Defining environmental sustainability

The European Commission commissioned a project to explore qualitatively and to assess quantitatively the way that ICTs can influence environmental sustainability.

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Introduction

At the European Council in Gothenburg (June 2001) the European Union adopted a common strategy for sustainable development as an integral part of the EU strategy for transition to a knowledge-based economy. Information and communication technologies (ICTs), such as computers, mobile phones and microchips, play a key role in the change towards this knowledge-based economy.

There are many single case studies on the impact of ICTs on isolated aspects of sustainability, but no coherent research on the full range of impacts has to date been carried out. The 'Institute for Prospective Technological Studies of the European Commission's Joint Research Centre' commissioned the project 'The future impact of ICT on environmental sustainability' to explore qualitatively and to assess quantitatively the way that ICTs can influence environmental sustainability.

To define environmental sustainability, the project took seven indicators as a reference:

- Greenhouse gas emissions,
- Energy intensity of the economy,
- Transport intensity of the economy,
- Modal split of transport,
- Share of renewables in electricity consumption,
- Urban air quality,
- Municipal waste collected but not recycled.

The geographical coverage of the project is the member states of European Union (EU 15) plus accession countries (AC 10). The time horizon is 2020.

Methodology

The project adopted a five step methodology. In the first step a set of environmental indicators was chosen and the economic sectors and ICT applications with the highest impact on these indicators were identified for further analysis.

The second step was to build up data as a basis for the project through an extensive literature review of the environmental impacts of selected ICT applications. Three kinds of impact were considered:

- The impacts and opportunities created by the physical existence of ICTs and the processes involved (first order effects);
- The impacts and opportunities created by the ongoing use and application of ICTs (second order effects);
- The impacts and opportunities created by the aggregated effects of large numbers of people using ICTs over the medium to long term (third order effects).

Thirdly, three consistent scenarios were developed, by choosing highly unpredictable factors likely to influence the development and use of ICTs in the future. The Table 1 shows the combination of uncertain factors in the following three scenarios:

- Technocracy: Government and business collude to produce high speed, growth-focused technology development.
- Government first: Heavy-handed government steers technology development to favour social outcomes, while business competes to exploit a slowing market.
- Stakeholders democracy: A positive environment for sustainable development, with all eyes on what ICT can deliver, but outcomes are not always straightforward.

In the fourth step a simulation model was built to quantify the future impact of ICTs on the environmental indicators for the three mentioned scenarios. The final step was to review the project results in setting them into the current EU policy context.

Table 1: Three future scenarios based on uncertain factors

Uncertain factor	Scenario A 'Technocracy'	Scenario B 'Government first'	Scenario C 'Stakeholders democracy'
Technology regulation	Incentives for innovation	Government intervention	Stakeholder approach
Attitudes to ICT	Moderate, conservative	Open and accepting	Highly accepting
ICT in business	High level of cooperation	High level of competition	Between A and B
Attitudes to the environment	Moderate/ controversial	High awareness and interest	High awareness and interest

This led to a range of detailed policy recommendations, which were then validated by a panel of experts.

Results

It is possible to estimate the isolated effects of ICTs on different indicators. However, the most relevant information is not the direct impact of ICTs on one indicator, but the whole picture, including the evolution of all the indicators in relation to the development of ICTs.

The following figure presents the development of environmental indicators by 2020. These figures are percentage increase/decrease from the base year 2000. A negative value indicates that the indicator level would be higher without ICT, a positive value indicates that ICTs contribute to growth of the indicator. The length of the bars indicates the uncertainty of the findings, as a result of both future scenario variation and data uncertainty. There are two bars per indicator: the upper (dark blue) bar shows the results for projected ICT development, the lower (light grey) bar shows the results for the so-called 'ICT freeze' simulations (i.e., ICT applications remain at the same level as in 2000). The impacts shown are aggregated values of all ICT applications considered in all scenarios simulated.

Recommendations

Freight and passenger transport.

ICT related efficiency improvements in transport must be combined with demand side management for an overall reduction in environmental impact. Time reduction and network capacity increases achieved by intelligent transport systems will pave the way for more transport, unless measures are taken to limit growth. The research indicates that the internalisation of environmental externalities, in particular raising energy prices and fuel prices, could bring demand levels down to a level where transport is no longer linked to economic growth. The option to complement such measures by including transport in emissions trading schemes also seems reasonable.

Moreover, Intelligent Transport Systems (ITS) could support public transport by:

- Directing research focus and allocating resources to multi-modal, seamless travel and public transport supported by intelligent transport systems;
- Increasing the attractiveness of public transport by developing and implementing systems for tailor-made information, such as adapted time-tables, route-planning, and so on;
- In the specific case of passenger transport, providing prerequisites for ICT supported work (such as wireless internet access) during train travel and on public transport.

Virtual mobility applications will not automatically generate significant transport savings unless policy initiatives are introduced to support this. Promotion of virtual meetings is probably the most effective e-Application for reducing the environmental impact from passenger transport. Attention should also be given to a potential passenger transport increase due to a growing number of mobile workers. Specific policy recommendations are:

- promoting development of affordable and reliable broadband access;
- Promoting the establishment of corporate policies and agreements for efficient e-work;
- Establishing policies and routines for virtual meetings while increasing the cost of passenger transport, which will promote a shift towards the virtual alternatives.

Energy consumption and share of renewables

Suggested energy measures apply to both the energy consumption and the supply side.

On the demand side, ICTs have two main roles to play. Firstly, ICTs could support energy saving measures in buildings and could have an important impact on the rational use of heating energy. Although it is highly uncertain under which conditions 'soft' measures supported by ICTs (such as intelligent heating systems) operate effectively and satisfactorily for the users, this issue deserves consideration because of the high energy consumption on heating. Heating accounts for roughly 30% of total energy consumption, and the most effective 'hard' measures apply only to the small annual share of buildings that are renovated or newly built. 'Soft' measures, even if they are less effective, have the advantage that they could, in principle, be applied in every building. Secondly, ICTs could also influence the demand side towards more sustainable consumption patterns, thus avoiding the rebound effect of increased consumption that outweighs positive effects.

Regarding the supply side, the deployment of ICT support systems for decentralised electricity production from renewable sources and the use of small combined heat and power devices are recommended. The development of low-cost metering and communication systems for the electricity grid, making small-scale electricity production easier to operate and maintain and more cost-effective than conventional approaches, is also recommended.

Greenhouse gas emissions

The recommendations for greenhouse gas emissions are cross-cutting, as they are closely connected to energy use in industry, transport and housing. This study's main findings suggest the need for ICT supported monitoring and reporting schemes, the adjustment of consumption of energy and transport to a sustainable level, and the promotion of research into ICT supported measures for the reduction of greenhouse gas emissions that can be accomplished in more cost-effective ways than by more traditional investment in energy savings.

Municipal waste collected but not recycled

ICTs impact on waste volumes both in the generation and management of waste electrical and electronic equipment, and the management and recycling of municipal solid waste. It is foreseen that the 6th Environmental Action Programme objective to break the link between economic growth and increases in municipal solid waste will be achieved. However, ICTs would add significantly to municipal solid waste not recycled if no measures are found to limit the growth of ICT waste. Recommended actions include:

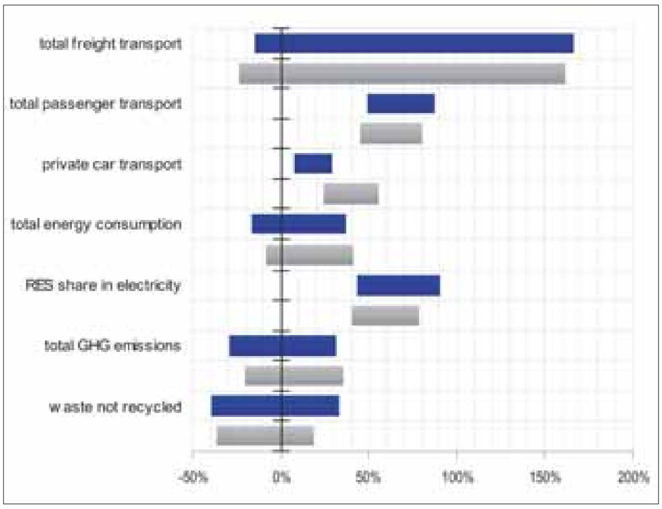
- Further enhancement of the implementation of the 1994 directive on packaging waste, by developing incentive systems for teleshopping retailers to reduce packaging waste (e.g. by designing their product, retail and shipping systems in ways that reduce the need for and use of packaging).
- Reduction of the amount of waste electrical and electronic equipment through:
  - providing incentives for producers to design and sell ICT products with a long life-span, thus reducing the churn rate,
  - effectively implementing the directive on waste electric and electronic equipment, which is based on the extended producer responsibility principle. This would encourage product designers and producers to minimise the waste stream, particularly if producers are held responsible for managing the waste of their own products,
  - limiting sales models that make ICT products of little or no value in a short period of time, such as subsidised mobile phones and subscription packages,
  - extending the depreciation time for ICT equipment (minimum time to 'write off' ICT equipment investments).
- Adaptation of the policy for limiting environmental impacts of the trends of pervasive computing and electronics embedded in non-traditional ICT products, that are not covered by the current policy framework (e.g. directives on waste electrical and electronic equipment and restriction of hazardous substances).
- Support of intelligent systems for recycling and other forms of recovery, thereby decreasing the waste fraction that goes to final disposal and incineration.

Crosscutting issues

There are two cross-cutting issues that effect the results as described above.

Rebound effect

The efficiency improvements (time, fuel, energy) made possible through technological advancements are counteracted by an increasing demand (growing consumption volumes) of energy, products, services, passenger and freight transport. In the model this is managed by determining *elasticities*, quantified by assigned numbers, for example by determining what proportion of savings are counteracted by increased consumption, or vice versa. For instance, a price elasticity value of -0,5 means that demand will decrease by 10 % if prices increase by 20 %, or that the demand will increase by 10 % if prices are 20 % lower. Another rebound effect is the *rematerialisation* effect, which could be exemplified by virtual information products such as information accessed via the Internet being printed out or burned on a CD. Rebound effects should be acknowledged and addressed by all policies which aim at increased efficiency, especially ICT policies.



Simulated development of environmental indicators by 2020

Accession countries

The simulation of the impact of ICT on the environmental indicators has been limited to EU 15, because of the lack of sufficient data for the 10 accession countries. Their economies show some particular characteristics, which will also have implications for the impact of ICT on the environmental indicators. High expected GDP growth inducing increased consumption of commodities, including ICT products, and very strong transport growth, are the environmental downside trends in the acceding countries. Improved material and energy efficiency in industry, including the energy industry, a shift to less polluting energy sources and more energy efficient and less polluting vehicles, are important environmentally positive trends. ICT will play a role for the acceding countries in all of these areas, and the role is likely to be more prominent than for EU 15, as a dramatic change in the economic structures is expected as a result of accession.

Conclusion

Although the study delivers a systematic and differentiated picture of the future impact of ICTs on environmental sustainability, significant uncertainties, both of future developments and data, still exist. Further holistic research is therefore necessary for a fuller understanding of the role of ICTs in meeting environmental goals. Special emphasis is to be given to the rebound effect and to developing countries with a poor data base. An important deficit on the action side is, that neither the important ICT-Push initiatives, such as eEurope, nor relevant environmental institutions, such as the European Environmental Agency adequately address the strong interactions between ICTs and environmental sustainability. ■

[i4d editorial team had invited two authors to submit contributions, which covered the same project. We present a combined story with attribution to both authors.]