International Telecommunication Union

eEnvironment

ITU e-Environment Toolkit and the e-Environment Readiness Index (EERI)

International Telecommunication Union

http://www.itu.int/ITU-D/cyb/app/e-env.html

I N T E R N A T I O N A L   T E L E C O M M U N I C A T I O N   U N I O N

INTERNATIONAL TELECOMMUNICATION UNION e-ENVIRONMENT TOOLKIT AND READINESS INDEX (EERI)

Acknowledgements

The *ITU's e-Environment Toolkit and Readiness Index (EERI)*, was prepared by Richard Labelle, in collaboration with Ralph Rodschat (Nortel), under the direction of Lilia Pérez-Chavolla and Marco Obiso, ICT Applications and Cybersecurity Division, and the overall direction of Mario Maniewicz, Chief, Policies and Strategies, Telecommunication Development Bureau (BDT).

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1 ABOUT THIS e-ENVIRONMENT TOOLKIT AND READINESS INDEX

The objective of the e-Environment Toolkit is to help countries, jurisdictions, communities and organizations, particularly those in the developing world, assess the contribution that information and communication technologies (ICTs) can make to reduce energy consumption and greenhouse gas (GHG) emissions, as part of a national climate change strategy and action plan. The e-Environment Toolkit proposes an approach and some tools for this purpose.

On the one hand, the Toolkit considers the readiness of countries and jurisdictions to use ICTs for mitigating and adjusting to the impacts of climate change. This readiness assessment is based on the use of indicators. Indicators of the readiness of countries are captured using the e-Environment Readiness Index (EERI). Readiness of jurisdictions, communities, regions of a country, organizations and other than country scale entities have to be calculated to derive an equivalent EERI. A more detailed list of indicators is also proposed for more detailed research on readiness for measuring the potential for using ICTs in a development context.

The Toolkit also proposes measuring the impact that ICTs can have on the energy and carbon balances of countries and of other entities, such as those above, as described for the EERI. This is a significant task in of itself, for which appropriate methodologies and standards are still in the process of being developed; therefore, the Toolkit only makes some broad assumptions in order to arrive at this assessment. For this purpose, the Toolkit borrows from recent research undertaken in the industrialized world on quantifying the role that ICTs can have in mitigating energy consumption and GHG emissions and considers their impact on the developing world.

It is felt that this approach is appropriate to begin applying the lessons learned and realize the potential energy and GHG emission reductions that increased ICT use could lead to, according to research conducted on this issue in other parts of the world.

The Toolkit focuses specifically on the needs and circumstances of developing countries. In this sense, it seeks to add value to the discussion on measuring the impact of ICTs on development in general and on environmental and climate change in particular. The authors of the Toolkit make suggestions and recommendations accordingly.

The e-Environment Toolkit aims to improve the understanding of the issues and factors that affect ICT use and energy consumption, as well as GHG emissions, in different sectors of the economy and at all levels of society throughout the country or jurisdiction in question. Through the use of this Toolkit and its EERI, a country or jurisdiction is expected to gain a better understanding of where it stands in terms of ICT use for promoting e-sustainability in comparison to other countries. The Toolkit can, therefore, be used to benchmark progress.

This knowledge can be used to justify and lay the ground work for planning on how to use ICTs to help mitigate, as well as adapt to the impacts of climate change, while at the same time contributing to enhancing the sustainability of development in the countries and jurisdictions concerned.

In time, as the results of research on the use of technologies and management practices applied to reducing energy consumption and GHG emissions are published, more detailed and quantitative knowledge of the actual savings from the use of ICTs for energy efficiency and for mitigating GHG emissions will be become available and applicable.

The assessment will be especially useful in identifying areas for further research and policy development that are relevant to the developed, as well as the developing world, in their efforts to cope with climate change, while promoting environmental sustainability. The results of this assessment will also help communicate the advantages of ICTs for abating environmental change, including climate change.

Given the enormity of the task at hand and the limited amount of scientific data on the impact of ICTs on energy consumption and GHG emissions, the e-Environment Toolkit can only be considered a first step in helping to raise awareness of the role that ICTs can play in helping countries abate the effects of climate change. At the same time, the Toolkit aims to help countries design appropriate tools and approaches to leverage the benefits of ICTs for sustainable development, that is, for e-sustainability.

Box 1: Definition of Key Terms
e-Environment and e-Sustainability

e-Environment

e-Environment is: a) The use and promotion of ICTs as an instrument for environmental protection and the sustainable use of natural resources; b) The initiation of actions and implementation of projects and programmes for sustainable production and consumption and the environmentally safe disposal and recycling of discarded hardware and components used in ICTs, and; c) The establishment of monitoring systems, using ICTs, to forecast and monitor the impact of natural and man-made disasters, particularly in developing countries, least developed countries and small economies.

e-Sustainability

The term "e-sustainability" refers to the use of ICTs for sustainable development. The concept is based on the work undertaken by Pamlin and others on using ICTs for sustainable development. It also takes into consideration the role of ICTs in reducing greenhouse gas emissions. In this document, e-sustainability refers to the broader issues of using ICTs for sustainable development, but recognizes the urgent priority of dealing with climate change in order to achieve sustainable development.

Source: ITU (2008). *ICTs for e-Environment: Guidelines for developing countries with a focus on climate change*. ITU. Geneva. 182 pp. See http://www.itu.int/ITU-D/cyb/app/docs/itu-icts-for-e-environment.pdf; Pamlin, D. & Thorslund, E. (2004). *An outline for a sustainable e-strategy - Sweden and a central issue for the future*. IT Forum Mislo. 35 pp. (originally published in Swedish). See http://www.pamlin.net/written/documents/An%20outline%20for%20a%20sustainable%20e-strategy%20for%20Sweden.pdf; Pamlin, D. Szomolanyl, K. (2006). *Saving the climate @ the speed of light. First roadmap for reduced CO2 emissions in the EU and beyond*. WWF. European Telecommunications Network Operators' Association (ETNO). 40 pp.

2 Setting the Scene

2.1 The role of the ITU

This report was commissioned by the ICT Applications and Cybersecurity Division (CYB) of the International Telecommunication Union's (ITU) Telecommunication Development Sector (ITU-D). The CYB Division is the ITU Telecommunication Development Sector's focal point for assisting developing countries in bridging the digital divide by advancing the use of ICT-based networks, services and applications, and promoting Cybersecurity.[1] One activity of the CYB Division is to develop guidelines on the technology and policy aspects of ICT applications, such as e-Environment.[2]

[1] See http://www.itu.int/ITU-D/cyb/. The CYB Division has coordination responsibility for Programme 3 of the Doha Action Plan adopted at the 2006 World Telecommunication Development Conference (WTDC-06). Priority activities of the Division include promoting cybersecurity, e-strategies, ICT applications, Internet and IP networks development, multilingualization, and community telecentres.

[2] Also see World Telecommunication Development Conference (Doha, 2006) Resolution 54: *Information and communication technology applications*. This Resolution instructs ITU-D to undertake studies on ICT applications,

ITU has also been identified as co-moderator/co-facilitator for follow-up on the World Summit on the Information Society (WSIS) Action Line C7 on e-Environment — together with the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO), the World Health Organization (WHO), the International Civil Aviation Organization (ICAO), and UN-Habitat.[3]

The International Telecommunication Union recognizes the important role that ICTs play in promoting sustainable development and in dealing with climate change. In a recent report on ICTs and climate change, the ITU summarizes the many activities that it is undertaking, in collaboration with its partners, to promote the use of ICTs in combating climate change.[4]

ITU has organized three symposia on ICTs and climate change, the last of which took place in July 2009[5] hosted by the Centro Internacional de Investigación Científica en Telecomunicaciones, Tecnologías de la Información y las Comunicaciones (CITIC)[6] in Quito, Ecuador.

2.2 Strategic planning framework

The ITU report "*ICTs for e-Environment: Guidelines for developing countries with a focus on climate change*"[7], which precedes this document, recommended strengthening the capacity of developing countries to use ICTs for environmental action in the areas of management, conservation and sustainable development. To do this, the e-Environment report recommended using, among other things, a structured and systematic approach in the form of a strategic planning framework and following this with an e-Environment action plan.

The first step in using a strategic planning approach is an assessment of the existing situation based on local specificities, needs and circumstances, as well as opportunities. The e-Environment Toolkit Report proposes a methodology, along with a tool, that can be used by a country to consider if and to what extent ICTs may have a role in promoting sustainable development and limiting the effects of climate change. By extension, the methodology and tool aim to help a country identify opportunities for action in which ICTs may help it reduce GHG emissions and enhance energy efficiency and use.

As mentioned in the e-Environment report, the environmental strategy and action plan should assist a country in defining the actions regarding environmental management and the use of ICTs that would help it achieve its vision and goals.[8] These goals include measures to reduce environmental impact, energy use and the emission of greenhouse gases.

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including e-Environment, and to circulate the outputs to all Member States. See http://www.itu.int/ITU-D/cyb/app/docs/wtdc_resolution_54.pdf.

[3] Additional information on WSIS Action Line C7 on e-Environment can be found at http://www.itu.int/wsis/c7/e-environment/. With regard to ITU's broader activities on climate change, see the ITU's dedicated website on ITU and Climate Change at http://www.itu.int/climate/.

[4] ITU (2009). *ITU background report. ITU Symposium on ICTs and climate change.* Hosted by CITIC. Quito, Ecuador, July 8-10, 2009. ITU. Geneva. 32 pp. See http://www.itu.int/dms_pub/itu-t/oth/06/0F/T060F00600C0004PDFE.pdf.

[5] ITU (2009). Third Symposium on ICTs and Climate Change in Quito, Ecuador on 8-10 July 2009. See http://www.itu.int/ITU-T/worksem/climatechange/200907/index.html.

[6] See http://www.citic.org.ec/

[7] ITU (2008). *ICTs for e-Environment: Guidelines for developing countries with a focus on climate change*. ICT Applications and Cybersecurity Division, Policies and Strategies Dept., ITU Telecommunication Development Sector. Final report. 182 pp. See http://www.itu.int/ITU-D/cyb/app/docs/itu-icts-for-e-environment.pdf.

[8] ITU (2008). Idem.

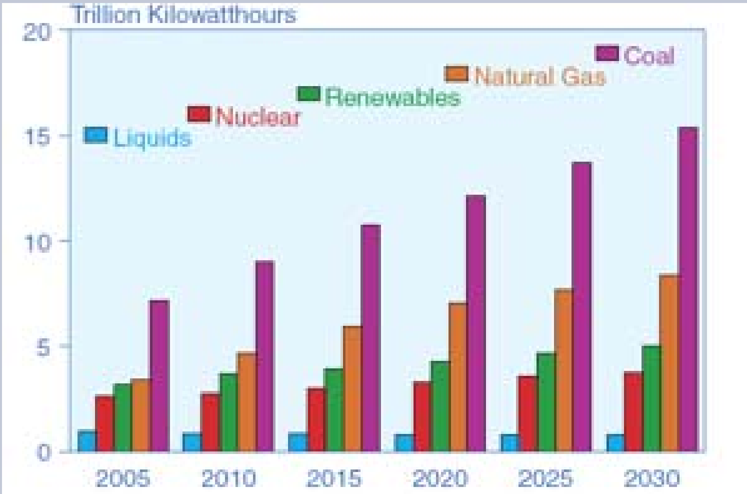
3 THE IMPACT OF ICTS ON THE ENVIRONMENT

3.1 The urgent situation regarding climate change

In a recent report, Stern states that for countries around the world to avoid the direst consequences of climate change, that is, increased levels of CO^2 in the atmosphere of greater than the 450 parts per million (ppm) "tipping point", "*most of the world's energy production will have to be decarbonised, while emissions from transport, land-use, buildings and industry will need to have been cut sharply*". Innovative technologies will have to be used with a special focus on the "*power, transport, industry and building sectors*".[9] ICTs will definitely be part of the innovative technology solutions to be considered.

According to the "International Energy Outlook 2008" report from the Energy Information Administration (EIA) of the United States, "*[w]orld net electricity generation nearly doubles in the reference case, from 17.3 trillion kilowatthours in 2005 to 24.4 trillion kilowatthours in 2015 and 33.3 trillion kilowatthours in 2030*".[10]

Figure 1: World Electricity Generation by Fuel, 2005-2030



Source: **2005:** Derived from the Energy Information Administration (EIA), *International Energy Annual 2005* (June-October 2007), website www.eia.doe.gov/eia. **Projections:** EIA, System for the Analysis of Global Energy Markets/Global Electricity Module (2008).

Under existing energy generating scenarios, this effective doubling will be met mostly by coal. International agreements to reduce GHG emissions could alter this scenario and may likely contribute to a somewhat different outcome; although, given the depth and extent of the current recession and the extended amount of time the recovery is expected to take, some observers in the investment world feel otherwise.[11]

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[9] Stern, N. (2008). *Key elements of a global deal on climate change*. London School of Economics and Political Science, London, 56 pp.

[10] Energy Information Administration (EIA) (2008) *International energy outlook 2008: Electricity*. See http://www.eia.doe.gov/oiaf/ieo/electricity.html and EIA (2008). *International energy outlook 2008*. US. Department of Energy. Washington, D.C. 260 pp. See http://www.eia.doe.gov/oiaf/ieo/index.html.

[11] Miller, D. (2008). *Nuclear and Coal: The Energy 'Dream Team' for Years to Come*. Seeking Alpha. Dec. 14, 2008. See http://seekingalpha.com/article/110526-nuclear-and-coal-the-energy-dream-team-for-years-to-come?source=yahoo.

There are many solutions being considered to mitigate and help adapt to climate and environmental changes. Alternative energy and various conservation measures, for example, are clearly an important part of the solution; nuclear power is also recognized as an alternative. However, one of these solutions is the intelligent and coordinated use of ICTs to reduce GHG emissions.

3.2 Can ICTs play a role in reducing carbon emissions?

3.2.1 ICTs' three-level impact

The effects of the use of ICTs on the environment are categorized at three levels: First, second and third order impacts.[12]

First order impacts address the direct environmental effect of ICT product cycles, from their conception (including research and development) to the production, operation and disposal of ICTs. These impacts are mostly negative, even though research and the green imperative are driving the development of newer and more energy efficient technologies.

Second order impacts are due to increases in process efficiency as a result of using ICTs for business and everyday uses. Some examples include e-commerce, e-government and related applications. Smart motor systems (smart buildings, etc.), virtual meetings and other forms of dematerialization are other examples.

Third order impacts result over the longer term and are systemic in nature. They are due to efficiencies resulting from humans and society changing their behaviour to take advantage of the efficiencies that ICTs provide, as well as the reduced environmental impacts that ICTs offer as a result of teleworking, teleconferencing, smart transportation systems, smart metering, and smart building designs, among others. Third order impacts may be the most important kind, but they are very difficult to measure, partly because they are not clearly understood and are only now beginning to be considered.

3.2.2 Action on using ICTs for dealing with climate change

Many advanced countries are moving ahead to develop ICT technologies that are more environmentally friendly and to use ICTs to reduce energy consumption and GHG emissions in applications, such as smart meters and smart buildings.

The private sector is also getting in on the act. According to a recent report by Gartner and the Worldwide Fund for Nature (WWF), "*BT, Fujitsu, HP and IBM, and Cisco*" are developing "*business solutions that tackle the enterprise's high-carbon areas*".[13] Other strong performers among the private sector companies that agreed to participate in this survey included Ericsson, and Nokia. Several other firms are showing promise, while some firms are clearly not ready to take on the low-Carbon (low-C) challenge. According to this report, the Asia region, with the exception of Japan, is lagging. It is noteworthy, however, that countries such as the Republic of Korea, have developed a "Green Growth" and a "Green IT"[14] strategy and have developed an economic stimulus package where e-sustainability is an important priority.

According to a recent report of the Organisation for Economic Cooperation and Development (OECD), the Republic of Korea has "…centered its economic stimulus package almost entirely on the topic of green technologies designed to realise low-carbon economy green growth and create

[12] ITU (2008).

[13] Mingay, S. and Pamlin, D. (2008). *Assessment of global low-Carbon and environmental leadership in the ICT sector*. WWF Gartner. 3 November 2008. 66 pp.

[14] Castro, D. (2009). Learning from the Korean Green IT strategy. Web Memo. The Information Technology and Innovation Foundation. See http://www.greenercomputing.com/research/report/2009/08/11/learning-korean-green-it-strategy.

more jobs and some related new 'growth engines'."[15] Meanwhile, Japan, according to the OECD report, will focus its stimulus package on intelligent transport systems and the "*creation of new industries such as environment-related IT*".[16]

Among non-OECD countries, China has the largest stimulus package of all. According to press reports, the HSBC bank states that it "*estimates that of China's roughly $586 billion package, $221 billion has green features, making it the largest green stimulus package in the world, followed by the US at $112 billion and South Korea at $31 billion. HSBC's green features included 'rail' and 'electricity grid', which are not mentioned under the green package in the original stimulus*".[17] According to China's chief climate change negotiator, "*more than 15 percent of the country's 4-trillion-yuan ($586 billion) stimulus package will be spent on cutting carbon emissions by the end of 2010*". This includes an investment of 210 billion Yuan in energy conservation, pollution reduction and ecological improvements, along with another 370 billion Yuan to be spent on technological upgrades and industrial restructuring in the country's energy-intensive factories.[18]

Along with IBM[19], HP and Cisco[20], transnational consulting firms such as Gartner, McKinsey[21] and the Boston Consulting Group[22] have recognized the importance of climate change and green solutions, and have developed service lines on energy management to respond to the opportunity it represents. Consideration is also being given to using ICTs for smart metering and for controlling the energy use of built environments, such as buildings. This is especially the case with utility companies.

Some of the companies in the power and energy generation sector, such as ABB, speak of their contribution to reduce greenhouse gas emissions by developing "*advanced industrial information technology to control and optimize power grids and industrial processes.*"[23] These companies are working also on alternative methods of power generation and promoting the early adoption and use of industrial information technology. Other large firms working in this sector, such as GE[24], are adopting a very proactive approach to dealing with climate change. GE undertakes research on "*technology integration including advanced controls for energy management*"[25] and is working on smart grid technologies as well. It is likely that other companies that produce motors and are involved in manufacturing machinery for power generation will soon adopt ICT solutions to improve the efficiency of energy generation. Even Google has identified smart metering as an opportunity and is working with utilities around the world to test its new product, the PowerMeter.[26] Green IT is a growing business around the world.

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[15] OECD (2009). *Policy responses to the economic crisis: investing in innovation for long-term growth.* June 2009. OECD, Paris. p. 32.

[16] Idem.

[17] Zhang Qi, China Daily (2009). *$30b set aside for green stimulus to double alternative fuel use*. China Daily. 2009-05-25 08:00. See http://www2.chinadaily.com.cn/bizchina/2009-05/25/content_7937667.htm#.

[18] Fu Jing and Li Xiaokun, China Daily (2009). *Billions from stimulus tagged to cut emissions*. China Daily. 2009-08-06 07:45. See http://www.chinadaily.com.cn/bizchina/2009-08/06/content_8531135.htm.

[19] See http://www.ibm.com/ibm/green/index.shtml.

[20] St. John, J. and Kanellos, M. (2009). *Cisco Jumps into Energy Management for Computers, Buildings*. Seeking Alpha. Greentech Media. Jan. 27, 2009. See www.seekingalpha.com.

[21] McKinsey (2009). *Climate change special initiative*. See http://www.mckinsey.com/clientservice/ccsi/index.asp.

[22] Boston Consulting Group. 2009. *Sustainability*. See http://www.bcg.com/expertise_impact/capabilities/sustainability/default.aspx.

[23] ABB (2009). *Climate change: How ABB cuts emissions*. See http://www.abb.com/cawp/abbzh258/d9ff2dabf819ce3fc125731500321ec5.aspx and http://www.abb.com/cawp/abbzh254/18beada58dd77b77c1256b54003baeb2.aspx.

[24] General Electric (GE) (2009). *GE's position on Innovation, Environmental Stewardship and Energy Security*. See http://www.ge-energy.com/corporate/ecomagination_home/ge_position_stragetic.htm.

[25] General Electric. See http://www.ge.com/citizenship/performance_areas/products_services_smartgrid.jsp.

[26] Google (2009). *The Google PowerMeter*. See http://www.google.org/powermeter/index.html.

Many of the advantages of using ICTs, as outlined in the Global e-Sustainability Initiative (GeSI) "*Smart 2020*" report[27], are now finding their way into the mainstream of business and of society in general. Some governments and public organizations have recognized the important contribution that ICTs can make to reducing energy consumption and GHG emissions. The European Union adopted a common strategy for "*…sustainable development as an integral part of the EU strategy for the transition to a knowledge based economy. Information and communication technologies (ICT) play a key role in this transition*".[28] Recently, the European Union recognized the important contribution that ICTs could make to energy conservation and their role in quantifying energy reductions.[29]

ITU has launched a major programme to examine the relationship between ICTs and climate change. A background report details its work on e-sustainability and climate change.[30] At a meeting of the Telecommunication Standardization Advisory Group (TSAG) in December 2007, a Technology Watch Briefing Report on this topic was reviewed. ITU held two international Symposia on ICTs and Climate Change in 2008 and one in 2009. These meetings led to the establishment of an ITU-T Focus Group on ICTs & Climate Change, whose work is now the basis for activities of ITU-T Study Group 5 (SG5) on the Environment and Climate Change. ITU-T, the ITU sector dedicated to standards setting, established SG5 to *"study methodologies for calculating the amount of GHG emissions from ICTs, and the amount of reduction in the GHG emissions in other sectors as a result of using ICTs*".[31]

Similarly, OECD has just held a second conference on ICTs and climate change[32] in collaboration with the Danish Ministry of Science, Technology and Innovation.

Developing countries, on the other hand, do not have the resources to follow-suit and take advantage of ICTs as a tool for environmental management, as well as environmental sustainability. Even in industrialized countries, there are few if any comprehensive e-sustainability strategies explaining how ICTs can be rolled out to reduce GHG emissions and energy consumption to sustainable levels. Similarly, there are few if any audits that have been undertaken to attempt to provide a more accurate measure of the real impacts and benefits of using ICTs to mitigate climate change.

In general, few national development strategies and plans in the developing world have taken into consideration the contribution that ICTs can make to sustainable development, as outlined in reports such as the ITU "*ICTs for e-Environment*" and GeSI's "*Smart 2020*" reports. It is hoped that the e-Environment Toolkit will help change this.

3.3 The contribution of ICTs to climate change

ICTs contribute between two and three percent of total greenhouse gas emissions globally, according to a report by Gartner. Some consider that ICTs actually contribute much more to GHG emissions. The European Union estimates that ICTs represent about 7.8 percent of all electricity consumption in the European Union (EU) and that this amount is likely to grow to 10.5 percent by

[27] The Climate Group and GeSI (2008). *Smart 2020: Enabling the low carbon economy in the information age*. 87 pp.
[28] Institute for Prospective Technological Studies (2004). *The future impact of ICTs on environmental sustainability*. European Commission. Joint Research Centre, Technical Report EUR21384 EN
[29] Commission of the European Communities (2009). *Communication from the Commission of the European Communities on mobilising information and communication technologies to facilitate the transition to an energy-efficient, low-carbon economy*. COM (2009) 111 final. Brussels, 12.3.2009. See http://ec.europa.eu/information_society/activities/sustainable_growth/docs/com_2009_111/com2009-111-en.pdf.
[30] ITU (2009). *ITU background report.* ITU Symposium on ICTs and climate change.
[31] For greater detail on ITU-T SG5, see http://www.itu.int/ITU-T/studygroups/com05/index.asp.
[32] High-level OECD Conference: ICTs, the Environment and Climate Change, 27-28 May 2009. See www.oecd.org/sti/ict/green-ict.

2020, under a business as usual (BAU) scenario.[33] The EU studies estimate that this represents 1.9 percent of the total CO^2 emissions for the EU 25 countries in 2005 and that this level would increase to 4.5 percent of CO^2 emissions by 2020, under a BAU scenario.

Conversely ICTs also contribute to reducing GHG emissions and energy use. In the European Union again, the Bio Intelligence Service study of the European Commission has estimated that ICTs can make a significant contribution to reducing energy consumption and, to a lesser extent, CO^2 emissions, as a result of using ICT-enabled heating ventilation and air conditioning systems (HVAC), ICT based lighting systems, industrial equipment and automation, and ICT enabled energy grids.[34] According to this report, it is projected that in the “Eco-scenario”, the net energy savings in terms of total electricity consumption in 2020 for the EU 27 will be 53.4 percent vs. 2.8 percent in the BAU scenario. In terms of CO^2 equivalent emissions, the study finds that the savings are only positive under the Eco-scenario and amount to 4.6 percent of the EU 27 CO^2 equivalent emission levels for 1990.

According to GeSI’s “*Smart 2020*” report, the largest influence of using ICTs is in “*enabling energy efficiencies in other sectors, an opportunity that could deliver carbon savings five times larger than the total emissions from the entire ICT sector in 2020*”.[35]

Along with the studies referred to here, the “*Smart 2020*” report identifies several ICT-based innovations and/or technologies that may offer the greatest potential at mitigating energy consumption and GHG emissions, as well as limiting the use and emission of pollutants, such as heavy metals and other substances that are dangerous to life.

At present, the greatest impact of ICT equipment is on the network side of the Internet, but with time and increasing bandwidth availability to end users, there will be greater opportunities to provide a variety of end user services based on triple play, for example, and the end user will become the most important source of power consumption in the network.[36]

This report proposes looking at these efficiency gains and extending the definition of efficiency to include business processes in general, and especially those associated with e-government and e-commerce. Both of these practices are gaining in their application. However, the significant environmental and climate change benefits associated with them are not sufficiently taken into consideration in national development planning. According to the Bio Intelligence report, the contribution of these electronic services to reducing energy consumption and, by extension, greenhouse gas emissions in industrialized countries may not be that significant;[37] yet, they could be significant for developing countries. This could be the case especially in lower income economies, where they could benefit not only government and larger corporations, but small and medium enterprises (SMEs) and especially people at the local and community level.

3.4 ICT-based opportunities for abating climate change

The following is a preliminary list of some of the opportunities for ICT-based technologies and practices that can be considered to mitigate the impact of climate change, as well as, in some cases, help countries adapt to climate change.

For the purposes of the e-Environment Toolkit, they need to be taken into consideration in assessing readiness and as options to deal with climate change. These opportunities may not apply to all countries and circumstances, and their application will be influenced by the

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[33] Commission of the European Communities (2009); Bio Intelligence Service (2008). *Final report: Impacts of information and communication technologies on energy efficiency*. European Commission DG INFSO. 432 pp. See ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/sustainable-growth/ict4ee-final-report_en.pdf.

[34] Bio Intelligence Service (2008). Idem.

[35] The Climate Group and GeSI (2008), p.10.

[36] The Energy Efficiency Inter-Operator Collaboration Group (EE IOCG) (2008). *The Energy Efficiency Inter-Operator Collaboration Group presentation*. PowerPoint presentation made on the occasion of the ITU climate change Symposium. London, United Kingdom, June 2008. 19 slides.

[37] Bio Intelligence Service (2008).

development status of a country. Given the results of the Bio Intelligence study, commissioned by the Commission of the European Communities, it will be helpful to consider how these results are relevant and important to developing countries.

A list of some of these opportunities follows:

- Better designed ICT devices and components:
    - More energy efficient ICTs: CPUs, display panels, power units, computer and network components and peripherals.
- Dematerialization:
    - Digitization of materials, such as paper, CDs and video tapes, so that content is manipulated using strictly digital technologies;
    - Server and desktop virtualization;
    - Travel replacement technologies, such as telepresence technologies and other high-definition, high-bandwidth video conferencing systems;
    - Replacement of brick and mortar retail outlets with digital malls, shops and storefronts;
    - e-Government: Online government services replace the need for physical presence across a country or jurisdiction.
        - e-Health: reduced need for travel
    - e-Commerce: Online purchasing of goods and services that replaces the need for physical presence.
- Increased process efficiency:
    - e-Business involves the automation of business processes. This generally results in an increased use of power-consuming ICTs. However, e-business and especially e-government and e-commerce can also contribute to reducing energy use and GHG emissions under certain circumstances. The savings are realized as a result of more efficient workflow and business processes.
    - e-Government:
        - Increased access to government information and services;
        - Shared services:[38]
            - IT services and infrastructure:
                - Includes data centres
            - Finance
            - Human resources
            - Procurement:
                - Increased access to jobs and other opportunities
            - Centralized facilities and building / property management
            - Document / records management
            - Legal services

[38] Accenture (2005). *Driving high performance in government: maximizing the value of public-sector shared services*. The Government Executive Series. Accenture. 40 pp. See http://www.accenture.com/xdoc/ca/locations/canada/insights/studies/driving.pdf.

                - Customer interaction / customer relationship management (CRM)
                - Centralized security services.
            – More efficient specialized services:
                - Justice information systems; customs processing and others.
    - e-Commerce:
        – Greater use of portable wireless devices to enhance business efficiency and reach;
        – Online buying and selling (online markets);
        – e-Procurement.

- Smart motor systems:
    - Motors and other power consuming devices that are operated and controlled by logic devices and applications, with a view to optimizing their performance from an energy consumption and C-emissions perspective.
- Smart logistics:
    - Real time freight management;
    - Supply chain management:
        – Just in time manufacturing.
- Smart transportation systems (a part of smart logistics):
    - Roadways with embedded devices linked to the Internet;
    - Global positioning systems (GPS), along with intelligent devices embedded in vehicles using the roadways, to allow more efficient traffic and transportation management, collision avoidance, most efficient route selection and navigation based on most recent and up to date traffic, weather, road construction and related information:
        – Based on real time monitoring and forecasting of traffic and weather conditions.
- Smart buildings:
    - Heating ventilating and air conditioning systems (HVAC) embedded with CPUs and connected to high speed networks;
    - Lighting systems.
- Efficiency in electricity generation and management: This includes using smart grids that will allow the monitoring of power consumption and use over the electricity grid. The goal is to allow more efficient power distribution and power use by the grid itself, including the possibility of making greater use of renewable and non GHG emitting sources of energy:
    - Energy demand management:
        – Remote appliance power management (Demand side management);
    - Enhancing the efficiency of alternate energy sources, such as wind power, by optimizing the supply and demand for energy generated using smart grids and "supporting decentralized energy production from renewable resources".[39]

[39] Institute for Prospective Technological Studies (2004).

- Smart human ecosystems: These are evolving and future human-build environments, where ICTs are ubiquitous and human behaviour integrates these technologies into as yet incompletely known ways of living and doing things that can have significant impacts in reducing GHG emissions and energy consumption.

Many of these opportunities are based on a few important ICTs:

- High speed networks such as fibre optic networks that extend to the individual at home (fibre to the home – FTTH) or to the office;
- Intelligent devices: Ones with a CPU and related chips and circuits, along with an appropriate application, to control the action or operation of the device in question;
- Radio frequency identification (RFID) devices that allow all of these intelligent and embedded devices to communicate with one another;
- The Internet Protocol (IP) and specifically Internet Protocol IP6, which allow a virtually unlimited number of unique IP addresses to be used to identify each connected device, facilitating their interaction through the Internet.

Some studies[40] suggest that ICTs may have a far higher potential for mitigating climate change and GHG emissions, in particular. Nevertheless, the benefits that ICTs bring may also lead to adverse effects through increased energy consumption, as a result of the increased efficiency and/or reduction in costs, sometimes called the "price rebound effect"[41] or Jevons Paradox.[42] This would lead to increased levels of CO^2 emissions and energy consumption. Either way, much more research is required to be able to substantiate these estimates and their impact on people, organizations, communities and countries. This is especially so in developing countries.

Whatever the case, the total benefit from these order of impacts has not been measured because they are still not well understood; yet, the benefit is likely to be very significant.

For the purpose of this Toolkit, we recognize that ICTs can make a contribution and that, even when it may not be possible to readily measure their impact on abating the effects of climate change, they need to be factored in when assessing their potential in meeting the challenge of climate change. At the very least, there is a need to examine how the results and evidence collected from research in industrialized economies may apply to developing countries.

3.4.1 Relevance of ICT-based climate change abatement technologies to the developing world

Many of the ICT-based abatement technologies listed above will be of limited relevance to developing countries. Despite this fact, some will be of significant use and should be recognized as such, even though it may not be possible to measure precisely the contribution they make to mitigate the impact of climate change. In these cases, increasing awareness among developing countries of the qualitative impact that these technologies have or could have may help pointing out opportunities for action against climate change.

Table 1 below lists the ICT-based opportunities for climate change that were presented above from the perspective of their perceived value in reducing energy consumption and GHG emissions in the developing world.

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40 Fuhr, J.P. and Pociask, S.B. (2007). *Broadband services: Economic and environmental benefits*. The American Consumer Institute; Climate Risk Pty (2007). *Towards a High-Bandwidth, Low-Carbon Future: Telecommunications-based Opportunities to Reduce Greenhouse Gas Emissions*. Fairlight, Australia. 109 pp. See http://www.climaterisk.com.au/wp-content/uploads/2007/CR_Telstra_ClimateReport.pdf.

41 Institute for Prospective Technological Studies (2004). Idem.

42 Wikipedia (2009). Jevons paradox. See http://en.wikipedia.org/wiki/Jevons_paradox (Downloaded 06/09/2009).

Table 1: ICTs and Related Business Practices of Greatest Potential Benefit for Abating the Impact of Climate Change in Developing Countries			
Nature of the ICT and/or related practice	**Extent of impact: (Range: -5 to +5) -5= Deleterious effect; 0= Limited or nonexistent effect; 5= Highly significant effect**	**Comments**	**Examples**
Better designed ICT devices and components:			
In general, countries are passive beneficiaries of these technological innovations, which are driven by technical innovation, market forces and the increasing cost of energy and carbon emissions.			
• More energy efficient CPUs, display panels, power units, computer and network components and peripherals.	**-2 to +1**: Developing countries are affected as any others, but the overall impact may be mitigated by increased demand and lower prices. The introduction of the One Laptop per Child (OLPC) low-cost energy efficient netbook computer, as well as other similar products, are a better solution than introducing large material and energy consuming desktop computers. Negative values will prevail when there are no computers installed. Positive values reflect replacement of less energy efficient desktop computers and other PCs for solutions like the OLPC and desktop virtualization alternatives discussed below.	With the financial crisis, computer manufacturers are promoting the sales of Pentium-based PCs, which are less expensive but which consume more energy than their more modern successors, such as the Intel Core 2 Duo Intel chips, and the most recent Penryn processor chips. Pentium-based processors can be up to 400 percent less efficient than newer Intel Core 2 Duo processors.[43]	
Dematerialization:			
• Digitization of materials, such as paper, CDs and videotapes, so that content is manipulated using strictly digital technologies.	**+1 to +4**: Developing countries benefit, as do any other counties. With increased dematerialization, ICTs can help reduce the need for freight transport, which may contribute to reduce energy consumption and GHG emissions.		A study commissioned by the Commission of the European Communities, indicates that working under best-case assumptions, "ICTs can avoid 17 percent of future freight transport"[44], as a result of dematerialization and reduced material throughput.
• Server and desktop virtualization	**-4 to +5**: Server[45] or desktop[46] virtualization can have many applications that can lead to significant savings in materials and energy, by replacing individual servers or PCs with virtual machines. This application could be very important in countries where the cost of electricity is prohibitive and more importantly, for countries where there are server farms or where the economy depends on IT services outsourcing (ITO), business process	Server virtualization technology based on server operating system virtualization has had a significant impact, but now, virtualization technology has made its way into several sectors with the development of novel applications in sectors such as education, tourism, libraries and Internet cafes. The benefits will be greatest with existing server farms. On the other hand, in keeping with the tenets of Jevons paradox, server virtualization may also increase ICT use.	Developing countries, such as the Philippines, Egypt, Tunisia, Morocco, South Africa, India, and China, which increasingly depend on off shoring, stand to benefit. Off shoring and related BPO

[43] Tom's Hardware (2007). *AMD CPU efficiency compared*. January 30, 2008. See http://www.tomshardware.com/2008/01/30/processor_efficiency_compared/.
[44] Institute for Prospective Technological Studies (2004).
[45] Turban, E. (2008). *E-commerce – A managerial perspective. Chapter 19. Building e-commerce applications and infrastructure.* pp. 27 - 29. Prentice Hall. See http://wps.prenhall.com/wps/media/objects/5073/5195381/pdf/Online_Chapter_19.pdf.
[46] Wikipedia (2009). *Desktop virtualization*. See http://en.wikipedia.org/wiki/Desktop_Virtualization. (Downloaded 06/10/2009).

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	outsourcing (BPO), and off shoring. This technology could have significant use in lower income economies, as well as in other countries. The impact of Jevons paradox will depend on the virtualization ratio, that is, the number of virtualized servers or desktops per physical server. A negative impact will reflect a situation where the installed base on ICTs is very small or limited and the introduction of virtualized machines will result in increased energy consumption where previously there were no PCs and peripherals to consume energy. A positive value will reflect the benefits of replacing individual desktops with virtualized ones.	As the example from Brazil points out, this technology could also increase the diffusion of ICTs.	and ITO services are server intensive, and any way of reducing the cost of powering server farms will be of great benefit, not only in reducing GHG emissions and energy consumption, but in increasing the competitiveness of the destinations in question. An interesting example is the supply of over 356,000 virtualized desktops to schools in all of Brazil's 5,560 municipalities with considerable savings in energy and materials.[47]
• Travel replacement technologies, such as telepresence technologies and other high-definition high-bandwidth video conferencing systems, along with other virtual mobility technologies (telework, teleshopping and virtual meetings).	**0 to +1**: Used for some educational applications, such as the African Virtual University, but of limited use for the general public and travellers in developing countries, especially for lower income economies. When the technology becomes available at a reasonable cost for government managers located in regional centres or offices, the benefits will become more obvious and significant. Such technologies may reduce the resistance from government and other employees to move to rural areas. The application of these technologies in education and health, as well as in justice and other sectors could greatly facilitate national governance, while reducing the cost of doing business for those who are located in more distant and/or rural areas of a country.	Limited benefit for developing countries in general because of the high cost of high-definition telepresence products. However, lower-end applications can be beneficial. As costs come down, demand will increase, as will GHG emissions associated with the use of these technologies. As the quality of the experience increases and costs come down, it is likely that significant travel replacement will ensue. The extent to which this is relevant to developing countries is conjectural at this time. The benefits will be felt mostly in countries where business people travel by air, and therefore, the impact in lower income economies may be less significant.	
• Replacement of brick and mortar retail outlets with digital malls, shops and storefronts.	**+1**: Limited impact on GHG emissions and energy consumption until there is more capacity to use e-commerce and sufficient market demand. This is not the case presently, especially in many developing countries.	There is limited capacity to take advantage of e-commerce in many developing countries. This is progressively changing in some countries.	

[47] Userful (2009). *Userful and ThinNetworks announce the world's largest desktop virtualization deployment - 356,800 green workstations*. Press release, February 17, 2009. See http://www2.userful.com/company/linux-desktop-virtualization.

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• e-Government: Online government services replace the need for physical presence across a country or jurisdiction.	**+4**: Reduces the need for building government offices and avoids the limitation imposed by maintaining ICT equipment at these locations for printing government forms, and other activities. This technology has some impact even in lower income economies, where the benefits are felt at a more local level.	While the absolute impact in terms of energy saved may not be significant to a country as a whole, in poorer countries and especially in more rural areas, the benefits can be significant to the individuals involved and their families. Replacing the need to establish and maintain full service government offices in a country with limited means will have significant impact and result in considerable savings. It will also allow services that would not be available otherwise to be made available. The downside is that there may not be the capacity to respond to the increased demand, as a result of making public services available online across a country. It tends to be combined with technologies such as server and desktop virtualization (see the Brazil education example cited above).	
- e-Health: reduced need for travel to obtain medical services.	**+2**: As per e-government. The most significant impact is reducing the need for travelling to distant locations to obtain medical and health-related services. Also applicable in lower income economies. More research is needed.	While the absolute impact in terms of energy saved may not be significant to a country as a whole, in poorer countries and especially in more rural areas, the benefits can be significant to the individuals involved and their families. Can be useful for extending the reach of regional medical facilities, such as hospitals, and has been the basis for developing online services to reach poorer communities in parts of India, for example.	
• e-Commerce: Online purchasing of goods and services, which replaces the need for physical presence.	**+3**: Its significance comes from reducing the need for travelling to distant locations to buy goods and services, with a focus on financial products and services. Also reduces the need for brick and mortar retail outlets. The savings can be significant when paired with smart logistics, such as supply chain management and just-in-time production associated with some direct sales models.	Of limited impact in lower income economies, where online banking is just making inroads. Online shopping may have a negative impact by increasing the demand for fulfilment services, which may result in increased transport associated with the delivery of goods purchased, and lead to increases in GHG emissions and energy consumption. The impact of this model in lower income as well as in some middle income economies is likely to be limited. The impact could be significant in countries with significant populations and/or population densities, such as India and China, and most importantly in countries with significant manufacturing bases, as is the case of China.	Dell's just-in-time manufacturing model is often quoted for its increased efficiency and ability to reduce inventory. The "Just-in-time" business model results in much efficiency in the case of industrial production.[48]

[48] Wikipedia (2009). Just-in-time (business). See http://en.wikipedia.org/wiki/Just_In_Time_(business) (Downloaded 06/08/2009).

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Increased process efficiency:			
• e-Business: Involves the automation of business processes in the public and/or private sectors.	**-5 to +3**: Automating office processes requires a significant amount of electrical power in lower income economies, especially in rural areas. The impact of ICTs on power consumption is a significant burden in some lower income economies. However, in some of the more densely populated countries, the impact may be positive. In countries where the installed base of ICTs is low, there will be a negative impact.	This generally results in an increased use of power consuming ICTs. However, e-business, and especially e-government and e-commerce, can contribute to reducing energy use and GHG emissions under certain circumstances. The savings are realized as a result of more efficient workflow and business processes. Much depends on the development status of the country in question.	
• e-Government			
- Increased access to government information and services.	**-3 to +3**: More significant impact by reducing the need for travelling to distant locations to obtain government or other documents and services. Results in greater use of ICTs, more emissions and greater energy consumption. The impact may be positive or negative, depending on the number of PCs already in use. Jevons paradox may apply.	Greater online access to government information and services will reduce the need to travel and line up in queues. Greater use of PCs in government will increase energy use and GHG emissions.	
- Shared services: Financial services; Human resource management; Legal services; Customer interaction / customer relationship management (CRM); Centralized security services.	**+2**: The impact of sharing services, instead of duplicating them across government, can be significant.	By centralizing services, governments can reduce duplication of equipment, and services, reducing power consumption and material use, while enhancing service delivery.	The impact of e-government on energy consumption and GHG emissions can be significant by encouraging co-location and shared services to create economies of scale.
• IT services and infrastructure:			
○ Data centres	**-5 to +5**: Centralized or co-located data centres can significantly reduce power consumption and the duplication of devices, especially if used in conjunction with server virtualization technologies. Introducing data centres will increase energy use and GHG emissions.	Establishing and managing centralized data centres involve much forward planning and the ability of different branches of government to work together.	
• Procurement	**0 to +1**: The benefits are associated with dematerialization of procurement documents and the elimination of postal or courier-based communication to transport documents. Re-materialization does occur, as documents still may have to be produced in hard copy. This will change	Centralized public procurement policies, as well as the adoption of e-procurement services have been shown to greatly reduce costs and the need to record and store transactions on paper. The use of e-procurement systems can eliminate photocopying, mailing and shipping, as well as the use of couriers and increase	The Government of Canada's Merx system has made significant reductions in the costs of running the procurement service.

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	over time as fully electronic procurement systems, e-contract, e-verification and authorization technologies are put into place. SMEs will also benefit from reduced energy compared to traditional procurement practices.	access to government procurement. e-Procurement services benefit the government, taxpayers and the private sector by reducing the use of materials and energy consumption.	
• Centralized facilities and building / property management	**+3**: The benefits are associated with enhanced energy efficiency and the resulting lower GHG emissions. The benefits are similar to those effected by implementing shared services.	Centralization of facilities management opens up the possibility of centrally managing lighting, heating ventilation and air conditioning systems (HVAC), and using intelligent building management systems in different buildings located across the city or across the world. Many government offices in lower income economies do not have HVAC controls and some buildings may not have electricity.	
• Document / records management applications (CMS/DMS).	**+1**: Content management systems (CMS) can greatly reduce paper-based records.	An electronic document management system can significantly reduce the use of paper records and cut the costs of acquiring, storing, retrieving, securing and transferring paper copies.	
- More efficient specialized services: • Justice information system.	**+1**: A specialized example among others. There are real advantages to computerizing the operation of the justice system, including better planning and coordination of court dates and proceedings, and overall increased efficiency in the operation of the justice system. From an energy management and GHG emissions perspective, this means less waste in time and energy and better scheduling of hearings, trails and related functions.	Legal professionals can better plan their activities; simple activities, such as sharing information on the logistics of hearings, dates and locations, can greatly accelerate the speed of legal proceedings and reduce unnecessary travel and communications. Justice information systems can help by dematerializing much of the paper work associated with the operation of the courts and the justice system. The energy consumption of the ICTs used will still be high, especially in lower income economies where the cost of ICTs and of the energy used to power them may still be significant.	
• E-commerce			
▪ Greater use of portable wireless devices to enhance business efficiency and reach.	**+1 to +3**: Reduces the need for travelling to distant locations for face-to-face meetings with clients and suppliers. Decreases the need for brick and mortar retail outlets. Savings can be significant when paired with smart logistics, such as supply chain management and just-in-time production, associated with some direct sales models.	Wireless devices reduce the energy and effort required to do business, while increasing the reach of the businessman. Especially significant for small and medium sized enterprises.	
▪ Online buying and selling (online markets)	**+1 to +3**: Reduces the need for travelling to distant locations to buy goods and services, with a focus on financial products and services. Decreases the need for brick and mortar retail outlets. Savings can be significant when paired with smart logistics, such as supply chain management and just-in-time production, associated with some direct	Greater efficiency in the operation of markets will reduce costs, as well as GHG emissions. It allows the possibility of checking purchases using a wireless device or online, instead of travelling to gather the required information.	

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	sales models.		
▪ e-Procurement	**0 to +1**: Same advantages as for public procurement. SMEs will also benefit from reduced energy expenditures in contrast to traditional procurement practices.		
▪ ITO & Information Technology enabled Services (ITeS): BPO / knowledge process outsourcing (KPO).	**0 to +5**: Selecting IT-related outsourcing services, including the operation of energy intensive data centres, to locations with more renewable energy, reduced energy costs and/or a lower carbon footprint.	Could be very significant. Some countries, such as Iceland, are positioning themselves as locations with such features.	Iceland and other countries located in colder regions of the globe.
Smart motor systems:			
• Motors, and other power consuming devices, which are operated and controlled by logic devices and applications with a view to optimizing their performance from an energy consumption and carbon emissions perspective.	**+1 to + 5**: Will be most significant in those countries that can take advantage of smart motor designs to optimize performance and maintenance cycles, especially of data centres but also in the operation of all power devices. Will be especially important in countries with a developed industrial and manufacturing base. Motors used for HVAC systems applications are dealt with separately under Smart buildings (see below). According to the Bio Intelligence Service report, the "*industrial sector could reduce its energy use for electrical drivers (motors) by almost 10%*".[49]	The use of ICTs to optimize the performance of motors and engines may have significant impacts on energy efficiency in power generation and use. Smart motor systems linked to the Internet and to a centralized control device can also be used to optimize performance and for measuring and recording motor efficiency over time to optimize maintenance. Smart motor systems may be programmed to start and stop at present times or under present conditions to optimize energy use.	The use of smart motors to manage and cool servers and data centres can be particularly useful in reducing energy demand, especially when their use is paired with improved cooling systems and designs. See references to ABB and GE's work on IT-related energy efficiency in motor design and operation.
Smart logistics:			
• Real time freight management	**0 to +4**: Greater use of ICTs can increase the efficiency of supply chain management and reduce the cost of transportation and warehousing of goods and services. Increased efficiency may also result in rebound effects that could lead to greater use of transport solutions. More research is required to better understand these relationships.	The impact on developing countries is likely minimal. An exception would be countries with a large manufacturing base, where such technologies will be especially appreciated. China and Mexico are two examples.	Work by companies such as GE on smart logistics.
• Supply chain management			
• Just-in-time business	**0 to +3**: Greater use of ICTs can increase the efficiency of supply chain management and reduce the cost of transportation and warehousing of goods and services. Increased efficiency may also result in rebound effects that could lead to greater use of transport solutions. More research is required to better understand these relationships.	The impact on developing countries is likely minimal. An exception would be countries with a large manufacturing base, where such technologies will be especially appreciated.	China, Mexico, Vietnam and the Philippines are some examples.

[49] Bio Intelligence Service (2008). Idem.

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Smart transportation systems (a part of smart logistics):			
• Roadways with embedded devices linked to the Internet • Global positioning systems (GPS), along with intelligent devices embedded in vehicles using these roadways to allow more efficient traffic and transportation management, collision avoidance, most efficient route selection and navigation based on most recent and up to date traffic, weather, road construction and related information.	**-2 to +4**: According to the Institute for Prospective Technological Studies (IPTS), the impact of ICTs on transportation is complex. In the case of people, intelligent transport systems (ITS) can make transport more efficient and result in increased demand for transport solutions. The IPTS suggests that the overall impact may be negative because of the rebound effect caused by ITS and the better utilization of time afforded by ICTs while in traffic. Virtual mobility solutions such as telework, teleshopping and virtual meetings may limit the use of transport system and thus encourage energy savings.	The impact in the developing world will vary with the development status of the country. Countries with extensive road networks and many vehicles, as well as high human population density, such as large cities, would benefit.	
Smart buildings:			
• Heating ventilating and air conditioning systems (HVAC) embedded with CPUs and connected to high speed networks.	**+2 to +5**: The Bio Intelligence Report finds a reduction of almost 35 percent in energy consumption in residential buildings and of 17.2 percent in the service sector. This is especially important because in Europe, the "*building sector represents over half the energy consumption in Europe*".[50] The use of advanced HVAC systems in data centres could also make a significant contribution to reducing GHG emissions associated with the ICT industry.	The impact will vary country by country and will greatly be influenced by the existing climate regime of the country in question and by the level of development of the country. Over time, the benefits will likely outweigh any deleterious impacts and any initial rebound effects. Smart buildings may represent one of the most significant contributions of ICTs to abating the impact of climate change over the longer time frame.	
• Lighting systems	**+2**: The savings are based on changing lighting sources to more efficient technologies and using ICTs to manage lighting systems in buildings and across commercial and government sites. According to the Bio Intelligence Report, energy savings in the order of 70-80 percent can be achieved by combining new light source technologies with advanced light control systems.[51] ICTs have a role to play in these light control systems.		
Efficiency in electricity generation and management. This includes using smart grids:			
• Energy demand management	**+2 to +5**: Demand side management[52] (DSM) can realize important energy savings for consumers and electrical utilities and help to even out energy loads, reducing brown outs. In some cases, this practice may be the only		Demand side management is being implemented in South Africa. Both consumers and Eskom, the

[50] Bio Intelligence Service (2008). Idem.
[51] Bio Intelligence Service (2008). Idem.
[52] Wikipedia (2009). *Energy demand management*. See http://en.wikipedia.org/wiki/Demand_side_management (Downloaded 06/10/2009).

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	alternative to help existing electrical utilities avoid black outs and brown outs without adding to existing energy generation capacity. Potential benefits in developing and industrialized countries are likely similar.		electricity utility of South Africa are obtaining savings.[53]
• Smart Grids	**0 to +4**: Smart grids optimize energy distribution and use throughout the electrical grid. Smart grids reduce cost and save energy.[54] Smart grids rely on the use of smart meters[55]—ICTs embedded in appliances and a variety of energy consuming devices—that report on energy use of the device instantaneously or over time. Some smart meters can also turn devices on or off.		Google is developing a smart meter product that will be available in the near future.[56] Google estimates that savings of 5 to 15 percent of residential energy bills can be realized.[57]
• Enhancing the efficiency of alternate energy sources, such as wind power, by optimizing supply and demand for energy generated using smart grids and "supporting decentralized energy production from renewable resources"[58]	**-2 to +5**: Benefits would include greater use of renewable energy and better return on the investment in renewables. Using appropriate ICTs, it may be possible to efficiently manage the contribution of local and decentralized energy production devices, such as fuel cells, solar cells and other technologies, for local power generation. It also allows measuring and accounting for the power generated that could then be sold back to the electrical grid. This could encourage local energy self-sufficiency through the greater and more optimized use of renewable energy technologies.	These technologies are still in the early stages of development. The benefits may not be readily available to lower income countries because the cost of installing and managing these technologies may not be readily available or initially affordable.	
Smart human ecosystems:	**+1 to + 5**: Smart human ecosystems have integrated ICTs in their living and working environments and modified their behaviour to take advantage of ICTs. Such a system will make the best possible use of ICT devices, applications and of the network to integrate ICTs into human environments as seamlessly as possible.	This is still a hypothetical state, but one which is logically possible to accede to. The cost of reaching this state still is to be calculated in environmental, energy, financial, and human terms.	

[53] Eskom (2009). *Welcome to demand side management*. See http://www.eskomdsm.co.za/?q=About_DSM.
[54] Wikipedia (2009). *Smart grid*. See http://en.wikipedia.org/wiki/Smart_grid (Downloaded 06/10/2009).
[55] Wikipedia (2009). *Smart meter*. See http://en.wikipedia.org/wiki/Smart_meter (Downloaded 06/10/2009).
[56] Google (2009). *Google PowerMeter* (Downloaded 06/10/2009); Wikipedia (2009). *Google PowerMeter.* See http://en.wikipedia.org/wiki/Google_PowerMeter (Downloaded 06/10/2009).
[57] Google (2009). *Google PowerMeter. Data sources.* See http://www.google.org/powermeter/calculation.html (Downloaded 06/10/2009).
[58] Institute for Prospective Technological Studies (2004).

3.5 ICT-based technologies for abating climate change in developing countries

ICTs can have an important role in abating climate change, but the conditions under which these benefits can be felt vary considerably. In many cases, further research and analysis needs to be undertaken in order to validate the role of ICTs.

In developing countries, various factors will influence the applicability and adoptability of the technologies described above. These factors include:

- <u>A lack of awareness of the potential that ICTs have to mitigate climate change.</u>

Developing countries are more likely to be less aware of the potential for ICTs to abate the impacts of climate change because they are likely to be less informed about these opportunities and how they can be realized in their own territories.

Even in the more industrialized countries, awareness needs to be increased. Few industrialized countries have adopted comprehensive policies and incentives to encourage investment in ICTs for dealing with climate change. This is rapidly changing as an increasing number of people are affected by power shortages and climate events and decision makers become aware of the impacts of climate change. Virtually no country, to our knowledge, has developed and implemented a comprehensive e-sustainability strategy and action plan.

- <u>The sometimes limited availability in developing countries of the technologies and practices described</u>

Lower income and lower middle-income economies will be less likely to implement some of the innovations described in this report due to a lack of resources or technical and managerial expertise to use them. Similarly, there may not be a middle class in some of these counties demanding action on the environment and climate change. Some countries, like South Africa, however, have implemented demand side management practices.

- <u>Proof of concept</u>

There is an increasing body of knowledge, based on scientific research, to substantiate the use of many of the technologies and practices outlined above. However, not all of these technologies are proven concepts and there is considerable research that needs to be completed to clearly prove not only the concepts outlined, but especially the technologies and practices that will deliver the promise. Similarly, while green ICT is a growing business sector in developed countries, the market for these technologies and opportunities in developing countries is still developing.

Large and middle sized transition and developing economies stand to benefit, such as Brazil, Russia, India, China, Mexico, the Philippines, Indonesia, Vietnam, Egypt, Malaysia, South Africa, Chile, and Argentina, as well as regional trade blocks and groupings, including the Commonwealth of Independent States, the Association of Southeast Asian Nations (ASEAN), and Mercosur. Countries with rapidly growing economies and significant GHG emissions also stand to benefit significantly.

- <u>Rural dwellers may be disadvantaged</u>

Many of the documented technologies and practices will be more appropriate in urban areas, where there is the infrastructure to take advantage of the network and power. The impact in many of the more rural parts of the developing world will be less, not only because of a lack of infrastructure, but because rural areas are usually poorer and more disenfranchised when compared to more urban areas. However, even within urban areas, slums and poorer areas will also be disadvantaged. On the other hand, most of the energy consumption and GHG emissions come from economically active sectors of the economy.

- The nature of economic activity that powers the economy.

Many of the benefits described above will be of lesser relevance to small-scale farmers and land managers. Larger industries and larger private sector operators will be better able to take advantage of some of the opportunities to use ICTs as described above. In these cases, the motivating factor may not only be protecting the environment and fighting climate change, but a need to save money by making better use of ICTs to reduce energy consumption.

3.5.1 Conclusion

Overall, the same benefits that accrue to advanced countries are expected to also benefit lower and lower middle income economies. The nature and extent of these advantages, as well as the modalities that may apply in order to exploit them remains to be determined. It is hoped that this report will increase awareness among decision makers of the opportunities that exist for developed and particularly for developing countries at the local, regional and international levels to help them assess their choices and plan accordingly.

3.5.2 Recommendations

It is proposed that countries integrate or mainstream the e-sustainability dimension in their development planning activities. This means that e-sustainability is to be taken into consideration at all stages of the process when undertaking strategies or action plans for national development or for ICTs, including, for example, e-government or e-commerce strategies.

This can be done by estimating qualitatively and eventually measuring quantitatively the carbon emission and energy consumption implications of the suggested interventions, along with an assessment of how ICTs will influence these measures and how. Business process analysis (BPA) may be a useful tool for undertaking this assessment and for developing scenarios and options for consideration. Undertaking this type of assessment while creating a national development or national ICT strategy will help planners and decision-makers consider the full picture, including the energy use and carbon emission implications of their actions.

The work now being undertaken by the ITU-T Study Group 5 on developing standards and methods for measuring the contribution of ICTs to energy consumption and GHG emissions will be of great assistance to planners working on mitigating climate change.

The e-Environment Toolkit proposes some tools for this purpose. In the meantime, it is incumbent on development planners to track research and developments on how ICTs contribute to abating climate change and how they help to conserve energy, natural resources and the environment in general.

4 Measuring Readiness for e-Sustainability

Along with identifying opportunities, as well as existing technologies, practices and trends to mitigate climate change using ICTs, this Toolkit considers measures of the readiness of countries to use ICTs for mitigating and adapting to climate change.

4.1 Approach

4.1.1 Measuring e-Environment readiness using the “e-Environment Readiness Index” (EERI).

The “e-Environment Readiness Index” or EERI is proposed to measure the readiness of countries to use ICTs for promoting environmental sustainability and for climate change abatement. This index uses data published on a select number of indicators of ICT diffusion and use, as well as indicators measuring environmental capacity and the readiness of countries to promote sustainable development. The EERI is proposed as a tool for undertaking a rapid assessment of a country's readiness for e-Environment.

4.1.2 Indicators

Beyond the EERI, the Toolkit proposes a broader list of indicators and a methodology that can be used to measure the role that ICTs have in promoting sound environmental management and sustainable development, and in contributing to helping mitigate and adapt to environmental and climate change.

The indicators included in the EERI are used to measure e-readiness at the country level, based on data usually readily available. In contrast, the use of the broader list of indicators will provide decision makers more detailed information to gather data that may not be available and to scale the assessment in order to evaluate readiness at a lower scale of analysis, such as in regions, municipalities, communities, organizations and other entities.

4.1.3 Assessment

As discussed above, the Toolkit also considers how it may be possible to assess, even in a first instance, the benefits that may accrue in terms of energy conservation and use, as well as of reduced GHG emissions, as a result of the use of ICTs.

The Toolkit proposes using business process analysis (BPA) to understand the potential energy and material savings and benefits to the environment that could accrue by making increased use of ICTs. This would permit planners in the public and private sector estimate and eventually account for savings in energy consumption and GHG emissions resulting from practices such as e-government, e-commerce and other e-enabled business processes.

4.2 Application of the Toolkit

The e-Environment Toolkit is designed to be a practical and easy to use tool that decision makers can employ to quickly assess their potential for using ICTs to contribute to sustainable development. It is also designed, if users so desire, to help countries undertake a more in depth assessment of the potential for using ICTs for the same purpose. As such, it can be used for developing an in depth e-sustainability strategy and action plan under conditions where data may not be readily available. The Toolkit methodology would then be used to plan data gathering in order to help overcome any data deficiencies identified when conducting a complete e-Environment readiness assessment.

What does this mean? Using the e-Environment Toolkit, it may be possible for planners and decision makers to identify systems, processes and practices that may be inefficient and that can be rendered more efficient using ICTs. Eventually, as more research is made available, the Toolkit can point users to sources of information, case studies and best practices that can help motivate action in favour of ICT-based initiatives to help countries and jurisdictions mitigate and adapt to climate change.

The e-Environment Toolkit can also be used to detect and analyze business processes that could benefit from greater efficiencies in terms of environmental and energy use. In this sense, the Toolkit may help developing countries identify opportunities to "'leapfrog' inefficient mechanisms and integrate state-of-the-art solutions into their evolving societies"[59] as suggested in the "*Smart 2020*" report. It could also help find examples of environmentally inefficient workflow and business processes.

The Toolkit is intended to help decision at all levels, but especially government decision makers. The e-Environment Toolkit identifies factors that influence the readiness of countries to use ICTs as a tool for fighting environmental change in general and climate change in particular. Depending

[59] The Climate Group and GeSI (2008), p.7.

on the circumstances, the use of some of the information and tools proposed in this Toolkit might assist countries in developing strategies for mitigating and adapting to environmental change, including climate change.

As an ancillary or corollary benefit, the Toolkit may also support the assessment of market opportunities for developing innovative products and services to meet the need for environmentally friendly and sustainable technologies and practices. Finally, the Toolkit could help people and organizations better understand the opportunities for using ICTs for sustainable development in a national development context.

In sum, the Toolkit is conceived as part of a comprehensive e-sustainability strategy. Such a strategy will consider and rationalize options for using ICTs systematically and in an intelligent, people-oriented and integrated way to reduce GHG emissions and energy consumption across all sectors of the economy, at all levels of society, across a given country.

5 THE EERI

The e-Environment Readiness Index (EERI) is based on a select number of published indicators of environmental and ICT status. For the purposes of this report, these are termed first tier indicators. A more complete list, including second tier indicators is discussed later.

The EERI is a relative measure of the potential contributions, both positive and negative, that ICTs make to:

1. GHG emissions;
2. Energy use;
3. Waste reduction in general, and the reduction and eventual elimination of toxic waste, in particular; and
4. The conservation of the environment and of natural resources.

The EERI indicators are grouped into two categories, as illustrated in Table 2 below. The list and description of these indicators appears in the accompanying ITU website, where the latest version of the EERI can be downloaded from.[60] There are 26 indicators in all. Each indicator is assigned a value and a weighting, based on its importance in computing the EERI.

Table 2: Categories of Indicators Used in the EERI
ICT and Environmental Indicators

ICT indicators	Environmental indicators
Infrastructure	Biodiversity measures
Applications	Greenhouse gases emissions
e-Environment	Long term preparedness
Energy quality	Policy and public awareness
Human capacity	

Source: ITU.

The ITU webpage dedicated to the EERI lists the calculated EERI scores for 132 countries for which data are available online. The spreadsheet is self-explanatory and includes instructions, as well as source information for the first tier indicators. The data obtained online was inserted into

[60] See www.itu.int/ITU-D/cyb/app/EERI.html.

the appropriate cells of the spreadsheet to calculate the EERI automatically. The EERI makes use of the first tier indicators listed in Table 3 below.

Table 3: EERI's First Tier Indicators
Description of indicators by type

Name of indicator	Description	Type of indicator
World Economic Forum (WEF) Network Readiness Index (NRI)	This composite indicator is a good overall reference for the level of applications used in a given country. It is a multi-factor composite index based on other data collection and weighted uniformly according to a published formula	ICT readiness
e-Government readiness index	Index measuring government use of ICTs in providing services and managing operations	ICT readiness
SSL Servers	Sites found in the survey where the common name in the certificate matched the hostname, and the certificate's digital signature was not detected as being self-signed	ICT readiness
Membership or participation in the Group on Earth Observations	GEOSS works to standardize and make GIS datasets more readily available	Readiness to acquire and exchange research /environmental data
Number of listings in Protected Areas Management Effectiveness Module	WDPA administered assessments of how protected areas are being managed	Environmental readiness
Number of geo-referenced occurrences in the GBIF datasets	The Global Biodiversity Information Facility (GBIF) lists species and records occurrences. The ranking relates to the number of occurrences	Availability of environmental data
Existence of public website for the agency responsible for the environment	Determines if the ministry or organization responsible for the environment has a readily accessible web page	Environmental readiness
TPES per Capita	Total Primary Energy source (TPES) per capita indicates the level of energy accessibility in a country	Energy availability
CO^2 / TPES	Indicates how efficient the energy production is by showing the amount of CO^2 generated over the total energy	Energy efficiency
Electrification Rate	Percentage of the population with access to electricity	Energy availability
Percentage of GDP expenditure on R&D	Indicator of the level of R&D investment; indirectly reflects a country's potential to use ICTs for the environment	Innovation capacity
World Bank Knowledge Economy Index (KEI)	Indicator of the knowledge and information capacity within a country	Innovation capacity
Total Telephone subscribers per 100 inhabitants (combined cellular and landline)	Shows the level of teledensity based on a combination of landlines and mobile lines in a given country	ICT indicator
Internet indicators: Broadband subscribers per 100 inhabitants	Indicates the development of high-speed internet connections	ICT indicator
Internet indicators: Subscribers per 100 inhabitants	Shows the penetration of internet subscribers in a country in subscribers per 100 inhabitants	ICT indicator

International Internet Bandwidth per inhabitant	Total on-going bandwidth per inhabitant in bits per second	ICT indicator
Millennium Development Goal (MDG) 7.6. Terrestrial areas protected to total surface area, percentage	Indicates the proportion of land set aside for protection in order to reduce the loss of species and bio-diversity	Environmental readiness
MDG 7.2. CO^2 emissions, total, per capita	Indicates the amount of CO^2 being generated per person	GHG emissions
MDG 7.1. Proportion of land area covered by forest	Indicates the amount of forest cover and can provide trends	Biocapacity
MDG 7.5. Proportion of total water resources used	Indicates how much of the available water is being used in a country	Biocapacity
Clean development mechanism (CDM) CERs issued	Indicates how well the available CDM resources are being utilized	Environmental readiness
Ecological Footprint vs. Biocapacity	Shows how much of the available environmental resources are being used in a country	Biocapacity / Environmental readiness
National Capacity Self-Assessment (NCSA) Status	The level to which the NCSA has been completed. NCSA is a self-assessment program that identifies the level to which environmental priorities are a part of the national policy. The level of completion is not an indicator of the state of the environment, simply an indicator of the level of awareness of the policy makers	Environmental readiness
Signatory to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	This convention controls the transport of hazardous waste across borders	Environmental readiness
Education Development Index	Indication of the level of development of education. Education is closely tied to environmental awareness	Educational attainment / Innovation capacity

Source: ITU.

5.1 Using the EERI

The EERI can be used both as a tool for evaluating the e-Environment readiness of a country, jurisdiction or enterprise, as well as a process for establishing baseline knowledge about the potential use and impact of ICT systems with respect to the environment. Described in this section are:

1. The proposed indicators for a first-level EERI evaluation
2. A method for performing a first-level EERI evaluation
3. A sample of first-level EERI values
4. An overview of the interpretation of the EERI

5.1.1 First Tier Indicators

The proposed EERI indicators (also called first tier indicators) have been selected according to the following criteria:

Ease of access: The reference indicators used for the first-level EERI are all available online, with minimal requirements for account access or subscriptions. They are drawn from a wide variety of sources that permit a better cross-correlation of the factors that contribute to e-Environment readiness.

Global coverage: In order to ensure that standardized and comparable EERI values are generated, the indicators were selected from sources that provide information for as many individual countries as possible.

Frequently updated: Reference indicators should be current and frequently updated in order to provide ongoing relevance to the EERI. Most of the indicators selected could also be used to generate historical EERI values to perform trend analysis.

Numerical, or standardized: The first-level EERI can only provide a numerical comparison, with the possibility for interpretation when numerical values are assigned to the individual indicators. As a result, the first tier indicators must have a standardized range of values that can be normalized and combined into the final EERI value.

Relevance to a specific segment of the EERI: The EERI is a composite index that provides a survey of the factors contributing to e-Environment readiness; consequently, the indicators were selected to provide coverage over the full range of sectors discussed above. An attempt was also made to provide equal weighting of the indicators, so that all areas would be represented.

5.1.2 Methodology

The criteria for selecting the first tier indicators were established to enable an assessment of a given country's EERI that would facilitate meaningful interpretations both currently and going forward. The location of the raw data, the weighting for each indicator and the tabulated outcome have been structured in an Excel spreadsheet that was populated with the available composite indicators.

The analysis tool was developed with a tiered structure that displays calculated, weighted values for the following hierarchy:

Normalized ICT Summary Indicator

Applications

e-Environment

Energy Quality

Human Capacity

Infrastructure

Normalized Environmental Summary Indicator

Biodiversity

Greenhouse gases

Long-term preparedness

Policy & Public Awareness

Each of these tiers is normalized on a scale of zero to ten, where ten represents the best-in-class performance in relation to that segment of indicators. Weighting is then associated with each indicator according to the relative number of indicators in that segment. In addition, weighting is balanced between the ICT and Environmental segments. In cases where data were not available for an indicator for a specific country, that factor and its relative weighting were not included in the calculation of the EERI. In this way the interpretation of the EERI can be performed while factoring in the contributing indicators. This permits both assessment, as well as prioritization, of the areas that are most lacking.

5.1.3 The 2009 EERI values and their interpretation

In preparing the EERI methodology, assessments were performed for a sample of countries that represent different levels of development from the perspective of environmental management and ICT diffusion. The results can be seen in Table 4 below for the sample countries. Higher scores are better. A score of 10 is the highest score achievable.

This tiered approach to reporting the EERI shows the factors that contribute to the first tier value of the EERI. Breaking down and listing the index components in this way helps to identify factors that influence the overall score and thus the ranking of a country. It also helps identify the issues that need to be addressed in order to strengthen the capacity of the country to use ICTs to mitigate the impact of climate change and to promote sustainable development.

The EERI scores are not directly correlated with the level of development, such as the Human Development Index (HDI) of a country, because the measures and indicators used are different. A strong ICT infrastructure is a major factor in the EERI score of an individual country. Similarly, the importance attached by a country to environmental protection and conservation can strongly impact the EERI.

In the sample listing of EERI scores in Table 4 below, Sweden scores the highest because of the strength of its ICT infrastructure, human capital and factors contributing to sound environmental management. Countries like Canada and Korea score relatively lower than Sweden due to factors such as the extent of GHG generation in those countries. Canada has a particularly low score on GHG emissions because of that country's reliance on fossil fuels. In contrast, Chile scores relatively closely to Canada because of low GHG emissions related to energy consumption, combined with a strong ICT infrastructure.

Applying the EERI helps to identify opportunities for realizing efficiencies and savings in GHG emissions and energy consumption through the use of ICTs and for strengthening the capacity of countries to do so. A detailed analysis of the component results of the EERI can also identify environmental concerns that may need to be recognized and addressed.

Table 4: EERI Calculation
Example for a sample of countries

	First Level EERI	**Normalized ICT Summary Indicator**	Applications	e-Environment	Energy Quality	Human Capacity	Infrastructure	**Normalized Environmental Summary Indicator**	Biodiversity	Green-house gases	Long-term preparedness	Policy & Public Awareness
Mongolia	**4.6**	**3.0**	4.0	3.1	2.6	3.6	1.9	**6.2**	3.5	8.7	6.4	5.7
Ethiopia	**4.0**	**2.3**	1.4	4.7	3.7	0.9	0.4	**5.6**	4.4	10.0	5.9	1.2
Chad	**3.4**	**1.4**	1.1	3.1	...	...	0.0	**5.4**	2.3	10.0	6.6	0.0
Kyrgyzstan	**4.3**	**3.5**	3.0	4.7	2.2	6.0	1.7	**5.0**	0.8	9.6	4.3	5.7
Chile	**6.5**	**5.9**	6.1	8.4	5.1	5.0	4.9	**7.2**	4.7	8.5	7.4	7.5
Guatemala	**5.6**	**3.8**	4.4	4.7	4.7	2.0	3.2	**7.3**	8.2	9.6	7.3	4.1
Trinidad and Tobago	**7.1**	**5.3**	4.7	4.7	7.9	3.6	5.0	**8.9**	9.7	10.0	7.8	9.9
Sweden	**7.9**	**8.5**	9.3	8.4	7.7	9.5	7.5	**7.4**	1.8	7.9	8.3	10.0
Canada	**7.1**	**8.4**	8.8	10.0	7.5	7.6	8.4	**5.7**	2.1	2.0	8.2	7.5
Korea, Republic of	**6.7**	**7.7**	8.6	8.4	5.9	7.8	7.9	**5.8**	1.1	6.1	6.6	8.3

Source: ITU.

Areas that are of specific interest can be isolated and then analyzed further using more detailed data analysis and/or other indicators. Because historical data exists, time series analysis can also be undertaken to identify multiyear trends in each segment of the EERI and overall. This can help understand where degradation or improvements have taken place and the factors that may have been responsible for causing these changes. In addition it is possible to do comparative analysis with other countries.

The EERI presents some of the following advantages and properties:

1. The Toolkit is a planning tool, an aide to decision-making, a tool to consider available options. As part of the Toolkit, the EERI could therefore be used as a preliminary part of the assessment phase of a strategy, plan or proposal because the data already exist and are relatively easy to calculate.
2. The EERI is a relative measure in that it allows comparison between countries, jurisdictions, organizations, communities and even al lower scales of aggregation. A more detailed measure can be obtained by undertaking research on a more extensive list of second tier indicators, discussed below, and would be required as part of a more detailed strategic planning exercise.
3. The Toolkit, along with the EERI, are readiness assessment tools that are to be used as part of a strategy to reduce GHG emissions and energy use while making best use of ICTs to achieve broader development objectives. For the purpose of this report, the main priority is to apply the Toolkit and the EERI at the national level, that is, in support of government policy making.
4. The Toolkit is a scalable tool. In contrast, the EERI applies at the country level and is not scalable. This is because the data for the first tier indicators used for the EERI is usually not collected below the country level, that is, at the local and community level, at the regional level, or at the organizational level.
    - However, the Toolkit can also be used to do an e-sustainability readiness assessment at the region, district, municipality, community and organization level.
    - The many indicators in the broader Toolkit can be used to assess e-readiness in more absolute terms, and people or organizations can also develop their own EERI, based on primary research.
    - Scalability allows for ready comparison between entities. In established indices, such as the Human Development Index (HDI), the tendency is to establish the index at the national level and then to move down to the regional and/or district levels, to allow comparisons of performance across regions or districts and determine appropriate policy action. The same idea would apply to the EERI. In both cases, research needs to be undertaken to collect the data on the indicators, as it is unlikely that the values of the indicators are already known.
5. The Toolkit and the EERI consider both negative and positive impacts of ICTs on the environment and GHG emissions.
6. The EERI can help shed light on the potential for reducing GHG emissions and energy use through the use of ICTs in a given country or jurisdiction.
7. The EERI could be useful in helping to substantiate or justify compliance or action on environmental change in general, and climate change, in particular.

5.2 Criteria for selecting indicators for the EERI

The following are some other criteria that are suggested for selecting indicators for the EERI:

- The indicator must be measurable and quantifiable;
- It is preferable if the indicator can be readily computed from easily or existing available facts, data or information. It is better still if the indicator data is available over the Internet. However, in many jurisdictions, the complete sets of data will not be available and will have

to be collected and computed first hand and in a scientific manner. In other cases, although data may be available at a national level (such as in the case of ITU statistics), the granularity may not be sufficient for a local jurisdiction, organization or sector analysis. The EERI encourages more detailed investigation at the local level as a way of acquiring empirical evidence and knowledge of readiness and the factors that influence readiness.

- The indicator must be easily understood and communicable;
- The indicator must reflect the situation being measured;
- The value obtained for a given indicator should be replicable; that is, the indicator can be applied by several and different people and yield comparable, if not the exact same results, based on the use of a common method of calculation and similar assumptions;
- The simpler the indicator is to understand and use, the better the indicator is;
- The indicator can be readily calculated based on published methodologies.

5.3 A two-tiered approach to developing indicators

For the purposes of this report, a list of factors that influence e-sustainability is presented in the form of first and second tier indicators. For the purposes of efficiency and simplicity, indicators considered to be most valuable in assessing impact are considered for the EERI. These are first tier indicators. The other indicators are the second tier indicators. These indicators along with the EERI are used for the more in depth analysis that the Toolkit proposes as part of the e-sustainability strategic planning process and to permit comparisons at other scales of analysis such as a community, a region of a country, an organization, etc.

5.3.1 First tier indicators

The first tier indicators are key indicators of the state or status of a particular relevant factor. The first tier indicators are measurable and most importantly, data about these indicators is readily available, usually online. Because they are important, these indicators provide a clear idea of the state and value of the variable or factor under consideration.

First tier indicators:

- Have a significant impact on e-sustainability;
- Are easy to measure;
- Are easy to understand;
- Are derived from official sources, usually national statistics offices working in collaboration with international organizations or networks;
- Are collected based on clear and scientific methods of data collection and analysis;
- Are recognized in the literature and otherwise as being important;
- Use data that may readily be available or readily derived from other existing indicators;
- May be used to measure or explain or influence a system state, as opposed to an individual environmental and/or sustainability variable;
- Are readily available to all users with an Internet connection; and
- Can be readily derived, applying published methodology, in cases where the data may not already exist, for example when undertaking an EERI assessment at a scale other than the country level.

5.3.2 Second tier indicators

The second tier indicators are useful for providing a more complete picture of the situation. Second tier indicators are also adaptable to being used at a more discrete scale and level of analysis. For example, in order to obtain an idea of readiness at the local and community level, in a district or in an organization for example. The second tier indicators provide more granularity. Data on these indicators may be published, but is not available for all countries.

Second tier indicators are:

- Based on many variables;
- More difficult to acquire and/or measure the data;
- More likely to be a derived value, based on primary indicators; and
- Do not have as important an impact on the EERI individually, but provide more detailed analysis and understanding when used together than the first tier indicators.

Using both the first and second tier indicators allow a more complete analysis and understanding of the situation. When discussing readiness for using ICTs for environmental sustainability, the use of second tier indicators along with the first tier indicators will help provide a better understanding of the state of readiness and of the options to consider in crafting an e-sustainability strategy.

6 CATEGORIES OF INDICATORS

The EERI is based on several types of indicators that are grouped under the following two categories: 1) ICT readiness indicators and 2) environmental and sustainability readiness indicators. The ICT readiness indicators measure the extent to which a country uses ICTs and its potential to adapt ICT use to meet new challenges and development goals. Environmental and sustainability readiness indicators, on the other hand, measure the readiness of a country to act to protect and conserve the environment and to promote sustainable development.[61] The latter category of indicators measures preparedness to mitigate and adapt to environmental change in general, and climate change, in particular. Environmental and sustainability readiness also recognizes existing achievements.

Each of these categories of indicators is described in more detail below and in Appendix 1 of the report.

6.1 ICT readiness indicators

ICT readiness considers all factors that affect the ability of a country and of its citizens, organizations and communities to use ICTs. Some of these indicators, such as the "ICT Infrastructure Indicators", measure access to the ICT service in question. Others measure factors that affect the capacity of people, organizations, the private sector and communities to make beneficial use of ICTs. Because of the importance of the private sector in driving the economy, factors that influence the ability of the private sector to use ICTs are of particular concern.

6.1.1 Indicators measuring general readiness to use ICTs and specifically to use ICTs in the environment area

- ICT infrastructure indicators (details below)
- Policy indicators:
    - Policies supportive of the private sector and especially of small and medium sized enterprises (SMEs):

[61] Sustainable development is defined as per the definition used by Brundtland in "Our Common Future". See http://sdgateway.net/introsd/definitions.htm.

    - Rankings in the "Doing Business" annual reports prepared by the World Bank[62]
  - Competition policy:
    - Signatory of the General Agreement on Trade in Services (GATS) and of the Agreement on Basic Telecommunications (ABT) that are also part of the WTO agreements;
    - Implementation of the GATS and ABT and related WTO agreements.
  - Trade promotion, integration and harmonization policies:
    - Adherence to the WTO
  - Protection of intellectual property (IP):
    - Indicators measuring level of protection of intellectual property (IP) rights:
      - Legislation;
      - Membership in the World Trade Organization, and signatory of the trade-related aspects of intellectual property rights (TRIPS) agreement;
      - Signatory of international treaties regarding IP (WIPO copyright treaties);
    - Indicators measuring the effectiveness of the legislation:
      - Application of the law by the courts;
      - TRIPS include strong measures to ensure compliance.
  - Consumer protection policies:
    - Membership in the International Consumer Protection and Enforcement Network (ICPEN)[63]
  - ICT specific policies:
    - National ICT vision, strategy and action plan;
    - Telecommunication policy, including policies related to universal access: GATS and ABT, as part of WTO obligations;
    - e-Business, e-government, e-commerce, SchoolNet, local and community access, etc.
- Energy availability and quality indicators (see below);
- ICT applications, including e-government and e-commerce indicators:
  - e-Government indicators;
  - e-Commerce indicators;
  - e-Environment indicators measuring the diffusion of ICTs in the environment sector. (The e-Environment indicators are to be described separately of the other non-environment related ICT applications).
  - Data management indicators:
    - Recognition of the legality of digital data;

[62] See http://www.doingbusiness.org/.
[63] See http://www.icpen.org/.

    - Data availability / collection capacity, data security and other indicators are also components of this indicator. The presence of a central data server in government is part of this;
    - Highest marks would be assigned to countries with an integrated data management system and centralized servers as part of e-government shared services offerings.
- Human (ICT) capacity indicators:
  - Number of certified ICT technicians, i.e. MCSE, CCNA, etc.;
  - Number of private sector ICT service and maintenance providers: Microsoft Solutions Partners, HP, and other corporate partners;
  - Number of ICT training centres in the public (universities, technical colleges, etc.), as well as the private sector, providing internationally recognized ICT certification or equivalent.

6.2 Environmental and sustainability readiness indicators

Environmental and sustainability readiness indicators measure the commitment and action of a country to manage and conserve the environment and to help mitigate and adapt to environmental change in general, and climate change, in particular.

- Public awareness of environmental issues and readiness to act on these issues:
  - Number of environmental groups and NGOs, including consumer groups and organizations;
  - Coverage of environmental issues in the media: Percentage coverage as measured by number and percentage of articles, interviews, mentions in coverage, etc.;
  - Results of relevant public opinion polls and market surveys.
- Policy (enabling environment) indicators:
  - Existence of policies, legislation and proven court action protecting the environment and promoting sustainable development;
  - Existence of policies, legislation and proven court action that address climate change (mitigation and/or adaptation);
  - Existence of policies promoting energy conservation;
  - Existence of policies promoting the use of renewable energy;
  - Existence of a carbon trading scheme;
  - Number of environmental and climate change conventions a country is signatory to:
    - Measurable action that countries have taken to honour their obligations under international environmental and related treaties.
- Innovation and R&D indicators:
  - Institutional capacity indicators:
    - Number of PhDs, research grants, participation in global research networks, number of scientific papers published, number of reports commissioned, participation in global supply chains, collaboration with TNCs (trans-national corporations, etc.
  - Indicators that measure general research readiness and capacity;

- Indicators that measure readiness and capacity for environmental R&D, management and sustainability.

- Preparedness to deal with changing environmental events over longer time scales;
- Preparedness to deal with rapidly changing environmental events (short time scale events).

A more detailed discussion of indicators appears in Appendix 1: Discussion of Indicators. This includes information on how these indicators complement the EERI and can be used to help develop a more detailed e-sustainability strategy and plan, as well as help derive an e-sustainability strategy for entities below country scale, such as a region or district, municipalities, communities and organizations.

7 Policy Implications: Integrating the e-Environment Toolkit in e-Sustainability Strategies and Action Plans

Assessing readiness to use ICTs, as well as analyzing what processes and practices could benefit the most from the use of ICTs to reduce greenhouse gas emissions and make better use of existing energy resources, is the first step in developing a comprehensive e-sustainability strategy and plan.

However, ultimately, policy decisions are needed to act on the results of the assessment in order to strengthen the capacity of developing countries to take actions that will enhance their capacity to use ICTs for making better use of existing energy resources and to further limit their carbon footprint. As the world moves to a post Kyoto agreement on emissions, it is clear that technology transfer will have a large part to play in helping the developing world deal with climate change.

The e-Environment Toolkit will help to identify the areas of greatest concern, as well as some of the technologies and related management practices that could be used to address these concerns in developing countries and elsewhere.

8 Next Steps

The methodology proposed here needs to be further refined and then adapted by testing it in a few countries. As a first step, it is recommended for the Toolkit methodology to be submitted to a "desk based assessment" of several countries around the world, using secondary research and existing data. This assessment would consider the present energy use and GHG emission profiles of these countries, as well as their EERI scores. Other information and data derived from Web based research, as well as consultation with a select number of experts, could also be used to help determine readiness to use ICTs for e-sustainability.

Countries could be selected based on a combination of factors, such as their gross national product (GNP) to identify low, lower middle, middle, upper middle and high income countries, as is used by the ITU in compiling ICT indicators. Other factors could be the EERI score of countries; the need to ensure a geographic balance in the choice of countries; or even countries more subject to the impact of climate change, such as small island developing states (SIDS).

Once the selection criteria have been determined, using existing data, much of which is published on the Web, an assessment of how ICTs could be used to reduce and / or help conserve energy consumption in the countries selected would be undertaken. Based on the nature of the economic activity, as well as existing research and consulting with some experts in the energy sector, it may be possible to come up with estimates for energy consumption and the extent to which ICTs could contribute to reducing consumption or more likely, to help make better use of existing energy generating capacity.

Once this secondary research has been completed, it will be possible to undertake a more detailed and empirical in-country assessment with the financial and expert support of organizations such as the UNDP, the World Bank, the regional development banks, as well as other international partners with a strong interest in using ICTs for development, such as the Korea International Cooperation Agency (KOICA).

Doing an initial desk-based assessment of the potential for using ICTs to mitigate climate change in several countries could be a way forward, since planning and undertaking a country-based assessment will take time and much more financial support than presently available. Proceeding using the steps suggested above would allow time for ITU to publicize the Toolkit and engage more partners in this endeavour.

Once an in-country assessment has been undertaken, the next step will be to develop a strategy with priorities for action clearly identified, as well as policies and interventions to support these conclusions.

The net benefit is expected to be a better understanding of how ICTs could be used to assist countries in meeting the mitigation and adaptation objectives agreed by the international community. This could serve as part of a national climate change mitigation / adaptation strategy.

APPENDIX 1. DISCUSSION OF INDICATORS

ICT readiness indicators

e-Readiness means the state of preparedness of a country, jurisdiction or other entity to make beneficial use of ICTs for development (ICT4D). Much work has already been done in the concept of e-readiness and some of it is summarized by Bridges.Org[64], a South Africa based NGO. Similarly, much work has and continues to be done on the use of ICT indicators by a variety of international organizations.[65]

e-Readiness assessments are based on the use of various indicators. The "*Network Readiness Index*" (NRI), published yearly by the World Economic Forum (WEF), looks at the readiness of countries and businesses to use ICTs. Similarly, the Economist Intelligence Unit (EIU) publishes e-readiness rankings annually[66] and modifies these rankings to reflect changes in technology and ICT diffusion globally. The earlier editions of the EIU e-readiness reports focused mostly on the economic development aspects of ICT use at the country level. The most recent editions are much more inclusive and look at a much broader range of development sectors.

For indicators of ICT use, the ITU is the main source of data. The ITU data are collected by national reporting agencies working with the ITU. Other indicators are computed regularly using the ITU indicators and other sources of information. In this area, the World Economic Forum (WEF) publishes the "*Network Readiness Index*" (NRI), which reflects the diffusion of ICTs in one of any 125 or so countries.

However, of these usual ICT indicators, those that are most relevant will reflect on e-Environment applications or uses that depend on the availability of broadband services; the prevalence of wireless networks; the use of sensor networks; the availability of computers, databases, database management systems, servers and server farms; electricity, as well as the engineering infrastructure, along with the human and institutional resources required to make beneficial use of these tools for environmental research, management and action.

As per the ITU "*Telecom Indicator Handbook*",[67] the EERI uses both measured and derived indicators. A listing and description of all of the indicators can be found in the accompanying ITU website for the EERI at http://www.itu.int/ITU-D/cyb/app/EERI.html. In the spreadsheet under the "Tier 1-2-3 Indicator List" worksheet, first tier indicators appear in green and other indicators appears either in yellow or pink.

ICT infrastructure indicators

These indicators measure the availability of ICTs in a country or jurisdiction in general, as this will influence the extent to which ICT infrastructure is available for environmental management and as a tool to promote environmental sustainability at all levels, including at the local and community levels.

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[64] See http://www.bridges.org/e_readiness_assessment.

[65] See, for example, UNCTAD (2006). *Welcome to the measuring ICT Website*. Available at http://new.unctad.org/default____575.aspx or UN ICT Task Force (2005). *Measuring ICT: The global status of ICT indicators.* Partnerships on measuring ICT for development. UN ICT Task Force. New York. 184 pp. Available at http://www.itu.int/ITU-D/ict/partnership/material/05-42742%20GLOBAL%20ICT.pdf.

[66] Economist Intelligence Unit (EIU) (2008). *E-readiness rankings 2008: Maintaining momentum*. A white paper from the Economist Intelligence Unit. The Economist, New York. 25 pp. See http://www.eiu.com/site_info.asp?info_name=ibm_ereadiness&page=noads.

[67] ITU. *Telecom Indicator Handbook*. Multilingual edition: Fr, En and Es. 115 pp. No publication date given. Version 1.1. See http://www.itu.int/ITU-D/ict/material/handbook.pdf.

These indicators are to be grouped together to obtain an estimate of:

- The amount of fixed and wireless broadband available throughout a country or jurisdiction;
- The extent of fixed and wireless broadband penetration throughout the country or jurisdiction and its availability;
- The extent of wireless coverage in a country that can be used for gathering and sharing environmental information at the local and community levels, for example;
- Internet availability;
- Extent of national coverage and quality of the electric power supply (rural electrification);
- The availability and level of penetration of newer consumer friendly technologies, such as smart phones like the Apple iPhone, the RIM Storm and other comparable devices, as well as other technologies that are comparable to those available in industrialized countries.

Some possible ICT infrastructure indicators groupings are provided by the ITU[68] and other agencies. The indicators in bold are proposed as first tier indicators:

- Indicators measuring access to power for ICT use:
    - **Percentage of households and communities electrified**
        - Amperage and type of electrification: for social lighting, recharging devices, etc. vs. for powering appliances, for space heating, for small scale industrial applications, etc.
    - Quality and reliability of electricity for powering electric motors and electronic devices: are standby generators or batteries and/or power line sanitizers or stabilizers required to operate ICTs from the mains?
- ICT infrastructure access indicators showing the type and availability of installed broadband infrastructure:
    - **Lowest cost of broadband, expressed as a percentage of income;**
    - Total fixed broadband Internet subscribers:
        - **Total fixed broadband Internet subscribers per 100 inhabitants. This is an indirect measure of Internet penetration; or**
        - **Percentage of households with fixed broadband access:**
            - Percentage of households in urban and rural areas with broadband access;
    - International Internet Bandwidth (Mbps):
        - **International Internet bandwidth per inhabitant (bits/s)**. This is a measure of broadband supply;
        - Wholesale cost per Mbps of Internet bandwidth;
        - Nature and percentage of connection to the global Internet backbone coming from:
            - Satellite
            - Fibre

[68] ITU (2007). *Definitions of world telecommunication/ICT indicators. Final Version* (April 2007). 10 pp. See http://www.itu.int/ITU-D/ict/material/IndDef_e_v2007.pdf.

        - Microwave
        - Others
    - Number of wireless hotspots;
    - Mobile cellular telephone subscribers - (Post-paid + Pre-paid):
        - Mobile cellular telephone subscribers (Digital);
        - **Number of mobile cellular subscribers with access to data communications at broadband speeds (per 100 inhabitants):**
            - Number and percentage of cellular phone subscribers using smart phones such as the iPhone, the Storm, etc.
        - **Percent of population within the reach of a cellular network signal.**
    - **Cost of a mobile telephone voice call as a percentage of income;**
    - Availability of mobile "smart" IP devices, such as the iPhone, the Storm and other smart phones:
        - Cost of mobile access to "smart" IP services: email, Web based services, instant messaging (IM), specialized applications, etc.
    - **Number of Internet hosts:**
        - Number of secure servers (to measure extent of e-commerce – see below);
        - Number of Web sites / pages
    - Estimated Internet users:
        - **Internet users per 100 inhabitants;**
        - Fixed vs. mobile (i.e. via smart phones) Internet users.

Several of these technologies are required to allow users to benefit from the second and third order impacts of ICT use. For example, for people to benefit from increased service delivery as a result of the diffusion and adoption of e-government and/or e-commerce services, and thus to benefit from easier and less energy intensive and also less expensive service delivery, they will need to be able to access the Internet using increasingly "smarter" cell phones, which in turn will require increasingly faster broadband connections.

Similarly, these technologies will also benefit people who want information about and services related to the environment, so they can be made aware of environmental issues and perhaps even participate in the management of the environment.

The first tier ICT infrastructure indicators to be used in the EERI are:

- International Internet bandwidth per inhabitant (bits/s);
- Total number of telephone subscribers (fixed + mobile) per 100 inhabitants;
- Broadband subscribers per 100 inhabitants; and
- Internet users per 100 inhabitants.

These first tier indicators provide an indication of existing and potential diffusion of the ICT infrastructure required to take the greatest advantage possible of ICTs for environmental sustainability. The key issue here of course is connectivity. If access to ICTs is universal, then ICT infrastructure will not be a factor limiting the use of e-Environment and related applications.

ICT application indicators

ICT infrastructure without content and applications is like a car without a driver. ICT application indicators are a measure of the extent of automation of business processes in general, and of environmental business processes, in particular. Highly integrated and transformative processes, such as e-government and e-commerce and component applications are especially important here.

One of these "component" applications is supply chain integration through the use of ICTs to link buyers and suppliers. It has been demonstrated that significant savings in energy use and GHG emissions have been attained through the use of these technologies (see the ITU "*ICTs for e-Environment*" report for more details). There are several others and they are described below.

General ICT application indicators

- Diffusion of e-business in general and of e-commerce and e-government, in particular, throughout the country, including at the local and community levels. Use of e-commerce and e-government and related rankings published by the United Nations Department of Economic and Social Affairs (UN DESA), Accenture, as well as indicators developed and published by the World Economic Forum (WEF) in its annual "*Network Readiness Index*" (NRI) and the "*Global Information Technology Report*" (GITR).
    - E-government rankings:
        - Accenture's ranking: Only top performing countries are ranked in this list. This list is based on extensive applied research undertaken by Accenture.
        - List developed by UN DESA: Most countries are ranked in this list; the list is developed by collecting information on a series of indicators.
    - Use of sector specific e-government and e-commerce applications: e-Health, distance learning, telemedicine, etc.
    - The ITU "*ICTs for e-Environment*" report estimates significant financial and environmental savings associated with the use of e-business and related applications and services. Countries and jurisdictions that promote and adopt e-business, including e-commerce and e-government, are clearly supporting environmental sustainability.
    - The availability of community access facilities (CACs) at the local and community levels as measured using some of the following community access indicators proposed by the ITU:
        - PIAC5: Total number of public Internet access centres (PIAC);
        - PIAC6: Total number of Digital Community Centres (DCC);
        - PIAC7: Total number of other public Internet access centres (PIAC);
        - PIAC3: Number of localities with public Internet access centres (PIAC);
        - PIAC1: Percentage of localities with public Internet access centres (PIAC); and
        - PIAC2: Percentage of the population with access to a public Internet access centre (PIAC).
- The use of e-procurement systems to increase efficiency, reduce corruption and reduce environmental waste associated with paper-based procurement processes and documents; the reliance of courier services and fax for delivering hard copies of procurement documents, as well as contracts and related are important considerations.

- o E-procurement contributes significantly to dematerialization. When the Government of Canada introduced the Merx online procurement system in the 1990, it saved over 6 million Canadian dollars in photocopying, courier and handling costs in the first year of operation alone.
  - o The greatest impact of e-procurement is on business. As a result of introducing e-procurement applications, businesses are more likely to adopt e-business and increase the efficiency of their operations, as well as lower the carbon footprint of their operations by moving their operations online. e-Procurement systems are a bell weather indicator of ICT adoption by the private sector and can be the first step in helping a country move to compete in the information economy and to attract the type of efficiency savings that promote environmental sustainability and help reduce GHG emissions.

- The use of open standards to ensure interoperability;
- The extent of the use of videoconferencing and VoIP tools;
- The extent of use of virtual presence tools;
- The prevalence of telecommuting.

The first tier indicators are:

- The Network Readiness Index score (NRI);
- The e-government ranking of a country or jurisdiction (UNPAN);
- The number of secure servers as a measure of the extent of e-commerce.[69]

Some of the indicators used in the compilation of the "*Network Readiness Index*" and of other indexes may also be useful.

Human (ICT) capacity indicators

- Indicators of human capacity to use ICTs at the technical, managerial, institutional and community levels.
  - o General technical skills indicators at the country or jurisdiction level;
  - o Specific skills indicators in the research and academic environments, and specifically among the community dealing with issues related to environmental sustainability and related issues;
  - o Effect of the brain drain on the availability of ICT technicians and experts.[70]
- A useful and internationally available and comparable indicator could be based on or chosen from the World Bank Knowledge Assessment Methodology (KAM).[71] The "*Knowledge Economy Index*" (KEI), an index derived from the KAM may also include this information.
- Innovation and R&D indicators
  - o This indicator is related to public support, that is, to government policies that promote research and development in the public interest. As with other activities, research is dependent on the use of ICTs.

[69] See http://news.netcraft.com/SSL-Survey/CMatch/.
[70] Measuring this would require undertaking as survey at the local level. Employment or labour market surveys would yield this information. This information would be available locally through the private sector and/or the department of labour or employment. The National Statistics Office would probably have this or equivalent information.
[71] World Bank (2008). *Knowledge Assessment Methodology*. See http://go.worldbank.org/JGAO5XE940.

- Innovation index, such as the Technology Achievement Index (TAI) proposed by UNDP in 2001 and made up of the following components:
  - – Number of centres of innovation (46 as per the UNDP Human Development Report 2001);
  - – Also, a recent survey (2008) on venture capital and the best centres of technology innovation worldwide also published in a recent edition of Business Week.

Energy availability and quality indicators

These indicators measure the overall availability and cost, both in monetary and environmental terms, of the energy sources available. The indicators also look at the source of energy for national power generation. The level of energy generation from alternative sources is given as a measure of readiness for environmental sustainability.

Energy has to first be available to run servers, data centres and network components, and the cost has to be such that it is not prohibitive for government officials and departments, as well as for environmental researchers and organizations who want to use ICTs for environmental research, observation, data gathering and analysis or management.

The availability of already exploited, as well as readily exploitable renewable sources of energy enhances the readiness score by reducing the carbon footprint of the ICTs used.

The extent to which a country has adopted energy conservation measures is also a measure of readiness for e-Environment. This indicator is associated with indicators related to policy and the enabling conditions that are in place to encourage the use of ICTs to promote environmental sustainability (see below).

If a country is to exploit the advantages of ICTs for environmental sustainability, then it is likely to also adopt accompanying measures, such as energy conservation and other steps to reduce the carbon footprint in its activities.

A related indicator will be the extent and seriousness of policies, including incentives, for promoting alternative energy generation and its adoption by consumers and businesses. So the existence of credits for alternative energy generation, as well as the possibility of selling back energy generated from alternative sources, would be two other indicators of environmental sustainability. There are probably others. Policy indicators are explained in more detail below.

The first tier indicators are:

- The cost, availability (extent of electrification), quality and reliability of electrical energy;
  - **Percentage of the population with access to electricity**[72]
- **The relative carbon footprint of existing energy generation technologies, that is, the Kg Carbon emitted / kWh generated**:
  - Fossil fuel: coal, gas, petrol vs.
  - Renewable: hydro, solar, geothermal, wind, heat pump, etc.

The cost and availability of energy will affect the use of ICTs for environmental research and management, among other activities. However, the cost and availability of energy also means that the efficiencies that may arise from the use of ICTs, that is, the second and third order effects of ICT use, could be even more important than otherwise.

[72] See http://hdrstats.undp.org/indicators/210.html for details.

Indicators of the use of ICTs for environmental sustainability

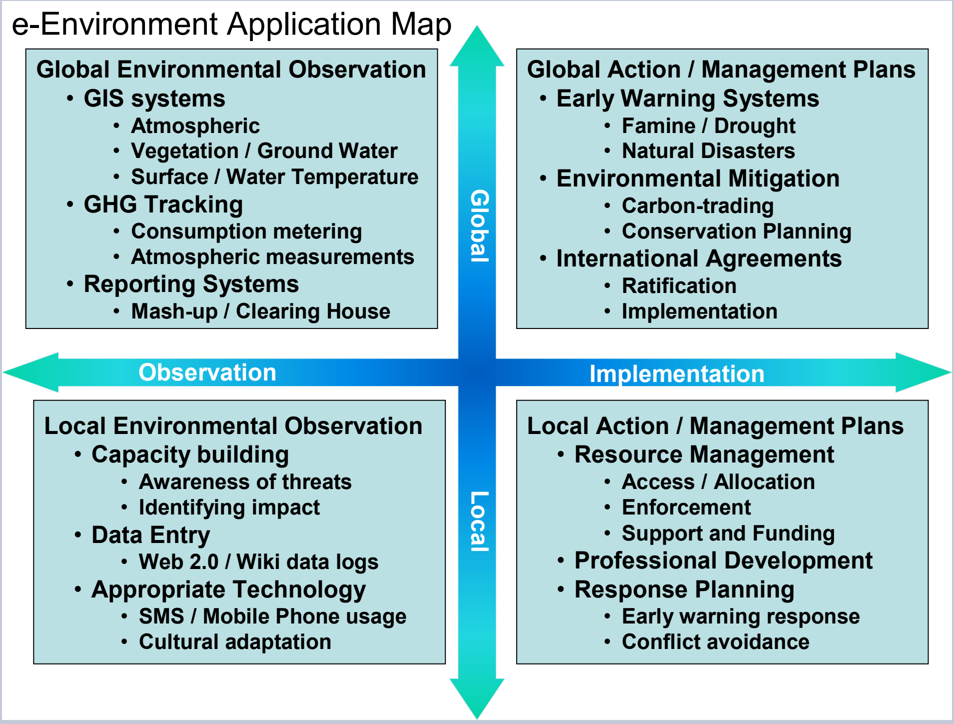
e-Environment indicators

- Extent of participation in global initiatives sharing environmental data and information, especially in digital form. Possible indicators here would be:
    - Extent of research networking with environmental sustainability groups in and outside the country or jurisdiction;
    - Membership / participation in the Group on Earth Observations (GEO) and Global Earth Observation System of Systems (GEOSS) initiatives and in other similar initiatives, such as the World Database for Protected Areas, operated by the United Nations Environment Programme's (UNEP) World Conservation Monitoring Centre (WCMC) and managed in cooperation with IUCN and the World Commission on Protected Areas (WCPA), or the Global Biodiversity Information Facility (GBIF). In the case of the GBIF[73], it would refer to the number of organizations and other entities in a country or jurisdiction that are registered as data providers or the existence of a GBIF "Participant node".[74]
    - Format in which data are shared with partner agencies. If data cannot be shared in digital form, then this may be an important indicator of capacity or lack thereof.
- Extent of use of remote sensing programmes, projects and activities, as well as related applications:
    - Use of remote sensing at the national and more local levels:
        - – The use of battery operated data collection services;
        - – The use of wireless sensor networks (WSNs).
    - Participation in international remote sensing activities, such as:
        - – Famine Early Warning System (FEWS) in Africa;
        - – GEO and GEOSS.
    - Extent to which these applications are used for and feed into decision making:
        - – Existence of decision support systems feeding information to government and other decision makers, including early warning systems plugged into local governments and networks at the local and community levels.
- Applications used for acquiring, managing and analyzing data and even for sharing data. The use of applications such as GIS, Web 2 based services, knowledge management and sharing tools, such as wikis, blogs, podcasting, video streaming, etc. are also indicators of capacity to make beneficial use of technology.
    - Extent of use of GIS software:
        - – Do you use GIS applications?
        - – If so, which applications do you use?
        - – How would you rate your expertise with GIS applications?
            - Novice, mid level expertise, expert.
    - Extent of use of Web 2 based services, including service-oriented architecture (SOA), mashups, etc. allowing more ready access to global data sets.

[73] For more details and information as applied to the GBIF in this case, see http://www.gbif.org/DataProviders/HowTo/HowToRegister.html.
[74] See http://www.gbif.org/nodes/nodes.

The first tier indicator is obtained as a result of performing a review to see if the country has implemented applications in each of the quadrants in Figure 2 below. A score of 0 would indicate no e-Environment applications, whereas a score of 4 means that applications are being used in all four quadrants.

Figure 2: e-Environment Application Map



Source: ITU (2008). *ICTs for e-Environment. Guidelines for developing countries with a focus on climate change*. ITU. Geneva. See http://www.itu.int/ITU-D/cyb/app/docs/itu-icts-for-e-environment.pdf.

- Availability of data in general, and on the environment, in particular:
  - Existence of efforts to collect primary scientific data of importance to environmental sustainability;
  - Existence of research or other institutions housing or collecting environmental information and data for scientific or applied research:

    – Research centres, universities, museums, herbaria, xylariums
  - Existence of data in analogue form;
  - Existence of data in digital form;
  - Use of database software (relational database management systems, geographic information systems (GIS), etc.) to manage environmental data and information, including spatial information.
- Capacity to use the data for policy making: Existence of trained staff, ability to integrate environmental data into decision making at all levels:

    - Existence of decision support systems to assess and use environmental data for decision-making.
- Extent of exchange of environmental data through research and academic networks, as well as through international mechanisms, such as the UNFCCC, UNCDD, the Biodiversity Convention, etc.
- Amount of data exchanged:
    - Analogue data sets: nature, size and quality (usability);
    - Digital data sets: nature, size and quality (usability).
- Use of data exchange standards, such as the Darwin Core for the "exchange of information about the geographic occurrence of species and the existence of specimens in collections".[75]

Environmental and e-sustainability policy indicators

Public awareness of environmental issues and readiness to act on these issues

This indicator or group of indicators measure popular concern for environmental issues, as well as the readiness to act on these issues. This is useful in showing how predisposed the public may or may not be to the idea of environmental sustainability and the extent to which they may or may not consider promotion and action on environmental sustainability as a component of their "civic duty" or of action, if such a concept does indeed exist.

The following are some possible indicators:

- Public awareness of environmental issues in general, and environmental sustainability in the face of environmental and climate change, in particular. The objective of undertaking these polls is to measure the value people associate with environmental sustainability and the behavioural changes they are prepared to make to promote environmental sustainability:
    - Undertake or use results of existing public opinion polls on the environment to assess awareness and knowledge of the threat, as well as the solutions;
    - Indirect indicators come from the media, civil society, NGOs, grass root as well as local and community level organizations;
    - Public perceptions in a given jurisdiction related to environmental sustainability (as measured in opinion polls, market research and otherwise);
    - Public reaction to environmentally unsustainable developments, such as pollution, waste disposal, food poisoning, etc.;
    - Government reaction to public discontent about environmental degradation and unsustainable developments;
    - Ability of people to use networks to act on, observe and manage the environment and act quickly to deal with environmental events (existence of Regional Climate Outlook Forums).

First tier indicator:

- A possible indicator to be included refers to the results of polls on the opinion of citizens about environmental issues, such as atmospheric pollution, waste, and contamination of food supplies. Many public opinion polls now look at consumers and the public around the

[75] For more about the Darwin Core, see http://wiki.tdwg.org/twiki/bin/view/DarwinCore/WebHome.

world and their perceptions to similar environmental and other concerns. The results of some of these opinion polls have been commented in the ITU "*ICTs for e-Environment*" report.

Second tier indicators:

- Some of these indicators can be found at the following site: http://www.sustainablemeasures.com/Database/Environment.html.

Policy (enabling environment) indicators: Public sector

These indicators will provide an indication of official, that is, government awareness of environmental sustainability, as measured by existing policies, rules, regulations and their adoption and implementation under the law or as part of corporate governance. These indicators will help to determine how serious the government of a country is about e-Environment and related issues.

The appropriate indicators are to be determined, but are probably associated with rules and legislation, as well as their application by the courts and officials at all levels of government. These indicators measure public sector commitment to environmental sustainability.

Some of these policies would include the following as indicators:

- Presence of programmes to save the environment and promote sustainable development, such as recycling programmes and related activities.
    - Does the country have an up to date Environmental Action Plan?
        - Existence of climate change adaptation action plans or strategies or equivalent: National Adaptation Plan of Action (NAPA), National Capacity Self Assessment (NCSA) plans;[76]
    - Existence of state of the environment (SOE) or equivalent reporting and policies and actions that SOE reporting has led to;
    - Effectiveness and reach of these programmes.
- The name and number of international environmental conventions the country has signed on to:
    - Is the country a signatory of the Kyoto Convention? Has the country ratified the Kyoto Convention? Is the country an Annex I or Annex 2?
- National Capacity Self-Assessment (NCSA) Status:[77] This measures the extent of energy conservation policies, incentives, etc. The indicator is the priority that is assigned by the country to NCSA status.
    - The existence of a national plan to combat environmental change and, in particular, to combat climate change:
        - The existence of quantified targets for GHG emissions and related indicators.
- The importance attached to environmental policies and the extent to which these policies are implemented. This includes looking at incentives for promoting alternative energy generation, as well as the extent of its adoption by consumers and businesses.[78]

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[76] National Capacity Self-Assessment: Provide countries with the opportunity to identify capacity needs to address cross-cutting global environmental issues. Countries are encouraged to develop a plan of action to achieve global environmental management objectives in the context of the CBD, the UNFCCC and the UNCCD; OECD (2007). *Survey of agencies' country level activities on environment and development*, OECD, DAC Environet.

[77] See the EERI website for more details at www.itu.int/ITU-D/cyb/app/EERI.html.

[78] It is important to assess the extent to which policies are implemented by governments. Not all government policies are equal. This can and is readily done by looking at ratification and more important, the ability of citizens and companies to act through the courts to seek redress. If there is no rule of law and if stakeholders have no recourse, then

  - The existence of credits for alternative energy generation;
  - The possibility for consumers and businesses to sell energy generated from alternative sources back to the electricity grid.
- The existence and adoption of policies, incentives, research and development activities and credits / incentives, regulations and laws that promote energy / carbon emission savings (mitigation & adaptation policies):
  - EnergyStar[79] (USA), 80 Plus programme[80] - a programme funded by public utilities (USA), etc.
  - Policies that promote the use of telecommuting, VoIP, video and teleconferencing, virtual presence tools and dematerialization;
  - Policies that promote smart metering:
    - Policies allowing supply side management, allowing utilities, with the consent of and in collaboration with consumers, control over the scheduling of power consumption of intelligent and networked appliances;
    - Similar policies for intelligent buildings;
    - Similar policies for intelligent roadways and vehicles;
    - Others.
- The existence of functional carbon trading regimes and markets, consistent with international best practice:
  - Does the country or jurisdiction have carbon / GHG emissions / energy consumption auditing and reporting procedures and obligations and are these consistent with international best practice? Are these operational and do they make a difference?
    - The existence of a green auditing bureau in the public sector;
    - The existence of a green auditing practice area in the private sector;
    - Is there a market for green auditing in the country or jurisdiction in question and how has this market changed over time?
- The existence of national policies that encourage the adoption of energy / carbon saving standards and behaviour by the IT industry (government mandated):
  - Policies that promote the concept of power on demand, not power “always on”;
  - Next generation networks (NGNs) make use of more recent standards, such as VDSL2 (ITU-T G.993.2), which specifies three power modes (full power, low power and sleep), whereas VDSL has only a single power mode: full power.
- The existence of national and/or local policies and regulations that encourage and/or provide incentives or require the IT industry to reduce toxic waste:

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no number of laws, or matter of public pronouncements and attendance at international events can make up for this short coming. Unfortunately, in developing countries especially, “environmental law” exists, but has little standing and is regularly flouted. Furthermore, one has only to look at the extent to which some sectors receive funding from governments to measure the relative importance attached to policies. Of course, in many developing countries, budget shortfalls are very real and many policies are there because the donors wanted them or for window dressing. In fact, there is no way that many of these policies can be implemented because there are no funds or capacity, human, technical or otherwise, to do so. Countries that go out of their way to do something about climate change, especially in the developing world, should be recognized accordingly for the very reasons mentioned here.

[79] Energy Star (2009). Home – Energy Star. See http://www.energystar.gov/.

[80] 80plus (2009). *What is 80 Plus?* See http://www.80plus.org/80what.htm.

    - The European Union Environmental Directive (EUED) initiative for the Restriction of Hazardous Substances (RoHS);
    - The ease / difficulty of importing and treating industrial and post consumer waste, especially industrial and post consumer ICT waste. Countries that are a dumping ground for toxic industrial and post consumer waste would rate here.
- The number of court actions to support environmental sustainability and their resolution; that is, the number and nature of prosecutions and the percentage of successful prosecutions and the severity of the charges levied and the extent to which the penalties have been imposed.

Institutional readiness and human capacity for environmental R&D, management and sustainability

These are considerations related to the readiness of a country to undertake research and development work related to environmental sustainability. These indicators measure the availability of researchers in general, and environmental researchers, in particular. These indicators also measure the capacity for innovation of a country. One indicator refers to the factors, such as the number of inventions, measured by the number of patents developed and registered by national companies or by citizens.

Preparedness to deal with changing environmental events over longer time scales

This category of indicator deals with the biocapacity of a country, as defined in the World Wide Fund for Nature (WWF) report.

- The level of preparedness of a country, jurisdiction or organization to deal with environmental change and/or challenges that occur over longer time frames, such as sea level rise, deforestation or desertification, and increased levels of pollution. This could be broken down into ecological resilience, that is, the ecological absorptive capacity of a country, based on the ecosystems in that country and the resilience of the ecosystems. This is measured by biocapacity, for example. Along with ecological resilience, there is human preparedness.
    - Awareness of the importance of disaster risk reduction (DRR);
    - Hazards assessment: A measure of exposure to natural hazards;
    - Existence of a national DRR strategy and action plan:
        – A functional and well funded national DRR agency;
    - Response times in dealing with disasters and other emergencies;
    - Response (operational) capacity in dealing with disasters and other emergencies.
- Biocapacity indicators, such as those derived by agencies like the WWF. One of these is the "ecological footprint". A series of similar and related indicators have been derived by the WWF and are documented in the "ecological footprint" of nations. See the Living planet report (August 2008) "*Readiness of the public, government, as well as the private sector and civil society to use ICTs for environmental sustainability*".
    - A key indicator of human preparedness would be the level of funding for environmental mitigation, management and/or adaptation, as a measure of the recognition of the importance of dealing with environmental change.
    - Extent of use of ICTs and modern management practices to manage the environment.

The first tier indicator is:

- Biocapacity, as well as trends;
- Ecological footprint and trends;
- Percentage of land covered by forests and the Millennium Development Goals (MDGs) indicators.

Short-term preparedness

Indicators related to the existence of functioning emergency response systems and their performance in dealing with natural disasters and emergencies, such as hurricanes, floods, wild fires, tornadoes, earthquakes, and tsunamis.

Indicators include:[81]

- Awareness of the importance of disaster risk reduction;
- Hazards assessment: A measure of exposure to natural hazards;
- Existence of a national DRR strategy and action plan:
    - A functional and well funded national DRR agency;
- Integration or mainstreaming of DRR principles and practices in development planning and implementation;
- Response times in dealing with disasters and other emergencies;
- Response (operational) capacity in dealing with disasters and other emergencies.

[81] Some of these indicators are derived from the following publication: Tearfund (2005). *Mainstreaming disaster risk reduction. A tool for development organizations*, Teddington (UK), 20 pp.

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