"Green" direct and enabling effects of ICT - focus on mobile

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'Green' direct and enabling effects of ICT – focus on mobile

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Introduction

In recent years the number of mobile devices and users of the mobile network has grown considerable and it is expected that this growth will continue especially in China and India. More users and a total increase in the use of telecommunications systems are putting greater demand on mobile operators to consider 'green aspects'.

In this paper focus is on two areas of the 'green aspects': on the direct effect - related to the emission reduction and energy savings within the mobile sector and on the indirect effect which refers to the reduction of GHG emissions and energy saving in other sectors e.g. transportation, power, buildings, industry.

We look closely into the product development and innovation processes within the mobile sector with main focus on contribution of the mobile network and applications on energy efficiency. This paper reviews Life Cycle Assessment (LCA) from a ICT perspective and highlights the need for its use within the ICT sector, and the importance of LCA as a decision making support tool.

The paper also identifies key challenges within green mobile areas for future research such as: development of innovative green applications, user acceptance and the rebound effect.

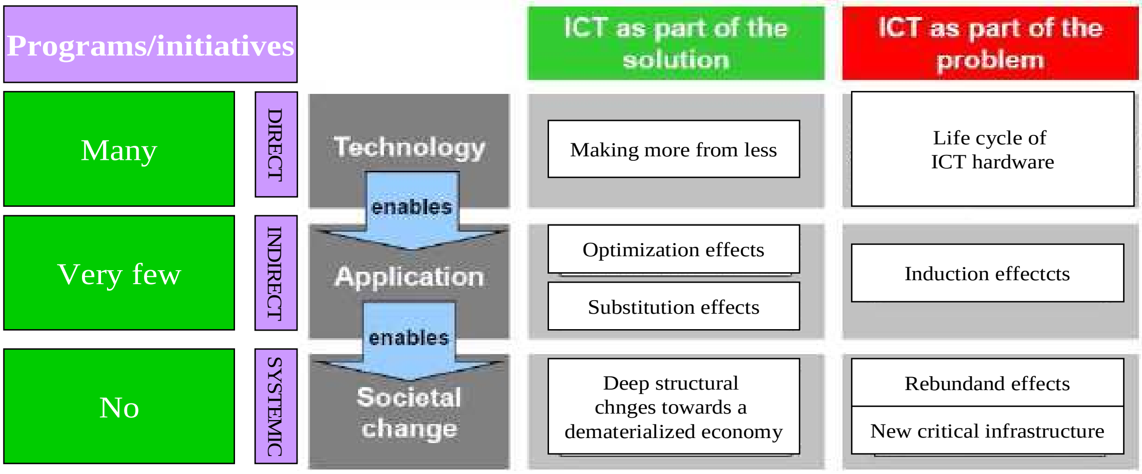
The role of ICT in energy efficiency - direct, indirect, systemic impact

ICT is looked upon as a facilitator and an enabler of environmental objectives. The use of ICT will deliver advantages to the system as well as disadvantages in the form of cost and environmental impact.

As ICT is responsible for 2% of carbon emission, of which 1,75% is due to the use of ICT products and services, and 0,25% to their production, the implementation of comprehensive programs/initiatives will only provide minor further energy savings in the overall eco-system.

However, in order to fully assess the potential role of ICTs in energy efficiency and GHG emission reduction it is necessary to look into three impacts: direct, indirect and systemic, by systematically identifying various changes in individual behaviour, economic and social structure (figure 1).

Figure 1. Direct, indirect and systemic impact of ICT

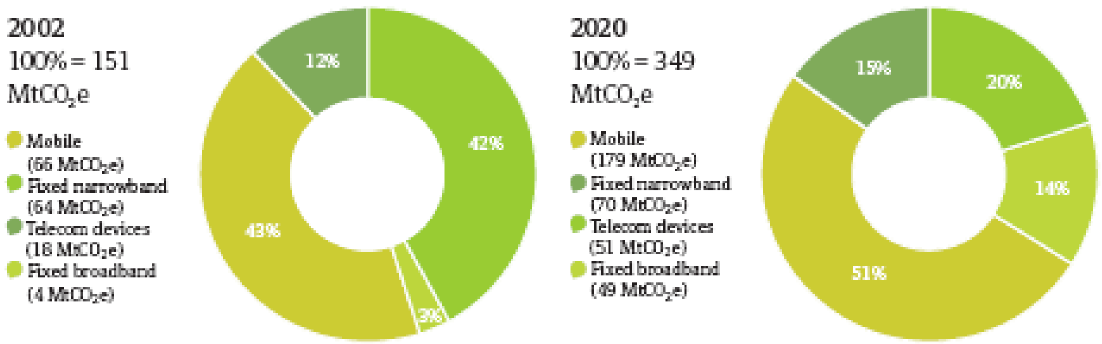


Source: Conceptual framework (Lorenz H., 2008)

Direct effects

Direct effects are related to the emission reduction and energy savings within ICT sector. The mobile industry forecasts that it will reduce its total global greenhouse gas emissions per connection by 40% by 2020 compared to 2009, including energy consumption from the radio network, buildings, energy consumption and emissions from transport. (GSMA 2009, Mobiles Green Manifesto, GSMA 2009). Examples of initiatives related to the development of the energy efficient networks and handset are: designing and deploying base-stations powered by renewable energy, designing low energy base station sites, reducing mobile life cycle emission through design and recycling. According to SMART 2020 report, mobile network will come to dominate the overall telecoms footprint by 2020.

Figure 2. Global telecom footprint (devices and infrastructure)



Mobile phones represented 3% of the total ICT footprint (11% of 30%).

Fixed broadband represented 1% of the total ICT footprint (3% of 30%).

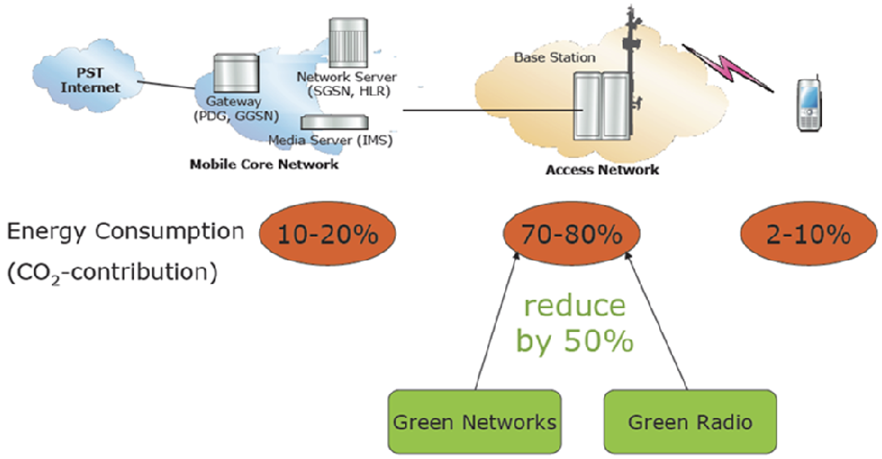
Mobile phones will represent 1% of the total ICT footprint (6% of 25%)

Mobile networks will represent 13% of the total ICT footprint (51% of 25%)

Fixed broadband will represent 4% of the total ICT footprint (14% of 25%)

As the mobile access network is leading in the direct emission/energy consumption of the mobile industry representing 70 - 80%, a number of initiatives have been taken in order to develop energy efficient networks, including implementing infrastructure optimization and sharing, deploying base stations powered by renewable energy.

Figure 3. Energy consumption - focus on present and future mobile cellular networks (LTE)



Sources: Dietrich Zeller, EARTH Project and GreenTouch Initiative, Bell Labs, Germany, WWRF Meeting, November 2010, London, UK

Many operators has committed to targets for energy efficiency and GHG emissions reductions, e.g. Alcatel-Lucent, France Telecom, Telenor, Nokia, Vodafon, Telecom Italia, Motorola. Ericsson as a provider of technology and services to telecom operators, has focused on energy efficiency and targeted to reduce carbon footprint by 40% from 2008 baseline.

In addition, Ericsson reported reductions in energy usage for its radio bases stations (15 percent since 2007, the equivalent of 1 million tons in carbon-dioxide emissions), for its mobile soft switch solutions (60 percent more efficiency per subscriber) and for site power management.

Nokia Siemens Networks is also committed to help GHG emission reduction and energy saving. In 2010, Nokia Siemens Networks has published wireless access network energy efficiency in accordance with new technical specifications published by the European Telecommunications Standards Institute (ETSI). Nokia Siemens Networks is also creating environmentally sustainable business solutions using renewable energy sources such as solar, wind, hybrid and fuel cell technology. They have implemented over 300 sites in 30 countries running on renewable power.

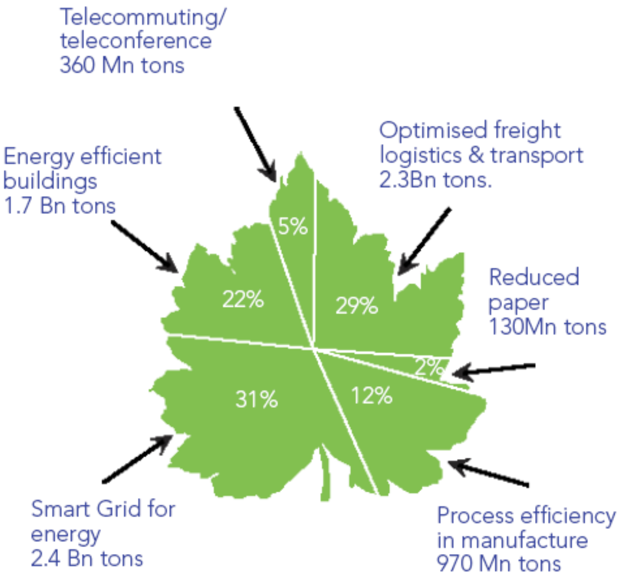
Motorola's energy action plan starts with their own products and operations. For instance, they have improved the energy efficiency of the set-top product line by approximately 50 percent in the last decade. They have improved the overall energy efficiency of cell phones, leading to longer talk times and less need to charge the battery. Motorola has reduced average standby power of mobile phone chargers by 70 percent since 2000, and reduced carbon life cycle impacts of typical mobile phones by 50 percent since 2004. Moreover, about 15 percent of the electricity Motorola purchase worldwide (as of Spring 2009) comes from renewable sources, up from 8.6 percent in 2008. The goal of the company is to increase the purchase of electricity from renewable sources to 20 percent by 2010 and 30 percent by 2020.

The examples presented clearly show that operators and manufacturers are aware of the fact that more users and a total increase in the use of telecommunications systems are putting greater demands on energy usage and therefore more environmentally friendly initiatives will have to be developed in the near future.

Indirect effects

Indirect effects refer to the reduction of GHG emissions in other sectors e.g. transportation, power, buildings, industry, agriculture, forestry and land use, by delivering so-called smart solutions.

Figure 4. Impacts of applying ICT on greenhouse gas emissions



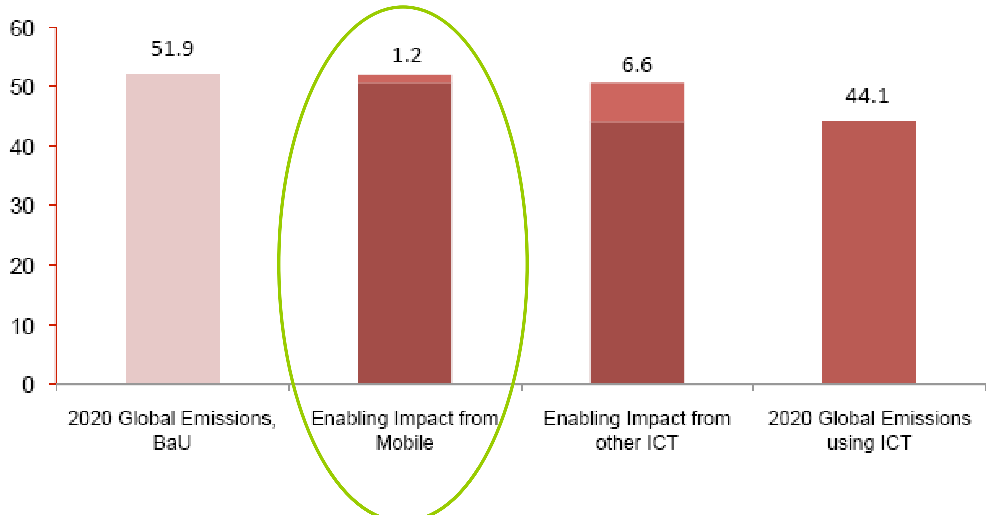
By 2020, GeSI forecasts 15% global reduction in emissions by applying ICTs, some 7.8 Bn tons

Source: The Climate Group, 2008

Mobile technologies are playing an important role in increasing energy efficiency by delivering smart intelligent solutions using SIM cards and radio modules embedded in machines and devices.

The report "SMART2020", published by GeSI and The Climate Group, assesses that the ICT sector, including mobile technologies, could reduce global GHG emissions by 7.8 Gt CO2e in 2020, from a total GHG emissions of 51.9 Gt CO2e on a "business-as- usual" trajectory. This amounts to five times the carbon footprint of the ICT sector itself in 2020.

Figure 5. Enabling impact of ICT and mobile sectors on global GHG emissions



Source: SMART2020

In 2009, Vodafone published a report: the “Carbon Connections" focusing on the positive effects that might derive from the implementation -at first- of 16 “smart” opportunities in 2020. These positive effects include energy savings and carbon emissions reduction. The 16 "smart" opportunities described in the report fall under the following categories:

- Dematerialisation – replacing physical goods, processes or travel with “virtual” alternatives, such as video-conferencing or e-commerce (online shopping).
- Smart grid – improving efficiency of electricity grids through active monitoring and reducing reliance on centralised electricity production.
- Smart logistics – monitoring and tracking vehicles and their loads to improve the efficiency of logistics operations by utilising vehicles more fully.
- Smart cities – improving traffic and utilities management.

For each of these categories Vodafone identify specific wireless telecoms opportunities that could be result in significant energy efficiency and carbon abatement[1].

The “SMART2020” report estimates that mobile technologies could reduce global GHG emissions in other sectors by four to five times its own footprint. But until now no industry initiatives have promoted mobile applications reducing the environmental impact across the complete life cycle. The few initiatives considering mobile products/services have mostly focused on specific life cycle phases e.g. the manufacturing or the use phase.

According to an OECD report[2], only one third of the program actually focused on using ICT in other sectors in areas where there is a major potential to dramatically improve performance, e.g. smart urban, transport and power distribution system, despite the fact that this is where ICT have the greatest potential to improve environmental performance.

Systemic effects

Systemic effects are macro-level indirect effects resulting from structural and behavioural changes and adaptation to the ICT services as a part of everyday life and business processes/ culture. These ICT-enabled changes affect economic and social parameters such as: the attitudes, expectations and behaviour of individuals and the demand and supply of goods and services;

LCA as a management tool

Life cycle assessment (LCA)

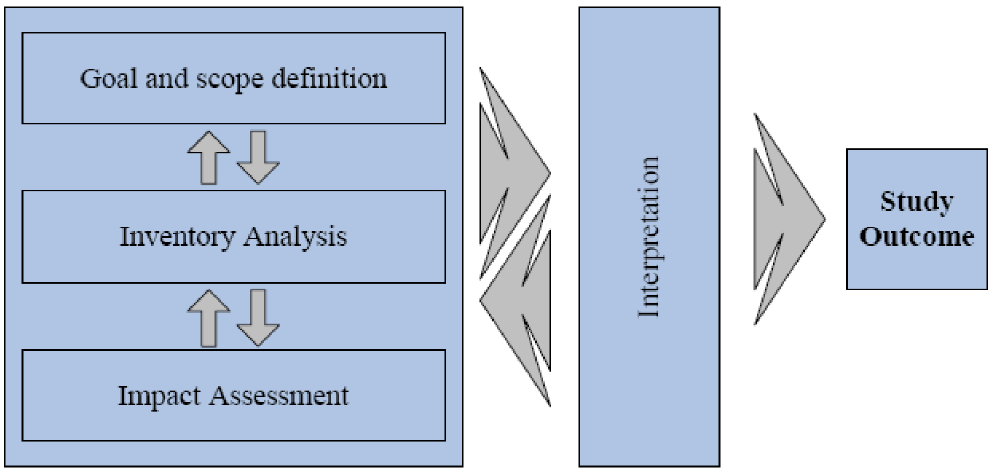
Life cycle assessment is a technique for comprehensive environmental assessments of products and processes. The unique feature of this methodology is its focus on the entire life cycle of a product, from raw material extraction, manufacturing, transportation and distribution, use, re-use, maintenance, recycling to final disposal. *(Graedel and Allenby, 1995, Graedel, T.E. and Allenby B.R. (1995), Industrial Ecology, Prentice Hall / AT&T, New Jersey).*

The LCA methodology is based on ISO 14040 and consists of four distinct analytical steps:

1. defining the goal and scope,
2. creating the life-cycle inventory,
3. assessing the impact
4. and finally interpreting the results

[ISO 14040 Environmental Management Life Cycle Assessment Principles and Framework; International Standards Organization: Brussels, Belgium, 2006].

Figure 6. Life-cycle assessment framework



Source: ISO 14040 Environmental Management Life Cycle Assessment Principles and Framework; International Standards Organization: Brussels, Belgium, 2006.

The International Organization for Standardization (ISO) recommends the use of life-cycle assessment (LCA) to better comprehend and reduce environmental impacts related to manufactured products and services offered to the society. The principles and framework for conducting and reporting LCA studies, including certain minimal requirements of LCA are presented in the international standard ISO 14040:2006 and ISO 14044:2006. Those standards have replaced the previous standards (ISO 14040:1997, ISO 14041:1999, ISO 14042:2000 and ISO 14043:2000). It is important to pointed out that the International Standard does not describe the life cycle assessment technique in detail and therefore the implementation of the standard is not simple, and a couple of studies have addressed the existing limitations[3].

[3] (Khan et al. 2002; Khan, F. I., Raveender, V., & Husain, T. (2002) Effective environmental management through life cycle assessment. Journal of Loss Prevention in the Process Industries, 15, 455–466). Ross and Evans 2002 Ross, S., & Evans, D. (2002). Use of life cycle assessment in environmental management. Environmental Management, 29(1), 132–142)

LCA of mobile networks

Life Cycle Assessment (LCA) has become an important management tool for many telecommunication companies when it comes to assessing the environmental performance of different products and services. The LCA study performed by companies has been used not only to analyse the environmental consequences of various product and activities through their life cycle but also to:

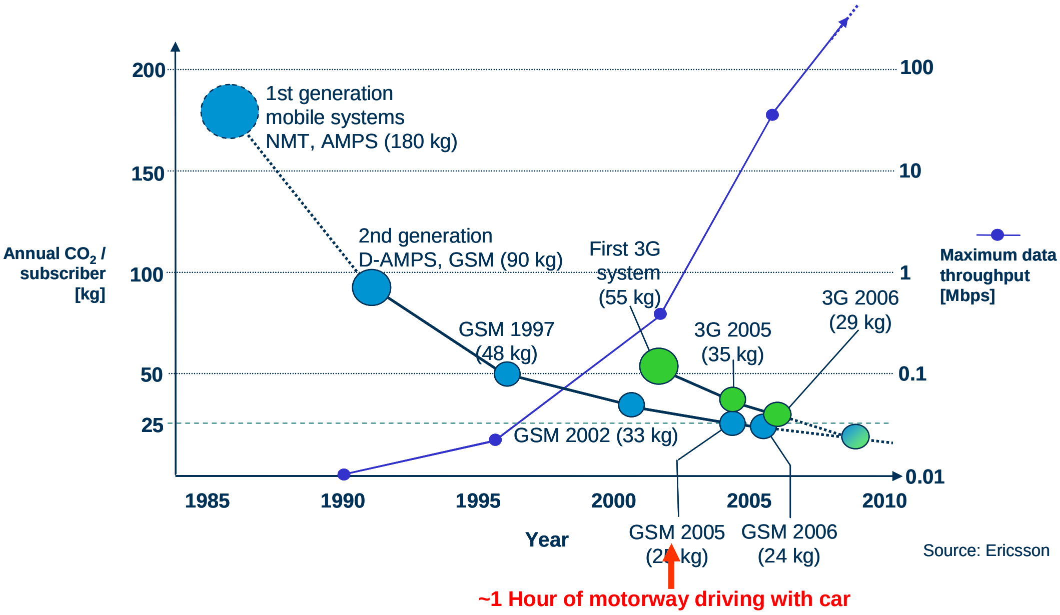
- compare products with the same functionality e.g. laptop and PC, 2G and 3G networks,
- identify important part in the life cycle that are critical to the total environmental impact, e.g. use, disposal phase. (Anderson et al., 1998, Andersson, K., Eide, M.H., Lundqvist, U. and Mattsson, B. (1998), The feasibility of including sustainability in LCA for product development, Journal of Cleaner Production, 6, 289-298.)

In order to fully address the LCA of mobile networks special attention needs to be paid to Life Cycle Inventory (LCI), which is an accounting of resources consumed, energy input and wastes generated across all the stages of life cycle. LCI is one of the four steps of the LCA methodology. The true value of LCI is the realization that a change in one portion of a product's life cycle will have some effect (either positive or negative) in other areas of the product's life cycle and therefore true improvement opportunities can be identified (Kuta et al., 1995).

Presently, many in-depth LCAs on a product level have been conducted. The comprehensive approach encompassing the whole life cycle of the telecommunication network has been performed only by few companies (e.g. The Ericsson LCA of the Third Generation (3G) Wireless Telecommunication System; Alcatel-Lucent, Bell Labs - FP7 ICT , The Network of the Future - EARTH: Driving the Energy Efficiency of Wireless Infrastructure to its Limits).

The Ericsson LCA of the Third Generation (3G) Wireless Telecommunication System is one of the first large-scale LCAs on system level performed by a manufacturer (Ericsson 2010).

Figure 7. Life Cycle Assessment (LCA). Annual CO2 emission per mobile subscriber



Source: Ericsson, 2010

The study conducted by Ericsson provides the picture on the environmental consequences associated with the transition from second generation to third generation mobile networks.

Figure 7 indicates that 3G mobile networks can provide the communication technology and technique that is needed in order to enable future data capacity for intensive mobile communication in an environmentally efficient way[4]. However, the environmental impacts of UMTS networks per functional unit are higher than impacts of GSM networks which is associated with a low subscriber load in the introduction phase. It was estimated that, with increasing subscriber numbers and increasing download volume, the environmental impact per functional unit decreases substantially, and therefore it is recommended to replace 2G networks as soon as possible by 3G technology. The transition period between networks deploying 2G networks and 3G network should be kept as short as possible. A parallel operation of 2G and 3G, 4G networks is environmentally adverse.

The comprehensive approach allows the identification of which phases in the life cycle of mobile network cause the main environmental impacts, as well as to take technical actions to reduce these impacts. The LCA results point out that the most significant environmental impacts from Ericsson systems are associated with energy consumption during their use. Radio base stations are the single largest consumers of energy. Consequently, measures taken to reduce this consumption can directly benefit society.

LCA as a management tool

LCA results may be useful inputs to a variety of environmental decision-making processes, which traditionally has been focused on three classes of approaches (Portney and Stavins 2000, Market-based environmental policies Paul Portney and Robert Stavins, 1998):

1. Zero risk approach - to avoid the occurrence of any adverse health/environmental effect.
2. Balancing approach - weighs competing outcomes and recommends regulatory action based on particular results. This approach involves the use of cost benefit analysis (CBA), which requires the translation of all environmental values into economic values.
3. Technology based approach - characterizes the minimum attainable pollution level based on the adoption of the best available technology (BAT). A problem with this approach is that it is difficult to define the “best technology” because emissions can often be further reduced at higher costs, and technologies are constantly changing.

Until now business associations and governments have introduced a range of programmes and initiatives on ICT and the environment to address issues such as global warming and energy use.

One of the initiatives was conducted by OECD in 2009 (OECD 2009, Towards Green ICT Strategies: Assessing Policies and Programmes on ICT and the Environment) and analyses 92 government programmes and business initiatives across 22 OECD countries plus the European Commission. Of these, 50 were established by governments and 42 by industry associations[5].

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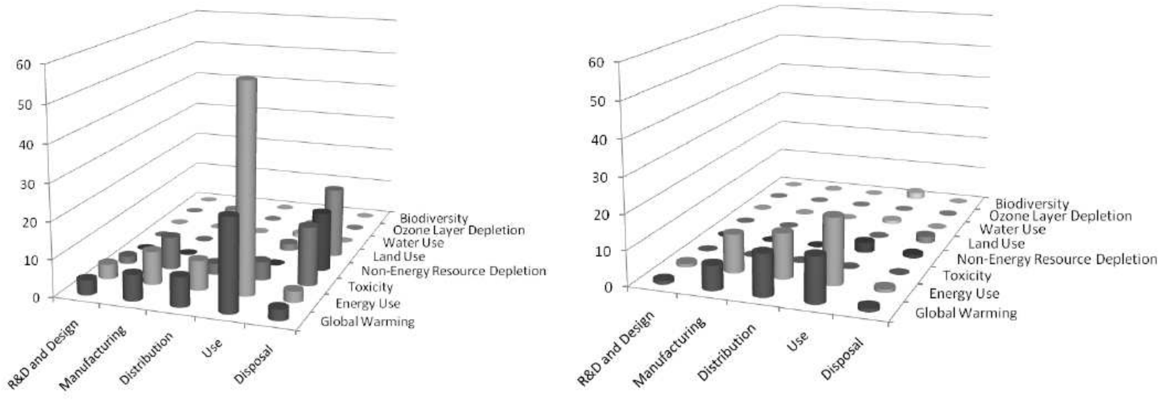
[4] UMTS networks are predestined to provide advanced mobile communication services to a large number of subscribers without the need to extend the network infrastructure. This large subscriber capacity results in a reduced relative environmental impact score per bit as soon as the UMTS networks are efficiently loaded.

[5] This report gives an overview of the main programmes and initiatives, but does not consider initiatives of single companies. It identifies the major actors and analyses their current objectives as well as their main policies and programmes. The term “Green ICT” refers to direct effects of ICTs, and the term “ICT application” to enabling effects

The most frequent objective of governments and businesses is to reduce the direct environmental impacts of ICTs. Over two thirds of the initiatives surveyed by the OECD focus on greening ICTs.

Figure 8. Number of initiatives focusing on direct effects (left) and enabling effects (right) of ICTs by life cycle phase and environmental impact category

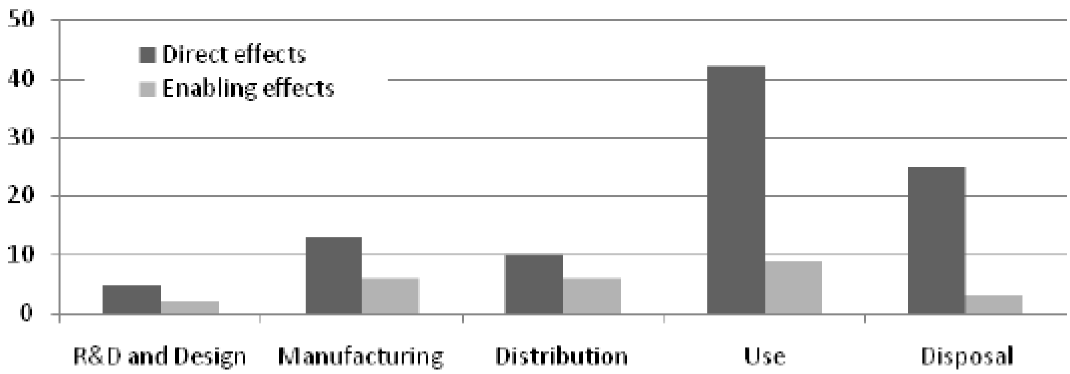


Source: OECD, 2009

Among various initiatives taken by business and government, it is less common tackling global warming and environmental degradation by using ICT applications as enablers of change. Only one tenth of the initiatives focus solely on using ICTs as an enabler, although almost one third of the initiatives look at both greening ICT infrastructures and at deploying ICT applications as enablers. According to the OECD survey, very few business associations have strategies to apply ICTs outside of the ICT sector[6].

Presently, ICT use is the most frequently targeted life cycle phase, and most initiatives focussing on direct effects primarily aim at reducing CO2 emissions and energy consumption of ICT use. Very few target reducing environmental impacts over the complete life-cycle, even though manufacturing, distribution and disposal can have higher environmental impacts. Moreover most initiatives aiming at reducing energy consumption and increasing energy efficiency of ICTs, has been driven rather by high energy prices than by environmental considerations.

Figure 9. Number of times life cycle phases targeted by industry associations



of ICTs. Green ICT in the narrow sense refers to ICTs with low environmental burdens; using ICT as an enabler reduces environmental impacts across the economy outside of the ICT sector.

[6] There are notable examples such as the Global e-Sustainability Initiative (GeSI) or The Digital Energy Solutions Campaign.

Source: OECD, 2009, Towards Green ICT Strategies: Assessing Policies and Programmes on ICT and the Environment, June 2009

In the future, there is a need for development strategies, policies to address environmental impacts over the complete ICT life-cycle using LCA analysis results.

LCA could also be more deeply included in decision-making processes of a company through further integration of it into environmental management schemes. This process may generate more environmental benefits in the long run.

LCA offers opportunities for assisting companies and policy makers in environmental management, as it provides indicators (like greenhouse gas emissions, climate change, resource depletion etc) of the sustainability of industrial systems.

Mobile energy efficient applications

The ICT sector is in a unique position to assist other sectors to work more efficiently and reduce their emissions. Some technologies enhance existing processes and drive incremental change; others are more transformational, enabling new ways of working, driving dematerialisation and leading to new business models. It is expected that the mobile sector will deliver a variety of innovative efficiency improvements which will help to replace physical processes with virtual alternatives, improve mobile working, and optimise processes.

In May 2008, a European Commission communication proposed to focus on three priority areas for use of “smart solutions” to reduce emissions: homes; electricity grids and lighting (due to their relative importance and potential for improvement). (Addressing the challenge of energy efficiency through Information and Communication Technologies, COM(2008)241 final, EC, 2008). Other sectors mentioned in the report with considerable energy-saving potential are the manufacturing industry and transport (estimated, by 2020, at around 25% and 26% of their total primary energy consumption).

ICT can make a major contribution to energy saving and GHG emission reductions by enabling smart applications that improve energy efficiency through real time monitoring and control of processes and wireless communications will enable this to be done remotely and on the move using cellular connections.

The innovative ICT/mobile application which support various sector can be divided into[7]:

- Enhancing applications;
- Enabling applications;
- Transforming applications.

Enhancing applications make existing processes more efficient. They play an important role many industrial systems were built in the past at a time when energy and natural resources were inexpensive. Presently mobile applications are adding environmental intelligence to these systems, allowing more efficient use of resources. Examples of applications that make existing processes more efficient are:

[7] Based on the Intellect, the trade association for the UK technology industry

- intelligent transport systems; the application of information technology to improve the efficiency of the transportation infrastructure; deployment of advanced sensors, analytical models and ubiquitous communications enable: less polluting forms of transport, reduced congestions, fewer and shorter delays, enhance operating capacity, improve safety e.g. bus lane management and transport smart cards make public transport more attractive, road charging reduces congestion and fleet logistics, tracking and telematics optimise vehicle efficiency, freight logistics and air traffic control management[8]. Mobile-enabled initiatives as: fleet tracking systems, load optimisation, onboard telematics, and synchronised traffic and notification systems can facilitate better communication and trip planning and driving a reduction in GHG emissions.
- smart buildings - building optimization and energy management systems - use of sensors and controls including smart meters, smart appliance, and low energy lighting in buildings to improve efficiency. It is estimated that more than 40% of the energy consumption in Europe is building-related (residential, public, commercial and industrial). The Action Plan for Energy Efficiency estimates that the largest cost-effective energy savings potential lies in the residential (around 27%) and commercial buildings (around 30%);
- smart grids: deploying smart meters and communication technologies within the electricity sector, implementing integrated renewable solutions - use of simulation analytical and management tools to enable a wide deployment of renewable energy. As the smart grid is in a process of radical change, ICTs will play a major role in reducing losses and increasing efficiency as well as in managing and controlling the distributed power grid to ensure stability and reinforce security as well as in supporting the establishment of a well functioning electricity retail market. The multiplication of local energy networks, the integration of renewable energy sources (RES), the spread of co- and micro-generation (micro-grids, virtual power plants), and new user demands require the use of the most advanced technologies for monitoring and control as well as for electronic trading of electricity. The Power Management System (PMS) - balances energy demands with the available energy supply, preventing disturbances or even blackouts in operations. Furthermore, it enables a company to control its energy costs, to enhance safety. PMS can provide monitoring and control of electrical devices. Smart meters will allow consumers to better manage their energy usage by providing more detailed information about their consumption with the opportunity to save money on their power bill and reduce greenhouse gas emissions.
- I-optimisation – use of ICT within production processes to improve operations and increase efficiency, improved industrial processes and techniques. Further environmental benefits of ICT applications are also evident in areas such as water management, biodiversity protection, pollution reduction.

Enabling applications allow people to do things differently e.g. the paperless office, teleworking, telecommuting;

- E-working – provides a number of solutions which can remove the need for travel. Secure intranet technologies and broadband allow people to access all the information they need to work effectively from any location.[9] It is expected that close to 100 million workers are e-

[8] Becoming a winner in a low-carbon economy: ICT solutions that help business and the planet, WWF, 2008
[9] Generally it is difficult to measure exactly how much energy is saved by teleworking, because factors such as need for day-time home heating/cooling and duplication of ICT equipment for home workers need to be included.

working either full-time or part-time in 2010. By implementing e-work companies will be able save money, enhance distributed work through e-collaboration, and manage the virtual workforce through effective communication.

- Video and teleconferencing – can create virtual meetings – providing more environmentally friendly solutions. Broadband enables the widespread deployment of electronic conferencing which can remove the need for travel. It is particularly effective in large organisations with operations spread between offices in different geographical locations. Video and teleconferencing could replace between 5 and 20% of global business travel.

Transforming applications: applications that lead to alternative low-carbon business models e.g. dematerialization – the substitution of high carbon products with low carbon alternatives – involves the shift from companies selling products to offering services: paper vs. e-mail, e-invoicing, e-banking; ticket vs. e/m-tickets (eliminate 25% of all paper), CDs vs. online music; books vs. e-books; shopping vs. m-commerce, e-commerce. It is expected that by the end of 2010 74,4 million people is using m-commerce worldwide; this number will double by the end of 2012. This will reduce person-transport and paper work.

Dematerialisation is in fact one of the categories, where wireless mobile products and services are already replacing physical goods, processes and travels.

Conclusion – future challenges for "Green mobile"

In the past few years, the total number of mobile users has grown considerable and it is expected that this grow will continue especially in Africa and Asia Pacific. Due to the scale factor, with over 4.5 billion mobile users globally, the energy use is substantial and is expected to grow in the future. More users and a total increase in the use of telecommunications systems are putting greater demands on mobile operators to consider green aspects. The mobile industry needs to ensure that this rapid growth is sustainable and needs to take closer look at various factors: energy consumed by the network in operation, energy consumed by network equipment and mobile devices through the whole life cycle, as well as emissions and energy use associated with buildings.

Even though many LCAs on a product level have been conducted, the comprehensive approach encompassing the whole life cycle of the telecommunication network has been performed only by few companies, mainly because of the complexity of the measurement, variety of business models, different configuration of the network and use of various frequency bands, sometimes because of outsourcing parts of the network in the case of the virtual operator.

Until now business associations and governments have introduced a range of programmes and initiatives on ICT and the environment, based on LCA, to address issues such global warming and energy use. But according to an OECD survey, very few business associations have strategies to apply innovative solutions outside of the ICT/mobile sector. Only one third of the programmes are actually focused on using mobile solutions in other sectors in areas where there is a major potential to dramatically improve performance, e.g. smart urban, transport and power distribution systems, despite the fact that this is where new technologies have the greatest potential to improve environmental performance.

Moreover most initiatives aiming at reducing energy consumption and increasing energy efficiency have been driven more by high energy prices than by environmental considerations. Consequently, mobile operators are committed to develop solutions related to radio access that reduce operating costs and have effects on the environment by increasing energy efficiency.

User acceptance

The consumers' demand for products/services with better environmental performance is still very low. The low level of awareness of the benefits and opportunities of green products/services in private life is a major problem affecting consumers demand for green products/services. On the other hand the lack of consumer demand is also a factor that can explain the delay in the roll out of innovative products/services or the reluctance to develop e-energy applications.

Consequently, there is a need for business models that overcome the participatory problem solving by motivating people to be a part of the solution. It has been reported that 40% of all carbon emissions are attributable to personal behaviour, i.e., the ability of the Renewable Energy Strategy to create a low carbon economy is dependent on individuals facing up to their responsibilities.

Existing initiatives are unlikely to bring about behavioural change on the scale required, with many individuals choosing to disregard the connection between their own emissions and the larger challenge. Mobile applications such as personal carbon trading, energy use – eco-calculator, smart meters might be the kind of radical measures needed to bring about behavioural change.

Make people aware of their energy consumption and how they can change their energy consumption behaviour might be the solution to the problem.

The rebound effect

Even though innovation within the communication sector has a major role to play in driving the efficiency of the economy there are some uncertainty in the net impacts of increased efficiency. Efficiency improvements in devices, machines and systems may lead to "rebound effects", where overall consumption continues to increase. For example, e-working which reduce commute to work may mean more time available for other potentially higher-carbon activities such as shopping.

According to the SMART 2020 report, ICT technologies can improve efficiency and this will lead to reduced emissions. However, prevention of the rebound effect requires an emissions-containing framework (such as emission linked to a global price for carbon) to encourage the transition to a low carbon economy. Without such constraints there is no guarantee that efficiency gains will not lead to increased emissions.