Will Broadband Networks Make the World Greener?

Evaluating Pros and Cons of Broadband Development

Orada TEPPAYAYON, Erik BOHLIN
Chalmers University of Technology, Sweden

Simon FORGE
SCF Associats, UK

Abstract: The environmental issue has generally received much attention from the public for decades, especially as a result of heavy industry - electrical energy, oil and gas, mining, steel and metals. Recently, attention has been paid to Information and Communication Technology (ICT) and its effect on the knowledge and related industries. Broadband, both fixed and mobile, is not an exception. Even though it has been recognized as a factor that has contributed to social and economic development, a negative effect can also be seen in particular regarding the environment.
This paper provides a review of how government policy, in particular by the EU and Japan, are moving towards the transition to sustainability by utilizing ICT, as well as an evaluation of the pros and cons of broadband development. There are many complex effects on sustainability due to ICT. Since ICT can have environmental effects both as enabling energy efficiency and causing rebound effects, the policies should respond to both direct and indirect effects. To facilitate policy analysis and recommendations, this paper categorizes ICT impacts by five orders of aggregation. These five orders of aggregation may contribute both positively and negatively to sustainability, and each level will need targeted policies. The five orders of aggregation suggest a comprehensive and long term view of policy development, encompassing even policies that seek to improve the quality of decision making in our societies, by utilizing ICTs.
Key words: broadband, sustainable development, green ICT.

■ Broadband development and environment issue

> "Humanity has the ability to make the development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development - The "Brundtland Commission", UN,1987).

The issue of sustainability has been rising on the world scene as one of the most important issues for the future of mankind. Competitiveness and sustainability have previously been portrayed as opposites by both theoretical and empirical research, but there is a growing recognition that these two issues are mutually reinforcing.

Concurrently, it is generally recognised that the information society will be instrumental to growth and well-being in the 21st century. The information society has become a central organising principle for the future society, and a long-term strategic concern. Not surprisingly, then, there has been a growing desire to find ways in which the information society will promote sustainability, and where sustainability will reinforce the uptake of the information society.

The tension between the social good and industrial benefit that is inherent in the sustainability problem has been long recognized in social science. Traditionally, political science has studied man's behaviour in the public arena; economics has studied man in the market place. Political science has often assumed that political man pursues the public interest. Economics has assumed that all men pursue their private interest, and has modelled this behaviour with a logic unique among the social sciences (MUELLER, 2003). This dichotomy may be the same on the issue of sustainability in the future of broadband development. Most research on broadband development nowadays focuses on tools and strategies of encouraging its penetration and usage, in particular, the implementation of market mechanisms as the main strategies. However, where the environment and global warming are concerned, the issue of broadband development in the future may not only be about the market; it could also be an issue for the green society of all nations. In an increasingly globalized world, the role of broadband, the knowledge society and sustainability is all the more significant.

On the one hand, broadband is becoming vital for business and offers such competitive advantages that it is being compared to utilities such as water and electricity (UNCTAD, 2006). Broadband is widely accepted as having strategic importance to all countries because of its ability to accelerate the contribution of ICTs to economic growth in all sectors, enhance social and cultural development, and facilitate innovation. The results of broadband penetration can be evidenced in growth and productivity in many studies. Policies and measures have been initiated in most countries around the world with an aim to encourage broadband deployment (TEPPAYAYON & BOHLIN, 2009). In addition, as the world's electricity consumption is increasing (IEA, 2009b), broadband connection can help to reduce energy consumption, for instance by lowering transport needs, reducing logistic costs and improving cross-border trade and transportation in landlocked countries. In addition, broadband can also improve electricity generation and distribution and to improve environmental performance of urban systems and building.

On the other hand, the environmental issue has generally received much attention from the public for decades, especially as a result of heavy industry - electrical energy, oil and gas, mining, steel and metals. World total energy consumption and CO_2 emission have increased year by year (IEA, 2009b). Recently, attention has been paid to information and communication technology (ICT) and its effect on knowledge and related industries. Broadband, both fixed and mobile, is not an exception to the issue. Even though it has been recognized as a factor that has contributed to social and economic development, negative effects can also be seen. There are both direct and indirect effects of broadband on environmental sustainability. Direct effects include increased electricity use from ICT equipment and waste, while indirect effects relate to increased consumption of goods and sevices, fuelled by broadband. These indirect effects are typically devoted rebound effects (HILTY *et al*., 2006a), especially in the situation where adverse effects if increased ICT use come about as a secondary effect of initially desirable ICT use (i.e. reduced travel due to on-line shopping but more transport due to customised delivey).The increased use of sophisticated IT equipment and broadband has accelerated the flow of information and resulted in increased consumption of electrical power. As a result of broadband connectivity, energy consumption from devices such as handsets, PCs and terminal equipments can have environmental impacts such as the direct energy used by devices and the power consumption involved in connecting remote networks.

Therefore, new initiatives for green IT have been proposed for policy action in many countries, particularly OECD [1], the European Union and Japan. At the EU level, a green knowledge society has been proposed to the European Commission in September 2009 as an ICT policy agenda until 2015 for Europe's future knowledge society (European Commission, 2009a; 2009b). In Japan, the "Green IT initiative" has been proposed since 2007 by the Ministry of Economy, Trade, and Industry (METI) with an attempt to

[1] OECD (2009), "Towards green ICT strategies".

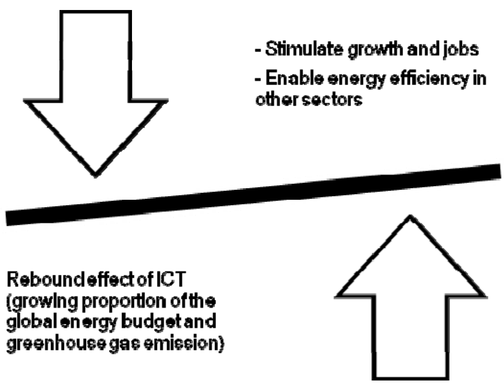
promote not only energy-saving products and technologies but an energy-saving system by introducing more efficient supply chains (MYOKEN, 2008).

Against this background, the paper will, on a descriptive basis, examine environmental issues arising from broadband development. Pros and cons of the development will be pointed out. Government initiatives, in particular by the EU and Japan, regarding the policy dealing with ICT sustainability will also be noted. Towards the end of the paper, the aggregation of fifth-order effects resulting from ICT together with future policy suggestions will be discussed.

Pros and cons of broadband development

Nowadays, broadband is widely accepted as having strategic importance to all countries because of its ability to accelerate the contribution of ICTs to economic growth in all sectors, enhance social and cultural development, and facilitate innovation. However, like other technology, it has both pros and cons. A literature review reveals some pros and cons of broadband development as shown in Figure 1 [2].

Figure 1 - Pros and cons of broadband development



[2] For an extensive treatment, see HILTY (2005), 'Information systems for sustainable development'.

Pros of broadband development

First, broadband connectivity can stimulate economic growth and jobs in regions or countries. Several studies reveal the same result on how broadband can contribute to and encourage growth in countries, as summarized in Table 1.

Table 1 - Research on broadband contribution to society

Study	*Result*
Lehr *et al*., 2006	Between 1998 and 2002, communities in which mass-market broadband was available by December 1999 experienced more rapid growth in employment, the number of businesses overall, and businesses in IT-intensive sectors, relative to comparable communities without broadband at that time.
MICUS 2008	In the EU, GDP growth has increased above average in the countries that have advanced knowledge societies, while below-average growth can be seen in countries that have less developed broadband. In addition, broadband-related employment growth in all economic sectors can be seen.
The Climate group 2008	Globally, the ICT sector contributed 16% of GDP growth from 2002 to 2007 and the sector itself has increased its share of GDP worldwide from 5.8 to 7.3%. The ICT sector's share of the economy is predicted to jump further to 8.7% of GDP worldwide from 2007 to 2020.
ITIF 2009	In the U.S., it is estimated that a spending of $10 billion USD of investment in 1 year in broadband networks will support an estimated 498,000 new or retained U.S. jobs for a year, of which 250,000 would be in small firms.

Secondly, broadband developments enable energy efficiency in other sectors. Aside from emissions associated with deforestation, the largest contribution to man-made GHG emissions comes from power generation and fuel used for transportation. It is therefore not surprising that the biggest role ICT could play is in helping to improve energy efficiency in power transmission and distribution (T&D), in buildings and factories that demand power, and in the use of transportation to deliver goods. According to one estimate, ICT could deliver approximately 7.8 $GtCO_2e$ of emissions savings in 2020. This represents 15% of emissions in 2020 based on a BAU estimation (Climate group, 2008).

Thus, the largest influence of ICT is potentially to be in enabling energy efficiencies in *other* sectors. According to the Climate Group, these could deliver CO_2 emissions savings five times greater than the total emissions from the entire ICT sector in 2020 (Climate Group, 2008). Up to 30 percent of energy savings worldwide are possible through better monitoring and management of electricity grids (Climate Group, 2008). Mobile communications alone could save 2.4 percent of total EU emissions by 2020 through efficiencies in industry and energy distribution practices (Vodafone, 2009). The EU's manufacturing sector accounts for 30 percent of its energy consumption. Applying ICTs across the value chain could make massive savings; e.g. intelligent motor drives could reduce electric motor consumption by 20-40 percent (European Commission, 2009b).

Cons of broadband development [3]

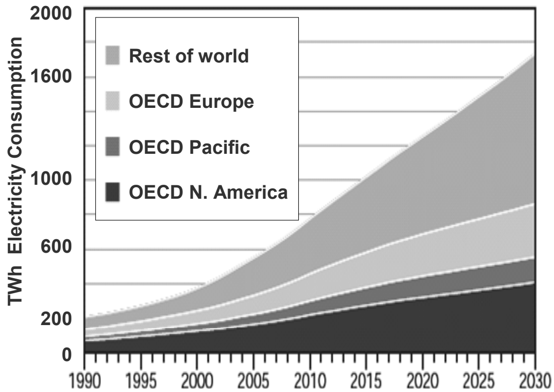
On the consumption side, ICTs take a growing proportion of the global energy budget and greenhouse gas emissions in themselves, be they for consumer goods, web searches or ICT use in business. CO_2 emissions from data centres are increasing with larger Internet web-server farms. Consumer ICT devices present the largest ICT energy load, especially mobile handsets, personal computers and TV sets (IEA, 2009a). There are some four billion mobile handsets globally, with about 500 million in Europe; they require recharging as well as energy consumption for manufacture and recycling on a vast scale. Never before have so many had such a critical need for electrical power for a personal device. ICT products and services consume some 7.8 percent of EU electricity and may grow to 10.5 percent by 2020 (European Commission, 2009a). Short product life leading to rapid replacement is a further burden. The extreme is mobile phones, which may have a life of less than 12 months in some cases. 'Planned obsolescence' is a key feature of ICT consumer marketing. The practice is also rampant for PCs, particularly using the leverage of operating system updates to sell more power-hungry machines.

Growth of electricity consumption by small electrical and electronic devices has been the most rapid of all appliance categories over the past five years. It represents about 15 percent of global residential electricity consumption. As shown in Figure 2, a seven-fold gain is expected in Europe over the period 1990-2030, for the residential sector for consumption by ICT and consumer electronic equipment. Further key environmental areas of concern with ICTs include:

3 This section built upon the considerations proposed by FORGE *et al*. on 'A Green Knowledge Society: An ICT policy agenda to 2015 for Europe's future knowledge society' (FORGE *et al*., 2009).

- energy and materials used in manufacturing that contribute to GHG emissions, and also the packaging and logistics of distribution of products,
- energy and material consumption during use, with possible health effects on users,
- disposal at the end of useful life: landfill and incineration with toxic waste as well as health hazards, for workers in recycling and for the general public.

Figure 2 - Estimated electricity consumption by ICT in the residential sector: 1990-2030

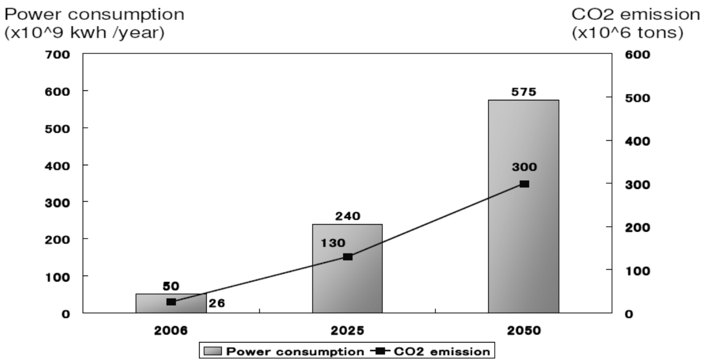


Source: IEA 2009a

For ICT energy consumption on the business side, corporate data centres are of particular concern. Overall, data centres are massive energy users, amplified by cooling demands. Inefficiencies in power distribution within the data centre may also increase net load by 100 percent (HÖLZLE, 2005) as only 50 percent of the power may reach servers. In Germany and the USA, the IT sector – largely data centres – consumes some 1.5 percent of all electricity. In the USA, data centre consumption increased by 100 percent between 2000 and 2008. Estimates for the UK are higher (SYMANTEC, 2008).

In Japan, METI published a forecast for energy supply and demand with a mid- to long-term view in March 2008. The forecast included calculations of expected reductions in CO_2 emissions. It estimated that the electricity consumption of IT equipment in 2025 will be five times what it was in 2006, and that it will be twelve times greater in 2050 (Figure 3).

Figure 3 - Forecast of national energy consumption and CO_2 emissions from IT equipment: 2006-2050



Source: MYOKEN, 2008

In addition, the rebound effects can contravene the benefits of broadband. For instance, HILTY *et al*. (2006b) provided a 20-year prospective simulation study where on an aggregated level; the positive and negative contributions of ICT on environment largely cancelled each other out.

■ Government initiatives

Since the accumulation of greenhouse gases (GHG) in the atmosphere is growing faster than originally predicted, government policies have been initiated in many countries − both policy to decrease energy consumption in ICT sectors and policy to use ICT as enabling energy efficiency in other sectors. Many public initiatives are proposed at national and international level. Among them, the European Union and Japan have several concrete policies regarding ICT and sustainability.

The European Union

Policies regarding sustainable development in the EU were first initiated in 2001 and recognized that emissions of greenhouse gases from human activity are causing global warming, and that climate change was likely to cause more extreme weather events (hurricanes, floods) with severe implications for infrastructure, property, health and nature (European

Commission, 2001). Even though the policy initiated in 2001 did not directly mention GHG emission from the ICT sector, there was a recognition that the next generation of communications infrastructure and services required a strategy for sustainable development.

The principles and objectives of sustainable development strategy – economic prosperity, social equity, environment protection and international responsibilities – as set out in 2001 were reaffirmed by the European Council in June 2005 when it adopted guiding principles for sustainable development (European Council, 2005).

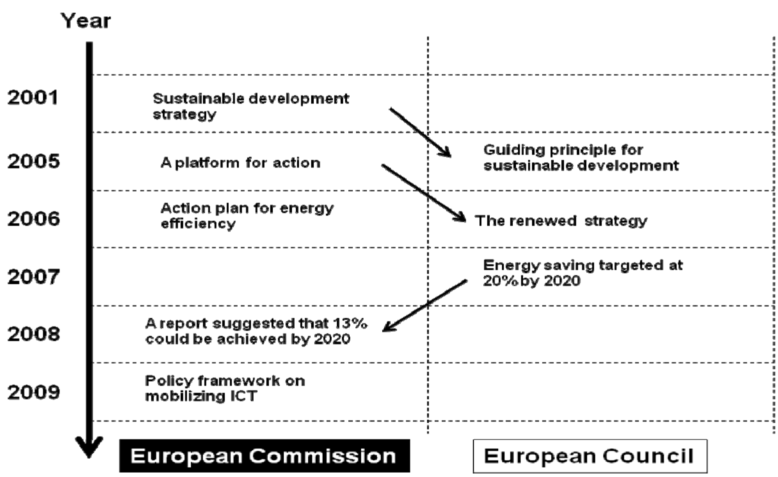
To further develop the sustainable development strategy, the European Commission issued 'A platform for action' in 2005 (European Commission, 2005). Under the platform for action, the European Commission recognized that the EU and Member States need to continue to invest in research and technology to find new cost-effective and resource-efficient ways of production and consumption. By harnessing new technologies – IT and communication tools, alternative energy generation, products and processes with low environmental impact, new fuels and transport technologies – it was expected that Europe can make a breakthrough in resource efficiency which has the potential to drive growth along a sustainable path.

The platform for action was adopted by the European Council in 2006 and was called 'the renewed strategy' (European Council, 2006). The overall aim of the renewed strategy was to identify and develop actions to enable the EU to achieve continuous improvement of quality of life both for current and for future generations, through the creation of sustainable communities able to manage and use resources efficiently and to tap the ecological and social innovation potential of the economy, ensuring prosperity, environmental protection and social cohesion. Since then, there have been significant efforts in terms of policy. Several communications from the European Commission were issued but the focus was on putting policy into practice.

Recently, the European Commission has proposed a set of measures which focus on what can be achieved in the short term both by the ICT sector and by fully exploiting the enabling capacity of ICT in all sectors of society and the economy (European Commission, 2009a). The recent proposal has recognized that energy efficiency is at the heart of the European Union's efforts to tackle the problem of energy security and climate change as set out by the policy in 2006 (European Commission, 2006a), but energy savings in Europe are not being realized fast enough.

Even if Europe has fully implemented all measures, energy savings could be achieved of about 13% by 2020 (European Commission, 2008) which still falls far short of what is needed [4] (European Council, 2007). Therefore the European Commission has issued a policy framework (European Commission, 2009a) in which the role of ICT both as enabling energy efficiency improvements in other sectors and as increasing energy consumption by ICT products is recognised. In the policy framework of 2009, it is stated that a recommendation which sets out tasks, targets and timelines, for industry stakeholders and member states to accelerate progress, will be proposed in the second half of 2009. All major policies taken are illustrated in Figure 4 below.

Figure 4 - Main development of ICT sustainability in Europe



Japan

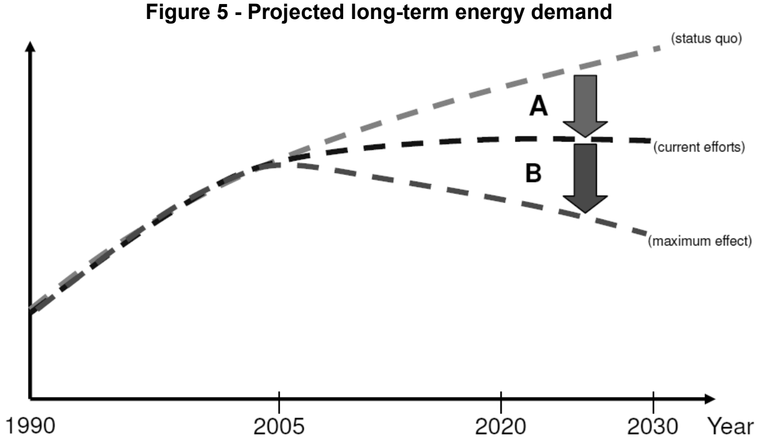
The "Green IT initiative" proposed in 2007 by the Ministry of Economy, Trade, and Industry (METI) attempts to promote not only energy-saving products and technologies but an energy-saving system by introducing more efficient supply chains (METI, 2008). Conventionally, the concept of green IT focuses largely on how to reduce the energy consumption of IT equipment

4 Europe has set itself targets for 2020: saving 20% of primary energy consumption, reducing greenhouse gas emissions by 20% and raising the share of renewable energy to 20%. Improved energy efficiency is a key to achieving these targets.

and systems (including data centres). A remarkable aspect of METI's green IT initiatives is that it focuses on both "energy-saving IT equipment and systems" and the creation of an "energy-efficient society by IT use". Under the auspices of the METI, JEITA (Japan Electronics and Information Technology Industries Association) declared on February 1, 2008 that it would assemble the Green IT Promotion Council.

In March 2008, METI published a forecast for energy supply and demand with a mid- to long-term view. This forecast included calculations of expected reductions in CO_2 emissions. It estimated that the electricity consumption of IT equipment in 2025 will be five times what it was in 2006, and that it will be twelve times greater in 2050. It also indicates the impact of continuous CO_2 reduction efforts through ongoing top-runner programmes employed in the field of electronics and consumer products, vehicles, houses and buildings as shown in Figure 5. Moreover, it forecasts the maximum reduction in CO_2 emissions anticipated through use of potential technologies pursued by green IT projects and next-generation vehicles. These efforts are expected to reduce CO_2 emissions to a level approximately the same as that observed in 1990. The Green IT Project is designed to achieve a drastic reduction in energy consumption for entire network systems, including not only IT devices but also whole IT systems such as data centres.

Figure 5 - Projected long-term energy demand



Source: METI "Long-term energy demand outlook"

Note A: The effect of energy-saving measures resulting from the maintenance of current efforts in targeted areas under the top-runner system (specifically: electronic appliances, automobiles, residences and buildings).

Note B: Maximum effect of energy-saving measures through the application of all potential energy-saving technologies to next-generation vehicles and green IT, etc.

The budget requested for the fiscal year 2008 is 3 billion yen (GBP 14.4 million). The government aims to develop cutting-edge energy-saving technologies, foster the visualisation of environmental contributions of IT to society as a whole, and encourage education, environmental management and IT management.

Since then, METI's policies and research strategies have been carried out by the New Energy and Industrial Technology Development Organisation (NEDO). NEDO will initiate three new research programmes focusing on green IT projects: 1) Nanobit technology, 2) Large OLED technology, and 3) Green Network System Technology. Here R&D is one of the main strategies for policy implementation; Japan is one of the countries that invest a large amount of money in knowledge with an aim of moving towards a sustainable green IT society. Evidence can be seen in Table 2 which shows the details of research topics that comply with the policy goal (note: though that the projects total is 30 million USD).

Table 2 - New Green IT Projects from 2008 to 2012

Project/ Budget	*Goal*	*Research topics*
1) Nanobit Technology For Ultra-High Density Magnetic Recording Budget: 909 million yen	Reduce power consumption per unit storage volume to 1/50 through HDD recording density innovation	- Ultra-high density nanobit magnetic technology - Ultra-high performance Magnetic Head (MH) - Ultra-high precision nano - Addressing technology - HDD system technology
2) Large OLED Technology Budget: 668 million yen	Reduce power consumption of a 40-inch display panel to 40W in the large-display manufacturing process	- Low-damage large-area electrode formation technology - Large-area transparent- sealing technology - Large-area organic-film technology - Verification for large-display production
3) Green Network System Technology Budget: 1,283 million yen	- Reduce network power consumption by 30% using traffic control technology - Reduce data centre power consumption by 30% using cooling technology, etc.	- Basic technology of data centre for optimisation of energy use - Technology for innovative energy-saving network and router

Source: NEDO

■ Discussion

While sustainability was initially formulated in terms of environmental preservation, the sustainability debate has broadened in scope to include social, economic and cultural aspects. It was initially held that the information society would contribute only to environmental sustainability, being driven by *immaterialization* and *dematerialization* of the economy, enabled by information and communication technologies (ICT). *Immaterialization* refers to the fact that the value added in the information society is intangible in nature, taking the form of information and knowledge. Information use and reuse is to a large extent a clean activity. *Dematerialization* refers to the fact that ICTs contribute towards an economy where output is raised at the same time as input of material resources is reduced (BOHLIN, 2001; DUCATEL, 2001; TOCHTERMANN, 2001; HILTY, 2006b).

However, while the information society will certainly restructure distance and time constraints, and hence the need for certain types of transport, the emerging new net-based market structure and increasingly information-based consumption may serve to increase environmental pollution as well. Therefore, a so-called *rebound* or *boomerang* effect might occur where the environmental gains from the dematerialization of the economy may be outweighed by increased resource-intensive or polluting demands elsewhere (BOHLIN, 2001; DUCATEL, 2001).

Furthermore, the transition towards the information society is creating challenges for employment, at least in some industries and for certain types of skills, thereby exerting new pressures upon our societies. However, the observation can be made that in the US, 38 states and the District of Columbia, job growth in the clean energy economy outperformed total job growth between 1998 and 2007. In a number of states, job gains in the clean energy economy have helped lessen total job losses (PEW, 2009).

On balance, there are then many complex effects on sustainability due to ICT. Since ICT can have environmental effects both as enabling energy efficiency and causing rebound, there should be criteria to measure the effectiveness of ICT policy. Generally, ICT impacts can be categorized as being of five different orders as shown in Table 3, which are aggregated based on their direct and indirect effects. These orders of aggregation also have different policy impacts, which will be elaborated upon below.

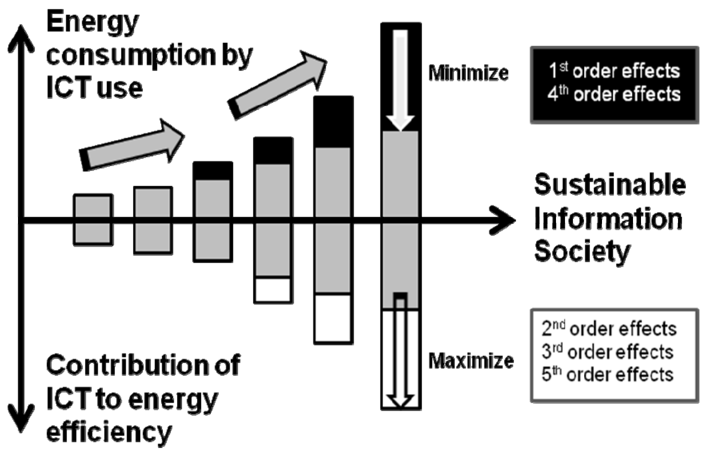
Table 3 - Classifying ICT sustainability impacts
Developed from 'A Green Knowledge Society' (FORGE *et al*., 2009)

Order of effect	*Potential impact*	*Hypothesized effect*
1st-order effects: production & use	Impacts due to a growing proportion of the global energy budget and greenhouse gas emission as a result of IST usage	Negative
2nd-order effects: ICT to cut energy/ pollutants/ water consumed	Impacts and opportunities created by the application of ICT to optimise unsustainable energy-consuming processes in other sectors such as transportation and logistics. This issue needs to be assessed regarding whether or not the ICT can bring in sustainable development as expected, in comparison to other technologies.	Positive
3rd-order effects: substitution for lifestyle practices	Impacts due to the aggregated effect of large numbers of people using ICT over medium to long term, as ICTs can have substitution effects, e.g. for physical travel, saving on travel, road congestion, with knock-on effects, in road construction, etc.	Positive
4th-order effects: rebound effect	Impacts constitute the negative rebound effect occurring as a result of dematerialization of economy, which may be outweighed by increased resource-intensive and high energy consumption.	Negative
5th-order effects: wisdom society	Improving society's overall decision-making capacity to implement sustainability policy, with a potential movement from a knowledge to a wisdom society	Positive

Previously, it has been common to divide the ICT effects on sustainability as either direct or indirect, or alternatively as a third order effect (HILTY *et al*., 2006b). However, our scheme has five dimensions in order to capture the full range of both direct and indirect effects. Especially, the relationship between ICT as an information source and analysis capability provides a platform toward the development of a knowledge society. Not only knowledge can be generated by ICT, but the proper application of participatory forms of decision-making enabled by ICT, can potentially improve the quality of decision-making, harnessing upon the strength of democratic values and inclusion. The 5th-order effect refer to this outlook.

In the long run, the implementation of those five effects in one policy could potentially result in a sustainable information society by decreasing energy consumption and reducing GHG emission (as shown in Figure 6).

Figure 6 - Towards a sustainable information society



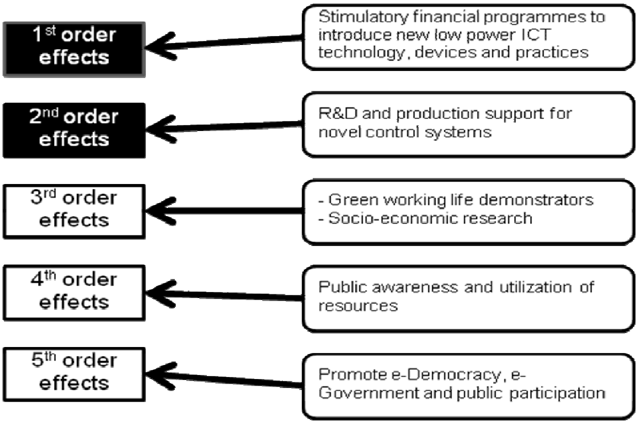
Source: adapted from 'Japan Green IT Initiative'

■ Conclusion

Finding a path toward a sustainable information society is important in the new emerging globalised context. It can be seen that the environment issue not only concerns a national agenda because it has an impact all over the world. When it comes to the idea of ICT sustainability, again, there will be a corresponding need to develop strategies that enhance and sustain the respective regions, as well as to develop strategies for mutual consensus and collaboration.

However, with the issue of collaboration in mind, every country also needs to have policy action in response to the fifth-order effects. Since this policy can enhance the competitiveness of a country at the same time, it should be set as a priority of national policy. Even though different countries may have different policy actions depending on their circumstances, several key strategies that should be implemented in response to those fifth-order effects are suggested here (as shown in Figure 7).

Figure 7 - Key strategies suggested in response to the 5th-order effects



Policy in response to the 1st-order effect, which focuses on the rebound effect of ICT, should support new technology development. For example, there should be stimulatory financial programmes to introduce new low-power ICT technology, devices and practices. In addition, it is necessary to set up and mobilise the industrial support, including R&D for new industrial control systems for heightened sustainability and for eco-efficient ICT products. In the meantime, demand has to be created through both regulatory push and customer pull by raising the public awareness and then implementing through incentive programmes.

Policy in response to the 2nd-order effect, which is based on ICT usage in other sectors, needs to have R&D and production support for novel control systems. Moreover, there should be measures to encourage sustainable ICT use, either by substituting ICTs for energy-consuming processes or with new ICT usage configurations such as cloud computing. Funding for going further than R&D will be needed, taking innovation from prototype to production, especially for SMEs, as well as tax incentives for both production and consumption. It also needs a whole industrial programme for sectors other than ICTs, developing and marketing technologies, processes and services to reduce emissions, toxics and water use across all sectors.

Policy in response to the 3rd-order effect, which focuses more on substitution effects regarding people's lifestyle, should encourage green working-life demonstrators, including policy to support social and economic research. A further important initiative is a programme to evaluate and drive substitution mechanisms. It would focus on introducing, promoting and exploring the optimal choices, in sustainability and economic terms. This would be done by examining social and working behaviour patterns and also evaluating the causal chain for the common mechanisms, beyond the direct impacts, e.g. into physical infrastructure energy and pollution costs. There also need to be implemented new lines of human behavioural research on these problems, specifically behavioural economics, to attract people to opt into, not to opt out of, substitution schemes.

Policy in response to the 4^{th}-order effect, which is the negative rebound from the widespread use of ICT, should focus on ICT utilization and public awareness. In so doing, there may be need for green ICT policy research which is an industrial-academic partnership, to coordinate green ICT measures with other sustainability efforts. A key task would be to identify how to utilize the resources and encourage public awareness of environmental issues resulting from the use of ICT devices. It could also initiate campaigns to take in a wider audience – citizens, business, SMEs, local government and policy makers.

Policy in response to the 5^{th}-order effect, which enhances decision-making capability, should encourage e-democracy by having a transparent society in a fully utilized knowledge-based economy. Though this effect hardly exists in the short term where the gap between people and society is the major problem, a long-term policy goal can be set. The main policy should focus on public participation and education of people while encouraging e-government.

In this context, a sustainable information society becomes a strategic concern, fundamental to long-term prosperity and security for any nation or region of the world seeking to have influence in the 21^{st} century. The strength of such a transformation will be based on private incentives of firms and business to produce goods and services that are more sustainable, stimulated and promoted by a more targeted policy and societal vision.

References

BOHLIN, Erik (2001): "A new age of enlightenment", *Foresight*, Vol. 03, No. 02.

Climate Group (2008): "SMART 2020: Enabling the low carbon economy in the information age", The Climate Group and the Global eSustainability Initiative.
http://www.theclimategroup.org/assets/resources/publications/Smart2020Report.pdf

DUCATEL, Ken (2001): "Balance of nature? Sustainable society in digital economy", *Foresight*, Vol. 03, No. 02.

European Commission:

- (2001): "A sustainable Europe for a better world: A European Union strategy for sustainable development", COM(2001)264 final, Brussels, 15 May 2001.
- (2005): "On the review of the sustainable development strategy − A platform for action", COM(2005) 658 final, Brussels, 13 December 2005.
- (2006): "Action plan for energy efficiency: Realising the potential", COM(2006) 545 final, Brussels, 19 October 2006.
- (2008): "Energy efficiency: delivering the 20% target", COM(2008) 772 final, Brussels, 13 November 2008.
- (2009a): "Mobilising information and communication technologies to facilitate the transition to an energy-efficient, low-carbon economy", COM (2009) 111 Final, 12 March 2009.
- (2009b): "ICT and energy efficiency: the case for manufacturing", DG Information Society, Unit G2 Microsystems, Recommendations of the Consultation Group, February.

European Council:

- (2005): "Presidency conclusions of the Brussels European Council", 10255/1/05 REV 1, Brussels, 16-17 June 2005.
- (2006): "Review of the EU sustainable development strategy (EU SDS) − Renewed Strategy", 10117/06, Brussels, 9 June 2006.
- (2007): "Presidency conclusions of the Brussels European Council", 7224/1/07, Brussels, 8-9 March 2007.

FORGE, Simon, BLACKMAN, Colin, BOHLIN, Erik, & CAVE, Martin (2009): "A green knowledge society: An ICT policy agenda to 2015 for Europe's future knowledge society − A study for the Ministry of Enterprise, Energy and Communications, Government Offices of Sweden", SCF Associates Ltd. .
http://www.se2009.eu/polopoly_fs/1.16246!menu/standard/file/A%20GREEN%20KNOWLEDGE%20SOCIETY_CREATIVE%20COMMONS_%20WEB1.pdf

HILTY, Lorenz M., SEIFERT, Eberhard K. & TREBERT, René. (2005): *Information systems for sustainable development*, Idea Group Publishing.

HILTY, L. M., KÖHLER, A., Von SCHÉELE, F., ZAH, R. & RUDDY, T. (2006a): "Rebound effects of progress in information technology", *Poiesis Prax*, Vol. 4, pp. 19-38.

HILTY, Lorenz M., ARNFALK, Peter, ERDMANN, Lorenz, GOODMAN, James, LEHMANN, Martin & WÄGER, Patrick A. (2006b): "The relevance of information and communication technologies for environmental sustainability – A prospective simulation study", *Environmental Modelling & Software*, Vol. 21, pp. 1618-1629.

Hölzle, U. (2005): "The dark side of computing power", *CERN Courier*, 2 November. http://cerncourier.com/cws/article/cern/29476

IEA:

- (2009a): "Gadgets and gigawatts: Policies for energy efficient electronics", International Energy Agency.
http://www.iea.org/Textbase/npsum/Gigawatts2009SUM.pdf
- (2009b): "Key world energy statistics", International Energy Agency.

ITIF (2009): "The digital road to recovery: a stimulus plan to create jobs, boost productivity and revitalize America". The Information Technology & Innovation Foundation.

LEHR, W.H., OSORIO, C.A., GILLET, S.E. & SIRBU, M.A. (2006): "Measuring broadband's economicimpact", Final report submitted to Economic Development Administration, U.S Department of Commerce, USA.

METI (2008): "Green IT initiatives in Japan", Ministry of Economy, Trade, and Industry, Japan.

MICUS (2008): "The impact of broadband on growth and productivity". Study for the European Commission.

MYOKEN, Yumiko (2008): "Japan's green IT initiatives".
http://ukinjapan.fco.gov.uk/resources/en/pdf/5606907/5633632/Green_IT_initiative.pdf

MUELLER, Dennis C. (2003): "Public choice III", Cambridge University Press, New York.

NEDO (2005): "Needs and prospects for ultrahigh-speed optical communication systems - Toward realization of 100 Gb/s or faster systems", New Energy and Industrial Technology Development Organization.

OECD (2009): "Towards green ICT strategies: Assessing policies and programmes on ICT and the environment", DSTI/ICCP/IE(2008)3/FINAL, 22 May 2009.

PEW (2009): "The clean energy economy: Repowering jobs, businesses and investments across America", The PEW Charitable Trust.

Symantec (2008): "The green data center: a Symantec green IT guide".
http://eval.symantec.com/mktginfo/enterprise/white_papers/b-whitepaper_the_green_datacenter_guide_04-2008.en-us.pdf.

TEPPAYAYON, O. & BOHLIN, E. (2009): "Government intervention: Why is competition not sufficient for broadband deployment?" , paper presented at the 37th Research Conference on Communication, Information and Internet Policy (TPRC), Virginia, USA, 25-27 September, 2009.

TOCHTERMANN, Klaus (2001): "Greening the superhighway: practical steps to sustainability in the information society", *Foresight*, Vol. 03, No. 02.

UN (1987): "Report of the World Commission on environment and development", United Nations, A/42/427, 4 August 1987.

UNCTAD (2006): "Information economy report 2006", United Nations Conference on Trade and Development.