Conference proceedings:
ICTs, the Environment and Climate Change

Proceedings of the high-level OECD Conference in Helsingør, Denmark, 27-28 May 2009

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OECD

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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FOREWORD

The two-day Conference on "ICTs, the environment and climate change" was co-organised by the OECD and the Danish Ministry of Science, Technology and Innovation. It took place on 27-28 May 2009 in Helsingør, Denmark. The OECD website www.oecd.org/sti/ict/green-ict contains links to Conference presentations, video webcasts, interviews and further information on OECD work on "Green ICTs".

The proceedings have been prepared by Arthur Mickoleit under the overall supervision of Graham Vickery, OECD Secretariat. Contributions were received from Joy Aeree Kim, Magdalena Olczak-Rancitelli, Christian Reimsbach Kounatze, Sacha Wunsch-Vincent (all OECD Secretariat), and Verena Weber, consultant. Further acknowledgements are due to session moderators and Conference rapporteurs for summarising key messages during the Conference as well as to all speakers and moderators for ensuring a successful Conference.

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CONFERENCE OUTCOMES

Mobilising "Green ICT"

Conference participants discussed strategies and proposed policies linking ICTs, the environment and climate change. Three levels were identified where ICTs interact with the environment and where "Green ICT" action and policies can improve environmental performance across the entire economy:

- **Direct effects**: tackling environmental issues directly related to ICTs and their widespread use. The ICT industry itself produces around 2% of the carbon footprint and this share is rising. There is still much to do to in terms of environmental impacts of ICT production and disposal, improved design for re-use and recyclability, managing international e-waste streams and working conditions in global supply chains. Discussions underlined that it is important to look at processes – the entire ICT value chain – rather than focussing on individual devices and functions. Life-cycle thinking in the ICT sector must become the norm.

- **Enabling effects**: The innovation potential of ICT applications can greatly benefit the environment in industry sectors which are responsible for the remaining 98% of global CO_2 emissions and other environmental damage. ICTs can potentially enable energy savings many times higher than what is consumed by the ICT equipment, especially through "smart" ICTs in buildings, transport and most of the energy sector – sectors that are responsible for the bulk of greenhouse gas emissions (GHGs). Sensor-based networks and the Internet also contribute to more sustainable use of global resources, for instance by tracking and monitoring water use, biodiversity, land use, pollution.

- **Systemic effects**: Advances in ICTs and other technologies facilitate behavioural and organisational changes towards sustainability. This means moving beyond energy-efficiency improvements in existing processes towards the development of new innovative products and processes that radically alter (and improve) environmental footprints. Changes in urban environments, for instance, can drive systemic innovation because urban systems and infrastructures satisfy the demands of large numbers of households and businesses, e.g. water and electricity networks, residential and commercial buildings. By integrating and improving communication between separate systems, ICTs can facilitate profound changes to the way people live and work.

Urgent action areas

The Conference underlined that the ICT sector, ICT innovation and applications across the economy can be of critical importance in fighting environmental degradation. The current state of climate change and environmental degradation demands moving rapidly from discussion to action.

The economic crisis has added further urgency to act. Many governments are using crisis recovery packages to promote green growth, innovation and investments in "smarter" infrastructures that improve environmental performance and minimise dependence on fossil fuels and other non-renewable energy sources (see www.oecd.org/innovation/crisis).

Urgent action is needed to harness the innovation potential of "Green ICTs" to tackle major environmental and economic challenges. Action areas repeated throughout the Conference include:

- **Agreeing on a global long-term vision**. There is need for an overarching vision for future directions of "Green ICTs". Multi-disciplinary research needs to explore systemic impacts of the development and use of ICTs and to develop scenarios of how ICTs can contribute to green growth.

- **Advocating the crucial role of technologies**. Few international initiatives, agreements and treaties on the environment and climate change refer to the importance of technologies. Sophisticated ICT infrastructures and applications will be required to realise ambitious GHG emissions reductions in a post-Kyoto framework and this needs emphasising.

- **Improving communication**. There are gaps between environmental, climate change, economic and ICT policy and scientific communities. They must be bridged for "Green ICTs" to deliver coherent solutions. Communication between countries must be advanced and the OECD provides a good forum. It was highlighted that OECD countries must lead by example to improve our collective environment.

- **Advancing research and analysis**. Better and more comprehensive life cycle analyses of ICTs are necessary to understand the diverse impacts of ICTs on the environment and should include socio-economic impacts. Technologies are key for economic recovery, but the detailed impacts of "Green ICTs" on growth and employment need careful analysis.

- **Establishing joint standards**. Jointly developed standards for information access and exchange within and across systems are necessary to reap environmental and economic benefits of "Green ICTs". Standards are also needed for business practices, e.g. comparable accounting and intellectual property processes.

- **Developing indicators and metrics**. Indicators and data on direct and enabling environmental impacts of ICTs are essential to create baselines for benchmarking, set clear targets for policies, evaluate and compare results internationally. The OECD has long experience in developing indicators on the information society and the environment and this needs to be harnessed (see also OECD, 2009a). Participants asked the OECD to elaborate and disseminate best practice approaches for measuring the impacts of ICTs on the environment.

Developing policies

Conference participants discussed next steps for governments and the OECD to meet the pressing challenges of climate change, environmental degradation and achieving green growth. As part of this fight, the OECD is working on a **policy recommendation to guide governments** in defining priorities for "Green ICTs".

A major question at the Conference was whether "Green ICT" policies are "business as usual" or whether new policies are required for new circumstances. Governments have traditionally supported the development of new technologies and diffusion by providing public goods and addressing market failures. This can include support for R&D, training and skill formation, infrastructure and information exchange. Governments can pave the way by investing in basic research and education, by investing in key infrastructures such as broadband networks and "smart" infrastructures, by encouraging innovation, being model users and supporting demonstrations that have potential to be scaled up.

Prices are a major factor for businesses to internalise environmental impacts and invest in environmentally beneficial technologies. However, the right prices to achieve changes in behaviour may not be achieved rapidly and need to be complemented by more direct research and technology-related interventions.

The **OECD survey of government policies and industry consortium initiatives** suggests that most governments are still following business as usual paths (OECD, 2009*b*). They overwhelmingly focus on improving direct environmental performance of ICTs along some parts of the value chain. Such an approach misses the opportunity to harness the ICT sector's innovation potential to develop "Green ICT" applications for the entire economy. Conference participants therefore agreed that effective "Green ICT" policies should follow these simple principles:

- **Crossing many sectors**. Government ICT strategies have moved from being sector-oriented to becoming mainstream economic policies. "Green ICT" policies too need to be co-ordinated with research and policy agendas of energy, environment, climate, employment and other communities. New partnerships and innovative institutional structures will be needed to realise higher degrees of co-ordination and synergy.

- **Displaying foresight**. Governments should support investments in "smart" infrastructures without "picking winners" or creating technology "lock-ins". Private sector investments can be encouraged by setting goals so that technologies can develop in competitive markets. Government intervention can then focus on addressing market failures and investing in public goods.

- **Co-ordinating internationally**. Governments can chose to innovate or imitate when formulating "Green ICT" strategies. The OECD can help identify best practices and disseminate them amongst member and non-member governments so that more coherent global strategies are developed. Ongoing work on green growth will guide in the development of innovative policies, also in developing countries and emerging economies.

ABOUT THE CONFERENCE

The two-day Conference was hosted by the **Danish Ministry of Science, Technology and Innovation** and took place at Marienlyst in **Helsingør, Denmark**.

The Conference was attended by **over 200 participants** (two-thirds from outside of Denmark) from national governments, international organisations, business, academia and civil society. In addition to the organisers (OECD and NITA), the Business and Industry Advisory and Trade Union Advisory Committees to the OECD (BIAC and TUAC, respectively) were also represented.

58 speakers and moderators contributed to the discussion of ICTs, the environment and climate change over two days. Plenary keynote sessions and a moderated roundtable opened the Conference. Parallel sessions on both days discussed key issues and strategies. Plenary sessions in the concluding part of the Conference discussed next steps towards effective policies for "Green ICTs".

The Internet played an integral part in the Conference. All speeches and presentations were made available as **live streams over the Internet** (see Box 1). Internet users were posting questions to a dedicated online forum before and during the event. These questions were monitored and added to panel discussions. **Blog and Twitter coverage** facilitated online discussions. One blogger calculated the amount of CO_2 emissions saved by following the Conference over the Internet as opposed to live presence (Lohier, 2009; see also Session 1 on comprehensively measuring the environmental footprint of ICTs and the Internet).

Box 1. Online features

All speeches, discussions and presentations are available for streaming and download at www.oecd.org/sti/ict/green-ict and http://itst.media.netamia.net/ict2009. The PDF version of this document contains links to the webcasts of speeches, panel discussions and, if available, presentations. Click on the underlined names to follow the links.

Participants on-site and online used a variety of online tools to exchange views on the Conference theme. Discussions on Twitter – using so-called "tweets" – gave insights into what online users regarded as important topics. A sample of Twitter feeds during the Conference can be consulted here: http://friendfeed.com/search?q=oecdict and http://www.google.fr/search?hl=en&q=%23oecdict+site:twitter.com.

Around **100 Internet users** followed the live video streams during each of the two Conference days (84 and 65 unique IP addresses on the first and second day respectively, most representing large organisations). Internet users continue to watch webcasts and presentations after the Conference. During the first month following the Conference, there were almost 10 000 hits (*i.e.* Internet users clicking a link on the webpage) with **over 50GB of traffic from watching webcasts** and over 15GB from downloading presentations and videos. Internet users from ten countries contributed to the bulk of web activity (in descending order of hits): Denmark, Austria, Korea, United States, United Kingdom, France, Japan, Germany, Finland, Belgium.

The success of this Conference is due to a large number of people that contributed to the organisation. Acknowledgements are due to staff at the Danish Ministry of Science, Technology and Innovation, National IT and Telecom Agency (NITA), OECD, the Session rapporteurs, chairs, moderators and all speakers.

The Danish IT Industry Association and the Danish NGO "Climate ICT" held a "Workshop on Climate Friendly Handling of Data" in parallel to the Conference. The workshop discussed green and economically profitable management of data centres and server storage (http://tiny.cc/mGZbm).

Agenda at a glance

27 May 2009 (1st Conference day)

9:00 – 9:30	**Welcome and Opening addresses**
9:30 – 10:30	**Key-note presentations: Defining the challenges**

11:00 – 12:30	**Roundtable: Building a green future. Clean innovation, investment and jobs**

Parallel sessions: **ICTs, the environment and climate change: Key issues**	
14:00 – 15:30	Session 1 **Reducing environmental impacts during the ICT life cycle**	Session 2 **Clean technologies for greener urban growth**
16:00 – 17:30	Session 3 **ICTs in pollution reduction and resource management**	Session 4 **Innovation and behavioural change**

28 May 2009 (2nd Conference day)

Parallel sessions: **Strategies to achieve environmental goals**	
9:00 – 10:30	Session 5 **The ICT sector in focus**	Session 6 **Fostering sustainable consumption and use**
10:30 – 11:00	Coffee break	
11:00 – 12:30	Session 7 **Cleaner technologies and smarter ICT applications**	Session 8 **Governments paving the way**

14:00 – 15:30	**Roundtable: New policy directions**

16:00 – 17:00	**Summary session: Meeting policy goals**
17:00 – 17:30	**Conclusions**

INTRODUCTION

Information and communication technologies (ICTs) have a major role in improving environmental performance and addressing climate change across all sectors of the economy. ICTs and the Internet can help reduce energy consumption and manage scarce resources. High-impact areas include urban infrastructures, buildings and the energy sector. ICT applications also enable monitoring and responding to pollution, biodiversity loss, land use patterns, desertification, etc. This is why, most speakers agreed, the ICT sector with its innovation potential can "punch above weight" in the fight against climate change.

Global warming and environmental challenges are at the same time economic challenges, which have become even more crucial in the global recession. "Smarter" government strategies will contribute to green growth in the recovery. Existing analysis indicates that "Green ICTs" will have a positive impact on economic growth and employment. But more research and analytical work is needed to address some challenges highlighted throughout two days of conferencing.

OECD work on "Green ICTs" is guided by the *Seoul Declaration on the Future of the Internet Economy*, which sets out the aim of researching "Green ICTs" and developing policy recommendations in this area. The Conference took up results from the "Green ICT" workshop hosted by the Danish government, OECD analysis of national "Green ICT" policies and measurement and indicators for "Green ICTs" (see www.oecd.org/sti/ict/green-ict). The Conference conclusions provided momentum for OECD governments to declare "Green Growth" a priority at the *OECD Ministerial Council Meeting* in June 2009 in Paris. The *OECD Ministerial Declaration on Green Growth* stresses the importance of innovation and "Green ICTs" for effectively fighting climate change, protecting biodiversity and managing water resources (Box 2).

Box 2. Green ICTs in OECD Ministerial Declaration on Green Growth

"We recognise that special efforts need to be made at the international level for co-operation on developing clean technology, including by reinforcing green ICT activities, fostering market mechanisms […] and other support to developing countries in their fight against climate change and the loss of biodiversity, and support in their water management."

Source: OECD Ministerial Declaration on Green Growth, 2009.

The OECD and international partners will further advance "Green ICTs" on the international policy agenda, most notably towards the **United Nations Climate Change Conference in December 2009, Copenhagen, Denmark (COP15)**. Ongoing OECD work will contribute to evaluating the role of ICTs and innovation to achieve green growth.

PLENARY SESSIONS

Welcome speeches and opening keynotes

Angel Gurría (OECD Secretary-General) highlighted the transformative potential of ICTs and described the challenge of harnessing ICT innovation to **tackle the urgent environment, economic and employment crises**. These are extracts of his speech (full speech available online):

"Our Internet economy holds promising solutions to even the biggest environmental challenges. … But until now, it has been a struggle to turn the concept into bold policies. Then came the crisis. … the first ever crisis where every single OECD country is in recession. … Many traditional sectors face wrenching change as they struggle to adapt to a low-carbon economy. The lesson is clear: We must foster cleaner industries to power growth in the 21st century. …

As governments strive to repair and rebuild, many are committing billions in stimulus funds to clean technologies. … In the run-up to [COP15] this gathering will spotlight the digital technologies that can help us combat global warming and help build momentum for international action. …

Yes - digital technologies consume energy. … Many initiatives to reduce the carbon footprint of the ICT sector already are underway. Japan's USD 32 million Green IT Project promotes highly energy efficient ICTs in three areas. …

We can do far more. Infuse green ICTs across industry and you can save up to ten times more energy than they use. The biggest gains are in power generation and distribution, buildings and transportation – three areas which contribute to the bulk of greenhouse gases. …

High-speed broadband networks – the backbone of our Internet economy – enable a continual two-way flow of information between customers and utilities. … A smart electricity grid would allow consumers to store electricity in smart appliances, like the battery of an electric car, when prices are low. …

To complement price signals and speed the benefits, we need policies to support the development of the "green" infrastructure. … Governments also need to focus on better measurement and evaluation. … To unlock energy savings and growth, policy makers must put a good regulatory framework in place, ensuring that "smart" grids, smart urban systems and smart transport systems adhere to a framework open to competition. … We also need to boost education and training around the skill sets for green jobs. … Finally, international collaboration on large-scale clean technology projects is important for speeding the global benefits and achieving large-scale impact."

Helge Sander (Danish Minister for Science, Technology and Innovation) welcomed Conference participants to Marienlyst in Helsingør. Sander underlined the **critical role of ICTs for tackling climate change, economic recovery and jobs creation** and urged participants to promote the role of ICTs on the way towards COP15. These are extracts of his speech (full speech available online):

"To be or not to be – green – that is the question. … Because there is no doubt that the world is facing an emerging climate crisis. However, the global agenda is currently also occupied with a deep economic crisis. … People lose jobs, businesses close and property prizes are falling. …

Certainly, technology will also play a vital role in any strategy to overcome the economic crisis. … Through green innovation we can create new technologies, new markets and new jobs. The goal, in short, is green growth.

CO2 emissions from the use of ICTs are a cause of concern. … But as you all know, ICTs are also a vital part of the solution. … The OECD countries are the richest and most advanced economies in the world. This status comes with great opportunities and great responsibilities. We must lead. If we do not, no one will follow. …

And we must spread the belief that thinking green leads to black numbers on the bottom line. So fighting climate change and fighting recession are not opposites. …

Denmark will be hosting the United Nations Climate Change Conference, COP15. The Danish Government will work hard to secure a binding agreement on CO2 reductions. The conference here in Helsingør will promote the role of ICTs as a way of reaching a low carbon society. "

Taegun Hyung (Korea Communications Commissioner) presented **Korea's Green ICT strategy** in the context of the country's Green New Deal, which aims to reduce the country's dependence on energy imports, to cut its greenhouse gas (GHG) emissions and to further its ICT industry as an engine of growth. Promotion of broadband Internet and ICT-related skills and education have been key in solidifying the global competitiveness of Korea's ICT industry. Ultra-broadband and sensor networks are also the basis to achieve a green economic recovery, foster social innovation and create employment. The Green ICT strategy includes support for building smart work centres in urban areas, integrating transportation, electricity and other networks, monitoring and responding to pollution of Korea's main rivers using real-time networks. Hyung highlighted the importance of the *OECD Ministerial Meeting on the Future of the Internet Economy*, 2008, in Korea, as a precursor to the current Conference. International co-operation was key to achieve global environmental and economic goals and he signalled upcoming events such as the Korea-ASEAN Summit, the ITU Climate Change Symposium and the OECD Ministerial Meeting.

Esko Aho (Executive Vice President, Nokia and Former Prime Minister of Finland) discussed the **role of innovation** to tackle the environmental and economic crisis. Based on his time as Prime Minster of Finland during a severe national economic crisis (1991-1995), he formulated suggestions on how policymakers should handle the current crisis. This includes maintaining (or increasing if possible) funding for education and R&D, harnessing people's increased mental and physical mobility during a crisis, and, most of all, not focussing on the coming election. Aho underlined that ICTs are vital to respond to the current crisis. ICTs have become a general-purpose technology and are the basis of many innovative goods and services. However, systemic changes are needed to bring about sustainable innovation. Tight regulation, he said, was not usually the best approach to fostering the sector's innovation potential.

Botaro Hirosaki (Senior Executive Vice President, NEC) named three **fundamental challenges to sustainability** that ICT innovation could help alleviate: climate change, fossil fuel dependence and North-South development divides. While technologies are a key component, behavioural changes are needed to generate long-term sustainability (*e.g.* the Japanese term "Mottainai" and its translation into the concept of "reduce, reuse, recycle"). Innovative indicators and merit systems must be developed to measure, assess and reward innovation for sustainability. For NEC, "Green ICTs" cover both reducing the energy use by IT equipment throughout its life cycle and ICT applications contributing to energy savings across the economy as a whole. The company aims to go carbon neutral by 2010 by balancing and reducing the environmental impacts of its ICT products and infrastructures against the emissions savings achieved through broadband networks and other ICT applications in telework, e-learning, e-medicine, logistics and transport. Supporting policy measures by governments should include funding for R&D and innovation, incentives to reform unsustainable

business processes (*e.g.* tax credits), international co-operation and promotion of technology transfer to developing countries.

Roundtable: Building a green future. Clean innovation, investment and jobs

This roundtable focused on how to promote long-term innovation and investments in clean technologies in the worsening economic climate. Topics included: high-impact areas of ICT applications for the green economic recovery and future employment; funding for green technology investments; technological innovation to help tackle challenges to a green future beyond CO2 emissions and climate change.

Leif Beck Fallesen (Editor-in-Chief and CEO, Dagbladet Børsen) initiated the roundtable by asking speakers to briefly present their ideas on how the ICT industry can drive innovation to improve the environment and create economic growth. He asked for specific action points towards COP15.

Larry Hirst (Chairman Europe, Middle East & Africa, IBM) urged discussants to **join more do-tanks** instead of think-tanks. He stated that each crisis in human history was preceded by a major invention or improvement (steam, electricity, oil) and the consequent boom period. The current economic crisis follows on the invention of the microprocessor and the ensuing ICT revolution. ICTs contribute to making the crisis a global phenomenon, but the industry and its products have an even more significant role in providing global solutions to environmental and economic challenges such as COP15 and the WTO's Doha Round. Hirst underlined that "smart" fiscal spending can restore faith in the economy and achieve long-term sustainability. ICT companies must improve their footprints, but more importantly provide innovative applications to governments, companies and investors. Radical change will come from the integration of "smart" systems, *e.g.* electricity grids and transport infrastructures. However, further R&D is needed to understand the interactions of different systems and their impact on the environment.

Jens Moberg (CEO, Better Place Denmark) presented the company's vision for **sustainable transportation** based on an electric car infrastructure. To develop an innovative system and to provide end users with the convenience known from traditional cars the company collaborates with car and battery manufacturers, electricity providers and grid operators, governments. The pivotal element is a sophisticated software to manage information and electricity flows between the different parts of the system. Better Place aims to realise significant environmental benefits through a smart electricity grid that supports renewable sources, distributed energy generation and feed-in, uses car batteries as intermediary storage, and improves personal transport efficiency. Test cases exist and roll-outs are planned in Israel and Denmark by 2011.

Russell Pullan (Director, New Energy & Clean Technology Ventures, Nomura International) outlined trends in **clean energy investments** and his view on the **role of governments**. Promising technologies attract funds only if they are compatible with existing supply chains and policy frameworks. Energy has been a "hot" investment area for some time, especially clean energy, although conditions to attract funds have hardened somewhat. There is media buzz around "smart" grids, but Pullan acknowledged the existence of highly promising areas such as energy storage, renewable and intermittent energy sources, new materials. Industrial efficiency is another "hot" investment area offering immediate paybacks.

The role of governments stems from divergences between investors' interests (returns within 2-3 years) and societal interests (long-term benefits). Some promising technologies, *e.g.* solar, CCS, hydrogen, require developing long-term infrastructures that governments should support through R&D funding. Governments should also create level playing fields by cutting harmful subsidies, installing price-support mechanisms and carefully assessing industrial policies. He contrasted

Denmark's success in promoting wind energy to the ambivalent economic benefits of Germany and Japan promoting solar energy.

Jeannette M. Wing (Assistant Director, National Science Foundation, United States) discussed **major research challenges** the ICT community had to address in order to realise environmental benefits in terms of direct, enabling and systemic effects. Private-sector R&D is important, but usually focussed on the short to medium term. Governments should focus on fundamental, open and long-term research that is so critical to providing solutions to future challenges.

Wing noted that remedies to the direct environmental impacts of ICTs have been developed in the private sector, *e.g.* energy-efficient semiconductors and data centres. However, computing systems as a whole are not yet well understood in terms of net energy use across the life cycle. Research areas include software, virtualisation and intelligent network control. To realise the enabling potential of ICTs, researchers need to further explore: barriers to making organisations and processes virtual, success factors for virtual collaboration, technologies with high usability. Systemic improvements depend on scientific modelling of climate and environmental systems, connecting various systems in order to create solid forecasts and scenarios. Research areas include: data structures, algorithms, software, and virtualisation. Finally, Wing mentioned the science and technology components of the US government's recovery plan, *e.g.* USD 3 billion for the National Science Foundation (equivalent to half its regular budget).

To start the **panel discussion**, Beck Fallesen asked panellists to name **technologies "in the pipeline"**, *i.e.* close to commercialisation, that are expected to significantly improve the environment. Discussants agreed on a set of high-impact areas for enabling effects of ICTs: "smart" grids for efficient energy generation, distribution and storage; electric car infrastructures; ultra-broadband deployment (up to 100Gbps) as a basis for social innovation; mobile phones as ambient sensors; water management, including desalinisation (strong links to nanotechnology applications).

Discussants pointed to prerequisites to the realisation of environmental and economic benefits of the above technologies:

Collaboration across industry sectors and research communities (environment, climate, energy, economy, social) determines economic and environmental success and ensures system-wide improvements. Smart electricity grids and electric car infrastructures, for instance, can achieve multiple goals: efficient use of resources, offering innovative modes of transport, supporting national energy security strategies, generating new business models for the energy, ICT and services industries.

Integration of technologies and systems is essential for holistic sustainability. IBM's smart grid collaboration with Malta and other partners, for instance, aims to make the island less dependent on fossil fuels by raising efficiency of energy generation and distribution. The challenge is to move beyond energy efficiency towards radical change of the entire system and the processes that actually consume energy. In Malta, large amounts of energy are used to desalinate sea water – 50% of the island's water supply is produced that way – and nanotechnology applications should soon help to significantly reduce energy use for desalinisation.

Complex software solutions are required to integrate systems. For Better Place, software is key to controlling the electricity grid and the network of electric cars connected to it. Analysis of the grid and its components enables, for instance, charging when green and cheap energy is available without limiting the user's convenience. Users can optimise travel routes, identify charging and battery changing stations, register time preferences for car usage, etc.

Education is critical to assure the supply of ICT-skilled engineers to develop and deploy green technologies. ICT and engineering programmes must re-gain in popularity in OECD countries, and

especially so amidst female graduates. Cross-discipline approaches (environment, energy, technology, economy, employment) will allow future graduates to analyse and optimise systems as a whole and across the entire life cycle.

Utilisation of existing technologies needs improvement in many areas and points to unexploited business and social potential. Wing mentioned that the more than 4 billion mobile phones around the world could serve the research community as ambient sensors capturing images, sound, movement, position. Real-time availability of such information would significantly enhance technological progress and scientific research in diverse areas, *e.g.* weather and climate science.

Analysis of demand-side developments can help to understand near-future technology trends. Pullan noted that rapid economic growth in Asia and large monetary resources in the Middle East would significantly influence trends in R&D and innovation (*e.g.* improving desalinisation, which is important in the Middle East).

Finally, discussants agreed that **governments** should create a stable economic context over a timeframe of ten years or more. This includes avoiding regulation at granular level because subsidies for particular technologies, *e.g.* fossil fuels or Ethanol, might prove economically unsustainable. Policies should set environmental objectives and allow technologies to develop in the market.

The discussion also touched upon **collaboration** for innovation and **intellectual property**. Panellists underlined the importance of open technologies and standards for the development of the Internet and social innovation. Global accounting standards and efficient intellectual property processes (patenting and licensing) were mentioned as major facilitators of innovation.

Roundtable: New policy directions

This roundtable examined and suggested innovative policies to improve environmental performance and sustainability through ICT applications. It included a stock-taking of existing policies and suggested directions for effective national and international "Green ICT" policy instruments.

John M. Jordan (Executive Director, Centre for Digital Transformation, Penn State University, United States) introduced the roundtable by indicating three key questions that policymakers face when defining "Green ICT" policies: *i*) How to reconcile the global nature of the challenges with the fact that governments work in nation states? Jordan indicated that defining measureable objectives and joint platforms for innovation can be a way. *ii*) How to promote advance green innovation without "picking winners"? Jordan suggested governments announce "Grand Challenges" to promote ground-breaking research and innovation. *iii*) How to navigate between governments and markets? Jordan pointed to the example of the United Kingdom, where the ICT sector is being encouraged to "clean up its act" in order to lend credibility in the provision of solutions for other industry sectors. Governments should also invest in pilot and demonstration projects. Jordan asked panellists to discuss externalities such as GHG emissions and other environmental burdens.

Bo Larsen (President Telecom, Union Network International) indicated that the issue of **sustainable employment** had become a high priority since the dot.com bust, which caused dramatic cost cuts and outsourcing from Western countries to Asia. Larsen discussed the importance of broadband, but pointed to huge national differences in terms of capacity and speed. Moreover, he criticised that the environmental benefits of broadband-based applications, *e.g.* smart electricity metering, have been heralded for a long time, but bold action plans or co-ordinated strategies were still missing. Neither had telework truly revolutionised labour markets yet.

Larsen argued that ICT applications for energy efficiency had been of little interest to businesses and governments as long as energy prices were low. This might change in the context of high energy

prices and enhanced knowledge about the impacts of ICTs on different socio-economic processes. He urged governments to show leadership through effective legislation, tax incentives and direct investments where costs or risks might be too high for private investors.

Suk-Ho Bang (President, Korea Information Society Development Institute) presented **Korea's Green Growth strategy**, which has a strong focus on "Green ICTs". Technologies to be strategically promoted include: energy-efficient servers, LEDs and next-generation displays, next-generation PCs. The Korean Communication Commission (KCC) announced a nation-wide deployment of gigabyte-broadband networks by 2012. Moreover, Bang presented the "Korean Ubiquitous City Construction Act", which supports the building of residential and commercial buildings equipped with IP-based networks and services.

Bang summarised preconditions for a successful implementation of "Green ICT" policies: a strong role of the central government and co-ordination across ministries; a long-term vision to realise the enabling impacts of ICTs, *e.g.* by re-educating construction workers and adjusting behaviours; focus on the demand side to maintain investment levels, *e.g.* through green public IT procurement; assessing and evaluating previous "Green ICT" policy initiatives.

Malcolm Johnson (Director, Telecommunication Standardization Bureau, International Telecommunication Union) presented ITU work on **standards for energy-efficient ICT products**, which are being developed in co-operation with the private sector. He underlined the need for improved measurements of both direct and enabling environmental impacts. To this purpose, the ITU has developed a methodology that will serve as a basis for a global standard that will also refer to ICT applications in areas such as teleconferencing and "smart" buildings. Johnson criticised that ICTs were not mentioned in the Kyoto Protocol and urged participants to advocate for inclusion in an agreement reached at COP15. There is sufficient reason for that since even conservative estimates put the potential for global GHG emission reductions through ICTs applications in the range of yearly emissions of the United States or China.

Mark Frequin (Director-General, Ministry for Economic Affairs, The Netherlands) presented the Ministry's vision of the **relationship between the ICT and energy sectors**. He underlined the need for long-term approaches in order to avoid the topic becoming victim to day-to-day politics. It was imperative to promote the role of ICT applications within climate and energy policy communities. Frequin presented the Dutch experience of government support for "smart" ICT applications for energy efficiency. The government has a central role to play in deployment, although different for each application area. Cap and trade schemes are an important incentive for ICT companies to develop energy-efficiency applications and can open new revenue streams. Frequin announced a Conference on ICTs and Energy, "WCIT2010", to be held in May 2010 in Amsterdam, the Netherlands.

Nick Rowley (Strategic Director, Copenhagen Climate Council) highlighted the importance of **effective measurement and indicator systems** to tackle climate change in measurable, reportable, and verifiable ways. Rowley criticised that reduction targets of many organisations are being established without an understanding of the dynamics that lead to the emissions in the first place. ICTs can help understand underlying causes and sources of GHG emissions. Moreover, ICTs could contribute to tackling climate change in a variety of ways. Online applications such as the Australian Building Sustainability Index (BASIX) allowed individuals and households to certify environmental criteria with little effort. Rowley also presented the "Copenhagen Call", where major global businesses gave their view on key requirements for an agreement at COP15. Rowley concluded that technologies could bridge the gap between bold intentions of solving the climate change challenge and the actual behavioural changes needed for this to happen.

The **panel discussion** focussed on "**Green ICTs" in the context of the economic crisis**. Panellists acknowledged that this crisis was an opportunity for long-term green technology investments. The crisis was also an opportunity to identify and jointly manage global risks. However, participants criticised that ICTs were rarely mentioned in international negotiations and declarations. Panellists acknowledged this but highlighted that awareness of the important role of technologies existed. It required stronger advocacy to make ICTs part of international negotiations and treaties, notably at COP15. Discussants furthermore agreed that comparable metrics are an imperative precondition for successful "Green ICT" policies.

Summary session: Meeting policy goals

The summary session was introduced by **Richard Simpson** (Director-General, Electronic Commerce, Industry Canada and Chair, OECD Committee for Information, Computer and Communications Policy), who invited the session rapporteurs Deborah Estrin and Lorenz Hilty to summarise main Conference findings before turning to Graham Vickery for the OECD view on main outcomes of the Conference and next steps.

Deborah Estrin (Director, Center for Embedded Networked Sensing, University of California, Los Angeles, United States) concluded that a **large array of ICT applications exist to improve energy-efficiency** in areas such as energy, transportation, buildings, work organisation. Cities can be a particular driver of radical change because of the concentration of systems and stakeholders/actors. Innovative pilot projects exist that connect so far disparate systems (*e.g.* buildings, transport, utilities) into networks to radically improve environmental performance. However, collective action requires standardised and consistent measurement systems to start with. Consumers and their behaviour have strong impact on the success of "Green ICT" strategies. Demand-side improvements must be supported by improving product design and improving consumer information through standardised and readable eco-labels. Finally, data ownership, privacy and security issues must be addressed.

ICT applications can contribute to effectively managing natural resources (beyond energy). Real-time observation and reaction to environmental pressures can help tackle wildfires, deforestation and biodiversity loss. Sensors, sensor-based networks and software allow to measure and model changes in eco-systems. The main challenge is to bridge gaps between separate research communities dealing with questions of energy, climate, environment, ICTs.

Lorenz Hilty (Head, Technology and Society Lab, EMPA, Switzerland) concluded that the ICT **sector should take leadership in a sustainable society** that aims to tackle environmental degradation as a whole and to improve social aspects, *e.g.* working conditions. "Green ICT" applications must be developed by the sector and should include life-cycle assessments of ICT goods and services, life-cycle inventories, design of energy-efficient ICT devices, use of renewable energy for ICT infrastructures, extended service life. Technologies must be simple and seamless, but should not exculpate users from environmental responsibility.

Lorenz indicated that governments should support investments in green technologies, use fiscal tools, implement pilot and demonstration projects, support green public IT procurement. ICT applications must be integrated into climate and environmental strategies. Governments should support the development of standardised metrics and use of life-cycle assessments for "Green ICT" policies.

Graham Vickery (Head, Information Economy Group, OECD) **furthered the discussion on policies**, underlining that responsibility for "smart" applications often lies within different government departments and requires improved co-ordination to best play out the potential of ICTs. Traditional policy areas of governments include: R&D support, training and education, infrastructure

investments, awareness-raising, demonstration programmes and public procurement. Vickery raised the question whether "smart" investments required changes to this set of policy instruments. He underlined that changes in institutional structures and new partnerships between the public and private sectors might be required.

Based on OECD work (OECD, 2009*b*), he accentuated that most government policies focus on the 2%, *i.e.* the narrow view of reducing the sector's environmental footprint only. Furthermore, most policies lack effective evaluation and measurement approaches. Vickery asked participants to further think about how these policies need to be restructured and refocused.

The **panel discussion**, steered by Richard Simpson, raised topics on **all three levels of the analytical framework for "Green ICTs"**: tackling direct environmental impacts of ICTs is important because their share in global GHG emissions is likely to rise due to increasing diffusion and use of ICTs; enabling impacts of ICT applications could be especially significant in improving entire power networks, *e.g.* through the integration of renewable sources; broadband networks are an important prerequisite to realize environmental benefits; systemic effects need to be carefully evaluated because smart ICT applications can have positive as well as negative externalities, *e.g.* rebound effects from increased efficiencies. Educating consumers is therefore an integral component to bring about behavioural change that is beneficial for the environment. Product information must be standardised, easy to read and compare and should include information on the total cost of ownership.

Discussants saw a **role for government and the OECD** in these areas: decreasing bureaucratic hurdles for investment in smart and "Green ICTs"; investments in basic and multi-disciplinary research to address long-term environmental challenges and improve understanding of systemic effects of ICT applications; tax incentives or other market support mechanisms for companies to implement complex and costly measurement systems; generating knowledge about the political economy of "Green ICTs", externalities, public goods and market failures; advocating ICT applications for the environment; identifying and disseminating best practices.

Future **work of the OECD's Committee for Information, Computer and Communications Policy** (ICCP) should be co-ordinated with environment, climate change and energy committees and organisations. "Green ICTs" require intersectoral policies, not focused solely on technology development and promotion. The OECD can be a forum for forging partnerships around the topic of green innovation.

Closing remarks

Andrew Wyckoff (Director, Science, Technology and Industry, OECD) thanked the Danish Ministry of Science, Technology and Industry and the National IT and Telecom Agency for hosting the Conference. He underlined the sense of **urgency to address joint environmental and economic challenges**. Awareness should be raised about the potential of ICTs to help ameliorate environmental problems. This includes reports and political declarations such as the *OECD Innovation Strategy* report (due in 2010) and the *OECD Seoul Declaration*. Pilot studies and demonstration projects must be continued and results disseminated, *e.g.* through OECD peer reviews. Aggregating these projects will provide data to build solid metrics and measurement systems. However, developing trusted and rigorous data requires time and serious methodological work. Wyckoff pointed to the initiative by Dennis Pamlin (WWF) on measuring environmental impacts of ICTs. To conclude, he stressed that technologies will be critical in the aftermath of COP15 to reach ambitious quotas. The ICT and environmental communities should forge relationships now to develop applications, which will then be urgently needed.

Jørgen Abild Andersen (Director-General, Ministry of Science, Technology and Innovation, Denmark) closed the Conference by thanking all participants for making this a successful event and the OECD Secretariat for co-operating in its organisation. He re-iterated statements during the welcome part that **"Green ICT" policies have increased in importance as a response to the economic crisis.** The full benefits of ICT applications come about when they are used to reduce, manage and rethink existing supply chains and systems. Common standards must be developed to monitor, measure and verify environmental impacts. He underlined the importance of government policies to further investments in R&D, education and innovation during the crisis. Finally, he underlined the Danish government's commitment to reaching an agreement on CO_2 emissions reductions at COP15. ICTs will provide means for all countries to achieve ambitious goals and commitments for CO_2 emissions reductions.

PARALLEL SESSIONS

Day 1: Key issues

Session 1: Reducing environmental impacts during the ICT life cycle

Chair: **Lorenz Erdmann** *(Project Manager, Institute for Futures Studies and Technology Assessment, Germany)*

The session discussed approaches to identify, measure and limit direct environmental impacts during the life cycle of ICTs. Main questions included: What are direct environmental impacts caused by the production, use and end-of-life treatment of ICT goods? How can impacts be measured, compared, assessed and reduced? How can social aspects be integrated into life-cycle assessments?

The session concluded that **Life Cycle Assessment (LCA) is an essential prerequisite to provide realistic data on the environmental impacts of ICTs** and to identify problems that can be solved easily and those that are more intractable. Speakers agreed that LCAs of direct and enabling effects need to be strengthened; that a priority list of LCAs should be compiled to allow allocation of funds for R&D on these challenges; that joint methodologies and frameworks should be created and disseminated; that life-cycle thinking should include considerations of R&D and design for end-of-life; that life-cycle thinking should not only cover the environmental dimension of ICTs, but also the social dimension (*e.g.* working conditions, employment effects) and economic dimension (*e.g.* life cycle costing).

Jens Malmodin (Senior Research Engineer, Ericsson) presented research on **life-cycle GHG emissions** of telecommunications networks and on **measuring the enabling potential** of ICTs. On the former, research at Ericsson served as a basis for estimating the ICT sector share of the global carbon footprint at 2%. Between 1995 and 2005 mobile communications operators have managed to halve the annual carbon footprint per subscriber to around 25kg CO2 emissions. But action areas for reductions persist: radio base stations use and manufacturing, mobile phone manufacturing. Impact areas vary for fixed broadband networks. If current trends continue, the ICT sector will contribute over 1 billion tons of CO2 emissions in 2020. However, Malmodin indicated the potential to stabilise the footprint at current levels while doubling the proliferation of ICTs and networks. Malmodin outlined research on using LCA to quantify the enabling potential of ICT services and applications, *e.g.* from dematerialisation and virtualisation. Although a complex area of work, it is the only way to scientifically assess the footprint of technologies as well as evaluate their potential to reduce emissions in other sectors.

Anders C. Schmidt (Senior R&D Coordinator, Force Technology) presented an LCA study that compares the **environmental impacts of digital document delivery** against paper-based delivery. He examined the case of E-Boks, a Danish online service with 2 million users receiving on average 50 documents per year. The environmental benefits of online document distribution turned out to be unequivocal and consistent: 60% reduced global warming potential and 70% reduced energy consumption, mainly driven by replacing paper print-outs with online viewing. Schmidt presented the results of a sensitivity analysis to indicate major factors that can alter the environmental benefits. These were mainly longer viewing times and higher frequency of domestic printing. The

study shows that benefits of the ICT application to a large degree depend on how the digital delivery service is used.

Masayuki Kanzaki (General Manager EcoLeaf, Japan Environmental Management Association for Industry) presented the **Japanese Eco-Leaf label, which uses LCA for ICT goods and services**. The label is a Type III ISO-certified environmental label, *i.e.* uses the most stringent approach to life-cycle assessment. Kanzaki showed how EcoLeaf can assess and compare products by different manufacturers. The next step is to move beyond using LCAs for individual products to using it to assess environmental impacts of services, applications and systems of applications (*e.g.* network infrastructures, food delivery chains). Life-cycle assessments of data centres have been done, but more research is needed to establish a common methodology. Kanzaki highlighted that LCAs can be used to evaluate the enabling impacts of ICTs, *i.e.* impacts of replacing existing processes with ICT-based applications. Private-sector data point to significant reduction potential of broadband-based applications in banking, communications, etc. The challenge is to make these measurements verifiable and comparable.

Marcus Courtney (Head Telecoms, Union Network International) offered a **labour perspective on the life-cycle approach to "Green ICTs"**. He discussed the definition of sustainability, arguing that it should include environmental, social and economic goals simultaneously. The global economic crisis has resulted in rapidly rising unemployment and the environmental crisis poses employment challenges too. He stressed that that a was a clear lack of knowledge about the real economic and social impacts of technological developments such the rapid growth of the ICT industry in the past decade: 75% of global ICT manufacturing is outsourced, mainly to Asia, because of lower labour costs and lower responsibilities regarding labour and environmental conditions. A large part of ICT recycling takes place in Asia, mostly in what is often termed an "informal" manner. Courtney warned that cost savings for companies came at the expense of disproportionately large societal costs in these countries, *e.g.* environmental degradation, impacts on workers' health, limited political liberties. He urged policymakers to take these issues into account for "Green ICT" policies. Co-ordination with ICT industry unions is necessary and actually beneficial as unions have often been at the forefront of technological developments, *e.g.* advocating the roll-out of broadband infrastructures.

The ensuing **panel discussion** highlighted that **LCAs have to reflect technological trends**, *e.g.* more efficient production processes and emerging technologies such as "netbooks". This also relates to the fact that around 98% of global semiconductor production is used in products outside the ICT sector, *e.g.* in vehicles and industrial automation. LCAs, Product Category Rules (PCRs) for these products should be developed and shared internationally. Language issues were mentioned as a possible inhibitor of the dissemination of knowledge.

Discussants highlighted that **LCAs should take into account and encourage eco-design principles**, *e.g.* for longer product life and re-use. The OECD should encourage inclusion of R&D and design for re-use in all life-cycle approaches. Moreover, it was suggested that LCAs should extend to integrate social aspects such as working conditions and employment impacts. So-called "social" LCA are being developed, but pose challenges such as data availability and sensitivity.

Session 2: Clean technologies for greener urban growth

Chair: ***Katherine Richardson*** *(Chair, Danish Commission on Climate Change Policy and Vice Dean, Faculty of Science, University of Copenhagen)*

The session discussed the role of ICT applications for making future urban environments more economically and environmentally efficient. Main questions included: What are achievable goals for

ICT-enabled energy efficiency in urban environments? What are trends in high-impact areas, *e.g.* buildings, transport, energy supply? What are existing barriers to wider application?

The session concluded that **cities are an important focus for ICT-enabled sustainability efforts**. They are important for climate change mitigation (75% of human-produced CO2 results from cities) and adaptation (75% of megacities are located on shores). Moreover, the concentration of diverse systems and infrastructures make them a suitable demonstration case for the potential of ICTs. Digital plans should be included in sustainability commitments formulated by (local) governments. Measurement and communication must be improved so that end-users can translate information into collective action. Incentives for private sector investments are important. Conflicts between stakeholders around use and commercialisation of data need to be resolved, including privacy issues, making this a possible case for government regulation.

Ignacio Campino (Vice President Sustainability and Climate Change, Deutsche Telekom) presented the **pilot project Friedrichshafen** (Germany), where ICTs are used to improve environmental performance as well as the quality of education, healthcare and other services. The involvement of companies in tackling climate change has become a critical success factor as they are major stakeholders and major sources of funding for innovation. Co-operation with local universities is crucial to research the impacts of technology deployment. Friedrichshafen is a good case as its population of 60 000 represents a typical German city so that best practices can be applied elsewhere. Broadband networks are a major facilitator to enable connecting and exchanging data on a broad scale, across systems and infrastructures. Campino referred to the "Smart 2020" report, which projects high net GHG emissions savings achievable through ICT use in cities.

Paulo Ferrão (Director, MIT-Portugal programme, Portugal) presented research on **ICTs for sustainable urban infrastructures**, which developed a model of "urban metabolism" to describe and analyse all material flows in and out of cities and to connect these flows with real-time information. Based on pilot projects in Lisbon and the Azoees island, the project has identified areas where ICTs can significantly reduce environmental footprints: construction, transport and material consumption. Smart metering, for instance, has proved to reduce household energy consumption by up to 20%. "Smart grids" have helped to double the use of renewable energy in the Azoees islands through integration of electric vehicles, demand-side metering and flexible electricity pricing.

Ferrão also stressed the gap between demonstration projects and wider national roll-outs. More scientific research and experiments are needed to determine the enabling impact of ICTs in relation to other independent variables. This includes controlling for factors such as social status, education, information about prices, contractual information as well as the impacts of various technological implementations, *e.g.* direct, ambient and indirect displays for smart meters.

Vin Sumner (Founder, Clicks and Links, United Kingdom) highlighted the **potential of cities to realise systemic changes** in the way that cities influence the environment. He criticised that this potential has not been reflected in urban policymakers' sustainability visions. Sumner demonstrated a smart metering application that makes environmental impacts visible to individuals by detailed real-time monitoring of energy use and GHG emissions as well as resulting household expenses. This information is put into a relevant context, *e.g.* by comparing it to neighbourhood or city averages, but incentives are needed to translate it into action, *e.g.* rewarding efficiency gains in neighbourhoods by allocating additional public services.

Sumner noted that many cities have committed to long-term visions and GHG emissions reductions (*e.g.* the EU Covenant of Mayors), but only few have a long-term vision of the role for ICT infrastructures. The Eurocities' "Green Digital Charter" can provide guidance on how all stakeholders in the city can use ICTs to increase energy efficiency and drive systemic change. The ICT industry and

vendors must provide solutions to integrate and exchange data across systems, but also to address challenges such as closely related privacy and security issues.

Nicola Villa (Global Director, Cisco Systems) presented Cisco's **Connected Urban Development** initiative as a means to balance the trade-off between rapid economic growth and increasing energy use in cities (especially in developing economies). Pilot projects indicate that next generation broadband infrastructures are a key element to raise environmental awareness, but even more so to generate intelligence and enable action. The Internet will connect billions of objects from sectors as diverse as transport, buildings, energy, manufacturing. The challenge is to use this data for simulation and decision-making as well as for incentive mechanisms such as emissions trading.

Villa presented an "Urban EcoMap" of San Francisco, which compares the environmental performance of different neighbourhoods, provides optimisation tips and integrates with social networking platforms such as Facebook and Google Maps. Main challenges to wider application include: promoting innovation in regional governance as cities are not strictly separate entities but integrated in their context; managing infrastructure financing because traditional financing by public sources alone cannot be sustained; widely rolling out broadband infrastructures.

The **panel discussion** touched upon the **role of local governments in facilitating organisational and behavioural change**, *e.g.* through demonstration projects. It was said that industry involvement needs further incentives, *e.g.* price signals, but also regulation and pressure from binding commitments. Technological developments can result in unintended negative impacts from changed user behaviours. Rebound and rejection effects of intelligent transport systems could, for instance, lead to more cars on the streets. Research of such effects needs to be integrated into pilot projects and demonstration projects. Further research design issues were discussed.

Privacy, security and licensing issues were discussed as a critical challenge to integrating large amounts of data from multiple sources: the private sector needs business cases to provide data, governments might oppose commercialisation of certain data and citizens' privacy needs to be assured.

Session 3: ICTs in pollution reduction and resource management

*Chair: **Daniela G. Battisti** (Agency for Inward Investments and Business Development, Italy and Chair, OECD Working Party on the Information Economy)*

The session discussed ICT applications to monitor and improve environmental performance in all sectors of the economy. Main questions included: How can sensor-based networks be used to monitor the environment and mitigate pollution impacts? What are main application areas to improve environmental performance across the economy? How can we measure and assess environmental effects of ICTs beyond energy use and greenhouse gas emissions?

Speakers highlighted the role of government in **promoting worldwide standards and interoperability**. Bridging the gap between environmental, climate and ICT communities is key to increase the diffusion of ICTs for pollution reduction and better resource management. Software is indispensable for effective environmental monitoring.

Rob Bernard (Chief Environmental Strategist, Microsoft) outlined the difficulties multinational companies face when **reporting environmental impacts of products and operations**. Governments worldwide should provide for guidance and clarity. Microsoft's environmental efforts included moving tangible products online, *i.e.* dematerialisation, using and procuring renewable energy and minimising the energy consumption of its data centres. Bernard suggested the ICT industry should aim to increase computing performance per energy unit consumed. Bernard concluded that environmental policies should not focus on single industries or environmental impact

categories, but reflect the interconnected eco-systems, which constitute our environment. Policies should address challenges at the system level.

Sandy Andelman (Vice President, Conservation International) argued that **ICTs are critical to effectively manage the planet's resources**. Critical knowledge of the reasons and impacts of climate change and how to deal with it have decreased compared to the scope of the actual challenge over the past 50 years. Better modelling and forecasting methods are critical to understand, for instance, that around 20% of global $CO2$ emissions are caused by cutting and burning of tropical forest. ICTs are key to monitoring and reducing emissions from deforestation and degradation (REDD). Conservation International's Tropical and Ecology Assessment Monitoring (TEAM) network uses satellite, airborne and ground measurement technologies to gather environmental data. However, these technologies are not readily available in developing countries – home to most of the world's tropical forests. Mechanisms to transfer these technologies are therefore needed. As another promising area, Andelman suggested using mobile phones as sensors for capturing the status of and changes to the environment. The increasing number of mobile phones in the world could enable citizen science and scale up the monitoring process of climate change.

Eddy Chan (Commissioner for Innovation and Technology, Government of the Hong Kong Special Administrative Region, China) presented the **environmental challenges posed by rapid economic development in the Pearl River Delta (PRD) region** – a "global manufacturing hub". A joint working group of the Hong Kong and Guangdong (China) local governments was formed to tackle regional pollution issues. ICT-based applications to monitor and improve environmental quality are: an air quality monitoring network to measure pollution and provide policy-makers and scientists real-time data online; a computational model for pollution flow distribution and water management in the PRD; a ground station for satellite remote-sensing, established together with the Chinese Ministry of Science and Technology. The station receives high-resolution images of the PRD region and enables environmental applications such as oil slicks monitoring and fire damage analysis. Chan mentioned other joint efforts that include: a joint funding scheme between Shenzhen (Guangdong) and Hong Kong, China, to strengthen regional innovation capacity on green technologies; the creation of a solar energy technology support centre for the development of thin-film photovoltaic technology and transfer of solar energy technologies to mainland China.

The **panel discussion** focused on governments and major companies as agents to promote pollution reduction, resource management and **global standards in areas such as measurement, accounting, emissions trading**. Interoperability of environmental monitoring and "smart" ICT applications is essential to guarantee smooth exchange of data between different systems. Software, it was agreed, plays an important role in processing and visualising such amounts of data as well as converting different types of information. Gaps between the environment and ICT expert communities are inhibiting wider diffusion of "Green ICT" applications and governments should support innovative co-operation schemes.

Session 4: Innovation and behavioural change

Chair: *Per Morten Hoff* (Secretary-General, ICT Norway)

The session discussed how ICTs can facilitate long-term structural changes towards sustainable behaviour of individuals and organisations. Main questions included: How will ICTs alter environmental behaviour in the long run? How can ICTs contribute to systemic change for more equitable and sustainable global development? What are barriers to such behavioural change? What technologies are being developed and how will they enable widespread sustainable behaviour?

Discussants agreed that **widespread behavioural change is key** to tackling environmental challenges and building sustainable economies. ICTs can be a driving force of such system-wide

change, but transparency and measurement must be provided. Policy environments should be designed to enable systematic change of individuals and institutions/organisations. Best practices and co-operation schemes should involve stakeholders from a variety of sectors.

Heather Creech (Director Global Connectivity, International Institute for Sustainable Development, Canada) conceptualised **systemic impacts of ICTs and the Internet** on the environment and society. Behaviours need to change to address climate change and other pressing issues such as land degradation and water management. ICTs can serve as a force for transformation, *e.g.* by using social networks to mobilise individuals. However, for information to transform into collective action, challenges needed to be addressed, *e.g.* online trust and identity, digital divides and inclusiveness. Creech highlighted that collaboration in the ICT sector (*e.g.* open source) could serve as an example to environmental and climate communities, but this is not being picked up yet. International policy efforts in the near future should refocus development aid around ICTs to transform and improve governance. The role of ICTs needs to be highlighted towards COP15.

Klaus Fichter (Director, Borderstep Institute for Innovation and Sustainability, Germany) presented **environmental opportunities of Thin Clients and server-based computing**. ICTs consume about 10% of electricity in OECD countries, Fichter explained. Running office computers alone requires energy production in the range of over 50 coal-fired power stations. Thin Clients and server-based computing could provide an effective way to reduce this energy consumption, but requires profound changes to organisations' IT infrastructures. Advantages besides energy savings include: space savings, reduced downtime, quick start up, less heat generation, lower noise levels, and reduced administrative overhead compared to conventional networked PC systems. Further possibilities for "Green ICT" should include the provision of best practices and guidelines for IT managers; developing regional "Green ICT" diffusion networks, developing sector-specific solutions for SMEs and co-operative approaches to technology roadmapping.

Martin Curley (Global Director IT Innovation and Director Intel Labs Europe, Intel) presented **the role of ICTs as an enabling technology for socio-economic changes** as presented in a study by the Institute for Prospective Technological Studies (IPTS, 2004). The "micro story" of environmental impacts refers to tackling direct impacts of ICTs, *e.g.* GHG emissions and pollution throughout the life cycle. The "macro story" of environmental effects of ICTs includes immediate benefits from changed business processes, *e.g.* travel substitution and e-business, and long-term structural changes. Curley argued that ICT companies and vendors could greatly influence direct and enabling effects. Intel, for instance, has collaborated with major stakeholders and research institutions to advance the energy efficiency of semiconductors. Policymakers, in turn, should focus on facilitating systemic changes towards improved environmental performance. Policies are necessary to radically change the material, energy and transportation intensities of our economies.

During the panel discussion, participants discussed the importance of measuring and presenting information in clear ways for business, institutions and households to change behavioural patterns. "Smart" electricity metering, for instance, can have significant impacts on energy consumption patterns. Challenges related to "Green ICTs" were primarily discussed from the angle of developing countries, which will require support to develop effective "Green ICT" infrastructures and policies.

Day 2: Strategies

Session 5: The ICT sector in focus

*Chair: **Takayuki Sumita** (Director, Information and Communication Electronics, Ministry of Economy, Trade and Industry, Japan)*

The session discussed innovative approaches to improve the environmental impacts of products, services and business operations in the ICT sector. Main questions included: What are key areas to improve environmental performance of the ICT sector? What are policy approaches to green the ICT sector? How can ICT companies be encouraged to spread positive experience to other sectors and activities?

The session positioned **measurement as the first step for improvement**. A life-cycle approach is vital in measuring the impact even if complete assessments cannot always be undertaken easily. Standardised measurement is essential to compare environmental impacts – between different companies, between old and new products, between traditional and new systems. The session concluded that there is room for policymakers to devise an innovative policy mix consisting of incentivising best practice and punishing polluters. Governments should use market mechanisms to raise the bar for environmental standards, especially related to measuring direct and enabling environmental impacts of ICTs.

Zeina Al-Hajj (Head, International Electronics Campaign, Greenpeace International) presented the **IT Climate Leaders Campaign**, launched on the Conference day. The campaign urges the IT industry to reduce its own environmental footprint, but more importantly to provide applications to tackle climate change across all industries. The ranking was led by IBM and Sun Microsystems. Criteria for the ranking are: *i*) the company's position on climate change and advocacy for significant global emissions reductions; *ii*) provision of ICT applications to reduce GHG emissions and to measure net environmental impacts; *iii*) commitment and action to reduce own GHG emissions. Al-Hajj also presented the "Guide to Greener Electronics", which has spurred competition amongst ICT companies to develop greener products, often beyond the requirements of legislation. Greenpeace encouraged the ICT sector to take leadership in providing innovative solutions for GHG emissions cuts across all industries. ICT firms should make good practices widely known to lift average industry performance.

Benjamin Kott (Head Green Business Operations Europe, Middle East & Africa, Google) presented efforts to **reduce environmental impacts of Google's data centres and IT infrastructures**. Data centres are a high-impact area, responsible for roughly 14% of the ICT sector's carbon footprint. Half of the energy consumed is not used to run the server, but relates to overhead from cooling, etc. Based on power usage effectiveness (PUE) metrics, Google was able to reduce its overhead to 19% and cut GHG emissions by half. Google also introduced systems to recycle and re-use the large amounts of water needed to cool data centres. The company funds the development of low-carbon technologies through projects on renewable energy, electric vehicles and energy storage and smart metering. Kott concluded that efforts to improve the energy efficiency of IT infrastructures lead to positive returns on investment.

Paolo Bertoldi (Project Officer, European Commission/Joint Research Centre) presented the European Codes of Conduct (CoC) to **tackle growing power consumption of servers and data centres**. The CoC for data centres aims to share best practices and monitor improvements over time. Rewards include public recognition, visible returns on investments, comparable metrics and measurements. The main target groups are data centre owners and operators, but the CoC can also be used to support "green" public procurement policies. The voluntary nature and stakeholder

involvement of the system is beneficial in a fast-changing area such as the ICT sector. Bertoldi said that voluntary commitments coupled with incentive mechanisms have resulted in concrete action by companies where regulation and caps might be difficult to develop and risk being implemented with a significant time lag.

Sarah O'Brien (EPEAT Outreach Director, Green Electronics Council, United States) presented the **EPEAT rating system for ICT products**, which uses market principles to encourage ICT companies to green their products. EPEAT is based on IEEE standards and covers aspects such as design for end-of-life. EPEAT was developed by various stakeholders and includes non-compliance mechanisms. Over 1 200 products are currently registered and the US government includes EPEAT in public procurement principles. EPEAT has contributed to: toxics reduction beyond demands of current legislation; increasing use of recyclable plastics; development of a benefits calculation tool.

A number of factors contributed to EPEAT's success in engaging the ICT sector: differentiation between mandatory and optional goals with rewards for meeting the latter; the declaration/verification system does not delay market entrance; stakeholder involvement in development and management broadens reach and acceptance; direct co-operation with distributors and vendors saves money. Finally, the rating can be consulted regardless of the geography or type of purchaser. O'Brien concluded that environmental purchasing and standards-setting can significantly impact on the design of ICT products to improve environmental performance over the entire life cycle.

The **panel discussion** picked up two critical issues to green the ICT sector: **measurement and regulation**. The ability to measure is critical to improve products, processes and behaviour over time as well as to spur competition towards the highest environmental standards. Common standards are especially important for comprehensive carbon footprints, *i.e.* including scope-3 emissions. Life cycle analysis (LCA) is vital to tackle environmental impacts holistically. In some instances requiring a complete LCA might impede market entry because of the complexity and duration of the process. Targeted policies for incremental but immediate action might then be preferable. On regulation, discussants indicated that governments should incentivise market participants to compete for highest standards. The OECD can support governments by promoting incentive mechanisms and highest environmental standards. The session chair placed "Green ICTs" in the context of wider work on innovation and the environment at the OECD and member countries. He referred to Japan's newly introduced "Eco-Points" system as both a stimulus measure and an ecological policy.

Session 6: Fostering sustainable consumption and use

*Chair: **Ed Mayo** (Chief Executive, Consumer Focus, United Kingdom)*

The session discussed the role of ICT goods and services for sustainable consumption. It highlighted opportunities and challenges for ICT to support development of a sustainable consumption market. The session addressed some key questions, including how can individuals minimise their environmental footprints through information technologies; what are promising approaches of using ICTs and the Internet to inform and educate consumers for sustainable development. Finally it also highlighted the role for governments and civil society in this regard.

The session concluded that **ICTs and the Internet are a key component to minimise consumer environmental footprints**. Consumption and use of ICT products themselves can be improved to lower environmental impacts, but the market is not yet mature. Standards for effective and easy-to-understand communication with consumers are critical to connect with the busy lives and complex choices of consumers. ICTs such as high-speed communication networks can support low-carbon consumption systems, in sectors such as transport, energy use and the household.

Trevor Bowden (Co-Founder, Big Room, Canada) presented his vision for an **international .eco domain** and highlighted the importance of **venture capital for sustainable consumption**. Big Room started out with the aim of providing a common international platform to guide consumers through the increasing number and different qualities of existing eco-labels. He argued that the market for sustainable consumption was not mature yet and consumers needed trustworthy and transparent information. The Internet and ICTs have a key role in providing this transparency. The proposed concept for the .eco domain would help companies present environmental credentials and help consumers understand and compare this information. Bowden noted that venture capital for business-to-consumer projects remains limited to consumers goods and their carbon footprints. Other areas are often considered to be too risky, *e.g.* because of difficulties in building a brand and perceived lack of competitive advantage. He concluded that there was a need for effective policy and regulatory frameworks as well as joint standards for consumer education and guidance.

Bernard Flüry-Hérard (Research Engineer, Ministry of Environment, Energy, Sustainable Development and Land Use Planning, France) presented results of a **study on energy consumption of ICTs in France** with focus on the consumer side. ICTs and electronic devices consume over 13% of total electricity in France and are responsible for 3-5% of domestic CO2 emissions. Especially consumer electronics devices are growing quickly and already represent 4% of domestic electricity consumption. The challenge is to raise consumer awareness about the energy use and resulting impacts on climate change. Consumers should, for instance, note that devices in stand-by mode account for around 10% of household energy consumption. Readable and comparable labelling schemes for TVs, PCs and other ICT devices are important to raise awareness. Smart electricity meters can help consumers optimise the power consumption of devices in their homes. But Flüry-Hérard also highlighted the great enabling potential of ICTs to contribute to a low-carbon economy, *e.g.* to increase the efficiency of the transport and energy sectors. Governments should promote such developments, for instance, through funding for demonstration projects.

Anja Ffrench (Director Marketing and Communications, Computer Aid International) highlighted the benefits of **promoting re-use of computers** in favour of recycling and **potential impacts on poverty reduction in developing countries**. She presented examples of refurbished computers supplied to schools and community organisations in developing countries. Ffrench noted that confusion around the recycling options available for old electronics in the United Kingdom has dramatically increased the amount of ICT products ending up in landfills. According to some studies, one half of British consumers fail to correctly recycle their old technology. This compared to 80% of Germans who regularly recycled ICTs equipment. According to Ffrench this represents a missed opportunity as one refurbished PC provides 6 000 hours of computer access over a period of three years - enough time to train 60 children to a vocational level of IT literacy.

Göran Wilke (Head, Danish Electricity Saving Trust, Denmark) presented an application, which allows users to **optimise household energy consumption**. He outlined areas where ICT applications are already contributing to tackling climate change, *e.g.* office automation, traffic and logistics. However, convenient applications for the home and households were missing – a challenge for "Green ICTs". Wilke noted that existing technologies could allow immediate energy savings of up to 50% in buildings. "MyHome" aims to contribute to reaching this goal through a web-based framework that can be used to develop applications to monitor and improve household energy consumption. The platform is open for developers and government authorities worldwide. It is scheduled to launch internationally at COP15.

The **panel discussion** highlighted the **importance of governments in promoting innovative solutions** that enable consumers to track their environmental footprints. Governments should develop education and information campaigns to raise awareness around sustainable consumption and "Green ICTs". Consumers are often confronted with conflicting messages between marketing

practices and sustainability (*e.g.* frequent upgrades of mobile phones and computers, well before their obsolescence, and resulting challenges around electronic waste). Governments should also support the setting of standards, *e.g.* eco-labels, to facilitate sustainable consumption choices.

Session 7: Cleaner technologies and smarter ICT applications

*Chair: **John Higgins** (Director-General, Intellect, United Kingdom)*

This session focused on how ICTs can improve environmental performance across various industry sectors. Main questions included: what are high-impact areas for the application of ICTs to improve environmental performance? What are successful strategies in reducing environmental impacts of key ICT infrastructure? How can "Green ICTs" contribute to job creation?

Discussants agreed that **"smart" ICT applications have major potential for improving environmental performance** in areas such as energy generation and management, construction and transport. Broadband networks are particularly important to the further deployment of smart systems. Speakers highlighted that benefits of smart grids and meters will be hard enough to achieve in the developed world. The stimulus money allocated to smart grids is minuscule compared to required investments. In developing countries the deployment of smart grids might be even harder. Finally, "Green ICTs" have important social and employment implications. Development of ICT skills and employment are key factors for green growth.

Michael Moesgaard (Chief Information Officer, DONG Energy) presented the company's **IT strategy for reducing direct GHG emissions,** which had achieved savings of around half a ton of emissions per employee. Moesgaard then cited three high-impact areas for even greater emissions reductions by harnessing the enabling impacts of "Green ICTs" in the energy sector: *i*) digital management of oilfields ("virtual oilfields"), for instance to avoid flights; *ii*) energy generated by wind parks, while managing the challenge of load balancing; *iii*) "smart" grids, which can have significant environmental benefits as well as ensuring the security of supplies. The company plans a roll-out across the entire electricity grid: "smart" homes, electric cars, renewable and decentralised energy generation, automated switching and load balancing. Although the roll-out will take several years, Moesgaard highlighted the enormous GHG emissions savings potential expected.

Rahul Tongia (Programme Director, Center for Study of Science, Technology and Policy, India) compared the **benefits of smart grids in developing and developed countries** as well as the main challenges to overcome. Smart grids offer important environmental and economic benefits to OECD countries, but the lack of open standards as well as proper accounting of costs and benefits poses challenges. Societal benefits, for instance, are not usually included in calculations done by utilities on their returns on investment. Additional funding is needed as stimulus money allocated to smart grids and "Green ICTs" is only a small percentage of required investments. In some developing countries, the deployment of smart grids might be even harder because of the dire state of existing infrastructures, but the small base of present grid deployment and upcoming growth might represent an opportunity to "leapfrog".

José Luis Angoso (Innovation Director, Indra) presented the **pilot project of the Spanish city Rivas-Vaciamadrid**, where ICT solutions play a key role in improving environmental performance and increasing the quality of life for residents. Cities are major contributors to GHG emissions and face major challenges in areas such as transportation, water, waste, energy, health and safety. Rivas-Vaciamadrid serves as an example for the potential of ICTs to connect the different systems in urban environments. The backbone of this infrastructure is an integrated IP-based network to connect systems for buildings management, transportation and traffic, TV and radio, emergency. This allows, for instance, real-time management of heating and lighting across all public buildings.

Roland Schneider (Senior Policy Advisor, Trade Union Advisory Committee to the OECD) presented the topic of **"smart" employment**. He argued that "Green ICTs" need to address employment issues. Investments in energy efficiency should also be seen in the context of creating green jobs across a range of industries. The digital road to recovery was a good start but not sufficient. Policy makers need to focus on qualifications and education. Overall, the concept of sustainability must be dealt with holistically, which includes analysing social and employment impacts. He concluded that training and education for "Green ICT" skills are key factors for green economic growth.

The **panel discussion** centred on questions around the **commitment of stakeholders to change behaviours** and expected savings through the use of "Green ICTs". Discussants underlined that rebound effects should be taken into account, especially in the fossil fuel industry where more efficient oil production due to the use of ICTs could potentially lower oil prices. Governments should focus on smart ICT investments and work towards addressing climate change jointly with societal issues. Regarding estimated savings, it is difficult to come up with concrete numbers as, especially in the field of smart electricity grids, they depend on the type of future investments.

Session 8: Governments paving the way

Chair: **Richard Beaird** *(Coordinator International Communications and Information Policy, Department of State, United States)*

The session discussed the role of the public sector in promoting ICT innovation for clean technologies and technology transfer. Main questions included: How can governments promote R&D, investments and uptake of ICT applications for sustainability, especially during the economic crisis? How can governments reduce the environmental impacts of their ICT infrastructures and provide best practices and model use? What are strategies to improve accountability and effective measurement of "Green ICT" policies? How can co-ordination within governments on "Green ICT" policies be improved?

Governments pointed to obvious **high-impact areas such as greening public sector IT infrastructures** and **improving the environmental footprint of public buildings**. Speakers underlined the importance of promoting R&D for "smart" applications. The involvement of various stakeholders was important in this process, *i.e.* government ministries and agencies, ICT and non-ICT companies, research institutes. Measurement was highlighted as a critical issue to assure accountability and success of "Green ICT" policies and programmes.

Kenichi Honda (Deputy Director Global ICT Strategy Bureau, Ministry of Internal Affairs and Communications, Japan) presented the work of **Japan's study group on "ICT policies to tackle global warming"**. The study group will develop future scenarios on the direct and enabling impacts of ICTs on CO_2 emissions and power consumption. The work emphasises the need to establish a method for evaluating CO_2 emission reduction effects. He cited ICT industry initiatives such as voluntary action plans and tax incentives introduced by the Japanese government to stimulate investments in energy-saving technologies. Honda mentioned the "Digital Japan Creation Project" as an initiative to realise wide-scale environmental benefits through the pervasive use of "Green ICTs".

Bernd-Wolfgang Weismann (Head of Division Information Society, IT-, Media-, Cultural and Creative Industries, Ministry of Economics and Technology, Germany) presented **Germany's "Action Plan Green IT"**, which is based on three pillars: *i*) developing ICT applications to harness the potential of enabling environmental impacts, *e.g.* through the E-Energy project in close co-operation with IT and energy companies; *ii*) using ICTs in an energy and resource-efficient manner with focus on data centres, green IT procurement and the provision of best practices (a recent study indicated the rising share of ICTs in national energy consumption); *iii*) promoting ICT innovation for

the environment through cross-sector business alliances and scientific networks. The Action Plan is a result of Germany's "IT-Summit", which facilitates the development of voluntary actions and networks between the national IT industry and related sectors.

Jørund Leknes (Political Advisor to Minister Røys, Ministry of Government Administration and Reform, Norway) discussed the **role of governments**. He argued that governments had reacted fast and with high budgets to the financial crisis. He asked governments to display the same kind of leadership in combating climate change, including "Green ICTs". Leknes highlighted data centres and green public procurement as high-impact areas. He underlined that ICTs could have even higher enabling effects in areas such as buildings and transportation. To go a step further, "smart" transportation could be realised through no transportation at all. Virtualisation and digitisation of government services, telework and teleconferencing should be regarded as serious means to reduce travelling. Challenges to realise this potential result from the need for open standards and operability. ICT policy instruments dealing with these issues are evidently not limited to the ICT sector, but are rather general economic policies.

Giovanni Tria (Economic Advisor to Minister Brunetta, Ministry for Public Administration and Innovation, Italy) explained the **role of the government in sustaining green innovation** and fostering the economic recovery. To this purpose, the Ministry had to co-ordinate policy initiatives throughout different government levels, to facilitate the innovation process, to promote a virtuous cycle between science and industry and to manage public funding for innovation. Tria presented the enabling effects of energy and load management technologies and building management systems as a basis for "smart" grids and buildings. Energy savings potentials through ICTs in existing public buildings stocks were high, up to 20% in schools and 25% in hospitals, but integrated approaches to energy efficiency through improved design and construction were missing. Governments could act as role models in this area, *e.g.* through demonstration projects, and should cover environmental, economic, social, and technological objectives in "Green ICT" policies.

Catalina McGregor (Government Deputy Champion Green ICT, CIO/CTO Council, Cabinet Office, United Kingdom) presented the **United Kingdom government's "Green ICT Strategy"** with its two principal initiatives: *i*) the "Green ICT Scorecard", which measures the energy consumption of ICT infrastructures, *e.g.* data centres, but also includes questions on behaviour, policies, and governance; *ii*) the "Green ICT Scoreboard", which assesses and compares the environmental footprint of the government's computing departments and highlights immediate actions that government CIOs can implement. The Strategy supports the government's targets for sustainable operations on the government estate (SOGE). McGregor mentioned challenges to implementing the strategy: answering scorecard questions can be time-consuming and sometimes requires consultation of ICT suppliers; ICT equipment shared between departments can cause problems in identifying emissions causes; CIOs are often facing long-term ICT contracts and rigid refresh cycles that make updates to more energy-efficient hardware difficult. Finally, she emphasised the necessity to take all environmental impacts during the life cycle of ICTs into account.

The **panel discussion** highlighted the **important role of governments in promoting "Green ICTs" and "smart" ICT applications**. Panellists agreed that governments should start by using green technologies within the public sector and thereby reduce the environmental footprint of administrations. Governments should act as lead users and encourage the use of "smart" ICT applications across the economy and society.

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