Information and communication technology (ICT) applications are widely seen to have the potential to improve environmental performance and tackle climate change. On the supply side, there are numerous areas in manufacturing, energy, transport systems, buildings and urban systems where smart ICT applications can help optimize performance and reduce inputs per unit of output. And on the demand side, better information and smoother communication foster sustainable consumption and greener lifestyles.

Boosting sustainable economic growth is a top priority for all economies. At the same time, economies and populations continue to grow, with accelerating global rates of production and consumption. Innovative and sustainable modes of production, consumption and living are needed to deal with environmental challenges, and ICTs can and will play a key role in addressing these challenges. Governments have a major role in both directly improving the environmental performance of their ICT-related activities, and in encouraging the wider application of ICTs across the economy to improve environmental performance and underpin green growth (for OECD work in this area, see www.oecd.org/sti/ict/green-ict). In particular, green growth strategies have become part of broader economic and industrial policies. They
have been somewhat eclipsed in the economic slowdown and debt crises in Europe, the United States and Japan, but nevertheless they remain a core preoccupation in many countries and have been embedded in national policies, even if not to the extent that was earlier hoped at the outset of the crisis.

**Defining “Green ICTs”**

Green ICTs are those that have positive impacts on environmental performance and ecosystems, either directly by reducing physical and energy inputs in their production, use, disposal and recycling, or indirectly through their wider application and use in other equipment and systems. ICTs and their applications can have both positive and negative impacts on the environment. For example, reductions in greenhouse gas emissions associated with ICT applications to improve energy efficiency in buildings, transport systems or electricity distribution must be balanced against increased emissions resulting from their development, production and operation and potential environmental degradation associated with their uncontrolled disposal. ICTs also fundamentally affect the ways in which people live and work and how goods and services are produced and delivered. They offer opportunities to significantly improve environmental performance, but at the same time the proliferation of electronic equipment and applications increases energy consumption, exhausts scarce resources, and increases disposal and recycling challenges.

The interaction of ICTs and the natural environment can be categorized at three levels: direct impacts, enabling impacts and systemic impacts, going from the most easily understood to the widest impacts (see Figure 1). Most analysis and the majority of environment-related ICT policies have focused on direct impacts, despite the potentially very much larger gains to be reaped from strategies focusing on increasing enabling and systemic impacts. (A comprehensive overview of policies focusing on direct and enabling impacts of ICTs is contained in Reimsbach-Kounatze, 2009.)

---

**FIGURE 1: FRAMEWORK FOR GREEN ICT IMPACTS.**

Three Levels of ICT Impacts on the Environment: Going from Direct Impacts to Systemic Impacts

Direct impacts: Direct impacts of ICTs on the environment (“first-order effects”) refer to positive and negative impacts due directly to ICT goods and services and related processes. Direct environmental impacts of ICT products come from ICT manufacturing and services producing firms and related intermediate goods producers, and from final consumers and users of ICTs. ICT producers affect the natural environment during ICT goods and services production and through related operations (e.g., operating infrastructures, building functions, vehicle fleets and logistics). All of these production operations can have more or less environmental impacts.

At the other end of the value chain, consumers and users influence the shape and impact of the direct environmental footprint through purchase, consumption, use and end-of-life treatment of ICT goods and services. Consumers can choose energy-efficient and certified “green” ICT equipment over other products. At the end of a product’s initial useful life, they can choose to return equipment for re-use and recycling, adopting “cradle-to-cradle” approaches to their purchase and disposal of ICT goods and services. This lowers the burden on the natural environment compared to disposal in a landfill, incineration or uncontrolled dumping in developing countries.

Enabling impacts: ICTs affect how other products are designed, produced, consumed, used and disposed of. Enabling impacts of ICTs (“second-order effects”) come from ICT applications that reduce environmental impacts across economic and social activities outside of the ICT-producing sector and straightforward ICT applications. But potential negative effects need to be measured when assessing “net” environmental impacts, such as greater use of energy by ICT-enabled systems to improve traffic flow or the functioning of buildings and urban systems, due to perceived efficiencies leading to greater use.

ICT products can affect the environmental footprint of other products in four main ways:

- **Optimization:** ICTs can reduce another product’s environmental impact. Examples include investing in embedded systems in cars for fuel-efficient driving, “smart” electricity distribution networks to reduce transmission and distribution losses, and intelligent heating and lighting systems in buildings and urban environments.

- **Dematerialization and substitution:** Physical products and processes can be replaced by digital ones with lower impacts on the environment. For example, digital music and video can replace physical music and film media, and teleconferences can replace business travel, with reduced environmental impacts.

- **Induction effects** occur if ICT products induce increased demand for other products. For example, more efficient printers stimulate demand for high quality paper, increasing pressure on forest and paper-making resources, even if direct resource use is decreased in the production and operation of printers.

- **Degradation** can occur if ICT devices embedded in non-ICT products lead to difficulties in disposal management. For example, “smart” tags in car tires, bottles and cardboard often require specific recycling procedures that are more onerous and potentially add to the pollution load.

Life-cycle analysis (LCA or cradle-to-grave analysis) is a necessary analytical tool to obtain an overall view of these impacts and the balance among them.
Systemic impacts: Systemic impacts of ICTs on the environment (“third-order effects”) are rooted in behaviour and behavioural change. Positive systemic outcomes of green ICT applications largely depend on end-user acceptance, lifestyle adjustments and changes in collective social behaviour.

ICT applications have systemic impacts in a number of ways, including:

- Providing and disclosing information: ICTs and the Internet facilitate monitoring, measuring and reporting information on the environment. Access to and display of data inform decisions by households (e.g., “smart” metres), businesses (e.g., choice of suppliers, “green” advertising claims) and governments (e.g., allocation of emission allowances). Sensor-based networks that collect data and computer-based interpretation can be used to adapt production, consumption and lifestyles. For example, ICT-enabled observation and research on rainfall, ground cover and desertification provide data for long-term agricultural, economic and social decision making.

- Enabling dynamic pricing and enhancing real-time price sensitivity: ICT applications enable dynamic pricing systems, e.g., in the provision of electricity or trade in farm products. Electricity customers can choose to turn off non-critical devices when renewable energy is scarce and turn them on again when it is more plentiful; small-scale rural producers can choose when and where to market their products.

- Changing technologies impacting consumer and user behaviour: The evolution from desktop PCs to laptops to netbooks to tablets is changing consumer preferences, with major effects on raw material exploitation and power use. Digital music, Internet communication, social networks and teleconferencing technologies are affecting the ways in which their physical counterparts are produced and consumed, with major impacts on recorded music, written letters, social gathering and physical business travel.

- Triggering rebound effects: Higher efficiencies at the micro level (e.g., the use of more energy-efficient products) do not necessarily translate into equivalent savings at the macro economy-wide level because of greater aggregate consumption and use of more efficient individual products. For example, nationwide application of a technology that is 30 per cent more efficient does not necessarily translate into aggregate energy savings of 30 per cent, due to greater use triggered by the greater efficiencies. Much lower semiconductor energy use must be weighed against the very rapid growth in numbers of ICT products incorporating these components, e.g., in smartphones and tablets. The “rebound effects” from increased use at the micro level may result in greater resource use at the macro level.

Systemic impacts of ICTs and their environmental repercussions are relatively unexplored, mainly because of the complexity of assessing technological change, production and consumption in the medium and longer term. Product life-cycle analysis is an important tool to provide insights into the effects of ICTs on behavioural change and the effects of behavioural change on ICTs.
What is the Role for Governments?

Governments have generally been slow to shift from a laudable but narrow focus on making the direct production, use and disposal of ICTs more environmentally positive. Initiatives have largely concentrated on greening ICTs rather than tackling global warming and environmental degradation through the use of ICT applications. Policies to address environmental impacts over the complete ICT life-cycle have been lacking, and initiatives targeting energy production and consumption have been pro-cyclical and followed energy price trends rather than being a part of longer-term economic strategies, and have led to, e.g., scrapping support for solar energies due to budget constraints. On the positive side, investments to support development and use of clean technologies were an important part of government economic stimulus packages over the last few years, and promoting the enabling environmental impacts of ICTs has been an important priority in ICT policies for economic recovery.

Governments need to tackle challenges at all levels. For example, a basic PC’s contribution to global warming is highest during its use phase, but significant environmental impacts also occur during the manufacturing and end-of-life phases, making life-cycle analysis crucial for better management of government computing investments. Government “green ICT” policies can be instrumental in promoting such life-cycle approaches, both in their own activities and through leading by example.

Across the economy, large environmental benefits are possible in major resource and energy-using sectors, e.g., transport, energy and housing where governments are both major producers and consumers, either directly or through procurement and public-private partnerships. To be effective, products must be co-developed and their diffusion well coordinated by all stakeholders, including governments. At geographically local levels, the priorities of government ICT managers have in some cases moved toward green ICT and sustainable cities. Over 50 per cent of the world’s population already lives in urban centres and they are responsible for 60-80 per cent of global emissions, illustrating the size of challenges locally and globally.

Information and communication are pivotal for system-wide mitigation of and adaptation to changes in the environment. However, further research into the systemic behavioural impacts of the diffusion of ICTs is needed to understand how ICTs and the Internet contribute to environmental policy goals such as fostering renewable energy sources, reducing transport volumes, optimizing household energy use and reducing material throughputs. Governments have a key role to play in supporting this research and in being innovative and systemic model users of ICTs.

Finally, at the international level, there have been ongoing initiatives to provide frameworks to enhance the positive impacts of ICTs on the environment. For example, the OECD (2010b) Recommendation of the Council on Information and Communication Technologies and the Environment laid out a 10-point checklist on how governments can employ ICTs to enhance national environmental performance. It encourages cross-sector cooperation and knowledge exchange on resource-efficient ICTs and “smart” applications, and highlights the importance of governments supporting R&D and innovation. By doing so, governments send positive signals for private sector investment.
References


Mickoleit, A. (2010). Greener and smarter: ICTs, the environment and climate change. Paris: OECD.


About IISD

The International Institute for Sustainable Development (IISD) contributes to sustainable development by advancing policy recommendations on international trade and investment, economic policy, climate change and energy, and management of natural and social capital, as well as the enabling role of communication technologies in these areas. We report on international negotiations and disseminate knowledge gained through collaborative projects, resulting in more rigorous research, capacity building in developing countries, better networks spanning the North and the South, and better global connections among researchers, practitioners, citizens and policy-makers.

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

Acknowledgement

IISD gratefully acknowledges the generous support of the International Development Research Centre (IDRC).