iisd International Institute for Sustainable Development / Institut international du développement durable

http://www.iisd.org

ICTs, Innovation and the Challenge of Climate Change

Don MacLean, Associate, International Institute for Sustainable Development
Bill St. Arnaud, Chief Research Officer, CANARIE Inc.

May 2008

Published by the International Institute for Sustainable Development

The International Institute for Sustainable Development (IISD) contributes to sustainable development by advancing policy recommendations on international trade and investment, economic policy, climate change and energy, measurement and assessment, and sustainable natural resources management. Through the Internet, we report on international negotiations and share knowledge gained through collaborative projects with global partners, resulting in more rigorous research, capacity building in developing countries and better dialogue between North and South.

IISD's vision is better living for all—sustainably. Its mission is to champion innovation, enabling societies to live sustainably. IISD is registered as a charitable organization in Canada and has 501(c)(3) status in the United States. IISD receives core operating support from the Government of Canada, provided through the Canadian International Development Agency (CIDA), the International Development Research Centre (IDRC) and Environment Canada; and from the Province of Manitoba. The Institute receives project funding from numerous governments inside and outside Canada, United Nations agencies, foundations and the private sector.

International Institute for Sustainable Development
161 Portage Avenue East, 6th Floor
Winnipeg, Manitoba
Canada R3B 0Y4
Tel: +1 204 958-7700
Fax: +1 204 958-7710

Web site: http://www.iisd.org

ICTs, Innovation and the Challenge of Climate Change

Don MacLean, Associate, International Institute for Sustainable Development
Bill St. Arnaud, Chief Research Officer, CANARIE Inc.

Authors' Note: This paper has been prepared on the invitation of Industry Canada as a voluntary contribution to the OECD Workshop on ICTs and Environmental Challenges in Copenhagen on May 22–23, 2008. It reflects the personal views of the authors, which are not necessarily those of Industry Canada, CANARIE or IISD. Background information on the proposals presented in this paper is available at http://green-broadband.blogspot.com/ and http://www.iisd.org/infosoc.

1.0 INTRODUCTION

The purpose of this paper is to provide comments and suggestions aimed at helping the OECD Working Party on the Information Economy (WPIE) develop a work program on the subject of "ICTs and the Environment" under the general theme "Impact of Networked ICTs on the Economy and Society." This is not a simple task, for the following reasons:

- *The complexity of the subject*: As demonstrated in a scoping paper prepared for the 5-6 December 2007 WPIE meeting, there are many dimensions to the relationship between ICTs and the environment. In addition, there are complex connections and trade-offs among the positive benefits, negative impacts, rebound effects and unintended consequences for the environment that flow from the development, use and disposal of ICTs throughout the economy and society.
- *The diversity of current discussion and debate:* In recent months, increasing attention has been paid to various aspects of the relationship between ICTs and the environment in a variety of international organizations, national governments, industry associations and non-governmental organizations, as well as in the technical and scientific research community. At the moment, there is no organizational focal point for this discussion and debate. Nor is there consensus on an overall policy framework for managing the relationship between ICTs and the environment.

In this situation, WPIE appears to have two general options in planning its work program. It could (1) attempt to mount a comprehensive program that would systematically address all of the issues that fall under the theme of ICTs and the environment, and thereby seek to provide an organizational and/or policy focal point for international discussion and debate; or (2) it could focus its program in areas that align with its mandate, build on its established competencies, avoid duplicating work done elsewhere and facilitate collaboration with other organizations working in this area.

We understand that at the December 2007 meeting WPIE members generally inclined to the latter view—i.e., they favoured a selective approach to designing the ICTs and environment work program—but that there was no consensus on areas of focus. In the sections that follow we propose:

- an area of focus—the relationship between ICTs, innovation, and the challenge of climate change;
- an approach to defining the scope of the WPIE work program, based on work done over the past decade to examine the relationship between ICTs, productivity and economic growth, but adapted to respond to the new issues raised by the challenge of reconciling ICT-enabled innovation and economic growth with reductions in greenhouse gas emissions and adaptation to the consequences of climate change; and
- WPIE work program topics and outputs

2.0 AREA OF FOCUS

The subject of ICTs, innovation and the environment covers a wide range of fields such as: using ICTs to improve practices in agriculture and forestry; monitoring atmospheric and water pollution;

waste management and recycling; disaster warning and relief; improving the efficiency of the energy, transportation, goods and services sectors; and ICTs as a source of toxic waste. Although these are all important areas of scientific research, standards development and public policy, **we propose that WPIE focus on a new issue that is emerging in response to what has clearly become the dominant environmental concern of our time—the relationship among ICTs, innovation and climate change.**

Years of scientific study and political debate have led to international consensus on the deleterious effects of greenhouse gases and the consequent need to radically reduce GHG emissions in developed countries in the medium- to longer-term, and to contain their growth in developing countries during this same period. In its most recent reports, the Intergovernmental Panel on Climate Change (IPCC) described the dimensions of this challenge in the following terms:

> Under most equity interpretations, developed countries as a group would need to reduce their emissions significantly by 2020 (10–40% below 1990 levels) and to still lower levels by 2050 (40–95% below 1990 levels) for low to medium stabilization levels (450–550 ppm CO_2-eq) … Under most of the regime designs considered for such stabilization levels, developing country emissions need to deviate below the projected baseline emissions within the next few decades *(high agreement, much evidence)*.[1]

The 2008 OECD Environmental Outlook to 2030 projected that, if appropriate policies were adopted by all countries, even the low stabilization target of 450 ppm CO_2-eq by 2050 could be met at a cost equivalent to a reduction in annual GDP growth of about 0.1 percentage points per annum on average. The report recognized the key role that "eco-innovation" can play in reducing GHG emissions to sustainable levels. To this end, it suggested that OECD countries should take the lead in strengthening international cooperation with a wider group of emerging economies, particularly the "BRIICS" (Brazil, Russia, India, Indonesia, China and South Africa).[2]

A number of reports have been published in recent years examining the relationship among ICTs, the environment and climate change at national and regional levels.[3] So far, however, relatively little attention has been paid in international governance institutions to the role ICT-based innovation could play in meeting the challenge of climate change or responding to other environmental issues. For example, the *2007 United Nations Global Environment Outlook* "GEO-4: Environment and Development"; the *2007/08 United Nations Human Development Report* "Fighting Climate Change: Human Solidarity in a Divided World"; the OECD's 2007 *Innovation and Growth* strategy; and the 2008 *OECD Environmental Outlook to 2030* all make only slight, passing reference to the role ICTs can play in relation to climate change and other environmental issues.

By focusing its work program on the relationship among ICTs, innovation and climate change, WPIE has an opportunity to raise awareness among global decision-makers of the role ICTs could play in responding to what is universally acknowledged as the most important environmental challenge facing the global community—and which is increasingly seen as one of its more significant economic challenges—moving to a low-carbon economy. By building on work that has already been done at national and regional levels—and by adding value based on its in-depth knowledge of the

---

[1] IPPC, 2007, p. 90

[2] OECD, 2008, Executive Summary, accessed at <http://www.oecd.org/dataoecd/29/33/40200582.pdf>

[3] See Pamlin (ed.) 2002; Forum for the Future, 2002; Willard and Halder, 2003; Erdmann et al., 2004; Pamlin and Szomolányi, 2007; Mallon et al., 2007;ITU, 2007; Global Action Plan, 2007; Forum for the Future, 2008

ICT sector and the economic and social changes associated with the use of ICTs—WPIE is ideally positioned to help catalyze cooperative international action aimed at using ICTs to help resolve the challenge of climate change.

2.1 Levels of analysis

The nature of this relationship among ICTs, innovation and climate change can be examined in terms of three distinct kinds of effects:[4]

- *First order or direct effects* that arise from the design, production, distribution, maintenance and disposal of ICT goods and services by the ICT industry. From this perspective, the impact of ICTs on climate change is related to the GHG emissions that result from the energy used to produce materials, build and operate facilities, transport goods, provide services, etc. The carbon footprint of the ICT industry is roughly proportional to its size as an economic sector. The ICT sector currently generates around 5+% of GDP in OECD countries and accounts for somewhat smaller proportions of GHG emissions, generally estimated to be in the range of 2–3%.

- *Second order or indirect effects* that arise from the application and use of ICTs throughout the economy and society, in government and public institutions, and in the research and academic communities. From this perspective, the impact of ICTs on climate change derives from the GHG emissions resulting from the energy required to power and cool ICT server, client and network devices in the myriad applications that characterize the information society. Second order impacts are significantly higher than first order impacts but much more difficult to measure at the macro level. One recent report estimated that indirect effects might account for 80% of ICT-generated GHG emissions.[5] Micro-level estimates can be helpful in visualizing the scope of the problem—e.g., the estimates that a medium-sized server has roughly the same annual carbon footprint as an SUV doing 15 mpg, or that depending on the initial data, a single Google search uses as much power as an energy-efficient 11-watt light bulb in 15 minutes to one hour.[6]

- *Third order or systemic effects* that arise from changes in economic and social structures and behaviour enabled by the availability, accessibility, application and use of ICT goods and services. These ICT-enabled changes affect economic and social parameters such as: the attitudes, expectations and behaviour of individuals as consumers, citizens and members of communities; the demand and supply of goods and services; organizational structures; production, distribution and service processes; and governance in the private and public sectors. From this perspective, the large-scale economic and social choices made by individuals, organizations and communities about how to use ICTs to change their structures and behaviours will play a potentially significant role in determining whether there is a successful global response to the challenge of climate change.

To date, much of the work that has been done on the relationship among ICTs, innovation and climate change has been focused on first- and second-order effects, which are relatively easy to

---

[4] The Forum for the Future proposed an analytic framework based on a distinction between the first-, second- and third-order effects of ICTs in "The Impact of ICT on Sustainable Development," EITO 2002. This framework has been adopted and applied in a number of the reports referenced in this paper.

[5] Madden and Weissbrod, 2008, p.7

[6] GAP, 2007, p. 4; <http://www.spiegel.de/international/business/0,1518,544053,00.html>

model and analyze. Studies on the overall relationship between ICTs, the environment and climate change have generally shown that most positive effects of ICTs in reducing GHG emissions are likely to result from: a reduction in the carbon footprint of the ICT industry itself; the use of ICTs to increase the efficiency and flexibility of energy production, distribution and consumption; the use of ICTs to increase the efficiency of production processes and facilities management; and "dematerialization"—the substitution of virtual products and services for their physical equivalents.[7]

Some recent studies have estimated that potentially significant reductions in GHG could result from the use of ICTs to improve the efficiency of transportation systems, and from the substitution of e-commerce and tele-work for their physical equivalents. However, other studies have suggested that the effect of ICTs on GHG emissions in these areas is likely to be minor in the absence of measures to alter demand. This is because of the central role the movement of physical goods and people plays in the economy and society, and the rebound effects likely to be triggered by factors such as increased demand resulting from lower prices, re-materialization and the substitution of private for public transportation.[8]

To fully assess the potential role of ICTs in supporting the achievement of medium- to long-term targets for GHG emission reduction (e.g., the target of 450 ppm CO_2-eq by 2050), we believe it is necessary to come to grips with third-order effects by systematically identifying the kinds of changes in individual behaviour, economic and social structures, and governance processes that would be needed to meet these targets; identifying the main policy issues associated with these changes; and assessing different options for responding to these issues, with a focus on the role of ICT-enabled innovation.

Coming to grips with third-order effects is a complex task. Clearly, there are linkages among actions taken to reduce the GHG emissions of the ICT sector; actions taken to reduce GHG emissions resulting from the application and use of ICT goods and services throughout the economy and society; resulting changes in the structure of economic and social activity; and global performance in terms of GHG emissions. However research and experience suggest that this relationship is unlikely to be linear; that the impact of ICTs is likely to be positive in some areas and negative in others; that its overall impact is not necessarily significant under current economic and social structures; and that alternative global governance options could significantly affect ICT impacts—for better or for worse—going forward. These were among the findings of a 2004 study done for the Joint Research Centre of the European Commission that used sophisticated modelling techniques to analyze the potential impact of ICTs on GHG emissions and other key environmental indicators to 2020. On the basis of their research, the study's authors concluded that:

> Political decisions made with regard to ICT or sustainable development (hopefully taking into account the interactions between the two fields) must be based on prospective analysis of the positive and negative effects of ICT. Such an analysis would be almost useless if it ignored the dynamics both of the development of ICT and of its impacts on the socio-economic system and its interactions with the environment.[9]

These findings confirm that, rather than being a relatively simple and straightforward matter of increased energy efficiency and a reduced carbon footprint in the ICT sector translating into

---

[7] See for example Erdmann et al., 2006; Mallon et al. 2007; Pamlin and Szomolányi, 2007; Global Action Plan, 2007: Neves, 2008

[8] See for example Pamlin (ed.), 2002; Willard and Halder, 2003; Erdmann et al., 2004; Forum for the Future, 2008

[9] Hilty et al., 2006, p. 1618

increased energy efficiency and a reduced carbon footprint throughout the economy and society—as a result of tele-work, e-commerce, and the many other tele- and e-substitution effects that have been mooted—the relationship between first-, second- and third-order effects is actually rather complex. Under current economic and social structures, it is filled with rebound effects and unintended consequences, and can look very different if full cost ("green") accounting and full life-cycle approaches are taken to analyzing the environmental benefits and costs of ICT production, application and use.

The opportunity and the challenge facing WPIE is to consolidate our current understanding of the first- and second-order effects of ICTs as a basis for undertaking the much more difficult task of exploring the relationship among ICTs, innovation and climate change in the future context of the information economy.

To come to grips with third-order effects, it is first necessary to confront a policy paradox.

2.2 The Khazzoom-Brookes Postulate

It is widely assumed that increased energy efficiency will result in reduced GHG emissions. In the case of the ICT sector, increased energy efficiency can result directly from the improved efficiency of ICT equipment itself, or indirectly in the application and use of ICTs in smart meters, congestion control systems, and other innovative products and services. However, these increased efficiencies will not necessarily translate into reduced GHG emissions because of a phenomenon known as the Khazzoom-Brookes Postulate, sometimes also referred to as the Jevons Paradox.[10] CIBC World Markets Inc. economist Jeff Rubin, in a recent report,[11] describes this as an "efficiency paradox" in which technology improvements allow for better energy efficiency, but those savings are lost to greater consumption.... "Improvements in efficiency have done little to reduce actual energy consumption, as consumers take advantage of those gains to drive bigger cars farther, or heat larger homes."

As a consequence, increased energy efficiency using ICTs or improving the efficiency of ICT equipment directly, paradoxically, may result in greater GHG emissions—not less. There has been considerable discussion among experts, in the context of the global supply chains that are a feature of the Internet economy, about using ICTs to improve the efficiency of these supply chains, from manufacturing, through shipping to final distribution and consumption. But if the Khazzoom-Brookes Postulate is correct, this increased energy efficiency may result in overall reduced costs, resulting in increased demand and therefore an overall increase in energy consumption and concomitant GHG emissions. To cite another example, it is by no means certain that tele-work and e-commerce will necessarily lead to reduced GHG emissions, as is often assumed, if they result in the substitution of more trips by private automobile or courier truck for fewer trips by public transportation.

Any strategy aimed at using ICTs to reduce GHG emissions and combat climate change must undertake a systematic analysis of the kinds of economic relationships and social behaviours that are enabled by the Internet economy, and not assume that individual energy savings of either ICT equipment or processes will necessarily result in overall global reduction in energy or GHG emissions. Energy efficiency of individual pieces of equipment may be the wrong focus from a public policy viewpoint, if it results in lower costs to the consumer that enable or incentivize

[10] See <http://en.wikipedia.org/wiki/Jevons_paradox>

[11] "Dim prospects that 'energy efficient' will pay off: CIBC," *The Globe and Mail,* 27 November 2007.

increased consumption and consequent increased GHG emissions overall. Current policy tools such as carbon taxes and carbon offsets that do not impose absolute targets for GHG emissions should be reviewed in light of this postulate, and any new policies that aim to encourage or require the use of ICTs to mitigate climate change should be analyzed carefully in terms of their ability to absolutely reduce GHG emissions on a global basis, not merely to slow down their rate of increase.

Inevitably, this analysis must look beyond the energy consumed and the GHGs emitted in the manufacture, distribution and use of the equipment, services and applications produced by the ICT sector. It must also take account of the energy consumption, GHG emissions and other environmental externalities associated with the patterns of economic and social activity enabled by ICTs and incentivized not only by prices, but by other factors as well. We postulate that the policy tools needed to resolve the Jevons Paradox are likely to be found in this broader analysis of the relationship among ICTs, innovation and GHG emissions. At the end of the day, policy-makers will need to discover what it will take to get producers and consumers to use ICTs in a manner that supports reductions in GHG emissions to levels that are economically, environmentally and socially sustainable. This is a complex challenge for which there is unlikely to be a simple "magic bullet" solution. **To respond successfully to the challenge of reducing GHG emissions, innovation is needed throughout the Internet economy—i.e., in technology, in products, services and applications, in economic and social structures and behaviours, and in governance processes.**

3.0 SCOPE OF WORK

In addition to the inherent importance of examining the direct, indirect and systemic contributions networked ICTs can make to mitigating GHG emissions, there are a number of other reasons we think the relationship between ICTs and climate change is the appropriate focus for the WPIE work plan on ICTs and the environment. These reasons in turn speak to the scope of the work program needed to successfully address this issue, not just as a matter of ICT sector policy, but as a broader question of innovation and sustainable growth policy.

3.1 Recognizing the complex, multi-dimensional nature of the policy challenge

Climate change is an overarching issue, with strong links to other key environmental policy issues related to energy, land use, the conservation and management of water, wildlife and other natural resources, human settlement patterns, and disaster prevention and relief. As such, policies aimed at maximizing the benefits of ICTs and minimizing their negative impacts could have powerful "policy multiplier effects" in these other fields, yielding a potentially significant return on the investment of policy resources in this area. However, achieving these returns is far from a simple matter.

As well as being overarching, climate change is a multi-dimensional issue that affects all parts of the economy and society. Successfully addressing the challenge of climate change, through the development and application of ICTs and by other means, will likely require changes in producer and consumer behaviour, as well as in the structure of economic and social activity. Making these changes will in turn likely require:

- coordinated policy responses in a number of different areas;
- deployment of a range of policy tools that are likely to include both incentives and prohibitions offered and enforced through a mixture of regulation, co-regulation and self-regulation;

- top-down and bottom-up approaches to policy development and implementation;
- governance arrangements that engage all stakeholders, including end-users, in their roles as citizens and consumers; and
- models that reflect the relationship among key variables and indicators that measure progress and support the analysis of policy options.

Because of its multi-dimensional nature, the policy challenges involved in responding to climate change are similar in scope and structure to the general policy challenge of promoting innovation and growth.[12]

3.2 Learning from previous policy experience

Coming to grips with such a high-leverage, complex policy challenge is clearly a daunting task. However, it is not the first such task that has faced ICT policy-makers. The work ICCP and WPIE have done over the past five–ten years to examine the relationship between ICTs and the economy provides a "policy template" that can be adapted and applied over the next five–ten years to examine the relationship among ICTs, economic growth, social development and the environment, with an initial focus on climate change. We suggest this is the case for the following reasons:

- As is the case today with respect to the relationship between ICTs and climate change, a decade ago a high-profile, overarching issue with wide-ranging economic and social ramifications helped concentrate policy-makers' minds and focus their work. This issue was the relationship between ICT investments and productivity. It became particularly acute after the collapse of the dot.com bubble, the general economic downturn that followed, and the changes to the structure of the global economy that became increasingly visible through the development of global supply chains for consumer goods and services.
- As is also the case today, the essential policy challenge involved in analyzing this relationship and formulating policy recommendations was encapsulated in a paradox—the so-called Solow Paradox expressed in the observation that "You can see the computer age everywhere these days, except in the productivity statistics."[13] Resolving this paradox was seen as a high-leverage policy challenge that was linked to, and would help address, other key economic and social policy issues, such as increasing innovation, enhancing competitiveness, and improving the efficiency and quality of public services.
- Examination of the Solow Paradox led policy-makers to the realization that the productivity gains and associated benefits stemming from investments in ICTs—whether in the public or private sectors, whether in a single organization or across a sector, whether for suppliers or consumers of goods and services, whether on a national or global basis—depended on network effects (e.g., "Metcalfe's Law"—the externalities arising from connecting network nodes and users), as well as on complementary investments in organizational change, process re-structuring, skills development, and the creation of an enabling environment that would support innovation and encourage producers, consumers and investors to change the way things were done.

In many respects, policy-makers face a similar, multi-faceted challenge today in seeking to develop

[12] See OECD 2007a

[13] See <http://en.wikipedia.org/wiki/Productivity_paradox>

policies that will maximize the benefits of investments in ICTs in ways that reconcile continuing economic growth with climate change mitigation and adaptation to climate change, on an economy- and society-wide basis. **As in the case of the Solow Paradox, resolving the Jevons Paradox is likely to require new models and indicators, coordinated policy responses, a range of policy tools, and innovative organizational and governance processes that seek maximum advantage from innovative network effects in economic, social and governance processes**.

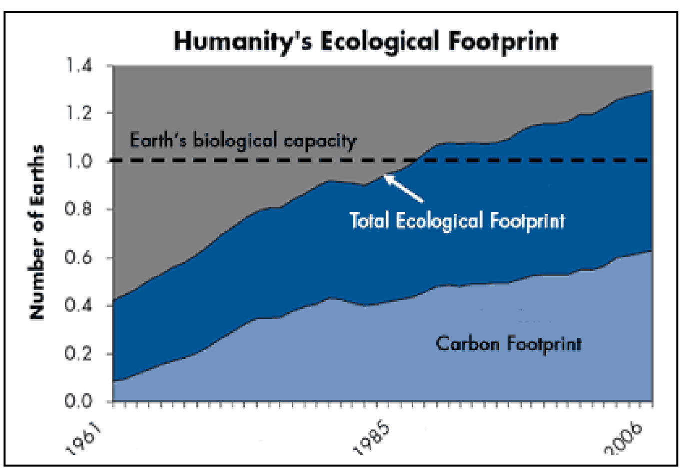
3.3 Learning to work within the limitations of the physical environment

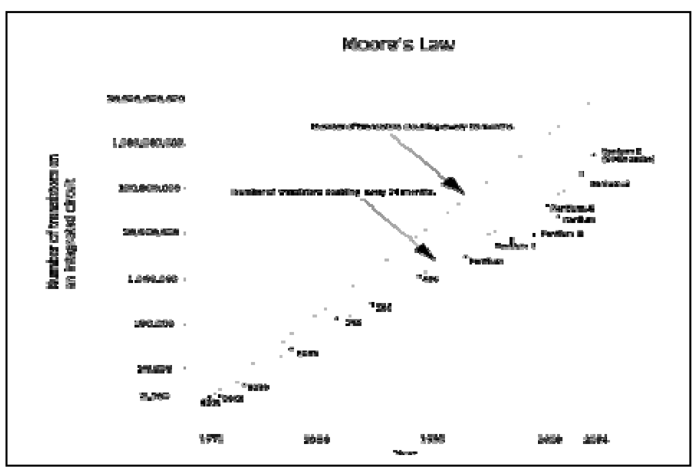
The mandate of WPIE emphasizes the need to look beyond the confines of the ICT sector in order to analyze the impacts of ICT development, diffusion, application and use in all economic and social sectors. This mandate appears to call for a similarly broad-based approach to analyzing the general relationship between ICTs and the environment, and the specific relationship between ICTs and climate change. However, this does not mean that the WPIE work program should simply replicate what has been done in the past. Although the productivity and climate change challenges are similar, we believe there are significant differences between them that require re-conceptualization of key issues, principles and methodologies.

At base, these requirements stem from differences between the task of formulating policy in an area that has relatively few physical limitations in principle or in practice—the development, application, diffusion and use of ICTs across the economy and society—as against the task of formulating policy which seeks to encourage economic development that respects agreed upon ecological parameters, such as reducing GHG emissions so that they do not exceed 450–550 ppm CO_2-eq (the limits necessary to avoid the potentially disastrous environmental, economic and social consequences that would result from climate change if those levels were exceeded).

One way to get a sense of these differences is to compare and contrast two iconic images of the fundamental forces that are driving the ICT sector on the one hand and the sustainable development community on the other hand—the graphic representations of Moore's Law and the Ecological Footprint presented in the accompanying boxes.

Moore's Law is based on the observation that the processing power of computer chips grows at an exponential rate, doubling every 18–24 months. This observation was originally made in 1965, has continued to hold for the past 40 years, and is projected to continue for some time into the future. Similar growth curves have characterized other foundational technologies in the ICT sector. The exponential increase of ICT processing power and communications capacity in relation to price has contributed to a world view that ICTs can "fix" any economic, social, or environmental problem, and that "sustainable development equals e-everything."[14] The Ecological Footprint, on the other hand, represents a very different world view, in which the earth's biological capacity to support its human population on a sustainable basis was exceeded two decades ago, and in which humanity's biological deficit continues to increase, to a significant extent because of our carbon footprint.





These two different world views are not necessarily incompatible. Changes to economic and social structures and behaviours enabled by ICTs may well have the potential to help move the world into a situation of greater biological balance by reducing our carbon footprint and through other means. However, the question of how to do this has not yet been fully and systematically explored by either sustainable development or ICT policy-makers.

The experience of the past decade has shown that coordinated policies, which reduce obstacles to ICT development, diffusion and application, increase competition in the supply of ICT goods and services, and enable or incentivize ICT use, tend to maximize economic and social benefits and minimize risks—if environmental impacts are left out of the equation. The experience also suggests that these policies may have had limited, locally beneficial environmental consequences in that they appear to have been associated with a slowing down in the growth rate of GHG emissions in at least some OECD countries. However, from a global perspective, it appears that the effect of these policies may have been neutral at best and possibly negative, because of the role they have played in enabling rapid economic development, with attendant increases in GHG emissions, in countries such as China and India.

From the point of view of long-term economic, environmental and social sustainability, there does not appear to be a "unseen hand" at work that is translating the very significant benefits that have resulted from the development, diffusion, application and use of ICTs in all economic and social sectors into equally significant environmental benefits. If anything, the Khazzoom-Brookes postulate suggests that the unseen hand may be working in the opposite direction.

A recent report, which contains a comparative analysis of governance approaches in the Internet/ICT and sustainable development communities, suggests that when policy-makers are dealing with challenges related to the preservation and use of limited environmental resources (such as a climate suitable for long-term human well-being), they are likely to rely on a different mix of tools to achieve their policy objectives than when they are dealing with challenges related to the growth of an expanding, potentially unlimited resource (such as ICTs and the creative activity they enable).[15]

In the case of the challenges related to climate change, on the basis of past practice (e.g., the UN Framework Convention on Climate Change, the Kyoto Protocol) and current international discussions aimed at concluding a post-Kyoto agreement, it seems reasonable to assume that the general policy context in which future ICT policy will be framed—as well as the specific policies governing the conduct of investors, producers and consumers in relation to GHG emission reduction—are likely to differ significantly from the framework policies that have provided the context for ICT policy in OECD countries in the past couple of decades.

Specifically, it seems reasonable to assume that if climate change has indeed brought the world to a tipping point, these framework policies are likely shift the balance that currently exists between market-driven development and sustainable development; between self-regulation and public oversight; between incentives and prohibitions; and between bottom-up and top-down approaches to governing change. This may come about as the result of global crisis and a top-down policy revolution, marked by the kinds of upheavals that gave rise to the "Washington Consensus" more than a decade ago. Or it may come about as the result of an evolutionary, bottom-up process.[16]

[15] MacLean, D., Vetter, T., Andjelkovic, M., 2007

[16] See "Shell Energy Scenarios to 2050" for an analysis of how these different kinds of governance scenarios might play out. Accessed at<http://www.shell.com/static/aboutshell-en/downloads/our_strategy/shell_global_scenarios/shell_energy_scenarios_2050.pdf>

However it comes about, it is likely to result in a perceptible shift in the policy environment, consistent with and in some ways reinforcing the impacts that have already been felt because of rising concerns about national, public and personal security—impacts that have begun to re-shape policy in a number of areas, including ICTs.[17]

The policies that have been developed to limit GHG emissions in recent years and much of the public discussion and debate that has surrounded the issue of climate change appear to confirm this hypothesis. The main emphasis has been on setting emission reduction targets through binding international agreements, and on the development of cap-and-trade systems, carbon taxes, vehicle emission standards, etc. as a way of moving toward these targets. While there has also been emphasis on innovation, (e.g., in the development of alternative, non-carbon energy sources and carbon sequestration techniques), and on consumer incentives (e.g., tax rebates for more fuel efficient cars, congestion charges to encourage the use of public transportation), these more market-based, bottom-up approaches have largely been framed within the context of the currently dominant top-down paradigm for responding to the challenge of climate change—a paradigm that appears unlikely to shift in the short- to medium-term.

In thinking through the policy challenges arising from the positive and negative relationships between ICTs and the environment, ICT policy-makers therefore likely will have to re-position themselves conceptually in a policy space that is less open and more bounded than the policy space that has both nurtured and been nurtured by ICT policy in the past decade or so. In this situation, it will be necessary to re-think ICT policy so that it works in a world characterized, in the words of the Brundtland Commission report, by "limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."

As they make this shift, the key challenge facing ICT policy-makers will be to maintain the momentum that has been developed over the past decade towards open systems that enable peer-to-peer communications, encourage innovation at the edges, and incent changes in the behaviour of producers and consumers. As a result of the work it has done during this period, particularly its recent work in preparation for the May 2008 Ministerial Conference on the Future of the Internet Economy, WPIE appears to be ideally positioned to examine the relationship between ICTs and climate change from this perspective.

4.0 WORK PROGRAM TOPICS AND OUTPUTS

What are some of the specific topics that could form part of a WPIE work program with the focus and scope proposed in the preceding sections? What outputs could result? The following suggestions are not intended to be exhaustive, but simply to contribute some specific work program proposals to the discussions that will take place at the May 22-23 WPIE Experts' Meeting on ICTs and environmental challenges.

4.1. Developing models and metrics

If WPIE agrees to focus its work on ICTs and the environment on the subject of climate change and to adopt a comprehensive approach of the kind we have proposed to addressing the problem, it will be entering largely unexplored territory. Although the ICT policy community has done a lot of work in the past couple of decades on the relationship between ICTs, economic growth and social

[17] See Raskin et al., 2002; SIL, 2005; and UNEP, 2007 for scenarios that model the potential impact on global governance of security concerns.

development, in general this work has either not included issues of environmental sustainability such as climate change, or not approached them with the same kind of rigour that has been applied to the analysis of economic and social issues. A recent example of this gap is the paper on "Measuring the Impacts of ICT Using Official Statistics" published by the Working Party on Indicators for the Information Society, which notes in its introduction that "while it is not covered in this paper, the environment is also affected by ICT, with direct environmental impacts arising from events such as poor disposal of PCs and the role of ICT in modelling climate change."[18]

Nor it should be noted has any greater progress been made in the sustainable development policy community, which has devoted a huge amount of effort over the past three or four decades to modelling and measuring the impact of economic and social activities on the environment, but has not yet come to grips with the full impacts of ICTs. As noted by a leading figure from the sustainable development policy community in a recent report, ICTs promise "enormous advances for sustainability, for tracking of trade-related E&SD, for accountability (e.g., for carbon credits) and for dealing with many biodiversity, pollution and other transboundary and global environmental matters. Likely the whole field of environmental and resource management will be transformed in the coming 20 years, but most intergovernmental and national agencies are poorly prepared, in both rich and poor countries."[19]

In this "greenfields" situation, WPIE faces an opportunity and a challenge—to take the lead in developing models and devising metrics that will give ICT policy-makers and their sustainable development counterparts, for the first time, a solid basis for understanding and analyzing the key relationships among ICT inputs; economic, social, and governance throughputs; and environmental outputs.

If WPIE decided to take on this task, it might consider structuring the project in two phases, so that it comprised an initial retrospective phase that would develop baseline models and metrics and apply them to analyze the impact of ICTs on climate change in the past couple of decades, in the context of the rise of the Internet economy. This could then be succeeded by a prospective phase that would aim to "think outside the box" by using these models and metrics to forecast the potential impact of ICTs on climate change over the next couple of decades, under different governance scenarios.

The retrospective phase could involve a mixture of macro and micro approaches to analysis, as suggested in the WPIE scoping paper on "ICTs and Environmental Challenges." For the prospective phase, consideration could be given to adopting and adapting the scenario-building and futures forecasting techniques that have been developed by the sustainable development policy community in order to move beyond the linear-projection, "ICTs can fix everything" approach to futures forecasting that has tended to typify the work of the ICT policy community, in favour of an approach that would more rigorously and systematically analyze the positive and negative impacts of ICTs on the environment, identify rebound effects and trade-offs, and anticipate the kinds of unintended consequences that often give rise to the most interesting policy challenges.[20]

4.2. Examining innovative opportunities for using ICTs to reduce climate change

To date, most approaches for using ICTs to reduce GHG emissions have focused on a "sackcloth

---

[18] See <http://www.oecd.org/dataoecd/43/25/39869939.pdf>

[19] Hanson, A. *Global Governance for Environment and Sustainable Development*. Winnipeg, IISD, 2007, p. 20. Available at <http://www.iisd.org/pdf/2007/igsd_global_gov.pdf>

[20] See Raskin et al., 2002; Erdmann et al. 2004; UNEP, 2007; and Shell, 2008 for examples of the use of scenario-building methodologies.

and ashes" approach to reducing energy consumption, or on encouraging emission-abatement techniques such as tele-commuting, tele-presence, etc. Various industry consortia and government programs have been set up to promote innovation in these areas. The difficulty with this approach is that there is very little incentive to induce a consumer or business to adopt innovative solutions, other than moral suasion.

While it has its place, moral suasion is not a sustainable solution to the challenge of climate change in the long term. The direct energy savings resulting from more energy efficient ICT equipment, or from abatement practices such as tele-commuting and tele-presence, are very small for a given business or consumer and are often outweighed by other factors such as convenience and financial costs. More importantly, as previously discussed any energy savings or carbon neutral plan may be undermined by the Khazzoom-Brookes postulate. Therefore greater incentives (or disincentives) are required, other than the direct energy savings, to encourage businesses and consumers to adopt practices that reduce GHG emissions.

Given the need for incentives, WPIE might wish to examine what kind of "eco-system" policy-makers can implement to encourage innovation and create economic opportunities for businesses and consumers to use ICTs to reduce climate change. To address this issue, it may be easiest to look at the ICT innovation landscape for creating economic opportunities from two broad perspectives:

- eliminating the direct carbon footprint of the ICT industry itself; and
- using ICT reward mechanisms to encourage businesses and consumers to adopt practices that reduce GHG emissions.

Finding innovative solutions that provide economic rewards, other than direct energy savings, will be necessary in both areas. In fact, innovation in current ICT business models and economics will probably be the most important first step. This in turn will hopefully lead to a virtuous feedback loop of innovation within the ICT sector to further enhance GHG emission reductions. Governments and policy-makers can play a critical role in this process by facilitating and creating economic environments that encourage these types of innovations.

4.2.1. Eliminating the carbon footprint of the ICT industry

The most obvious opportunity is first to tackle the carbon footprint of the ICT industry. Current attempts are largely focused on increasing the energy efficiency of ICT devices, components and systems. But as discussed above, this is likely to result in a mixed blessing at best, due to the Khazzoom-Brookes postulate. A "zero-carbon" strategy is essential. Thankfully new technology trends in the ICT industry such as clouds and grids using Web 2.0 technologies, Service Oriented Architecture (SOA) and virtualization, combined with zero-carbon data centres co-located with renewable energy sources and linked by optical networks, are enabling the possibility of the ICT industry adopting a zero-carbon strategy.

While these enabling developments have the potential to address the supply side of GHG emissions for the ICT industry, they are unlikely to address the consumer side. Currently it is estimated that consumer technology—including PCs, cell phones, printers, etc. —produce 40% of the ICT sector's GHG emissions. However, with the advent of clouds and Web 2.0, many consumer applications are becoming virtualized, so much that smaller, more energy efficient devices (such as the Apple iTouch or the RIM Blackberry) may become the predominant tools for accessing the Internet and other applications. It is quite conceivable that these new interface devices can be solar powered or use human body movement for their energy sources.

In sum, a very exciting confluence of technologies and circumstances holds the promise of linking development of the next generation Internet with innovative economic opportunities that will help address the challenge of climate change by substantially reducing and possibly eliminating GHG emissions resulting from the production and use of ICTs. Up to now, research into next-generation Internet has focused on such issues as issues of scalability, reliability, security and so forth. If a broader view was taken, which linked the future of the Internet with the biggest environmental challenge of our lifetime, a creative explosion of new ideas and concepts of how the ICT industry could more effectively mitigate GHG emissions might well result. Research has only just begun to explore the possibilities of this linkage, which will likely create many opportunities for innovation and consequent economic development. WPIE could play a leadership role in examining the policy issues related to these developments and identify the options that are likely to create the greatest benefits in the shortest possible time.

4.2.2. Using ICTs as a reward mechanism for consumers to reduce GHG emissions

Reducing or eliminating the ICT industry's direct GHG emissions through zero carbon data centers and new network and distributed computing architectures is most likely the "low hanging fruit" of an ICT strategy aimed at mitigating climate change. The much bigger challenge is how to use ICT technology to induce businesses and consumers to reduce the carbon footprint that results from their daily activities, such as building heating or cooling and transportation.

According to a recent report of the Confederation of British Industry (CBI),[21] consumers control or influence 60% of all GHG emissions, of which 35% are under direct consumer control through their own consumption and use, and 25% through consumer-influenced sectors such as food and drink, entertainment, etc. As such, finding ways to encourage consumer to reduce their carbon footprint will have a dramatic impact on overall global GHG emissions.

Past attempts at such a strategy have focused on efforts like tele-commuting or tele-presence. Although these continue to be worthwhile initiatives, they lack widespread consumer appeal due to externalities such as basic inconvenience, insufficient broadband bandwidth, and lack of incentive to adopt what is at present an inferior technique of interacting with colleagues and friends. Making a difference to GHG emissions by changing consumer behaviour is likely to require a different approach.

One of the outstanding successes of the Internet economy over the past decade has been the growth in consumer-oriented electronic products and services such as music, film, advertising, photography online searches and so on. Many business processes are also moving to the Internet through such applications as Service Oriented Architecture (SOA) and Web 2.0 applications. The portion of the economy dedicated to e-products and services is expected to grow significantly over the coming years. Therefore it is postulated that one area of possible innovation and economic opportunity is to see if new applications and services can be developed to encourage consumers to reduce their carbon footprints by trading activities, products and services that result in GHG emissions for Internet and ICT-based activities, products and services that do not.

There are a number of different ways markets could be created that would allow consumers to trade reductions in their GHG emissions for "bits and bandwidth." For example, companies like Google, Yahoo, Microsoft, Amazon and eBay, with their close consumer relationships, could possibly have a significant impact on CO_2 emissions by partnering with energy companies to develop bundling strategies that would encourage individual consumers to reduce their carbon footprint in exchange

[21] CBI, 2007

for access to e-products and e-services for free, or at preferential prices. This is not "pie in the sky" thinking but a common marketing tool that already exists with resale gas and electric companies. Surprisingly the concept has not been taken up or implemented by the Internet industry.

This is but one example of the kinds of innovative, incentive-based approaches to changing consumer and business behaviour, in response to the global imperative of reducing GHG emissions, which are enabled by the rise of the Internet economy. As such, this line of inquiry seems a natural extension of the work WPIE has been doing in recent years.

REFERENCES

CBI – Confederation of British Industries, 2007. *Climate change; Everyone's business*. Report of the CBI Climate Change Task Force. Accessed at <http://www.atvclient.co.uk/climatereport/>

EITO – European Information Technology Observatory, 2002. "The Impact of ICT on Sustainable Development", *EITO 2002*. European Economic Interest Grouping, Frankfurt am Main, pp. 250-283. Accessed at <http://www.digital-eu.org/uploadstore/eito_forum_2002.pdf>

Erdmann, Lorenz, Lorenz Hilty, James Goodman, Peter Arnfalk, 2004. *The Future Impact of ICTs on Environmental Sustainability*. European Commission Joint Research Centre, Institute for Prospective Technological Studies (IPTS), Sevilla, August 2004. Accessed at <http://ftp.jrc.es/eur21384en.pdf>

GAP – Global Action Plan, 2007. *An Inefficient Truth*. Global Action Plan, London, December 2007. Accessed at <http://www.globalactionplan.org.uk/upload/resource/Full-report.pdf>

Hanson, Arthur, 2007. *Global Governance for Environment and Sustainable Development*. IISD, Winnipeg, 2007, p. 20. Accessed at <http://www.iisd.org/pdf/2007/igsd_global_gov.pdf>

Hilty, Lorenz M., Peter Arnfalk, Lorenz Erdmann, James Goodman, Martin Lehmann, Patrick A. Wäger, 2006. "The Relevance of Information and Communication Technologies for Environmental Sustainability – A Prospective Simulation Study". *Environmental Modelling & Software* 21 (2006) 1618-1629

IPCC – Intergovernmental Panel on Climate Change, 2007. *Climate Change 2007: Mitigation*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Accessed at <http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-ts.pdf>

ITU – International Telecommunication Union, 2007. *ICTs and Climate Change*. ITU Background Report, ITU Symposia on ICTs and Climate Change, 2008. Accessed at <http://www.itu.int/ITU-T/worksem/climatechange/>

MacLean, Don, Maja Andjelkovic, Tony Vetter, 2007. *Internet Governance and Sustainable Development; Towards a Common Agenda*. IISD, Winnipeg, 2007 <http://www.iisd.org/pdf/2007/igsd_common_agenda.pdf>

Madden, Peter and Ilka Weissbrod, 2008. *Connected: ICT and Sustainable Development*. Forum for the Future, London, April 2008. Accessed at <http://www.forumforthefuture.org.uk/files/Connected.pdf>

Mallon, Karl, Gareth Johnston, Donovan Burton, Jeremy Cavanagh, 2007. *Towards a High-Bandwidth, Low-Carbon Future: Telecommunications-Based Opportunities to Reduce Greenhouse Gas Emissions*. Climate Risk Pty, Australia. Accessed at <http://www.climaterisk.com.au/wp-content/uploads/2007/CR_Telstra_ClimateReport.pdf>

Neves, Luis, 2008. "Climate Change: ICTs to the Rescue?". ITU/MIC Symposium on ICTs and Climate Change, Kyoto, 15-16 April 2008. Accessed at <http://www.itu.int/dms_pub/itu-t/oth/06/0F/T060F0060080003PDFE.pdf>

OECD – Organisation for Economic Co-operation and Development, 2007a. *Innovation and Growth: Rationale for an Innovation Strategy*. OECD Accessed at <http://www.oecd.org/dataoecd/2/31/39374789.pdf>

OECD, 2007b. *ICTs and Environmental Challenges: Scoping Outline.* OECD Directorate for Science, Technology and Industry (DTI), Committee for Information, Computer and Communications Policy (ICCP), Working Party on the Information Economy (WPIE), November, 2007

OECD, 2008. *Environmental Outlook to 2030: Summary in English* OECD, Paris, 2008. Accessed at <http://www.oecd.org/dataoecd/29/33/40200582.pdf>

Pamlin, Dennis (ed.). *Sustainability@the speed of light*. WWF Sweden, 2002. Accessed at <http://assets.panda.org/downloads/wwf_ic_1.pdf>

Pamlin, Dennis and Szomolányi, Katalin, 2007. *Saving the climate @the speed of light*. ETNO and WWF, 2007. Accessed at <http://www.etno.be/Portals/34/ETNO%20Documents/Sustainability/Climate%20Change%20Road%20Map.pdf>

Raskin, Paul, Tariq Banuri, Gilberto Gallopín, Pablo Gutman, Al Hammond, Robert Kates, Robert Swart, 2002. *Great Transition: The Promise and Lure of the Times Ahead*. Stockholm Environment Institute, Boston, 2002. Accessed at <http://www.tellus.org/Documents/Great_Transitions.pdf>

SIL – Shell International Limited, 2005. *The Shell Global Scenarios to 2025*. Accessed at <http://www.shell.com/static/aboutshell-en/downloads/our_strategy/shell_global_scenarios/exsum_23052005.pdf>

SIBV – Shell International BV, 2008. *Shell Energy Scenarios to 2050*. Accessed at <http://www.shell.com/static/aboutshell-en/downloads/our_strategy/shell_global_scenarios/shell_energy_scenarios_2050.pdf>

UNDP – United Nations Development Program, 2007. *Fighting Climate Change: Human Solidarity in a Divided World*. Human Development Report 2007/08. Palgrave Macmillan, Basingstoke, Hampshire and New York, 2007. Accessed at <http://hdr.undp.org/en/media/hdr_20072008_en_complete.pdf>

UNEP –United Nations Environment Program, 2007. *GEO-4: Environment and Development*. Global Environment Outlook. Accessed at <http://www.unep.org/geo/geo4/report/GEO-4_Report_Full_en.pdf>

Willard, Terri and Halder, Michael, 2003. *The Information Society and Sustainable Development: Exploring the Linkages*. IISD, Winnipeg, 2003. Accessed at <http://www.iisd.org/pdf/2003/networks_sd_exploring_linkages.pdf>