bio Intelligence Service

European Commission DG INFSO

Impacts of Information and Communication Technologies on Energy Efficiency

[Tender No. CPP 16A-2007 / 2007/S 68-082361]

Final report – Executive summary

September 2008

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Industrial ecology - Nutritional health
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Executive summary

Context

Climate change is one of the biggest environmental challenges of the 21st Century and has been the subject of increasing political attention worldwide. Various scientific sources link the climate change directly to the increasing Green House Gases (GHG) emissions, and more specifically CO_2 emissions. Rising CO_2 emissions are pushing up earth's carbon stock and increasing global temperatures.

Three targets were presented by the European Commission (EC) on January 23rd 2008, in the **integrated proposal for climate action.** The three EU policy targets are:

- A reduction of at least 20 % in GHG emissions by 2020[1]
- A 20 % share of renewable energies in EU energy consumption by 2020.
- A 20 % reduction of the EU's total primary energy consumption by 2020 through increased energy efficiency

Achieving 20 % savings of energy consumption by 2020 through energy efficiency is underlined as one of the key ways in which CO_2 emission savings can be realised[2]. Earlier, the Green Paper for Energy Efficiency (March 2006) had also identified energy efficiency as the most effective, most cost-effective and rapid manner for reducing greenhouse gas emissions. Finally, in the recent Communication[3] "Addressing the challenge of energy efficiency through Information and Communication Technologies" (May 2008) the EC identified that Information and Communication Technologies (ICT) have an important role to play in reducing the energy intensity[4] and increasing the energy efficiency of the EU economy.

In this context, this study examines the impacts of Information and Communication Technologies (ICT) on the energy efficiency in Europe with a 2005-2020 outlook. This work deals with the interrelated issues of energy efficiency, renewables and energy production, and GHG emissions. This study analyses not only the environmental footprint of the ICT sector itself, but also the effects of using ICT applications in support

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[1] Rising to 30% if there is an international agreement committing other developed countries to "comparable emission reductions and economically more advanced developing countries to contributing adequately according to their responsibilities and respective capabilities".

[2] 20 20 by 2020 - Europe's climate change opportunity, COM(2008) 30 final - 23 January 2008

[3] Addressing the challenge of energy efficiency through Information and Communication Technologies COM(2008) 241 final – 13 May 2008

[4] The energy intensity is defined as : *The amount of energy required to produce a unit of Gross Domestic Product (GDP) (in* COM(2008) 241 final)

of higher energy efficiency and energy savings in other areas (building, industry, and energy) (Task 2). Further, the study also explores the use of ICT applications in support of dematerialisation practices (Task 3).

In order to analyse and estimate the potential that ICT-based applications can provide, various scenarios were developed for each of the areas investigated:

- *Baseline scenarios* (reference scenarios) mainly based on data from the literature, these scenarios do not take into account the increase in the use of ICT-based applications. These scenarios are the reference against which the alternative scenarios are evaluated.
- *Business-as-Usual scenarios* (BAU) which assume continuity is maintained considering the current situation and trends (market, technology, policy, etc.).
- *Eco-scenarios* which assume that there is a push (market based or technology based) for ICT-based energy efficient solutions (assuming higher improvement potential and/or higher uptake of energy efficient ICT-based technologies).

In cases, where robust quantified data could not be obtained, "low", "medium" and "high" assumptions were used in order to provide a reasonable range of data and order of magnitude.

A bottom-up approach was used to develop these scenarios. To begin with, case studies were identified which could provide quantified data regarding the improvement potential enabled by ICT applications in different sectors. Then extrapolation of the data from these case studies was made to the EU-27 level and at a horizon of 2020, taking into consideration market trends, technology trends, current and future policy frameworks and business initiatives e.g. Eco-design Directive, Directive on energy efficiency and energy services, Directive on the Energy Performance of Buildings, and voluntary initiatives such as Energy Star, EU Codes of Conduct, Climate savers computing initiative, and Greengrid.

The scenarios development, the implied necessary assumptions and restrictions of the scope (i.e. not all aspects could be covered in the study) and the methodology lead to some limitation mainly because of the unavailability of reliable data on status and trends for all ICT-based energy efficiency enabling technologies. However, the results of this study still provide a good order of magnitude.

Task 1: The ICT sector (2005-2020)

This task analysed the impacts of the ICT sector itself. It assessed the total electricity consumption of ICT equipment during the use phase (both in terms of ICT end-user devices and Infrastructure). End of life phase and production phase were also investigated.

The analyses shows that total electricity consumption related to ICT end-user-equipment and ICT infrastructure amounts to **214.5 TWh** for the reference year 2005 (i.e. **8 % share of total EU-25 electricity use**). This is equivalent to 98.3 Mt CO_2 equivalent[5] (i.e. **1.9 % of the total CO_2 emissions** of the EU-25 in 2005[6]).

The projections of BAU scenario shows that in 2020, the ICT sector could consume 409.7 TWh (187 Mt CO_2 equivalent[6]) **which represents 10.5 % of the total EU-25 electricity consumption** (i.e. 4.2 % of EU-25 CO_2 emission**s**) in contrast to an electricity consumption of **288.2 TWh in the Eco-scenario** (i.e. 132.1 Mt CO_2 equivalent[6]) **which represents 7.4% of the total EU-25 electricity consumption** (i.e. about 3 % of the EU-25 CO_2 emissions).

This shows that the increase in the stock of ICT appliances and network infrastructure combined with an extending power-on periods will lead to a **significant increase in the carbon footprint of the ICT sector**, despite the development of **energy efficient technologies** and the **miniaturisation of ICT devices which is encouraged by market forces.**

In parallel, the **demand on servers and data storage capacity is estimated to** drastically increase due to the extensive utilisation of ICT end-user devices. The study also provides estimate for EU-27 (see Table 1 **,** Figure 1**,** and Figure 2).

Table 1: EU wide estimates of the ICT sector electricity consumption

	2005	2020 BAU	2020 ECO
Total ICT sector electricity use in EU 25 (TWh/a)	214.5	409.7	288.2
ICT sector **without consumer electronics** in EU-25 (TWh/a)	118.6	245.1	185.2
Total ICT sector electricity use in EU-27 (TWh/a)	216.0	433.1	304.7
ICT sector **without consumer electronics** in EU-27 (TWh/a)	119.4	259.1	195.8
Share of the ICT sector electricity use over total EU-27 electricity use (%)	7.8%	10.9%	7.7%
Share of the ICT sector electricity use (**without consumer electronics**) over total EU-27 electricity use (%)	4.3%	6.5%	4.9%

[5] For converting the electricity into CO_2 eq. we used the carbon emission factor used by the EuP EcoReport tool which the official life cycle analysis tool used developed in the context of the EuP Directive 32/2005/EC (0.4582 kg CO2 eq. /kWh). This factor was assumed to remain constant throughout the 2005-2020 period.

[6] EU 25 CO_2 in 2005 = 4923.3 MtCO_2 (source : European Environmental Agency, Annual European Community greenhouse gas inventory 1990 - 2006 and inventory report 2008)

Figure 1: BAU-scenario until 2020 – ICT sector total electricity use (use-phase) (EU-25)

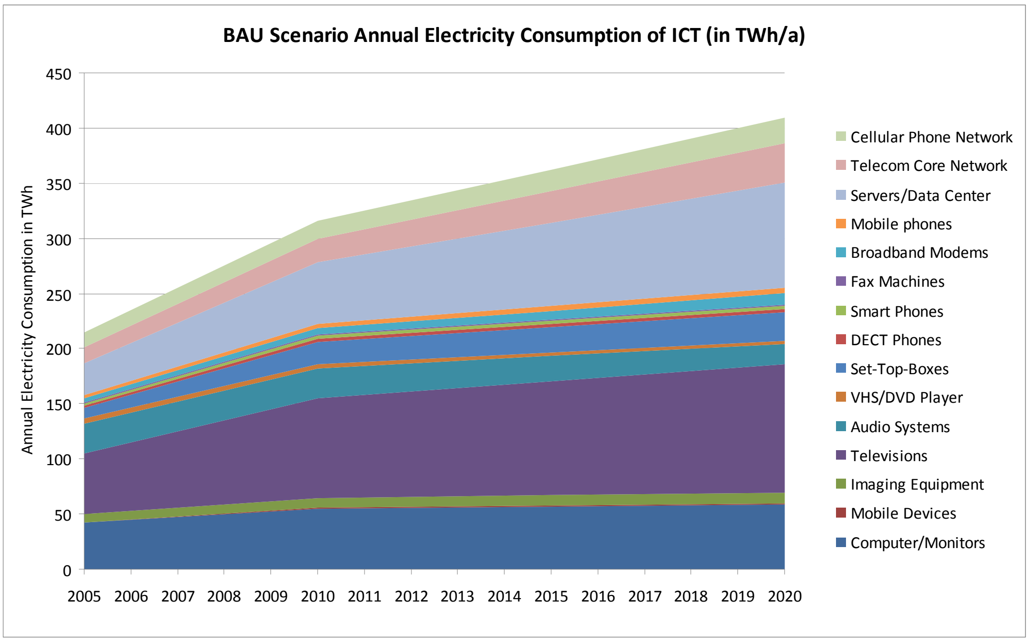
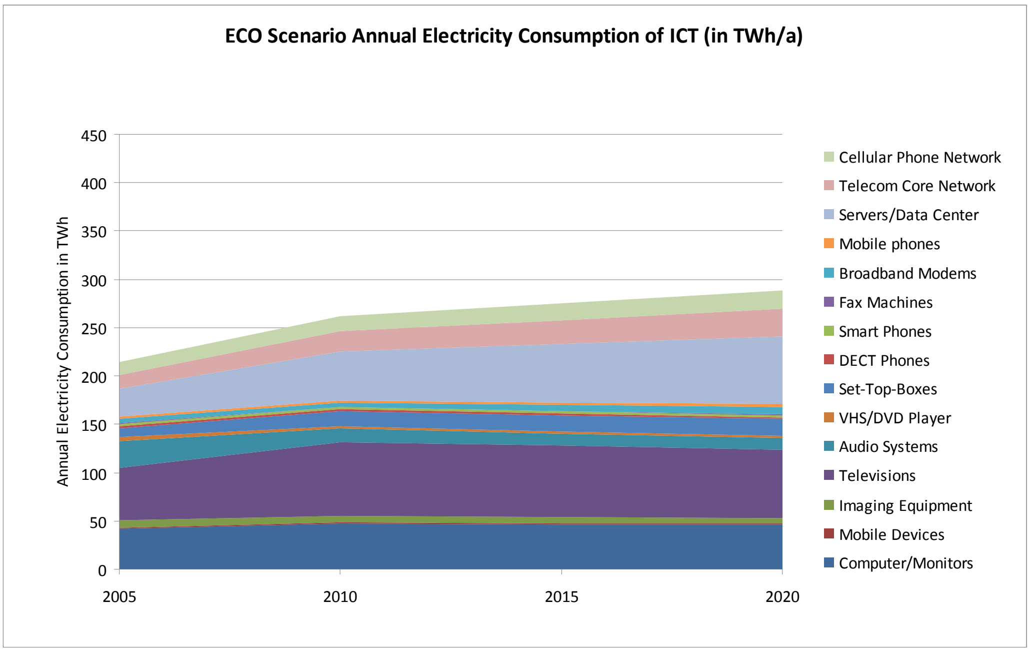


Figure 2: Eco-scenario until 2020 – ICT sector total electricity use (use-phase) (EU-25)



General recommendations in order to reach the targets set by the Eco-scenario include:

- Information to consumers to promote value efficiency and life cycle cost over purchase costs
- Adoption of a European Green Public Procurement scheme
- Extension of the European Energy Star labelling program or of the Energy label to other ICT devices (with priority on the products with significant energy consumption)

- Develop financial incentives to foster green products
- Ensure that innovation in R&D is rewarded through appropriate means (e.g. tax credit)
- Encourage further research activities towards more energy efficient ICT components and systems

The total electricity consumption of the ICT sector should however be put into perspective with the potential energy savings enabled by the use of ICT technologies in other sectors such as the buildings sector, the energy sector, the industry and in the service sector, which is the focus of Task 2.

Task 2: Quantification of Energy Efficiency in other sectors enabled by ICT Applications – 2020 Outlook

Task 2 analysed the impacts of ICT-based applications in:

- Buildings

- Heating Ventilation Air Conditioning (HVAC) systems: HVAC systems were analysed considering the potential efficiency gains enabled by ICT control and monitoring capabilities (e.g. temperature monitoring and heating control, switchable vacuum insulated panels, switchable mirror film on windows, integrated cooling of ICT equipment, integrated control of clean room conditions).
- Lighting systems: increased energy efficiency of lighting systems through ICT-based lighting technologies (e.g. LED lighting) and control systems were also explored (e.g. occupancy and daylight sensors).

- Industrial equipment and automation

- Electrical drivers (motors, pumps and fans): increased energy efficiency based on ICT technology in motors was the main point of focus.

- Energy grid

- The development of a supply and demand management system supported by ICT technologies and of the potential savings it could bring was analysed.

The analysis shows that in the Eco-scenario:

- Energy consumption of residential buildings could be reduced by almost 35 % which represents a saving of 1766.6 TWh/a (151.9 Mtoe). In the service sector, the energy consumption of buildings could be reduced by 17.2 % which represents 348.TWh (30 Mtoe). The important savings in the buildings sector need to be considered in perspective with the overall significance of the building's sector in Europe which represents over half of the electricity consumption in Europe (EU 27).
- The industrial sector could reduce its energy use for electrical drivers (motors) by almost 10% leading to a saving of 134.9 TWh/a (11.6 Mtoe)

* The energy sector (Energy Grid) could reduce its primary energy consumption by 37.2 Mtoe. This primary energy could produce (in theory) 148 TWh of electricity[7] which is equivalent to 12.8 Mtoe[8].

This means a total saving of 2 398 TWh (equivalent to 60 % of EU-27 total projected electricity use for the year 2020) compared to a total of 521 TWh savings (equivalent to 13 % of EU-27 total projected electricity use for the year 2020) in a BAU scenario.

Main recommendations suggested for achieving the Eco-scenario include: further support of multidisciplinary R&D and Innovation demonstrating the potential of ICT-based solutions, improvement and monitoring of statistical data, regulatory watch (initiating and monitoring self-regulation), information and guidelines, public and private partnership developments.

Task 3: Quantification of Energy Efficiency through dematerialisation by the use of ICT applications – 2020 Outlook

This task showed that the implementation of ICT applications in favour of dematerialisation in various areas could potentially provide energy savings through increased energy efficiency and reduction in the consumption of other resources (e.g. paper, CD material).

Main areas which were investigated include e-government (focus on e-health and e-taxation), Audio/video conferencing, e-work, Dematerialisation of materials and services (including e-ticketing, mobile ticketing, e-banking, e-invoicing, digital music, e-books, and virtual answering machines), e-commerce, RFID applications (Radio-Frequency IDentification), CAD (Computer Aided Design), and virtual reality applications. In order to provide robust analyses, the scenarios were limited to the following dematerialisation practices for which reliable data on status and trends could be obtained:

* e-government (focus on e-health and e-taxation)
* Audio/video conferencing
* e-work
* Dematerialisation of materials and services (e-ticketing, mobile ticketing, and digital music)

The analysis of Task 3 shows that in the Eco-scenario, the dematerialisation practices (mainly teleworking and videoconferencing) could provide energy savings equivalent to 0.8 % of EU-27 total electricity consumption (projected data for the year 2020) which is equivalent to 0.6 % savings in the EU-27 total CO_2 emissions.

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[7] Calculations based on the EuP EcoReport factor: 1 MWh electricity = 10500 MJ= 0.251 toe primary energy

[8] 1 toe = 11.63 MWh

These relatively "low" savings provided by the "dematerialisation" in this report need to be interpreted with care. This limited calculation does not reflect the potential of dematerialisation in Europe if all other dematerialisation practices (listed above) were included in the analysis. This, however, was not feasible mainly because of the unavailability of reliable data on status and trends of other dematerialisation practices.

In the case of dematerialisation through RFID and CAD/virtual reality, the lack of available data and the variety of existing applications prevented any extrapolation or quantification at EU level. However, some case studies indicate that opportunities for saving time, energy and resources could be created by ICT applications in this domain.

Main actions to achieve energy efficiency through ICT application in dematerialisation include: improvement and monitoring of statistical data, financial incentives to promote the uptake of selected dematerialisation practices, support of public/private partnerships (e.g. in transport), information and guidelines, technology development (e.g. improvement of internet transaction security), and harmonisation in various areas such as eco-assessment methodology, eco-assessment data, data compatibility, and also of existing and upcoming environmental legislation.

ICT for Energy Efficiency?

The study shows that the overall net energy savings[9] enabled by ICT-based technologies are positive both in the BAU and Eco scenario (Figure 3).

When compared to the EU-27 total electricity consumption[10] projected for the year 2020, the net energy savings can amount to 2.8 % (111.3 TWh) of EU-27 total electricity consumption in the BAU scenario and 53.4 % (2,127 TWh) in the Eco-scenario.

In order to provide an order of magnitude for putting the results in perspective with the EU policy target on primary energy reduction, the net savings can be expressed in terms of equivalent primary energy required, to produce the same amount of TWh of electricity. Such equivalence (the primary energy required to produce 111.3 TWh and 2,127 TWh of electricity is 27.9 Mtoe and 533.9 Mtoe respectively[11]) indicates that,

[9] i.e. savings enabled by ICT applications in other sectors to which is subtracted the energy consumption of the ICT sector itself

[10] This comparison is realised only to provide an order of magnitude, however, it should be noted that the energy savings enabled by ICT do not only refer to electricity savings (e.g. HVAC systems in buildings are based on different types of energy : oil, gas, etc).

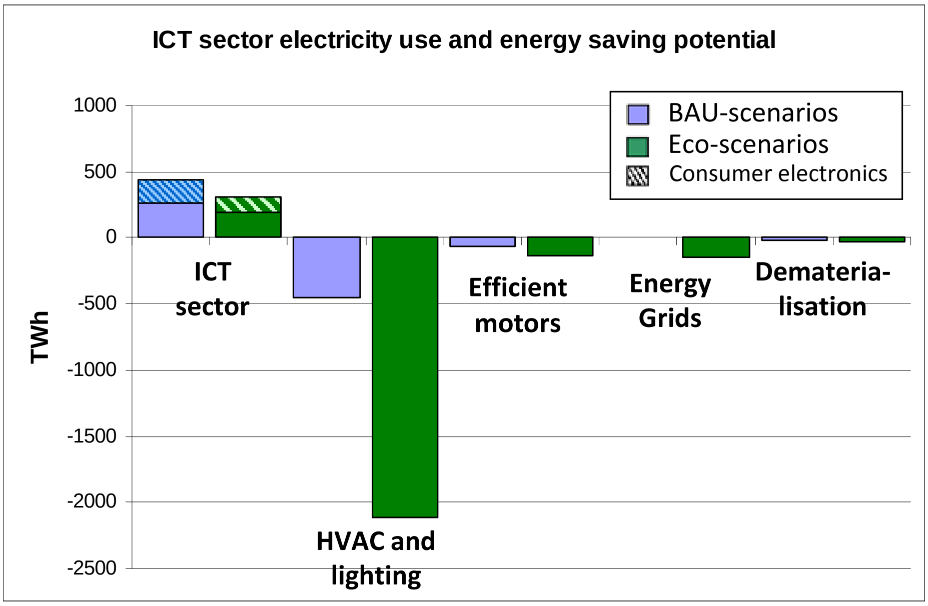
[11] Such equivalence was calculated using the conversion factors from the EcoReport tool which is the official life cycle analysis tool developed in the framework of the Eco-Design Directive 2005/32/EC i.e. 1MWh electricity = 10,500 MJ primary energy = 0.251 toe primary energy

when compared to the total EU-27 projected primary energy consumption[12], the net savings could represent between 1.7 % (BAU) and 32.5 % (Eco).

Taking out the consumer electronics from the total electricity consumption represented by the ICT sector (i.e. TVs, mobile devices, audio systems, VHS/DVD equipment, and set-top boxes, which are assumed to play a less important role in supporting the enabling effects of ICT technologies) the net energy savings were estimated to 285.3 TWh in a BAU-scenario and 2,246.6 TWh in an Eco-scenario.

However, these numbers should be interpreted with care as they only suggest an order of magnitude (i.e. all the energy savings do not refer to the electricity savings).

Figure 3: ICT electricity use and energy saving potential in other sectors (EU-27)



In terms of CO_2 eq. emissions, the study finds that the net savings are only positive in the Eco-scenario and amount to 4.6 % of EU-27 CO_2 eq. emission level of 1990[13] (see Figure 4). Taking out the CO_2 emissions from consumer electronics, the net savings in the Eco-scenario reach 5.4 % of EU-27 CO_2 eq. emission level of 1990.

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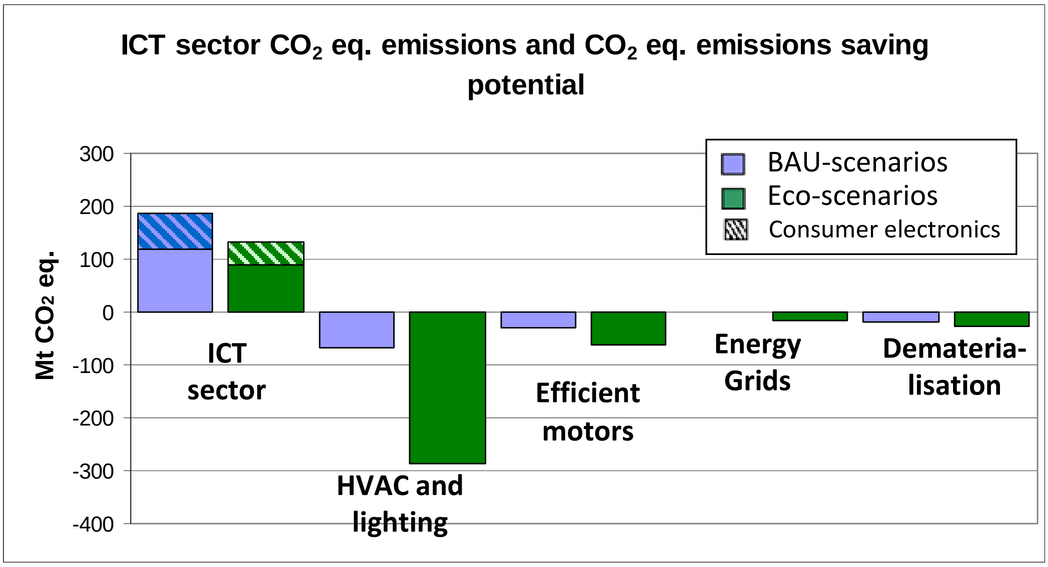
[12] Forecasted primary energy consumption for EU 27 in 2020 is 1634.3 Mtoe according to the European Commission Directorate-General for Energy and Transport: European Energy and Transport - Trends to 2030, update 2007, Belgium 2008

[13] 5572.2 Mt CO_2 eq. According to the EEA *Annual European Community greenhouse gas inventory 1990–2006 and inventory report 2008 Submission to the UNFCCC Secretariat*, May 2008

Figure 4: ICT sector CO_2 eq. emissions and CO_2 eq. emissions saving potential (EU-27)



To conclude, the study shows that in the Eco-scenario, the savings could represent over 7 times the ICT sector's direct impacts in terms of energy and about 3 times in terms of CO_2 emissions.

In the BAU scenario, the savings are found to be slightly higher than ICT sector's footprint in terms of energy consumption (savings represent 1.26 times the ICT sector electricity consumption). However, in terms of CO_2 eq. emissions, ICT sector's emissions are estimated to be higher than the CO_2 savings (1.7 times higher).

The necessary assumptions[14] made in order to convert the energy savings into CO_2 equivalent emission savings lead to an overestimation of the CO_2 emissions and therefore the results in terms of CO_2 equivalent emission should be interpreted with care. Nevertheless, the estimates still provide an order of magnitude.

The results illustrate that key actions are needed to achieve the Eco-scenario. They are suggested in sector-specific recommendations for each of the three ICT effects on energy efficiency analysed in study. The recommendations provided are covering the following aspects:

- Development of standardised methods to measure environmental performance of ICT based products and services

[14] Throughout the 2005-2020 period, a fixed CO_2 equivalent emission factor was assumed and used for converting electricity use into CO_2 equivalent emissions (please note that this approach is also the approach adopted in the various EuP preparatory studies conducted in the framework of the Directive 2005/32/EC on Eco-design). However, the evolution of the energy sector forecasts an increase in renewable energy and less fossil fuel based energy sources which will decrease the emission factor in the future. Also business lead initiatives in the ICT sector to promote the use of renewable energy were not taken into account (further detail in section related to the definition of conversion factors used. Therefore the results in terms of CO_2 equivalent emissions should be interpreted with care.

- Improvement and monitoring of statistical data to make efficiency and effectiveness a reality
- Development of appropriate incentives to encourage the take up of energy efficient technologies and practices
- Promotion of public-private partnerships in energy efficiency
- Provide Information and guidelines
- Development of internet connectivity to facilitate ICT-based solutions
- Identification of R&D needed in ICT and further support for R&D together with Innovation actions
- Development of open standards and interoperability