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postnote

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ICT AND CO_2 EMISSIONS

The global greenhouse gas emissions from information and communication technology (ICT) are comparable with those of the aviation industry. This POSTnote focuses on the energy consumption of ICT equipment, and looks at action being taken to reduce it. It also mentions the wider environmental impact of ICT, and looks briefly at the significant contribution that ICT can make to reducing emissions in other sectors. These approaches are collectively referred to as 'green ICT'.

Background

Technology analysts estimate that the manufacture, use and disposal of ICT equipment contribute around 2% of global emissions of carbon dioxide.[1] This is about the same as aviation, although the ICT sector is larger and aviation emissions have a greater effect on climate as they are released in the upper atmosphere. As the use of ICT grows, its emissions are likely to increase despite improvements in efficiency. It is estimated that ICT will be responsible for 3% of global emissions by 2020.[1]

Environmental considerations tend to come second to cost considerations in managing ICT emissions, while corporate image may also have a role. The cost of non-domestic electricity roughly doubled between 2003 and 2007 so controlling electricity use has become more important to organisations.

ICT can also be used to increase energy efficiency and reduce emissions in other sectors, such as transport and manufacturing. It is thus suggested that the use of ICT can cause an overall reduction in emissions even if its direct emissions increase.[1]

Direct energy use of ICT

Data centres

A data centre is a dedicated facility used to house ICT equipment such as servers (computers that offer services over a network) and data storage. Data centres are used by businesses, universities and government and account for around a quarter of ICT's emissions, and 2-3% of the UK's total electricity use.[2]

Box 1. Improvements to data centres

There are three main areas where the energy efficiency of data centres can be improved: the facility itself; the ICT equipment housed there; and how that equipment is used.

- **The facility:** around half of the electricity going into a standard data centre is used just to cool the equipment inside it. The layout of the building has a big impact on the efficiency of the cooling systems. It should avoid as much as possible the mixing of hot and cold air. Some advanced facilities use liquid cooling or 'fresh-air' cooling, which uses air from outside the facility to cool the inside rather than recirculating air internally.
- **The equipment:** components of the servers used in data centres, such as processor chips, are becoming more energy efficient. Power supply units have also become much more efficient with initiatives such as the 80 PLUS programme (funded by electric utility companies), which certifies power supplies that are more than 80% efficient. New solid state data storage devices can be operated at a wider range of temperatures than hard disks, though they are more expensive and not suitable for all applications.
- **The workload:** in traditional data centres, the servers are used inefficiently. For example, a server will still draw around 70-90% of its maximum power usage even when doing no useful work. A technology called virtualisation allows applications that would otherwise be run on several different servers to share one, and in the longer term applications will be rewritten to run naturally using shared resources. This means that servers can run closer to their maximum capacity, which is more efficient. Redundant servers can then be removed.

Their consumption has become an issue because of high electricity costs and problems with power supply capacity. Most of the energy going in to data centres is lost to cooling systems, power supplies and inefficient servers, and only a small fraction converted to useful output. Technical ways to increase the efficiency of a data centre are outlined in Box 1.

A simple metric to quantify improvements in the data centre is the power usage effectiveness (PUE), defined as the total power going into a data centre divided by the power used by the ICT equipment. Today's typical data

centres have a PUE greater than 2, though values vary widely according to the configuration of the data centre and requirements on its availability. The US Environmental Protection Agency suggests that by 2011 this could be reduced to 1.7 simply by operating existing equipment more efficiently and to 1.2 by implementing state-of-the-art technologies.

However, the British Computer Society (BCS) has pointed out that a data centre is a complex system, and simply assembling a collection of improved components will not necessarily result in the most energy efficient whole. BCS and the Carbon Trust are releasing a simulation tool that will allow data centre owners to model the effects of changes before they implement them. The European Commission launched a voluntary code of conduct for data centres in November 2008, which aims to raise awareness of their energy use. It recommends best practice and targets for data centre owners, whilst avoiding prescription of specific technologies.

ICT equipment in the office

Data centres are where ICT equipment is most concentrated, but around half of all ICT's energy consumption comes from office equipment including PCs, laptops, printers and telephones.[2] This energy use is more difficult to tackle than that of data centres because it relies on the behaviour of many individuals, but some technological improvements are possible (Box 2).

Switching off

According to a survey by the National Energy Foundation (NEF),[3] 18% of office workers never switch off their PC at night or weekends and a further 13% leave it on some nights each week, producing about 700,000 tonnes of CO_2 emissions (equivalent to the annual emissions of a typical gas-fired power station). Rather than trying to change behaviour, it may be more effective to enforce these measures. Centralised 'active power management' software can automatically switch off all equipment in an office between certain hours, while allowing it to be switched back on out of hours for remote software maintenance. NEF estimates this could save £175,000 a year for a business with 20,000 staff.

Energy use and the ICT life-chain

Energy efficiency initiatives in ICT have mostly focused on consumption while in use. However, a large part of the environmental impact of a device comes during its manufacture and disposal. The whole life impact of equipment is much more difficult to measure than the in-use energy consumption, because it is spread through a long supply chain. This uncertainty makes it difficult to know when it is better to extend the life of equipment, thus reducing the sector's total emissions from manufacture and disposal; or when to replace old equipment with new equipment that is more efficient in use. In October 2008, the British Standards Institute launched a methodology (known as PAS 2050) for measuring whole life emissions from goods and services. Companies who measure their emissions and commit to reducing them will be able to use an official carbon label.

Box 2. Improvements in the office

- **More efficient components:** the micro-processors within electronic equipment require energy both to operate and for cooling fans. Advances in chip design (such as 'multi-core' processors) can save 30-60% of the energy used by the processor if software is written to take advantage of this capacity.
- **Power management:** almost all computers now have a low power mode which they can enter automatically after a period of user inactivity. In such modes they will consume very little power but can often be woken up within seconds. Power management options are sometimes enabled as a default.
- **Laptop computers:** these can sometimes use as little as a third of the energy of a desktop.[4] Some organisations are replacing desktops in the office with laptops. Similarly, flat screen monitors are much more efficient than old-fashioned cathode ray tubes.
- **Thin clients:** these are terminals that do not do processing themselves, but allow the user to connect to central servers and display the output. The German Fraunhofer Institute estimated that a thin client configuration is twice as energy efficient as using desktop PCs,[5] though these findings have been disputed as underestimating the cost of the increased power usage of servers needed to support the clients.
- **Multi-functional devices:** printers now often include scanning, copying and fax functions, which is more efficient than running several separate devices. The number of printers per person can also be reduced, and printers can be set to enforce double-sided printing to save paper and use of the printer.

Wider environmental impact

Although not a focus of this note, the whole life environmental impact of ICT concerns not just emissions but also the extraction and disposal of harmful materials. EU legislation has had an impact here. The Waste Electronic and Electrical Equipment (WEEE) Directive (POSTnote 291) was implemented in the UK in 2007. It requires producers of ICT equipment to pay for the cost of treatment, recycling and disposal of waste equipment. The Restriction of Hazardous Substances (RoHS) Directive which came into force in the UK in 2006 regulates the use of some harmful chemicals in products.

Use of ICT in other sectors

Several reports have pointed out that the use of ICT in other sectors has the potential to reduce carbon emissions by far more than ICT's direct contribution (Box 3). Intellect, the trade association for the UK technology industry breaks this down into:[6]

- Enhancing: technologies that make existing processes more efficient e.g. intelligent transport.
- Enabling: technologies that allow us to do things differently e.g. the paperless office.
- Transforming: technologies that lead to alternative low-carbon business models e.g. broadband.

In May 2008, a European Commission communication identified three priority areas for use of ICT to reduce emissions: homes; electricity grids and lighting.[7] The UK government response to this communication broadly agreed with its aims, but expressed some concern that the introduction of new ICT into the electricity network might compromise its operational security.

Box 3. ICT in other sectors

WWF, the global conservation organisation suggests ten uses of ICT in other sectors that could each reduce global carbon dioxide emissions by at least 100 million tonnes by 2020.[8] Several of these applications are described in more detail in past or forthcoming POSTnotes.

- Smart city planning: deploying simulation software to improve urban design to optimise energy efficiency.
- Smart appliances: use of ICT within appliances to improve efficiency and to tailor their use with needs.
- Smart industry: deploying software to forecast, simulate and analyse energy use in production processes.
- Smart grid: deploying smart meters and communication technologies within electricity networks.
- Smart work: use of the internet to work remotely and avoid business trips or physical commuting.
- Smart buildings: use of sensors and controls in buildings to improve efficiency.
- Dematerialisation services: use of ICT to substitute for physical products and interactions e.g. online shopping.
- I-optimisation: use of ICT within production processes to improve operations and increase efficiency.
- Integrated renewable solutions: use of simulation, analytical and management tools to enable a wide deployment of renewable energy.
- Intelligent transport: deployment of advanced sensors, analytical models and ubiquitous communications to enable less polluting forms of transport.

Teleworking

Teleworking is often cited as a key way of reducing emissions, by cutting down on commuter travel and business trips. Some proponents of next-generation broadband (POSTnote 303) argue that the full benefits of teleworking will not be realised until there is faster broadband to allow, for example, high-resolution video-conferencing. Also, it is difficult to measure exactly how much energy is saved by teleworking, once factors such as the need for day-time home heating and duplication of ICT equipment for home workers are included.[9]

Putting ICT emissions reductions into practice

Corporate attitudes

Although the energy use of ICT is moving up the corporate agenda, there is much scope for improvement in certain areas.

- Measurement: 42% of executives responding to an Economist survey[10] said their organisation does not monitor its ICT-related energy spending.
- Accountability: often the ICT department of a company is not responsible for the company's energy bills. The data centre simulation tool being developed by the BCS can be used to break down the energy use in the data centre between the services being run there, allowing it to be billed appropriately.
- Procurement: 63% said reliability was a critical factor in ICT procurement and 32% said price. Only 12% said that energy efficiency was critical.
- Advertising: some businesses are concerned that 'greenness' is being used by manufacturers as a sales tactic, without them providing sufficient impartial and robust evidence of the benefits of using their equipment. This has become known as 'green-wash'.

Legislation

The Energy-using Products Directive was adopted by the European Parliament in 2005. It aims to encourage manufacturers to design products, including ICT equipment, with whole life environmental impacts in mind. For each product group covered, minimum standards for energy efficiency will be set, and only goods meeting them will be eligible for sale in the EU. A preparatory study on the requirements for computers and monitors analysed existing products and looked at the improvements that could be achieved through the technologies described earlier (Box 2).

General measures restricting the total carbon emissions of companies may have more impact than ICT-specific legislation. For example, the 2007 Energy White Paper introduced the Carbon Reduction Commitment (CRC), a mandatory emissions trading scheme for large organisations. The BCS has expressed concern that the CRC as it currently stands excludes outsourced data centres from a company's requirement to report emissions that it is responsible for. This creates an incentive for companies to outsource data centres, doing nothing to reduce emissions and potentially moving skilled jobs overseas.

Laws regarding data retention may have a counter-productive effect on ICT's efficiency. Requiring that more data must be stored in an instantly retrievable form increases the need for storage in data centres.

Labelling

One way to promote ICT emissions reductions is by labelling equipment to show its energy efficiency. This informs consumer decisions, and the requirements of particular labels may be specified for procurement contracts. Labels can be voluntary or mandatory, and can address just in-use energy or try to look at the whole life impact. The most widely used label is ENERGY STAR, which focuses mainly on the energy efficiency in-use (in on, standby and off modes). Other voluntary eco-labels include wider indicators of environmental impact (Box 4). In 2008, the EU ENERGY STAR regulation was amended to require that central government organisations specify energy efficiency requirements for ICT equipment purchases no less demanding than ENERGY STAR.

Mandatory labelling

The EU introduced mandatory energy labelling for white goods in 2006, ranking energy efficiency from A to G. A similar system has been suggested for ICT equipment, but manufacturers argue that this is over-simplistic as ICT equipment can be operated in many different modes. They would prefer to label simply with the power used in defined 'typical' modes, but customers may not understand wattages, and converting them into an energy cost depends on the electricity price that individual users pay. Intellect is piloting a 'green sheet' to accompany all equipment, which would bring together data on energy consumption and information to help consumers optimise the efficiency of their devices.

Box 4. Eco-labels

- ENERGY STAR: started by the US Environmental Protection Agency in 1992 to promote energy efficient products including PCs and monitors. The ENERGY STAR label aims to qualify only the top performing 25% of products at the time a specification is agreed. In 2001 the EU agreed with the US government to co-ordinate energy efficiency labelling for office equipment, based on ENERGY STAR. The latest version of ENERGY STAR will include specifications for the servers used in data centres.
- TCO label: a global label started in 1992 that also addresses other issues regarding the work environment, such as image quality, visual and work load ergonomics, noise, electromagnetic- and chemical emissions. Mainly used for displays rather than computers.
- Energy Saving Recommended (ESR) label: run by the UK Energy Saving Trust, it covers amongst other products computers, monitors and some imaging equipment. ESR aims to qualify around the top 20% of the market. The requirements for ICT products are based on ENERGY STAR (sometimes slightly more stringent) as well as manufacturer compliance with the WEEE and RoHS directives.
- Electronic Product Environmental Assessment Tool (EPEAT): managed by the non-profit US Green Electronics Council, it helps businesses to compare ICT equipment on a number of environmental factors. It includes the ENERGY STAR efficiency requirements. EPEAT is developing to cover new categories such as mobile phones, displays and printers.

Government involvement

Several government departments are involved in this area. The Department of the Environment, Food and Rural Affairs (Defra) has responsibility for energy efficiency and wider environmental impacts, and within it the Market Transformation Programme (MTP) supports policy on sustainable consumption and production. The Department of Business Enterprise and Regulatory Reform (BERR) takes the lead on the use of ICT in other sectors. The Information Age Partnership within BERR, an industry-government forum on ICT and environment, points to the growth potential for the UK in the provision of products and services for ICT emissions reduction.[11]

In 2007, the pan-government Green ICT Delivery Group was set up by the Cabinet Office chief information officer and chief technology officer councils. It published the government's strategy on "Greening Government ICT" in July 2008 (Box 5).[12]

Procurement

Government procurement policy can have a major impact on manufacturers. The UK government owns around 2m PCs.[3] The MTP maintains a database called Quick Wins, which lists minimum standards for products procured by government departments, including ICT equipment. From 2008 it also lists more stringent best practice targets. However, a 2007 report by the Sustainable Development Commission noted that 9 of 21 departments did not include Quick Wins as part of their procurement contracts, despite it being mandatory since 2003. Following the report, the government established a new Centre of Expertise for Sustainable Procurement within the Office of Government Commerce.

Box 5. Government strategy

The Cabinet Office strategy "Greening Government ICT" sets a target for the in-use energy consumption of government ICT to be carbon neutral by 2012, and its whole-life consumption by 2020. Key targets of the strategy are:

- extending the lifetimes of all ICT purchases to their natural demise as opposed to frequent automatic replacement programmes (often as short as 2 years);
- reducing the number of PCs and laptops used by organisations to as close to one per person as possible;
- implementing active power management software to reduce power consumption;
- reducing the number of printers, replacing with multi-functional devices where possible and using efficient printing defaults e.g. duplex, greyscale, low resolution;
- increasing average server utilisation to a minimum of 50% as part of a commitment to comply with the EU code of conduct for data centres.

The government is piloting a 'green ICT scorecard' to benchmark organisational behaviour, policy, governance, procurement, energy efficiency, labelling and disposal. The results will be available in February 2009.

Overview

- The information and communications technology sector is responsible for about 2% of global carbon dioxide emissions.
- There are many easy ways to increase the energy efficiency of ICT equipment, particularly in data centres.
- A comprehensive perspective looks at the whole life emissions of ICT, not just energy efficiency in use.
- The use of ICT can also reduce emissions in other sectors, potentially saving far more than the direct impact of ICT itself.
- Policy approaches to reducing ICT emissions include legislation, eco-labelling and procurement standards.

Endnotes

1 http://www.mckinseyquarterly.com/Information_Technology/Management/How_IT_can_cut_carbon_emissions_2221
2 *An Inefficient Truth*, Global Action Plan, December 2007
3 *The PC Energy Report*, National Energy Foundation, 2007
4 *Green ICT? Current research into the environmental impact of ICT*, Socitm, November 2007
5 *Environmental comparison of PC and thin client desktop equipment*, Fraunhofer Institute, April 2008
6 *High Tech: Low Carbon*, Intellect, February 2008
7 *Addressing the challenge of energy efficiency through Information and Communication Technologies*, EC, May 2008
8 *Becoming a winner in a low-carbon economy: ICT solutions that help business and the planet*, WWF, 2008
9 *The costs of transport on the environment – the role of teleworking in reducing carbon emissions*, D. Banister et al., June 2007
10 Economist Intelligence Unit survey, 2007
11 *Driving the virtuous circle: How ICT can enable the carbon-effective organisation*, Information Age Partnership, June 2008
12 *Greening Government ICT*, Cabinet Office, July 2008

POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of public policy issues that have a basis in science and technology. POST is grateful to all contributors and reviewers. For further information on this subject, please contact the author, Dr Martin Griffiths, at POST.

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