Chapter 4
Greener and Smarter: Information Technology can Improve the Environment in Many Ways

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Smart information and communication technology (ICT) applications have the potential to improve the environment and tackle climate change. Application areas with major room for improvement through smart ICT applications include manufacturing, energy, transport, and buildings. And 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 modes of production, consumption, and living are needed to deal with environmental challenges, and technologies 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 the wider environmental performance and underpin green growth (for OECD work in this area see www.oecd.org/sti/ict/green-ict).

What are "Green ICTs"?

ICTs and their applications can have both positive and negative impacts on the environment. This means, for example, balancing greenhouse gas emissions resulting from the development, production, and operation of ICT products against emission reductions associated with the application of these ICTs to improve energy efficiency

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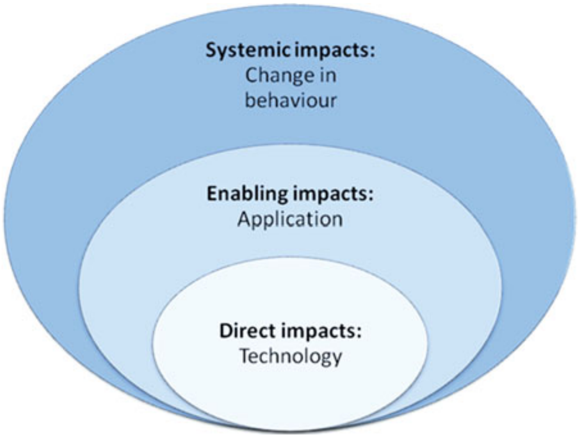

Fig. 4.1 Framework for green ICT impacts. *Source*: OECD

in buildings, transport systems, or electricity distribution and in a host of other applications. Besides these immediate impacts, ICTs and their application also fundamentally affect the ways in which people live and work and how goods and services are produced and delivered, all of which offer opportunities to significantly improve environmental performance.

The interaction of ICTs and the natural environment can be categorised as having three levels: direct impacts, enabling impacts, and systemic impacts, going from the most easily captured to the widest impacts (see Fig. 4.1).

The Three Levels of ICT Impacts on the Environment

Direct impacts: Direct impacts of ICTs on the environment (or "first-order effects") refer to positive and negative impacts directly due to ICT products (goods and services) and related processes. The sources of direct environmental impacts of ICT products are ICT producers, including ICT manufacturing and services firms, and related intermediate goods producers, and final consumers and users of ICTs. ICT producers affect the natural environment during the production of ICT hardware, components, and ICT services and through the operations related to production (e.g. operating infrastructures, office and building functions, vehicle fleets). Energy-efficient components, for example, can reduce the energy used by ICT equipment used by producers for the production of ICT goods and services, thereby reducing their energy consumption, with potentially positive effects on the environment.

At the other end of the value chain, consumers and users influence the direct environmental footprint through their purchase, consumption, and 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 useful life, they can choose to return equipment for re-use, recycling, etc. This lowers the burden on the natural environment compared to disposal in a landfill, incineration, or uncontrolled dumping in developing countries.

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

ICT products can affect the environmental footprint of other products and activities across the economy in four ways:

- *Optimisation*: 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.
- *Dematerialisation and substitution*: Technological advances in ICTs and other technologies facilitate the replacement of physical products and processes by digital products and processes with lower impacts on the environment. For example, digital music may replace physical music media and teleconferences may replace business travel, with reduced environmental impacts in both cases.
- *Induction* effects occur if ICT products increase demand for other products, e.g. more efficient printers may stimulate demand for paper, increasing pressure on forest resources, even if electricity and other resource use is decreased due to the greater efficiencies.
- *Degradation* can occur if ICT devices embedded in non-ICT products create difficulties for waste management. Car tyres, bottles, and cardboard equipped with "smart" tags, for example, often require specific recycling procedures that are more onerous and potentially add to the pollution load.

The overall wider impacts of ICTs will depend on the balance between these different impacts, and life-cycle analysis (LCA or cradle-to-grave analysis) is a necessary analytical tool to obtain an overall view of these wider impacts of ICTs.

Systemic impacts: Systemic impacts of ICTs and their application on the environment (or "third-order effects") involve behavioural change. Positive environmental outcomes of green ICT applications largely depend on wide end-user acceptance and adjustments to individual lifestyles and collective social behaviour. Product LCA can also be used to comprehensively examine the environmental impacts of ICTs, including the effects of ICTs on behavioural change and the effects of behavioural change on ICTs.

ICT applications can have systemic impacts on economies and societies in one or more of the following ways:

- *Providing and disclosing information*: ICTs and the Internet facilitate monitoring, measuring, and reporting changes to the natural environment. Access to and display of data inform decisions by households (e.g. "smart" meters), businesses (e.g. choice of suppliers, "green" claims in advertising and promotional material), and governments (e.g. allocation of emission allowances, territorial development policies). Sensor-based networks that collect information and computer-based interpretation of data can be used to adapt lifestyles, production, and trade. For example, ICT-enabled observation, data-collection and research on rainfall distribution, ground cover destruction, and desertification trends provide data for long-term economic decision-making in areas that are environmentally fragile.
- *Enabling dynamic pricing and fostering price sensitivity*: ICT applications form the basis of dynamic or adaptive pricing systems, e.g. for the provision of electricity or trade in agricultural products. Electricity customers, for example, can choose to turn off non-critical devices when cheap (and renewable) energy is scarce and turn them on again when it is more plentiful.
- *Fostering technology adoption*: The "evolution" from desktop PCs to laptops to netbooks is an example of changing consumer preferences with major effects on raw material extraction and power use. Digital music, e-mail communications, and teleconferencing technologies are affecting the ways in which their physical counterparts are produced and consumed, i.e. recorded music, written letters, and physical business travel.
- *Triggering rebound effects*: Rebound effects refer to the phenomenon that higher efficiencies at the micro level (e.g. the use of a more energy-efficient product) do not necessarily translate into equivalent savings at the macro level (e.g. economy-wide). For example, nationwide application of a technology that is 30% more efficient does not necessarily translate into aggregate energy savings of 30%. Much greater energy efficiencies of semiconductors must be weighed against the overall very rapid growth of the use of ICT products incorporating more efficient components, e.g. in smartphones and tablets. "Rebound effects" from greater use at the micro level partly offset individual efficiencies and result in greater use at macro level.

Systemic impacts of ICTs and their environmental repercussions are relatively unexplored, mainly because of the complexity of assessing directions of production and consumption in the medium and longer term, as the rapid growth of new consumer product markets witnesses.

What can we Conclude for Governments?

Government IT managers and ICT policy-makers must consider all direct and enabling and systemic impacts of ICTs on the environment. Direct environmental impacts are considerable in areas such as energy use, materials throughput, and end-of-life treatment. 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 LCA crucial for better management of government computing investments to minimise negative environmental impacts. Improved R&D and design can help to tackle direct impacts throughout the entire life cycle of ICT goods, services, and systems. Government "green ICT" policies can be instrumental in promoting such life-cycle approaches both in their own activities and through leading by example.

At the same time, innovative ICT systems enable more sustainable production and consumption across the entire economy. They range from product-specific improvements, e.g. embedded ICTs for energy-efficient vehicles, to entire systems, e.g. ICTs for smarter transport management. Large environmental benefits are possible in major resource and energy using sectors, e.g. transport, energy, and housing. But to be effective, products must be co-developed between producers and users, and their diffusion well co-ordinated by stakeholders including governments.

Information and communication are pivotal for system-wide mitigation of and adaptation to changes in the environment. ICTs provide easy access to reliable environment-related information about goods and services and subsequent analysis of this information and changes in systemic behaviour. However, further research into the systemic 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, optimising household energy use, and reducing material throughputs via systemic behavioural change. Governments have a key role to play in supporting this research and in being innovative model users of ICTs.