Towards Green ICT Strategies:

Assessing Policies and Programmes on ICT and the Environment

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Foreword

This report was presented to the Working Party on the Information Economy (WPIE) in December 2008, and declassified by the Committee for Information, Computer and Communications Policy in March 2009.

The report was prepared by Christian Reimsbach Kounatze, consultant, as part of the WPIE's work on ICT's and the environment under the overall direction of Graham Vickery, OECD Secretariat. It contributed to the OECD Conference on "ICTs, the environment and climate change", Helsingør, Denmark, 27-28 May 2009 (www.oecd.org/sti/ict/green-ict) and is a contribution to the OECD work on Green Growth. The report includes data collected until 30 April 2009.

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SUMMARY

Improving environmental performance, tackling global warming and enhancing resource management are high on the list of global challenges that must be addressed urgently. The information and communications technology (ICT) industry needs to further improve its environmental performance (it is responsible for around 2-3% of the global carbon footprint), and ICT applications have very large potential to enhance performance across the economy and society (the remaining 97-98%). Governments and business associations have introduced a range of programmes and initiatives on ICT and the environment to address environmental challenges, particularly global warming and energy use. Some government programmes also contribute to national targets set in the Kyoto Protocol (*e.g.* Denmark's *Action Plan for Green IT* and Japan's *Green IT Initiative*). Business associations have mainly developed initiatives to reduce energy costs and to demonstrate corporate social responsibility.

This survey analyses 92 government programmes and business initiatives across 22 OECD countries plus the European Commission. Fifty of these have been introduced by governments and the remaining 42 have been developed by business associations, mostly international. Over two-thirds of these focus on improving performance in the ICT industry. Only one third focus on using ICTs across the economy and society in areas where there is major potential to dramatically improve performance, for example in "smart" urban, transport and power distribution systems, despite the fact that this is where ICT have the greatest potential to improve environmental performance.

Government programmes and business initiatives concentrate on reducing energy consumption and CO_2 emissions during *ICT use* (close to two-thirds of the total). Reducing environmental impacts of *ICT disposal,* and using ICT applications to reduce energy consumption and CO_2 emission during distribution and use of *non-ICT goods,* are each the target of around one-quarter of the total. The high concentration of programmes and initiatives targeting energy consumption shows that many of them have both economic and environmental rationales. However with the global recession, energy prices have fallen sharply (in May 2009, oil prices were less than 40% of those in July 2008), capital and credit have tightened to choking point, and both public and private sectors may be less likely to invest in green ICTs and ICT applications. Other environmental impact categories such as biodiversity, water or land use are rarely targeted, despite ICT impacts (*e.g.* water consumption in ICT production, or the impact of dematerialisation on land use).

Government programmes cover the domains of R&D, ICT diffusion, and skills and awareness, with many having multiple objectives:

- *Stimulating R&D and innovation*: *R&D programmes* are the most common for governments, focussing on developing resource-efficient ICTs (*e.g.* Japan's *Green IT Project*), but also resource saving applications such as smart homes, smart buildings, or smart transportation systems. This set of programmes also includes *government Green ICT procurement* often designed to increase innovation among ICT providers, encouraging *co-operation* between firms and academia, and they also include support for the *internationalisation of R&D and innovation.*
- *Increasing Green ICT diffusion and ICT applications*: This is the largest group overall and includes *Green ICT diffusion to businesses,* including sharing best practices and developing and using measuring tools, and *eco labels and standards* (with a total of over one-half of programmes). Governments also *act as a lead user*, as well as promoting the *diffusion of ICT*

applications to individuals and households. Finally, governments are encouraging *organisational change* including promoting tele-working, e-government, and e-business.

- *Promoting environmental-related ICT skills and awareness*: These measures mainly include increasing awareness and knowledge of *consumers and users* of the environmental impact of ICTs as well as the advantages in using ICT applications such as smart metering. They also include *increasing management skills* through job-related training.

Initiatives of industry associations and consortia cover:

- *Encouraging R&D and innovation*: This is the largest group of initiatives and mainly includes but is not limited to *encouraging innovation* and exchange of knowledge about energy saving technologies (almost one-half of initiatives of industry associations – the most common initiative). They also include promoting *design of resource-efficient ICTs e.g.* the *Climate Savers Computing Initiatives* (one third).
- *Increasing Green ICT diffusion and ICT applications*: These include the development and promotion of *Green ICT standards and labels* indicating the resource efficiency of ICTs, and increasing energy cost transparency (*e.g.* the *multi-stakeholder task force* of the Global e-Sustainability Initiative, GeSI) (close to one-half of initiatives). They also include increasing energy efficiency of *data centres* through virtualisation for server consolidation and improved power and cooling systems (*e.g.* The Green Grid). Furthermore, they include *green procurement* of recyclable, reusable, and energy efficient ICT components. Green purchasing also applies to end-users (*e.g. myGreenElectronics.org* of the Consumer Electronics Association). A few initiatives promote *ICT applications* such as energy saving tools or tele-working.
- *Optimising ICT value chains*: Fewer initiatives focus on this area, and mainly cover reducing energy consumption and resource use in ICT supply chains, production and distribution (*e.g.* ICT Norway).

Only one-fifth of all government programmes and industry association initiatives have measurable targets and indicators to measure whether these targets are being achieved. Industry association initiatives have hard targets less frequently than government programmes (measurable targets are part of only two of 42 industry association initiatives). On the input side, most government R&D programmes have published R&D budgets. On the impact side, initiatives with measurable targets most frequently focus on CO_2 *emission* and *energy costs*. Very few governments and industry associations measure the quality and impact of their policies and programmes. The *Green ICT scorecard* of the United Kingdom and GeSI's *GRI Telecom Supplement* are rare, but promising, examples.

Overall, much more needs doing to develop and apply clear and measurable policies and initiatives to improve environmental performance of ICTs, and to apply ICTs across the economy to tackle the challenges of global warming and environmental degradation. In particular, policies and initiatives can encourage improvement of environmental performance along the entire ICT life cycle and promote ICT applications to make the life cycles of non-ICT sectors more resource efficient. "Smart" urban, transport and power distribution applications and systems are promising avenues to reduce pollution, and these areas could benefit greatly from increased ICT policy attention, particularly in the current economic setting of recession and low resource prices. Finally, government policies and industry initiatives could be better co-ordinated and implemented internationally.

TOWARDS GREEN ICT STRATEGIES: ASSESSING POLICIES AND PROGRAMMES ON ICT AND THE ENVIRONMENT

INTRODUCTION

Improving environmental performance, tackling global warming and improving resource management are high on the list of global challenges that need addressing urgently. The information and communications technology (ICT) industry needs to further improve its environmental performance (it is responsible for around 2-3% of the global carbon footprint), and ICT applications have very large potential to enhance performance across the economy and society (the remaining 97%).

To address these environmental challenges, governments and industry associations have introduced an increasing range of policies and initiatives on ICT and the environment. Governments as well as industry associations and consortia, and companies of the ICT sector, are the main initiator of large-scale programmes to reduce direct effects of ICTs and increase their enabling effects across the economy.

This report gives an overview of the main programmes and initiatives, but does not consider initiatives of single companies.[1] 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* 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.

Definitions and approach

A total of 92 government programmes and industry initiatives[2] on ICT and the environment across 22 OECD countries[3] plus the European Union have been analysed. They are classified into

1 Initiatives on ICT and the environment of non-profit organisations such as consumer associations, labour unions, research institutes and universities have not been included. However, some of these data have been collected and could be used in a follow-up study: The GreenICT foundation (NGO, Netherland), *80 PLUS* by Ecos (consulting company, United States), *CECP certification* by CECP (NGO, China), *TCO Certification* by TCO Development. Research institutions include: The *ICT Environmental Sustainable Group* of the Australian Computer Society (ACS), the *Working Group "Computer and Environment"* of the International Federation for Information Processing (IFIP) and the International Institute for Sustainable Development (IISD). International organisations have not been included either, *e.g.* the *ISO standards* of the International Standard Organisation (ISO).

2 Government programmes and industry initiatives can be composed of sub-programmes and sub-initiatives. Some governmental bodies and industry associations have a number of small programmes and initiatives, which are not directly comparable with large ones. In order to make these programmes and initiatives more comparable, they have been regrouped by the body that initiated them. In other words, programmes and initiatives of the same government body or industry association are treated as one programme or initiative.

3 Programmes and initiatives on ICT and the environment of governments and industry associations cover: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hungary, Iceland, Ireland, Italy, Japan, Korea, the Netherlands, New Zealand, Norway, Portugal, Slovak Republic,

policy areas and business activity areas adapted from the ICT policy framework of the *Information Technology Outlook 2008* (OECD, 2008) and the *Information Technology Outlook* policy questionnaire. Policy areas cover: *i) stimulating R&D and innovation* for Green ICTs and ICT applications, *ii) increasing Green ICT diffusion and ICT applications* in public and private sectors, and *iii) promoting environment related ICT skills and education*. Industry association business activity areas comprise: *i) encouraging R&D and innovation* among member firms*, ii) increasing Green ICT diffusion and ICT applications* in the ICT and non-ICT sectors, and *iii) optimising energy efficiency in ICT value chains*.

An analytical matrix classifies programmes and initiatives by the following three criteria:

- *Direct* or *enabling effects*: Policies and programmes can focus on *direct effects* when targeting the environmental impacts of ICTs, or they can focus on *enabling effects* when using ICT applications to reduce environmental impacts across economic and social activities.

- *Environmental impact category*: The impact categories used follow the general scheme for Life Cycle Impact Assessments (LCIA) in compliance with ISO 14042: *i) Global warming, ii) primary energy use, iii) toxicity,*[4] *iv) non-energy resource depletion, v) land use*, *vi) water use*, *vii) ozone layer depletion*, and *viii) biodiversity*.[5] This analysis focuses on the first two environmental impact categories, as they are part of most policies and programmes.

  Life cycle phase: Goods and services go through different life cycle phases. Policies and programmes focussing on the direct environmental effects of ICTs can target one or more life cycle phases, *ICT R&D and design*, *manufacturing*, *distribution, use* or *disposal*. Policies and programmes can also focus on the enabling effects of ICTs at a specific life cycle phase. For example, they can promote ICT applications that make *manufacturing*, *distribution* or *use* of goods in non-ICT sectors more resource efficient. The life cycle concept is used to structure policies and programmes whether they focus on the direct or enabling effects of ICTs.[6]

The matrix in Table 1. is used to classify policies and programmes for both direct and enabling effects of ICTs. Each cell within the matrix represents one potential target and shows where policies and programmes are concentrated.

Sweden, the United Kingdom, and the United States. Switzerland announced the development of its national initiatives on ICT and the environment at the beginning of 2009.

4 This includes degradation of air, water and soil for instance, through smog, eutrophication, and acidification.

5 Some initiatives also target other environmental impact categories such as *electromagnetic* and *noise emissions*, which have not been included.

6 In some life cycle approaches, *material extraction* and *packaging* are separate life cycle phases. In order to keep the life cycle as simple as possible, these are included in the manufacturing and distribution phases respectively. It should also be noted that in other life cycle approaches distribution is part of the manufacturing phase.

Table 1. Matrix for classifying po*licies and programmes on IC*T and *the* environment

		Life Cycle Phases				
	Direct / enabling Effects of ICTs	R&D and Design	Manufacturing	Distribution	Use	Disposal
Env. Impact Categories	Global Warming					
	Energy Use					
	Toxicity					
	Non-Energy Resource Depletion					
	Land Use					
	Water Use					
	Ozone Layer Depletion					
	Biodiversity					

This survey is based on documents and information provided by governments and industry associations and on publicly available information. This approach does not provide information on how well governments and industry associations have implemented their policies and initiatives, and their outcomes, which would require follow-up study.

Structure

This report is divided into two parts, focussing on governments and industry associations and consortia, respectively. Each part is divided into four sections covering:

1. Administration and co-ordination.
2. Policy areas and business activity areas.
3. Whether policies and initiatives are targeted at *direct* or *enabling effects*, and their *environmental impact categories* and *life cycle phases* as shown in Table 1 above.
4. Whether programmes and initiatives have measurable targets and whether they are evaluated.

GOVERNMENT POLICIES AND PROGRAMMES

An increasing number of governments are seeing ICTs as an important part of their strategies for tackling environmental problems. Most OECD governments have established policies and programmes on ICT and the environment. However, despite some common focus points and targets, the administration of these policies and programmes, their targeted objectives and the quality of their assessment and evaluation differ significantly across countries.

Administration and co-ordination

There are several types of actors administering governmental policies and programmes on ICT and the environment. Most frequently, government policies and programmes have been established and managed within the central government by a single ministry or national agency. However, some are organised in a decentralised way by local administrations, and co-ordinated by a government-wide institution, usually a national board of Chief Information Officers (CIOs). Some policies and programmes are also organised through intergovernmental institutions.

Denmark, Japan and the United States are countries where policies and programmes are administered centrally, yet, with some differences. Denmark's *Action Plan for Green IT* has been established by the Ministry of Science, Technology and Innovation (2008). Japan's *Green IT initiative* has been created by the Ministry of Economy, Trade and Industry (METI, 2008). However, the Ministry of Internal Affairs and Communications (MIC, 2008) is also contributing to Japan's efforts on improving the environmental impact of ICTs and by using ICT applications. In the United States, two national agencies have each initiated Green ICT-related measures. The US Department of Energy (DOE) has established the *DOE Data Center Energy Efficiency Program* (DOE, 2008), and the US Environmental Protection Agency (EPA) the *ENERGY STAR* label (see Box 3 for more details). DOE and EPA are also co-operating on energy efficiency (DOE and EPA, 2008; DOE and EPA, 2009).

In the United Kingdom and the United States, for instance, governmental programmes are organised in a decentralised way by departments or local administrations, and co-ordinated by a national board of *e.g.* CIOs of the public sector. In the United Kingdom, each government department is responsible for applying Green ICT. However, the Chief Information Officer (CIO) Council and the Chief Technology Officer (CTO) Council have established a government-wide *Green ICT Strategy* in order to co-ordinate the efforts of each department (Cabinet Office of the United Kingdom, 2008). A *Green ICT Delivery group*, which has been established by the Ministry of Defence (MOD), is supporting the implementation of *the Green ICT Strategy* across all departments. In the United States, as another example, the National Association of State CIOs (NASCIO) has created a *Green IT Video Working Group* (formerly *Greening of IT Working Group*) in order to co-ordinate the Green ICT-related efforts of state CIOs (NASCIO, 2008, 2008a).

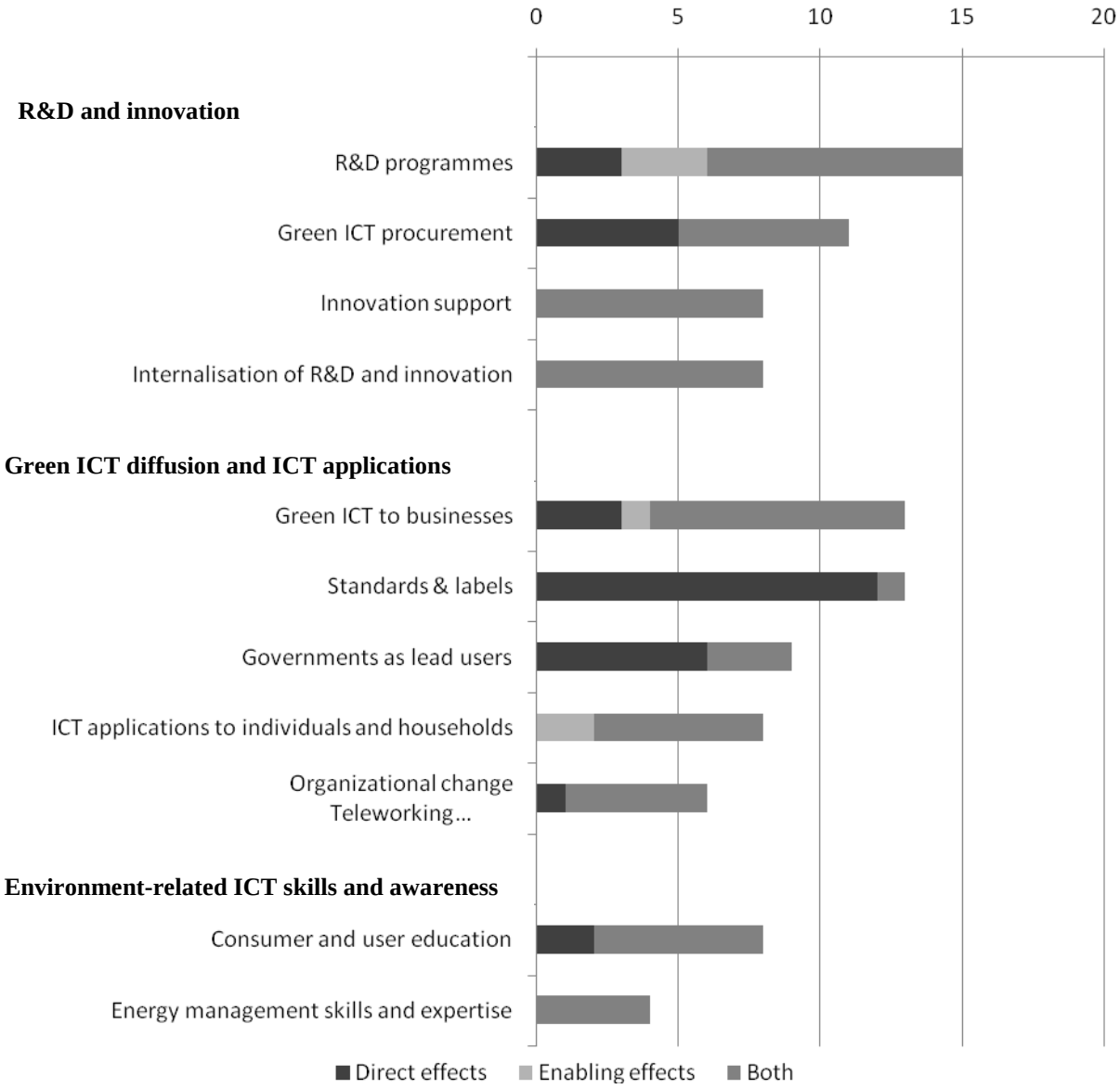
The European Commission (EC) and the Asia-Pacific Economic Cooperation (APEC) are examples of intergovernmental institutions with programmes on ICT and the environment. The EC has formulated one of these in its Communication *"Addressing the challenge of energy efficiency through ICTs"* (EC, 2008). Another example is APEC's *Energy Standards Information System (APEC-*

ESIS), which provides information about energy efficiency standards in member countries (APEC, 2008).

Policies

Governments have adopted a range of ICT and the environment policies, covering R&D and innovation, Green ICT diffusion and ICT application and usage, and education on ICT and the environment. Figure 1. shows the main policy areas and the number of governments envisioning those areas by type of effect.

Figure 1. Number of government programmes by policy area and type of effect[1]



1. Based on 50 policies and programmes of governments in a survey of 92 programmes and initiatives across 22 OECD countries plus the European Union (42 initiatives of industry associations).

Note: **Direct effects of ICTs**: Initiatives focussing on environmental impacts produced by ICTs themselves.
Enabling effects of ICTs: Initiatives focussing on reducing environmental impacts by using ICT applications.

Government can focus on a single policy such as Australia's *Minimum Energy Performance Scheme*, which includes mandatory eco standards enforced by the Australian government legislation. Others, such as Denmark's *Action Plan for Green IT*, can include several policies (see Box 1).

Box 1. Denmark's *Action Plan for Green IT*

Focus area 1, "Greener IT use", includes four "initiatives" aiming at reducing the environmental impact of ICTs:

- The first aims at reducing the environmental impact of ICT usage within companies, mainly by promoting green ICTs to businesses.
- The second focuses on promoting greener ICT usage by children and young people through an information campaign.
- The third focuses on Green ICT guidelines for public authorities.
- The last initiative in focus area 1 aims at providing a "knowledge base for energy and CO_2 calculation".

Focus area 2, "IT solutions for a sustainable future", includes three initiatives aiming at reducing society's impact on the environment.

- The first aims at R&D on Green ICT, pervasive computing and e-Government.
- The second focuses on the export of Green ICTs know-how and technology.
- The last initiative concerns international conferences on Green ICT hosted by Denmark.

Besides those two focus areas, in the eighth initiative of the *Action Plan for Green IT,* the Danish Ministry of Science, Technology and Innovation plans to take the lead in using Green ICT in its own activities, in particular reducing annual electricity consumption by 10%.

Source: Ministry of Science, Technology and Innovation, Denmark (2008).

Stimulating R&D and innovation

Reducing direct effects of ICTs or increasing enabling effects of ICTs necessitates the development of resource-efficient ICTs and ICT applications respectively. Most governments are stimulating R&D and innovation in energy-saving technologies. Increasing R&D spending on green technologies has also been a priority in recent economic stimulus packages of governments in OECD and major non-OECD countries (see Box 2).

Box 2. Green technologies in policy responses to the economic crisis and to underpin recovery

Governments in OECD and major non-OECD countries are launching economic stimulus packages to address the recession. Governments are also using their economic stimulus packages to help the greening of the economy and promote investment in green technologies. In most stimulus packages, investment in green technologies is an important part (after infrastructure investments, education, and R&D). Germany, for example, has dedicated EUR 5.7 billion to green technologies, Australia AUD 5.7 billion, and Canada CAD 2.8 billion.

In many cases these plans rely directly or indirectly on ICTs, *e.g.* the development of "intelligent" transport systems, smart buildings and smart electricity grids which will save energy. Substantial amounts of money are directed at green technology research areas. Promotion of energy-saving and new energy technologies (*e.g.* next-generation solar power) and tax measures that encourage green investment or the purchase of green products rank high in these plans. Performance requirements and measures to promote green products (including ICT products) are a priority.

Korea has focused its KRW 50 trillion stimulus package almost entirely on development and use of green technologies, many with an ICT component, for example using ICTs in green transportation systems. The U.S. *American Recovery and Reinvestment Act of 2009* provides USD 59 billion for green technologies, including USD 11 billion for a smart electricity grid. This new interest partly makes up for the previously low frequency of policies to support green ICT applications.

Source: Assessing Policy Responses to the Economic Crisis: Investing in Innovation for Long-Term Growth, DSTI/IND/STP/ICCP(2009)1/ADD/FINAL.

The following measures have been adopted most frequently in government Green ICT policies.

R&D programmes

Programmes to increase R&D and innovation activities are the most common (15 of 50 government initiatives). This area especially includes R&D for energy efficient ICTs as well as ICT applications for increasing energy efficiency outside of the ICT sector.

For example, Japan has established the *Green IT Project* as part of its *Green IT initiative*, in which energy efficient technologies will be developed in collaboration with industry and academia (see Box 3). As another example, Korea's *Comprehensive Program for Green ICT in the Communications Sector* is promoting among others new communications technologies that enable energy saving in (non-ICT) sectors. As part of Korea's *New Growth Engine of the Broadcasting and Communication Industry*, the Korea Communications Commission (KCC) has carried out research on ICT applications such as smart transportation applications (KCC, 2008).

Box 3. The *Green IT Project* of Japan

In addition to existing programmes, Japan's *Green IT Project*, which is part of the *Green IT Initiative,* is promoting high energy efficient ICTs (with an annual budget of JPY 3 billion in fiscal year 2008). The *Green IT Project* will especially focus on three main research fields:

Networks: One objective of the *Green IT Project* is to reduce energy consumption of network components by more than 30%. Technologies for optimising router power consumption and traffic volume are promoted with funding of JPY 1 283 million.

Data centres: The *Green IT Project* also aims at reducing the energy consumption of data centres, especially of servers and storage devices, by more than 30%. It is therefore promoting technologies like ultra-high density Hard Disk Drives (HDD) and high-efficiency cooling systems. JPY 909 million have been dedicated to this research.

Displays: The objective of the third research field is to reduce the power consumption of displays by 50%. Organic Light Emitting Diodes (OLED) are one of the technologies that will be promoted. The fund dedicated to displays is JPY 668 million.

Source: Ministry of Economy, Trade and Industry, Japan (2008) and Myoken (2008).

Some governments are targeting energy efficiency across other industries and households through intelligent ICT applications. The EC, for instance, has initiated several projects on "energy-smart" power grids, homes and buildings, some within its *Seventh Research Framework Programme* (FP7) (EC, 2008). Denmark, as another example, has established a DKK 36 million research fund for Green IT, pervasive computing and e-government, which is promoting "research in how the development of IT can contribute to a greener society". It includes R&D on "alternative" hardware and software technologies improving tele-working and virtual meetings. Additionally, the funding can also "be used to promote research capable of contributing to global energy conservation" (Ministry of Science, Technology and Innovation, 2008).

Government Green ICT procurement

In many countries, governments are one of the largest purchasers of ICT products and services. Thus, by setting environmental requirements for ICT procurement, governments can not only reduce the environmental impact of their own ICTs, but they can also use their purchasing power to increase competition and innovation among ICT providers. In 11 of 50 cases, governments are implementing Green ICT procurement.

The *Green ICT Strategy* of the United Kingdom, for instance, stipulates the specification of environmental criteria for the procurement of ICTs in line with advice developed by the Centre of Expertise in Sustainable Procurement of the Office of Government Commerce (OGC). Hansel Ltd, the central procurement unit of the Finnish Government, together with the Finnish Environment Institute, has developed environmental criteria for its tendering procedures and framework agreements (Hansel, 2008). The Austrian federal government has also adopted quantitative and qualitative objectives for environmentally friendly purchases at the federal level. IT equipment is one of five priority product groups.

Innovation support

Some governments are stimulating innovation among firms directly, for example by encouraging co-operation between firms and the establishment of firm clusters and innovation networks as well as by providing access to finance and business support services (8 of 50 government programmes).

For instance, *Intelligent Energy - Europe* (IEE), a sub-programme of the EC's *Competitiveness and Innovation Framework Programme* (CIP), is funding innovation projects focussing on topics like energy efficiency, new and renewable energy sources and new energy sources in transport. Small and medium-sized enterprises (SMEs) are the main targets. As another example, the Japanese government has initiated the foundation of the *Green IT Promotion Council*, to improve co-operation between academia, government and industry experts. The *Action plan "Germany: Green IT Pioneer"* of the German Federal Ministry of Economics and Technology places a high emphasis on co-operation between firms and firm clusters. For the *e-Energy* project, for instance, six model regions including several (local) firms and research institutes have been selected (*e.g.* EnBW, IBM Germany, SAP, and the Karlsruhe Institute of Technology in the Baden model region MEREGIO) (Federal Ministry of Economics and Technology, Germany, 2008a).

Internationalisation of R&D and innovation

Governments' efforts to promote R&D and innovation are not only within their national borders. Some governments are also promoting R&D and innovation at international level, for instance, by supporting knowledge exchange between academia, industries and governments through international workshops, meetings, and conferences (8 of 50 government programmes). Increasing co-operation with international organisations is another example to promote the internationalisation of R&D and innovation on ICT and the environment.

Denmark and Japan, for instance, have both hosted international conferences on ICT and the environment. In 2008, Denmark, in co-operation with the OECD, organised a *Workshop on ICTs and Environmental Challenges*, attended by over 100 participants ranging from governments, national experts and scientists, representatives of international organisations, businesses and civil society (65 from outside of Denmark). An *OECD Conference on ICTs, the Environment and Climate Change*, which will be hosted by the Danish Ministry of Science, Technology and Innovation, will follow in May 2009, contributing to the *United Nations Climate Change Conference* in Copenhagen in 2009 (COP 15).[7] Japan, as another example, hosted the *Green IT International Symposium* in May 2008, in which business representatives of multinational ICT firms have presented and discussed their efforts and experiences around Green ICT.

Government can also promote internationalisation of R&D and innovation by co-operating with national and international institutions in the public as well as private sector. The Portuguese Ministry of Science, Technology and Higher Education, for instance, is co-operating with the Massachusetts Institute of Technology (MIT) on R&D and post-graduate education programmes including ICT and the environment. Japan's *Green IT Promotion Council*, as another example, has established a working relation with *The Green Grid* and the *Climate Savers Computing Initiatives,* focussing on information exchange and joint activities on Green ICTs.

7 High-level OECD Conference on "ICTs, the Environment and Climate Change" (*www.oecd.org/sti/ict/green-ict*).

Increasing Green ICT diffusion and ICT applications

Increasing the diffusion of both Green ICTs and ICT applications is the largest group of government programmes and policies on ICT and the environment. Governments are encouraging the usage of Green ICTs and ICT applications among businesses and households, applying Green ICT in public administration, and acting as a lead user as well as promoting eco-labels and standards.

Green ICT diffusion to businesses

Moving businesses to Green ICT is a major concern of governments and over one-half of governments have programmes in this area. Most governments developing these policies are encouraging businesses to apply Green ICT, essentially by providing best practices for the appropriate use of Green ICT and by providing measuring tools, which can increase the transparency of energy costs (26 of 50 government programmes included 13 standards and labels). Those policies are expected to increase transparency, identified as a major obstacle companies are facing during their path to Green ICT (Bouwer *et alia*, 2006; IDC 2008; Wikberg, 2008).

Best practice approaches include Denmark's *Action Plan for Green IT*, which is accumulating information about the experience of Danish companies using Green ICT, which will be made available for other companies interested in greening their ICTs. Another example is the *DOE Data Center Energy Efficiency Program* of the United States, which provides metrics for overall data centre energy intensity as well as tools and guidelines to drive continuous improvement.

Furthermore, governments are encouraging businesses to apply Green ICT by increasing the transparency of ICT energy costs. This can be done by providing *measuring tools* or by disseminating information about the energy consumption of ICT equipment, for instance through eco labels (see Box 4). In the *Save Energy Now* initiative, the United States is providing measuring tools to increase energy cost transparency. The *Data Center Energy Profiler*, for instance, is a free software tool, which profiles the energy usage within data centres (DOE, 2008). EPAs *ENERGY STAR* is one of the most popular eco-labels, certifying energy efficient electronic equipment (see Box 4).

Last, but not least, governments can encourage the usage of Green ICTs by rules that can be voluntary Codes of Conduct (CoC) or mandatory national laws. For example, the EC has formulated two CoCs of relevance for Green ICT: In the *EU Codes of Conduct for Broadband equipment*, companies commit to reduce energy consumption of broadband equipment (EC, 2008a). The *EU Codes of Conduct for data centres* sets energy efficiency goals and measures standards for data centre providers (EC, 2008b). The relatively small number of signatory companies of the *EU Codes of Conduct for Broadband equipment*, however, suggests that the CoCs have not yet been widely accepted. However, CoCs could be useful for non-signatory companies as they include best practices and standards. The WEEE and the ROHS directive of the EC are examples of mandatory rules regulating ICT disposal (EC, 2002, 2002a).

Box 4. Eco labels of governments

Eco labels are an instrument for certifying products and services regarding their environmental impacts. There are many different eco labels, only a minority of them established by governments alone. The following list describes some of those eco labels most used in OECD and non-OECD countries:

ENERGY STAR is the US standard for energy efficient electronic equipment. It was established in 1992 by the Environmental Protection Agency for computer equipment, but now includes other electronic equipment such as heating and cooling systems, office equipment, home electronics, etc. (EPA, 2003). According to the EPA, "Americans, with the help of ENERGY STAR, prevented 40 million metric tons of greenhouse gas emissions in 2007 alone […] and saved more than $16 billion on their utility bills". In 2007, the EPA introduced ENERGY STAR 4.0, which has stricter requirements on workstations, desktop PCs and notebooks, especially because it does not only consider standby and soft-off modes, but also the on/idle mode. Additionally, it requires the usage of 80-Plus power supply units (PSUs) (see Box 6). In March 2009, the EPA finalised the ENERGY STAR 5.0 specification for displays, now including digital picture frames and large commercial displays. ENERGY STAR has been adopted by other countries and economies including Australia, Canada, Japan, New Zealand, Chinese Taipei and the European Union.

European Union Eco-label (Flower label) was established in 1992 by the Environment Directorate of the European Commission as part of its strategy to promote sustainable consumption and production (EC, 2006, 2006a). It is used in the European Union and in Norway, Liechtenstein and Iceland. The European Eco-label stipulates the environmental impact analysis of products or services throughout their complete life cycle, including raw material extraction, production, distribution and disposal.

Der Blaue Engel (The Blue Angel) is one of the oldest eco-labels. It was established on the initiative of the German Federal Minister of the Interior and approved by the Ministers of the Environment of the German federal government and the German federal states in 1978. The Jury Umweltzeichen, a group of 13 persons across society, administrates *Der Blaue Engel*. This label has certified more than 3 600 products categories covering papers, oil burners, wall paints and ICT equipment. Criteria used for certification were the pollution and energy consumption associated with the goods and their recyclability. Until now, *Der Blaue Engel* has been used by more than 520 enterprises in more than 20 countries.

Governments as lead users

By applying Green ICT within public administration, governments can reduce the environmental impact of their own ICTs, and they can also encourage the usage of Green ICTs within the private sector. Government's efforts include but are not limited to increasing energy efficiency of public ICTs, or applying Green ICT procurement. The influence of public procurement on Green ICT-related innovation has already been mentioned.

However, fewer governmental policies explicitly include the government's role as a lead user (8 of 50 programmes). The *Green ICT Strategy* of the United Kingdom, for instance, defines measures to be taken by government departments, including procurement, configuration of ICT equipment, and e-waste. It sets a list of "immediate steps" for "the early implementation of some simple but high impact actions", including use guidelines like "turning off PC's overnight, at weekends and during holiday periods" or "ensuring peripheral equipment is switched off overnight". The *Green ICT Strategy* also defines measures of a more strategic nature, such as increasing server and device consolidation by using virtualisation and dematerialisation amongst others.

Within Denmark's *Action Plan for Green IT*, the Danish Ministry of Science, Technology and Innovation has committed itself to save 10% of its annual electricity consumption each year. In order to reach this objective, it is undertaking measures such as the prioritisation of energy-saving

computers including laptops and thin clients. The Ministry is also using AutoPowerOff plug banks, which automatically turn off peripheral equipments when computers are turned off. Furthermore, it has also introduced an internal competition for the department with the greatest energy reduction. Last but not least, the *Action Plan for Green IT* provides advice for public administrations.

ICT applications to individuals and households

Governments have widely acknowledged the important contribution of ICTs in reducing CO_2 emission and energy consumption in households. But only nine of 50 government programmes are promoting the diffusion of ICT applications to individuals and households. Using ICTs to disseminate environmental information is one of the most frequent ICT applications.

Ireland's *Workflow programme* is based on a local wireless sensor network, which is used to measure the traffic around Dublin and to disseminate that information to households. Individuals are encouraged to use the traffic information to adjust their own behaviour and working conditions (Department of Communications, Energy and Natural Resources, Ireland, 2008). Australia's *Solar Cities Program* is a large-scale trial project, in which distributed solar technologies are applied. ICTs are used to improve energy efficiency, load management, smart metering, and cost-reflective pricing. Smart meters will be installed in households, in order to monitor and plan energy consumption as well as for billing (Department of the Environment, Water, Heritage and the Arts, Australia, 2008).

Organisational change

ICT applications can reduce the environmental impact of organisations. This includes ICTs for new way of production and collaboration like tele-working and tele-conference applications, or moving businesses and governments to the Internet (e-government, e-business, e-commerce). Promoting tele-working and tele-conferences, however, are one of the less frequently adopted policies (6 of 50 programmes). This is probably because many governments have already implemented tele-working and tele-conference applications (OECD, 2008).

Norway's Green ICT initiative, established by the Ministry of Government Administration and Reform, is promoting tele-conferencing and e-co-operation through the dissemination of best practices. Denmark's *Action Plan for Green IT*, besides the promotion of tele-working, is also focussing on e-government, and the United Kingdom is also promoting tele-working and tele-conferences.

Promoting environmental-related ICT skills and awareness

Reducing the environmental impact of ICTs through ICT applications, makes considerable demands on management skills, as environmental skills are needed in addition to ICT-related skills. Furthermore, using ICT applications also necessitates a minimum awareness about the environmental implications of personal behaviour. Governments are engaged in increasing public knowledge about ICT and its effects on the environment, as well as supporting environment related ICT skills and education. This also includes using e-learning for increasing environmental understanding and awareness.

Consumer and user education

Intelligent ICT solutions such as smart homes will not reduce energy consumption if users continue to dissipate energy by not changing their behaviour patterns. Consumer and user education is thus an important complementary element to policies and programmes on ICT and the

environment (see OECD, 2009 for OECD work on consumer education and sustainable consumption). Eight of 50 government policies are targeting consumer and user education.

Denmark's *Action Plan for Green IT*, for instance, highlights children and young people as the largest group of private ICT consumers. It envisions increasing their environmental awareness by using their favoured communication platforms such as online computer games or social networking sites. Additionally, Denmark's Ministry of Science, Technology and Innovation will inform its employees about their everyday electricity consumption.

Japan's *Green IT initiative* aims at increasing society's environmental awareness through measurement and visualisation of the net impact of ICTs on the environment. Korea's Ministry of Public Administration and Security (MOPAS), as another example, has established a *task force for green informatisation*, which is developing a comprehensive plan to supply information on greening government's computing resources. Other examples include Hungary's promotion of "environmental information technologies" in order to monitor and publish environmental data of public interest.

Energy management skills and expertise

The lack of energy management skills and expertise is a major obstacle companies face during their path to Green ICT (IDC, 2008; Wikberg, 2008). Beside the provision of best practices, a small number of governments are additionally providing Green ICT related training for managers and their employees (4 of 50 programmes).

Through its *Save Energy Now initiative* the United States is providing training to enhance energy management skills. The training is accompanied by regular publications about best practices and improvements in energy efficiency technologies. A different example is the *Collaborative Labelling and Appliance Standards Program* (CLASP), launched by the United States Agency for International Development (USAID) as a partnership between governmental institutions world-wide.[8] CLASP is aiming at technical assistance for the national implementation of standards and labels to over 50 countries. This includes building the necessary skills and institutional capacity in those countries.

Main objectives

Governments have targeted different objectives in the policies presented above. The matrix in Table 1. is used to classify objectives according to the following criteria: *type of effect, environmental impact category*, and *life cycle phase*.

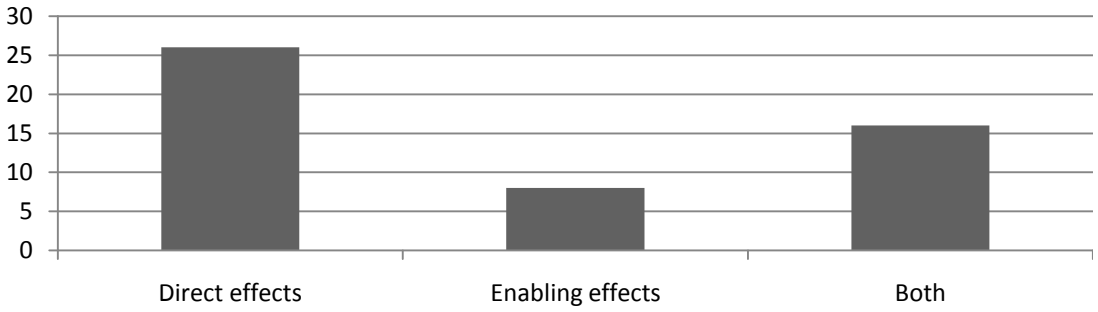
Direct effects and enabling effects

Government policies on ICT and the environment can be divided into three main groups regarding the type of effects they focus on. The first group focuses on reducing the environmental impact of ICTs (*direct effects* of ICTs) (26 of 50 government policies and programmes). The second

8 The following public and non-profit organisations participate in the CLASP: The United States Agency for International Development; the United Nations Foundation; the Australian Department of the Environment, Water, Heritage and the Arts; the Energy Foundation; Energy Efficiency Conservation Authority of New Zealand; Enova of Norway; the International Copper Association; the Ministry of Economy, Trade and Industry of Japan; Renewable Energy and Energy Efficiency Partnership; the United Nations Development Program; the United Nations Department of Economic and Social Affairs; the US Department of Energy; the US Department of State; the US Environmental Protection Agency and the World Bank.

group aims at using ICT applications to reduce society's environmental impact (*enabling effects* of ICTs) (8 of 50 government policies and programmes). The last group aims at both the direct and enabling effects of ICTs (16 of 50 government policies and programmes). The group focussing on direct effects only is more than three times larger than that focussing on enabling effects only and almost twice as large as those considering both types of effects. When combined with that focussing on both types of effects, the group focussing on direct effects is still almost twice as large as the group focussing on enabling effects (see Figure 2).

Figure 2. Number of government programmes by type of effect[1]



1. Based on 50 policies and programmes of governments in a survey of 92 programmes and initiatives across 22 OECD countries plus the European Union (42 initiatives of industry associations).

Note: **Direct effects of ICTs**: Initiatives focussing on environmental impacts produced by ICTs themselves. **Enabling effects of ICTs**: Initiatives focussing on reducing environmental impacts by using ICT applications.

In the United Kingdom and the United States some programmes are focussing on direct effects of ICTs. The United Kingdom, through its *Green ICT Strategy,* aims at reducing energy consumption and CO_2 emission of the government's ICTs. In the United States, EPA's *ENERGY STAR* label indicates the energy efficiency of ICT equipment.

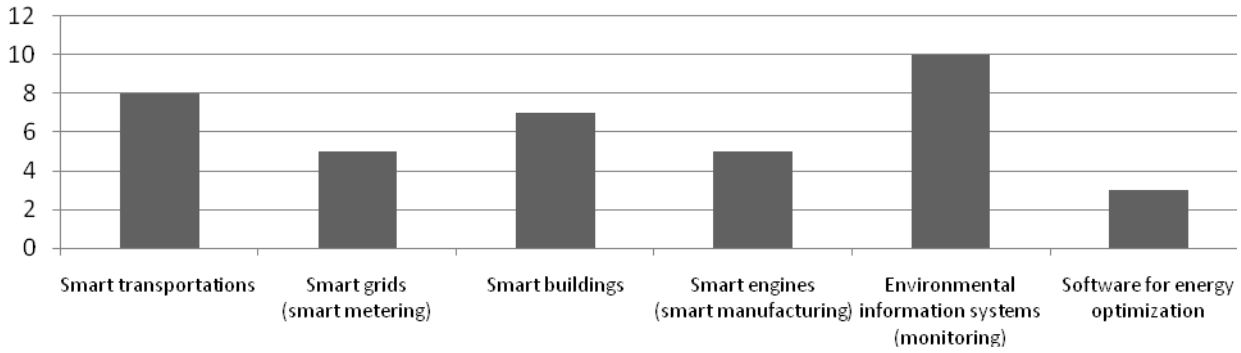
In contrast, in Hungary and Ireland programmes are focussing on enabling effects. The *Environment and Energy Operational Program* of Hungary (2007) sets a high emphasis on "environmental information technologies" in its "priority axis" for "sustainable lifestyle and consumption patterns". ICTs are considered as an enabler for "environmental democracy", providing the basis for monitoring and publishing environmental data of public interest. Ireland's *Workflow programme*, as another example, has been initiated by the Department of Communications, Energy and Natural Resources (2008) to measure traffic around Dublin through a local wireless sensor network. The collected information is made available, enabling households to adjust their behaviour and working conditions.

There are programmes considering both direct and enabling effects in Denmark, Japan and the United States. Denmark's *Action Plan for Green IT* defines two "focus areas": The first area is on "Greener IT use" in the private and public sector. The second focus area is on "IT solutions for a sustainable future" (see Box 1). Japan's *Green IT initiative* also focuses on both aspects: "Saving energy of IT" and "Energy-efficient society by IT". In the United States, DOE's *Save Energy Now* initiative aims at increasing energy efficiency of industries. It provides among others a collection of software tools such as *The Quick Plant Energy Profiler*, which help diagnose how energy is used in industrial facilities (enabling effects). With its *Data Center Energy Efficiency Program,* it especially aims at increasing energy efficiency of data centres. DOE does not place any emphasis on ICT applications to improve energy efficiency, although it has proposed using some ICT applications such

as energy management software. A distribution of programmes by type of effects and OECD member country is summarised in a separate Annex.

Among the 24 government programmes considering enabling effects of ICTs (either exclusively or together with direct effects), ICT applications used for the dissemination of environmental information have most frequently been promoted (10 of 24 government initiatives), followed by smart transportation, smart grids (including smart metering), and smart buildings. Smart engines (including smart manufacturing facilities) and software for energy optimisation have been promoted in fewer cases (see Figure 3).

Figure 3. Government programmes considering the enabling effects of ICTs[1] by ICT application[2]



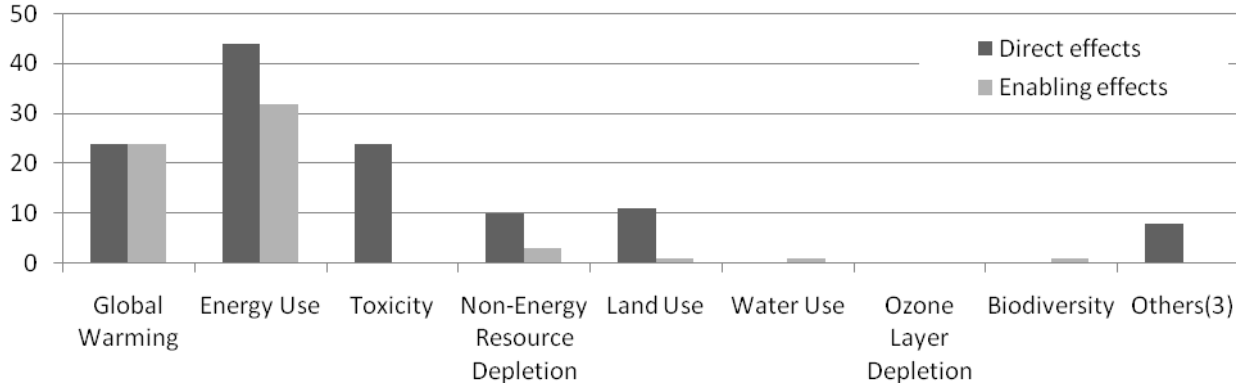
1. **Enabling effects of ICTs**: Initiatives focussing on reducing environmental impacts by using ICT applications.

2. Based on 24 of 50 government initiatives in a survey of 92 initiatives across 22 OECD countries plus the European Union (42 initiatives of industry associations).

Environmental impact categories

As mentioned above, policies and programmes can target several categories of environmental impacts. However, governments have only considered a few environmental impact categories, on which the present section will focus. As Figure 4 shows, reducing *primary energy use* and *global warming* are the main objectives of policies and programmes focussing on both direct and enabling effects. Direct effects on *toxicity*, *non-energy resource depletion*, and *land use* have also been targeted quite frequently, mainly in conjunction with *ICT disposal* (see the next section on life cycle phases).

Figure 4. Number of times[1] environmental impact categories has been targeted by governments[2]



1. The number indicates how often initiatives or programmes have targeted an environmental impact category during the complete life cycle. Note that, for each initiative or programme, an environmental impact category could have been targeted five times at maximum, one time for each life cycle phase. For example, if *global warming* is targeted by an initiative in the *R&D and design*, *manufacturing*, *distribution*, *use,* and *disposal* phases, it will in increase the value for *global warming* to "5", thus better reflecting the impact of the initiative on *global warming* throughout the entire life cycle.

2. Based on 50 policies and programmes of governments in a survey of 92 programmes and initiatives across 22 OECD countries plus the European Union (42 initiatives of industry associations).

3. "Others" includes electromagnetic and noise emissions.

Note: **Direct effects of ICTs**: Initiatives focussing on environmental impacts produced by ICTs themselves.
Enabling effects of ICTs: Initiatives focussing on reducing environmental impacts by using ICT applications.

Other environmental impact categories such as *water use* have rarely been targeted, despite ICTs having direct effects on those categories (*e.g.* water consumption for cooling and semiconductor manufacturing), and being used as enablers (*e.g.* ICT applications optimising water consumption) (see ongoing OECD work on *Sensors, sensor networks and the environment: Technologies, applications and impacts*). Some other environmental impact categories have not been targeted, despite government programmes having implicit impacts on them, for example the impact of virtualisation and dematerialisation on land use.

Primary energy use

Governments have most frequently targeted the reduction of ICT and non-ICT related energy usage and increase energy efficiency. Although there is a correlation between the reduction of global warming and the reduction of energy usage, the objectives are not identical. This is because energy usage does not only include fossil energy sources, but also nuclear and renewable energy sources, which produce less CO_2 emissions, at least during energy generation. The reduction of primary energy use, however, appears to have been driven mainly by high energy costs.

The *DOE Data Center Energy Efficiency Program* of the United States, for instance, aims at increasing energy efficiency of at least 1 500 "mid-tier and enterprise-class data centres" by 25% (on average) and of at least 200 "enterprise-class data centres" by 50% (on average) by 2011 (DOE, 2008). In Denmark's *Action Plan for Green IT*, the Danish Ministry of Science, Technology and Innovation has committed itself to save 10% of its annual electricity consumption each year.

Global warming

The second most common area for policies and programmes is as a support to meet national targets set in the Kyoto Protocol. This is true for policies and programmes focussing on direct effects such as the *Green ICT Strategy* of the United Kingdom. *The Green ICT Strategy* is expected to contribute to the Sustainable Operations on the Government Estate (SOGE) targets, which are to reduce greenhouse gases (GHG) produced by the central government office estate by at least 30% by 2020 and by 60% or more by 2050. This also applies to policies and programmes considering enabling effects for example Japan's *Green IT initiative* is to use ICTs for reducing national CO_2 emissions by at least 50% by 2050.

Toxicity

Toxicity includes all kind of toxic degradation of air, water or soil, such as smog, eutrophication or acidification, having direct or indirect impacts on human health and biodiversity. As some ICT equipment contains hazardous substances such as flame retardant substances (*e.g.* plastic parts), mercury (*e.g.* LCD monitors), or cadmium (*e.g.* batteries), increased toxicity is an important direct effect of ICTs (EC, 2006, 2006a).

Some government programmes are focussing on reducing toxicity produced by ICTs, especially during ICT manufacturing and disposal. This is especially the case with *eco-labels* such as the *European Union Eco-Label* (*Flower label*) for PCs and laptops (EC, 2006, 2006a, see Box 4). Government programmes focussing on *ICT disposal* are presented in more detail in the next section on life cycle phases.

Non-energy resource depletion

Environmental damage can also be related to the depletion of natural non-renewable (non-energy) resources such as lead, tin or copper; scarce resources which are being used, for example, for solder and printed circuit boards. According to Hauschild and Wenzel (1998) (derived from the Ministry of the Environment, Denmark, 2006), the supply horizon for lead is expected to be only 20 years, for tin 27 years, and for copper 36 years. Subsequently, the price of these resources can be expected to increase dramatically (Ministry of the Environment, Denmark, 2006).[9]

Government initiatives stipulating *recycling*, *maintainability* and *upgrading* of ICT products are reducing the direct effect of ICTs on *non-energy resource depletion*. Here again, *eco-labels* as well as government initiatives focussing on *ICT disposal* (see next section on life cycle phases) have most frequently considered *non-energy resource depletion* as an environmental impact category.

Land use

Land use describes impacts made on the environment through land occupation and transformation, leading to a reduction of available soil and localised surfaces (Scholz, 2007). This especially includes the reduction of land surfaces caused by waste. ICTs can have direct effects on

9 Resource depletion (as well as land and water use) can also become an issue in terms of security. According to the United Nations Environment Programme (UNEP), "forty percent of all intrastate conflicts are related to natural resources" (UNEP, 2009). For example, minerals such as tin, tungsten, tantalum and lithium, which are essential for the manufacturing of many ICT devices (*e.g.* mobile phones and battery technologies), have originated from conflict regions such as the eastern Democratic Republic of Congo (Global Witness, 2009; Prendergast, 2009).

land use when, for instance, ICT equipments are being *disposed of*, leading to the occurrence of electronic waste (e-waste). Most governments targeting *land use* have done so in connection with *ICT disposal* (see next section on life cycle phases).

Data centre facilities occupy large areas which can reach more than 300 000 square feet (around 28 000 square meters) per facility (Brodkin, 2007). However, additional land use can be reduced thanks to virtualisation techniques substituting physical servers with software applications simulating those servers. As multiple virtualised servers can be run on a single physical machine, there is less need for building new data centre facilities. Yet, no government has targeted reducing land use explicitly, even though they are encouraging virtualisation.

Water use

Water consumed by the ICT sector can be significant. Almost 1 500 kg are used, for instance, for the production of a single PC (Williams, 2003). The ICT sector is estimated to be one of the six most water-consuming industries and water consumption in the semiconductor industry in Chinese Taipei has increased from nearby 100 000 tons a day in 2002 to over 150 000 tons a day in 2006 (Lin *et al*., 2006). In some regions, the semiconductor industry has had problems getting additional water needed for expanding production or building new fabrication plants (Donovan, 2002).

Despite water scarcity and water management being one (underestimated) major environmental problem in the future (Harvey, 2008), few governments have considered direct or enabling effects of ICTs on *water use*. Hungary, for instance, is developing and harmonising its databases for involving and informing the public in the implementation of the Water Framework Directive (WFD).

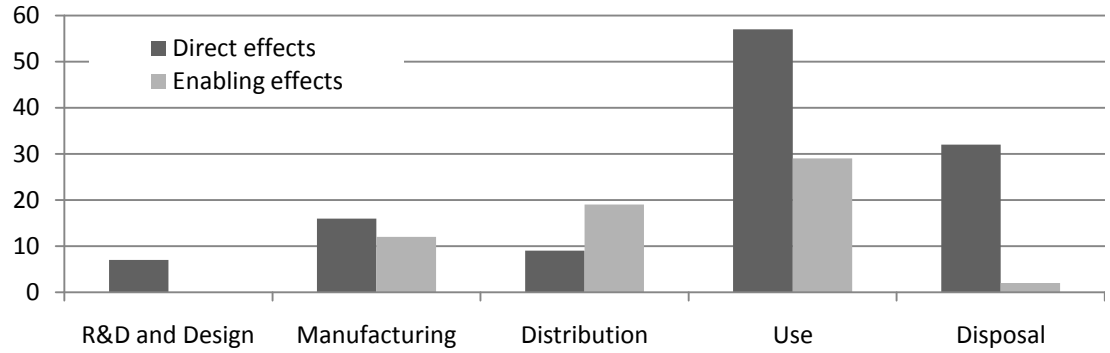
Life cycle phases

Environmental impacts occur during the use of ICTs, but higher environmental impacts often occur before and after the use phase, and environmental impacts need to be considered along the complete life cycle. For instance, Greenhouse Gas (GHG) emissions of California's residential and commercial PCs in 2005 were estimated to be 4.18 Mt CO_2 a year in the *manufacturing phase*[10], 1.72 Mt CO_2 a year in the *use phase*, and 0.004 Mt CO_2 a year in the *disposal phase* (California Energy Commission, 2005). See also the ongoing OECD work on *Reducing Environmental Impacts in the Life Cycle of ICT Goods*.

The life cycle is used in order to structure both policies and programmes aiming at direct as well as enabling effects of ICTs. As can be seen in Figure 5, governments are focussing more on use than on other life cycle phases, whether they are considering both direct or enabling effects.

10 The *manufacturing phase* does not include transportation of ICT equipment.

Figure 5. Number of times[1] life cycle phases are targeted by governments[2]



1. The number indicates how often initiatives or programmes have targeted an environmental impact category within each life cycle phase. Note that for each initiative or programme a life cycle phase can be targeted 10 times at maximum, one time for each environmental category. For example, an initiative, which targets all environmental impact categories considered in this paper (*e.g. i) global warming, ii) primary energy use, iii) toxicity*, *iv) non-energy resource depletion, v) land use*, *vi) water use*, *vii) ozone layer depletion*, *viii) biodiversity, ix) electromagnetic emissions*, and *x) noise emissions*) in the *use* phase, would increase its value to "10".

2. Based on 50 policies and programmes of governments in a survey of 92 programmes and initiatives across 22 OECD countries plus the European Union (42 initiatives of industry associations).

Direct effects

Only a minority of policies or programmes are targeting all life cycle phases of ICT goods: ICT *R&D and design*, ICT *manufacturing*, ICT *distribution*, ICT *use*, and ICT *disposal*.

All main life cycle phases

Denmark's *Action Plan for Green IT* and *the Green ICT Strategy* of the United Kingdom are among the few taking all of the main life cycle phases of ICTs at least into consideration. Denmark is promoting through its *Action Plan for Green IT* R&D activities on "sustainable development of IT", "sustainable production of IT", "sustainable use of IT", and "sustainable disposal of IT". The United Kingdom's *Green ICT Strategy* aims to make Government ICT carbon neutral across its lifecycle by 2020. "This will cover carbon neutrality and sustainable processes for use of materials, water, accommodation and transport, in the manufacture, use and disposal of ICT" (Cabinet Office of the United Kingdom, 2008).

ICT use

ICT *use* is the most frequently targeted life cycle phase, and most initiatives focussing on direct effects primarily aim at reducing CO_2 emissions and energy consumption of ICT use. The *DOE Data Center Energy Efficiency Program* of the United States, for example, aims at reducing energy consumption of data centres. As another example, the *Equipment Energy Efficiency* (E3) *Program* of Australia and New Zealand sets mandatory energy performance standards for the use of ICT equipment (also see the ENERGY STAR initiative of the United States).

ICT disposal

ICT *disposal* is another phase targeted frequently overall. However, the *disposal phase* is rarely considered in initiatives administered centrally. This is probably because electronic waste (e-waste) is often targeted by central government measures outside initiatives on ICT and the environment.

Japan and the EC, for instance, are not considering e-waste within their initiatives on ICT and the environment. However, *Japan's New Action Plan towards a Global Zero Waste Society* is tackling e-waste. The EC has adopted two directives targeting the disposal of ICTs: The *Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment* (ROHS) (EC, 2002) and the *Directive on waste electrical and electronic equipment* (WEEE) (EC, 2002a) (see ongoing OECD work on *Reducing Environmental Impacts in the Life Cycle of ICT Goods*).

In contrast, some initiatives aiming at "greening" governments' ICTs have placed a high emphasis on ICT disposal. The United Kingdom has one of the largest Government Disposal Services Authorities (DSA), which is an integral part of MOD's *Defence Equipment & Support* (DE&S, 2007). The DSA is responsible for the re-use, resale and recycling of ICT equipment as well as other goods such as buildings, vehicles, furniture, and textiles, across 61 government bodies. The DSA also runs its own e-auction platform, in which government second-hand equipment is directly sold to the public.[11] DSA's e-auction platform is one of the few ICT applications aiming at the *disposal phase* (see Figure 5).

Enabling effects

No governmental programme surveyed has promoted reducing the environmental impact across the complete life cycle of ICT applications outside of the ICT sector. Governments focus on single ICT applications, which are expected to improve the environmental impact of specific life cycle phases. ICT applications having an impact on the *use* phase and the *distribution* phase are most frequently promoted. Fewer initiatives are promoting ICT application for *manufacturing* (also see ongoing OECD work on *Sensors, sensor networks and the environment: Technologies, applications and impacts*).

ICT applications in the use phase

The EC, for instance, is promoting ICT applications having an impact on the *use* phase by stimulating R&D on intelligent energy management solutions for buildings in its FP7 programme. ICT applications include, for instance, smart metering, which analyses and visualises the real-time energy consumption, helping businesses and households to increase their energy efficiency.

ICT applications in the distribution phase

Regarding the distribution phase, the Korea Communications Commission (KCC, 2008) is promoting *Intelligent Transportation Systems* (ITS) a Global Positioning System (GPS)-based application as part of its *New Growth Engine of the Broadcasting and Communications Industry* to reduce traffic congestion. As another example, the EC is promoting intelligent energy distribution networks through its *Intelligent Energy - Europe* (IEE) programme.

ICT applications in the manufacturing phase

Smart metering is also applied to improve energy generation, as examples in Australia and Germany show. Through its *Solar Cities Program*, Australia is applying smart metering for improving monitoring and forecasting of households' energy consumption. The forecast is mainly used to optimise energy generation (Department of the Environment, Water, Heritage and the Arts,

11 DSA's e-auction platform (*www.edisposals.com*) has been awarded the *E-Government Awards for 2008* by the Cabinet Office' in the category for "Excellence in Shared Services pan-Government".

Australia, 2008). Germany's "flagship project" *E-Energy* under the *Action Plan "Germany: Green IT Pioneer"* also aims at optimising energy supply through ICT-based systems. This includes digital interconnection of *e.g.* smart meters, intelligent energy management systems, and electronic energy markets (Federal Ministry of Economics and Technology, Germany, 2008a).

Governments have also promoted ICT applications for energy saving manufacturing of (non-ICT) goods. Italy's *Energy Efficiency* programme, for instance, is part of the *Industry 2015* initiative of Italy's Ministry of Economic Development (2008). Its objectives are to increase energy savings in production processes and end-use as well as using renewable energy sources in order to improve energy security. Some of the research projects funded by the programme are focussing on ICTs (*e.g.* the research projects led by Telecom Italia or Enel Produzione) (Fortina, 2009).

Direct effects of ICT applications

It should be noted that ICT application themselves not only generate enabling effects, but also have direct effects. For instance, deploying wireless sensors networks in order to reduce traffic congestion is accompanied by an increase in ICT *manufacturing*, ICT *distribution*, ICT *usage*, and ICT *disposal*, including all the related environmental impacts. However, no governmental initiative so far is addressing the net impact of their promoted ICT applications.

Focus areas

Finally, focus areas of governments can be identified by classifying policy and programme objectives according to the criteria *life cycle phase* and *environmental impact category* simultaneously (see Figure 6 and Figure 7).

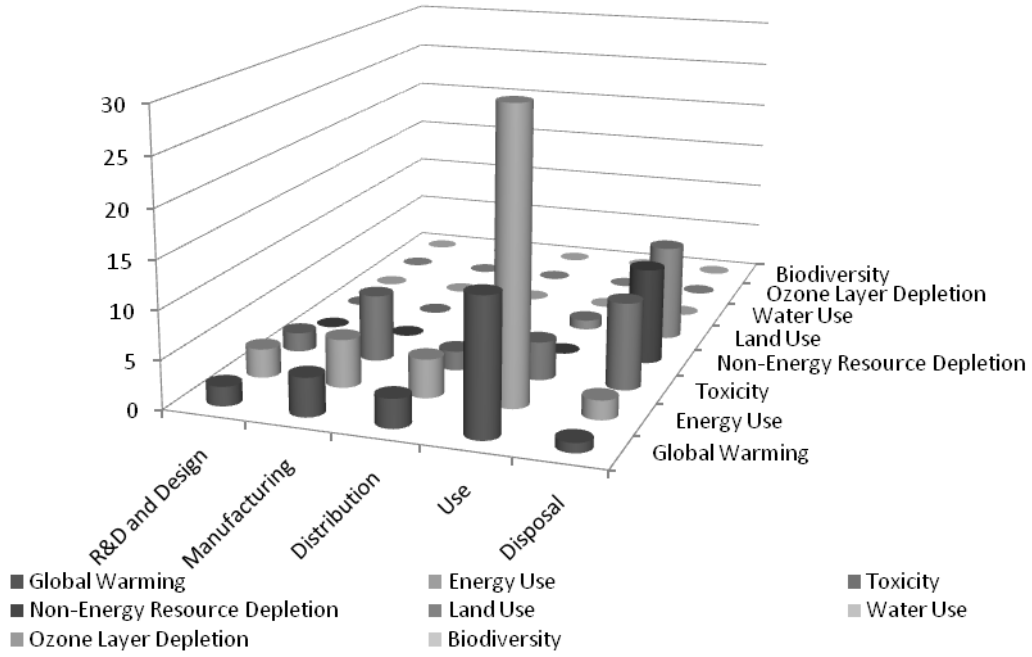
Direct effects

The high concentration of initiatives focused on *energy use* and *global warming* during the *use phase* of ICTs is clearly seen (Figure 6, see also Figure 4 and Figure 5). *Toxicity*, *non-energy resource depletion*, and *land use* are primarily in the *disposal phase* of ICTs. There are also areas of modest concentration of initiatives (*e.g.* direct effects of ICTs on *global warming*, *energy use* and *toxicity* during ICT *manufacturing*). Most striking, however, is the large "empty" area with no initiatives (*e.g. biodiversity*, *ozone layer depletion* and *water use* during ICT *R&D and design*, ICT *manufacturing* and ICT *distribution*) (see upper left corner in Figure 6).

Enabling effects

The high concentration of initiatives considering *energy use* and *global warming* during the *manufacturing*, the *distribution* and the *use phase* outside the ICT sector can also be observed (Figure 7, see also Figure 4 and Figure 5). Figure 7 also confirms that initiatives have not considered other areas for ICT applications to be promoted, despite the need for ICT applications in these areas (*e.g. water consumption* during *manufacturing*).

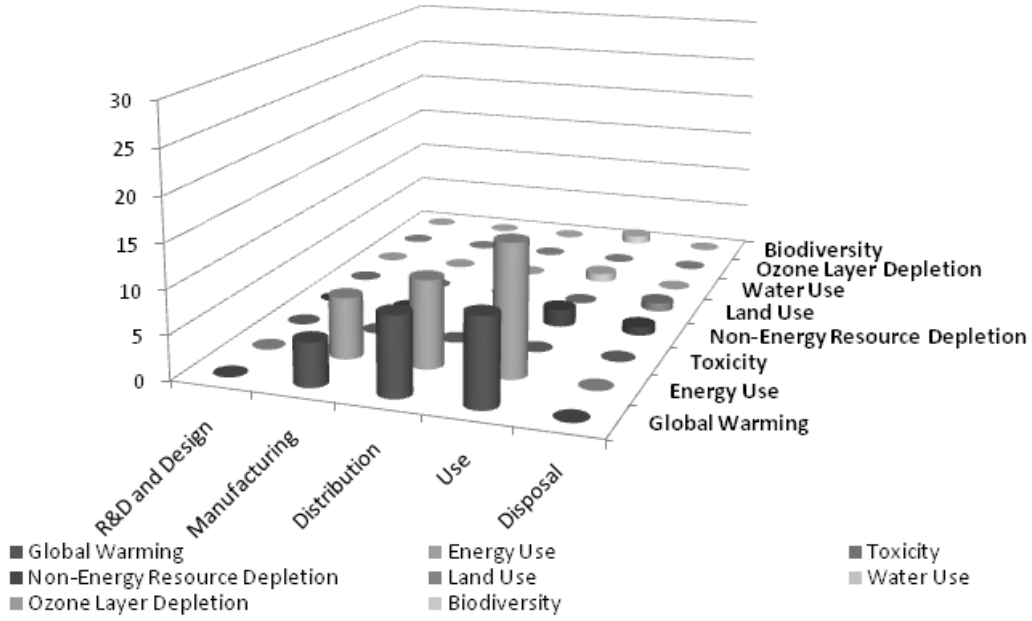
Figure 6. Number of government programmes focussing on direct effects[1] of ICTs by life cycle phase and environmental impact category[2]



1. Direct effects of ICTs: Initiatives focussing on environmental impacts produced by ICTs themselves.

2. Based on 50 policies and programmes of governments in a survey of 92 programmes and initiatives across 22 OECD countries plus the European Union (42 initiatives of industry associations).

Figure 7. Number of government programmes focussing on enabling effects[1] of ICTs by life cycle phase and environmental impact category[2]



1. Enabling effects of ICTs: Initiatives focussing on reducing environmental impacts by using ICT applications.

2. Based on 50 policies and programmes of governments in a survey of 92 programmes and initiatives across 22 OECD countries plus the European Union (42 initiatives of industry associations).

Measurement and evaluation

Monitoring government policies and evaluating their outcomes are important for policy accountability and success. This necessitates linking policy objectives to measurable output targets and defining indicators to monitor inputs and evaluate outputs (see OECD and Eurostat, 1999).

Objectives and targets

All governments have formulated objectives for their initiatives, but only 17 of 50 government initiatives have measurable targets. As mentioned above, reduction of global warming and increasing energy efficiency are targeted most frequently. Initiatives in which targets are defined have most frequently used *CO_2 emission* and *energy costs* as an indicator.

For example, Japan's *Green IT initiative* has as a target the reduction of national CO_2 emissions by at least 50% by 2050. The United Kingdom through its *Green ICT Strategy* is targeting the reduction of GHG produced by the central government office estate by at least 30% by 2020 and by 60% or more by 2050. Denmark's *Action Plan for Green IT* has targeted the reduction of electricity costs for public administration by DKK 150 million over a three-year period. An overview on all government initiatives with their objectives and targets is presented in a separate Annex.

Box 5. The Green ICT Scorecard

The Green ICT Scorecard is an instrument used by organisations for benchmarking the environmental impact of their ICTs. The current version was developed in 2008 in conjunction with the CIO/CTO Council of the United Kingdom. Best practices of the UK Ministry of Defence were integrated within the scorecard. Currently, several UK departments are applying the scorecard within a pan-governmental pilot project.

The scorecard is based on a collection of Green ICT-related questions (currently 301 questions), which are structured in three different categories:

- The first category of questions aims at determining the **sustainable development and corporate social responsibility** of organisations. It includes questions on, for example, the sustainability of buildings, corporate sponsorship of Green initiatives, or the compliance with "Green" standards such as the EC directive on Waste Electrical and Electronic Equipment (WEEE).
- The second category is related to **technology optimisation** within organisations. It includes questions on power consumption per end user, the Power Usage Efficiency (PUE) of data centres, or the ratio of ICT staff to PC users. Technology optimisation has the highest weight within the scorecard.
- The third and last category focuses on organisations' **Green ICT policies**. It includes questions on the usage of environmental impact assessment of ICT equipment, Green ICT procurement practices, and Waste Management.

All answers are weighted depending on question categories and aggregated to a single value, which is then compared with the values of other organisations in the database. The scorecard thus shows how green organisations are in comparison to each other, and helps identify strengths and weaknesses in Green ICT strategies and their implementation.

Source: Cabinet Office of the United Kingdom (2008); Gartner Consulting, (2008).

Policy assessment and evaluation

Only a minority of government policies have formalised assessment and evaluation (10 of 50 programmes). In the United Kingdom the CIO/CTO Council has developed a *Green ICT Scorecard* for benchmarking "organisational behaviour, policy, governance, procurement, energy efficiency, labelling and disposals, in both internal and out-source structures" as part of the *Green ICT Strategy* (see Box 5).

R&D and innovation

Most governments envisioning R&D activities have published their R&D budget related to their initiatives (9 of the 15 initiatives with a R&D programme). Japan's *Green IT project* has dedicated JPY 3 billion (fiscal year 2008) for its three main research pillars on Green ICT, which are networks (JPY 1 283 million), data centres (JPY 909 million), and large OLED (JPY 668 million) (see Box 3). However, no governmental Green ICT initiative surveyed so far, has published any indicators measuring the impacts or success of their Green ICT related R&D policies.

ICT diffusion and usage

The diffusion of *ICT applications* to households seems to be better monitored and evaluated by governments. Seven of nine initiatives envisioning ICT diffusion to individuals and households have defined hard targets and five of nine have established a monitoring and evaluation process. This is probably because the diffusion to households still is in an experimental stage in the majority of cases and governments are planning to scale up the experimental results (see Ireland's *Workflow programme*, Australia's *Solar Cities Program*, and the FP7 ICT Work Programme of the EC).

The provision of best cases and measuring tools to businesses does not seem to be monitored and evaluated by government. Governments, however, are monitoring the number of products and services using their eco labels, which enable them to estimate their impacts (see EPA's ENERGY STAR label). However, eco label initiatives have rarely defined measurable targets.

Green ICT- related skill and education

No governmental initiative surveyed so far is monitoring and evaluating their policies on environmental-related ICT skills and education. This may be because evaluating policies on environmental related ICT skills and education is difficult. First, a long-term evaluation would be necessary and, second, indicators measuring environmental awareness are difficult to develop.

INDUSTRY ASSOCIATION INITIATIVES

Industry associations and industry consortia are major developers of large-scale initiatives on ICT and the environment. These industry initiatives have the potential to reduce the environmental impact of large parts of the ICT sector. Industry associations differ in the type of their members, and therefore in their programmes and objectives and overall impacts.

Sector specific, cross-sector and standards associations

Three different types of industry associations have been identified as having established large-scale initiatives on ICT and the environment: *Sector specific* industry associations, which only include companies within a specific sector. Examples are the Consumer Electronics Association (CEA), the European Telecommunications Network Operators' association (ETNO), or the Silicon Valley Leadership Group. Industry associations can be international like ETNO or national like CEA.

The second type of industry associations are *non-sector specific* industry associations, consisting of companies across multiple sectors, which have mainly come together to establish their initiative on ICT and the environment. Some examples are the Climate Savers Computing Initiatives, the Green Grid and the Global e-Sustainability Initiative (GeSI). Most non-sector specific industry associations are operating globally.

The third and last type of industry associations have been established to promote standardisation among members. Examples are the Alliance for Telecommunications Industry Solutions (ATIS), The European Telecommunications Standards Institute (ETSI), and the Institute of Electrical and Electronics Engineers (IEEE).

Some industry associations' initiatives have also been conducted in partnership with governments. The Green IT Promotion Council, for instance, was initiated by METI in co-operation with several Japanese industry associations in the ICT sector.[12] Another example is the web portal *www.ITK-beschaffung.de* that has been established in partnership between the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the German Federal Environment Agency and the German Association for Information Technology, Telecommunications and New Media (BITKOM).

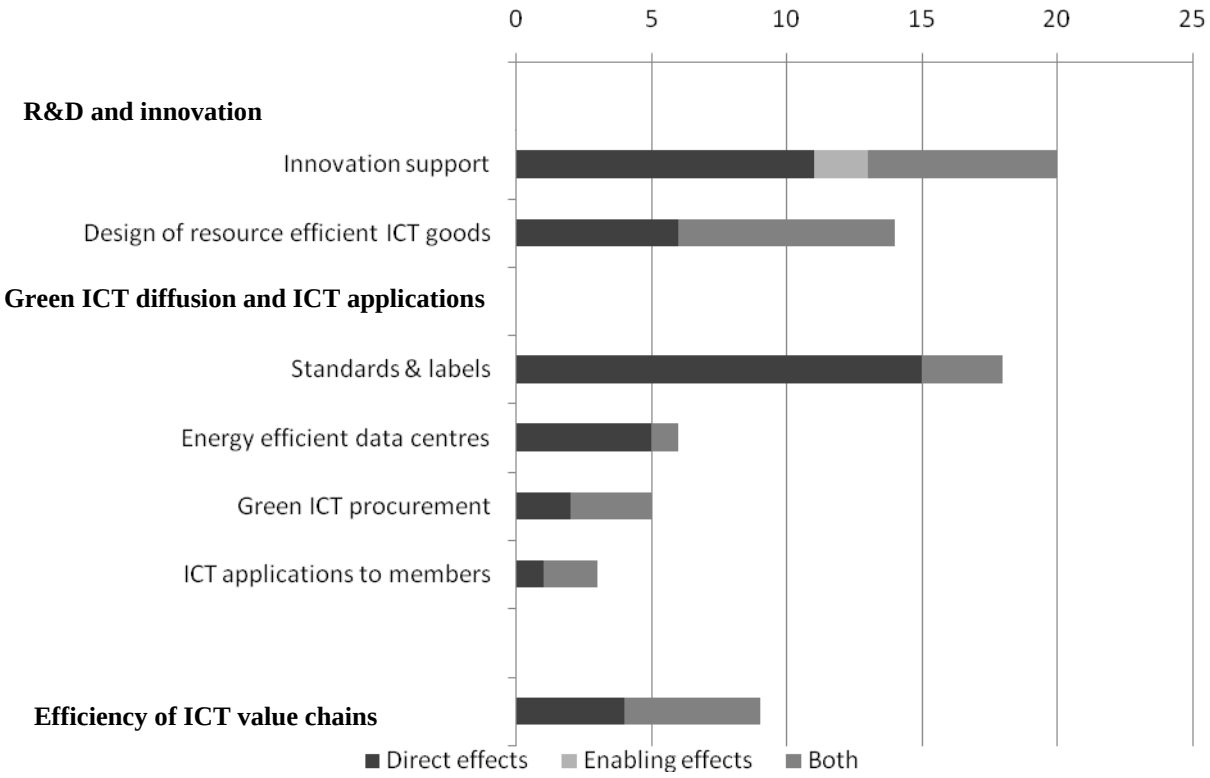
Programmes

Industry associations' initiatives have adopted a range of programmes covering R&D and innovation, Green ICT diffusion and ICT application, and ICT value chain optimisation in order to

12 The Green IT Promotion Council includes the following industry associations: Japan Electronics and Information Technology Industries Association (JETA); Japan Electrical Manufacturers' Association (JEMA); Japan Electric Measuring Instruments Manufacturers' Association (JEMIMA); Communications and Information network Association of Japan (CIAJ); Japan Business Machine and Information System Industries Association (JBMIA); Japan Information Technology Services Industry Association (JISA) and Japan Users Association of Information Systems (JUSA).

fulfil their environmental objectives. Figure 8 lists main business activity areas and the number of industry associations envisioning those areas by type of effects.

Figure 8. Number of initiatives of industry associations by business activity area and type of effect[1]



1. Based on 42 initiatives of industry associations in a survey of 92 policies and initiatives across 22 OECD countries plus the European Union (50 policies of governments).

Note: **Direct effects of ICTs**: Initiatives focussing on environmental impacts produced by ICTs themselves.
Enabling effects of ICTs: Initiatives focussing on reducing environmental impacts by using ICT applications.

Encouraging R&D and innovation

As energy and material efficiency become more important purchase criteria, producers of ICT goods are motivated to increase the energy and material efficiency of their products and services. Regulation and Corporate Social Responsibility (CSR) are other factors, which also motivate increasing energy and material efficiency.

Innovation support

Innovation support is one of the most frequent activities of industry associations. Twenty of 42 industry associations are stimulating innovation among their members, strengthening co-operation and exchange of information and knowledge between their members.

For instance, Intellect through its *Consumer Electronics Energy Efficiency Group* is identifying best low carbon technologies among its members and promoting their development. As another

example, the Energy Efficiency Inter-Operator Collaboration Group (EE IOCG) is sharing information on "energy critical issues" of ICT equipment and networks.

Design of resource-efficient ICT goods

Product design is an essential stage of production for improving energy and material efficiency of ICTs. This also includes R&D on energy and material efficient ICTs and ICT components. Fourteen of 42 initiatives of industry associations are promoting the design of resource efficient ICTs and components.

For instance, members of the *Climate Savers Computing Initiatives* have to commit to "develop products that meet or exceed the Initiative's Program Criteria". For desktops, laptops and workstation computers, the Program Criteria equal the ENERGY STAR 4.0 specifications. The European Information and Communication Technology Industry Association (EICTA), as another example, is promoting the "integration of environmental considerations at the stage of product design with the aim of reducing all relevant potential environmental impacts over its entire life cycle".

Box 6. Eco labels established by non-government organisations

More eco labels have been established by industry associations or by single companies and non-profit organisations than by governments alone. The following describes some established by the private sector:

80-Plus is an initiative established in 2004 by Ecos, a US consulting company. 80-Plus certifies energy efficient PSUs. It requires PSUs to have a minimum efficiency rate of 80% at 20%, 50% and 100% load rate. This means, at a load rate of 20%, 50% and 100%, 20% at maximum of the power consumed by PSUs is wasted. In 2008, Bronze, Silver, and Gold 80-Plus were introduced to distinguish between various levels of efficiency. Thirty-eight companies used 80-Plus for labelling their PSUs in 2007.

The **Electronic Product Environmental Assessment Tool** (EPEAT) is a system for supporting green procurement of desktop computers, notebooks and computer displays. It was developed in 2007 in compliance with the IEEE 1680- 2006 standard by the Zero Waste Alliance, a non-profit organisation including universities, government and industry. EPEAT is based on environmental criteria including "reduction/elimination of environmentally sensitive materials", the usage of recyclable and biodegradable material, and "product longevity / life cycle extension". Like 80-Plus, EPEAT also differentiates between three quality tiers, EPEAT Bronze, Silver, and Gold, depending on the fulfilment of optional criteria.

The **PC Green Label** was developed in 2004 by Japan's PC3R Promotion Center. Its goal is to develop principles to reduce, reuse and recycle (3Rs) of computers and computer displays as in the Japanese "Law for Promotion of Effective Utilization of Resources". It considers all main life cycle phases: R&D and Design, Manufacturing, Use, and Disposal, and also focuses on the energy efficiency of computers and computer displays.

TCO Certification for ICT and office equipment has been established by TCO Development, a non-profit organisation of the Swedish Confederation of Professional Employees. TCO Certification was first introduced in 1992 (TCO'92) for certifying low electromagnetic emissions of computer displays. Now it is available for a wide range of ICT and office equipment, for instance, headsets (TCO'07), media displays (TCO'06), desktop computers (TCO'05), notebooks (TCO'05), office furniture (TCO'04), and mobile phones (TCO'01). Besides energy efficiency and environmental criteria, TCO Certification also includes ergonomic criteria.

Increasing Green ICT diffusion and ICT applications

Industry associations have acknowledged the potential of saving energy costs throughout their sector, and are increasing the diffusion and usage of both Green ICT and ICT applications for reducing environmental impacts. This includes Green ICT standards and labels, Green procurement, and ICT applications such as energy saving tools as well as tele-working applications for reducing travelling.

Green ICT standards and labels

One continuing barrier to Green ICT is the lack of standardised instruments for monitoring and evaluating energy cost of ICTs (IDC 2008; Wikberg, 2008). Instruments can consist of eco-labels, which indicate energy and material efficiency of ICTs (see Boxes 4 and 6) or measurement and accounting tools.

Eighteen of 42 industry associations are promoting Green ICT standards and labels, including measurement and accounting tools, as well as guidelines used for improving the accountability of energy costs. GeSI, for instance, is developing a reporting guideline within its *multi-stakeholder task force*.

Energy efficient data centres

Data centres have shown to be one of the most energy hungry ICT applications. As the quantity of data to be stored and managed is continuing to increase dramatically, more data centres will be used in the future (Chaize, 2008; Hasson, 2009; Brodkin, 2009). Six of 42 initiatives of industry associations have focussed their activities on improving data centres in terms of energy efficiency.

As well as the consolidation of physical servers through virtualisation, industry association are promoting the optimisation of power supply and cooling systems within data centre facilities. For instance, the *Telecommunications Infrastructure Standard for Data Centers* of the Telecommunications Industry Association (TIA) specifies standards for data centre facilities, including "site space and layout, cabling, tiered reliability and environmental considerations". Its new project, *Addendum 2*, will also include wider ranges of temperature and humidity, "permitting lower power consumption and reducing of Heating, Ventilating and Air Conditioning (HVAC)".

Green ICT procurement

Green procurement is another activity increasing the diffusion of Green ICTs. It encompasses the purchase of recyclable, reusable, and energy efficient components, which are necessary for the production of energy and material efficient products. Additionally, green procurement is available for households. Five of 42 initiatives are promoting green ICT procurement.

The Consumer Electronics Association (CEA), for instance, has developed a website (myGreenElectronics.org), where "'Green products' can be registered for free exposure". It is aimed at supporting the purchase of energy efficient ICT products by households and businesses.

ICT applications to members

Three of 42 initiatives of industry associations are also encouraging the use of Green ICT by their members. This includes energy saving tools such as power management applications, but also

changing the organisation of work and production through applications such as tele-working and tele-conferencing.

The *Climate Savers Computing Initiatives*, for instance, stipulate the use of improved power management applications on personal computers for all members. ICT Norway, as another example, is proposing tele-working applications to all its members in order to reduce travelling.

Some industry associations such as the CEA are also promoting applications focussing on *ICT disposal*. The CEA is providing a web service called "recycler locator", used to inform consumers about the nearest local recycler. CEA invites companies to host the "recycler locator" on their website, in order to "brand […] as environmentally friendly".

Optimising ICT value chains

Industry association are also focussing on increasing efficiency throughout their value chain, in order to reduce the ecological footprint of the ICT sector. Nine of 42 initiatives are therefore aiming optimising ICT supply chains, as well as production and distribution networks in terms of energy consumption.

The *Green IT project* of the Norwegian ICT industry association, for instance, is promoting joint transportation of goods in order to reduce transport costs. As another example, the *Voluntary Action Plan on Global Warming Prevention* of the Liaison Group of Japanese Electrical and Electronic Industries for Global Warning Prevention encourages improving production capacity in order to reduce CO_2 emissions per basic unit of production.

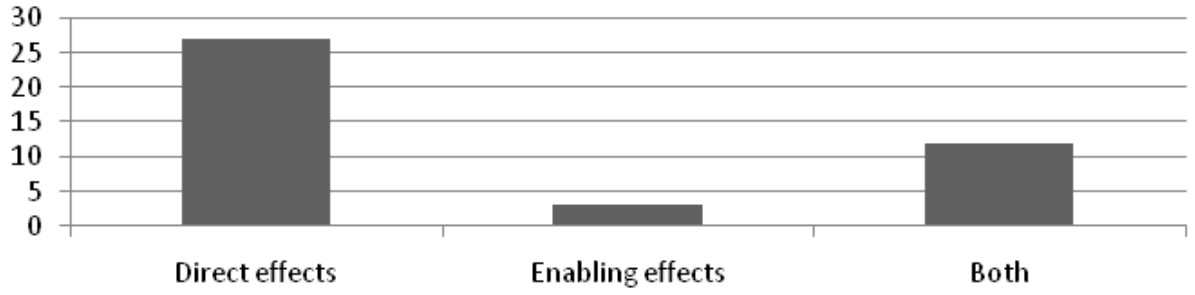
Main objectives

Industry associations through their programmes presented above have targeted several objectives, which differ significantly. Those objectives are analysed using the following criteria: *Type of effect*, *environmental impact category*, and *life cycle phases*.

Direct effects and enabling effects

As is the case with governmental initiatives, industry association initiative can be divided into three main groups regarding the focus of their programmes. The first group of initiatives is mainly focussing on direct effects of ICTs (27 of 42 initiatives). The next large group is focussing on both direct and enabling effects of ICTs (12 of 42 initiatives). Only a minority of initiatives focus on enabling effects (see Figure 9).

Figure 9. Number of initiatives of industry associations by type of effect[1]



1. Based on 42 initiatives of industry associations in a survey of 92 policies and initiatives across 22 OECD countries plus the European Union (50 policies of governments).

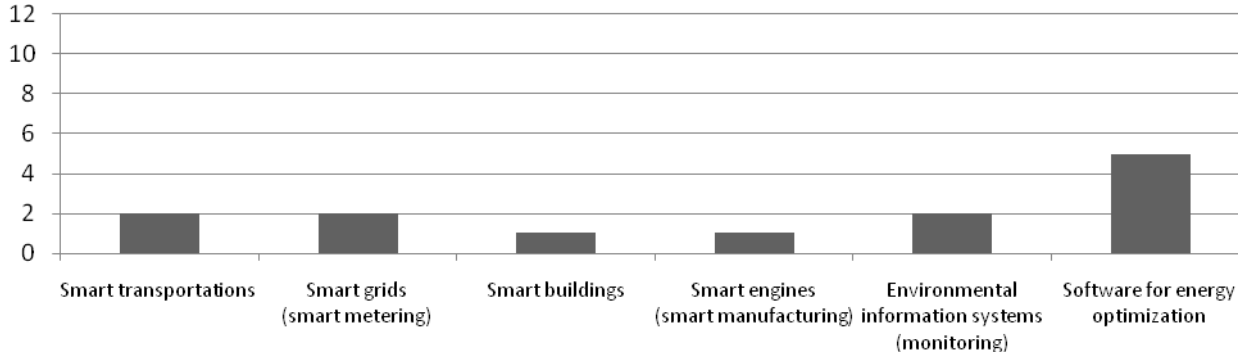
Note: **Direct effects of ICTs**: Initiatives focussing on environmental impacts produced by ICTs themselves.
Enabling effects of ICTs: Initiatives focussing on reducing environmental impacts by using ICT applications.

For instance, the EICTA, the Korean Telecommunications Technology Association (TTA) and the Silicon Valley Leadership Group are focussing on direct effects of ICTs. EICTA, through its *Environment Policy Group* (EPG) is identifying and promoting best practice low-carbon ICTs and accelerating their development and implementation between its members. TTA is promoting standards for mobile telephone chargers including end-of-life management. The Silicon Valley Leadership Group through its *Clean & Green Energy Action Plan* is encouraging the increase of energy efficient data centres.

In contrast, industry associations like Global e-Sustainability Initiative (GeSI, 2008) and the UK Centre for Economic and Environmental Development (UK CEED) are industry associations considering reducing *direct* and *enabling impacts* of ICTs. GeSI is promoting sustainable development in the ICT sector. This includes, for instance, the promotion of programmes to reuse and recycle ICT equipment, as well as the promotion of ICT applications such as smart buildings and smart transportation systems. UK CEED through its *SustainIT* initiative is also promoting the development and usage of ICT applications for sustainable development including green ICTs. ICT Norway is promoting joint transportation of goods in order to reduce energy costs of its members, as well as encouraging the usage of tele-working applications.

Among the few industry association initiatives considering enabling effects of ICTs (15 initiatives), software for energy optimisation has most frequently been promoted (5 of 15 industry association initiatives), followed by smart transportation, smart grids (including smart metering), and environmental information systems. Smart buildings and smart engines (including smart manufacturing facilities) have been promoted in fewer cases (see Figure 10).

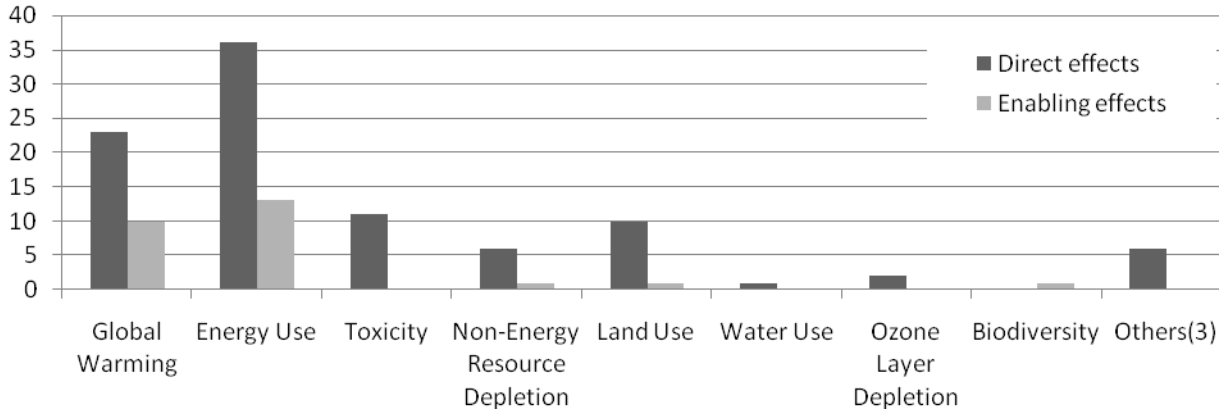
Figure 10. Industry association initiatives considering the enabling effects of ICTs[1] by ICT application[2]



1. Based on 42 initiatives of industry associations in a survey of 92 policies and initiatives across 22 OECD countries plus the European Union (50 policies of governments).

2. **Enabling effects of ICTs**: Initiatives focussing on reducing environmental impacts by using ICT applications.

Figure 11. Number of times[1] environmental impact categories have been targeted by industry associations[2]



1. The number indicates how often initiatives or programmes have targeted an environmental impact category during the complete life cycle. Note that, for each initiative or programme, an environmental impact category could have been targeted five times at maximum, once for each life cycle phase. For example, if *global warming* is targeted by an initiative in the *R&D and design*, *manufacturing*, *distribution*, *use* and *disposal* phases, it will in increase the value for *global warming* to "5", thus better reflecting the impact of the initiative on *global warming* throughout the entire life cycle.

2. Based on 42 initiatives of industry associations in a survey of 92 policies and initiatives across 22 OECD countries plus the European Union (50 government policies).

3. "Others" includes electromagnetic and noise emissions.

Note: **Direct effects of ICTs**: Initiatives focussing on environmental impacts produced by ICTs themselves.
Enabling effects of ICTs: Initiatives focussing on reducing environmental impacts by using ICT applications.

Environmental impact categories

As is the case for governments, industry associations have mainly focused their initiatives on reducing the direct effects of ICTs on *global warming* and *primary energy use* (see Figure 11). *Toxic waste* has most frequently been targeted by eco label initiatives, as is the case with governments.

Other environmental impact categories have rarely been targeted, although industry associations through their initiatives may have an impact on those categories as well (see the impact of virtualisation on land use described in the section on government initiatives).

Primary energy use

Industry associations have most frequently targeted the reduction of ICT related energy usage within their initiatives. This goes hand in hand with their effort to increase energy efficiency. Here again the reduction of primary energy use appears to be driven mainly by the high energy costs in the past.

The objective of the *Green Grid* initiative, for instance, is to develop "user-centric models and metrics", which will be used to increase energy efficiency within data centres. The *Efficient-Server* initiative, as another example, is an international consortium co-ordinated by the Austrian Energy Agency and including companies such as IBM and SUN, which aims at demonstrating the energy saving potential due to efficient server technology.

Global warming

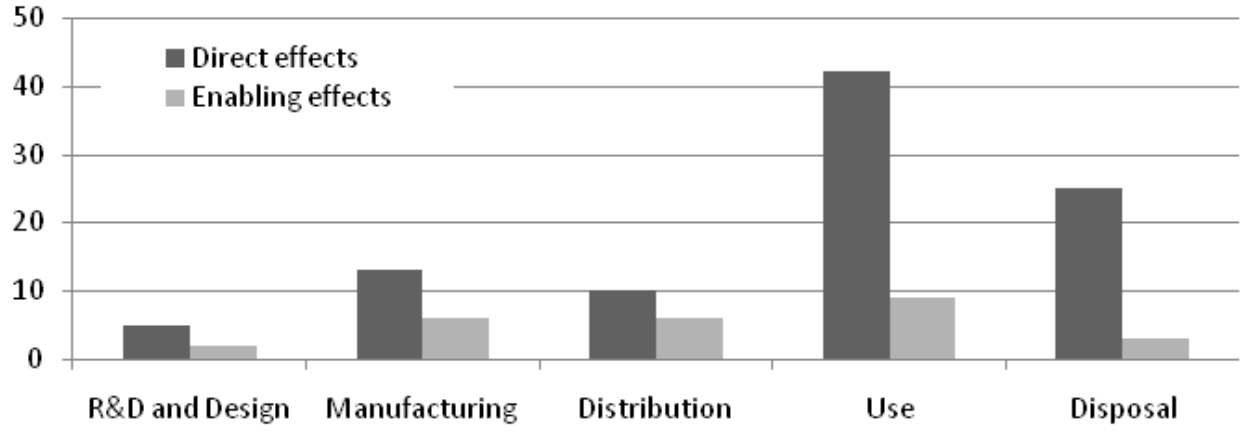
Most industry associations targeting direct effects of ICTs on *energy use* are also considering the direct effects of ICTs on *global warming* explicitly (24 of 30 initiatives focussing on primary energy use). The objective of the *Climate Savers Computing Initiatives*, for instance, is to reduce global CO_2 emissions from the operation of computers by 54 million tons per year by 2010. It thus expects that members will save a total of USD 5.5 billion in energy costs. As another example, the GSMA Development Fund through its *Green Power for Mobile* (GPM) initiative aims at reducing the need for diesel consumption for powering off-grid base stations, for instance, by using renewable energy sources. This is expected to reduce CO_2 emissions.

The reduction of *global warming* and *primary energy use* seem to be motivated by firms' consideration for CSR, in addition to the high energy prices in recent years. ETNO, for instance, has formulated the *Sustainability Charter of the European Telecommunications Network Operators' Association,* in which signatory members (21 of 43 members) commit to the "sustainable provision of products and services with significant environmental, social and economic benefits" as part of their CSR.

Life cycle phases

The life cycle approach is used in order to structure both programmes aiming at direct and enabling effects of ICTs. Like governmental initiatives, industry associations are focussing more on some specific phases of the life cycle than on others, independent of whether they are considering direct or enabling effects. As can be seen in Figure 12, industry associations have most frequently targeted the direct effects of ICTs during the *use phase* and the *disposal phase*, while the *enabling effects* of ICTs have rarely been considered along the complete life cycle.

Figure 12. Number of times[1] life cycle phases have been targeted by industry associations[2]



1. The number indicates how often initiatives or programmes have targeted an environmental impact category within each life cycle phase. Note that for each initiative or programme a life cycle phase can be targeted 10 times at maximum, one time for each environmental category. For example, an initiative, which targets all environmental impact categories considered in this paper (*e.g.* (i) *global warming,* (ii) *primary energy use,* (iii) *toxicity*, (iv) *non-energy resource depletion,* (v) *land use*, (vi) *water use*, (vii) *ozone layer depletion*, (viii) *biodiversity,* (ix) *electromagnetic emissions*, and (x) *noise emissions*) in the *use phase*, would increase its value to "10".

2. Based on 42 initiatives of industry associations in a survey of 92 policies and initiatives across 22 OECD countries plus the European Union (50 policies of governments).

Direct effects

All main life cycle phases

A minority of industry associations are considering the complete life cycle of ICTs within their initiatives. The *Environment Policy Group* (EPG) of the European Information and Communication Technology Industry Association (EICTA), for instance, is encouraging "environmental considerations at the stage of product design with the aim of reducing all relevant potential environmental impacts over its entire life cycle". The *Voluntary Action Plan on Global Warming Prevention* of the Liaison Group of Japanese Electrical and Electronic Industries for Global Warning Prevention envisions "considering all stages of the product lifecycle".

ICT usage

ICT usage is the life cycle phase most frequently targeted by industry associations' initiatives. Members of the *Climate Savers Computing Initiative* (such as the Intel Corporation, Google, Dell, and EDS) commit to (i) develop products that meet or exceed the ENERGY STAR 4.0 criteria; (ii) purchase "high-efficiency systems for a majority of [their] corporate personal computer and volume server computer"; and (iii) educate "end-users about the benefits of energy-efficient computers and power-management tools for business and home use". All those commitments are mainly targeting the *use phase* of ICTs.

ICT disposal

ICT disposal has also been considered frequently within initiatives of industry associations. GeSI, for instance, is working with the *Mobile Phone Partnership Initiative* (MPPI, Basel Convention, 2003), in order to reduce the environmental impact of mobile phones at their end-of-life. Environmentally sound management of used and discarded mobile phones is being promoted. However, most initiatives targeting *ICT disposal* as an objective are eco label initiatives like the *Electronic Product Environmental Assessment Tool* (EPEAT) (see Box 6).

Enabling effects

No industry association's initiative has promoted ICT applications reducing the environmental impact across the complete life cycle. The few initiatives considering ICT applications mostly focus on specific life cycle phases. The *manufacturing* phase, *distribution* phase and *use* phase have most frequently been promoted, as is the case with government initiatives.

For instance, the *Gridwise Architecture Council* in the United States is promoting communications architecture and standards, which would enable the use of smart grids (*manufacturing* phase). In its current report, GeSI (2008) has highlighted a wide range of applications, which could save ca. 7.8 gigatonne of CO_2 emissions. Smart motor systems, smart buildings, and smart grids are examples for ICT applications targeting the *use* phase within non-ICT sectors. In addition, smart logistics are targeting the *distribution* phase.

Focus areas

Finally, by classifying programme objectives according to the criteria *life cycle phase* and *environmental impact category* simultaneously, areas in which industry associations are focussing can be identified depending on whether they are considering direct or enabling effects of ICTs (see Figure 13 and Figure 14).

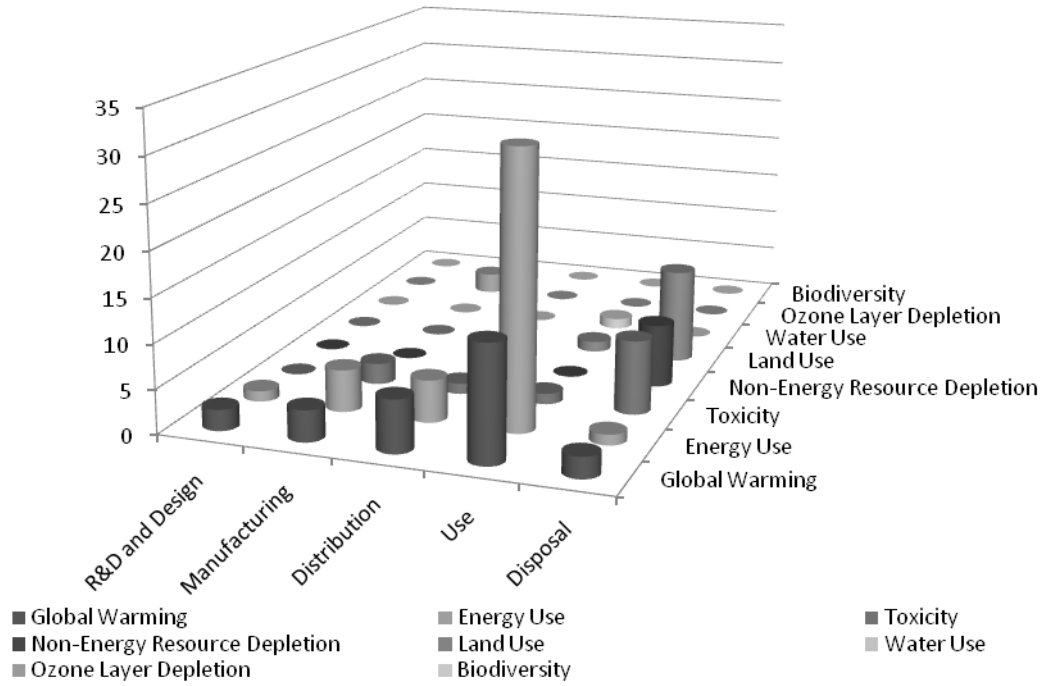
Direct effects

As with governments, a high concentration of initiatives considering *energy use* and *global warming* during the *use phase* of ICTs can be observed (compare Figure 13 with Figure 11 and Figure 12). *Toxicity*, *non-energy resource depletion*, and *land use*, also show up as primarily related with the *disposal phase* of ICTs. Areas of low concentration of initiatives (*e.g.* direct effects of ICTs on *global warming*, *energy use* and *toxicity* during ICT *manufacturing*) can also be observed, as well as a large "empty" area with no initiatives (*e.g. biodiversity* and *water use* during ICT *R&D and design*, ICT *manufacturing* and ICT *distribution*) (see upper left corner in Figure 13).

Enabling effects

As already shown in Figure 11 and Figure 12, industry associations have barely considered the enabling effects of ICTs. Moreover, as is the case for government initiatives, those few industry associations considering enabling effects mainly concentrate on *energy use* and *global warming* during the *manufacturing*, *distribution* and *use* phases (see Figure 14).

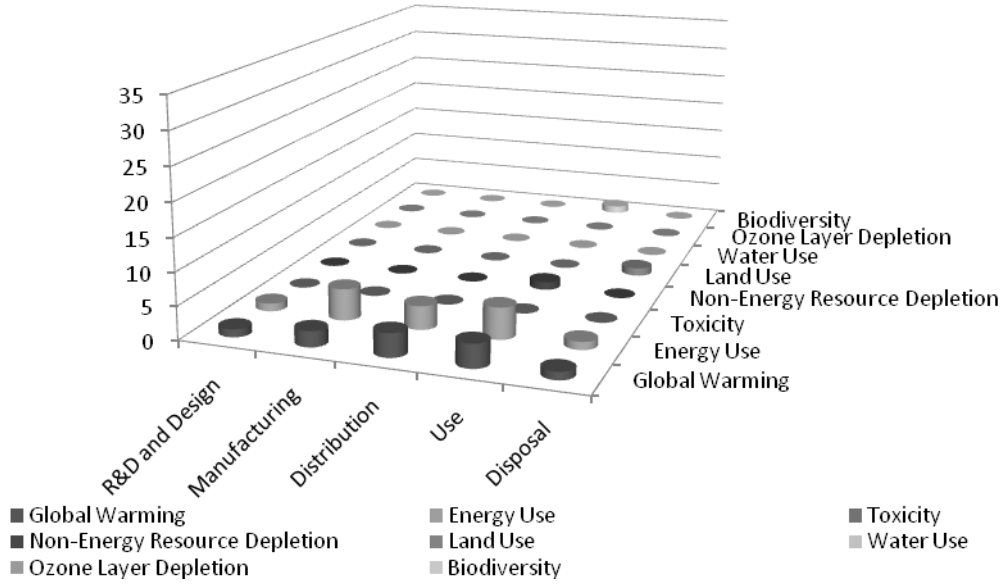
Figure 13. Number of initiatives of industry associations focussing on direct effects[1] of ICTs by life cycle phase and environmental impact category[2]



1. Direct effects of ICTs: Initiatives focussing on environmental impacts produced by ICTs themselves.

2. Based on 42 initiatives of industry associations in a survey of 92 policies and initiatives across 22 OECD countries plus the European Union (50 policies of governments).

Figure 14. Number of initiatives of industry associations focussing on enabling effects[1] of ICTs by life cycle phase and environmental impact category[2]



1. Enabling effects of ICTs: Initiatives focussing on reducing environmental impacts by using ICT applications.

2. Based on 42 initiatives of industry associations in a survey of 92 policies and initiatives across 22 OECD countries plus the European Union (50 policies of governments).

Measurement and evaluation

Monitoring industry associations' programmes and evaluating their outcomes are as important for industry associations as for governments. However, only a minority of industry association initiatives surveyed so far have defined measurable targets within their initiatives. Measurable indicators for monitoring the programmes and measuring their outputs are rarely available.

Nevertheless, there are an increasing number of initiatives measuring energy efficiency improvements or accounting for energy costs of ICTs. Examples are GeSI's *Supply Chain Working Group* (SCWG), which is developing a "set of tools and processes to measure, monitor and improve supply chain and social corporate responsibility performance across the ICT sector". Another example is *the Green Grid* initiative that is developing "user-centric models and metrics", to be used for the development of energy efficient standards and processes within data centres.

Finally, this analysis on initiatives of industry associations indicates that Green ICT strategies may be weakly implemented within companies as well. This trend is confirmed by recent surveys, such as the survey for the *Green IT Index*[13] of the Swedish IT and Telecom Industries (also see Ceres, 2008; Socitm, 2007). According to this survey, 50% of the nearly 1 000 CIOs in both the private and public sectors in Sweden have integrated Green ICT as part of their environmental strategy. However, only 4% of those CIOs integrating Green ICT fully comply with their own strategies, 34% said they comply quite well, and 40% admitted to comply only to a certain extent or not at all. One explanation for the low share of CIOs fully complying with their own strategies is that clear goals have been set in only one in four green ICT strategies (Wikberg, 2008). The survey also confirmed that the public sector has progressed further than the private sector.

13 The *Green IT Index*, is based on a survey of nearly 1 000 Swedish private and public sector managers on how they see IT's environmental impact and how they are working to take advantage of IT. The index measures: (i) insight and awareness of Green IT, (ii) action plans, policies and strategies, (iii) implementation and realisation, and (iv) follow up and evaluation.

CONCLUSION

This survey analyses 92 programmes and initiatives on ICT and the environment across 22 OECD countries plus the European Union. Of these, 50 were established by governments and 42 by industry associations.

Governments have mainly focused on policies *stimulating R&D and innovation* on Green ICTs and ICT applications, *increasing Green ICT diffusion and ICT applications* in the public and private sectors, and *promoting environment-related ICT skills and education*. Industry associations were additionally promoting *optimising ICT value chains* in the ICT sector, but rarely focused on environment-related ICT skills and education.

The objectives of policies and programmes on ICT and the environment are classified by three criteria: *type of effect (direct* or *enabling)*, *environmental impact category*, and *life cycle phase.* The high concentration of government programmes and industry initiatives targeting *energy efficiency* in the direct use of ICTs and in enabling applications is particularly notable. This may be a cause for concern if the continuing global recession and low energy prices make investments in Green ICTs and ICT applications uneconomic on cost grounds.

The measurement and evaluation of initiatives on ICT and the environment are included in only a minority of programmes and initiatives, with governments more frequently using measurable indicators to track inputs and impacts than industry associations. However, some governments and industry associations are developing and promoting instruments for measuring and analysing the quality of their programmes and initiatives. This study does not provide information on how well governments and industry associations have implemented their programmes and initiatives, and what the impacts and outcomes are. More work is needed to analyse these impacts and outcomes.

Finally, programmes and initiatives focussing on ICT and the environment are not the only ones harnessing ICTs to tackle environmental burdens. A wide range of environmental and agricultural policies and programmes also apply ICT applications, such as the *Digital Green* (DG) research project in India, which aims at disseminating "agricultural information to small and marginal farmers in India through digital video". Follow-up work on policies and programmes on ICT and the environment should also cover such applications.

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ANNEX 1. GOVERNMENT PROGRAMMES AND INITIATIVES

Table 1. Government initiatives on ICT and the environment by type of effect

OECD Countries	Governments	First order effects	Second Order effects	Both
Australia	X	X	X	X
Austria	X	X	(X)	
Belgium	X		X	
Canada	X	X	X	X
Czech Republic				
Denmark	X	X		X
Finland	X	X		
France	X			X
Germany	X	X		X
Greece				
Hungary	X		X	
Iceland	X	X		
Ireland	X		X	
Italy	X		X	
Japan	X			X
Korea	X	X		X
Luxembourg				
Mexico				
Netherlands	(X)		(X)	
New Zealand	X	X		
Norway	X	X		X
Poland				
Portugal	X			X
Slovak Republic	X	X		
Spain				
Sweden	X	X	X	X
Switzerland	(X)			
Turkey				
United Kingdom	X	X		X
United States	X	X		X
Number of OECD Countries	**21**	**14**	**7**	**12**

Note: (X) During the compilation of this document no detailed information about the following initiatives was available:

Austria announced its third energy research tender "Neue Energien 2020", which will focus on "smart" energy infrastructure. It is financed through the *Klima- und Energiefonds*.

The Dutch Ministry for Economic Affairs (ECN) together with KEMA, an energy consultant company, have opened a laboratory in the Netherlands to research and test "smart" grid technologies.

Switzerland announced the development of national initiatives on ICT and the environment at the beginning of 2009.