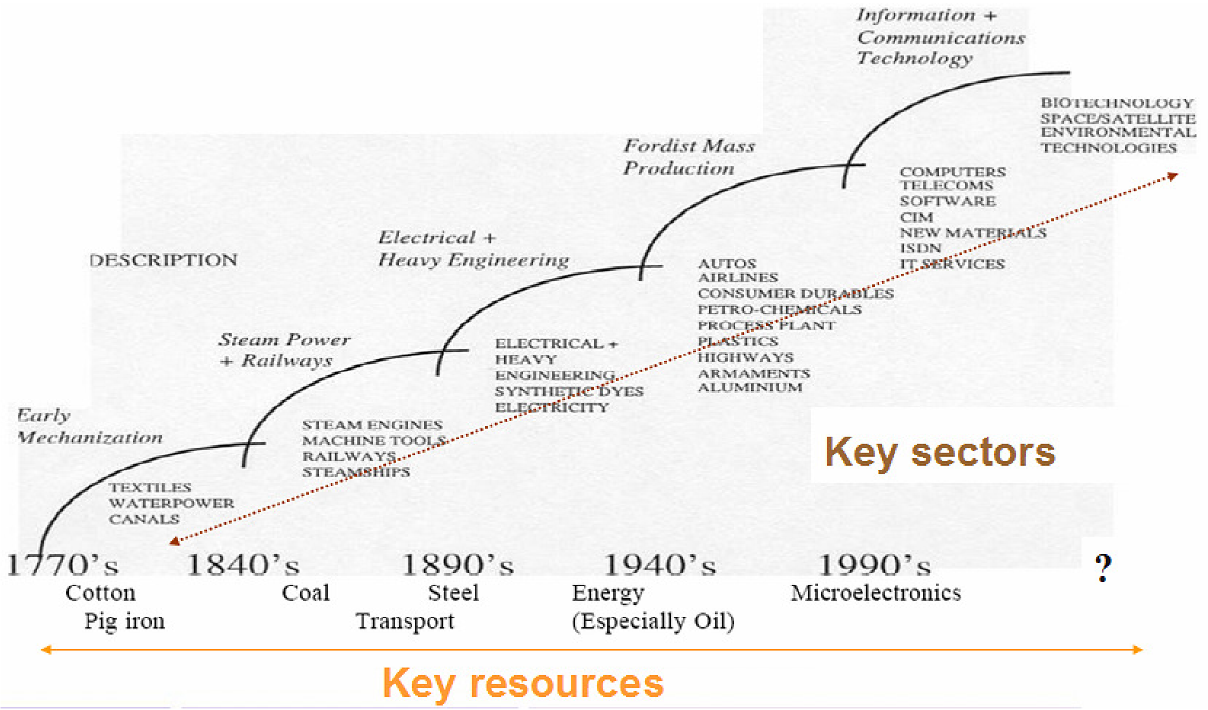
Source: Common & Stagl (2006), *Ecological Economics*, p. 87.

Figure 3: The path to a sustainable development



Provided that proper incentives are in place, ICTs might help reduce the environmental footprint of industrial societies. For example, smart energy meters may trigger energy-saving behaviours among consumers and eventually reduce greenhouse gases, and at the product level electronic gasoline injection reduces the energy consumption of explosion engines. Also, the exponential growth of knowledge delivered to our doorstep through the Internet thanks to ICTs may enable the emergence of responsible behaviours towards the most invisible actors of our societies such as the poorest humans or endangered species.
What role can evolutionary economists play in this sustainable development transition? Their neoschumpeterian analyses are at the heart of innovation strategies that fuel the economic growth of industrialised societies. According to the "Sussex school", long waves of technological development are enabled by a key resource that is broadly available and at a cheap price, for example microelectronics in the case of the 5th wave (Perez, 1985):

Figure 4: Waves of technological development



In "The Economics of Hope" (Freeman, 1992) or in "As Time Goes By" (Freeman & Louçã) as well as in an issue of "Futures" entitled "The greening of technology", there has been a debate among evolutionary economists about the role of ecoinnovations in the next wave. Following the Schumpeterian process of creative destruction, they might replace resource-intensive technologies and substitute atoms with bits, dematerialising our economies and decoupling the growth of welfare from the consumption of natural resources.

However, so far the creativity of the destruction of innovations has not integrated the use of natural resources, and even ICTs do not diffuse without exploiting the services of natural ecosystems. We argue that a genuine creative destruction needs to integrate those services, otherwise the green wave will keep an economic focus crowding out environmental objectives. So far, the evolutionary research agenda does not seem to have addressed this key question: how can innovation not entail a process "destructive destruction"? In our opinion, it would be a failure of green growth strategies if they could not enable a genuine process of creative destruction.

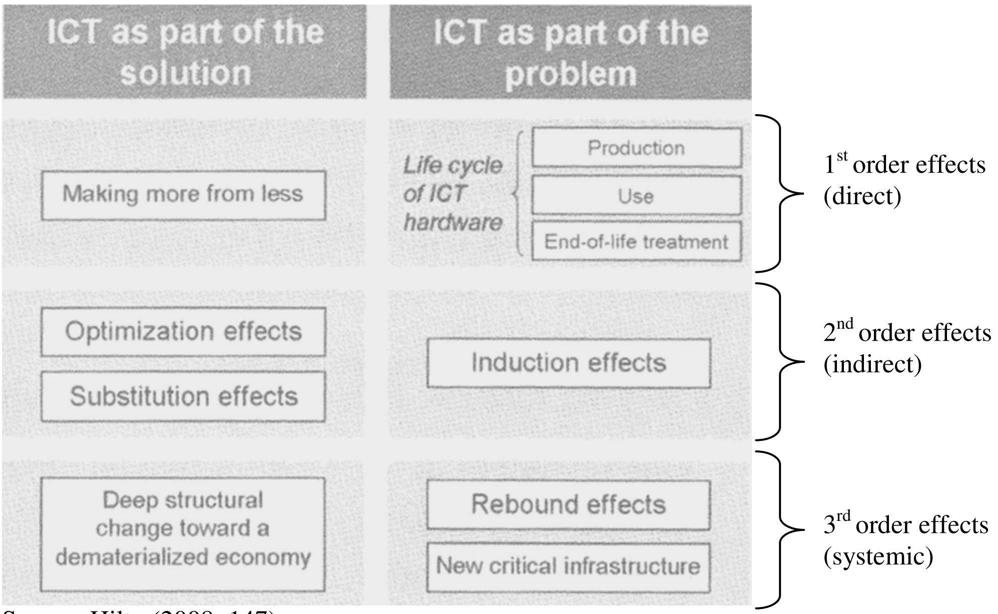
Scholars such as Ashford & al. (1985) and Porter & Van Der Linde (1995) have suggested that technological innovation could "co-optimise" environmental goals and economic growth provided that environmental policies were properly designed. The amount of "win-win" gains then depends on "innovation-friendly environmental policies"[9], which offset the costs of environmental compliance by allowing firms to derive economic benefits from ecoinnovations. To depart from a business-as-usual perspective, green growth strategies need to demonstrate that they contribute to reduce the ecological footprint of a given society. In the case of ICTs, we argue that this contribution is overestimated, notably because rebound effect are disregarded.

The next section discusses how ICTs could contribute to the greening of industrial societies, and then the limits to these contributions are examined as well as the ways to make up for these limits.

2. ICTs & the greening of industrial societies[10]

ICTs can be used by a range of actors to solve environmental problems. As shown in the following figure, ICTs can both alleviate or worsen the pressures human societies exert on natural ecosystems:

Figure 5: ICTs and the environmental dimension of sustainable development



Source: Hilty (2008: 147).

We focus in this section on how firms are using ICTs to solve environmental problems[11]. The first box entitled "Making more from less" suggests that ICT can contribute to improve the efficiency of existing technologies in the design phase. For example, electronic injection can reduce gasoline consumption, and the SAP software can improve the productivity of organisations. The second box corresponds to the effects of the use of ICTs: substituting letters by emails, improving traffic flows, etc. The third box suggests that the diffusion of ICT

[9] See Gouldson & Murphy (1998) and Kemp (1997).
[10] This section draws on a research project funded by the Telecom Institute and carried out in 2008. See http://gdrtics.u-paris10.fr/pdf/lettre/2007-12-12_ECOTIC.pdf (project proposal, in French).
[11] Gossart (2008) addresses how local authorities are using ICTs for their sustainable development (in French).

can enable a decoupling between economic growth and the use of the services provided by natural ecosystems (see Figure 1).
In the past few years there has been a growing interest in what has been termed "green IT". Whether it is the sector itself that is trying to reduce its environmental impacts, or ICT firms offering their services to reduce the environmental burden to other socioeconomic actors, the green wave is up and flowing at full speed. Besides, the recent economic crisis has led politicians and entrepreneurs to place great hopes in the capacity of the ICT sector to revive growth through a green transformation and dematerialisation of industrialised economies. For example, the president of the International Telecommunications Union has declared in January 2009 that "climate change is happening right now, and poses far greater long-term threats than the current financial crisis", and suggested that "business-as-usual is simply not an option"[12]. We will now examine how ICT firms integrate environmental issues in their strategies and to what extent it contributes to green growth.

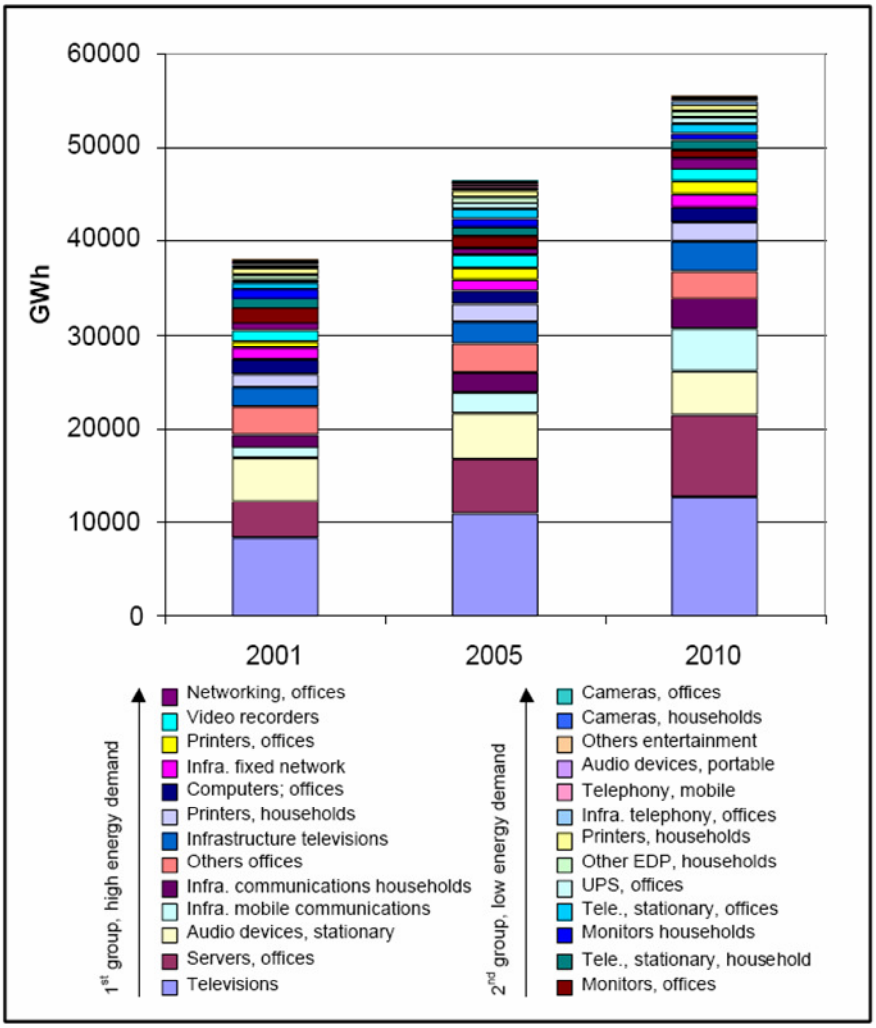
In order to account for the strategies developed by ICT firms we have compiled information diffused by French ICT journals and websites throughout the year 2008[13]. This analysis gives a snapshot of green IT strategies of ICT firms. We summarise these strategies for six key product categories. The information collected did not mean to be exhaustive, since we just wanted to identify different trends in the strategies of ICT firms. We could notice that 50% of the articles were dealing with energy efficiency, far ahead of recycling (20%) and CO2 emissions (10%). The products concerned with green IT strategies were computers (one third), telephones (20%), softwares or data centres (10%) and TV sets (5%). To cross-examine these information we have looked at the content of the richest website attached to a major IT journal in France (http://greenit.lemondeinformatique.fr). Its green IT pages contained in March 2009 some 200 news, and again the first topic dealt with was energy efficiency (20%), far ahead of health, waste of GHGs (5% each). The criteria used by the Top 12 of Green IT by the journal *Computerworld* suggest that this focus on energy efficiency is not a French idiosyncrasy[14].

Servers and data centres

According to researchers from a project funded by the EU Programme "Energy intelligent Europe", energy costs for the operation of servers are expected to exceed the costs of server hardware by 2015[15]. They underline that servers use up to 1.5% of total European electricity consumption, the equivalent of around 40 TWh or an annual energy cost of about €4.8 billion. They also quote a study revealing that for the German market, the electricity consumption of servers will increase by 50 % between 2005 and 2010. As shown in the following graph, servers are one of the IT equipment for which the energy consumption will most rise:

[12] Source : http://www.itu.int/osg/sg/speeches/2009/jan22.html.
[13] For example: http://www.zdnet.fr/actualites/0,39051260,4000084997q,00.htm, http://www.greenit.fr, http://greenit.lemondeinformatique.fr, http://www.silicon.fr/categories/actualite/green_it/, or http://www.vnunet.fr/dossiers-green_it/.
[14] See the Computerworld ranking based on companies' self-declarative surveys: 2008 Top Green-IT users and vendors, http://www.computerworld.com/action/article.do?command=viewArticleBasic&articleId=312485.
[15] Source: http://www.efficient-servers.eu/.

Figure 6: Energy demand of ICT according to appliance types

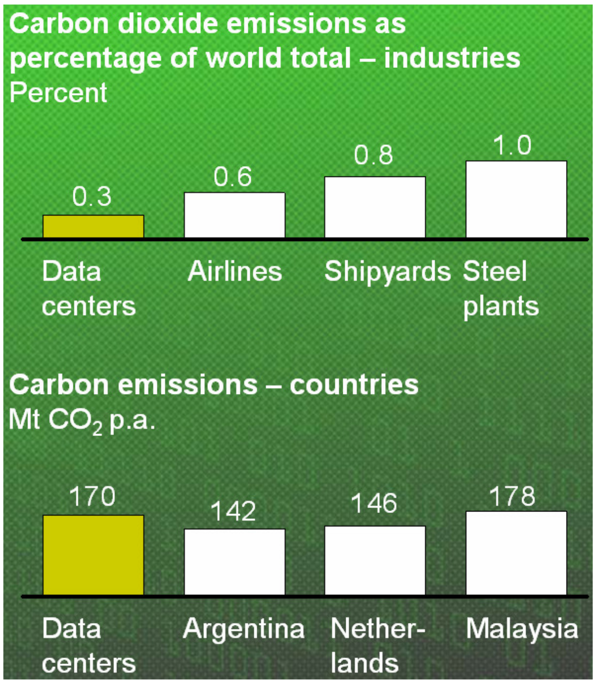


Source : Cremer et al. (2003, p. 27).

An argument brought forward by Porter & Van der Linde (1995) underlines that firms can derive financial benefits from reducing their pollution, because pollution is a type of waste. It is very much the case with servers since according to a study by McKinsey and the Uptime Institute, the average use of a server is around 6%, about 30% of them are dead, and two servers out of three have peak and average utilisation below 10%, suggesting significant overcapacity. Considering that the greenest energy is the one that is neither used nor produced, there are considerable energy savings achievable in data centres. Besides, facility costs are growing more rapidly (20%) than overall IT spend (6%), and it is IT hardware energy consumption that drives facility costs. As a consequence, GHG emissions of data centres are significant[16], and they are set to quadruple by 2020:

[16] Source: Presentation available at: http://uptimeinstitute.org/content/view/168/57. Paper available at: http://www.mckinsey.com/clientservice/bto/pointofview/pdf/Revolutionizing_Data_Center_Efficiency.pdf.

Figure 7: The environmental impacts of data centres



Source: see footnote 16.

To take up the energy efficiency challenge, the Green Grid was created in 2007 by firms of the sector to improve their energy efficiency[17]. It aims at reducing the energy consumption of data centres by 11% by 2011 (11 TWh, 7 billion tonnes of CO2).
IBM offers a "green data centre" by allowing its clients to measure online their energy consumption for free, but also provide the services of 850 "energy efficiency architects" [18]. This firm is reducing the number of internal applications as well as the numbers of data centres through server consolidation (many small physical servers are replaced by one larger physical server) and server virtualisation (one single machine is used to run several operating systems functioning separately). The aim is to improve the "Power Usage Effectiveness", a metric created by members of the Green Grid used to determine the energy efficiency of a data centre. It is calculated by dividing the amount of power entering a data centre by the power used to run the computer infrastructure within it. Dell also uses virtualisation to optimise its data centres and reduce their energy consumption[19].
Google has also jumped in the Green Grid bandwagon[20], and in 2007 has launched with Intel the Climate Savers initiative to cut carbon dioxide emissions, and demonstrate that reducing emissions is good business[21].
Finally, the Green500 list confirms that energy efficiency is a hot topic for data centre manufacturers, since it provides a ranking of the most energy-efficient supercomputers in the world[22].

Computers

In 1999, the US DOE published a forecast on the increase of the energy consumption of PCs[23]. Within the next 20 years, the electricity consumption of office equipments is set to

[17] See http://www.thegreengrid.org.
[18] See http://www-03.ibm.com/systems/greendc/resources/info/green20/howgreen/.
[19] See http://content.dell.com/us/en/enterprise/virtualization.aspx.
[20] See http://www.google.com/corporate/green/datacenters/.
[21] See http://www.climatesaverscomputing.org/.
[22] See http://www.green500.org/.

grow twice as much as overall electricity consumption, i.e. 3,2% per year. The same study reasserted in 2004 that the first quarter of this century will witness the fastest growth ever in the electricity consumption for PCs[24]. The latest data from 2009 confirm that the highest growth of electricity consumption will be the one of PCs, together with ADSL TV sets:

Table 1. Residential sector key indicators and consumption

(Quadrillion Btu per Year, Unless Otherwise Noted)

Key Indicators and Consumption	Reference Case							Annual Growth 2007-2030 (percent)
	2006	2007	2010	2015	2020	2025	2030	
Delivered Energy Consumption by End Use								
Space Heating	4.37	4.89	4.91	4.95	4.99	4.99	4.95	0.1%
Space Cooling	0.84	0.89	0.86	0.90	0.97	1.03	1.09	0.9%
Water Heating	1.99	1.98	1.95	1.95	2.00	2.00	1.95	-0.1%
Refrigeration	0.39	0.39	0.37	0.37	0.39	0.40	0.42	0.4%
Cooking	0.35	0.36	0.37	0.38	0.41	0.42	0.43	0.9%
Clothes Dryers	0.34	0.34	0.34	0.34	0.35	0.36	0.38	0.4%
Freezers	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.4%
Lighting	0.74	0.73	0.72	0.59	0.55	0.53	0.52	-1.5%
Clothes Washers[1]	0.04	0.03	0.03	0.03	0.03	0.03	0.03	-0.9%
Dishwashers[1]	0.10	0.10	0.09	0.10	0.10	0.11	0.12	0.8%
Color Televisions and Set-Top Boxes	0.34	0.36	0.40	0.41	0.44	0.49	0.56	1.9%
Personal Computers and Related Equipment	0.14	0.15	0.18	0.19	0.20	0.21	0.23	1.7%
Furnace Fans and Boiler Circulation Pumps	0.11	0.13	0.13	0.14	0.15	0.16	0.16	1.1%
Other Uses[6]	0.94	0.97	1.01	1.09	1.20	1.32	1.43	1.7%
Delivered Energy	**10.77**	**11.40**	**11.45**	**11.53**	**11.86**	**12.14**	**12.36**	**0.4%**

Source: EIE (2009), p. 10.

Apart from monitors using ecolabels (TCO, Energy Star), for there are very few environment-friendly PCs. For example, only five PCs and seven laptops have received the European ecolabel[25]. Fujitsu Siemens created a Green IT label focusing on energy efficiency[26], and a French SME called Ashelvea offers ecodesigned PCs made of biodegradable plastics and recyclable components[27].

Mobile phones

In 2008, the ITU celebrated the fact that humanity had exceeded the threshold of 4 billion mobile phones in use on the planet[28]. It did not mention that only 3% of them will be recycled (i.e. 120 million)[29]. Mobile phone manufacturers have recently been more prone to using environment-friendly features as a source of comparative advantage. For example, Sony-Ericsson offers an "environmental guarantee" assuring that if one of their phones is returned to one of their collecting points, it will be recycled according to state-of-the-art standards (Individual Producer Responsibility). The Swedish firms also offers ecodesigned phones using recycled plastics and packaging as well as an energy efficient charger[30]. Motorola's green phone uses plastic produced out of recycled bottles in order to capture a new market niche. A US-based company has produced the first phone made 95% of spare parts of other mobile phones. The emissions generated by its production are compensated, but most of them

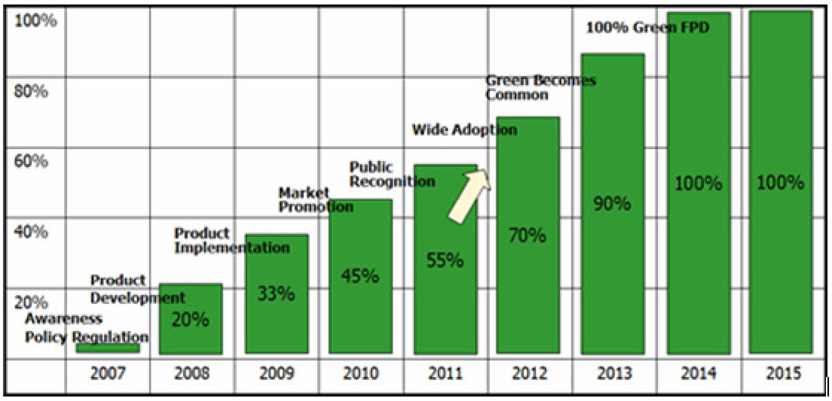
[23] See http://www.eia.doe.gov/emeu/consumptionbriefs/cbecs/pcsterminals.html.
[24] See http://www.eia.doe.gov/oiaf/aeo/overview.html#consumption.
[25] See http://www.eco-label.com/.
[26] See http://www.informaticien.be/articles_item-4612-Nouveau_label_Green_IT.html.
[27] See http://www.lemondeinformatique.fr/actualites/lire-la-start-up-ashelvea-cree-un-pc-biodegradable-27327.html.
[28] See http://www.itu.int/ITU-D/ict/newslog/Worldwide+Mobile+Cellular+Subscribers+To+Reach+4+Billion+Mark+Late+2008.aspx.
[29] See http://www.lemondeinformatique.fr/actualites/lire-97-des-telephones-mobiles-ne-sont-pas-recycles-26541.html et http://www.mobiles-actus.com/actualite/nokia-we-recycle.htm.
[30] See http://www.sonyericsson.com/cws/corporate/press/pressreleases/pressreleasedetails/sustainabilityfinal-20080924.

are generated during the user phase. Samsung also offers green phones using bioplastics made of natural corn and not containing any toxic chemical. As for Nokia, the recurrent top ranker of Greenpeace's "Guide to greener electronics"[31], the body of its 3110 is 90% recyclable, and the Finish firm claims that it is 20% more energy efficient than a similar phone[32]. It also supports the WWF by giving it 5 euros for every Nokia phone taken back by their customers. These competitors are also working on the harmonisation of chargers: at the end of 2008 they set up a ranking of the energy consumption of chargers to raise consumer awareness[33]. Finally, Bio Intelligence Service, the leader of LCAs in France, was asked by Orange and the WWF to develop a method to compare the environmental performance of all the products sold by Orange[34].

TV sets

The dominant flat panel display (FDP) screen design causes recycling problems since it is more costly to dismantle safely. It also uses a strong GHG[35], and FDPs will be the main source of increase in the energy consumption of households in the coming years (see above Figure 6 and Table 1). According to Enertech (2008), FDPs are using on average between 1.5 and 5 times more energy than CRTs. A study by DisplaySearch reveals that in 2008, 20% of FPD shipments had green features, and this share is expected to soar to 70% by 2012 and dominate the market by 2014. But the consultancy firm defines green FDPs in a broad sense since to be green an FDP needs to meet only one of the following conditions: using environmentally friendly components and materials, achieving lower power consumption by using new components or technologies, compliant with environmental regulations such as waste disposal (!), using production processes that reduce energy and materials consumed, completely or partially recyclable after useful life, or use of green or eco-friendly concepts in product design, packaging methods or materials. The consultancy finds that FPD supply chain participants work on green FPD because of environmental regulations, cost reduction, social responsibility, and the prevention of future damages or customers claims. The following graph shows the gradual match between consumers and green FDPs:

Figure 8: Green display trends



Source: "Green is the Next Wave in Flat Panel Displays", http://www.displaysearch.com/cps/rde/xchg/displaysearch/hs.xsl/green_is_next_wave_in_flat_panel_displays011909.asp.

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[31] See http://www.greenpeace.org/international/campaigns/toxics/electronics/how-the-companies-line-up.

[32] See http://www.nokia.com/A4136001?newsid=1172937.

[33] See http://cellwireless.com/index.php?option=com_content&task=view&id=523&Itemid=1.

[34] See http://orange-en-france.orange.fr/Developpement_durable/etiquetage_ecologique.html.

[35] Nitrogen trifluoride (NF3). See http://www.articlesbase.com/home-improvement-articles/is-your-flat-screen-lcd-tv-really-ecofriendly-730251.html.

Sharp has 75 FPDs which obtained the European ecolabel. However, for example if the plasma model LC-42DH77E does have energy saving features, it costs 1200 Euros and consumes 210 Watts, twice as much as a large LCD panel. Finally, not being satisfied with the European ecolabel, Philips created its own « green logo », which is awarded by external auditors and based on energy efficiency but also on recyclability and the absence of hazardous substances[36]. As in aforementioned case of the DisplaySearch study, it suffices to meet only one of the criteria to obtain the label, and all the FPD having it were only meeting the energy efficiency criteria[37].

Softwares

Although Hilty's second column (see Figure 5) about the environmental impacts of ICT suggests that environmental impacts of ICT products will come from hardware, software have a huge potential to reduce the environmental burden of our societies, including by improving the design of their programmes themselves. Free software has been developed to help reduce the energy consumption of PCs[38]. IBM also offers software solutions to reduce energy consumption by up to 35%, because its clients face unprecedented increases in energy costs, capacity demands and regulatory attention. For the US firm, "going green is not just socially responsible, but an economic imperative"[39]. In this respect, older software might be slower but demand less power to function. Programmers are now using watt meters to reveal the hidden contribution of software to energy bills, and compare different programmes. This can eventually lead consumers to opt for older software, which are still available on the net[40]. Finally, WYSE claims that client-server architecture networks and can help save 90% of energy every year. It also argues that thin clients have a longer life span than computers (5 years instead of 3), and that modern recycling operations can recover more than 90% of thin client device components for the secondary metals and other recyclate markets[41].

Routers and data networks

Router manufacturers have also started integrating environmental criteria in the design of their products. Cisco Energy Assurance Program offers a free system to estimate the energy efficiency of IT operations and identify energy efficiency gains[42]. But its competitor Nortel argues that his data networks use up to 40% less energy and cost less to run than comparable Cisco networks[43]. It provides an online calculator to show how much energy, money, and GHG can be saved by switching away from CISCO products… This suggests that energy saving technologies are being used as a source of comparative advantage in the data network business.

Looking at Hilty's categories, many activities of ICT firms aim at making more from less, as in the case of servers that require less energy for equal performance. These activities suggest that ICTs have a strong potential to contribute to green growth, especially with respect to energy efficiency gains. The focus on energy efficiency when labelling a green technology can be explained by using the win-win hypothesis: the firm co-optimises its economic

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[36] See http://www.philips.com/about/sustainability/ourgreenproducts/index.page.
[37] See http://tk-cc.marcomxchange.philips.com/2023/3505/35991111/#2.
[38] See http://www.vnunet.com/business-green/news/2230721/free-software-designed-slash-pc.
[39] See http://www-01.ibm.com/software/solutions/green/index.html.
[40] See for example http://www.oldversion.com/.
[41] See report available from http://www.wyse.com/resources/whitepapers/environmental_benefits_register.asp.
[42] See http://www.cisco.com/en/US/solutions/ns708/networking_solutions_products_genericcontent0900aecd806fd493.html.
[43] See "The Nortel tax relief plan" at: http://www33.nortel.com/energycalculator/en/saveenergy.html.

competitiveness with a reduction of its ecological footprint. Thus, it develops green technologies only if there is a market for it or if it can help cut on input costs. But are both really co-optimised? Are eco-innovations contributing to reduce our environmental impacts as much as they contribute to capture new market niches? To put bluntly, policies supporting eco-innovations assume that their diffusion will help decoupling economic growth from the consumption of natural resources. But producing them still requires to consume natural resources. The substitution argument points out that less resources will be used by replacing atoms by bits and further expanding the digital and knowledge economy.

There are two important limits to the contribution of ICTs to green growth, which are linked to the substitution argument. At first, one cannot assume that an ICT-based economy is greener per se; it needs to be demonstrated by carrying out a full analysis of the environmental impacts of ICTs. The problem is that the assumed lightness of the information society leads to assume that the diffusion of ICTs will eventually lead to a decoupling (see Figure 1). It is the case of the core document of the EU strategy aiming to support the diffusion of ICTs to improve energy efficiency (EC communication COM(2008) 241 final). Several analyses suggest that this positive contribution is over-evaluated. For example, it is often assumed that reading an electronic document is always better for the environment than reading it on paper. Well, as Hilty (2008) puts it: it depends! The LCAs carried out by his team suggest that if one wants to apply a rule of thumb it is actually worth reading something on paper if it exceeds 50 pages (but of course that depends on how the document is printed: his book was printed by Books On Demand on ecological paper…).

Also, one may argue that the more ICTs diffuse in societies to monitor our environmental impacts and to "make more from less", the more ewaste will be generated. This would be acceptable from an environmental point of view if economies were functioning in closed loops, namely by recycling most of their waste, and if the energy used to fuel ICT terminals and infrastructures was renewable plus carbon and risk neutral… But regarding the ewaste issue, as underlined by the international consortium StEP (Solving the Ewaste Problem) led by the UNU in Bonn, more than 30% of ewaste is illegally exported to developing countries, in breach of the Basle convention that forbids the export of hazardous waste. This "leakage" is one of the many examples of rebound effects associated with the diffusion of ICTs, which are not taken into account when evaluating the environmental benefits of these technologies.

Finally, another source of overvaluation of the green benefits of ICTs is the assumption that more ICTs means greater environmental awareness and eventually amore changes in peoples' behaviour towards more responsible consumption for example. But information cannot be equated with knowledge, and once knowledge is acquired, it does not necessarily lead to a change in behaviour. In the movie "About Schmidt", Jack Nicholson is watching TV ads which all aim at making him buy specific products. In the middle of these ads, one of them asks him to patronise a child in a developing country so that he can go to school. For some reason, Mr Schmidt takes his check book, sends money to the charity, and then forgets about it all. At the end of the movie, he appears as a lonely and pretty depressed man. One day, looking at his mail he sees a letter from his patronised kid who is grateful for his support that has allowed him to pass to the next class. Mr Schmidt starts smiling again. What has led him to respond to a message coming from a charity that was drawn in the middle of dozens of other messages released by private firms? The difficulty to answer this question underlines that ICT per se do not trigger behavioural change. We can make the same analysis with recycling campaigns. Studies show that recycling rates increase when such campaigns are launched. But still, recycling rates remain rather low in France for example, although people know that recycling is "good for the environment". What will make them change their behaviour? Not the mere fact that they have a 24 hour access to the Internet, where they can read anything they want about ewaste, biodiversity loss, and climate change. The recycling case is a good example to underline what is needed to enable ICTs to contribute to reduce our ecological footprint: without strong public policies recycling rates do not increase. And for these policies to be equally supportive of job creation and of reducing the consumption of natural ecosystems' services, the two objectives need to be integrated in the very design of these policies (environmental policy integration). We examine in the next section the case of the implementation of the WEEE directive in France, and underline how a public policy can help overcome the aforementioned limits to the contribution of ICTs to green growth.

3. Overcoming the barriers to green growth

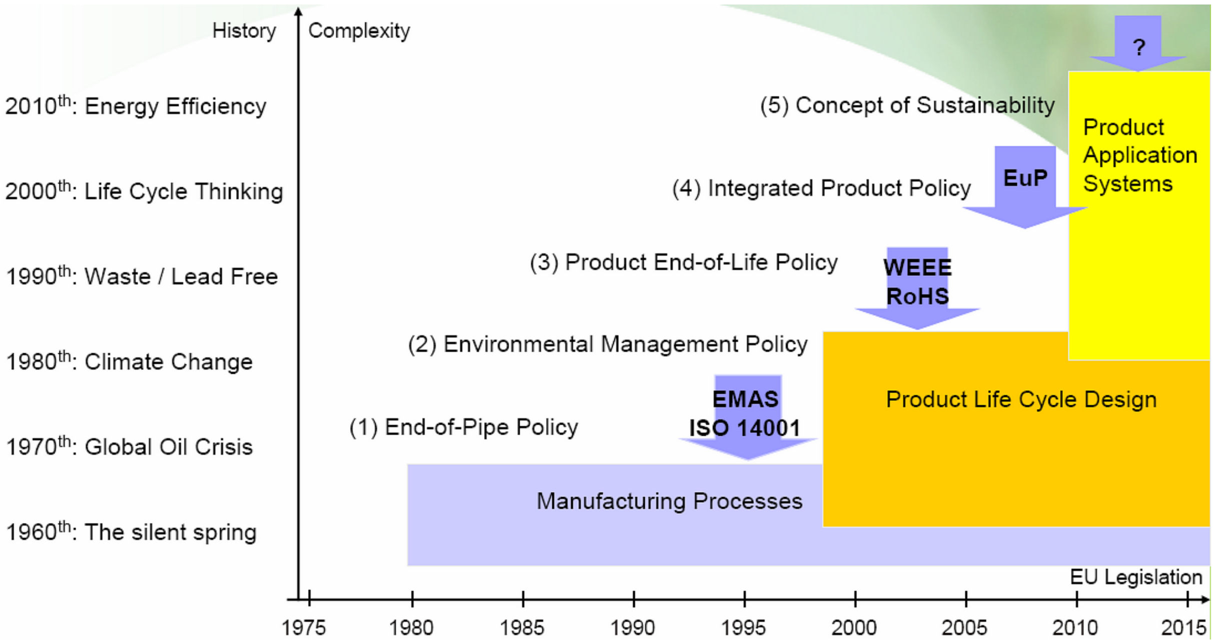
We have suggested in the previous section that without ad hoc public policies, it is unlikely that ICTs will contribute to a green growth that is not business-as-usual. Indeed, notably because of the rebound effect, the positive contribution of ICTs to green growth is likely to be overestimated[44]. Argues Richard Hawkins, if ICT manufacturers are jumping on the green IT bandwagon because they have passed the green test by measuring their greenness with ICTs' ecological footprint, because of rebound effects the environmental benefits of ICTs might be overvalued and the negative environmental impacts undervalued[45]. For example, a greener product made more efficient thanks to the use of ICTs will also sell more and increase the production of this good and thus the consumption of natural resources. For example, cars equipped with electronic injection have individually a higher energy efficiency. But as they become more popular, especially when gasoline prices are high, the overall number of cars on the roads will increase and so will the energy consumption of the country. At the household level, say that a government invests in ICTs to save energy (as advised by the EC (2008) communication COM(2008) 241 final). The aim is not only to save energy at the household level, but at the country level. It will design a policy to diffuse ICTs in houses to monitor energy (e.g. EdF is replacing its 35 millions old meters with smart meters) and to improve the efficiency of electric heaters. This is likely to induce energy savings for households. But the extent to which such a policy will result in overall energy-savings depends on what households will do with the money saved on energy bills. And it is likely that they will spend it to buy goods and services that will in the end increase their energy consumption. Many modest households will actually choose to increase the temperature inside their dwelling, leading them to consume more energy (substitution effect). If they are consuming enough of the energy service, they can then choose to use the saved money to buy a larger TV screen or to go on holidays to more distant locations implying to travel by plane (income effect). Another example of a rebound effect linked to ICTs relates to the replacement of old energy inefficient products such as refrigerators. In this case, old fridges are removed from the market but in such a way that their cooling circuit is often damaged, resulting in the leakage of CFC, a powerful GHG as well as ozone depleting substance. In France, 50% of the collected old fridges end up in recycling facilities with a broken fluid circuit. In this case, replacing old fridges by new ones may lead to generate more GHG emissions in comparison with the ones saved by reducing energy consumption, especially in a country where 80% of electricity is nuclear. Besides, replacing old machines by more efficient ones is a resource-intensive process since the new products machines are seldom made of recycled parts. Not to mention the fact that the old ones increase the ewaste flow.

The rebound effect is a clear obstacle for ICTs to contribute to a green growth that does not prioritise economic objectives but also truly reduces our ecological footprint. Its existence, which has been evidenced by several studies, reduces the positive environmental benefits of these technologies. What instruments can be used to make up for this rebound effect? To

[44] For a definition of the rebound effect, see Berkhout et al. (2000), and Sorrell & Dimitropoulos (2008).
[45] See http://www.ucalgary.ca/news/utoday/feb24-09/ITnotgreen.

follow up on the example of the rebound effects related to the replacement of old fridges by new and more energy efficient ones, we will now look at whether the main public policy addressing ewaste can avoid this rebound effect and allow ICTs to contribute to a green growth that departs from a business-as-usual scenario. The following figure gives a representation of the different European policies affecting the ICT sector over time.

Figure 9: Environmental Policy in Electronics



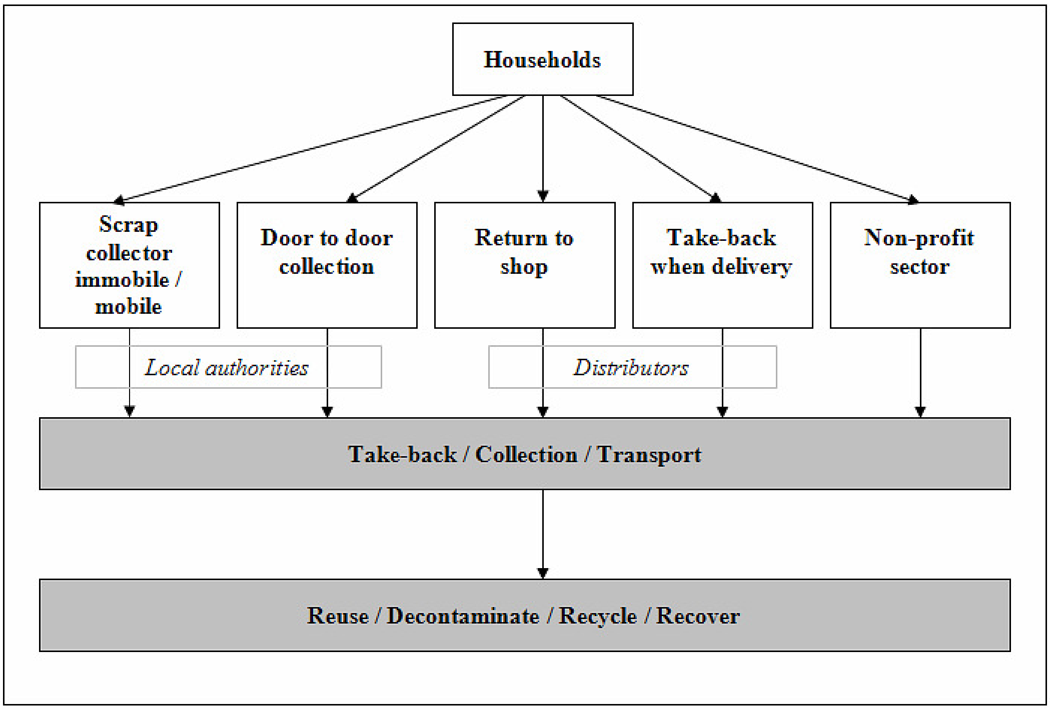
Source: Shailendra Mudgal, BIO IS, http://www2.uca.es/grup-invest/cit/G_RAEEs_archivos/Eup%20weee%20bruselas.pdf.

This figure shows that energy efficiency concerns are quite recent for the ICT sector and for European policy-makers, whose main regulatory instrument to integrate this issue in the strategies of the sector is the EuP directive (Energy using Products). Other instruments include ecolabels, such as the European version of Energy Star or the Swedish label TCO, and technical standards (17% of the norms managed by the ISO concern the electronics, telecom and information technologies). But let us look at a directive which has now been in place for some time, and examine to what extent it can contribute to green growth.

The WEEE (Waste of Electrical and Electronic Equipment) directive 2002/96/CE aims to foster the recycling of EEE (Electrical and Electronic Equipment). It obliges manufacturers and importers of EEE to cover take back and treatment costs (Extended Producer Responsibility-EPR). In was implemented in France with two years delay, and only in 2008 will this country meet the collection target of 4 kg/inh./year. It is based on five principles:

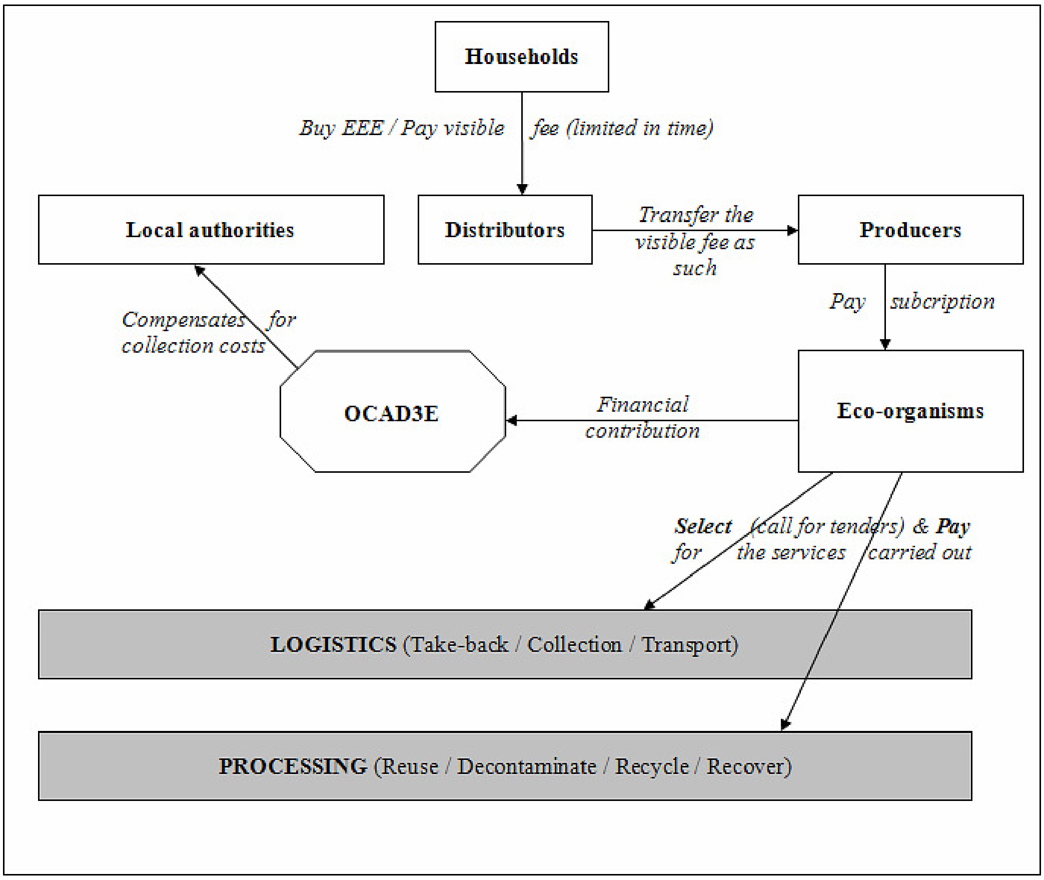
1) Polluter-pays principle (visible fee),
2) EPR principle (incentive for firms to invest in ecodesign),
3) Old for new principle,
4) Creation of independent eco-organisms (4 in France, notably in charge of information campaigns and of collecting and redistributing money of the visible fee),
5) Quantified targets (4 kg/an/hab. by the end of 2006 for household waste).

Figure 10: Physical flows of WEEE in France



Source : ADEME (2007).

Figure 11: Financial flows related with the management of WEEE in France



Source : ADEME (2007).

The WEEE directive is being revised[46], in order to increase collection targets and to harmonise it with other directives such as EuP. It also seeks to reduce the illegal exports of ewaste[47].

The implementation of the directive in France suggests that without the directive the French take back system would have taken more time to be put in place. The objective of the EPR was to induce firms into investing in ecodesigned EEE that could be more easily recycled, which has not been achieved[48]. Indeed, few firms are involved in design for recycling activities. In this respect, the WEEE directive has not succeeded in supporting ecoinnovations enabling a reduction of ewaste flows (e.g. by extending products' life span) or of the treatment costs of WEEE while creating a market niche for ecodesigned EEE. Indeed, ecodesign efforts mostly concern energy efficiency gains, fostered by the European energy tag. Thus, the WEEE directive is still pretty much perceived as a financial burden by firms, who would prefer an Individual Producer Responsibility (IPR) over the EPR. Nowadays, some argue in favor of transferring all ecodesign requirements to the EuP directive, but the latter only concerns energy aspects. For the WEEE directive to support the contribution of ICTs to green growth, it would need to better support the ecodesign of ICT products.

The WEEE directive and the Basle convention have great difficulties in limiting the rebound effects related to the diffusion of ICTs to reduce our ecological footprint. Sometimes, environmental policies even have conflicting goals. On one hand the EuP directive supports the replacement of old refrigerators by new and more energy efficient ones, on the other hand replacing old EEE implies to consume more resources to build the new fridges, and to generate more ewaste to dispose of the old ones. Finally for the WEEE directive, eco-organisms are entrusted to raise the awareness of the public regarding ewaste recycling, but they fall short in this important matter. We cannot help underlining here the paradox of asking an organisation whose existence lies in the management of the flows of ewaste to reduce this very flow, which seems like asking it to cut the branch on which it is sitting. Under these conditions, eco-organisms have little incentive to reduce the flow of ewaste at its source, which may for example entail to support a reduction in the consumption of EEE.

An incentive could come from initiatives undertaken by NGOs, possibly through public private partnership. For example, we mentioned earlier the action between Orange and the WWF in order to compare the environmental impacts of all the products sold by Orange. Another civil society initiative that may support the ecodesign of ICTs is Greenpeace's guide to greener electronics[49]. It compares how ICT firms fulfil a set of criteria which go beyond the mere reduction of ICT environmental impacts (precautionary principle, toxic chemicals management, voluntary take back, information to final consumers, quantities recycled, support to the reduction of GHGs, content of recycled plastics, energy efficiency of new models, publication of the carbon footprint, etc.). For example, Nokia has received extra points for helping India to set up a state-of-the-art recycling facility, thereby reducing the impacts of ewaste recycling on health and on natural ecosystems[50].

[46] About the revision process, see http://ec.europa.eu/environment/waste/weee/index_en.htm and http://www.euractiv.com/en/environment/commission-industry-clash-electronic-waste-collection/article-178986.
[47] A recent experiment by Greenpeace could track with a GPS a broken TV set which should never have been exported from the public recycling site where it had been brought by its owner. It went as far as Lagos, Nigeria. http://www.computerworlduk.com/toolbox/green-computing/best-practice/news/index.cfm?newsid=13435&tsb=comment.
[48] For a comparative analysis of different take-back systems in the world, see the white paper recently published by StEP, available from its publications page at http://www.step-initiative.org.
[49] See http://www.greenpeace.org/international/campaigns/toxics/electronics/how-the-companies-line-up.
[50] About these impacts, see the 2 films shot in Asia & Africa by the Basle Action Network, http://www.ban.org.

It is not clear whether the WEEE directive has managed to at least partly counter the rebound effects associated with the diffusion of ICTs. As far as ewaste leakages is concerned it has failed to avoid the export of ewaste to countries which are not equipped to treat such hazardous waste. But as customs officer argue, the cost of avoiding such exports is very high, given that they already lack the resources to check for other illegal imports such as drugs. This raises the question of whether European customers want to pay to avoid their waste being exported to developing countries (mostly to Asia, especially China), when they are already paying the visible fee which barely covers the costs of the take back system at home. This suggests that the negative externalities of ICTs are far from being covered, hence a likely overvaluation of its green benefits. However, the implementation of the WEEE directive did succeed in some case to co-optimise job creation and environmental protection. For example, in France some EEE distributors are working with charities to employ jobless workers in facilities to treat, dismantle, and sometimes repair and resell ewaste. Darty has for example created 800 jobs in two NGOs by sending them most of their collected WEEE (Envie and Emmaüs).

4. Conclusion

We have explained in this paper that the strategies of firms using ICTs for green growth is mostly focusing on energy efficiency, which is also the case of many public policies. We have argued that these policies are based on the assumption of a positive contribution of ICTs to this objective, but that this assumption might be false because the benefits of ICTs to green growth are likely to be overvalued. We have explained the processes leading to such a bias, and examined whether public policies could help overcome this bias.

We finally suggested that evolutionary economists can make important contributions to the green growth debate. However, such a shift in their research priorities might require to reconsider some of the key focuses of the discipline, such as the role of technology in enabling societal changes. It also raises the issue of how to integrate the limits to the services provided by natural ecosystems in the development of the successive waves of creative destruction.

Since ICTs will not trigger green growth per se, the conditions under which ICTs could contribute to the objectives of the environmental dimension of sustainable development need to be clarified. Some of these conditions were examined in this paper, but a lot remains to be done to understand what policies will enable ICTs to contribute to green growth. Some have argued that environmental policy integration might be the solution, others call for a "third industrial revolution[51].

What will evolutionary economists offer?

[51] See Klaus Jacob & Martin Jänicke (2009), A Third Industrial Revolution? Solutions to the crisis of resource-intensive growth, FFU-report 02-2009, available from the Environmental Policy Research Centre of the FUB: http://www.polsoz.fu-berlin.de/polwiss/forschung/systeme/ffu/publikationen/2009/jaenicke_martin_jacob_klaus_2009/index.html.

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