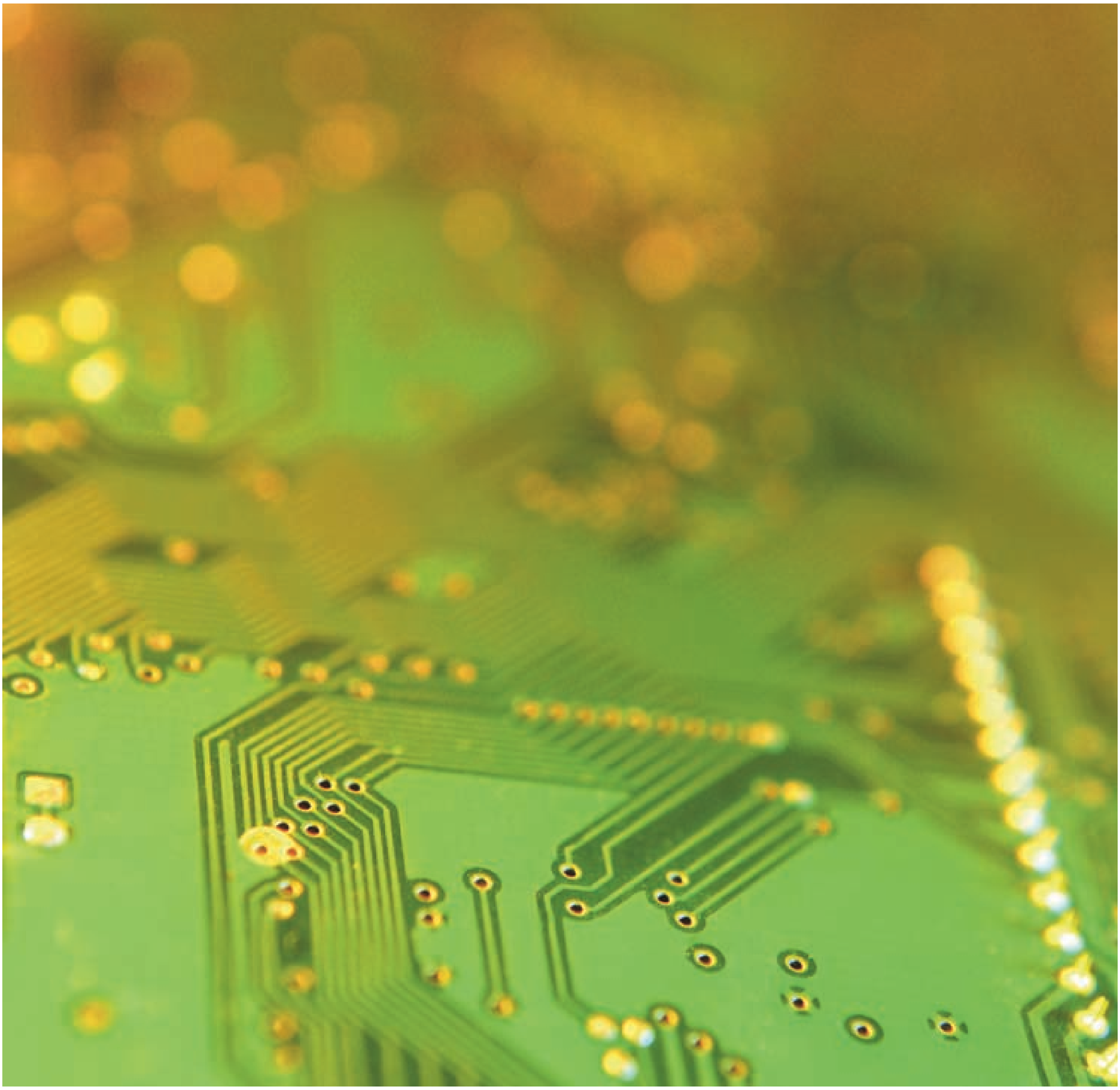
JISC

Sustainable ICT in Further and Higher Education

January 2009



Sustainable ICT in Further and Higher Education

A Report for the
Joint Information Services Committee (JISC)

Final Version 13 January 2009

Peter James and Lisa Hopkinson

Higher Education Environmental Performance Improvement Project, University of Bradford

SustainIT, UK Centre for Economic and Environmental Development

Project website: www.susteit.org.uk

Contents

About the Organisations

The SusteIT (Sustainable IT in Tertiary Education) project has been funded by JISC, and builds on the experience of its two managing organisations:

The *Higher Education Environmental Performance Improvement* (HEEPI) project supports sustainable development, and especially environmental improvement, in higher and further education through: identification and dissemination of best practice; creation and maintenance of networks; development of benchmarking data and processes; and in other ways. It is based at the University of Bradford, and has mainly been funded by the Leadership, Governance and Management (LGM) initiative of the Higher Education Funding Council for England (HEFCE). Since its inception, HEEPI has run almost 70 events, with almost 3,000 delegates; prepared many case studies, guidance documents and tools, including one for campus sustainability assessment (see www.goodcampus.org); and established a sustainable laboratories initiative in partnership with the US Labs21 programme. See www.heepi.org.uk for more details.

SustainIT is a unit of the national, not-for-profit, sustainable development charity UK CEED (UK Centre for Economic and Environmental Development). It was founded in 1999 to research and promote uses of ICT that deliver tangible social, economic and environmental benefits. Since then, it has worked on research and dissemination projects on sustainable ICT in partnership with a wide range of organisations, including the European Commission, UK Government departments (Communities and Local Government, Defra and DFID), a number of regional agencies, local authorities, IDEA, AOL, BT, Brother and Vodafone. It also organises the annual eWell-Being Awards. See www.sustainit.org for more details.

About the Authors

Peter James is (part-time) Professor of Environmental Management at the University of Bradford, co-director of HEEPI, and an associate of SustainIT. He has previously undertaken a number of research projects on ICT sustainability, environmental innovation and related topics for the European Commission, UK Government agencies, and the private sector, and was co-ordinator of the EU Sustel (Sustainable Teleworking) project. He was a member of the EU's Expert Group on Environmental Technology, and is a current member of the Expert Group on ICT and Energy Efficiency. His publications include *Driving Eco-Innovation*, *The Green Bottom Line*, and *Sustainable Measures*.

Lisa Hopkinson is currently a researcher with HEEPI at the University of Bradford. Her previous experience includes environmental consultancy in the UK and Hong Kong, campaigns coordinator for Friends of the Earth (Hong Kong) and co-founder and Head of Research for a non profit public policy thinktank, Civic Exchange, in Hong Kong.

Acknowledgements

Special thanks for help with this report, and other SusteIT outputs, are due to Dave Berry (formerly Grid Computing Now!), Hugh Beedie (University of Cardiff), Rob Bristow (JISC), Chris Cartledge (formerly University of Sheffield), Rae Earnshaw (University of Bradford) and Howard Noble (University of Oxford). The authors also thank the individuals and organisations below for their contributions in being interviewed, providing information for cases, presenting at events, providing feedback on outputs, and in other ways. Any remaining errors in the document are the sole responsibility of the authors.

Arizona State University: Eric Williams
Ave Maria University: Bryan Mehaffey
Beamont College: Liz Howarth
British Computer Society: Liam Newcombe
Carbon Trust: Richard Rugg
Cardiff University: Chris Dickson; James Osborne
City & Islington College: Paul Upson
City College Norwich: John Pollitt
Computer Aid: Anja Ffrench
Coventry University: Mark Abrams
DCS Ltd: Farshad Saffarian
Defra: Laurie McAndrew; David O'Gorman
Durham University: Mike Cameron
Dyer Architects: Stephen Blowers
EMEA: David Angwin
EMPA, Switzerland: Martin Eugster; Roland Hischier
Environment Agency: Simon Redding
Gloucestershire College: James Billingham
HEFCE: Joanna Simpson; Andrew Smith
IVF: Anna-Karin Jönbrink
JANET: Paul Bonnett; Bob Day; Lara Van de Langeryt
JISC: Amy Butterworth; Jane Charlton; Bill Olivier; Craig Wentworth
JISC Regional Support Centres: Thomas Rochford (Eastern); Marion Miller (Yorkshire & Humber); Andrew Quarmby (Northwest);
King's College, London: Ian Caldwell; Keith McIntyre
Kyocera: Helen Hopper
Lawrence Berkeley National Laboratory: Geoffrey Bell; Eric Masanet; Lynne Price
Learning and Skills Council (LSC): Mary Kelly; Steve Nichols
Leeds Metropolitan University: Mike Briggs; Mark Warner
London Universities Purchasing Consortium (LUPC): Mike Kilner
Loughborough University: Anne Mumford
Lowestoft College: Tony Bartley
Middlesex University: Penny Duquenoy
National e-science centre (NeSC): Gillian Law
Newcastle College: Becky Ferry
North Eastern Universities Purchasing Consortium (NEUPC): Simon Toplass
Norwich City College: John Pollitt
Nottingham Trent University: Grant Anderson; Gillian Crofts; Alex Mcfarlane
NSC Global: Chris Wilson
PE International: Constantin Herrmann
Performance Building Partnership: Ken Gray
Queen Margaret University: Fraser Muir; Steve Scott
Queen Mary University: Sarah Pearce
Queens University Belfast: Julie-Ann McGregor
SCOPE: Julie Burley
Sheffield Hallam University: Dave Thornley
Somerset College of Arts and Technology: Kirsti Norris
Stockport College: Dave Gay
Strategies International: Martyn Rose
Sun Microsystems Ltd: Simon Schouten
UCISA: Peter Tinsley
UK Market Transformation Programme: Catriona McAlister; Anson Wu
University of Birmingham: Rob Arnold; Ray Tier
University of Bradford: Peter Cowling; Mick Cribb; Andrew Day; Sara Eyre; Peter Hartley; Graham Hill; Peter Hopkinson; Brian Pickles; David Robison; Ian Robshaw Ian Stow; Darren Sugden

University of Buckinghamshire: Trevor Nicholls
University of Dundee: Peter Gregor; Colin McNally; Derek Mitchell; John Yule
University of Edinburgh: Mike Brown; David Somervell
University of Exeter: Godfrey Whitehouse
University of Gloucestershire: Clive Fenton
University of Liverpool: Lisa Nelson
University of Oxford: Daniel Curtis; Howard Noble
University of Plymouth: Gregory Regan
University of Reading: Derek Clements Croome
University of Sheffield: Chris Cartledge (former employee); Julian Dean; Phil Riley; Chris Sexton
University of St Andrews: David Stutchfield
University of York: Willy Hoederman; John Mason
Welsh Video Network: Phil Davison

Executive Summary

ICT is becoming ever more ubiquitous within further and higher education, for e-learning, in research, e-administration and other ways. This creates many benefits, including ones of direct relevance to sustainable development such as improving accessibility for disadvantaged groups, and reducing environmental impacts by substituting virtual for physical activities (as when conferencing substitutes for face-to-face meetings).

ICT in UK further and higher education has a large environmental footprint

However, the benefits of ICT are partially offset by 'hidden' environmental, and, on occasion, social costs. A scaling up of findings at the University of Sheffield, Lowestoft College and City College, Norwich, suggests that UK universities and colleges as a whole:

Utilise nearly 1,470,000 computers, 250,000 printers and 240,000 servers

Will have ICT-related electricity bills of around £116m in 2009, and

Are indirectly emitting over 500,000t of carbon dioxide (CO_2) emissions from this electricity use

The production, and disposal, of ICT equipment also involves the release of many hazardous substances; consumes large quantities of energy and water; generates large amounts of waste; and sometimes involves dangerous and exploitative working practices (discarded computers from UK universities have been seen, for example, at unsafe recycling sites in Africa).

There is a growing consensus amongst experts, leading ICT suppliers and policy makers, that the combination of rapid ICT growth and negative environmental impacts of the kind described, make current ICT practices and trajectories unsustainable. Several studies have suggested that ICT is already responsible for 2% of global carbon emissions, and that its relative share will increase further.

Why further and higher education needs more sustainable ICT

Although our project has identified (and highlighted through case studies) examples of positive actions for sustainable ICT within the sector, these are not representative, and more needs to be done. Almost all respondents to a survey we conducted felt that it is important to make ICT more sustainable, and three-quarters stated that it is very important. The reasons why include: demands from stakeholders; increasingly stringent regulation (such as the Carbon Reduction Commitment and EU Energy Using Products Directive); opportunities for financial savings and reduction of risk; opportunities for new areas of teaching and research; and enhancing the sector's reputation.

Taking action – integrating different time perspectives

The Government has a long-term target of an 80% reduction in CO_2 emissions by 2050, compared to 1990 levels, which requires radical changes in all areas of economic and social life. It is therefore probable that sustainable ICT in 2050, or even 2020, will be very different from that today. Devices may contain radically different materials; their environmental impacts may be tracked through all stages of supply so that it is easy to distinguish more sustainable variants; computing tasks could be related to environmental impacts; e-reading may have replaced paper in many applications; cloud computing may be ubiquitous and demonstrably superior in environmental terms to current computing models; many data centres may be utilising renewable energy; and many meetings and learning sessions may be virtual.

In the short - medium term, however, the sector must work with sub-optimal technologies, inadequate information and poorly developed processes – and limited leverage with suppliers – in addressing 'upstream' environmental impacts. It therefore makes sense to focus initially on reducing the resource consumption (eg electricity, paper) of its own ICT activities as this is within its control, and can create financial as well as environmental benefits.

Taking action – minimising ICT impacts

Actions in individual institutions will depend upon organisational circumstances and IT configurations. It is important that sustainability is always considered fully when strategic IT decisions are being made as:

> 'Thin client' approaches are already reducing lifetime use of energy and materials, as well as providing other benefits, in a number of institutions, and should be considered for any applications that do not require large scale computing power
>
> There is great potential for distributed computing and/or outsourced/shared service solutions to increase the currently very low utilisation levels of PCs and servers, and
>
> Growing volumes of data mean that decisions (or lack of decisions) about storage have considerable energy implications – more rigorous information on life cycle management is needed, to eliminate storage of data that are no longer required, or to increase the proportion that utilises low energy storage, rather than 'always on' spinning disks
>
> There is enormous scope to create much more sustainable data centres through: purchasing servers with lower power requirements; increasing utilisation rates through consolidation and virtualisation; and by changing physical aspects such as layouts, cooling and power supply, so that their energy 'overhead' above that used by servers is only 20–30%, compared to the current 40–100%. In the medium term, greater use of renewable or low carbon energy supply is feasible. This could be facilitated by a move to shared service data centres if these enable more optimal choices of location for renewable energy and/or economies of scale in cooling

This study estimates that personal computing accounts for around 50% of ICT-related electricity consumption in universities and colleges. Much of this is wasted, because many devices: are energy inefficient; are often left switched on when not in use (eg at night or in holiday periods), or in more active states than they need to be for much of the time; are considerably under-utilised even when they are in use; and are often more powerful than is required for the activities they are undertaking.

A strategic approach to personal computing is required to reduce this wastage, and to meet student and staff needs in the most cost-effective and sustainable way possible. This requires a cross-functional team bringing together (at least) IT staff, users, and energy or environmental managers, and chaired by a relatively senior manager. Key elements of their work will be: auditing of the computing footprint within the institution; defining user needs and matching appropriately; seriously examining low impact alternatives (such as thin client); and building awareness and support amongst users. Actions are also needed to:

> Purchase appropriate hardware and software, and especially models which are – at a minimum – Energy Star 4.0 compliant, and preferably exceed its requirements considerably
>
> Reduce energy consumption, for example, by increased powering down of devices, and
>
> Increase longevity through extending refresh cycles, and avoiding software-induced replacement

Electronic printing and copying accounts for at least 10–16% of ICT-related electricity consumption, and survey respondents were printing an average 224 sheets a week, or 10,000 annually. This sums to well over

£1m of printing and copying costs in larger universities. Volumes, costs and environmental impacts are generally rising, and 'out of control' in some institutions. No more than half of those responding to the SusteIT survey were undertaking any of three key measures for sustainable printing: replacing single with multifunctional devices; setting duplex (double-sided) printing as a default; and use of 100% recycled paper. Other measures to reduce the energy consumption and environmental impacts of printing and copying include:

Document and print management, including: development of a green printing strategy; maximising print substitution; effective document management; consolidation of devices; and building user support

Purchasing appropriate equipment: involving careful definition of basic equipment needs, using relevant procurement standards, and assessing vendor commitment to sustainability

Reducing energy consumption: by enabling and using power management, and by switching equipment off to a greater degree; and

Reducing paper and consumables usage: by purchasing recycled and/or lighter weight paper, encouraging more paper efficient printing, and other means

Taking action – maximising beneficial ICT applications

A recent study has estimated that ICT applications could reduce global CO_2 equivalent emissions in 2020 by 15%, and avoid approximately 5t of CO_2 emissions for each tonne that they generate through production, use and disposal of equipment. It highlights the potential of two areas of relevance to further and higher education. The energy consumption of buildings can be greatly reduced by making them more intelligent. And 'dematerialisation' can substitute carbon-intense activities such as meetings, or teaching sessions involving travel, with low carbon equivalents, such as videoconferencing. One study has found that distance learning courses reduced energy consumption and carbon emissions by 90% compared to conventional campus-based ones.

The sector has some examples of good practice with regard to buildings, and there is a high level of interest in taking more action. Our survey also found that 60% of respondents would like to do more work remotely, and that 77% felt that there was scope for more use of videoconferencing. The sector currently has a sophisticated videoconferencing infrastructure, which is under-utilised. Better marketing and other measures could create a considerable growth in uptake without excessive additional investment.

Taking action – management

Sustainable IT is not achieved overnight, but requires long-term commitment and change. This in turn requires its embedding into activities and systems, both within IT departments and in other areas of the institution. Our research identified a number of barriers – survey respondents felt that the most important were: time/staff resource constraints; lack of coordination between different parts of the organisation; budgetary constraints; lack of guidance on how to reduce environmental and social impacts; lack of information on environmental and social impacts of equipment/services; lack of choices on type of ICT equipment that can be purchased; lack of awareness of sustainable ICT issues amongst staff/departments; and lack of whole life costing or consideration of environmental impacts during the procurement process. Experience in other areas of environmental improvement suggests that overcoming these barriers requires:

Clear organisational commitments, and effective implementation processes such as greater responsibility for energy consumption (our survey found that less than half of the respondents from IT departments were aware of the energy costs associated with their activities)

A continuous improvement approach within IT departments, eg by setting up environmental and sustainability champion(s), and by more measurement, targeting and monitoring, and

More effective measurement of total cost of ownership, as current procurement decisions often ignore or underestimate energy or other environmental costs

Taking action – sector bodies

Funding councils, JISC and other sector bodies must provide more support to institutions in their transition to sustainable ICT because: some relevant expertise or knowledge may be impossible for institutions (especially smaller ones) to develop in practice; some actions can only be accomplished at regional or national level (as with effective procurement agreements) or require a critical mass of activity in a number of institutions (as with videoconferencing); and many actions require cross-functional collaboration, which can be facilitated by 'top down' national initiatives involving relevant professional bodies. Such actions can be justified both by the importance of sustainable ICT, and also because they will be synergistic with other strategic drivers of further and higher education. For example:

Moves towards whole life costing of ICT purchases, and greater budgetary responsibility for energy costs by IT departments, would contribute to the objectives of achieving greater value for money, and cost transparency in research and teaching

The potential capacity constraints created by high electricity consumption in data centres (and other areas) should often be an important aspect of institutional risk assessments

Some of the innovations to achieve greater energy efficiency could be best achieved on a shared service basis, and

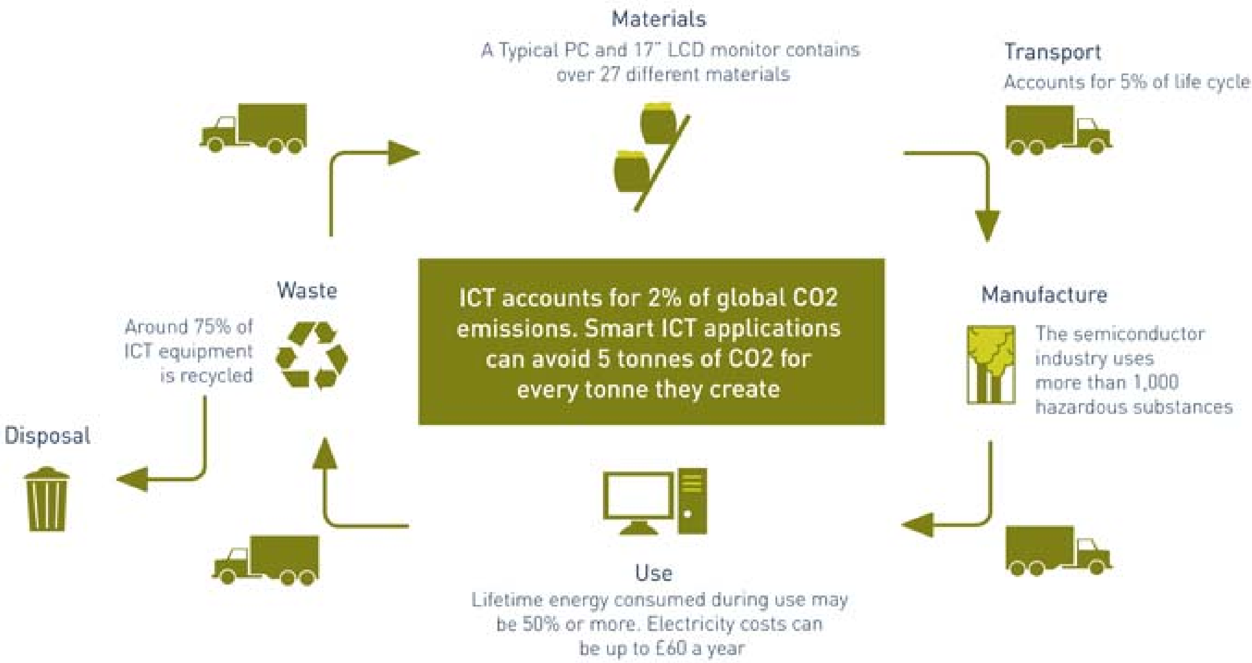
The capacity of work-related applications to provide better work–life balance and other personal and social benefits has many connections with the well-being agenda

Table 10 (at the end of Chapter 6) identifies eight possible forms of support – strengthening capacity; providing funding; giving direction; strengthening grant conditions; strengthening coordination; strengthening sustainable procurement; funding exemplar projects; and financing relevant investigation and research – which could be provided by sector bodies, and makes detailed recommendations as to how they can be achieved.

Project details

The study took place between January and December 2008 and was based on: desk research; interviews with many practitioners and experts within and outside the sector; an online survey, which gathered 183 responses, from 49 institutions; and discussions at five workshops, which were attended by almost 300 people. It is accompanied by: three detailed reports on data centres, personal computing, and printing; over 20 case studies; a detailed audit of ICT use at the University of Sheffield; and two open source tools. One enables an energy and carbon footprinting of ICT use, and the other analyses the environmental and financial implications of thin client computing. During 2008 the project team made over 20 presentations, to almost 1,000 people, on their work and findings. They have also worked with the Environmental Association of Universities and Colleges to gain Scottish Funding Council support for a follow-on project, based on the footprinting tool, and with the Regional Support Centres to gain JISC funding for three sustainable ICT conferences in 2009.

Figure 1 Key Impacts of ICT



Introduction

The topic of sustainable ICT – ie the economic, environmental and social impacts of information and communication technologies – is at the intersection of two trends that are having a profound effect on further and higher education:

- The sector's growing reliance on ICT, and
- The growing pressures for it to do more to mitigate the environmental and social impacts of its activities

Universities and colleges routinely use ICT for many administrative and support tasks, such as payroll and marketing, and specialist activities such as scientific research. Until recently, this was less true of its use in their core activity of teaching and learning (Collis, 2002; Oliver, 2005), but this too is changing as they move into 'e-learning', both of their own volition, and through encouragement by the Funding Councils. As Appendix 1 demonstrates, this means that UK further and higher education ICT now:

- Utilises nearly 1,470,000 computers, 250,000 printers and 240,000 servers
- Consumes around 966,000 Mega Watt-hours (MWh) of electricity annually – equivalent to 15–20% of total non-residential electricity consumption in the sector and likely to cost around £116m in 2009, and
- Is indirectly emitting over 500,000t of CO_2 emissions from this electricity use (with further substantial quantities being emitted in the production of the ICT equipment)

As with society generally, universities and colleges are also under pressure to make a greater contribution to sustainable development. This includes mitigating environmental impacts through:

- Minimising their energy consumption
- Minimising the travel undertaken by staff and students in connection with their work and study
- Minimising their carbon footprint, in the previous, and in other, ways
- Maximising the biodiversity of campuses, and
- Minimising generation of waste, and maximising recycling and reuse

It also involves creating social benefits (and avoiding 'disbenefits') through such means as:

- Assisting social inclusion through increasing access to education amongst disadvantaged groups
- Supporting local communities
- Helping to improve living conditions and access to opportunities in developing countries, and
- Ensuring health and safety, and privacy, for staff and students

Scope and content of the report

This report is an output of the SusteIT project, which is a collaboration between the Higher Education Environmental Performance Improvement Initiative (HEEPI) and SustainIT, a unit of the independent charity, the UK Centre for Economic and Environmental Development. The project was established by the Joint Information Services Committee (JISC) to:

- Analyse environmentally sustainable ICT practices in further and higher education, and the extent of an institution's strategic engagement with them
- Develop best practice cases and tools in order to assist the further development of sustainable ICT, and
- Examine the role of shared services within sustainable ICT

As other networks and projects are examining the education and social impacts of ICT within the sector, especially with regard to e-learning, the report's main focus is on environmental aspects of sustainability. However, it does comment on social aspects where appropriate. Similarly, although the report's primary focus is on short - medium-term developments, it does recognise that the longer term development of ICT may create both opportunities and threats that could invalidate some of its discussion.

The report content is based on:

- Extensive desk research, and follow up discussions arising from it with international experts
- Interviews with many practitioners and experts within and outside the sector
- An online survey, which gathered 183 responses, from 49 institutions, as detailed in Box 1, and a separate paper (James and Hopkinson, 2008d)
- A pilot 'footprinting' of ICT energy consumption in use at the University of Sheffield (described in detail in Cartledge, 2008a)
- Discussions at five workshops, on Data Centre Cooling and Power Supply (at Cardiff University), New Ways of Working (at Queen Margaret University), The Sustainable Desktop (at the University of Sheffield) and The Intelligent Campus (two linked workshops at Birkbeck College and King's College in London) with almost 300 attendees
- Over 20 case studies of best practice within universities and colleges (see Appendix 5).

Structure of the report

The structure of the remainder of the report is as follows:

- Chapter 1 provides an overview of the environmental and social impacts of ICT in further and higher education
- Chapter 2 discusses the responsibility, regulatory, financial, reputation and risk drivers, which mean that universities and colleges require more sustainable ICT
- Chapter 3 examines – for enterprise architecture, data centres, PCs and printing – ways in which adverse environmental and social impacts from devices and networks can be minimised, and positive ones, maximised

Chapter 4 examines the environmental and social aspects of the application of ICT in universities and colleges, especially for learning, work and buildings

Chapter 5 discusses institutional barriers to sustainable ICT, and the management actions that can overcome them

Chapter 6 provides conclusions

Appendix 1 summarises the ICT-related energy usage and carbon footprint of UK higher education

Appendix 2 provides contextual information on UK electricity consumption for ICT and other activities

Appendix 3 summarises key environmental regulations of relevance to the sector, and

Appendix 4 provides details of sustainable ICT procurement, and examines whether the sector could make more use of environmental labelling schemes

Appendix 5 summarises the case studies and associated technical papers.

Three supporting technical papers, on personal computing, data centres and printing, have also been prepared (James and Hopkinson, 2008a,b,c). They can be downloaded from www.susteit.org.uk. The site also has two tools available for download – one to prepare an energy and carbon footprinting of ICT use, and the other to enable analysis of the environmental and business benefits of thin client computing.

Box 1 The SusteIT Survey

Our survey was conducted in March–April 2008. To ensure that people were not asked to answer questions beyond their competence, it employed a high degree of routeing. It was filled in by a total of 183 individuals, from 49 institutions, which were mostly universities. Responses were received from almost all the IT-intensive universities, eg those making considerable use of high-performance computing. Although we did not specifically ask people to identify their areas of work, the numbers answering the specific section questions suggest that around half had IT backgrounds.

In some cases, one individual answered the survey on behalf of an institution, so the effective number of people involved providing survey responses is probably around 200–300. This constitutes a significant proportion of people in the sector who have a strong interest in sustainable ICT.

The survey results are summarised at relevant points in the text. Full details are available in a separate paper (James and Hopkinson, 2008d).

Box 2 The Digital Footprint of Higher Education

Appendix 1 scales up the findings of a SusteIT audit of ICT at the University of Sheffield and suggests that UK higher education operates around 760,000 PCs, 215,000 servers and 148,000 networked printers, and will pay a total ICT-related electricity bill of over £61m – or about £50 per student – in 2009. This equates to around 275,000t of CO_2, reflecting the fact that – as around a third of UK electricity comes from coal – the sector is effectively running approximately 325,000 coal-fired computers.

A similar scaling up of results from Lowestoft College and City College, Norwich suggests that UK further education operates around 708,000 PCs, 23,000 servers and 98,000 networked printers, and will pay a total ICT-related electricity bill of around £54m – or about £12 per student – in 2009. This equates to around 244,000t of CO_2.

Box 3 ICT Use in Further and Higher Education

In simple terms, ICT activities within universities and colleges comprises the following elements:

- Centralised data management and storage activities, mainly undertaken in data centres
- Networks and associated routing and switching devices
- Desktop computers and associated peripherals provided for staff and students
- High performance computers, and associated high-speed connections, used for research
- Computing clusters used for teaching and research
- Mainframe computers sometimes used for research and administrative purposes
- Imaging equipment such as copiers and printers
- Audiovisual equipment used in teaching and research, and
- Telephony, conferencing and other communication systems

Universities and colleges also depend upon (and therefore have a partial environmental responsibility for) external ICT activities such as the internet and telephone infrastructures, and influence the use of ICT by students, both for study purposes and – for those in university accommodation – leisure.

Chapter 1 – Environmental and Social Impacts of ICT in Further and Higher Education: Summary of Key Points

ICT has a surprisingly heavy environmental footprint – a typical European office PC and monitor contains around 20kg of materials, and generates 66kg of waste and 1,096kg of CO_2 during its lifetime.

Most environmental impacts are concentrated in production, but there is disagreement about whether energy consumption in use is more or less than that consumed in production – however, a reasonable rule of thumb for the UK is that the two are similar.

ICT use in further and higher education will use over £116m of electricity in 2009, and generate over 500,000t of CO_2 emissions.

Personal computing is the main driver of ICT-related energy consumption and CO_2 emissions within universities and colleges.

ICT accounts for around 2% of global CO_2 equivalent emissions (less than aviation, despite claims to the contrary), and around 3% of UK electricity consumption.

ICT applications such as smart buildings could avoid 5t of CO_2 emissions for every tonne they indirectly generate, and could reduce global CO_2 equivalent emissions by 15% by 2020.

1. Environmental and Social Impacts of ICT in Further and Higher Education

There is now a considerable literature on the relationship between ICT and sustainable development (eg, Climate Group, 2008; Global Action Plan, 2007; Hilty, 2008; Kohler & Erdmann, 2004; Pamlin, 2002; and Park and Roome, 2002). Most studies conclude that it is double edged. In the words of one recent report:

> If we develop and apply ICT badly, it could add to the world's problems. It could devour energy and accelerate climate change, worsen inequality for those who do not have access and increase pollution and resource use by encouraging ever more frenetic consumerism.
>
> If we apply ICT well, the rewards could be enormous. It could help to enhance creativity and innovation to solve our problems, build communities, give more people access to goods and services and use precious resources much more efficiently. (Madden and Weißbrod, 2008)

This ambiguity also applies within the context of further and higher education. As the following pages show, ICT is already supporting more effective learning, research and administration; enabling greater access and a better student experience; and minimising energy consumption and environmental impacts. But other pages also demonstrate a pattern of growing ICT-related energy consumption, and some doubts about the value and/or effectiveness of a number of ICT applications.

To consider these issues in detail it is important to distinguish between:

> The primary effects of devices and networks – the environmental and social impacts associated with the production, use and disposal of ICT equipment
>
> The secondary effects of user applications – the way in which devices, and the software they run, support everyday educational activities such as learning, research, management, travel and student life, and
>
> The tertiary effects of the adaption of economic and social life to user applications (often termed the systemic effects) (European Telecommunications Network Operators Association and World Wide Fund for Nature, 2006; Hilty, 2008; Madden and Weißbrod, 2008).

1.1 ICT Devices and Networks

The following sections briefly discuss the main primary effects for each stage of the ICT life cycle. Further information can found in the three technical papers on personal computing, data centres and printing, which accompany this report (James and Hopkinson, 2008a,b,c).

1.1.1 Production of ICT equipment and components

According to one detailed study, a European PC and 17 inch LCD monitor in 2005 used 20kg of materials during their production (IVF, 2007). By weight, 51% of these were ferrous metals and 17% plastics.

Producing ICT devices is a complex process, involving the creation first of subcomponents, then components and peripherals such as microprocessors and keyboards (around 30 for a typical PC), and finally finished products.

The most significant environmental – and especially energy – impacts associated with production are generated in the production of the main 'raw material' for computers and other electronic devices, integrated circuits (IC). This is due to the energy consumption of refining silicon and precious metals to high levels of purity, and then assembling them within very highly serviced clean rooms (Eugster *et al.*, 2007).

The environmental impacts from manufacturing are difficult to calculate, but are generally considerably lower than for the materials stage – only about one-fifth in the case of CO_2 equivalent emissions associated with production of an office desktop PC (excluding monitor), according to one study (IVF, 2007). (See James and Hopkinson, 2008a for further details.)

The production (materials extraction and manufacturing) of a typical European office PC and LCD monitor involved:

- Disposing of 37kg of non-hazardous waste and 0.7kg of hazardous waste (compared to 61kg of non-hazardous waste and 5kg of hazardous waste over its lifetime)
- Consuming 3,244MJ of energy (compared to 23,396MJ over its lifetime)
- Using 920l of process water (compared to 2,146l over its lifetime)
- Generating 193kg of greenhouse gases (CO_2 equivalent) (compared to 1,097kg over its lifetime), and
- Releasing considerable quantities of heavy metals, acid rain precursors and other air and water pollutants (IVF, 2007)

Most other ICT equipment also has a similarly large 'hidden' environmental burden.

The impacts per unit of output have been reducing over time as more efficient, and less damaging, processes are adopted. One study has calculated that the energy consumption involved in making a transistor (including manufacturing) fell by 98% between 1995 and 2005 (Williams, 2008). However, this was offset by the inclusion of many more transistors on assembled chips, so that the energy use to make an individual chip remained relatively constant.

Another, often ignored, component of ICT's footprint is cabling. Data cables are a major market for virgin copper, and in most cases are jacketed with polyvinyl chloride (PVC) – up to 1.65kg per 100m – a plastic that is energy intensive to produce, may contain lead, and can emit toxic smoke in fires (Cisco, 2007).

A large amount of ICT production of materials, components and products takes place in developing countries. There have been several critical reports on health and safety and working conditions within the ICT supply chain in these countries (Greenpeace International, 2008a). Many individual ICT companies have taken action as a result, and most leading ones have committed to implement an Electronics Industry Code of Conduct (Electronics Industry Citizenship Coalition, 2005). However, this is inevitably difficult in an industry with multiple supply stages, and many small and medium-sized enterprises (SMEs) within them, and the topic continues to generate controversy.

Box 4 The Lifetime Energy and Environmental Impacts of ICT

It is not easy to aggregate all the different impacts – over all stages of the life cycle – of a computer or other device into a single measure (see our supporting paper, James and Hopkinson, 2008a for a detailed discussion). One method, which has been used as a proxy, and is widely cited, is cumulative energy consumption. This captures one key impact directly, is a close proxy for another (carbon emissions) and a crude proxy for many others (eg energy-intensive materials processing and manufacturing are often correlated with pollution, waste creation and water consumption). The exercise involves summing the:

'Embedded (or embodied) energy' within devices and equipment arising from the extraction of their raw materials, the production of components and their assembly into devices, and associated transport

Energy consumed over their operating life, and

Energy consumed in their disposal (negative in the past, but increasingly positive because of growing levels of recycling, which create a net recovery of energy because of reuse of the embedded energy within equipment)

The higher the ratio of embedded energy to energy in use, the more it makes environmental sense to extend the life of devices and equipment beyond current norms. (This also has other environmental benefits from reducing the need to produce new equipment, with consequent avoidance of resource consumption, pollution and waste.) However, if the ratio is low, and if current devices and equipment are a) considerably more energy efficient than those they are replacing, and b) very intensively used (as with some servers), it could make environmental sense to have faster replacement times (Kiatkittipong *et al.*, 2008).

The most cited study on lifetime embedded energy, by Eric Williams (2003, 2004), concluded that embedded energy in desktop computers was four times greater than their energy in use. However, this is at variance with some other publications on the topic, with the most comprehensive – a study for the European Union – finding that energy in use of non-domestic desktop computers was four times greater than embedded energy, ie the exact opposite of the Williams study (IVF, 2007). As a separate paper discusses, these differences are partly due to varying assumptions about equipment longevity, development of more energy efficient production processes and other reasons (James and Hopkinson, 2008a). A reasonable 'rule of thumb' for UK circumstances seems to be that embedded energy is certainly no greater than energy in use, and perhaps less.

1.1.2 Use

The main environmental impact from ICT use is consumption of energy, mainly in the form of electricity. Much of this electricity is actually used for cooling microprocessors, which generate large quantities of heat. In PCs this is dissipated through internal fans, but servers require additional cooling.

In the UK (and also in the world's main production centre for ICT equipment and components, China) much of this electricity is derived from coal-fired power stations (this varies by year, but is roughly 33% and 66% of total generation respectively). Electricity generation from all fossil fuels, but coal especially, creates many serious environmental impacts in fuel production and processing, and through combustion in power stations. These include CO_2 emissions, land and water take, pollution and waste. Generating power from fossil fuels is also a very inefficient process, with only a small percentage of the energy in the original fuel actually reaching a computer's power supply in practice.

As Box 5 shows, global and UK ICT electricity use is high and rising, and this is reflected in universities and colleges. Appendix 1 provides information on three UK institutions – the University of Sheffield, Lowestoft College, and City College, Norwich – which used the SusteIT footprinting tool to assess their ICT usage. It demonstrates that:

ICT was responsible for 18% of the University of Sheffield's non-domestic electricity use, and 15% of its total non-domestic CO_2 emissions (Riley, 2008)

The ICT-related electricity bill will top £1m annually at the University of Sheffield in 2009 (Riley, 2008), and an estimated (assuming the same electricity price as Sheffield) £200,000 in the two colleges combined, and

49% of ICT-related electricity consumption at the University of Sheffield, and 41–44% at Lowestoft and City College, Norwich, came from PCs

These figures are different from some estimates in other sectors. For example, the consultancy group 451 (Lawrence 2008) has estimated that the ratio of data centre and network electricity consumption to that of PCs in commercial organisations is the reverse of our findings, ie 3:2 rather than 1:2.5 at Sheffield, and 1:1.3–2.3 at the two colleges. The likely explanation is that universities and colleges have greater PC usage by students as well as staff, and that some also have high levels of HPC usage in addition. Another is that figures outside the sector are less robust than our own study, which was very painstaking in the case of the University of Sheffield (see Cartledge, 2008a).

Our figures are also likely to be an underestimate, because they are derived from a university with a good record in ICT energy efficiency, and exclude some areas of use, eg computing devices embedded within scientific instruments. ICT's relative share of electricity consumption is also likely to grow as a) e-learning, more computing-intense research and other drivers increase demand, and b) as energy efficiency initiatives in areas such as lighting result in less rapidly growing, or even reductions in, demand from other activities.

1.1.3 End of life

The disposal of electronic waste consumes space in a landfill, and has the potential to release harmful substances that could have adverse health impacts on people and/or create water pollution. If potentially recyclable or reusable equipment is being disposed of, the opportunity to reduce the production of new materials and components is also being lost. However, the dismantling and recycling of old equipment can be hazardous to workers, and highly polluting, if not done properly (Greenpeace International, 2008a).

A study based on 2005 data estimated that 76% of the 20kg of materials in an average European office PC and 17 inch LCD monitor were recycled, and 24% were disposed of (IVF, 2007). The recycling rate will now be higher as a result of increases in commodity prices (notwithstanding the partial fallback arising from the credit crunch) and implementation of the EU Waste Electrical and Electronic Equipment (WEEE) Directive (see Appendix 3 for details). The SusteIT survey obtained data from five institutions, which were generating an average of 33t per year of WEEE (with a range of 19–70t), and spending an average of £9,400 on its management. The majority of this waste is likely to be old PCs and monitors. The SusteIT case on Nottingham Trent University provides an example of an effective response to this, including the benefit of greater reuse of ICT equipment.

Currently, a considerable proportion of ICT recycling is conducted in developing countries, often with no regard for worker or community health and safety. Greenpeace studies have found that as much as 75% of electronic waste arising in the EU is unaccounted for, and therefore probably improperly disposed of (Greenpeace International, 2008a, 2008b). One of the studies also found high levels of hazardous chemicals in soil and sediment around scrapyards disassembling waste electrical and electronic equipment in Ghana (Greenpeace International, 2008b). According to one observer, the equipment being disassembled in that country included computers and monitors from UK universities (Marshall, 2008). The SusteIT case on City & Islington College, which donates its old computers to developing countries via the charity Computer Aid, shows how this can be avoided.

Box 5 Energy Consumption of ICT Use

There is considerable uncertainty, and some disagreement, about the precise energy and carbon global consumption of ICT. The difficulties include patchy information on numbers of devices; differing definitions (eg some studies include consumer electronics and/or energy, others exclude them); varying patterns of use (eg amount of time devices are switched off, or in power-saving modes); and different national or regional fuel mixes – and therefore carbon emissions – in the generation of the electricity that is used in ICT devices. A recent global analysis involving the consultants McKinsey (Climate Group, 2008) has estimated that:

> ICT use in 2007 accounted for 2% of all human-made carbon emissions (roughly 1.5% from use, and 0.5% embedded within equipment)
>
> 23% of these emissions in 2007 occurred in China (mainly related to embodied energy in production), 20% in North America and 14% in OECD Europe (essentially Europe minus Russia) – with the equivalent figures for 2020 forecast to be 27%, 14% and 12%, respectively, and
>
> 49% of emissions in 2007 were related to PCs, peripherals and printers, 37% to telecoms infrastructure and 14% to data centres – which are forecast to change to 57%, 25% and 18%, respectively, by 2020

An earlier, less detailed, study (Gartner Consulting, 2007) also calculated that ICT accounts for 2% of global carbon emissions, and claimed that this was the same level as aviation. However, the comparison is misleading, a) because the equivalent 2% figure for aviation only refers to use (ie the energy embedded in airports, planes etc is excluded), and b) carbon emissions in the upper atmosphere are thought to have greater impacts on global warming than those on the surface.

In the USA, Huber and Mills (1999) calculated that the 'digital economy' consumed 10% of US electricity consumption. Several authors argued that this conclusion was exaggerated, including Koomey (2007), who found that the proportion of US and world electricity demand accounted for by servers was 1.5%. A UK study has calculated that ICT accounted for around 5% of non-domestic, and 2% of domestic, electricity demand in 2007 (MTP, 2008 – see Appendix 2 for further details). Servers were around 0.8% of total non-domestic demand and 0.4% of total national electricity demand. For comparison, this was slightly more than street lighting, but only about 15% of total commercial refrigeration demand, ie substantial, but not as significant as is sometimes claimed. The MTP (2008) study also concluded that on a 'business as usual' basis, non-domestic consumption could rise by about 20% by 2020, but could fall by 30% if ambitious, but cost-effective, efficiency measures were taken. Some other studies are less conservative, eg Sun has suggested a 40% increase over a similar period (quoted in Global Action Plan, 2007).

The main factors increasing energy consumption are: an increasing number of devices; growth of data centres to cope with increased networking, storage and other requirements; rising LCD screen sizes; and an expansion of printing, especially in colour (Market Transformation Programme, 2007).

1.2 User Applications

Universities and colleges could not function without ICT, which is ubiquitous for administration, communication, information gathering and research, and is rapidly becoming so for teaching and learning. Asked a question on this in our survey, 60% of respondents felt that there would be greater use of ICT-mediated teaching equipment/applications over the next 3–5 years, and 30% thought that it would rise a great deal (James and Hopkinson, 2008d).

Most ICT applications are used for administrative, financial, pedagogic and other purposes unrelated to sustainability. However, they can have ancillary environmental and/or social benefits, as when electronic records are replaced by paper ones.

Several recent studies (Climate Group, 2008; European Telecommunications Network Operators Association (ETNOA) and World Wide Fund for Nature (WWF), 2006) have argued that greater take-up of many ICT applications could have a very positive net environmental impact, especially through conservation of energy and subsequent mitigation of CO_2 emissions. The Climate Group (2008) report, for example, calculated that ICT applications could:

- Reduce global CO_2 equivalent emissions in 2020 by 15%, creating $946 billion of cost savings in the process
- Avoid approximately 5t of CO_2 emissions through applications for every tonne created by the production, use and disposal of ICT equipment, and
- Deliver especially great reductions from: better management and monitoring of electricity grids and distribution networks (26% of potential emission reductions by 2020); improved building design, management and automation (21%); optimised logistics (19%); the use of smarter motors and automation in manufacturing (12%); and dematerialisation (substitution of high carbon activities and products such as meetings with low carbon equivalents, such as conferencing) (6%)

From the latter list, improved building design and dematerialisation are clearly areas of great relevance to universities and colleges. ICT-intense 'smart' buildings are those which minimise energy consumption (and achieve benefits) through better monitoring and management of activities such as heating, ventilation and air conditioning, the integration of these activities with other building services, and through other means. There are already many examples within the sector of buildings that have saved energy through building management systems (BMS) that link a central controller with a network of sensors and local controls (see, for example, successive editions of the Green Gown Awards brochure (HEEPI, 2008a).

As major generators of travel for study and work, and major consumers of paper, further and higher education also have considerable potential to dematerialise by substituting electronic activities or products for physical ones. ICT can achieve this by:

- Substituting face-to-face learning sessions or meetings with virtual equivalents
- Enabling people to reduce commuting and other work-related journeys by 'teleworking' at home, or other remote locations, and
- Replacing paper documents with electronic ones, which can be read on screen

Of course, all of these can be difficult to make work. However, as Chapter 4 discusses, it has been done in some institutions, and could be done in more. Another threat is that the benefits could be swallowed up by secondary 'rebound' effects, as when car commuters use ICT to work from home but they or family members use the vehicle to make additional journeys. However, although serious, most research suggests that a) such rebound effects only partially offset the gains from more beneficial applications, and b) that they are very strongly influenced by 'framework conditions' such as the cost of fuel (Hilty, 2008). Hence, avoiding such applications could be 'throwing the baby out with the bathwater' if medium–long-term changes in framework conditions are likely to increase benefits, and reduce 'disbenefits' (James, 2008).

ICT can also create indirect sustainability benefits by enabling greater access to information, which in turn leads to heightened awareness and understanding. This is particularly relevant to further and higher education, which has considerable potential to use ICT to influence the attitudes and behaviour with regard to sustainability of many of tomorrow's decision makers and opinion formers.

However, ICT in universities and colleges also has an 'invisible environmental overhead', as described in the previous section. This may become much greater in future, for example as many areas of research become more computing-intense, or as Web 2.0 technologies create more complex Virtual Learning Environments, that in turn require more servers and therefore energy consumption to support them. (However, as discussed in Chapter 3, some or perhaps even all of the potential increase could be avoided by more energy efficient data centres.)

Some ICT applications also have a potential 'social overhead' (Anderson, Brynin, Raban & Gershuny, 2006). They can potentially support a 'surveillance society', which erodes or compromises privacy (Crainer, 2008) and/or an atomised social world in which meaningful human interaction is replaced with less satisfying or inclusive virtual relationships (Wilsden, 2001). Within education, they could create or exacerbate divisions between students because of differing levels of use (see Chapter 4 for more discussion of this).

1.3 Conclusions

It is clear that ICT within further and higher education has a very considerable environmental and social footprint, which is usually underestimated. Few people realise that many of the gleaming devices on their desktop, or in specialist facilities, are effectively coal-fired, with all the wastage and pollution that implies. Moreover, the relative importance of this footprint vis-a-vis others (such as making buildings comfortable through heating and ventilation) is increasing as, on the one hand, ICT applications mushroom and, on the other, energy efficiency measures are taken to reduce impacts in other areas.

The main environmental impacts overall (although probably not for energy and carbon emissions) are concentrated in the materials and manufacturing stages. Universities and colleges can only influence this indirectly via procurement (but could nonetheless make a significant difference because of their collective purchasing power – see Chapter 6). The area that is most under their direct control is electricity consumption in use, which almost certainly accounts for half, and perhaps more, of the majority of lifetime energy consumption, and associated carbon emissions. As action in this area can also create financial benefit, it is clear that it should be a very high priority issue for the sector in the short–medium term. However, it is equally important to recognise that other impacts are significant, and need to be addressed. This may require moves to new architectures and technologies over the next decade.

Of course, substantial ICT-related environmental impacts are inevitable if universities and colleges are to achieve their core mission in an increasingly digital world. However, there is the opportunity to offset some of these impacts. ICT applications, such as smarter buildings, and more virtual working, can create great environmental benefit. And, in the long term, the biggest impact of universities and colleges with regard to sustainable development will be through the influence of their teaching, research and third-mission activities on students and society as a whole. If ICT enables this to happen more effectively, it will be an enormous contribution to a more sustainable world.

Chapter 2 – Why Universities and Colleges Need More Sustainable ICT: Summary of Key Points

The Greening Government ICT Strategy is that office use of ICT will be carbon neutral by 2012, and that by 2020 Government ICT will be carbon neutral across its lifecycle.

Seven European Union Directives will impact on ICT use in universities and colleges in the near future – several of these will enable external comparison of an institution's performance.

Sector funding bodies see sustainability – and therefore sustainable ICT – as one of the most significant challenges for universities and colleges.

Many sustainable ICT actions have short paybacks, sometimes less than a year.

ICT accounts for around 6% of world GDP, and is therefore a major source of graduate employment and research funding – which will increasingly reflect the industry's growing emphasis on sustainability issues.

One manifestation of this is UC San Diego's $2.6m green computing research facility.

75% of respondents to a SusteIT survey felt that it is very important to make ICT within the sector more sustainable, with the main concerns being energy consumption in use and end-of-life issues.

2. Why Universities and Colleges Need More Sustainable ICT

Many drivers are now requiring further and higher education to pay greater attention to the environmental and social impacts of their ICT use. These drivers include: responsibility; regulation; financial impacts; stakeholder demands; reputational impacts and risk. The following sections discuss each in greater detail.

2.1 The Case for Change

2.1.1 The responsibility case

Corporate social responsibility (CSR) is now a common feature of the strategies of many commercial organisations. For example, more than 1,500 companies globally report on CSR using the Sustainability Reporting Guidelines of the Global Reporting Initiative (GRI, 2006), and the UK Business in the Community (BITC) charity has more than 850 member companies, representing one in five of the UK private-sector workforce.

CSR's central tenet is that organisations are part of a broader social context, and so have moral responsibilities beyond profit and other commercial objectives. These responsibilities include assisting community development, helping to create a better quality of life for staff and their families, and preserving the natural environment. Whilst in many cases actions to achieve this will have business benefits, such as enhanced image, reputation and trustworthiness, there is also a sense that such actions sometimes need to be taken for their own sake. As ICT clearly contributes to these objectives, it is an important dimension of CSR approaches.

Most universities and colleges already deal with some aspects of CSR. However, the results from a pilot applying The CSR and environmental performance benchmarking indexes of Business in the Community (2007) to 25 sector institutions found that there was scope for considerable improvement. As ICT is central to some of the key indicators identified within the pilot, especially energy and climate change, moves towards more systematic approaches to CSR within the sector will inevitably involve more attention being paid to it.

2.1.2 The stakeholder case

UK further and higher education receives a large proportion of its funding from public sources. Central Government has set ambitious national environmental targets (see below), and has made it clear that sustainable ICT is an important means of achieving these. It has recently published a Greening Government IT Strategy, which is intended to stimulate improvement across the public sector (Cabinet Office, 2008 – see Box 6).

The sector-funding bodies are now responding to this challenge. HEFCE (2008), for example, has recently stated that:

> We want to make sustainable development a central part of our strategy for the future development of the HE sector. We still consider our vision set out in 2005 to be valid, namely that: within the next 10 years, the HE sector in this country will be recognised as a major contributor to society's efforts to achieve sustainability – through the skills and knowledge that its graduates learn and put into practice, and through its own strategies and operations.

It is likely that this will lead to a target for CO_2 emissions, and perhaps other 'carrot and stick' measures to drive environmental improvement, in higher education, and that further education will follow.

HEFCE (2008) has also observed that:

> Universities and colleges are major users of information and communications technology (ICT) and have opportunities to lower the environmental impact of that part of their activities. This encompasses not just the electricity consumed and the carbon produced by the use of the ICT, but the contribution that technology can make to more efficient use of the estate, to reducing travel, to improving productivity and in the environmental impact of the procurement and disposal of equipment.

It is therefore likely there will be increasing pressure on universities and colleges from key stakeholders to minimise the environmental impacts of their ICT use, and to do more to achieve the potential of ICT applications for positive environmental improvement.

Box 6 The Greening Government ICT Strategy

The Government vision for ICT in Central Departments is that:

- The energy consumption of Government ICT on the office estate will be carbon neutral by 2012, and that
- By 2020 Government ICT will be carbon neutral across its lifecycle (Cabinet Office, 2008)

The strategy commits all UK Government departments to developing a green ICT action plan, and to take measures to:

- Extend the lifecycle of all ICT purchases to their natural demise … as opposed to frequent automatic refresh and replacement programmes
- Reduce the overall number of PCs and laptops used by the organisation to reach as close to a 1:1 ratio as possible
- Implement a range of active device power management actions to significantly reduce power consumption
- Reduce the overall number of printers used by the organisation … and use green printing defaults wherever possible (such as double-sided and multiple pages printing)
- Increase average server capacity utilisation to achieve a minimum of 50% where possible, as part of a commitment to comply with the European Code of Conduct for Energy Efficient Data Centres(European Commission Joint Research Centre, 2008)

2.1.3 The regulatory case

Government environmental targets are implemented through legislation and detailed regulations, which are having an increasing impact on the sector. Many of these are the UK implementation of European Union Directives. In addition to their direct effects, these directives also influence suppliers of ICT equipment and services.

Several directives are specifically targeted at ICT, notably those on:

- Waste Electrical and Electronic Equipment (WEEE)
- Hazardous Substances in ICT Equipment, and
- Energy Using Products (EUP)

Others are more general, and have indirect impacts, notably those on:

- Energy Performance of Buildings
- Carbon Reduction
- Energy End Use and Energy Services, and
- Batteries

Table 1 summarises these regulations, and Appendix 3 provides further details.

The need to meet stretching EU and UK Government targets for carbon emissions and other environmental impacts means that regulations are likely to become more stringent over time. Timely anticipation is usually a lower cost response than pressurised actions in response to deadlines, and a possible need for retrofitting. Hence, it would be sensible for universities and colleges to be more proactive in anticipating tightening of regulatory standards, especially with regard to longer term investments such as data centre cooling and power supply, and ICT-related aspects of buildings.

Table 1: Regulations relevant to ICT in universities and colleges

Legislation	Date	Impact on Universities and Colleges
Waste Electrical and Electronic Equipment Directive and UK Regulations	Jan 2007 in UK	WEEE should be separated from the main waste stream, and sent to authorised facilities or exporters. Generally the regulations create additional costs for institutions, although the nature and size of these can be influenced by supply contracts.
Restrictions on Hazardous Substances (RoHS) Directive and UK Regulations	Feb 2008 in UK	Sets limits on lead, cadmium, mercury, flame retardants and other hazardous substances in new electrical and electronic equipment. Most suppliers are now compliant with the regulations but institutions need to specify ROHS-compliant equipment to guard against any problems.
Eco-design of Energy Using Products (EuP) Directive	Aug 2007 in EU	A framework directive aiming to set minimum performance requirements for energy consumption in manufacture and use of ICT and other energy using products. The first products will be covered in 2009.
Energy Performance of Buildings Directive, and UK Regulations	Phased 2007–2011	Requires minimum energy performance requirements in new and existing buildings (via Building Regulations); energy certification of buildings (enabling easier comparison of performance); and inspection (with improvement recommendations) of cooling installations such as those in data centres every five years.
Climate Change Act – Carbon Reduction Commitment (CRC)	Jan 2010	This sets a legally binding target for reducing UK CO_2 emissions by 26% by 2020 and 80% by 2050, compared to 1990 levels. The Act also sets up the CRC. This will require medium-large electricity users (including many universities) to monitor their fossil fuel and electricity consumption, and participate in a scheme that financially rewards reductions in carbon emissions (from ICT, and other sources), and penalises poor performance.
Energy End Use Efficiency and Services Directive and UK Regulations	Early 2009	Intended to enhance the cost-effective improvement of energy end use efficiency in Member States. Article 5 requires the public sector to fulfil an exemplary role in achieving this. The education sector is likely to have a voluntary agreement based on the Government's 'Buy Sustainable – Quick Wins' initiative. This will require minimum procurement standards for ICT devices and other equipment.
Batteries Directive	2009	Requires battery collection schemes and restricts mercury and cadmium levels. Many elements of the draft UK Batteries Regulations are similar to those of the WEEE Regulations and it is likely universities and colleges will need to set up battery collection schemes.

2.1.4 The financial case

Chapter 1 demonstrated that ICT energy use will cost UK further and higher education around £116m in 2009, and that this figure is likely to rise. Other environmental and social effects can also have direct financial consequences, such as more onerous regulations to deal with electronic waste.

This situation means that many measures to create more sustainable ICT can have short payback periods of 1–2 years, or even less. Our cases provide several examples, including:

- Powerdown of PCs at the University of Liverpool and other institutions
- Low energy servers at the University of Sheffield
- Virtualised servers at City of Bristol College and Sheffield Hallam University, and
- Innovative approaches to data-centre cooling and power supply at Cardiff University

Many other sustainable ICT measures have payback periods of less than five years.

Such paybacks are based on current conditions in the medium–long term. However, many people expect such conditions to change in future. Energy prices are likely to rise further (notwithstanding short-term fluctuations in response to the credit crunch), and carbon regulations are also expected to have an increasing financial impact. Sustainable ICT measures therefore have an additional value as insurance against such contingencies.

2.1.5 The risk case

The Funding Councils have advised institutions to pay greater attention to identifying and minimising 'the threat or possibility that an action or event will adversely or beneficially affect an organisation's ability to achieve its objectives' (Committee of University Chairmen, 2004). Sustainable IT can help to avoid or mitigate a number of potential financial and other risks, including those of:

- Unexpected rises in utilities costs, which can only be met by cutbacks in core activities, which jeopardise institutional performance
- Costly retrofitting to data infrastructure if new regulations are applied to existing facilities – as is increasingly the case as Governments try to meet their long-term targets for reducing CO_2 emissions
- Electrical capacity constraints preventing future expansion, or making it very expensive because of a need for additional, and expensive, utility infrastructure, and
- Buildings that are not easily adaptable to future IT requirements

2.1.6 The reputation case

There is evidence that staff and students pay attention to the environmental and social performance of institutions when making study or work choices (Forum for the Future, 2007). Performance in these areas can also be of interest to other institutional stakeholders, such as local authorities. The collection and publication of more data about them – both voluntarily, or because it is required by regulations – is also making comparison easier (if not always robust). In the UK, for example, the student group People and Planet (2008) publishes an annual 'Green League Table' of institutional performance. The implementation of the Environmental Performance of Buildings Directive also requires publication of the energy consumption of buildings – which therefore enables direct comparison of stand-alone data centres. Some universities and colleges are responding to these changes by seeing sustainability as an important, and positive, part of their corporate 'brand', which helps to differentiate them from other institutions. As an example, a SusteIT case study describes how the University of Gloucestershire's policies in this regard have stimulated greater action to achieve sustainable ICT.

As an important part of further and higher education activities, ICT clearly has the potential to influence perceptions of the sector's environmental and social performance. With some exceptions – many of which are highlighted in the following pages – our research suggests that this is seldom as positive as it could be.

2.1.7 The teaching and research case

Sustainable ICT is a topic of growing concern to both suppliers and major users. They therefore need employees and advisors who understand the issues, and access to relevant external research and information. Universities and colleges therefore need to respond to such requirements by ensuring that students are equipped to meet them, and that they have relevant expertise amongst their staff. As the ICT industry is one of the world's largest – accounting for around 6% of GDP in Europe and North America (Indepen and Ovum, 2005) – there is the potential for considerable rewards (in student numbers, course and research funding and other ways) for institutions that are seen to be responding effectively. Box 7 shows how UC (University of California) San Diego is exploiting this potential in the USA. The SusteIT case on the University of Middlesex also shows how UK institutions can have a considerable external impact in the field.

2.1.8 The leadership case

To date, and despite the exceptions highlighted throughout the report, it is fair to say that universities and colleges have generally been followers rather than leaders with regard to sustainable ICT. However, most organisations are struggling to come to terms with its demands, so that the leaders are not that far ahead of the pack. Within this context, further and higher education has a number of potential advantages, which could enable it to play more of a leadership role in future. These include:

- Intensive use of ICT and a correspondingly high level of ICT expertise
- Ability to form collaborative partnerships with other players such as suppliers or other public-sector organisations
- A mission, by tradition and Government request, of supporting innovation, and
- A variety of campus locations and configurations, which create opportunities to deploy many innovative approaches to energy supply and infrastructure, especially for data centres

Chapter 6 examines these opportunities in detail but in general terms they could provide a means of strengthening the reputation of UK universities and colleges at both national and international level, and at relatively limited cost. This would be especially the case if they were part of a high profile, and integrated, initiative whose overall impact was more than the sum of its individual parts.

Box 7 UC San Diego Plays a Lead Role in Green Computing

The University of California, San Diego's $2.6m GreenLight facility provides both a computing resource for scientific research (in metagenomics; ocean observing; microscopy; bioinformatics; and digital media), and a testbed to better understand the drivers of data-centre energy consumption (Ramsay, 2008). The facility will comprise two Sun Modular Datacenters, containing up to 280 servers each. These use a closed-loop water-cooling system and other features to reduce cooling costs, it is claimed, by up to 40% of traditional server rooms. It is set up to provide fine-grained monitoring of the impact of different computational loads on the operation of the servers themselves, and on ambient conditions. The latter is achieved through 40 temperature sensors in different points of the air stream, and additional sensors for humidity, energy consumption and other variables. These also allow assessment of the impact of experimental hardware configurations alongside the traditional rack-mounted servers.

Amongst other benefits, the research is expected to provide a better understanding of the energy impacts of different architectures and tasks ('effective work per watt'); identify the most effective measures to improve energy efficiency within data centres; enable more optimal allocation of different computing tasks within virtualised environments; and support the development of more efficient hardware and better management software. It will also track the behavioural impacts of better information about energy costs on the facility's users.

Table 2: Results for survey question 'How important do you consider it is to make ICT use in further and higher education more sustainable, by reducing environmental impacts and in other ways?'

	Number of respondents	%
Very important	137	75
Quite important	35	19
Neutral	6	3
Quite unimportant	4	2
Very unimportant	1	1
Total respondents	183	

Table 3: Results for survey question 'Which of the following would you see as the most important issues with regard to sustainable use of ICT in further and higher education?'

Issue	**Number of respondents**	%
Energy usage of ICT equipment	128	70
Disposal/reuse end-of-life ICT equipment	109	60
Usage/disposal ICT consumables	95	52
More efficient use of resources (eg buildings) enabled by ICT	69	38
Manufacture of ICT equipment	60	33
Short life span ICT equipment	47	26
Travel reductions enabled by ICT	41	22
Quality of ICT-enabled learning experience for students	34	19
Exploitation of workers in ICT supply chains	26	14
Privacy and social control issues related to ICT	26	14
Enabling better access to knowledge for disadvantaged people	26	14
ICT related H&S issues	17	9
Other issues	17	9
Total Respondents[1]	183	

[1] Note that respondents could choose more than one option.

2.2 Sector Views on Sustainable ICT

The issue of sustainable ICT is resonating with many people in universities and colleges. As Table 2 shows, almost all respondents to the SusteIT survey felt that it is important to make ICT within the sector more sustainable, and three-quarters said that it is very important. There were no significant variations between people with different backgrounds (as assessed by their answering of the detailed survey sections) in this respect.

Table 3 shows that the main issues of concern for most respondents were those connected with the ICT use phase, especially energy consumption and end-of-life issues. Conversely, only a relatively small proportion of respondents felt that social issues are of great importance to the sector. This may, of course, reflect the relatively technical bias of survey responses, with little representation by academics from humanities or social sciences.

2.3 Conclusions

The preceding points combine to make a compelling case for greater action to achieve sustainable ICT within further and higher education. In the short term, most will see the financial arguments as the strongest. Given the size of the sector's bills, there is a real opportunity to divert tens of millions of pounds from wasteful consumption of energy to investment in research and teaching. The next chapter discusses how this can be achieved.

In the medium–long term though, the other arguments for action are equally persuasive. Simply to protect its position, and reduce the risks to finances and reputation, the sector needs to take greater action to keep up with the mainstream. But there is also an opportunity to do more than this, and to establish UK universities and colleges at the forefront of sustainable ICT. This could create major benefits for their finances, reputation, and research and teaching base.

Chapter 3: Taking Action – ICT Devices and Connections: Summary of Key Points

80–85% of the capacity of a typical PC or server is wasted, and so considerable energy and financial savings can be achieved through grid computing, virtualisation and other methods of increasing utilisation.

Cloud computing and shared services can have sustainability benefits if they are based on highly utilised and energy-efficient data centres, with high usage of renewable or low carbon energy sources, but this is not inevitable.

Data centre electricity consumption in cooling, power supply and other support activities is generally 40–100% that of the servers themselves, with very few approaching best practice standards of 25–30%.

The main methods for minimising data-centre energy consumption are purchasing more energy efficient devices; changing programming configurations and approaches; and changing physical aspects such as layouts and cooling.

Thin client is not always environmental beneficial, or suitable for all applications, but it can reduce the environmental impact of personal computing through reduced energy consumption and other means in many circumstances.

PCs account for 40–50% of total ICT-related electricity consumption in universities and colleges.

There is a large potential range for the energy consumed by different PCs. Electricity costs can range from £3 to £61 per year depending on power rating, usage and levels of power management.

The environmental impacts of PCs can be reduced by purchasing the most energy-efficient hardware and software that meets user needs; configuring for energy efficiency when in active use and switching off completely whenever possible; examining low impact alternatives; and increasing their useful life.

Higher education has 148,000 copiers and printers, and further education 98,000 – digital printing accounts for at least 10–16% of ICT-related energy costs.

Per printed page, laser printers have a larger environmental footprint than inkjets at low volumes, but smaller at high volumes.

Key actions to minimise the impacts of printing/copying include consolidation onto a smaller number of heavily utilised devices; effective print substitution/management; purchase of energy-efficient devices and effective power management; purchasing recycled and/or lighter weight paper, and achieving more paper-efficient printing.

3. Taking Action – ICT Devices and Networks

This chapter is based upon three more detailed SusteIT papers on environmental best practice in personal computing, data centres and printing (James and Hopkinson 2008a,b,c). It summarises their findings on the main options for reducing the energy consumption, and other environmental impacts, of ICT in further and higher education, within the context of the current system. However, as discussed below, and in following chapters, it is possible that sustainable ICT may require more radical approaches – which are especially likely to be adopted when they also meet other strategic objectives within the sector.

3.1 Taking Action – Architecture

The individual elements of a university's or college's ICT activities form part of an 'enterprise architecture' (Anderson and Backhouse, 2008; American National Standards Institute/Institute of Electrical Electronics Engineers, 2008). This has four dimensions:

- Business – including high-level objectives and goals, and key processes, functions and structures
- Applications – the ICT-based services that support the business processes, and the relationship between them
- Information – the creation, use, storage and management of the data that is used in applications, and
- Technology – the hardware and software supporting the organisation, including desktop and server hardware; operating systems; and network connectivity components (Platt, 2002)

Strategic decisions about architecture therefore have great influence on the environmental and social impacts of ICT in universities and colleges, because they influence the kinds of device purchased, the connections between them, and the pattern of their use (Microsoft, 2008). Some key strategic areas of relevance to sustainable ICT are:

- 'Thick client' versus 'thin client' approaches to the delivery of ICT functionality to users
- Centralised versus distributed computing
- Information life-cycle management, and
- Outsourcing and partnership arrangements for service provision

Change in all these areas is driven substantially or primarily by business and performance considerations, so that energy and environmental benefits can be seen as peripheral factors. However, many have important sustainability implications – positive as well as negative – and it is therefore vital that these are prominent in decision-making about them.

3.1.1 Thick versus thin clients

'Client' devices are ones which are connected to a network, and depend on centralised servers or other kinds of computer to function fully. In broad terms, there are two kinds of devices:

- 'Thick clients' – such as a desktop computer – which do most of the processing for user activities locally, and have considerable storage capacity (although it may not always be used), and
- 'Thin clients', which generally have limited, and sometimes minimal, processing capacity and storage, and are therefore largely dependent upon a centralised machine to operate effectively

The early days of university and college computing were based on a thin-client approach, in the form of terminals connected to a central mainframe. After the development of desktop computers, the sector generally followed other organisations in moving to a thick-client approach of multiple PCs connected via centralised servers. However, some vendors are now marketing updated thin-client approaches, in part because of their claimed energy, environmental and health and safety benefits. These benefits – vis a vis desktops – are said to be:

- Greater longevity, due to the avoidance of software obsolescence, limited points of failure, immunity from malware, and low intrinsic value which discourages theft
- Facilitation of virtualisation and other energy efficiency measures on central servers
- Lower energy consumption in use (and therefore a reduced need for cooling)
- Low volume and weight, resulting in less production impact, more efficient transport and smaller amounts of waste
- Low footprint, enabling more efficient use of space, and
- Low noise, due to an absence of fans

Any assessment of these claims has to reflect the fact that thin client approaches are very dependent upon servers and an associated network infrastructure, which can increase:

- Processing loads at the centre, and
- Network energy consumption through the mouse movements, keystrokes and screen updates that are transmitted from/to end-users (although these may be offset by less file transfer, eg of documents for printing, than would be the case for desktops)

The most detailed study done to date does corroborate the case for thin client (Fraunhofer Institute for Environment, Safety and Energy Technology, 2007). An accompanying paper on personal computing (James and Hopkinson, 2008a) discusses its findings and implications in greater detail. It concludes that, whilst thin client is not suitable for all applications, and environmental benefits are not guaranteed, it can be beneficial in many circumstances.

3.1.2 Dispersed computing

A confusing range of terms is used to describe aspects of a generic trend away from device-specific and tightly coupled computing within a small geographic area (word processing on my PC, accessing data from a central application-specific server over my institution's network) to a model using internal networks or the internet to undertake coordinated computing activities between a wider number of devices, and/or a wider geographic area. The terms include: distributed computing; grid computing; cloud computing; service-oriented computing; and utility computing (see Box 8). Many experts see these approaches as becoming much more common in future, due to cost, performance and reliability advantages (eg, Johnson, 2008).

Environmentally, these dispersed computing approaches can reduce the overall need for devices by providing two common benefits:

- Making better use of computing devices (such as the 80–85% of PC or server capacity, which is typically under-utilised when they are switched on), and/or

- Enabling tasks to be done with greater computing efficiency

Of course, dispersed computing increases energy use in the host PCs and servers, and within the network equipment that is handling increased traffic. Hence, apparent reductions in energy consumption may be misleading as some has simply moved elsewhere.

No definitive studies have been done but it is often suggested that the effects will be positive (Prompt, 2008). One potential opportunity is certainly for computing activities to be concentrated in a smaller number of much more sustainable data centres. These could take advantage of economies of scale (for example, in cooling equipment), and also be sited optimally to take advantage of renewable energy availability and/or lower ambient air temperatures.

Net benefits are especially likely with two particular forms of dispersed computing currently utilised in further and higher education, high performance computing (HPC) and CPU harvesting within institutions, as both use machines whose energy consumption is only modestly related to utilisation, and involve only local network use. The national and international grids – such as the Large Hadron Collider (LHC) grid managed by CERN, which has a number of participating sites in the UK – that are growing for scientific and other computing-intensive applications obviously involve more network energy use, and therefore a less favourable (but still potentially positive) positive energy balance sheet.

Box 8 Next Generation Computing – Cloudy Grids or Distributed Utility?

The terms 'distributed computing' and 'grid computing' are often used interchangeably to describe the parallel processing of complex tasks on two or more (and often hundreds or thousands of) computers. However, some use the term 'grid' to refer to relatively loosely coupled parallel computing, occurring over conventional networks, such as the 'CPU harvesting' achieved by CONDOR software when it distributes tasks between networked PCs which would otherwise be idle (see the SusteIT case study of Cardiff University, which has found that this is most energy efficient when the pool contains newer PCs.) Distributed computing would then be used to refer to more tightly coupled parallel computing, typically involving more powerful computers, high-speed connections, and – in many cases – co-location. This encompasses high-performance computing (HPC) and clustering, with the former being associated with more powerful devices and very high capacity inter-connection.

'Cloud computing' is a global client-server model in which multiple kinds and numbers of client devices (eg PCs, PDAs and dedicated client devices) access applications and data over the internet. It encompasses activities such as using Skype for telephony. (Note that grid computing conducted via peer-to-peer networks over the internet, such as the SETI@home project, which searches for extraterrestrial activities, is also part of the 'cloud'.)

Utility computing is another sub-set of the 'cloud' and describes the provision of 'metered' computing services over the internet, which are as standardised and as easily usable as the

3.1.3 Information life-cycle management

Ever increasing amounts of data require ever increasing amounts of storage, which already accounts for up to 10% of ICT-related energy consumption within data centres and is likely to increase further (Cartledge, 2008b; Schulz, 2007). Three important means of minimising this consumption are:

- Using storage more effectively
- Classifying data in terms of required availability (ie how rapidly does it need to be accessed?), and
- Minimising the total amount of data stored

NetApp claims that the average enterprise uses only 75–80% of its storage capacity (Cohen *et al*., 2008). More-effective utilisation can reduce capital and operating expenditure, and energy consumption.

Better classification allows data where rapid response is not required to be stored on disks that can be powered down when in not in use. Vendors claim that this can reduce energy consumption by 50% or more (Schulz, 2008). Even greater savings can be obtained when infrequently accessed data is archived onto tapes and other media that require minimal energy to keep.

Most university data centres also have storage requirements many times greater than the core data they hold. This is because different versions of the same file are usually stored at multiple locations (eg attachments to emails). In most cases, this is not for any essential reason. Hence, there is the potential for data de-duplication by holding a single reference copy, with multiple pointers to it (Schulz, 2007). Some storage servers offer this as a feature, eg Netapp. The University of Sheffield has used this and other means to achieve de-duplication, with 20–90% savings, depending on the type of data (Cartledge, 2008b). (Generally, savings have been at the lower end of the spectrum.)

3.1.4 Outsourcing and shared services

Discussion on this topic is confusing as it takes place within different topic 'spaces' – for example, cloud computing, shared services and outsourcing – which, to some degree, involve different people from different backgrounds. Debates about these topics also have many aspects, with sustainability being only one of these.

The shared feature of these discussions is that they are all about utilising the relatively new ability to move large amounts of data over long distances, relatively cheaply, in order to conduct 'dispersed computing', ie ICT activities outside an institution's own site boundaries. This is of course enabled by a shared infrastructure service, in the form of the JANET network. A new 'dispersed computing' agenda is therefore emerging, which involves single institutions, or groups of them (for example, those which collaborate within Metropolitan Area Networks), partnering with each other, or external suppliers, to migrate ICT activities they would previously have done internally to servers in external locations (Duke and Jordan, 2008a,b). This includes (in approximate order of computing and organisational complexity):

- Rental of server space at external commercial data centres to undertake computing tasks that previously would have done in house – there are few if any examples of this in the sector due to concerns about reliability and security
- Direct contracting between an individual university or college and a supplier for the latter to provide specific services that would normally be undertaken internally – such as Leeds Metropolitan University's arrangement with Google which involves the latter providing student email addresses,

and online word-processing capability (through Google Apps), thereby avoiding the need to purchase multiple copies of Microsoft Word or other software

Similar, but more partnership-based arrangements between a group of universities and colleges and a supplier for the latter to provide specific services that would normally be undertaken internally – such as the backup and email-filtering service provided by the London Metropolitan Network to members in the capital (see SusteIT case study), or the Association of Northern Ireland Colleges (ANIC) consortium, which provides Corporate Information Services to the country's six large multi-site further education colleges

More ambitious outsourcing arrangements involving an institution outsourcing a basket of services to a supplier or collaborative partnership – as with the Research Councils UK (RCUK) Shared Services Centre Project, which covers HR, payroll, finance, procurement, IT, telecommunications and grants processing, and

Common data centres – in which several institutions share a single data centre, which is under their control. This could be managed by themselves, but is more likely to be managed by a specialist supplier. The collaboration between the University of the West of Scotland and South Lanarkshire Council (who manage the shared centre) is one of the few examples in the sector, but several feasibility studies have been done on additional projects (see below)

Common data centres are made feasible by virtualisation, which breaks the link between applications and specific servers, and therefore makes it possible to locate the latter almost anywhere.

Initiatives of this kind are generally driven by mainstream business considerations, but a number of ICT suppliers, and other organisations and experts, have argued that they can also provide net sustainability benefits. These fall into two broad categories: the potential generic benefits of all remote computing activities; and the more specific benefits attached to particular options such as common data centres. The generic sustainability benefits that remote computing could achieve include:

More energy-efficient means of providing the same computing requirements, eg using Word on a PC is likely to have a relatively high energy consumption because it may well be the main application running on a relatively high-powered but under-utilised machine, whereas online provision of the same functionality could use less CPU-intensive software and/or take place on virtualised servers that achieve much higher levels of utilisation

A reduced need for duplication and redundancy (eg three separate institutions running their own data centres will require three backup locations, whereas when they use a common facility only one or two will be required)

Greater locational choice for data centres, which allows them to use sites favourable to energy efficiency and/or low carbon or renewable energy supply, eg able to use on-site wind energy – indeed, one analyst has argued that Google and Microsoft are developing a 'cloud computing' business model, which has 100% on-site renewable energy as an important component (Denegri, 2008), and

Data centres with a higher intrinsic energy efficiency than local ones, because they can take advantage of economies of scale and scope, increased flexibility, and/or the expertise of a supplier who is managing or running multiple data centres

On the latter point, vendors marketing managed shared service data centres into higher education claim that this can result in any or all of:

Avoidance of unnecessary build and infrastructure (with associated financial and energy costs) because institutions do not have to exactly predict their future requirements from day one, but can easily add additional capacity as required

The difficulties of specifying and maintaining complex specialised data centres, which is not part of an education establishment's main business

More precise cooling and power supply (which is typically provided through self-contained 'pods' within the data centre), so that this can be concentrated on servers that need it, rather than whole rooms, and

A greater ability to invest in energy-efficient, but capital-intensive, solutions (eg free cooling, which involves additional capital cost but creates great reductions in operating cost), because this can be spread over an increased activity base

However, some of these benefits could be achieved internally, at least within larger institutions. Two key issues are therefore whether this is likely to occur in practice, and whether the claims of external suppliers that they can offer expertise and economies of scale is 100% reliable. Transferring large amounts of data for long distances over a network also carries an energy penalty, which is related to the energy efficiency of network data centres and other infrastructure. Hence, whilst supplier claims may be accurate, they need to be examined carefully, and validated against realistic alternative scenarios before any decisions are made.

The most detailed examination of these issues was a study undertaken for Derby, Salford and Sheffield Hallam universities under the auspices of HEFCE's Shared Services initiative. Although the study was confidential, it is possible to report the conclusion that the creation of a shared service data centre was technically feasible, and could be financially viable, but that the greatest benefits were likely to be achieved by collaborations between institutions that were located within close proximity to each other. A reduction in energy consumption, compared to local data centres, was an important feature of the business case. One aspect of this work is now being taken forward by universities within the Yorkshire and Humberside Metropolitan Area Network. By reducing distances for data transfer, shared centres between more local institutions could reduce network energy consumption, but this may be at the cost of more constraints on location, which precludes the use of renewable energy.

Box 9 An Introduction to Data Centres

Data centres, aka server rooms, are the 'brains' of a university's or college's IT network, undertaking many high-speed computational tasks and storing large amounts of data. Until the 1990s, they were very self-contained, containing a small number of mainframe and other large computers that had limited external linkages. A few universities continue to operate such mainframes for particular tasks, albeit with more specialised connectivity. The centralised model also lives on in some areas of research computing, where co-located and tightly coupled 'high performance computers' (HPC), or 'supercomputers', process, transmit and receive huge amounts of data at very high speed.

However, most university and college computing today uses a more decentralised 'client-server' model. This involves a relatively large number of 'servers' providing services and managing networked resources for an even greater number of 'clients', such as personal computers, which do much of the actual computing 'work' required by users. The devices communicate through networks, both internally with each other, and externally through the internet. A typical data centre, or 'server room', therefore contains:

- Servers, such as application servers (usually dedicated to single applications, in order to reduce software conflicts), file servers (which retrieve and archive data such as documents, images and database entries) and print servers (which process files for printing)
- Storage devices, to store 'instantly accessible' content (eg user files) and backup data, and
- Routers and switches, which control data transmission within the data centre, and between it and external devices such as PCs and printers

Data centres range in size from one room of a building, one or more floors, to an entire building. Universities and colleges typically contain a small number of central data centres run by the IT department (usually at least two, to protect against one going down), but many will also have secondary sites providing specific services to schools, departments, research groups etc.

Servers, and some storage and other devices, are usually housed within standardised racked cabinets. As they generate large amounts of heat, some form of cooling is required (generally cold air, but sometimes chilled water or liquid carbon dioxide in sealed circuits). To guard against power failures, data centres also require an 'uninterruptible power supply' (UPS), essentially large batteries, which instantly provide backup power. Some also have emergency generators to cope with prolonged outages.

3.2 Taking Action – Data Centres and Networks

The demand for greater data-centre capacity is rising rapidly, for reasons that include:

- The growing use of internet media and online learning, and demands for faster connectivity from users
- A move to web-based interfaces, which are more compute-intensive to deliver
- A move to comprehensive enterprise resource planning (ERP) software solutions, which are much more compute-intensive than earlier software
- Increasing requirements for comprehensive business continuity and disaster recovery arrangements, which results in duplication of facilities
- Increasing digitisation of data, and
- Rapidly expanding data storage requirements

The SusteIT survey found that 63% of responding institutions were expecting to make additional investments in housing servers within the next two years (James and Hopkinson, 2008d). This rate of growth is an important environmental issue for further and higher education because:

- The production of their devices, especially servers, has a 'hidden' environmental footprint (similar to that of PCs – see the next section for more information)
- Their growing energy consumption makes them increasingly expensive to operate, and is one of the fastest growing components of an institution's 'carbon footprint', and
- Their hunger for power can create constraints on expansion in areas where the electricity grid is near capacity, such as central London

In addition to the power consumption of servers and other equipment in data centres, there is additional consumption for cooling, and in the form of losses in power supply units. This 'overhead' consumption can be equivalent to the equipment itself (US EPA, 2007a). However, centres that have been designed for energy efficiency can bring this down to 30–40% (Emerson, 2007; US EPA, 2007a). As our cases show, this level of efficiency is already being achieved by some UK institutions, such as Cardiff University and the University of Edinburgh.

Table 4: Data centre energy efficiency scenarios 2007–11 (US EPA, 2007a)

Scenario	IT Equipment	Power and Cooling
Improved operation – 'low-hanging fruit', which requires little or no capital investment	• Continue current trends for server consolidation • Eliminate unused servers (eg legacy applications) • Adopt 'energy-efficient' servers to modest level • Enable power management on 100% of applicable servers • Assume modest decline in energy use of enterprise storage equipment	30% improvement in infrastructure energy efficiency from improved airflow management
Best practice – more widespread adoption of the practices and technologies used in today's most energy-efficient data centres	All measures in 'Improved operation' scenario, plus: • Consolidate servers to moderate extent • Aggressively adopt 'energy-efficient' servers • Assume moderate storage consolidation	Up to 70% improvement in infrastructure energy efficiency from all measures in 'Improved operation' scenario, plus: • Improved transformers and uninterruptible power supplies • Improved efficiency chillers, fans and pumps • Free cooling
State-of-the-art – maximum energy-efficiency savings from the most efficient technologies and best management practices	All measures in 'Best practice' scenario, plus: • Aggressively consolidate servers • Aggressively consolidate storage • Enable power management at data centre level of applications, servers, and equipment for networking and storage	Up to 80% improvement in infrastructure energy efficiency, due to all measures in 'Best practice' scenario, plus: • Direct liquid cooling • Combined heat and power

3.2.1 Data centre solutions

The main methods for minimising data-centre energy consumption and environmental impacts are:

- Purchasing more energy-efficient devices
- Changing programming configurations and approaches, and
- Changing physical aspects such as layouts and cooling

These are described briefly below, and in more detail in a companion paper (James and Hopkinson, 2008b). Table 4 provides a summary from a US study.

Energy-efficient device options include:

- Moving to blade servers – these are 10–20 'stripped down' servers containing only a CPU, memory and a hard disk, mounted in a chassis with a common power supply. They require less cooling than conventional servers of the same performance due to their shared features, and also have greater space efficiency
- Low-power conventional servers, with features such as low-power processors (see section 3.3.1), optimal memory configuration, reduction in power supplies, and lower power disks, and
- Multi-core devices – these use multiple CPUs (up to four currently, and up to eight predicted in the near future), with extremely high transistor densities, all on the same integrated circuit, and undertaking parallel processing of tasks. Compared with traditional single-core devices, they can reduce energy through: more effective utilisation of capacity; reduced electrical leakage; operation at lower frequencies (which reduces maximum temperatures and therefore overall fan cooling requirements); and in other ways (Brownstein, 2008)

Although the more energy-efficient servers often have a slightly higher capital cost, the energy savings they create can mean the additional expenditure can be paid back in a year or less.

Changes to programming configurations and approaches that can improve energy efficiency and reduce environmental impacts include:

- Use of power management – data centres are sized for peak conditions that rarely exist and server power consumption remains relatively high even as server load decreases (Barroso and Holzle, 2007). Hence, power management software (which is often built into servers, but not often fully exploited in practice) has great potential to reduce energy costs, perhaps by as much as 8% (Emerson, 2007)
- Consolidation and virtualisation of servers – the traditional approach of having servers dedicated to individual applications means that rates of utilisation can be as low as 5–10% (Fujitsu Siemens Computers and Knürr, 2007). This can be reduced by consolidating different applications onto a single physical servers or, more radically, creating 'virtual servers', which can run independently of each other on any physical server, within the data centre or beyond (see James and Hopkinson, 2008b for more details).
- More efficient storage – the most energy-intensive devices are those which are permanently powered, as is the cases with any devices that are constantly online. The energy consumption of storage can therefore be cut if more data is stored offline, or on slower drives online; and the total

amount of data storage is reduced, both by data de-duplication (avoiding storing multiple copies of the same data by simply holding a small number of reference copies, with links to them) and information life-cycle management

There are also a number of changes to the physical and energy supply aspects of data centres, which can increase energy efficiency, including:

Changing device housings and locations – this can minimise mixing of hot and cold air, which is a major source of energy inefficiency. The means of doing so include separation of cold air and hot air through hot aisle/cold aisle arrangements and other means; optimising cold air flows through optimum positioning of fans and minimizing obstructions; sealing gaps in floors; and using blanking panels in open spaces in racks

Adopting more energy-efficient means of air cooling – this includes matching the supply of cooling air more closely with actual loads through variable frequency fan motors and other means; using smaller supplemental cooling units, which can be placed closer to the source of heat; and using 'free cooling' through use of ambient air when temperatures are sufficiently low, either directly (after filtering) or indirectly, as a substitute for chillers

Adopting water-based cooling – water is a more effective heat transfer medium than air, so its use for cooling (in the form of a sealed chilled water circuit built into server racks) can greatly reduce energy consumption, as the SusteIT case study on Cardiff University shows

Adopting more energy-efficient means of power supply – data centres contain transformers and an 'uninterruptible power supply' (UPS), ie a unit containing batteries, which provide sufficient power in the event of a grid failure to enable emergency generators to kick in, or a controlled shutdown to occur), which cause power losses through heat generation. Power supply in the past has often had a conversion efficiency of only 70–80%, but 90% or greater is now possible

Reducing lighting – in addition to its direct power consumption, lighting generates heat, which makes the cooling system work harder. Dark operation is therefore desirable, with energy-efficient lighting for use when maintenance or other activities need to be undertaken

Better monitoring and control – rising equipment densities often create humidity and temperature diversity, to the point where server failure rates at the top of racks (which, as hot air rises, is generally the warmest zone) are sometimes higher than at the bottom. Cooling control systems can monitor conditions across the data centre and coordinate them effectively

Renewable or low-carbon energy supply – both Google and Microsoft are said to be seeking 100% renewable energy sourcing, and technical developments in a number of areas such as fuel cells, trigeneration (when an energy centre produces cooling, electricity and heat from the same fuel source) and ground source heat pumps are enabling this (Denegri, 2008).

As Table 5 shows, few of these potential solutions are widely used within the sector. The one most commonly used is blade servers. However, whilst advantageous, these are not the most environmentally superior option because their increased energy efficiency compared to conventional servers is partially offset by an increased need for cooling due to their very high heat density. More positively, 73% of responding institutions were expecting to take significant measures to minimise server energy consumption in the near future.

One crucial requirement for success in this area will be effective collaboration between Estates and IT departments, as cooling and power issues clearly involve both.

Table 5: Results for survey question 'Have you implemented any of the following innovations to reduce energy consumption in your data centre/server room(s)? Please choose all that apply.' (Analysis by institution rather than individual respondent)

	Number of responding institutions	%
Blade servers	8	73
Server virtualisation	6	55
Power management features	5	45
Low-power processors	4	36
High-efficiency power supplies	4	36
415V AC power distribution	3	27
Layout changes	3	27
Water cooling	2	18
Variable capacity cooling	2	18
Heat recovery	1	9
Fresh-air cooling	0	0
Other	0	0
None of these	2	18
Don't know	0	0
Total Institutions	11	100

Table 6: Average energy performance of computers and monitors in 2000 and 2008 (MTP, 2007) (Based on UK stock averages for non-domestic devices; 2008 figures are projections)

Year	**ICT Device**	**Power/Mode (Watts)**		
		On-idle (or On-active for monitors)	**Sleep**	**Off**
2000	Desktop computers (non-domestic)	78.3	6.1	3.1
	Laptop computers (non-domestic)	28.7	2.6	1.1
	Monitors	60.9	3.4	2.4
2008	Desktop computers (non-domestic)	66.4	4.2	2.4
	Laptop computers (non-domestic)	16.9	1.7	1.1
	Monitors	38.5	1.1	1

3.3 Taking Action – the Desktop

As noted earlier, PCs account for 40–50% of total ICT-related electricity consumption in universities and colleges. In addition, of course, the production and disposal of these devices also has considerable energy and environmental impacts (see companion paper, James and Hopkinson, 2008a). They should therefore be a high priority in sustainable ICT initiatives.

A typical desktop in a university or college will contain a personal computer, attached to a monitor, keyboard and mouse. Other peripherals, such as a personal printer, or VOIP phone, will also be present in some cases. A few staff may have replaced a PC with a laptop and docking station, but the SusteIT survey found that that at least a quarter of respondents were using both a desktop and a laptop (James and Hopkinson, 2008a). It also found that the sector has made a significant transition to LCD/TFT screens.

The microprocessors and other components within desktop devices have become more efficient over time. Hence, as Table 6 shows for the UK as a whole, the rated power consumption of the most common ones fell considerably between 2000 and 2008. This was especially true of monitors, largely because of the transition from CRT to LCD models. (Our survey suggested that the latter now account for 80% of display devices in universities and colleges.) Laptop power consumption also fell considerably, mainly because of the continued development of lower power chips – using approaches that are now being transferred to desktop PCs. (As Table 6 shows, laptop devices have a considerably lower power rating than desktops, and also tend to have more effective power management, so that they are a much more energy-efficient option.)

However, this increased processing efficiency has been considerably outweighed by:

- An increasing number of machines (eg many academics having a desktop and a laptop), and
- More sophisticated applications, requiring greater processing power

There are few signs of these trends changing, and so the energy and environmental impacts of personal computing are likely to increase considerably in absolute terms.

The actual amount of energy consumed, and therefore CO_2 indirectly emitted, by a PC depends upon:

- The type of computer and associated energy consumption, ie some computer models have higher power requirements than others, as shown in our technical paper on personal computing (James and Hopkinson, 2008a)
- The applications being run – eg 3D, office applications, DVDs – which can make a difference of a factor of 2 or 3 when the computer is in actual use
- The operating system – initial versions of Vista, for example, consumed 25% more power than Windows XP (IBM Global Technology Services, 2007)
- The time it is actually used – 24/7 or just for a few hours per day
- The extent to which internal or external power management software is used to minimise consumption when activity is not required
- The time it is switched off at the mains (as opposed to the device itself), and
- The way in which the electricity is generated (eg on-site renewable electricity versus grid electricity)

These factors lead to a large potential range for the energy consumed by different PCs. A higher energy, high-usage PC with no power management could cost £61 per year in electricity compared to a lower energy, low-usage PC with power management costing £3 per year (James and Hopkinson, 2008a). The potential energy savings from powerdown have also been highlighted in a study by the National Energy Foundation, which calculated that, for UK offices as a whole, powering down networked computers when not in use could avoid 700,000t of CO_2 emissions and £115m of costs (1E and National Energy Foundation, 2006).

3.3.1 Desktop solutions

A strategic approach to personal computing is required to ensure that the approaches adopted, and the equipment purchased, meet student and staff needs in the most cost-effective and sustainable way possible. The starting point is assembling a team. To be effective, this needs to bring together (at least) IT staff, users, and energy or environmental managers, and be chaired by a relatively senior manager. Auditing current usage will also be important to help understand issues such as user needs (so that they can be better matched with devices), duplication (and the extent to which buying docking stations for laptops could make sense) and the potential for introducing more radical changes such as netbooks or thin clients in the medium term. Changes such as these are often unpopular and so it is important to build support by developing awareness of the environmental benefits they create.

Four key actions will be:

- Purchasing hardware and software, which is energy efficient, and appropriate to needs, achieved in part through following the advice of the Government's 'Buy Sustainable – Quick Wins' programme (Defra, 2008a), which includes only purchasing devices compliant with the Energy Star 4.0 standard

- Reducing energy consumption in use through configuring for energy efficiency when in active use (eg by minimising the number of items in the start-up menu and avoiding screensavers); powering devices down when not in immediate use (either via the network, or altering local settings); and switching off completely whenever possible

- Examining low impact alternatives, such as netbooks or compact desktop devices, as a substitute for desktops or high-powered laptops, and, more radically, thin client (see section 3.1.1)

- Increasing longevity through avoiding software-induced replacement (though the support implications and other costs of this should be properly assessed), and increasing the useful life of devices by extending the period of refresh cycles, or by creating a 'second life' by donating to staff or charity

More details of all of these options are contained in a supporting technical paper (James and Hopkinson, 2008a).

Box 10 Carbon Impacts of Daily ICT-related Activities

According to the Carbon Trust (2008a):

- Leaving a computer on overnight for a year creates enough CO_2 to fill a double-decker bus

- A photocopier left on standby overnight wastes enough energy to make 30 cups of tea, and

- Air conditioning an office for one extra hour a day uses enough energy to power 12 TVs for over a year

3.4 Taking Action – Printing

A separate paper (James and Hopkinson, 2008c) contains detailed information on printing in the sector, and ways in which its environmental impacts can be reduced.

Universities and colleges spend considerable amounts of money on printing and copying, with bills at larger institutions being well in excess of £1m annually (AIMS & Associates, 2007). The last decade has seen three major changes in printing patterns:

- A higher proportion of all central print being produced on copiers and other digital devices, rather than analogue methods such as offset litho
- The proportion of total print being undertaken by central print units reducing as: a) the number of networked printers and MFDs provided by IT departments, and personal printers purchased by staff, has increased; and b) more printing of course materials has been directly by students, and
- More colour printing (which is more expensive, and has greater environmental impacts, than mono) – which is estimated to be 10–20% of networked print output in universities (Wyse, 2007)

A recent analysis of these changes by one of the outputs from a Value for Money study has commented that:

> The university sector has been fortunate to have benefited from a highly economical framework vehicle for the procurement of traditional photocopier devices. As the responsibility for these devices has shifted from Print Unit to IT team, the benefit of the buying framework has been diluted. IT teams are happy buying HP printers. They are cheap to acquire. Once installed, the IT team then pass the responsibility for running the printer on to the department. Costs of running a fleet of printers have been virtually impossible to isolate. Copier costs have been very visible and focused on by management. The truth is that print volumes have grown, copy volumes have fallen, and document production costs are under less control than five years ago. (Wyse, 2007)

This has obvious environmental impacts in terms of additional energy, waste and other impacts related to the additional volume of equipment, paper and consumables. It can also result in outputs being printed on the most environmentally damaging devices even though they could be produced on others, which are less so.

These findings are reflected in the SusteIT research, which found that that:

- Higher education has around 148,000 printers, and further education 98,000
- Digital printing accounts for at least 10–16% of ICT-related costs, and therefore 2–3% of the sector's total electricity consumption
- Laser printers are the most common device, with 72% of survey respondents having access to one
- Multifunctional devices are also common, with 42% of survey respondents having access to one, and
- Survey respondents printed an average 224 sheets a week, or 10,000 annually (James and Hopkinson, 2008d)

Printing and imaging devices have similar impacts to computers with regard to their electronic components and casings. However, they differ in having mechanical and thermal processes – with resulting additional energy consumption – and in using paper and consumables, which have high embedded energy and other impacts from their production. Printing devices also have different characteristics – with a particularly sharp distinction between inkjet and electrophotographic (EP, a category which includes xerographic copiers and laser printers) devices. EP devices have higher standby power requirements than inkjets but generally consume less power and resources to print an individual page. Hence, if well utilised, they generally have a smaller environmental footprint, per page printed.

However, this is not necessarily true of the multifunctional devices (MFD), which are becoming increasingly common in further and higher education. An inkjet MFD can consume twice the energy, a dedicated laser printer could consume five times and a laser MFD 15 times the average energy consumption of a dedicated inkjet printer in some circumstances (Market Transformation Programme, 2007). If MFDs (especially laser ones) genuinely replace dedicated devices such as copiers, faxes or printers, and are heavily used, then they are environmentally superior. However, if this is not the case, they may not be.

Table 7 summarises some of the key factors that influence the environmental impacts of all kinds of printing equipment in use. As Figure 2 shows, the lowest environmental impacts arise from draft quality, double sided, reduced size, and black and white output on recycled paper.

Just over half of the respondents who answered specialist questions on printing were indeed replacing single with multifunctional devices (see James and Hopkinson, 2008c). Around half were also undertaking two other key printing actions that can minimise impacts – duplex (double sided) printing as a default and use of 100% recycled paper. Whilst this is encouraging, it also demonstrates that there are many institutions that have not yet taken significant measures to minimise their energy and environmental footprints.

Table 7: Factors affecting environmental impacts of imaging equipment in use (adapted from VHK, 2005)

Usage	Toner Use	Energy use	Other
Number of copies per period Copy size (A4 or A3) Double-sided or single-sided copying Full-size copy (copy size = original size) or 2 in 1 (copy size = 50% of original or less) Type/weight of paper/media	Colour or black and white Output quality (draft, standard, premium)	Power management enabled Number of copy-jobs per day and copy-job sizes (copies per job) – which affect duty cycle Whether power is switched off manually at night and/or long periods of inactivity Standby power consumption (laser printers are generally higher than inkjets)	The use of additional paper handling functions (sorting/stapling) The use of the 'copier' for other functions (scanner, fax and/or printer)

Figure 2: Best and worst case environmental impacts from printing use (VHK, 2005)

Lowest environmental impact →	**Highest environmental impact**
Double-sided 50% reduced (A3 to A4)	Single-sided full-sized (or enlarged)
Draft quality	Premium quality
B/W copy	Colour copy
Recycled and/or thin unbleached A4 paper	Premium paper or transparencies

3.4.1 Printing and imaging solutions

As with desktop solutions, a strategic approach to print/imaging management – embodied in a cross-functional team – is vital to ensure that the equipment purchased meets student and staff needs in the most cost-effective and sustainable way possible. Five key topics need to be considered:

- Print and paper auditing to help identify priorities, and to justify investment in measures to cut paper usage
- The potential for print substitution – research suggests that much printing is easily avoidable, and that good Intranets and document management systems can help to reduce it
- Consolidation of imaging devices into a smaller number of more heavily utilised ones
- Effective print management, and
- Overcoming barriers – changes in printing practices are often unpopular and so it is important to maximise benefits (eg greater convenience from the ability to print from multiple locations), and to develop understanding of the environmental benefits of change

Buying appropriate equipment, which is as energy efficient as possible (at least meeting the Energy Star 4.0 standard), is not over-specified for user requirements, and is purchased from vendors who can provide information and support on sustainability issues, is also important.

Enabling and using power management on printers to the maximum, and switching them off whenever feasible, is even more vital for printers than computers as they generally have higher levels of energy consumption within the same state. The energy, waste and pollution impacts attached to paper consumption can also be reduced further (after substitution measures have been taken) by measures such as purchasing recycled and/or lighter weight paper, and achieving more paper-efficient printing. The latter includes encouraging people to print duplex (double-sided) or booklet style (A5, double-sided); to use word processor settings to avoid double-spacing, large margins and unnecessary white space; to use print preview and print in economy mode; and to use scrap paper for draft copies whenever possible.

3.5 Conclusions

It is evident that sustainable ICT in 2050, or even in 2020, will be very different from that of today. In the short–medium term, however, the sector must work with suboptimal technologies, inadequate information and poorly developed processes – and limited leverage with suppliers – to address ‘upstream’ environmental impacts. It therefore makes sense to focus initially on reducing the resource consumption (eg electricity, paper) of its own ICT activities as this is within its control, and can create financial as well as environmental benefits. There is also much to be done because there is a great deal of wastage (as with ICT usage in most sectors) in current practices. One reason for this is that many devices are:

- Less energy inefficient than alternative ones that could have been purchased, and would be likely to have a lower TCO
- In more active states than they need to be for much of the time
- Considerably under-utilised even when they are in use, and
- Often more powerful than is actually required for the activities they are undertaking

Data centres too often have very energy-inefficient cooling and power supplies. And many pages are printed – often with greater environmental impacts than are necessary – which could be avoided through alternative methods. Indeed, when the embedded energy and environmental impacts of paper are taken into account, it may be the largest part of the carbon and environmental footprint of many institutions.

The examples within this report, and in our case studies, illustrate that many of the potential actions that could be taken to reduce these impacts are already being implemented in at least a few institutions. Clearly, if they can do it, others can follow, and a key challenge is therefore one of greater take-up through disseminating best practice more effectively. The case for action, and the benefits of doing so, are also increased greatly by high energy prices (which will remain so even after post-credit crunch falls).

A number of the options for more sustainable ICT can be taken by IT departments within relatively short time frames, and without any significant strategic implications. However, alongside these 'quick wins' are a number of options that are longer term and more strategic, because they require collaboration between IT and other departments, and/or involve a complex mix of environmental and non-environmental considerations. Environmental and sustainability considerations will only be one element in the decision-making about these options and their implementation (which means that environmental benefit is not inevitable, as they can be introduced in different ways), but it is important that they are recognised and given appropriate weight.

It is relatively straightforward to create a list of short–medium term measures, as there is a broad consensus about what should be on it. However, it is more difficult to rank them, both because precise figures are not available about relative benefits and costs, and also because their value depends upon organisational circumstances and IT configurations. None the less, Box 11 provides our interpretation of the most promising options with regard to ICT architectures and devices for universities and colleges.

Box 11 Taking Action: Key Measures and Priorities

Short-term Priorities within IT Control

Specifying lower power equipment
Automatically powering down networked devices (copiers, PCs etc)
Manually powering down/switching off all devices when no automatic powerdown
Modifying data centre layout
Increasing refresh cycle of devices

Short-term Priorities Involving Cross-functional Collaboration

Auditing ICT assets and electricity consumption
User awareness campaigns to encourage powering down/shutting off of non-networked devices, and other measures
Setting printers' and copiers' default to duplex and purchase 100% recycled paper
Upgrading data centre power-supply arrangements when short paybacks are available
Increasing use of videoconferencing

Medium-term Priorities within IT Control

Consolidating the number of devices
An effective information life-cycle management policy, which reduces storage requirements
Virtualisation of servers wherever feasible
Increasing computer CPU utilisation through grid computing
Positive investigation of shared service approaches that utilise 'greener' data centres

Medium-term Priorities Involving Cross-functional Collaboration

Increasing IT department responsibility for electricity bills
Maximum use of thin client where demonstrably effective
Achieving high efficiency data-centre cooling
Incorporating non-energy environmental issues into procurement requirements

Chapter 4 – ICT Application in Universities and Colleges: Summary of Key Points

Much current discussion of ICT applications focuses on their potential to replace or supplement current activities – however, completely new ways of achieving current objectives may emerge, and indeed may be essential if radical sustainability targets are to be met.

e-Learning can increase access and reduce the environmental impacts of buildings and transport – one study found that distance learning consumed 90% less energy per student than conventional campus-based courses.

e-Learning can also result in additional student purchases of equipment and printing, and has the potential for adverse health and safety impacts by encouraging excessive, unergonomic computer use by students.

ICT enables location-independent working, which can save energy, space and improve work–life balance – 60% of respondents to the SusteIT wanted to do more work remotely.

JANET provides one of the world's most sophisticated multi-organisational VC infrastructures – although use is increasing rapidly, with 20,000 centrally booked conferences in 2007 (and at least double that set up independently), there is the scope for much greater usage – both in technical capacity and potential user interest.

Buildings, and the activities within them, account for a large proportion of a university's or college's energy consumption. Smart buildings, which use ICT to monitor and manage this consumption, have the potential to reduce utilities consumption by 10–20%.

4. ICT Application in Universities and Colleges

ICT is integral to a modern university or college. Admissions, payroll, student records and other administrative tasks would be extremely cumbersome without it. Learners are increasingly dependent upon it for their work, to obtain course-related and general information, and for academic (and sometimes private) communication. Academics are similarly dependent, for communication, for information to support research and teaching, and in other ways. All of these activities can be of enormous benefit to further and higher education. For example, they:

- Enable institutions to work more efficiently, and to research and teach more effectively
- Provide unprecedented access to information and peer networks for staff and learners, and
- Allow institutions to overcome many constraints of location or time zone and therefore reach larger markets, or have greater impact

However, they also carry an 'invisible overhead' of environmental impacts, which is seldom fully appreciated. Although it is impossible currently to allocate ICT impacts between different activities, it is clear that some are of disproportionate importance. These include:

- Research using supercomputers, which require considerable energy for cooling
- The increasing deployment of graphic and/or video-rich web applications
- Storage of information, such as old emails and complex research data, which is growing very rapidly and currently uses a considerable amount of energy within data centres
- High-capacity connections to student residences (which can require the allocation of 10% of an institution's bandwidth to enable cable television access)

Some activities also have a potential 'social overhead', for example:

- Degradation of the learning experience through reduced face-to-face contact
- Creation, or exacerbation, of student exclusion, because use of online networking sites such as Facebook or other Web 2.0 opportunities results in the creation of a 'virtual in crowd' of those most adept in these new environments, and
- Health and safety implications of university moves towards e-learning environments requiring students to spend much more time on computers.

It is beyond the scope of this study to fully assess the balance between the broader benefits of ICT to universities and colleges, and any negative environmental and social impacts they create. However, it is important that:

- Decision makers and opinion formers understand that there are considerable 'disbenefits' associated with increased ICT dependence, such as that inherent in the move to Virtual Learning Environments (VLEs)
- Increased ICT dependence is matched by increased commitment and action to environmental improvement and social responsibility so that there is not a proportionate rise in impacts, and

Emerging issues such as ICT-related health and safety, and social inclusion, issues amongst students are addressed

It is also important that activities within further and higher education where the application of ICT can assist sustainability are recognised and encouraged. Activities with potential environmental benefit include:

Substitution of physical activities or artefacts with electronic ones (eg participating in a virtual meeting or tutorial, rather than travelling to a face-to-face one, putting documents online rather than printing)

Consolidation or integration of multiple activities or artefacts into ones with a smaller footprint (eg a reduced requirement for floor space as a result of better utilisation), and

Optimisation of activities (eg reducing cooling or heating by more sophisticated responses to ambient conditions)

ICT-related activities creating potential social benefit (of relevance to common definitions of sustainability) include:

Improving access to, and benefits from, educational opportunities for disadvantaged groups and individuals

Improving quality of life for staff, and

Reduce time spent undertaking administrative tasks, so freeing people to engage in the more creative aspects of teaching, learning and research

The following sections examine these impacts with regard to three areas of learning, work and facilities. As this report is primarily focused on short–medium-term improvement opportunities, the discussion focuses on the potential for ICT to replace or supplement current activities. However, it is important to remember that completely new ways of achieving current objectives may emerge, and indeed be essential if radical sustainability targets are to be met.[2]

4.1 e-Learning

The traditional model of good education, which retains great resonance, is one which is based on physical learning activities, in the form of face-to-face contact between learners and teaching staff, and study of paper-based sources. This is now challenged by a move to virtual learning, and consequent impacts on content, location, timing and methods, with results such as the:

Rise of 'student centred' approaches, a key aspect of which is the role of the learner in actively acquiring and assimilating information from multiple sources to meet their own objectives, eg solving specific problems, developing specific competencies

Development of electronic repositories for many teaching materials, such as lecture presentations, reading lists and resources etc

[2] We are grateful to Howard Noble of the University of Oxford for commentary on this point, and others, which has been of benefit to our report.

Use of the internet and other electronic sources for research, and learning-related communication activities

Substitution of virtual interactions for physical ones, eg through distance learning materials and online tutorials, and

Ability of students to work in many more locations than in the past, both on and off campus (Economist Intelligence Unit, 2008)

Our survey found that use of VLEs is not yet ubiquitous amongst the subgroup who identified themselves as being involved in teaching, with under half undertaking such tasks as uploading teaching materials or using in-class teaching aids (James and Hopkinson, 2008d). However, 60% of respondents expected to make greater use of ICT-mediated teaching equipment and applications over the next 3–5 years.

There is now a considerable literature on the pedagogic impacts of these changes (eg, Boys and Ford, 2008; JISC InfoNet, 2008). Interestingly, only 31% of (the relatively small number of) respondents to the teaching section of our survey felt that the impact of ICT on the educational experience of learners and teachers in universities and colleges was generally positive, with most of the remainder (52%) seeing a more mixed picture of positive and negative features (see James and Hopkinson, 2008d).

The main concern of our project is the environmental and (for those of relevance to sustainable development) social impacts of these changes. Unfortunately, there is little research on the former topic. One notable exception is a study by Open University researchers (Roy *et al*., 2005). They found that distance learning courses in higher education on average consume 90% less energy and produce 90% fewer CO_2 emissions per student than conventional campus-based courses. The better environmental performance of distance learning was mainly due to a major reduction in the amount of student travel; economies of scale in use of the campus site; and the elimination of much of the energy consumption of students' housing.

Such findings focus attention on the transport impacts connected to recruitment of overseas students, and whether this represents the most sustainable option in the longer run.

Another environmental topic of considerable interest is the effect of e-learning on student use of ICT. Many universities and colleges now advise students to acquire a computer, which is increasingly likely to be a laptop. Where universities have a policy of providing sufficient computing facilities to meet all student needs, this could result in additional purchases of equipment. It can also encourage acquisition of additional peripherals, such as monitors and printers.

A related point is the impact of VLEs on printing. Although this generally reduces institutional printing volumes, anecdotal evidence suggests that it is leading to increased printing by students, which, when it happens, is likely to be on smaller, typically inkjet, printers, which are less energy efficient than volume devices.

It is therefore conceivable that any environmental benefits from VLEs within the institutional context are outweighed by increased impact amongst learners. Some further research to establish whether this is happening and, if so, how it can be minimised, would be helpful.

e-Learning is also encouraging students who already tend to be intensive computer users to spend more hours upon them. Unlike staff, they seldom have access to health and safety advice, and observation suggests that use of ergonomic measures such as wrist pads is infrequent. Students often, for example, use laptops on desks – a practice which is forbidden for staff in some universities because of health and safety concerns. Although the legal position is unclear, it is conceivable that an institution could be held responsible for repetitive strain injury, back and vision problems, or other adverse outcomes if their provision effectively required students to spend large amounts of additional time on laptops and PCs. Even if this is not the case, some may feel that there is a moral responsibility to provide similar advice and support to students as to staff, in order to reduce the risks of such outcomes occurring.

e-Learning also has implications for increasing access to (and maintenance of involvement in) further and higher education. It can encourage this by overcoming locational constraints, reducing learner costs, eg of transport, and assisting people with disabilities (Guardian, 2008; JISC InfoNet, 2008). For example, our case study on Beaumont College demonstrates how ICT can support the learning and development of physically disabled students and there are a number of similar case studies on JISC's TechDis website. e-Learning can also play an important role in supporting a wider agenda of 'social equality'. In the words of one study:

> This includes widening participation, increasing employment options for graduates and the provision of space for the essential consideration of different or challenging perspectives in ways that would have been impossible prior to the introduction of online and distance learning. (JISC InfoNET 2008, p.254)

However, e-learning can also discourage access by requiring (or appearing to require) knowledge of ICT, and perhaps the need to buy a computer. More research is needed on this topic, too. None the less, it is encouraging that, as Table 8 shows, respondents to the SusteIT survey were generally positive about the impacts of ICT on access.

Table 8: Results for survey question 'What do you feel is the impact of ICT on access to further and higher education?' (Question answered only by respondents involved in teaching and research)

Response	Number of respondents	%
Generally positive	9	31
Often positive, but can also have negative impacts	10	35
Mix of good and bad impacts	5	17
Often negative, but can also have positive impacts	0	0
Generally negative	1	3
Too complex a question to answer here	2	7
Other	1	3
Don't know	1	3
Total respondents	29	

Box 12 Making Learning Free

The world now has easy access to academic knowledge on many topics through iTunesU, a repository of learning resources, which forms part of Apple's iStore. Users can download materials for listening or viewing on an iPod or compatible device. A number of UK universities, including the Open University and University College, London, are making lectures and other course materials available at no charge. Institutions can also set up 'walled gardens', which are only accessible to staff and students. The Open University believes that: 'Offering material free of charge is consistent with our mission. We hope that people will want to take it further and enrol on our courses' (Lightfoot, 2008).

Box 13 e-Readers – The Missing Link?

VLEs can potentially encourage students to read course materials and other content online, therefore replacing paper-based methods. Some studies have even suggested that it will become normal to access books in this way in future (Guardian, 2008).

A Swedish life cycle assessment (Moberg *et al.*, 2007) compared the environmental impacts of a printed newspaper with reading the same content on a PC (for 10 minutes daily) and an e-reader (for 30 minutes daily). It found that the main environmental impact of both the printed newspaper and the e-reader arose from their production, whereas that of web-based newspaper was electricity in use. The overall impacts were highest for the newspaper, and lowest for the e-reader, but the researchers noted that many variables could change the verdict. However, they also noted that, as a new product, the e-reader had considerable potential to reduce its impact, especially through effective recycling. This could involve new versions using plastic- rather than silicon-based components (Copeland, 2008).

e-Readers could also have two further sustainability advantages. One, potentially, is reducing some of the health and safety risks associated with the use of computers, such as repetitive strain injury (RSI) arising from excessive keyboard and mouse use, and eyesight problems from monitors. A second would be eliminating the need for a conventional personal computer through combined use of an e-reader and another small device (such as a netbook, 3G PDA or thin-client terminal) to undertake tasks such as email and web-based word processing.

4.2 Work

Two ICT applications are of particular relevance to work in universities and colleges:

- Location independent working, and
- Virtual meetings

4.2.1 Flexible working

There are many forms of flexible working, but those most relevant to sustainability include working from home, or other alternative locations, rather than a fixed office (often called 'location independent working'). This is because a number of studies have shown that, when well managed, and in most circumstances, such working patterns can create net reductions in both work-related travel and office space requirements (Banister, Newson & Ledbury, 2007; Cairns *et al.*, 2004; Climate Group, 2008). Indeed, one recent study has suggested that they have the potential to reduce global CO_2 equivalent emissions by up to 260 million tonnes by 2020 (Climate Group, 2008).

Of course, location independent working can have some negative environmental impacts – such as increased heating of homes when people work there for longer – but the balance of evidence is that these are outweighed by benefits, especially when organised schemes allow reductions in overall space requirements, and therefore the environmental impacts of building use (James, 2008). Cisco (2007), for example, compared two adjacent buildings, one with conventional ICT infrastructure and working practices, and the other with features such as hot-desking, a high-capacity wireless network, and other features associated with flexible working. It found that the latter building could reduce energy load by 47%, and space per employee by 40%, which translated (in US metrics) into avoidance of 1,500 tons of concrete, 280 tons of steel and 2,850 tons of greenhouse gas emissions if an office could be sized at 100,000 rather than 140,000 square feet as a result.

The same point also applies to personal and social impacts, with well-managed schemes reporting high levels of staff satisfaction, and relatively low incidences of negative impacts such as social isolation (SUSTEL 2004).

Around 8% of the UK workforce worked in a location-independent way in 2005 – double the level of 1997 – and the number continues to increase (Ruiz and Walling, 2005). The SusteIT survey suggests that it is even more widespread in further and higher education (see James and Hopkinson, 2008d for details), with:

- 47% of respondents saying that they worked remotely at least once a week
- 82% of respondents who worked remotely saying that they had checked email, and 67% saying that they had accessed an Intranet, from home (the main site of remote working), and
- 60% of respondents saying they wanted to do more work remotely, with the main reasons being reduced travel time (64% of those wishing to work more remotely), improved work–life balance (62%) and a desire to work more effectively (51%)

Of course, the respondents were mainly academics, researchers or managers, and the percentage working remotely, or perhaps wanting to, is almost certainly much lower amongst administrative and other staff. However, the figures do suggest that there is a demand for more progress in this area.

There are also many external drivers encouraging greater movement towards location-independent working, including:

- Finding solutions to the widespread public and policy concern about excessive working hours, and the resulting problems of achieving a satisfactory work–life balance, within the UK (which has the longest average working hours within the EU)

Widespread public and policy concern about car-related environmental impacts, and growing problems of traffic congestion and overloaded public transport during rush-hour periods (resulting in increased travel-to-work times and, for many people, increased stress), and

Increasing employer awareness that location independent working can provide significant business benefits, for example, in improved employee morale, performance and retention, and – in the case of more radical initiatives – very considerable reductions in office costs (Dwelly & Lake, 2008)

These drivers are reflected in a number of Government policies that are encouraging e-work, as with proposed new flexible-working legislation.

Of course, there can be downsides to location-independent working, including difficulties of management control, less effective transfer of knowledge between staff, and social isolation. However, several studies have suggested that these can be minimised by good management, and are then far outweighed by benefits such as improved performance, reduced absenteeism and better work–life balance (eg, SUSTEL, 2004). This is borne out by the experience of Coventry University, whose internal scheme is now being expanded through a JISC exemplar project (see SusteIT case study).

4.2.2 Virtual meetings

The replacement of face-to-face meetings by video and other forms of electronic conferencing has been predicted for many years. Although progress has been slower than hoped for by its advocates, audio and web conferencing have become widely used, and video conferencing (VC) use is also increasing. A number of studies have shown that this usage can create significant business, personal and transport benefits (Hopkinson, James, & Maruyama, 2003; James 2007; Cairns *et al*., 2004). A recent study has also calculated that greater use of VC has the potential to reduce global CO_2 equivalent emissions by up to 80 million tonnes by 2020 (Climate Group, 2008),

Most UK universities and colleges have access to one of the world's most sophisticated multi-organisational VC infrastructures, as measured by ease of bridging multiple sites, speed of data transmission and quality of sound and vision (compared to commercial offerings at similar investment levels for participating institutions). The use of its main offerings, the JANET Videoconferencing Service (JVCS) and Access Grid (see Box 14), is growing rapidly, JVCS hosted over 20,000 video conferences in the academic year 2007/08, double the number for the previous four years combined. In addition, JVCS believes that a similar, and perhaps even greater, number of video conferences are taking place using the same facilities, but arranged directly between participants rather than using the JVCS booking and support service.

However, this picture is slightly less positive when the pattern of usage is analysed. A relatively small number of sites account for a high proportion of all JVCS video conferences. Indeed, in spring 2008, the top four sites in all of the UK – accounting for around a quarter of all calls on the network – were all located in a relatively small Welsh further education college in Gwynedd, Coleg Meirion-Dwyfor. By autumn 2008 it had been joined by another 'power user', the Scottish Universities Physics Alliance (see SusteIT case). Whilst these bodies have clearly embedded VC within their activities, they are clearly the exception which proves the rule that most have not. This was confirmed by our survey, which found that 43% of respondents had never used conferencing of any kind, and only 9% were regular users (James and Hopkinson, 2008d). However, 77% felt that there was scope for more use.

There are many reasons for this low usage. Some will – and perhaps should – never be overcome, because they relate to the effectiveness of communication, which is generally higher when people are in physical proximity. However, the aim of a sensible conferencing strategy is not to replace 'high value' face-to-face meetings. The environmentally beneficial opportunities are those which substitute for relatively 'low value' ones – such as some meetings between people who get together regularly – or sessions where travel times and/or costs are disproportionate to benefit. Another opportunity is interactions that would have been impossible if travel had been involved, but these are more about creating social benefits than environmental ones.

Other, more surmountable barriers include:

- Lack of connection between the cost savings that other parts of the institutions can achieve from reduced business travel, and the additional resource needed within IT departments to support VC, with the result that the latter often see it as an unwelcome overhead involving money and time
- Absence of strong, and coordinated, messages from key sector bodies that institutions should be making more use of VC
- Limited internal marketing, with end-users often being unaware of equipment or services available to them, and how to use/access them
- Lack of knowledge in IT departments of how to handle VC solutions leading to a reliance on 'friendly suppliers' and resulting variation in standards and systems, which can sometimes be unable to inter-operate with JVCS
- Lack of understanding by non-experts about the VC offerings, and the differences between them
- Too few, and too inconvenient, sites within institutions, and
- A lack of supporting functionality, such as live minute taking and collaborative tools (although much of this can be attributed to groups and regions adopting different systems and methodologies as they were unaware of the national systems)

These findings are unfortunate because the sector infrastructure has the capability to handle a much higher number of calls than are being undertaken, and is therefore considerably under-utilised. This is true even at periods of peak demand, but there is also considerable potential to expand usage during off-peak periods. The fact that usage could therefore be ramped up quickly with relatively low additional costs compared to savings suggest that this should be a priority area for further action.

Box 14 Videoconferencing in Further and Higher Education

JANET (UK) has three full videoconferencing (VC) systems, and an additional pilot project:

The JANET Videoconferencing Service (JVCS) – this service provides support and centralised equipment to universities, colleges, research centres and schools with H.323 standards-based VC equipment. It has the technical capability to link any number of registered venues (currently 4,600, ranging from dedicated conferencing suites, to desktop configurations) to other sites in the network, or around the world, in a secure and managed fashion. It includes a support service, which covers a secure booking service, telephone support desk, quality assessment, and advice.

Access Grid – this PC-based solution has two different software versions: Access Grid Toolkit, a free open-licence client, and IOCOM, a commercial platform. Both interwork, and include collaborative tools such as online chat and the sharing of applications or documents, which may be used by participants interacting within a virtual meeting room. There is a dedicated Access Grid Support Centre (AGSC). It is potentially more flexible than JVCS due to its collaborative nature (although it is sometimes used as a simple VC facility). It can be accessed in a conference room with a server, several high specification cameras and large display boards, or from a desktop computer equipped with a webcam and headset. It has been used successfully in a number of specialist communities, eg particle physicists, and for specialised teaching, eg The Taught Course Centre (TCC), which relays mathematics lectures simultaneously to PhD students across its five member universities: Oxford, Warwick, Imperial College, Bath and Bristol.

EVO (Enabling Virtual Organisations) – a web-based, desktop, VC solution that is closely allied to, and interoperable with, Access Grid, as is was originally built from the same core components. It can also work directly with H.323 videoconferencing. It too is supported by the AGSC. To date it has mainly been used for specific JANET projects, especially amongst particle physicists. It is a relatively low-cost solution to run and maintain, and is currently being rolled out across all academic establishments in Australia.

Collaborate – a pilot service open to teachers, lecturers and content providers looking for opportunities to work collaboratively. Once in contact they can use any method of communication, but use of JVCS is likely in many cases. Users can set up a scheduled VC 'opportunity' at a particular time such as a seminar or speaker Q&A session, which other users can join. Or 'open-ended opportunities' can be set up by users posting requests and then arranging a VC session with those who respond.

4.3 Facilities

Buildings, and the activities within them, account for a large proportion of a university or college's energy consumption. Measures to reduce this are obviously beneficial in their own right, but are also synergistic with other aspects of building functionality. As the SusteIT case shows, the University of Dundee's Queen Mother Building is a simple, low-energy design, which saves energy, reduces environmental impacts, enhances productivity and has brought great reputation benefits to both the university and the Computing School which is housed within it.

ICT is central to low-energy buildings because it allows energy consumption to be more effectively monitored and managed. Advanced building management applications can be of especially great value in optimising energy efficiency within data centres (Johnson Controls, 2008).

One difficulty in managing many buildings within the sector today is the isolation of different systems, so that data cannot be transferred between them and operators must handle multiple interfaces. The systems that are often separate include:

- Energy management
- Fire and safety
- HVAC control
- Lighting control
- Lifts
- Room booking
- Security (access control, video surveillance and visitor management)
- Space management
- Telecommunications

Not only are these systems isolated from each other, but Estates administrative systems are generally separate from others within an institution (Duke and Jordan, 2008a).

ICT can potentially enable many performance and sustainability benefits from greater integration of these activities, achieved through:

- A common Internet Protocol (IP) network for all building sensing, controlling and management activities
- Integration, or inter-operability, of key building services and controls, so that data can be transferred between them, and common user interfaces adopted, and
- Consolidation of wiring and cabling into common channels, where practicable (Cisco 2008)

The sustainability implications of such systems can include:

- More effective use of space and other resources
- Better control of energy-consuming activities such as cooling, heating and lighting, so that they respond more precisely to demand
- Linking energy controls to other building systems such as room bookings so that, for example, empty rooms are not serviced to the same degree as others, and
- Increased economic feasibility of sophisticated controls as overhead costs are shared with other services

A new US institution, Ave Maria University in Naples, Florida, estimates that using an IP approach has saved 10–20% of the utility costs it would have had with a more conventional approach (Madsen, 2008 – see also the SusteIT case study).[3]

4.4 Conclusions

Applications are a crucial area of sustainable ICT for universities and colleges. However, in many cases, they are difficult to address because of their diffuseness, and the fact that environmental and sometimes social impacts are only one element in a complex decision-making situation.

Perhaps the greatest impact of universities and colleges on sustainable development is the legacy of learning, as manifested in the attitudes and behaviour of students as they progress through their lives. If e-learning can help to increase access to specific knowledge of the topic, and to support the development of social equality and active citizenship, then can it make a very positive difference.

Of course, it is also possible that e-learning could lead to poorer quality, and less humane, education, just as location-independent working and virtual meetings could lead to more atomised and less fulfilling lives for staff. However, the balance of evidence is that these dangers can be avoided, and that net environmental and social benefits can result. This could be even more true if the long-term opportunities to use ICT to completely rethink the ways that some activities are conducted are taken, so that they are more sustainable without being less effective.

The application of ICT within the sector's buildings also has the potential to create environmental benefits – especially those arising from reduced energy consumption – to offset much if not all of the footprint arising from its use in other areas. Institutions dedicated to intelligence can benefit enormously from smarter buildings, and by doing so could make a difference to the economy more generally, as Chapter 6 discusses.

[3] Note that potential savings in the UK may be slightly lower as some control features that are unusual in the USA are already widely adopted here.

Chapter 5 – Management: Summary of Key Points

The most significant general barriers to sustainable ICT appear to be time/staff resource constraints; lack of coordination between different parts of the organisation; and budgetary constraints.

Few IT departments have responsibility for, or even knowledge of, ICT-related energy costs.

Even when energy costs are billed to research projects or other activities, they generally cover only direct electricity consumption by ICT equipment, and therefore ignore other substantial costs such as cooling and power supply.

Sustainability has only a limited presence in ICT procurement – although procurement bodies are taking action, this is hampered by a lack of standard assessment approaches.

Only 17% of survey respondents conducted a detailed analysis of the whole life energy costs associated with ICT equipment purchases.

Successful organisational action for sustainable ICT requires clear strategic commitment; a continuous improvement approach within IT departments and elsewhere; and effective use of TCO (total cost of ownership) analysis.

Better collaboration between Estates and IT departments is especially important if barriers to sustainable IC T are to be overcome.

There is no 'one size fits all' approach to sustainable ICT – this is influenced by the extent and depth of an institution's strategic commitment to sustainability, and its internal capacity. Four broad approaches can be identified in practice: first steps; making connections (between separate areas of activity); joined up actions (to achieve effective integration); and radical change.

5. Management

Sustainable ICT is not achieved overnight, but requires long-term commitment and change. This in turn requires its embedding into activities and systems, both within IT departments and in other areas of the institution. The next section describes the current barriers to this, and the following section describes means by which they can be overcome.

5.1 Barriers to Sustainable ICT

We asked survey respondents what they felt were the main barriers to achieving sustainable ICT. The questions were tailored to six specific areas (teaching and research; ICT management; server management; procurement of computers; procurement of printing; and energy and environmental management). Table 9 (on the next page) provides figures for barriers which were common to them all. (Note that the figures are only indicative, as there is some double counting where people felt qualified to answer more than one of the specialist sections.) The following sections discuss each of these barriers in turn, based on material gathered from our events and interviews.

Two additional barriers, which are also discussed, are ones which emerged as very important for specific groups. These were 'lack of awareness of sustainable ICT issues amongst staff/departments' (the highest rated amongst teaching/research staff, and also one of the highest rated by IT managers) and 'lack of whole life costing or consideration of environmental impacts during the procurement process' (seen as a major barrier by roughly a third of the procurement and energy/environmental management groups). A separate paper (James and Hopkinson, 2008d) contains more detailed figures on survey responses.

5.1.1 Time/staff resource constraints

As with organisations in general, IT and other departments in universities and colleges face increasing demands without commensurate increases in staff. Moreover, whilst some of these demands are straightforward, many of those related to sustainable ICT can appear to be complex and time consuming (as discussed below). Programming-related changes, for example, obviously require considerable technical knowledge and skill to implement, and have the potential to disrupt an institution if they go wrong. In the absence of strong pressure, it is often easiest – and feasible – to take the simplest options, or even no action at all.

To some degree, of course, time/staff constraints relax as people become more familiar with the issues, and as more credible advice and information becomes available. This is presumably one reason why a small majority of respondents do not consider this barrier to be significant. However, it does seem likely to remain important. One reason for believing this is the fact that time/staff constraints have often been identified as a major barrier to other kinds of environmental action, for example, the development of high-performance buildings (HEEPI, 2008).

Table 9: Results of survey question 'What are the main barriers, if any, to minimising the energy consumption and other adverse environmental and social impacts of ICT equipment related to teaching and research? Please choose all that apply.' (Aggregation of all respondents)

Barrier	**All**		**Teaching and research**	**ICT management**	**Server management**	**Procurement (ICT)**	**Procurement (Imaging)**	**Energy and Environment**
	Responses	%	%	%	%	%	%	%
Time/staff resource constraints	122	46	42	55	61	47	44	44
Lack of coordination between different parts of the organisation	102	39	35	40	28	37	48	48
Budgetary constraints	98	37	31	44	67	37	29	29
Lack of guidance on how to reduce environmental & social impacts[4]	70	26	31	29	22	22	27	27
Lack of information on environmental & social impacts of equipment/services[5]	65	25	40	21	17	24	23	23
Lack of choices on type of ICT equipment that can be purchased	36	14	33	15	0	8	8	8
Number of respondents	Varies		48	66	18	59	48	48

[4] The question varies slightly, eg for server managers, the question asks specifically about servers; for print procurement staff, the question is specifically on printing/copying etc.

[5] As above

5.1.2 Lack of coordination

The SusteIT events and interviews show that this barrier has several dimensions. One is a disconnect between high-level aspirations for sustainability within institutional policies, and an absence of mechanisms for effective implementation with regard to ICT (and other areas). The other is a lack of integration – and in some cases, an absence of effective communication – between particular departments and specialisms.

One especially significant problem is a lack of any connection between IT and facilities. As one senior IT executive has observed in the US commercial sector:

> Regardless of how much electricity is being consumed by the data center, chief information officers aren't usually the ones writing the utility checks. This disconnect often fuels an unnecessary debate about the importance of compute power over cost savings. IT and facilities organisations need to collaborate to make sure both understand how energy-efficient computing will help address both. (Worrall, 2008)

The following section indicates that this comment is also valid for UK further and higher education. It is also reflected in limited interaction between IT and energy or environmental managers (who are generally located within the Estates function) within their organisation. Only 32% of energy/environmental managers said that they had an involvement with IT on sustainable ICT issues, and only 8% of the latter said that they worked closely together (James and Hopkinson, 2008d).

Examples of other areas where coordination can be problematic include:

- Purchase and operation of large amounts of ICT equipment by schools, departments and other units independent of the IT function (which is not necessarily bad, but can inhibit institution-wide initiatives)

- IT departments that are within broader learning support units sometimes have difficulty in persuading non-expert managers to back actions and/or approve expenditure whose value may not be obvious without technical understanding

- There is often a gulf of mutual incomprehension between the cultures of IT and Estates, even though effective collaboration is increasingly important to ensure well-specified buildings, and to minimise the cooling and power supply loads of data centres

- Continued focus on first life costs by senior financial managers, and

- The multiplicity of procurement routes for IT equipment (see section 5.1.5) can make it difficult to implement 'best practice' purchasing tools that are also supportive of sustainability, such as total cost of ownership (TCO)

By definition, the solutions to these barriers cannot be achieved by individual departments or staff in isolation, but require more 'joined up approaches', and better communication and understanding between them.

5.1.3 Budgetary constraints

Most ICT investment is capital constrained. Universities and colleges believe that they are under-funded and therefore have to stretch capital budgets very thinly, and to focus them on ICT activities that contribute to immediate goals. Unlike the commercial sector, universities and colleges are also at a disadvantage because investments in energy efficiency and environmental improvement do not qualify for

Enhanced Capital Allowance. Of course, the savings arising from energy efficiency measures will result in lower operational costs. However, normal budgeting systems within universities and colleges make it difficult to finance any additional capital costs from operational budgets, even within a single financial year.

This barrier can be overcome by the creation of ring-fenced energy efficiency budgets to finance such additional capital expenditure. This is now being supported by matched funding, in the form of interest-free recoverable grants to finance projects that result in financial and carbon savings, by Salix Finance (an affiliate of the Carbon Trust) and HEFCE with their Revolving Green Fund. This provides institutions with interest-free loans for projects that reduce greenhouse gas emissions. The scheme is too recent to enable its impact on sustainable ICT to be assessed, but IT staff from several universities have commented either that they were not aware of the funding, or that they have found difficulties in getting ICT projects into initial organisational bids. Their perception was that the Estates departments that were putting this together had a preference for more conventional energy efficiency projects.

Any such schemes also rely on good knowledge of what ICT-related energy consumption and costs actually are. However, a survey of IT professionals in UK organisations found that:

> 68% of IT departments did not pay for the energy consumed by their activity
>
> 56% had no idea what the bills were, and
>
> 12% of those who did pay did so in ways that were unconnected with their total activities, ie on the basis of a standard allocation for all departments, or for large data centres only (Global Action Plan, 2007)

This is also true of further and higher education. Our own survey found that only 47% of the respondents from IT departments were aware of the energy costs associated with their activities (James and Hopkinson, 2008d). Although these were individual rather than corporate responses, it does correspond to anecdotal evidence that few IT departments in further and higher education have a full understanding of the energy costs associated with their activities, even though – as the University of Sheffield figures (Cartledge, 2008a) show – they are considerable.

One exception to this finding is research computing installations, whose energy costs may be sufficiently large to require budgeting and internal invoicing from the start. However, in at least some cases, these costs are of direct electricity consumption by computers only, and do not include some or all of the ancillary costs such as cooling and power supply.

An additional barrier for activities involving contracts with external providers for equipment or outsourcing is that universities and colleges cannot reclaim VAT.

5.1.4 Lack of guidance and information

For many people, the topic of 'Green' or 'Sustainable IT' seems to have emerged from nowhere. Hence, it can be difficult to find information, or know how reliable it is once found. The task is made additionally difficult by vendors jumping on a 'green bandwagon', which can make it difficult to distinguish hype from reality. In practice, the reality in the UK seems to be that most vendors have little real concern for the issues. A recent survey of 1,000 IT Directors in the UK (and 8,000 across Europe) found that almost 60% felt that their employer's environmental credentials were 'not good at all', or worse (Brocade, 2008).

One common internal obstacle is lack of information about assets and their utilisation. Many devices are not owned by IT departments, and detailed information is often not available to those which are. However, the situation is changing as vendors are bringing relevant software to market. To date, this has had the greatest impact on printing, but computing should catch up in the near future. There is also a lack of information, and standardised metrics, relating to computing activities. A better understanding of the energy consumption associated with specific computer tasks is also a prerequisite for more effective management. This should be achieved by initiatives such as GreenLight at UC San Diego (Ramsay, 2008; see also Box 8 in Chapter 2), or the British Computer Society and Carbon Trust partnership to develop a simulation software tool to help companies understand the energy use within data centres, and allocate it to specific services or applications (Carbon Trust, 2008b).

Lack of information of this kind makes it difficult to utilise another central feature of successful continuous improvement initiatives, which is setting targets and monitoring their achievement. It is therefore unsurprising that we came across few examples of universities and colleges doing this with regard to sustainable ICT.

5.1.5 Unsupportive procurement frameworks

Procuring ICT equipment that is energy efficient and has a relative small environmental footprint, can make a huge difference to institutional performance. This is especially true of devices that are regularly replenished, such as servers and PCs.

Greener ICT procurement is a high priority for central Government. The latter published its Sustainable Procurement Action Plan (SPAP) in 2007 (Defra, 2007a) and mandatory standards in 2008 (Defra, 2008a). The standards for IT have been further updated in the Greening Government ICT initiative (Cabinet Office, 2008; see also Box 7 in Chapter 2).

However, achieving more sustainable procurement is currently difficult because of:

- Lack of a credible labelling scheme for equipment environmental performance throughout its life cycle, which could be specified in tenders (see Appendix 4)
- Lack of consideration of environmental and social issues within many current invitation to tender (ITT) processes for ICT, and
- Absence, or superficial use, of techniques to highlight the energy consumption and costs of ICT equipment, especially total cost of ownership (TCO – also known as whole life costing)

The latter point was substantiated by our survey, which found that only 17% of respondents conducted detailed whole life costing assessments (see James and Hopkinson, 2008d).

Of course, ICT procurement in further and higher education is a complex activity. Purchases can be – and are – made by IT departments, by corporate users (schools, departments etc) and by individuals. IT departments themselves can purchase independently, or through the national, inter-regional (ie involving two or more consortia) and regional agreements, which are negotiated by the sector's purchasing consortia (see Appendix 4). These typically involve accrediting suppliers, on the basis of defined specifications, and negotiating prices with them.

The main *raison d'être* of the agreements is to use the consortia's purchasing power to negotiate lower prices and/or additional benefits from suppliers. As they have already complied with EU Procurement

Directives, they also enable individual universities to bypass this requirement. However, the converse of this is that institutions working within the agreement cannot substantially change their basic terms and specifications – which would include adding significantly new environmental or social requirements to any purchases.

Most people interviewed for this project felt that the inclusion of environmental and social issues in current agreements is limited and ad-hoc, with some exceptions such as the new regional agreement for Audio Visual (AV) equipment (see Box 15), and the draft 2009 inter-regional desktop agreement and national notebook agreement (Kilner, 2008). There is also considerable uncertainty amongst university procurement staff about relevant sustainability issues, and how these could be taken into account within procurement specifications. This may improve in future as the coordinating body for the regional purchasing consortia, the English National Purchasing Consortium (ENPC), is currently developing a common checklist of environmental questions to include in ICT tender documents, but further action could also be beneficial.

Individual institutions can make a difference too by taking a more strategic view of IT procurement, which goes beyond energy efficient equipment to consider approaches that actually use less of it, such as thin client and virtualisation.[6]

Box 15 Greener AV Equipment

The North Eastern Universities regional agreement for AV equipment required all suppliers to complete an environmental questionnaire, which accounted for 5–10% of the total points. The energy consumption and carbon emissions associated with the operation of AV equipment in different modes (eg active, standby) was also required – the first time a purchasing consortium has requested information on carbon emissions (Toplass, 2008).

[6] We are grateful to Alex McFarlane of Nottingham Trent University for these suggestions, and others which have been of benefit to our report.

5.2 Taking Action within Institutions

The following sections discuss ways in which institutions can take positive management action, and overcome where necessary the previously identified barriers. Experience of other areas of environmental improvement in universities and colleges suggests that three areas are critical to this:

- Clear strategic commitment
- A continuous improvement approach within IT departments, and elsewhere, and
- Effective use of TCO (total cost of ownership) analysis

There is also a case for some sector-level actions to provide support for these, and to address areas that are difficult for any one institution to deal with, as the next chapter discusses.

5.2.1 Clear strategic commitment

If universities or colleges want more sustainable ICT, they must adopt a holistic approach that takes account of all aspects of sustainable development, including upstream impacts. It must also be embedded formally in their governance and management processes, and informally in the behaviours of those who provide leadership of them. Senior managers who ‘talk green’ but, for example, ask their secretaries to print off emails, or have never participated in a conference call, are unlikely to inspire deep change towards sustainable ICT within their organisations. IT departments are also driven by customers, and can often do little if they request a service that results in large amounts of electricity consumption. One of the quickest ways to sustainable ICT is when other sections of a university or college change their own requirements to support it. The SusteIT case study on the MESAS research group at the University of Sheffield shows how this can happen, with the group independently reducing the environmental footprint, and costs, of its (environmentally beneficial) research through more energy-efficient servers.

Commitments must also be implemented, and the keys to doing this have been summarised in several sector-specific publications (EAUC, 2007; People and Planet, 2006) and illustrated in the Continuous Improvement category of the Green Gown Awards (HEEPI, 2008). They include:

- Champions – in the case of ICT, likely to be a member of the management team with overall responsibility for sustainability, and a ‘dotted line’ relationship with a more ICT-specific champion at middle management level (see below)
- Dedicated resources, in the form of staff devoting some or all of their time to sustainable ICT issues, and a ring-fenced improvement budget (eg that connected with the HEFCE/Salix Revolving Green Fund), which can be used to finance (cost-effective) improvements
- A place for ICT within a strategic Environmental Group, chaired by a high-level champion, so that good relationships can be built with other departments such as Estates and Finance
- Unambiguous policies and action plans, which have quantified targets, and clear dates and responsibilities to achieve them, and
- Regular monitoring and review to establish baselines, track progress, make any changes in response to feedback, and develop new policies and targets

5.2.2 Continuous improvement in sustainable IT

The ICT area often appears special, but so too do many other areas where environmental and social improvement has been required. In practice, there are many common features in successful processes to achieve this, especially:

- Environmental and sustainability champion(s), and
- Measurement, targeting and monitoring

IT departments are busy and often over-worked. It can therefore be difficult to take account of what may appear to be non-core issues, such as sustainability. This is the case even when individuals have a personal interest in the topic. Changing this situation is only likely when one or more individuals within the department have a clear responsibility for dealing with sustainable IT issues, and are given the resources, time and – above all – senior management support to do the job effectively. Whilst the 'job description' will obviously be influenced by the size and nature of the institution, at a minimum it is likely to involve:

- Acting as a point of contact for information about sustainable ICT issues
- Developing cross-functional linkages
- Participating in sector networks and activities on the topic, and
- Being involved in key decisions such as major procurement contracts, or strategic decisions on IT architecture

Three interesting examples of ICT champions in practice (described in more detail in the relevant cases) are:

- Cardiff University, which has a very unusual position of Chief Technology Officer, whose incumbent has seen the introduction of more energy-efficient computing as an important part of his strategic role
- The University of Gloucestershire, where the IT Director was co-opted onto a university-wide environmental improvement initiative, and became more proactive in driving environmental improvement within his department as a result, and
- The University of Liverpool, where an environmentally committed senior systems analyst was allowed to develop powerdown software, which is now freely available as an open source product for other universities

'You can't manage what you can't measure' is an old and still relevant adage. However, detailed data on the energy and environmental impacts of ICT within universities and colleges are seldom if ever available. Yet the footprinting of electricity consumption and carbon emissions from ICT use at the University of Sheffield, which was carried out for the SusteIT project (Cartledge 2008a), demonstrates how powerful the information can be when collected. It motivates action by highlighting the importance of the topic – in particular by the finding that the University's ICT electricity bill will be over £1m in 2009 – and also directs attention to the areas of greatest consumption, which turn out to be PCs.

Targets are also important because they provide a sense of how far people need to go. The ambition of current Government and sector targets – especially that of an 80% reduction in carbon emissions by 2050

– means that simple requests for individuals and institutions to minimise as much as possible may be insufficient. In the medium term, setting ambitious targets may be made easier by the development of external mechanisms such as a sector target set by funding councils, or the 'league tables' that are being created by the Carbon Reduction Commitment. Until these are developed, simple year-on-year percentage targets for areas such as PC and data centre energy consumption, and amount of paper purchased, will probably be all that is feasible.

5.2.3 Total cost of ownership

TCO is a key feature of sustainable ICT management. It looks beyond acquisition costs, to also consider the costs of operation and disposal. It can be utilised in a variety of ways – strategically, to identify needs and develop a business case; and in procurement to decide between contracts. As ICT-related energy consumption and, to a lesser degree, end-of-life management is a growing proportion of whole life costs, a thorough analysis will usually be helpful to environmental improvement, even if it is undertaken for purely financial reasons. For example, the electricity costs for a typical educational PC (excluding monitor) over a 6-year lifetime could range from £30 to £260 (James and Hopkinson, 2008a), which in some cases will exceed the purchase price of the equipment. It is therefore another area where 'green IT' coincides with 'effective IT'.

Some important issues that can be picked up by a detailed analysis include:

- The trajectory of electricity costs over the lifetime of purchased equipment or facilities (forecasting these precisely is obviously impossible, but most procurers underestimated how much they would rise in recent years)
- The TCO of alternative options, such as purchase of low-power devices
- Secondary costs, which may be incurred as a result of a decision or purchase (eg existing cooling or power facilities may be inadequate, and need to be upgraded)

Conventional TCO deals only with financial data, and so must convert environmental impacts into monetary terms. This is happening increasingly, as the costs of environmental impacts are being internalised into prices – a process that is being encouraged by regulations such as the Carbon Reduction Commitment and WEE Directive (see Appendix 3). However, the potential for more direct consideration of the carbon costs of ownership is also emerging with the development of new standards for carbon accounting such as PAS 2050 (British Standards Institute2008). Gathering data on the carbon impacts of ICT use is relatively straightforward (and can be assisted, for example, by use of the SusteIT footprinting tool). More problematic is gathering data on the carbon impacts of purchased equipment, as this in turn depends upon first tier suppliers gathering information from many other downstream organisations in generally complex supply chains. It remains to be seen how quickly such data might be available to assist procurement within universities and colleges.

5.3 Institutional Contexts

Universities and colleges vary widely in their circumstances and degree of interest in – and capacity to take action about – sustainability issues. Contingencies such as development of a new building, an IT expansion programme or new senior management, can also provide one-off opportunities for change (as shown by the SusteIT case on Queen Margaret University – see below), and therefore should be a key 'intervention target' for JISC, funding councils and others wanting to encourage improvement. Hence, there will never be a ‘one size fits all’ approach to achieving sustainable ICT. Nevertheless, our interviews, and discussions at the workshops we have organised, suggest that two especially important variables are:

- The extent to which the institution has a strategic commitment to sustainability, and has embedded this within its operations – the more this is the case, the easier it will be to develop effective and integrated sustainable ICT initiatives and to build the cross-functional linkages that are needed for effective implementation, and
- The extent to which the organisation has some sustainable ICT ‘capacity’, in the form of individuals who have some knowledge of the field and are motivated to take action to achieve it

Using these variables allows us to distinguish four broad kinds of institutional approach, which we term:

- First steps
- Making connections
- Joined up actions, and
- Radical change

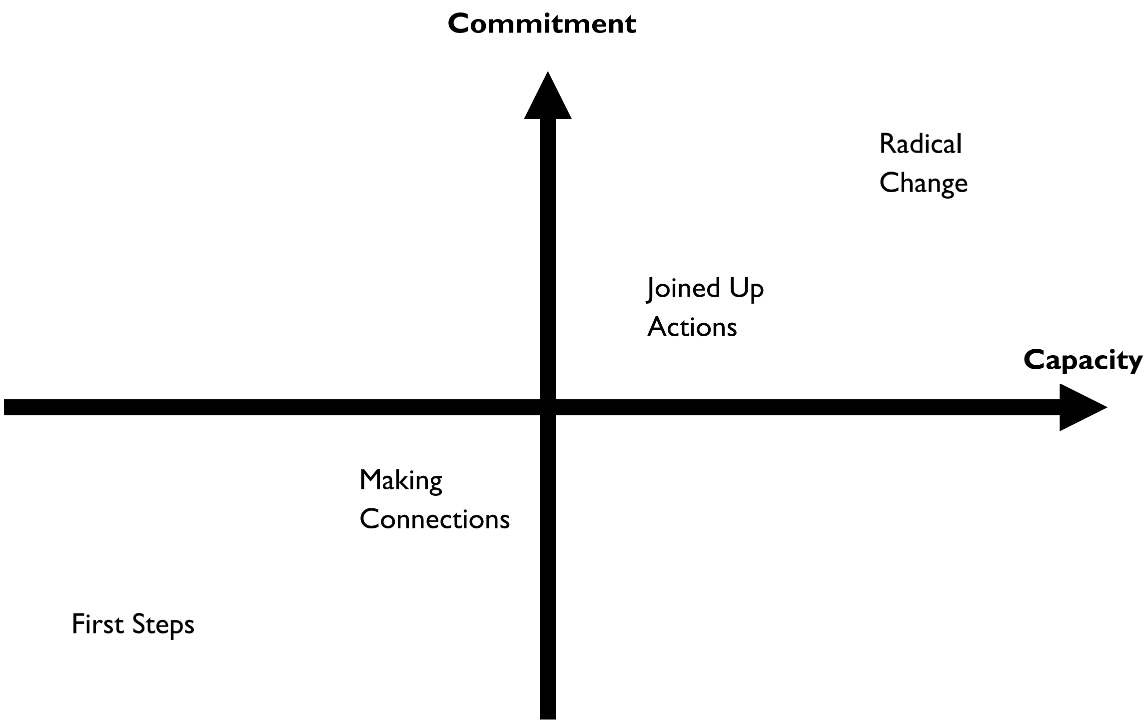
First steps – institutions in this category clearly have a difficult task in making their ICT more sustainable, with limited capacity and fragmented support mechanisms. Although not inevitable (and both further and higher education have examples of small institutions with a commitment to sustainability, which have been able to move quickly precisely because they are small), there is probably a broad correlation between being in this position and size. However, successful actions within this context are likely to be simple, self contained, and provide rapid and tangible organisational benefits – especially financial ones – beyond those of sustainability alone. Some obvious targets are powering down centrally managed computers, and more effective print management. Institutions in this category will require considerable external support, including access to information and technical assistance.

Making connections – institutions in this category have the benefit of a degree of organisational commitment, some internal capacity, but lack any truly coordinated approach to sustainability. As well as taking the more obvious actions that are within the control of IT departments, ‘bottom up’ actions to build bridges with other departments and individuals to create broader support for implementation and assistance with implementation, will be needed to make progress. In addition to completing any ‘first steps’ measures, institutions in this category are likely to focus on cross-institution awareness initiatives, procurement of lower power devices, and consolidation and virtualisation of some servers.

Joined up actions – institutions in this category have sustainability commitments in place and mechanisms to implement them, such as an Environmental or Sustainability Steering Group. Hence, broader resources can be mobilised in order to build internal capacity and take appropriate action, around sustainable ICT. The SusteIT case study of the University of Gloucestershire, for example, shows how this has been achieved through involvement of a senior IT manager in the environmental management system within the university. In addition to the measures identified in previous paragraphs, a key action point in these institutions will be greater involvement by IT in cross-institutional initiatives, resulting in a continuous improvement approach, which delivers measurable progress. Improved collaboration with Estates to identify and implement means of reducing the energy consumption associated with cooling and power supply in data centres and to build sustainable IT into the specifications for new and refurbished buildings, is also likely to be a high priority.

Radical change – institutions in this category will be the pioneers, who combine a strong and deep commitment to sustainability – and its associated mainstream issues such as space efficiency – with internal capacity in sustainable ICT. The SusteIT Queen Margaret University case, for example, provides a fascinating example of a desire for a green and space-efficient campus leading to a complete rethink of ICT policies, and the consequent adoption of a thin client approach that has virtually eradicated PCs from its site. However, even the most advanced universities and colleges will have more to do to achieve truly sustainable ICT. Some key issues for institutions in this category are likely to be development of ultra-energy-efficient data centres (perhaps on a shared basis, and linked with highly virtualised environments); development of alternatives to conventional desktop/laptop approaches (not only thin client but also compact PCs); greater weight on life cycle environmental impacts in procurement decisions; and internet Protocol services to buildings.

Figure 3: Four modes of institutional change



5.4 Conclusions

It is clear that institutions face many barriers to achieving more sustainable ICT and that sustainability is not yet embedded into ICT management or, to a lesser degree, procurement. Indeed, it is fair to say that sustainability has not been an important feature of ICT agendas within the sector to date. In addition to lack of awareness, one reason for this is a feeling that ICT is a relatively 'lightweight' activity compared to more obvious areas of environmental impact, such as energy supply, transport or waste. And, even when greater note is taken of the issue (often as a result of an internal champion directing attention to it), action can appear to be difficult and/or expensive.

Experience in other areas suggests that one of the most significant barriers to improvement is unsupportive financial structures. There is clearly a compelling financial case for action and many cost-effective measures that can be taken, but this is often negated by the combination of a disconnect between decision-making and budgetary responsibility, and lack of knowledge about the full financial impacts of high ICT-related energy costs, and of the whole-life environmental impacts of ICT devices.

Increased collaboration and mutual understanding between IT and other departments are also essential. When those departments are customers, better understanding of sustainable ICT can help overcome possible resistance to measures to achieve it. The relationship between IT and Estates is especially important, because reducing ICT electricity consumption could be greatly enabled through more joint work to better understand patterns of consumption, optimise the configuration and layout of data centres, adopt innovative cooling and power supply methods, and achieve the potential of 'intelligent buildings' (indeed, for these and other reasons, some organisations are actually merging the two functions – see the SusteIT case study on Ave Maria University, for example).

Box 16 Sector Organisations Relevant to Sustainable ICT Management

Most ICT activities in UK further and higher education institutions are managed by the institution itself. However, the Joint Information Services Committee (JISC) provides central support, directly in the form of advice, information and funding for special projects, and indirectly through provision of technical services such as email and videoconferencing, which are managed by an independent company, JANET (UK). As the name implies, JISC is not an independent legal body, but a joint agency of the four UK higher education funding agencies for England, Northern Ireland, Scotland and Wales. These provide most of its finance, with much of the remainder coming from the Learning and Skills Council (LSC). The latter supports ICT advice to non-higher education institutions providing degree level courses, achieved through 13 Regional Support Centres (RSCs). JISC has relevance to sustainable ICT through:

- The equipment and activities of its 200 or so staff, many of whom work remotely
- A thought leadership role in the sector, which is driving many ICT applications
- The research, development, demonstration and dissemination projects that it funds, and
- Its management, or direct support, of energy-using infrastructure, eg the JANET network.

A number of other sector bodies also have activities relating to sustainable ICT, notably:

- The Research Councils, especially those for science and technology areas
- The Universities and Colleges Information Systems Association (UCISA), for IT managers
- The Association of University Directors of Estates (AUDE)
- The Association of University Procurement Officers (AUPO)
- The University Print Managers' Group (UPMG)
- The British Universities Finance Directors Group (BUFDG)
- The Environmental Association of Universities and Colleges (EAUC), whose members include energy and environmental managers seeking to reduce ICT-related impacts, and
- The British Educational Communications and Technology Agency (BECTA), which supports ICT in further education and schools.

Several external bodies also conduct relevant activities within the sector, including:

- The British Computer Society, which has an Ethics and Environment Committee
- The Carbon Trust, which funds a Carbon Management Programme for universities
- Grid Computing Now!, a Government-funded Knowledge Transfer Network, which disseminates best practice on grid computing and virtualisation

6. Conclusions – Towards Sustainable ICT in Further and Higher Education

Our report shows that:

- ICT within further and higher education has a large and increasing (both absolutely, and relative to other activities) energy and environmental footprint, and growing social impacts
- There is a compelling financial and corporate responsibility case for the sector to take action to minimise this footprint, and to take other actions to encourage environmentally and socially positive applications
- The sector has sufficient examples of existing good practice to demonstrate that, in many areas, further action is cost-effective and technically straightforward, but
- There are some areas where it will be hard for individual institutions to take the actions that are desirable, without greater support from sector bodies such as JISC

The latter is particularly true with regard to environmental impacts, which at present have no strong organisational focus or support within the sector. This is less true of many of the social impacts relevant to sustainability, such as access to education and privacy, as many of them are closely related to e-learning, where there are well-established networks.

One important point with regard to environmental opportunities in ICT is their synergy with many of the other strategic drivers of further and higher education. For example:

- Moves towards more effective consideration of total cost of ownership of ICT purchases and greater budgetary responsibility for energy costs by IT departments, would contribute to the objective of achieving greater cost transparency in research and teaching
- Action to reduce carbon emissions, both in use and embedded within equipment purchases, could assist the achievement of HEFCE's planned carbon reduction target for the sector
- The potential capacity constraints created by high electricity consumption in data centres (and other areas) should often be an important aspect of institutional risk assessments
- Some of the innovations to achieve greater energy efficiency could be best achieved on a shared service basis, and
- The capacity of work-related applications to provide better work–life balance and other personal and social benefits has many connections with the well-being agenda

The anticipated growth in ICT usage creates great challenges for the sector. Two of the most prominent are the need to respond to the national carbon reduction agenda and to consider environmental impacts across the whole life cycle. Government targets now require an 80% reduction in UK CO_2 emissions from 1990 levels by 2050, and the funding councils have already signalled the sector's need to contribute to this. Although energy and carbon impacts themselves seem to be concentrated in the use phase, their upstream impact is considerable. Other environmental impacts such as hazardous emissions and waste occur mainly upstream. Hence, achieving mechanisms to deal with these – through the medium of procurement – is also vital.

This is especially true, given that financial and sustainability drivers could diverge if energy prices fall back, or once the 'low hanging fruit' is picked. There is a danger that too much of an economic perspective could embed an 'unsustainable' way of thinking about the issues, which makes it difficult to envisage and implement more radical approaches.

Such approaches are likely to become more feasible in future as ICT develops. Devices may contain radically different materials; their environmental impacts may be tracked through all stages of supply so that it is easy to distinguish more- from less-sustainable variants; computing tasks could be more easily related to environmental impacts; e-reading may have replaced paper in many applications; cloud computing may be ubiquitous, and clearly sustainable because its data centres are ultra efficient and utilising renewable energy; and many meetings and learning sessions may be virtual.

In the short–medium term, however, it is likely that much effort with regard to sustainable ICT will focus on reducing its electricity consumption. Although not the largest component of demand in further and higher education, it is one where:

- Institutions can have direct influence, compared to their indirect influence over upstream environmental issues
- Actions achieve a 'double win', in the form of financial savings and reductions in CO_2 emissions
- Universities and colleges are required to meet the letter, and spirit, of new regulations such as the Carbon Reduction Commitment
- Action to make a difference is easily possible in the short–medium term
- There is relatively low risk, in that universities and colleges would be moving in step with external organisations and could, in most cases, build on best practice examples that already exist within the sector
- Financial benefits can accrue, within a total cost of ownership framework, and a context of rising energy prices in the medium–long term, and
- There are many synergies with other ICT trends

Many of the following recommendations therefore relate to this topic.

6.1 Recommendations for Sector Institutions

Chapter 3 summarised the short–medium actions that can be taken at institutional level. However, there is a wide variation between the position and capabilities of individual institutions. Many are in need of external support if their ICT is to become more sustainable. Even those that are in a strong position, and have already taken considerable action, could do even more with greater external support. Hence, there is also a case for some sector-level actions to provide support for these, and to address areas that are difficult for any one institution to deal with. This is because:

- Some relevant expertise or knowledge may be impossible for institutions – and especially smaller ones – to develop in practice
- Some actions can only be accomplished at regional or national level

- Some actions, such as videoconferencing, require a critical mass of activity in a number of institutions, which requires external encouragement and support, and
- National professional bodies are likely to play an important role in supporting greater cross-functional collaboration

Table 10 summarises some possible sector actions that could be taken to achieve these objectives. These are divided into those which could be accomplished within the short term (a year or less), those which are medium-term (1–3 years) and those which are longer term.

There are many sector-level organisation bodies that could lead, or assist with, these actions, including funding councils, JISC, procurement consortia and representative bodies such as UCISA (see Box 16). Of course, each of these bodies has distinctive (and often limited) mandates to influence the actions and policies of institutions (especially universities), which limits the kind of support that can be provided. None the less, eight possible forms of support can be identified:

- Strengthening capacity
- Providing funding
- Giving direction
- Strengthening grant conditions
- Strengthening coordination
- Strengthening sustainable procurement
- Funding exemplar projects, and
- Financing relevant investigation and research

6.1.1 Strengthening capacity

As noted above, many universities and colleges lack the capacity to introduce some or all aspects of sustainable ICT. One solution to this barrier would be the internal provision of more specialist resources. However, whilst this may be feasible in larger institutions – and has been done in some – it is probably impracticable for many.

Another solution is to outsource action to vendors. This is possible in many cases, as some vendors are starting to differentiate themselves on the sustainability benefits of their technologies. However, whilst this is a welcome development, there are several dangers in the sector not developing some greater internal capacity to consider, and access, the relevant issues. One danger is of an over-dependence on a few suppliers, reflected in relatively high prices for their offerings. Another is the possibility of some self-serving in their claims, which leads to sub-optimal outcomes from a sustainability perspective.

A third solution is the development of shared capacity between institutions. The funding bodies could assist this by:

- Strengthening sector networks
- Enabling greater technical capacity, and

Promoting more cross-institutional exchange

The large numbers of people attending the SusteIT and other events on the topic over the last year, and the high value they placed on meeting and hearing about the experience of peers, demonstrates the value of sector networks. They are also cost-effective, with only limited costs required for administration and venues for events, and supporting activities such as newsletters. An ongoing Sustainable IT Forum, linked to relevant sector bodies such as UCISA and running a small number of events each year, could therefore have a disproportionate influence.

A second way of strengthening capacity is the provision of technical assistance from outside an institution. This has been accomplished in other areas of environmental improvement within universities through the Carbon Trust's Carbon Management Programme, which has provided consultancy support to assist organisations to measure their carbon footprint and to take measures to reduce it. (The Programme has also begun using the SusteIT footprinting tool to assist with sustainable ICT issues.) JISC's Regional Support Centres also provide similar support in some areas. Additional or expanded initiatives of the same kind focused on sustainable ICT could be very helpful, especially in organisations that are just beginning to consider the topic.

Initiatives to strengthen capacity could also have a more imaginative component of encouraging greater exchange within the sector. Advice from respected peers is especially valued, and informal arrangements can be used to gain such assistance. (A number of attendees at the SusteIT events, for example, arranged subsequent meetings with the host institutions to access such advice.) Some modest funding could enable payment for such assistance, which could be helpful not only to the recipients of advice, but also to the individuals giving it as a form of personal development. Such internal consultancy could be supplemented by secondments of well-informed staff to bodies such as the RSCs.

6.1.2 Providing funding

The reality of the sector's organisation means that the main onus for financing sustainable ICT is always likely to be placed on institutions, especially within the higher education sector. However, the barriers described above suggest that some sector-level assistance could be helpful in overcoming barriers, and perhaps in seeding cooperative activities between institutions.

Two obvious forms of support are grants and interest free loans, both of which have already been implemented in other areas of environmental improvement. In the case of further education, the Learning and Skills Council has provided additional capital sums for buildings to encourage implementation of environmental improvement measures. Within higher education, the HEFCE/Salix Finance Revolving Green Fund encompasses sustainable ICT but – given many attractive opportunities in more conventional areas of energy and environmental improvement – will not necessarily result in a large number of ICT projects being submitted. Hence, more publicity about the funding opportunities from this and other existing sources (eg the Leadership, Governance and Management Fund) could be helpful. Potential opportunities for other funding could also be explored. For example, the hosts of shared service data centres could potentially access funding for wind power, and perhaps other renewables, from the Carbon Trust's Partnership for Renewables agency.

It is also important that sustainable ICT issues have a high profile in JISC's regular funding initiatives.

6.1.3 Giving direction

The funding bodies and JISC can influence sector practices generally through the:

- Conditions they attach to funding
- The contacts they have with key bodies representing universities and their staff, such as UUK and UCISA, and
- The actions they take within their own spheres of activity

There are several areas where this leverage could be applied to assist sustainable ICT through clear policy statements:

- Adopting the goals and targets of the Greening Government ICT initiative within the sector (and forming more formal links with it), eg to increase average server capacity utilisation to at least 50% by 2013
- Endorsing and supporting the new EU Code of Conduct for Energy Efficient Data Centres (eg by making its acceptance and implementation mandatory for any projects that they are funding), which can provide a useful road map of how to make data centres more sustainable, and also provides a context for comparison of performance and sharing of experience, both within the sector and between it and external organisations, and
- Endorsing Energy Star and other energy and environmental labelling schemes, and working with sector procurement bodies to ensure that universities and colleges are only purchasing the highest rated devices (see below)

The latter point has, of course, to be balanced against other requirements for procurers to obtain best overall value for money. There may be occasions when the highest energy-rated machine is not best value, even after factoring in energy in usage costs and all other TCO factors. However, this potential conflict should be reduced by implementation of the EU Directive on Energy End Use Efficiency and Energy Services, which will introduce a voluntary agreement for universities and colleges to purchase energy-efficient equipment, according to the Government's 'Buy Sustainable – Quick Wins' specifications (Defra, 2008a).

The funding bodies could also provide an example within their own activities. They employ appreciable numbers of staff and control a large number of ICT devices. Some actions have been taken, notably by HEFCE – for example, in its adoption of the ISO14001 environmental management standard and its adoption and achievement of business travel reduction targets, both of which have ICT implications (see the SusteIT case on its use of videoconferencing) – but more could be done. For example, by purchasing only the most energy-efficient computers and peripherals, or by greater encouragement of videoconferencing for internal and external meetings, where these are not already happening.

6.1.4 Strengthening grant conditions

Many grants from the funding bodies and JISC are to projects that are purchasing ICT equipment. Within current circumstances, where many recipients of such grants do not pay the running costs of their equipment, there is little incentive to purchase more energy efficient and/or more environmentally superior alternatives if these have a higher capital cost. Possible measures to avoid this range from information and exhortation, to mandatory requirements such as use of standardised TCO approaches (including national reference values for future energy costs) and/or purchasing only the 'greenest' devices or solutions.

The same problem exists with many projects funded by the Research Councils. A dialogue between them and the funding bodies is an essential first step to changing practices across the sector.

6.1.5 Strengthening coordination

As noted above, there are limited connections between IT and other functions such as Estates, Finance and Procurement with regard to sustainable ICT, even though such cooperation is increasingly important to effective action. The value of better connections was demonstrated by a number of SusteIT events, which succeeded in their aim of attracting delegates from Estates and IT. Many remarked that it was the first time they had engaged in a serious dialogue, and gave very positive feedback about its value.

These, and other functions within the sector, have well established and effective representative bodies, which provide the natural channels to achieve greater interaction and coordination. The important bodies from this perspective include UUK, AUDE, AUPO, BUFDG, UCISA and UPMG (see Box 16). JISC in particular could play a greater role in providing relevant information and perhaps 'brokering' greater contact between them. Possible means of doing so include greater participation in the annual conferences of the various representative bodies, and convening working groups to identify opportunities for greater action. Three opportunities for such groups are:

- Working with AUDE, ICT bodies and others to explore opportunities for future collaboration on Estates/IT issues, such as more efficient cooling and power supply in data centres, and development of more intelligent buildings
- Working with JANET, UUK and others to examine and champions ways of increasing videoconferencing use within the sector, and
- Working with AUDE, AUPO, UPMG, BUFDG, ENPC and other sector procurement bodies to develop an action plan to better integrate sustainability into IT procurement, to examine ways of overcoming capital/revenue disconnects and to use the sector's purchasing power to assist sustainable ICT (see next section)

6.1.6 Strengthening sustainable procurement

As discussed in Chapter 5, procurement could do much to make the sector's ICT more sustainable, but its full potential is not yet being realised. Although actions would need the endorsement and practical buy-in of sector procurement organisations, there is scope for one or more funding bodies to take a lead in motivating key players to take greater action and in shaping its practical form. Possible measures could include:

- Endorsing the Government's 'Buy Sustainable – Quick Wins' procurement measures for sustainable ICT, and incorporating them into sector purchasing at the earliest date
- Working with suppliers and others to establish a viable system of environmental labelling, encompassing whole life environmental issues (perhaps by encouraging greater development and take-up of PC eco-labels such as EPEAT within the UK and Europe; see Appendix 3)
- Development of simple TCO software, which could highlight key sustainability-related costs and benefits, and provide more standardised approaches to ICT purchasing decisions
- Development of simple systems (such as a wiki-like database that could be populated by a community of users), which could collate data on the energy consumption of devices, and provide this in a form that could be used in a standardised TCO model, and
- Negotiation of national 'bulk buy' rates for a small number of key energy efficiency devices, such as low-power PCs and servers

6.1.7 Funding exemplar projects

There are a number of areas of sustainable ICT where there is strong interest, but where many people require practical demonstrations to be convinced. In these and some other cases, there are also opportunities for universities and colleges to have an influence beyond their sector and to enhance the reputation of UK further and higher education, both nationally and internationally. Indeed, many enjoy a unique combination of factors, which could support the development of a 'lead role' in sustainable ICT, including:

- Technically advanced and/or unusually large scale ICT activities in relevant areas, eg grid computing, videoconferencing
- A high level of in-house ICT-related expertise
- A policy regime that is encouraging the sector to support innovation more effectively and to develop more shared activities, and
- A variety of campus locations and configurations that provide a number of niches to introduce energy efficiency and renewable energy measures

One area where a sector exemplar would be feasible would be a 'zero carbon data centre'. A few leading-edge examples in the USA have greatly improved efficiency, but none has quite reached this goal. However, it will probably be required anyway for any new data centre developments – and all new buildings – in a few years. The Greening Government IT initiative requires zero carbon in Government offices – and therefore in ICT and, in many cases, data centres – by 2012 (Cabinet Office, 2008). The Welsh Assembly Government also requires all publicly funded new developments in Wales to be 'zero carbon' from 2011. Hence, a goal of zero-carbon data centres could be a question more of bringing the inevitable forward, than of radical trailblazing.

Zero-carbon data centres would fit well with the drive for more shared services within ICT, and especially the suggestion of one recent report that: 'The JISC should consider establishing an exemplar service, using the existing network infrastructure, to provide a range of services including machine rooms, data services and administrative services' (Duke and Jordan, 2008b). The greater freedom of location, which could result from shared services, could enable optimal siting for renewable energy and other relevant technologies such as tri-generation and underground thermal storage, thereby achieving zero-carbon targets in an exemplary fashion without excessive rises in capital cost. They could also assist the technical capability and credibility of a variety of commercial sectors such as architects, engineering consultancies and equipment providers.

Another potential exemplar area is 'next generation' intelligent buildings, which have high levels of responsiveness and user control, and in which all building services are run over Internet Protocol backbones and can therefore communicate and interact with each other. This can produce many benefits, including the sustainable ICT ones of more effective use of energy and more precise environmental monitoring. A new US university, Ave Maria, is already seen as a showcase for this beyond its sector in North America (see SusteIT case study) but – as their presentation at a SusteIT event showed – is still marginal to overall building practice there. The UK is more familiar with the concepts, and is already developing and applying some of their key technologies. A coordinated approach within UK further and higher education – involving collaboration with key suppliers – could therefore have a realistic possibility of both enhancing the sector's energy and operational efficiency and making a major contribution to the development of a new 'UK area of excellence'. This could create benefits for a wide range of sub-sectors, including architects, engineering and IT consultancies, hardware and software developers, and property management.

A third example of an exemplar area is videoconferencing. After many years of false promises, this is beginning to take off as a genuine means of travel substitution, in large measure because it can also provide other benefits such as avoiding the financial costs and unproductive use of time associated with travel. UK universities and colleges are already well placed because they enjoy a unique infrastructure, in terms of both scale and inter-connectedness, and a number of examples of effective use. The fact that this infrastructure appears to be underutilised currently is also an advantage, because it would be possible to achieve a significant increase in uptake without commensurate investment needs. If this could be achieved, there would then be a strong business and environmental case for further investment. One additional advantage of this could be to strengthen the position of the UK as a 'digital hub' for many areas of learning and research, with consequent benefits in building stronger connections with academics and potential students around the world. Developing better supporting software to support conferencing – such as agenda setting and running, live minute taking, download and concurrent presentations on portables with note taking and voice capture, voting, and collaboration and messaging tools (or encouraging greater take-up where it does exist) – could assist this, and potentially also have considerable commercial pay offs.[7]

6.1.8 Financing relevant investigation and research

There are a number of areas where more detailed information about key issues, possible options, best practice etc are currently lacking. These could be the focus of a future call for research and/or demonstration projects by JISC.

The most important of these is further work on the strategic development of sustainable ICT agendas. At present, it appears that the short–medium priorities identified in this report, which essentially rest on utilitarian arguments for change based on financial and other tangible business benefits, and the development of credible environmental assessment schemes to address upstream issues, is synergistic with longer term strategic objectives of greatly reducing the environmental footprint of – and especially the carbon emissions associated with – the sector's activities. However, this could change, so there needs to be a regular review of how developments in both technology (both ICT and supporting activities such as energy supply) and financial and regulatory drivers (such as the development of carbon trading schemes) are influencing this position. Such reviews could be supported by ongoing debates, facilitated by Web 2.0 technologies such as a sector blog and/or wiki site on the topic.

At a more operational level, one important topic is the most effective budgetary mechanisms to strengthen 'ownership' of ICT-related electricity consumption by those in a position to actually influence its consumption, eg IT departments, so that this has greater importance in their decision-making. The most obvious way is direct billing for the energy consumption that is under their control. However, while this might be relatively straightforward for self-contained activities such as data centres and PC clusters – and is already the case in a few institutions, especially research-intensive universities – it can be problematic for more dispersed activities such as office PCs and printers. Also, in many institutions the IT department may not be the body that determines strategy and requirements, so other end-users/decision makers will need to be influenced. Alternative mechanisms – such as making energy consumption one of the performance targets for an IT director or senior manager, or by providing financial rewards linked to achieved savings –

[7] We are grateful to Bill Olivier of JISC for these suggestions, and others which have been of benefit to our report.

could possibly be as effective, but less complex to administer. A means of finding out would be to provide matched funding for several different approaches, and evaluate the outcomes.

Another important area for research is the development of 'best practice' models, and supporting information such as model tender specifications, for building design and procurement, which is sensitive to the needs of ICT in general, and sustainable ICT in particular. Our events and interviews showed that this is an area of great interest for institutions who are developing capital programmes, and want to do the most they can to 'future proof' them and minimise long-term running costs. Several of the RSCs are already providing ad hoc advice on this, but a greater evidence basis for advice would be helpful.

Two other topics of potential research, which have been discussed in previous pages, include the health and safety and associated liability implications of the current moves to e-learning, and a life-cycle assessment of personal computing within a UK further and higher education context.

Box 17 Computing for the Future of the Planet?

The University of Cambridge Computer Laboratory hosts a Computing for the Future of the Planet programme, based on the belief that computing can 'provide alternatives to our current activities and, through availability of information and education, an impetus for changing our lifestyles' (Hopper and Rice, 2008). Its research agenda has four goals:

Creating an optimal digital infrastructure, which maximises the potential environmental benefits of computing by making efficient use of the energy consumed in manufacture, operation and disposal

Sensing and optimising the environment in order to minimise the energy consumption and footprint of physical infrastructure

Predicting and reacting to future events in natural systems by modelling their behaviour, and

Developing sustainable digital alternatives to physical activities

Box 18 The Internet's Carbon Footprint

Several researchers have suggested that internet use involves considerable energy use and carbon emissions. One study is by Alex Wissner-Gross, who has established CO2Stats, a service which calculates a web site's energy consumption, makes suggestions for improvement, and invests appropriate amounts in renewable energy to offset carbon emissions (Leake and Woods, 2009). He estimates that a Google search creates 7g of CO_2, making two the equivalent of boiling a kettle for a cup of tea. Other estimates vary between 1 and 10g (Leake and Woods, 2009). Google searches are said to be particularly energy intensive because they use a system of parallel searches between different data centres which may be located large distances from each other. However, Google itself says that the figures are exaggerated.

Nicholas Carr also calculated that the avatar of a high user of Second Life consumed 1,752 kWh per year (Carr et al, 2006). This is similar to the 1,884kWh consumption of a Brazilian for all purposes (although much smaller than the average 7,702kWh/year in developed countries). In a comment on Carr's post, Sun's Dave Douglas added that this '1,752 kWh equates to about 1.17 tons of CO2, or the equivalent of driving an SUV around 2,300 miles, or a Prius around 4,000' (Carr et al, 2006).

Of course, any precise figures on such a complex topic – whose results are determined by the allocation of consumption between different activities, and which requires very detailed research (see Appendix 1 of James and Hopkinson, 2008a, for a discussion of such research on the lifetime energy impacts of PCs) – can be questioned, and indeed Google has done so, saying that the real figure is 0.2g per search (Holzle, 2009). Nonetheless, they indicate that the 'virtual' world is in reality very physical.

Table 10: Recommendations for Funding Councils, JISC and other sector bodies

Category	**Rationale**	**Specific Actions (Classified as Short-Term (S-T), Medium-Term (M-T) and Long-Term (L-T))**
Strengthening Capacity	Lack of internal capacity within many institutions and need to avoid excessive reliance on vendors.	Development of networks, eg through newsletter and other communication channels and regular events (S-T). More in-house expertise within sector support bodies, eg JISC Regional Support Centres, possibly through secondments (S-T). More sector-specific training opportunities (M-T). Facilitation of internal consultancy between institutions (M-T).
Providing funding	Difficulties in financing sustainable ICT within institutions due to capital/revenue budget disconnects.	Encourage more applications for sustainable ICT projects to established funding sources such as the HEFCE/Salix Revolving Green Fund, or the Leadership, Governance and Management Fund (S-T/M-T). Explore other potential opportunities for sustainable ICT (M-T).
Providing direction	Clear sector-wide signals are needed as to the future importance of sustainable ICT, and how can it be achieved; to help overcome barriers; and to build understanding of what needs to happen.	Adopt the goals and targets of the Greening Government ICT initiative within the sector (and establish more formal links with it) (S-T). Endorse and market the new EU Code of Conduct for Data Centres (S-T). Set an example by developing a green IT action plan for own activities (when not already being undertaken) (S-T).
Strengthening grant	Many Funding Council, Research Council, and other grants unwittingly encourage capital	Establish dialogue with key funders to identify feasible solutions (S-T, for

conditions	expenditure that pays no regard to lifetime energy or other costs, and provide no incentives for recipients to purchase environmentally superior alternatives.	M-T outcomes). Introduce mandatory requirements, such as use of standardised TCO approaches and/or purchasing only the 'greenest' devices or solutions once suitable mechanisms are available (M-T).
Strengthening coordination	Sustainable ICT requires better connections between IT and other functions such as Estates, Finance and Procurement, both within institutions and at national level.	Formation of a joint working group between AUDE, ICT bodies and others to explore opportunities for future collaboration on Estates/IT issues (S-T, for M-T outcomes). Formation of a joint working group with AUDE, AUPO, BUFDG and sector procurement bodies to develop an action plan for more sustainable ICT procurement (S-T, for M-T outcomes).
Strengthening sustainable procurement	Sustainable procurement is crucial to making energy-efficient devices affordable and to reducing the upstream burden of university and college ICT activities, but the full potential of the sectors' well-organised purchasing mechanisms is not being achieved.	Endorse and introduce the Government's 'Buy Sustainable – Quick Wins' advice on sustainable ICT procurement at the earliest opportunity (S-T). Develop simple systems (such as a wiki-like database that could be populated by users) to collate data on usefulness of approaches or energy consumption of devices (S-T). Develop simple TCO software to provide more standard approaches to ICT purchasing decisions (M-T). Negotiate national bulk buy rates for key energy-efficient devices such as low-power PCs and servers (M-T). Work with suppliers and others to establish a viable system of environmental labelling (perhaps encouraging greater uptake of the Electronic Product Environmental Assessment Tool (EPEAT) (M-T/L-T).
Funding	Provide practical demonstrations of the benefits	Encourage greater utilisation of the videoconferencing infrastructure, and

exemplar projects	of sustainable ICT approaches or technologies in areas where there is strong interest, but many people require practical demonstrations to be convinced, and/or where there are opportunities to enhance the reputation of UK further and higher education.	assist development of software to improve value to users (S-T/M-T). Encourage development of a 'zero carbon' data centre through top-up funding and other means (M-T). Work with suppliers and others to encourage development of 'next generation' intelligent buildings with high levels of responsiveness and user control (M-T, L-T).
Financing relevant investment and research	There are currently information gaps about a number of key issues, possible options, and best practice.	Investigate health and safety and associated liability implications, of greater student use of computers arising from e-learning, eg back problems, RSI (S-T). Identify effective budgetary mechanisms to strengthen 'ownership' of ICT-related electricity consumption by IT departments and academics so this has greater importance in their decision making (M-T). Fund a life-cycle assessment of personal computing to understand better the distribution of sector impacts, and prioritise actions to deal with them (M-T). Development of 'best practice' tender specifications for building design and procurement which facilitates sustainable ICT (M-T). Monitor strategic development of sustainable ICT agendas – regular reviews of impacts of developments in technology and financial and regulatory drivers (M-T/L-T).

Appendix 1. Energy and Carbon Footprint of ICT Use in UK Further and Higher Education

This appendix estimates the energy and carbon footprint of ICT in use within UK further and higher education by scaling up the ICT energy and carbon footprint data produced by using the SusteIT tool at the University of Sheffield (described in Cartledge, 2008a) and at Lowestoft College and City College, Norwich. Table A1.1 summarises the results.[8] Of course, three institutions cannot be representative, and there are bound to be differences between different types of university or college. For example, research-intensive universities – where high performance computing (HPC) will be a significant proportion of impacts – are likely to be very different from others. Hence, the third column of Table A1.1 restates the Sheffield figures with HPC excluded. Moreover, the exercise does not include estimates of energy consumption and other carbon-related impacts in other stages of the product life cycle. None the less, the figures do provide some reasonable ballpark figures for the sector's total ICT-related energy and carbon footprint.

Table A1.1: Total electricity consumption at different institutions and breakdown by category

ICT Category	Electricity Consumption (kWh/y)				
	University of Sheffield	**University of Sheffield (excl. HPC)**	**Lowestoft College**	**City College Norwich**	**FE Average (% only)**
Total ICT Electricity	8,680,806 (100%)	7,472,188 (100%)	453,714 (100%)	1,241,700 (100%)	100%
PCs and monitors	4,164,477 (48%)	4,164,477 (56%)	197,402 (44%)	510,896 (41%)	42%
Servers	1,520,736 (18%)	1,520,736 (20%)	135,999 (30%)	226,665 (18%)	21%
HPC	1,208,617 (14%)	0	0	0	0
Imaging	835,659 (10%)	835,659 (11%)	42,171 (9%)	236,901 (19%)	16%
Networks	687,362 (8%)	687,362 (9%)	68,538 (15%)	156,629 (13%)	13%
AV	61,598 (1%)	61,598 (1%)	7,482 (2%)	89,936 (7%)	6%
Telephony	202,356 (2%)	202,536 (3%)	2,122 (<1%)	12,790 (1%)	1%

[8] We are extremely grateful to Chris Sexton and Phil Riley, University of Sheffield, John Pollitt of City College Norwich and Tony Bartley of Lowestoft College for the permission to use their figures.

A1.1 Higher Education

Table A1.2 shows scaled up results according to the proportion of students (FTE) and the total electricity consumption at the University of Sheffield in 2005/06, compared with the figures for the sector as a whole. This proportion is, respectively, 1.6% and 1.8%. It suggests that energy consumption associated with ICT in use within the UK higher education sector is somewhere between 480,000–540,000 MWh/y, at a total cost of around £58–65m. This equates to carbon dioxide (CO_2) emissions of between 260,000–290,000t per year. This is roughly equivalent to the emissions of 400,000 desktop PCs (200 Watts) running continuously for a year.

Table A1.2: Estimates of ICT electricity consumption and costs for the higher education sector[9]

	ICT non-residential electricity (MWh)	**ICT non-residential electricity costs (£m)**	**ICT non-residential CO_2 emissions (t)**
Sheffield	8,680	1	4,661
HE UK (based on 1.6%)	542,500	65	291,000
HE UK (based on 1.8%)	482,000	58	259,000
HE UK (average)	512,225	61.5	275,000

The equivalent ICT-related CO_2 emission and cost figures per student in the sector are:

232kg of CO_2 emissions per year, and

£50 of electricity costs per year

Table A1.3 below shows ballpark estimates of the total number of key ICT devices in higher education as a whole, scaling up in the same way the number of devices at Sheffield. Based on this it is estimated that the sector uses around 720,000–800,000 PCs, 139,000–146,000 printers and 200,000–230,000 servers. The rounded average figures are 760,000 PCs, 147,000 printers and 215,000 servers.

Table A1.3: Estimates of number of ICT devices in higher education sector

	PCs	**Printers**	**Servers**
Sheffield	13,000	2,500	3,600
HE UK (using 1.6%)	800,000	156,000	230,000
HE UK (using 1.8%)	720,000	139,000	200,000

[9] Based on the anticipated electricity cost of 12p/kWh, which the University will be paying in 2009 (Riley, 2008), and the Defra conversion figure of 0.53702kg CO_2/kWh (Defra, 2008b).

HE UK (average)	760,000	147,500	215,000

A1.2 Further Education

The energy and carbon footprint of ICT use in further education has been estimated by scaling up the results from Lowestoft College and City College, Norwich according to their percentage of total learners within the sector (0.42% for both combined), based on 2005/06 LSC figures (Learning and Skills Council , 2006). The results are shown in Table A1.4. Note that the LSC figures only relate to England and do not include Scotland, Wales and Northern Ireland. The following calculations therefore also scale the English figures up based on England's 84% share of total UK population in mid-2006 (Office of National Statistics, 2007).

Table A1.4: Estimates of ICT electricity consumption and carbon emissions for further education sector in England and UK (cost and carbon assumptions as Table A1.1) (to nearest 1,000)

	ICT electricity (MWh)	ICT CO_2 emissions (t)
Lowestoft (0.16% learners)	454	244
FE England (grossed)	284,000	153,000
City College Norwich (0.26% learners)	1,242	667
FE England (grossed)	478,000	257,000
FE England (average)	381,000	205,000
FE UK (average)	454,000	244,000

The exercise suggests that energy consumption associated with ICT in the UK further education sector is somewhere around 454,000 MWh/y. Assuming an electricity cost of 12p/kWh, this equates to a total cost of around £54m. This is also equivalent to CO_2 emissions of around 244,000t per year.

The equivalent ICT use-related CO_2 emissions and energy cost per learner in the sector is:

53kg CO_2 associated with ICT per student per year

£12 electricity costs associated with ICT per student per year

Table A1.5 shows ballpark estimates of the total number of key ICT devices in further education in the UK, scaling up in the same way the number of devices at the two colleges. It suggests that there are around 708,000 PCs, 98,000 printers and around 23,000 servers in the sector.

Table A1.5 Estimates of number of devices in the further education sector in England (to nearest 1,000)

	PCs (excl. laptops)	Printers	Servers
Lowestoft	550	95	30
FE England (grossed up)	344,000	59,000	19,000
City College Norwich	2,200	275	52
FE England (grossed up)	846,000	106,000	20,000
FE England (average)	595,000	82,500	19,500
FE UK (average)	708,000	98,000	23,000

A1.3 Further and Higher Education Combined

Table A1.6 summarises the findings of previous sections.

Table A1.6: Grossed up figures for UK further and higher education (to nearest 1,000)

	HE	**FE**	**HE + FE**
Energy (MWh)	512,000	454,000	966,000
Cost (£m)	61.5	54	116
Carbon Dioxide (t)	275,000	244,000	519,000
No. PCs	760,000	708,000	1,468,000
No. Printers	148,000	98,000	246,000
No. Servers	215,000	23,000	238,000

Appendix 2. Current and Projected UK Electricity Demand for ICT

Table A2.1: Summary of ICT electricity demand (MTP, 2008)

	Electricity (GWh)				Carbon (CO_2 Equivalent, million t)			
	REF (2007)	**REF (2020)**	**PI (2020)**	**PI % Reduction from 2007**	**REF (2007)**	**REF (2020)**	**PI (2020)**	**PI % Reduction from 2007**
Total Domestic	500,432	532,524	484,146	3	129	130	117	9
ICT	11,969	14,617	7,139	40	6.4	6.2	3.8	41
Total Non-Domestic	498,766	518,672	456,236	9	228	192	172	25
Total ICT	25,538	30,738	17,601	31	228	192	172	25
- Servers	3,730	7,209	4,978	-33 (increase)	2.0	3.0	2.0	0
- ICT (Devices)	21,628	23,529	12,623	42	11.6	9.9	6.8	41

REF = Business as usual, policies agreed to-date superimposed on evident market and technology trends

PI = Defined and highly feasible set of product policies to save carbon, which on implementation have zero marginal net cost impact on the UK economy

Table A2.2: ICT and other components of UK domestic electricity demand and related carbon emissions (MTP, 2008)

	Electricity (GWh)			Carbon (CO_2 Equivalent, million t)		
	REF (2007)	**REF (2020)**	**P1 (2020)**	**REF (2007)**	**REF (2020)**	**P1 (2020)**
Cold	15,578	13,706	10,962	8.3	5.8	4.9
Wet	14,374	15,501	14,701	7.7	6.5	6.2
Lighting	17,216	19,185	8,923	9.2	8.1	5.2
Consumer electronics	18,489	34,024	22,722	9.9	14.3	10.8
ICT	11,969	14,617	7,139	6.4	6.2	3.8
Cooking – electric	13,171	13,102	12,301	7.1	5.5	5.3
Cooking – gas	7,509	7,365	6,908	1.4	1.4	1.3
Heating – gas boilers	367,004	377,048	363,910	70.0	71.9	69.4
Heating – oil boilers	35,122	37,976	36,580	9.3	10.0	9.7

Table A2.3: ICT and other components of UK non-domestic electricity demand and related carbon emissions (MTP, 2008)

	Electricity (GWh)			Carbon (CO_2 Equivalent, million t)		
	REF (2007)	**REF (2020)**	**P1 (2020)**	**REF (2007)**	**REF (2020)**	**P1 (2020)**
Air-conditioning	15,390	19,952	16,493	8.2	8.4	6.4
Refrigerators	26,585	26,921	22,848	14.2	11.4	9.9
Street lighting	2,574	3,190	2,934	1.4	1.3	1.2
Commercial lighting	46,734	40,875	31,730	25.0	17.2	14.8
Servers	3,730	7,209	4,978	2.0	3.0	2.0
ICT	21,628	23,529	12,623	11.6	9.9	6.8
Heat-pump heating	4,237	5,136	5,136	2.3	2.2	2.2
Motors (all-overlap)	150,466	159,333	143,529	80.5	67.2	61.4
Motors (non-overlap)	110,589	114,804	106,155	59.2	48.4	45.2
Gas boilers	104,536	106,501	98,950	19.9	20.3	18.9
Oil boilers	12,297	11221.7	10,860	3.2	3.0	2.9

Appendix 3. Key Environmental Regulations Affecting ICT in Further and Higher Education

A number of European Union Directives have been introduced in recent years that have effects on ICT use in universities and colleges. This is a result both of their implementation into UK law, and as a result of their effects on suppliers of ICT equipment and services. Some of these directives are specifically targeted at ICT, notably those on:

1. Waste Electrical and Electronic Equipment
2. Hazardous Substances in ICT Equipment
3. Energy-Using Products

Others are more general, and have indirect impacts, notably those on:

4. Energy Performance of Buildings
5. Carbon Reduction
6. Energy End Use and Energy Services
7. Batteries Directive
8. Renewable Energy

A3.1 Waste Electrical and Electronic Equipment

The Waste Electrical and Electronic Equipment (WEEE) Regulations brought the WEEE Directive, 2002/96/EC, into force in the UK in January 2007 (Department for Business Enterprise and Regulatory Reform (BERR), 2006).

The WEEE Directive and Regulations aim to minimise the impact of EEE on the environment, by increasing reuse and recycling and reducing the amount of WEEE going to landfill. It places requirements on EEE producers and distributors. Producers must be registered with a Producers Compliance Scheme (PCS) and are responsible for financing collection and recycling of WEEE by sending to authorised facilities or authorised exporters, as well as marking new equipment with the date of manufacture and the crossed out wheeled bin symbol. IT and telecommunications equipment are covered by the Directive (BERR, 2006).

The WEEE regulations require end-of-life equipment to be collected and disposed of, separately to other waste. In addition, some WEEE may also be hazardous waste and additional steps will be required to satisfy the Duty of Care.

Implications for further and higher education

Institutions are responsible for ensuring the recovery and recycling and for the financing of some WEEE. In order to work out their obligations, institutions will need to establish the date on which a particular piece of equipment was purchased.

While there are no estimates for the total WEEE volumes generated by further and higher education, even a small college can generate several tonnes of WEEE per year, and for a larger institution this may be as high as 70t per year (results from survey carried out as part of this study). Hence, the total quantity from the sector is likely to be at least 1% of the total UK volume of around 900,000t a year, and a much higher proportion of the electronic component of this (Environment Agency, 2008).

While there may be costs incurred in the disposal of historic WEEE, institutions need to ensure that there is a requirement in future procurement agreements for producers to take back end-of-life EEE free of charge. The Regulations allow producers to negotiate alternative financing arrangements with their customers. This means that they can pass on the cost of recovering and recycling goods at the end of life to their customers.

WEEE works by requiring producers to develop takeback schemes, either individually or in collaboration. Hence, the sector procurement bodies are the main point of contact with the Regulations. They have established working groups and produced sector-specific guidance notes to assist in compliance.

The separation, management and disposal of WEEE incurs operational costs and resources for institutions. Although the Regulations place the responsibility on producers, some institutions, depending on the arrangements with their suppliers, may bear the costs of the disposal of WEEE. Based on the survey carried out as part of this study, costs can range from zero to tens of thousands of pounds per year. There are also a large number of different Producer Compliance Schemes adding to complexity of compliance. For example, one university dealt with 24 schemes in its last financial year.

Although the Regulations place the responsibility on producers, they allow them to negotiate alternative financing arrangements with their customers. This can involve transferring the costs of recovering and recycling goods to customers, which has happened with some institutions. The Environmental Association of University and College's (EAUC) WEEE Insight Guide notes that:

> Some producers may try and discharge their recycling obligation by writing into supply contracts that their customer is responsible for the cost of recycling WEEE at the end of its life. All staff involved in the purchasing of EEE need to be made aware of this and ensure that they read all the small print in future supply contracts.
>
> In addition, negotiating who will pay for the disposal of new equipment when it becomes WEEE is a commercial decision and should form part of the supply contract negotiating process, as different suppliers may offer different services and charge varying amounts. Distributors or suppliers have no direct obligations under WEEE. However, it would be prudent for institutions to ensure when purchasing equipment through a distributor that they have been supplied with relevant details about the producer and the compliance scheme of which they are a member so as to facilitate future disposal. (EAUC, 2007)

A3.2 Restriction of Hazardous Substances

The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive 2002/95/EC, and implementing UK ROHS Regulations 2008, bans the placing on the EU market of new electrical and electronic equipment containing more than agreed levels of lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE) flame retardants (NetRegs, 2008a). IT and telecommunications equipment are covered by the Directive. There is a move towards global compliance with China, Japan, South Korea, Taiwan, Australia, Canada and many US states adopting similar restrictions.

Under the UK Regulations, any equipment put on the market after 1 February 2008 should not contain more than 0.1% (or 0.01% in case of cadmium) by weight of hazardous substances listed in the Directive. There are some exemptions (National Weights and Measure Laboratory, 2008).

Implications for further and higher education

The RoHS Directive and Regulations do not require any direct action by universities and colleges as the responsibility lies with the producer rather than the purchaser. However, institutions should ensure that they specify ROHS-compliant equipment. ICT products purchased after 1 February 2008 will have fewer hazardous substances within them, or used in their production.

A3.3 Energy-using Products

The Framework Directive on the Eco-design of Energy-using Products (EuP) provides a framework for establishing minimum eco-design requirements for energy-using products (EuP) (Defra, 2007b). It allows the European Commission to set performance requirements for EuPs placed on the EU market. In addition to the energy consumed by products while in use, these requirements set minimum performance standards for the energy consumed in the manufacture of EuPs, and in the eventual disposal of such products. The scope of the Directive covers all EuPs, except transport. The European Commission (EC) is presently developing proposals for implementing measures for various products and product groups (European Commission, 2008a).

The first round of preparatory studies was divided into 14 lots corresponding to families of EuPs. The preparatory studies for computers and monitors, imaging equipment (printers, multi-functional devices and photocopiers) and Standby (a study looking at all products that consume energy while in standby mode) are complete (European Commission, 2008a). Eco-design requirements for Standby have been proposed by the EC, but requirements for computers, monitors and imaging equipment have yet to be proposed (European Commission 2008b). These are not expected to be in force until 2010 (McAndrew, 2008).

Implications for further and higher education

The EuP Directive and Regulations do not require any immediate or direct action by universities and colleges. However, it is likely to lead to mandatory energy efficiency requirements and labelling, initially for standby mode of energy-using products, with computers, monitors, imaging equipment by 2010, which will ultimately reduce energy consumption and environmental impacts across the entire life cycle of such products.

A3.4 Energy Performance of Buildings

The Energy Performance of Buildings Directive (EPBD), 2002/91/EC, promotes the improvement of energy performance of buildings through the setting of minimum energy performance requirements in new and existing buildings, energy certification of buildings and inspection and assessment of heating and cooling installations. It is implemented in the UK largely through the Building Regulations.

As of 1 October 2008, public sector buildings over 1,000m^2 are required to post Display Energy Certificates (DEC), which contain details of the last 12 months of energy consumption, verified by an approved Energy Assessor (Communities and Local Government (CLG), 2008).

In the medium–long term, the application of ICT in 'intelligent buildings' will play an important role in achieving the Directive's long-term aim of reducing consumption in public buildings.

Implications for further and higher education

The EPBD and Regulations could have a significant effect on universities and colleges. Current guidance allows a site-based approach for the first year where it is not possible to produce individual DECS, ie for a campus, only one DEC based on the total energy consumption of buildings on site is required (CLG, 2008). However, in the long term DECs for individual buildings will be needed.

This will probably require additional investment in metering, and the engagement or training of an accredited Energy Assessor. They will also allow inter-institutional comparison of buildings with a substantial amount of ICT activity within them, eg data centres. In addition, universities will be required to have any air-conditioning systems with a rated output of over 250kW (from 2009) and over 12kW (from 2011) inspected every five years, which will affect data centres.

Although there is no legal requirement or financial incentive under the Regulations to reduce the operational energy, it is likely that reputational factors will drive universities and colleges to reduce energy associated with buildings covered by the EPBD. This in turn will drive reductions in energy associated with ICT equipment and services.

A3.5 Carbon Reduction

The Climate Change Act, which received Royal Assent in November 2008, contains provisions that will set a legally binding target for reducing UK CO_2 emission by at least 26% by 2020 and at least 80% by 2050, compared to 1990 levels. The Act requires the Government to publish five yearly carbon budgets as from 2008; create a Committee on Climate Change; requires the Committee on Climate Change to advise the Government on the levels of carbon budgets to be set, the balance between domestic emissions reductions and the use of carbon credits, and whether the 2050 target should be increased; places a duty on the Government to assess the risk to the UK from the impacts of climate change; provides powers to establish trading schemes for the purpose of limiting greenhouse gas; confers powers to create waste reduction pilot schemes; and amends the provisions of the Energy Act 2004 on renewable transport fuel obligations (Parliament, 2008). Of particular relevance to further and higher education are the enabling powers to introduce new trading schemes, including the Carbon Reduction Commitment (CRC) (Defra, 2008c).

CRC is a proposed new mandatory auction-based cap and trade scheme for the UK, and will cover organisations whose annual half-hourly metered electricity use is over 6,000MWh per year. Designed to cover both direct energy use emissions and electricity use, CRC will also focus on emissions outside Climate Change Agreements and the EU ETS. The CRC is due to start in January 2010 with a three-year introductory phase featuring simple fixed price sales of allowances. From 2013 there will be a Government-imposed cap on the number of allowances, and all allowances will be sold each year via an auction. Revenue raised by the auction will be recycled to participants in proportion to their average annual emissions since the start of the scheme, with a bonus/penalty depending on their position in a CRC league table.

Defra have conducted consultations on the design of the scheme and later in 2008 plan to issue a user guide for organisations to assess whether they qualify and guide them through the registration process (Defra, 2008c).

Implications for further and higher education

The CRC is expected to affect 80–100 further and higher education institutions (Hopkinson and James, 2007).

Participants will be required to submit annual data statements via an online registry to the Environment Agency on a self-certified basis, either using their own meter readings or with reference to annual energy bills (Defra, 2008c). Participation in the scheme will require an organisation to undertake the following (Defra, 2008c):

- Calculate their total organisation-wide energy use emissions
- At the start of each compliance year, purchase allowances from the auction (or fixed price sale during the introductory phase) to cover their total emissions

Monitor, assess and manage emissions throughout the emissions year (1 April to 31 March)

Report emissions and surrender sufficient allowances to cover emissions by the end of July via an online registry

Receive recycling performance payment at the end of October, incorporating a bonus/penalty calculated on the basis of their position in the performance league table

Although it is intended to be a 'light touch' implementation, it is likely that it will require considerable staff resources and up-front costs to administer for those institutions covered by the scheme. For example, one mid-sized university estimated it will cost between £150,000 and £350,000 per annum in the first three years – depending at what level Defra decides to set the price of pre-purchased carbon – and possibly more thereafter (Bradley 2008).

These costs can be reduced (which is part of the incentive) as energy savings are made and if a good position in the league table is achieved. However, there is the possibility of significant financial risk, particularly if institutions decide a strategy of a combination of carbon mitigation measures and buying carbon spot market.

Given that ICT products can account for a considerable proportion of an institution's carbon emissions, this scheme could encourage a switch to more energy-efficient equipment and increased enabling of power management functionality.

A3.6 Energy End Use and Energy Services

The Energy End Use and Energy Services Directive, 2006/32/EC, is intended to enhance the cost-effective improvement of energy end use efficiency in Member States. It covers all forms of energy, and applies to providers of energy efficiency measures, energy distributors, distribution system operators and retail energy sales companies, and all energy users except those involved with the EU carbon emissions trading scheme.

Article 5, Annex VI of the Directive, which came into effect in May 2008, requires the public sector to take up cost-effective energy efficiency improvements that generate the largest savings in the shortest space of time (Defra, 2007b). In practice, this means that equipment and vehicles should conform to the energy efficiency specifications detailed in 'Buy Sustainable – Quick Wins' (Defra, 2008a). The agreements for implementation provide discretion on how organisations deal with the requirements.

Implications for further and higher education

Article 5, Annex VI of the Directive sets out a number of measures on procurement, of which the public sector is required to implement at least two. Public-sector bodies will be required to procure energy using equipment and vehicles in line with specifications set out in a list setting out energy-efficiency specifications that will also consider energy use in different modes (Defra, 2007b). For central government these agreements will build on the current mandate to use the common minimum environmental standards 'Buy Sustainable – Quick Wins' and the commitment by NHS PASA to promote the adoption of minimum product standards in line with 'Buy Sustainable – Quick Wins'. For the education sector a voluntary agreement requiring bodies to use the energy-efficiency specifications, to be agreed with the lead representative bodies, has been proposed (Defra, 2008b). The 'Buy Sustainable – Quick Wins' specifications are likely to be those adopted. HEFCE is supportive of this and has incorporated the following actions into its draft Sustainable Development Action Plan (Smith, 2008):

We will work with DECC, the UUK Strategic Procurement Group and others to determine the best approach to implementing and monitoring the requirements of Article 5. We will join with others to undertake a pilot carbon foot-printing project.

Details of the 'Buy Sustainable – Quick Wins' standards for ICT devices can be found in Appendix 4.

A3.7 Batteries Directive

The Batteries and Accumulators and Waste Batteries and Accumulators Directive, 2006/66/EC, is a producer responsibility directive, which seeks to improve the environmental performance of batteries and accumulators across their entire life cycle. It applies to all battery types, and requires collection schemes for the return of used portable batteries, sets collection rate targets for household batteries and restricts the levels of mercury and cadmium in batteries placed on the market.. The UK has already implemented the parts of the Directive that relate to the manufacture and labelling of new batteries, and to the design of certain battery-powered appliances. New regulations to transpose the remaining parts of the Directive in the UK were due to be in force by September 2008 (Department for Business Enterprise & Regulatory Reform (BERR), 2008a), but were delayed until 2009. A second round of consultation on the draft implementing regulations was launched at the end of 2008. These largely relate to producer responsibility requirements for the collection and recycling of waste batteries (industrial, automotive and portable). It is expected that the regulations will be similar to the WEEE Regulations.

Implications for further and higher education

It is likely that universities and colleges will be required to set up collection schemes for all batteries.

A3.8 Draft Renewables Directive

A decision of the European Parliament and European Council established an overall binding target of a 20% share of renewable energy sources in total energy consumption (electricity, heat and transport) for Europe as a whole, as well as binding national targets by 2020 in line with the overall EU target of 20% (European Commission, 2008c). The Commission has proposed that 15% of the total energy consumed in the UK should come from renewable sources by 2020 (BERR, 2008b).

The UK has a number of bills proposed to facilitate renewables: the Planning Bill by speeding up planning process for renewable energy projects, and the Energy Bill by facilitating an increase in the number of Renewable Obligation Certificates (ROCs) for certain types of technologies. There is also a Private Members, Planning and Energy Bill, to support the Merton Rule, which requires developers to source at least 10% of new buildings energy from renewables. Already many local planning authorities are embedding such requirements in their local plans.

Implications for further and higher education

University new build, including data centres, will likely require at least 10% of energy to come from renewable sources.

Appendix 4. ICT Equipment Procurement

A large proportion of bulk purchases of ICT equipment within universities are done under the auspices of national, inter-regional or regional procurement agreements. Universities can either award contracts directly where the terms laid down in the framework agreements are sufficiently precise, or add further requirements and hold a mini-competition between the suppliers who are party to the agreement.

The national agreements are negotiated and managed by collaborative working parties, which include ones on Computer and Stationery Supplies, Photocopiers, and Waste Electrical and Electronic Equipment (WEEE) disposal contracts. There are also a number of regional purchasing consortia, which have various commodity groups (eg desktop PCs, printers and peripherals, photocopier paper) with representatives from their member institution on these groups. This established infrastructure, and the aggregated buying power it creates, gives considerable potential for more proactive procurement actions to support sustainable ICT.

ICT procurement in further education is more fragmented, in part because purchases are lower in value than for most higher education institutions. A recent National Audit Office (2006) report found that ICT purchases accounted for an average £291,000 per annum, or 4.4% of average college budgets in England. The report also found that ICT was one of the areas where colleges had least knowledge of purchasing costs, with only 16% of respondents to a survey able to provide information on their spending. One of the report's recommendations was that colleges should develop more external collaboration for procurement, and sustainable ICT is clearly one area where they could work more closely with higher education procurement agencies.

Sustainable ICT procurement is made much easier when standardised methods are available to assess environmental impacts. For example, a PC can use 10% less power than an equivalent, but contain more toxic compounds, and create greater pollution problems at the manufacturing stage. Reaching an overall judgement as to how green this is – and how it compares with other models – is very difficult, as Appendix 1 of the supporting paper on personal computing discusses (James and Hopkinson, 2008a). The task is made even more difficult because manufacturer's claims are not always accurate. This is not necessarily for fraudulent reasons, but because test conditions may differ from those in the field, or because they do not know of upstream impacts from production of brought-in components.

Table A4.1 shows the details of the Government's 'Buy Sustainable – Quick Wins', which sets minimum and best practice procurement standards for office equipment and other products purchased by Central Government. It is likely that the education sector will need to follow these standards as part of the implementation of the Energy End Use and Services Directive.

Table A4.1: 'Buy Sustainable – Quick Wins' procurement standards for ICT devices (Defra, 2008a)

Device	2008 Minimum specifications	2008 Best Practice specifications
Workstations	1. Must meet three of the six specifications in the Energy Star criteria 2. Must have a Typical Electricity Consumption power level (PTEC) of equal to or less than: 0.35 x [PMAX + (#HDDs x 5)]W PMAX is the maximum power (see page 19 of the criteria) #HDDs is the number of installed hard drives in the system	In addition to minimum specification: 1. Power management capability to be present and enabled on delivery 2. At least two of the following seven design for disassembly, recycling and product life time extension criteria to be met: i. Parts that have to be treated separately are separable ii. Plastic materials in covers/housing have no surface coating iii. Plastic parts >100g consist of one material or of separable materials iv. Plastic parts >25g have material codes according, or equivalent, to ISO 11469 v. Plastic parts are free from metal inlays or have inlays that can be removed with commonly available tools vi. Labels are separable (this requirement does not apply to safety labels) vii. Product components can be upgraded, eg with memory
Personal computers	1. Must consume 4W or less in sleep mode 2. Must consume 2W or less in off mode (standby) 3. Cat. A computers must consume 50W or less in Idle state 4. Cat. B computers must consume 65W or less in Idle state 5. Cat. C computers must consume 95W or less in Idle state See Energy Star criteria	In addition to the minimum specification 1. Power management capability must be present and enabled on delivery 2. At least two of the following seven design for disassembly, recycling and product life time extension criteria, shall be met: i. Parts that have to be treated separately are separable ii. Plastic materials in covers/housing have no surface coating iii. Plastic parts >100g consist of one material or of separable materials iv. Plastic parts >25g have material codes according, or equivalent, to ISO 11469 v. Plastic parts are free from metal inlays or have inlays that can be removed with commonly available tools vi. Labels are separable (this requirement does not apply to safety labels) vii. Product components can be upgraded eg with processor, memory, cards or drives. Upgrading can be done using commonly available tools
Computer monitors	1. Must consume 2W or less in sleep mode 2. Must consume 1W or less in off mode See Energy Star criteria	In addition to the minimum specification 1. Power management capability must be present and enabled on delivery 2. At least one of the following six design for disassembly and recycling criteria shall be met: i. Parts that have to be treated separately are separable ii. Plastic materials in covers/housing have no surface coating . iii. Plastic parts >100g consist of one material or of separable materials iv. Plastic parts >25g have material codes according, or equivalent, to ISO 11469 v. Plastic parts are free from metal inlays or have inlays that can be removed with commonly

		available tools vi. Labels are separable (this requirement does not apply to safety labels)
Portable computers	1. Must consume 1.7W or less in sleep mode 2. Must consume 1W or less in off mode 3. Category A computers must consume 14W or less in Idle state 4. Category B computers must consume 22W or less in Idle state See Energy Star criteria	In addition to the minimum specification. 1. Power management capability is present and enabled on delivery 2. At least two of the following seven design for disassembly, recycling and product life time extension criteria, are met: i. Parts that have to be treated separately are separable ii. Plastic materials in covers/housing have no surface coating iii. Plastic parts >100g consist of one material or of separable materials iv. Plastic parts >25g have material codes according, or equivalent, to ISO 11469 v. Plastic parts are free from metal inlays or have inlays that can be removed with commonly available tools vi. Labels are separable (this requirement does not apply to safety labels) vii. Product components can be upgraded eg with memory
Single and Multi-functional Devices	Must meet the Energy Star criteria Specifications: Page 9 – Duplexing Page 11 – Product speed Page 12 – Delay time Page 13 – Standby Power levels	In addition to the minimum specification: 1. Photocopiers and faxes are to be suitable for use with recycled paper. 2. All devices power management capability to be present and enabled on delivery 3. At least two of the following seven design for disassembly, recycling and product life time extension criteria are met: i. Parts that have to be treated separately are separable ii. Plastic materials in covers/housing have no surface coating iii. Plastic parts >100g consist of one material or of separable materials iv. Plastic parts >25g have material codes according, or equivalent, to ISO 11469 v. Plastic parts are free from metal inlays or have inlays that can be removed with commonly available tools vi. Labels are separable (this requirement does not apply to safety labels) vii. Product components can be upgraded eg with memory

A4.1 Energy and Environmental Labels for ICT Products

The following section discusses, and compares and contrasts, the three – all labelling schemes – which seem to have the greatest feasibility for greater adoption within UK further and higher education. (IVF, 2007 also has a useful discussion of the different eco-labels for PC, including national or regional schemes outside the UK such as Blue Angel in Germany and Nordic Swan in Scandinavia). The three schemes are:

Energy Star – an official European Union (EU) scheme that covers energy consumption in use

ECMA Eco-Declaration – a European scheme developed by suppliers, which covers energy but also broader environmental issues such as hazardous substances and the company's environmental policy and management

EPEAT – a US equivalent to ECMA, which is of relevance to the UK because many of the models covered are sold here

A4.1.1 Energy Star

This is the most developed labelling scheme, but only addresses energy consumption in use. It was developed in the USA, but is now – at least as far as ICT is concerned – a joint activity between the US Environmental Protection Agency and the European Commission (EU Energy Star website). It has specifications for computers (covering computers, workstations, games consoles and laptops); imaging equipment (covering copiers, fax machines, multi-functional devices (MFDs), printers, and scanners), and monitors.

Because it is an EU scheme, Energy Star-rated devices are readily available in the UK. For example at the end of October 2008 there were 450 desktop, 743 notebooks/tablets and 939 MFD models listed in the EU database (EU Energy Star website). As newer and more stringent versions of Energy Star are introduced the numbers drop back and then gradually increase as manufacturers improve their products. The current version is 4.0, but a new version for computers and monitors is expected in 2009, which will drive energy consumption down further.

A4.1.2 ECMA Eco-Declaration

The European Computer Manufacturers Association (ECMA) – which includes many suppliers from Asia and North America who manufacture in Europe – has developed ECMA-370 (ECMA web site). This is intended to be a global scheme, but is focusing on EU implementation in the first instance. The scheme specifies environmental attributes and measurement methods for ICT and CE products according to known regulations, standards, guidelines and currently accepted practices. It can be applied to finished products, or subassemblies, components, accessories and/or optional parts. It addresses company programmes and product-related attributes, not the manufacturing processes and logistic aspects. Supplier compliance is monitored by a mandatory third-party verification. The ECMA-370 scheme is still in its early stages and it is difficult to find lists of models that have been certified as compliant, or examples of organisations that are using it in procurement. However, this is likely to change with time.

A4.1.3 EPEAT

The Electronic Product Environmental Assessment Tool (EPEAT) has been developed by the US Green Electronics Council (2008). It is used to assess laptop and desktop computers and monitors, in terns of a number of 51 performance criteria (23 required, and 28 optional), including environmental design, manufacture, end-of-life management and corporate performance (see Table A4.4). The criteria are based on an IEEE Standard. EPEAT has three tiers of environmental performance – Bronze, Silver and Gold – which are determined by the number of credits achieved. Manufacturer's self-certify, but these are subject to spot checks by the Green Electronics Council. Computacenter has introduced the scheme to the UK, and a larger scale scheme is under consideration for adoption by the UK Greening Government IT initiative (Cabinet Office 2008).

At the end of 2008 there were 149 desktops and 424 notebooks listed in the EPEAT scheme, from 30 manufacturers. Of these, 85 desktops and 133 laptops, were gold rated, reaching the highest standard. According to the Green Electronics Council, EPEAT-qualified products accounted for about 22% of worldwide notebook and desktop sales in 2007, up from 10% of all units in 2006 when the first EPEAT-rated products began hitting the market (US Green Electronics Council, 2008). However, it is noticeable that the EPEAT list only includes two (Dell and NEC) of the six suppliers on the current inter-regional desktop agreement, suggesting that many EU manufacturers are not participating.

Organisations currently using EPEAT in the USA include the US Federal Government (~ $60b in EPEAT purchasing); the Canadian Federal Government; several US cities, states and provinces and a number of private-sector firms such as Marriott International, Premier Inc, McKesson and Deloitte (O'Brien, 2008). One large UK financial services firm also specified a minimum EPEAT silver rating for its global computer purchases of 7,764 desktops and 14,532 monitors in 2007, and estimated that this would save over 11,000MWh of energy and £1.14m in costs – and also that, if all purchases were of EPEAT gold products, this would increase to over 13,000MWh of energy and over £1.3m in costs (O'Brien, 2008). (Whole life cost savings can be estimated through a life-cycle environmental benefits calculator (Center for Clean Products and Clean Technologies, 2008).

Table A4.2 Selected EPEAT gold desktop and notebook models that are sold in the UK (EPEAT website)

Desktop EPEAT gold model examples	Notebook EPEAT gold model examples
DELL OptiPlex 740 Energy Smart MT	DELL Latitude D630
HP Compaq dc7800 Ultra-slim Desktop PC	HP Compaq 2710p Notebook PC
Apple Mac Pro, Two 2.8GHz Quad-Core Xeon processor	Apple 15-inch MacBook Pro, 2.4GHz (MB470LL)
Lenovo ThinkCentre M57 Desktop	Toshiba Portege R500 - PPR50U

A4.1.4 Comparison of ECMA and EPEAT

A key issue for these two schemes is the extent to which they reflect the true life-cycle impacts of a PC. For example, while EPEAT has credits for eliminating toxic substances such as lead, mercury and cadmium, there are few credits for reducing pollution during the production stage – possibly because most of these occur in the materials extraction phase, over which computer manufacturers have little control. There are also a number of credits in EPEAT that play a relatively minor part in the overall life-cycle impacts of a computer but which perhaps have a large 'feel good' factor, such as the emphasis on packaging. Many of the benefits associated with EPEAT also derive from other standards such as Energy Star or the Reduction of Hazardous Substances (RoHS) Directive – which is a legal standard for computers sold in the EU (although not in the USA). There are also no energy conservation credits in EPEAT relating to energy use during manufacture. Many of the EPEAT standards relating to design for end-of-life will also be driven in the EU by the WEEE Directive.

The ECMA-370 credits are more comprehensive, with 71 credits of which 53 are mandatory (ECMA, 2007). As with EPEAT, energy consumption only covers energy in use, though there are more credits for material and substance content and the list of restricted hazardous substances is wider.

A4.1.5 Conclusions

Table A4.3 compares and contrasts the three schemes. It is based in part on an analysis of existing, established sustainable product standards, databases for energy-saving products and product lists (ERM, 2008).

Our provisional view is that Energy Star is proven, easier to use and more applicable to the EU, and should therefore be used more widely in sector purchasing activities.

However, both EPEAT and ECMA go beyond current legal standards in the EU and therefore a computer with either EPEAT or ECMA-370 eco-labels will offer more environmental benefits than one with Energy Star alone. However, some of these (eg corporate environmental performance reporting) may be addressed directly at the procurement stage through environmental questionnaires to the suppliers. In the short to medium term, however, in the absence of a fully working EU scheme, EPEAT is the current best option in terms of an eco-label.

Table A4.3: Pros and cons of EPEAT, ECMA-370 and Energy Star eco-labels (based on ERM, 2008)

Pros and Cons	EPEAT	ECMA-370	Energy Star
Robustness and credibility	Incorporates Energy Star. Self-declaration, with spot checks	Unclear how many organisations have implemented standard Implementation controlled via third party	Follows principles of due process, openness and consensus. Verification?
Coverage of life-cycle environmental issues	Somewhat limited	Greater coverage, though not comprehensive	Very limited – energy in use only
Availability of information	Accessible	Less accessible	Accessible
Potential benefits	Reduction in energy bills, PR benefits and health and well-being benefits	Continuity across the globe. Covers majority of priority areas of spend	Reduction in energy bills. Benefits easily measured using tool on the web
Ease of use	Fairly difficult to review as full criteria must be purchased. Standard mildly complicated	Fairly complicated and prescriptive. Difficult to monitor consistency with each organisation using its own third-party accreditation	Extremely easy for consumers to access
Applicability to the UK	Limited to main suppliers because a US scheme – may exclude a number of EU suppliers	Greater coverage, because EU scheme	Very applicable

Table A4.4: EPEAT criteria (paraphrased) for desktop personal computers, notebook personal computers and personal computer monitors (US Green Electronics Council, undated)

Category	Criteria	Criteria
	Required	**Optional**
4.1 Reduction/elimination of environmentally sensitive materials	4.1.1.1 Compliance with provisions of EU RoHS Directive	4.1.2.1 Elimination of intentionally added cadmium
	4.1.3.1 Reporting on amount of mercury used in light sources	4.1.3.2 Low threshold for amount of mercury used in light sources
		4.1.3.3 Elimination of intentionally added mercury in light sources
		4.1.4.1 Elimination of intentionally added lead in certain applications
		4.1.5 Elimination of intentionally added hexavalent chromium
	4.1.6.1 Elimination of intentionally added Short Chain Chlorinated Paraffin flame retardants and plasticisers in certain applications	4.1.6.2 Large plastic parts free of certain flame retardants classified under EU Directive 67/548/EEC
		4.1.7.1 Batteries free of lead, cadmium and mercury
		4.1.8 Polyvinyl chloride and chlorinated plastics
4.2 Materials Selection	4.2.1.1 Declaration of post-consumer recycled plastic content	4.2.1.2 Minimum content of post-consumer recycled plastic
		4.2.1.2 higher content of post-consumer recycled plastic
	4.2.2.1 Declaration of renewable/biobased plastic material content	4.2.2.2 Minimum content of renewable/biobased plastic material
	4.2.3.1 Declaration of product weight	
4.3 Design for end-of-life	4.3.1.1 Identification of materials with special handling needs	4.3.1.6 Reduced number of plastic material types
	4.3.1.2 Elimination of paints or coatings that are not compatible with recycling or reuse	4.3.1.7 Moulded/glued-in metal eliminated or removable
	4.3.1.3 Easy disassembly of external enclosure	4.3.1.8 Minimum 65% reusable/recyclable

	4.3.1.4 Marking of plastic components	4.3.1.9 Minimum 90% reusable/recyclable
	4.3.1.5 Identification and removal of components containing hazardous materials	
		4.3.2.1 Manual separation of plastics
		4.3.2.2 Marking of plastics
4.4. Product longevity/life-cycle extension	4.4.1.1 Availability of additional 3 year warranty or service agreement	
	4.4.2.1 Upgradeable with common tools	4.4.2.2 Modular design
		4.4.3.1 Availability of replacement parts
4.5 Energy conservation	4.5.1.1 Energy Star	4.5.1.2 Early adoption of new Energy Star specification
		4.5.2.1 Renewable energy accessory available
		4.5.2.2 Renewable energy accessory standard
4.6 End-of-life management	4.6.1 Provision of product take-back service	4.6.1.2 Auditing of recycling services
	4.6.2.1 Provision of a rechargeable battery take-back service	
4.7 Corporate performance	4.7.1.1 Demonstration of corporate environmental policy consistent with ISO 14001	
	4.7.2.1 Self-certified environmental management system for design and manufacturing facilities	4.7.2.2 Third-party certified environmental management system for design and manufacturing facilities
	4.7.3.1 Corporate report consistent with Performance Track or Global Reporting Initiative	4.7.3.2 Corporate report based on Global Reporting Initiative
4.8 Packaging	4.8.1.1 Reduction/elimination of intentionally added toxics in packaging	
	4.8.2.1 Separable packing materials	4.8.2.2 Packaging 90% recyclable and plastics labelled
	4.8.3.1 Declaration of recycled content	4.8.3.2 Minimum post-consumer content guidelines
		4.8.4.1 Provision of take-back programme for packaging
		4.8.5.1 Documentation of reusable packaging

Appendix 5. List of Cases

Table A5.1: List of SusteIT case studies

No.	Title	Summary
1	PC PowerDown at the University of Liverpool	The University's self-developed software is powering down computers that are idle, typically for over ten hours daily, saving over 500t of CO_2 emissions, and £64,000 of electricity, annually.
2	A Green IT Building at the University of Dundee	The University's Queen Mother Building, purpose-built to house the Computing School, is a simple, low-energy design, which saves energy, reduces environmental impacts and enhances productivity.
3	Cooling Crays at the University of Edinburgh	Free cooling, avoidance of hot/cold air arrangements, and variable speed drives, are saving over £500,000 per annum in energy costs at the Hector site, compared to older, unoptimised facilities.
4	Systematic IT Environmental Improvement at the University of Gloucestershire	Participation of the ICT Manager in the university's environmental improvement initiative has stimulated actions for greener procurement, print management and virtualisation.
5	Green Research at Sheffield University	The MESAS (Multiscale Engineering Simulations at Sheffield) group has reduced the environmental footprint and costs of its (environmentally beneficial) research through more energy-efficient servers.
6	Beaumont College's ICT Gives People With Communication Difficulties a Voice	Beaumont College of Further Education's Wheeltop Project is using ICT to support the learning and development of physically disabled students.
7	Estimating ICT Electricity Use at the University of Sheffield	The University of Sheffield has undertaken a detailed estimate of the energy/carbon footprint of its ICT estate. This has been used to develop a generic tool to help other institutions estimate their ICT footprint.
8	City & Islington College PCs are Reused in Developing Countries	City & Islington College donates its old computers to developing countries via the charity Computer Aid, aiding educational organisations in those countries and extending the useful life of the machines.
9	Virtualisation at Sheffield Hallam University	Replacing 120 physical servers with 300 'virtual' servers has enabled Sheffield Hallam University to expand server capacity and utilisation considerably in a limited space, while reducing energy and maintenance costs.
10	Less ICT Waste at Nottingham Trent University	Measures to limit production and improve management of Waste Electrical and Electronic Equipment (WEEE) has led to greater reuse of ICT equipment, and reduced costs and

		environmental risks at Nottingham Trent University.
11	Welsh Institutions Work Together through Video	The Welsh Video Network supports videoconferencing studios in every university and college in Wales, and facilitated over 4,800 conferences in 2006–07, creating tangible benefits of enhanced learning, reduced administrative/management costs and associated travel savings.
12	An Ethical Approach to Sustainable ICT at Middlesex University	In collaboration with the British Computer Society, the University's teaching and research on the ethical and social impacts of ICT is having an international impact, and is now extending to environmental issues.
13	Power Management at the University of York	Powering down networked computers has reduced the university's total energy consumption by 3%.
14	Scottish Physicists Stretch Time by Conferencing	The use of videoconferencing (VC) has allowed physics postgraduate courses at six Scottish universities to pool teaching resources, enhancing learning and saving significant time and travel costs.
15	Integration of IT and facilities management at Ave Maria University, Florida, USA	Ave Maria University has connected all its IT and facilities management, including air conditioning, lighting, security cameras, fire alarms, electrical and building-access control systems, into one network.
16	Reducing Business Travel through Conferencing at HEFCE	The Higher Education Funding Council for England (HEFCE) has reduced business travel through phone and videoconferencing, reducing carbon emissions and travel costs significantly.
17	Low energy PCs at the University of Birmingham	The University of Birmingham is saving energy, money and space, and fostering local innovation, by systematically replacing its standard PCs with compact PCs, based on laptop technology, mounted directly which saves energy, space and overall lifetime costs.
18	Shared storage has business and energy benefits	London Metropolitan Network (LMN) provides a data back up solution to London institutions which is more reliable, cheaper and more energy efficient than in-house equivalents
19	Location independence works at Coventry University	Building on earlier achievements, a JISC exemplar project is creating business, environmental and personal benefits.

Table A5.2: List of SusteIT/Grid Computing Now! long case studies and technical papers

No.	Title	Summary
1	Virtualisation at Sheffield Hallam University	Replacing 120 physical servers with 13 VMware ESX host servers has enabled Sheffield Hallam to expand server capacity considerably, while reducing energy costs and space requirements.
2	Queen Margaret University (QMU) thin client saves energy costs	A newly designed campus in Edinburgh has reduced space requirement and energy consumption through use of 1250 thin client terminals.
3	Cutting power use with Condor at Cardiff University	Cardiff is using grid computing to utilise 'wasted' CPU capacity in PCs. However, the exercise only has significant environmental benefits when newer PCs are utilised.
4	Saving power and space in the data centre at Cardiff University	Total cost of ownership significantly reduced through more efficient processors, cooling and power systems, whilst new technology has allowed twice as many servers in less space.
5	Keeping cool naturally at University of Edinburgh's Hector Facility	A more detailed version of short case study 3, showing how free cooling, avoidance of hot/cold air arrangements, and variable speed drives, are saving over £500,000 per annum in energy costs.
6	Virtualisation at City of Bristol College	Space and financial savings from virtualisation.
7	Data Centre Cooling	An overview of key approaches.
8	Virtualisation	A background paper on its key features.
9	EU Code of Conduct on Energy Efficient Data Centres	Short summary of key features.

Glossary

AUDE:	Association of University Directors of Estates
AUPO:	Association of University Procurement Officers
BCS:	British Computer Society
BECTA:	British Educational Communications and Technology Agency
BERR:	Business, Enterprise and Regulatory Reform (Department)
BUFDG:	The British Universities Finance Directors Group
CLG:	Communities and Local Government (Department)
CO2:	Carbon Dioxide
CRC:	Carbon Reduction Commitment (under Climate Change Act)
CRT:	Cathode Ray Tube (monitors)
DBERR:	Department for Business, Enterprise and Regulatory Reform
DEC:	Display Energy Certificate
DECC:	Department for Energy and Climate Change
Defra:	Department for Environment, Food and Rural Affairs
DVD:	Digital Video Disc
EAUC:	Environmental Association of Universities and Colleges
ECMA:	European Computer Manufacturers Association
EP:	Electrophotographic
EPBD:	Energy Performance in Buildings Directive
EPEAT:	Electronic Product Environmental Assessment Tool
EU:	European Union
EU ETS:	European Union Emission Trading Scheme
EuP:	Energy Using Products (Directive)
EVO:	Enabling Virtual Organisations
FHE:	Further and Higher Education
GHG:	Greenhouse Gases
HEEPI:	Higher Education Environmental Performance Improvement
ICT:	Information and Communications Technology
IP:	Internet Protocol
IT:	Information Technology
JANET:	Joint Academic Network
JISC:	Joint Information Services Committee
JVCS:	JANET Videoconferencing Service
Kg:	Kilogrammes
kWh:	kilowatthours
LCD:	Liquid Crystal Display (monitors)
LSC:	Learning and Skills Council
MWh:	MegaWatt hours
PBB:	Polybrominated biphenyl
PBDE:	Polybrominated diphenyl ether
PC:	Personal Computer

ROCS:	Renewable Obligation Certificates
ROHS:	Restriction of the Use of Certain Hazardous Substances (in Electrical and Electronic Equipment Directive)
RSC:	Regional Support Centres
SPAP:	Sustainable Procurement Action Plan
SusteIT:	Sustainable IT In Tertiary Education
TCO:	Total Cost of Ownership
TFT:	Thin-film Transistor (monitors)
UCISA:	Universities and Colleges Information Systems Association
UKERNA:	United Kingdom Education and Research Network Association
UPMG:	University Print Managers' Group
UPS:	Uninterruptible Power Supply
USEPA:	United States Environmental Protection Agency
UUK:	Universities UK
VLE:	Virtual Learning Environment
VOIP:	Voice over Internet Protocol
WEEE:	Waste Electrical and Electronic Equipment (Directive)

Bibliography

1E and National Energy Foundation, 2006. Assessment of Potential for Energy Savings from PC Software Management. [Online] Available at: www.1e.com/energycampaign/downloads/1ENEFReport.pdf [Accessed 24 October 2008].

AIMS & Associates, 2007. *The Business Case for Change*. Paper for SCHOMS Getting VFM from Printing and Copying project. June 2007. [Online] Available at: www.lboro.ac.uk/mediaservices/ex/schoms/printing/outcomes/reviewing.html [Accessed 4 October 2008].

American National Standards Institute (ANSI)/Institute of Electrical Electronics Engineers (IEEE), 2008. *ANSI/IEEE Standard 1471, IEEE Recommended Practice for Architecture Description of Software-Intensive Systems.* [Online] Available at: www.iso-architecture.org/ieee-1471 [Accessed 20 June 2008].

Anderson, P. & Backhouse, G., 2008. *Enterprise Architecture, An Introduction.* JISC Briefing Paper, September 2008. [Online] Available at: www.jisc.ac.uk/media/documents/publications/bpenterprisearchitecturev1.pdf [Accessed 10 November 2008].

Anderson, B., Brynin, M., Raban, Y. & Gershuny. J., 2006. *Information and Communications Technologies in Society: E-living in a Digital Europe.* London: Routledge.

Banister, D., Newson, C., and Ledbury, M., 2007. *The Costs of Transport on the Environment – the role of teleworking in reducing carbon emissions*. Oxford: Transport Studies Unit. [Online] Available at: http://www.tsu.ox.ac.uk/research/pubs/1024-banister-etal.pdf [Accessed 15 December 2008].

Barroso, L. & Holzle, U., 2007. The Case for Energy-Proportional Computing, *IEEE Compute,r* December 2007. [Online] Available at: www.barroso.org/publications/ieee_computer07.pdf [Accessed 31 December 2008].

Boys, J. & Ford, P., 2008. *The E-Revolution and Post Compulsory Education*. London: Routledge.

Bradley, R., 2008. CRC. [Email]. Message sent to Environmental Association of Universities and Colleges (EAUC) members-JISC mail. [Sent 5 February 2008].

British Standards Institute, 2008. PAS 2050 – Assessing the life cycle greenhouse gas emissions of goods and services. Milton Keynes. [Online] Available at: www.bsi-global.com/en/Standards-and-Publications/How-we-can-help-you/Professional-Standards-Service/PAS-2050 [Accessed 17 December 2008].

Brocade, 2008. *Brocade Green Market Research – Top-level findings*. Press release, no date. [Online] Available at: http://media.corporate-ir.net/media_files/irol/90/90440/BRCD_GreenMarketResearch.pdf [Accessed 6 October 2008].

Brownstein, M., 2008. Tips for Buying Green. *Processor*, 30 (3), 18 January 2008. [Online] Available at: www.processor.com/editorial/article.asp?article=articles/p3003/22p03/22p03.asp [Accessed 1 October 2008].

Business in the Community (BITC) *et al*., 2008. *Universities that Count*. London. [Online] Available at: www.bitc.org.uk/resources/publications/universities_count.html [Accessed 8 September 2008].

Cabinet Office, 2008. *Greening Government ICT*. [Online] London. Available at: www.cabinetoffice.gov.uk/~/media/assets/www.cabinetoffice.gov.uk/publications/reports/greening_government/greening_government_ict pdf.ashx. [Accessed 28 July 2008].

Cairns, S. *et al*., 2004. *Smarter Choices - Changing the way we travel.* [Online] Report for the UK Department for Transport, July 2004. Available at: www.dft.gov.uk/stellent/groups/dft_susttravel/documents/page/dft_susttravel_029721.hcsp [Accessed 23 June 2008].

Carbon Trust, 2008a. *Employee Awareness Posters – fact calculations*. [Online] Available at: www.carbontrust.co.uk/energy/startsaving/posterfactcalculations.htm [Accessed 30 November 2008].

Carbon Trust, 2008b. *Carbon Trust joins up with British Computer Society to cut carbon from data centres*. Press release, 26 June 2008. [Online] Available at: www.carbontrust.co.uk/News/presscentre/British-Computer-Society.htm [Accessed 30 December 2008].

Carr, N, 2006. Avatars consume as much electricity as Brazilians. Rough Type blog, 5 December 2006. [Online] Available at: http://www.roughtype.com/archives/2006/12/avatars_consume.php [Accessed 31 December 2009].

Cartledge, C., 2008a. *Sheffield ICT Footprint Commentary*. Report for SusteIT. [Online] Available at: www.susteit.org.uk (under tools). [Accessed 20 November 2008].

Cartledge, C. 2008b. Personal Communication between Chris Cartledge, formerly University of Sheffield and Peter James, 30 December 2008.

Center for Clean Products and Clean Technologies, 2008. Electronics Environmental Benefit Calculator, [Online] Available at: http://eerc.ra.utk.edu/ccpct/eebc/eebc.html. [Accessed 3 October 2008].

Cisco, 2007. *How Cisco Achieved Environmental Sustainability in the Workplace*. Case study. [Online] Available from: www.cisco.com/web/about/ciscoitatwork/downloads/ciscoitatwork/pdf/Cisco_IT_Case_Study_Green_Office_Design.pdf [Accessed 30 November 2008].

Cisco, 2008. *Real Estate Today: A Market Transformation*. No publication information. [Online] White Paper. Available at: www.cisco.com/web/strategy/docs/trec/Realestatetodayamarkettransformation_v2.pdf [Accessed 28 July 2008].

Climate Group, 2008. *Smart 2020 – Enabling the Low Carbon Economy in the Information Age*. Global eSustainability Initiative. www.theclimategroup.org/assets/resources/publications/Smart2020Report.pdf [Accessed 1 August 2008].

Cohen, S., Oren, G. and Maheras G., 2008. Empowering IT to Optimize Storage Capacity Management. NetApp White Paper. November 2008. [Online] Available at: http://media.netapp.com/documents/wp-7060-empowering-it.pdf [Accessed 31 December 2008].

Collis, B., 2002. Information technologies for education and training. In: Adelsberger, H., Collis, B. & Pawlowski, J. (eds) *Handbook on Technologies for Information and Training*. Berlin: Springer Verlag.

Committee of University Chairmen (CUC), 2004. *Guide for Members of Higher Education Governing Bodies in the UK*. November 2004. [Online]. Available at: www.hefce.ac.uk/pubs/hefce/2004/04_40 [Accessed 25 November 2008].

Communities and Local Government (CLG), 2008. Display Energy Certificate webpage. [Online] Available at: www.communities.gov.uk/planningandbuilding/theenvironment/energyperformance/publiccommercialbuildings/displayenergycertificates [Accessed 5 August 2008].

Copeland, M., 2008. Plastic Fantastic. *Fortune*, 9 September 2008. [Online] Available at: http://techland.blogs.fortune.cnn.com/2008/09/09/plastic-fantastic [Accessed: 3 November 2008].

Crainer, S., 2008. Keeping an eye on Big Brother, The Independent. 3 June 2008. Available at: http://findarticles.com/p/articles/mi_qn4158/is_/ai_n25482212 [Accessed 10 November 2008].

Denegri, S., 2008. Microsoft and Google: Cloud Computing Dominance Through Renewable Energy. *Virtual Strategy Magazine*, 30 October 30 2008. [Online] Available at: www.virtual-strategy.com/Features/Abstract-Microsoft-and-Google-Cloud-Computing-Dominance-Through-Renewable-Energy.html [Accessed 31 October 2008].

UK Department for Business, Enterprise & Regulatory Reform (BERR), 2006. *WEEE Regulations 2006. Government Guidance Notes*, December 2007. [Online] Available at: www.berr.gov.uk/files/file42909.pdf [Accessed 15 August 2008].

Department for Business Enterprise & Regulatory Reform (BERR), 2008a. *Consultation Document on the Implementation of the Batteries and Accumulators and Waste Batteries and Accumulators Directive (2006/66/EC)*. [Online] Available at: www.berr.gov.uk/consultations/page43278.html [Accessed 15 August 2008].

Department for Business, Enterprise & Regulatory Reform (BERR), 2008b. *UK Renewable Energy Strategy Consultation*. June 2008. [Online] Available at: www.berr.gov.uk/energy/sources/renewables/strategy/page43356.html [Accessed 13 August 2008].

Department for Environment, Food & Rural Affairs (Defra), 2007a. UK Government Sustainable Procurement Action Plan. [Online] Available at: http://www.sustainable-development.gov.uk/publications/pdf/SustainableProcurementActionPlan.pdf [Accessed 5 November 2008].Department for Environment, Food & Rural Affairs (Defra), 2007b. *Consultation on the promotion of energy end-use efficiency and energy services. Implementing Article 5 of Directive 2006/32/EC in the UK.* December 2007. [Online] Available at: www.defra.gov.uk/corporate/consult/energyservices-article5/consultation-document.pdf [Accessed 30 June 2008].

Department for Environment, Food & Rural Affairs (Defra), 2008a. Buy Sustainable – Quick Wins. [Online] Available at: www.defra.gov.uk/sustainable/government/what/priority/consumption-production/quickWins/index.htm [Accessed 5 November 2008].

Department for Environment, Food & Rural Affairs (Defra), 2008b. *Guidelines for Greenhouse Gas Conversion Factors for Company Reporting*. [Online] Available at: www.defra.gov.uk/environment/business/envrp/conversion-factors.htm [accessed June 2008].

Department for Environment, Food & Rural Affairs (Defra), 2008c. *Carbon Reduction Commitment* webpages. [Online] Available at: www.defra.gov.uk/environment/climatechange/uk/business/crc/index.htm [Accessed 11 August 2008].

Duke & Jordan Ltd., 2008a. *JISC Study of Shared Services in UK Further and Higher Education. Report 1: The current landscape of shared systems*. Report for JISC by Duke & Jordan Ltd with AlphaPlus Ltd, M. Auckland, C. Cartledge, S. Marsden and B. Powell. [Online]. Available at: www.jisc.ac.uk/media/documents/programmes/jos/sharedservicesreport1.pdf [Accessed 10 November 2008].

Duke & Jordan Ltd., 2008b. *JISC Study of Shared Services in UK Further and Higher Education. Report 4: Conclusions and Proposals.* Report for JISC by Duke & Jordan Ltd with AlphaPlus Ltd, M. Auckland, C. Cartledge, S. Marsden and B. Powell. [Online]. Available at: www.jisc.ac.uk/media/documents/programmes/jos/jisc_shared_services_report_4 .pdf [Accessed 10 November 2008].

Dwelly, T. and Lake A., (eds.), *Can Homeworking Save the Planet? How homes can become workspace in a low carbon economy*. London: Smith Institute, 2008. [Online] Available at: http://www.smith-institute.org.uk/pdfs/can_homeworking_save_the_planet.pdf [Accessed 11 December 2008].

ECMA, 2007. Environmental criteria comparison between TED – The Eco Declaration, ECMA-370 for Personal Computers and TCO, Blue Angel, EU Flower, Nordic Swan, US EPEAT. Version 1. 2007. [Online] Available at: www.hp.com/hpinfo/globalcitizenship/environment/pdf/iteco_comp_pcs.pdf [Accessed 14 October 2008].

ECMA website, undated. [Online] Available at: www.ecma-international.org/publications/standards/Ecma-370.htm [Accessed 5 October 2008].

Economist Intelligence Unit, 2008. *The future of higher education: How technology will shape learning*. Report for the New Media Consortium. [Online] Available at: www.nmc.org/pdf/Future-of-Higher-Ed-(NMC).pdf [Accessed 10 October 2008].

Electronics Industry Citizenship Coalition, 2005. *Electronics Industry Code of Conduct*. [Online] Available at: www.eicc.info/downloads/EICC_English.pdf [Accessed 21 April 2008].

Emerson, 2007. *Energy Logic, Reducing Data Center Energy Consumption by Creating Savings that Cascade Across Systems*. [Online] White Paper. Available at: www.liebert.com/common/ViewDocument.aspx?id=880 [Accessed 23 June 2008].

Environment Agency, 2008. [Figures on UK WEEE arisings] (Email Personal Communication 18 August 2008). Personal Communication between Waste and Industry Regulation Service, Environment Agency and Lisa Hopkinson, SUSTEIT on 18 August 2008.

Environmental Association for Universities and Colleges (EAUC), 2007. *WEEE Insight Guide*. [e-Book] Available at: www.eauc.org.uk/file_uploads/weee_insight_guide_1.pdf [Accessed 11 August 2008].

Environmental Resources Management (ERM), 2008. *Mapping and analysis of sustainable product standards*. Report for Defra, March 2008. [Online]. Available at: www.defra.gov.uk/environment/consumerprod/pdf/MTP-ProductAssessmentStandards.pdf [Accessed 29 October 2008].

EPEAT website, undated. [Online] Available at: www.epeat.net [Accessed: 3 October 2008].

EU Energy Star website, undated. Available at: www.eu-energystar.org/en [Accessed 25 November 2008].

Eugster, M., Hischier, R. & Duan, H., 2007. Key Environmental Impacts of the Chinese EEE-Industry. A Life Cycle Assessment Study. [Online]. Available at: http://ewasteguide.info/Eugster_2007_Empa [Accessed 20 October 2008].

European Commission, 2008a. *Eco-design of Energy-Using Products. On going product specific preparatory studies*. [Online] Available at: http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm [Accessed 12 May 2008].

European Commission, 2008b. *Energy Efficiency*. [Online] Webpage. Available at: http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm#consultation_forum [Accessed 11 August 2008].

European Commission, 2008c. *Decision of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020*. Communication COM (2008) 17 Final, January 2008. [Online] Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0017:FIN:EN:PDF [Accessed 11 August 2008].

European Commission Joint Research Centre, 2007. *Code of Conduct on Data Centres Energy Efficiency, Version 1.0*. 30 October 2008. [Online] Available at: http://sunbird.jrc.it/energyefficiency/html/standby_initiative_data%20centers.htm [Accessed 10 November 2008].

European Telecommunications Network Operators Association (ETNOA) and World Wide Fund for Nature (WWF), 2006. *Saving the climate @ the speed of light. First road map for reducing CO_2 emissions in the EU and beyond*. [Online] Available at: www.etno.be/Portals/34/ETNO Documents/Sustainability/Climate Change Road Map.pdf [Accessed 21 October 2008].

Forum for the Future, 2007. Future Leaders Survey 2006/07. 23 January 2007. [Online] Available at: www.forumforthefuture.org/node/865 [Accessed 21 October 2008].

Fraunhofer Institute for Environmental, Safety and Energy Technology, 2007. *Environmental comparison of PC and thin client desktop equipment*. [Online] Oberhausen 2007. Available at: http://it.umsicht.fraunhofer.de/TCecology/docs/TCecology_en.pdf [Accessed 12 May 2008].

Fujitsu Siemens Computers and Knürr, 2007. *Energy Efficient Infrastructures for Data Centers*. [Online] White Paper. July 2007. Available at: http://sp.fujitsu-siemens.com/dmsp/docs/wp_energy_efficiency_knuerr_fsc.pdf [Accessed 23 June 2008].

Gartner Consulting, 2007. *Gartner Estimates ICT Industry Accounts for 2 Percent of Global CO2 Emissions*. Press Release 26 April 2007. [Online] Available at: http://www.gartner.com/it/page.jsp?id=503867 [Accessed 31 December 2008].

Global Action Plan, 2007. *An Inefficient Truth*. December 2007. [Online] Available at: www.globalactionplan.org.uk/event_detail.aspx?eid=2696e0e0-28fe-4121-bd36-3670c02eda49 [Accessed 23 June 2008].

Greenpeace International, 2008a. *Toxic Tech – Not in Our Backyard*. February 2008. [Online] Available at: www.greenpeace.org/raw/content/international/press/reports/not-in-our-backyard.pdf [Accessed 15 August 2008].

Greenpeace International, 2008b. Brigden, K., Labunska, I., Santillo, D. & Johnston, P., *Chemical contamination at e-waste recycling and disposal sites in Accra and Korforidua, Ghana*. August 2008. [Online] www.greenpeace.org/raw/content/international/press/reports/chemical-contamination-at-e-wa.pdf [Accessed 15 August 2008].

Guardian, 2008. Libraries Unleashed. *Education Guardian* supplement. 22 April 2008. [Online] Available at: http://education.guardian.co.uk/librariesunleashed [Accessed 5 October 2008].

HEEPI, 2008a. Green Gown brochures. [Online] Available at: www.heepi.org.uk [Accessed 27 November 2008].

HEEPI, Sust & Thirdwave, 2008b. High Performance Building Reports. [Online] Available at www.heepi.org.uk [Accessed 27 November 2008].

Higher Education Funding Council for England (HEFCE), 2008. *Sustainable development in higher education*. [Online] Consultation on 2008 update to strategic statement and action plan. Available at: www.hefce.ac.uk/pubs/hefce/2008/08_18 [Accessed 25 November 2008].

Hilty, L., 2008. *Information Technology and Sustainability*. Nordersedt: Herstellung und Verlag.

Holzle, U., 2009. Powering a Google search. Googleblog 11 January 2009. http://googleblog.blogspot.com/2009/01/powering-google-search.html [Online] Available at: [Accessed 12 January 2009].

Hopkinson, L. & James, P., 2007. *Carbon Reduction Regulation and Higher Education – The EU-Emission Trading Scheme, Display Energy Certificates and the Carbon Reduction Commitment*. HEEPI Final Report v4, 4 June 2007. Available at: www.heepi.org.uk [Accessed 23 June 2008].

Hopkinson, P., James, P. & Maruyama, T., 2003. *Conferencing at BT – results of a survey on its economic, environmental and social impacts.* [Online] Report by SustainIT, UK CEED, Peterborough, 2003. Available at: www.sustainit.org/publications/files/8-Conferencing_report_2003.pdf [Accessed 21 October 2008].

Huber, P. & Mills M.P., 1999. Dig more coal – the PCs are coming. *Forbes*, 31 May, pp.70–72.

Hutt, J.-C., 2006. Energy Efficiency and Intelligent Buildings. Presentation for Schneider Electric at CBA Conference, Cambridge, May 2006. [Online] Available at: http://cba.mit.edu/events/06.05.energy/hutt.ppt [Accessed 21 October 2008].

IBM Global Technology Services, 2007. *'Green IT': the next burning issue for business*. January 2007. [Online] Available at: www-935.ibm.com/services/uk/igs/pdf/greenit_pov_final_0107.pdf [Accessed 23 June 2008].

Indepen & Ovum, 2005. Achieving the Lisbon Agenda: the contribution of ICT. A report for Brussels Round Table. Executive Summary. [Online]. Available at: www.indepen.co.uk/docs/achieving_the_lisbon_agenda-summary.pdf [Accessed 20 November 2008].

Industry Council for Electronic Waste Recycling (ICER), 2004. *WEEE – Green List Waste: A Study for the Environment Agency.* Available at: www.icer.org.uk/ExportsReportFinal.pdf [Accessed 11August 2008].

IVF Industrial Research and Development Corporation, 2007. *Lot 3: Personal Computers (desktops and laptops) and Computer Monitors.* Final Report (Task 1–8). Preparatory studies for Eco-design Requirements of EuPs. Report for the European Commission, August 2007. [Online] Available at: http://extra.ivf.se/ecocomputer/downloads/Eup Lot 3 Final Report 070913 published.pdf [Accessed 15 May 2008].

James, P., 2007. Conferencing at DFID - The Economic, Environmental and Social Impacts. Peterborough: SustainIT. [Online] Available at: http://www.sustainit.org/publications/conferencing_at_dfid_may_%2007.doc [Accessed 1December 2008].

James, P., 2008. 'Homeworking and carbon reduction - the evidence'. Chapter in Dwelly, T. and Lake A., (eds.), *Can Homeworking Save the Planet? How homes can become workspace in a low carbon economy.* London: Smith Institute, 2008. [Online] Available at: http://www.smith-institute.org.uk/pdfs/can_homeworking_save_the_planet.pdf [Accessed 11 December 2008].

James, P. & Hopkinson, L., 2008a. *Energy and Environmental Impacts of Personal Computing*. A Best Practice Review prepared for the Joint Information Services Committee (JISC). [Online] Available at: www.susteit.org.uk [Accessed 31 December 2008].

James, P. & Hopkinson, L., 2008b. *Energy Efficient Data Centres in Further and Higher Education*. A Best Practice Review prepared for the Joint Information Services Committee (JISC). [Online] Available at: www.susteit.org.uk [Accessed 31 December 2008].

James, P. & Hopkinson, L., 2008c. *Energy Efficient Printing and Imaging in Further and Higher Education*. A Best Practice Review prepared for the Joint Information Services Committee (JISC). [Online] Available at: www.susteit.org.uk [Accessed 31 December 2008].

James, P. & Hopkinson, L., 2008d. *Results of the 2008 SusteIT Survey*. A Best Practice Review prepared for the Joint Information Services Committee (JISC). [Online] Available at: www.susteit.org.uk [Accessed 31 December 2008].

JISC InfoNet, 2008. *Exploring Tangible Benefits of e-Learning*. Newcastle: Northumbria University.

Johnson, B., 2008. The brains behind the operation. *Guardian*, 30 June 2008. [Online] Available at: www.guardian.co.uk/science/2008/jun/30/cern.computer.technology [Accessed 21 October 2008].

Johnson Controls, 2008. *Johnson Controls and IBM Develop Software Solution to Help Data Center Management*. Press Release, 11 July 2008. [Online] Available at: http://www.johnsoncontrols.co.uk/publish/gb/en/news.html?newsitem=http%3A%2F%2Fjohnsoncontrols.mediaroom.com%2Findex.php%3Fs%3D113%26amp%3Bitem%3D1619 [Accessed 31 December 2008].

Kiatkittipong, W., Wongsuchoto, P., Meevasana, K. & Pavasant, P., 2008. When to buy new electrical/electronic products? *www.sciencedirect.com/science/journal/09596526*, September 2008.

Kilner, 2008 [Discussion procurement specifications] (Personal Communication, 11 December 2008). Personal Communication between Mike Kilner, LUPC Commodity Group Manager (Computing), National Notebook Agreement Group (Chairman), Inter-Regional PC Group (Chairman), London Universities Purchasing Consortium and Lisa Hopkinson, SUSTEIT, 11 December 2008.

Kohler, A. & Erdmann, L., 2004. Expected Environmental Impacts of Pervasive Computing. *Human and Ecological Risk Assessment*, 10: 831–852. [Online] Available at: www.empa.ch/plugin/template/empa/*/51472/---/l=2 [Accessed 21 October 2008].

Koomey, J., 2007, *Estimating Total Power Consumption by Servers in the US and the World*. February 2007. [Online] Available at: http://enterprise.amd.com/Downloads/svrpwrusecompletefinal.pdf [Accessed 23 June 2008].

Lawrence, A., 2008. *The Next Phase of Green IT*. Presentation to European Green IT Summit, Sheraton Park Lane Hotel, London, 14 March 2008.

Leake, J. and Woods, R., 2009. 'Revealed: the environmental impact of Google searches', The Sunday Times, 11 January 2009. [Online] Available at: http://technology.timesonline.co.uk/tol/news/tech_and_web/article5489134.ece [Accessed 12 January 2009].

Learning and Skills Council (LSC), 2006. *Learner number and enrolment analyses 2005–06*. [Online] Available at: www.lsc.gov.uk/providers/Data/statistics/learner/KeyFacts.htm [Accessed 31 October 2008].

Lightfoot, L., 2008. Click twice for the online revolution. *Independent*, 19 June 2008.

Madden, P. & Weißbrod, I., 2008. *Connected – ICT and sustainable development*. London: Forum for the Future. April 2008. [Online] Available at: www.forumforthefuture.org.uk/files/Connected.pdf [Accessed 29 August 2008].

Madsen, J., 2008. The Realization of Intelligent Buildings. *Buildings.com*, March 2008. [Online] Available at: www.buildings.com/articles/detail.aspx?contentID=5736 [Accessed 29 August 2008].

Market Transformation Programme (MTP), 2007. *Chapter 5. Improving the energy performance of information and communication technology products.* Consultation on sustainable products – improving the efficiency of energy-using products, December 2007. [Online] Available at: www.mtprog.com/Whitepaper.aspx [Accessed 23 June 2008].

Market Transformation Programme (MTP), 2008. *Policy Analysis and Projections 2006/08*. [Online]. Available at: www.mtprog.com/ReferenceLibrary/10_07_08 PA&P 08 v1.pdf [Accessed 30 November 2008].

Marshall, R., 2008. Illegal African E-waste Dumping Highlights Need for Better Policies. *Greener Computing*, 25 August 2008. [Online] Available at www.greenercomputing.com/news/2008/08/25/illegal-african-e-waste-dumping-highlights-need [Accessed 11 August 2008].

McAndrew, L., 2008. [Discussion Energy-Using Products Directive]. Personal communication between Laure McAndrew, Market Transformation programme, Defra, and Lisa Hopkinson, 5 November 2008.

Microsoft, 2008. Special Issue on Green Computing. *The Architecture Journal*, 18. [Online] Available at: http://msdn.microsoft.com/en-us/library/bb410935.aspx [Accessed 31 December 2008].

Moberg, A., Johansson, M., Finnveden, G. & Jonsson, A., 2007. Screening environmental life cycle assessment of printed, web based and tablet e-paper newspaper. [Online] Available at: www.infra.kth.se/fms/pdf/Report_epaper_final.pdf [Accessed 31 October 2008].

National Audit Office (NAO), 2006. *Improving procurement in further education colleges in England*. Report by the Comptroller and Auditor General, HC 1632 Session 2005–2006, 25 October 2006. [Online]. Available at: www.nao.org.uk/publications/nao_reports/05-06/05061632.pdf [Accessed 23 June 2008].

National Audit Office (NAO), 2007. *Improving the disposal of public sector ICT equipment*. Report by the Comptroller and Auditor General, HC 531, 31 July 2007. [Online] Available at: www.nao.org.uk/pn/06-07/0607531.htm [Accessed 23 June 2008].

National Weights and Measures Laboratory, 2008. RoHS website. [Online] Available at: www.rohs.gov.uk [Accessed 11 August 2008].

NetRegs, 2008a. RoHS webpage. [Online] Available at: www.netregs.gov.uk/netregs/275207/1628456/?lang=_e [Accessed 11 August 2008].

O'Brien, S., 2008. *Green Electronics Purchasing*. Presentation on behalf of Green Electronics Council at NYS Forum event Green IT: IT's easy being GREEN, 10 April 2008, Albany, New York. [Online]. Available at: www.nysforum.org/documents/ppt/2008/itgreening/EPEATOBrien.ppt [Accessed 15 April 2008].

Office of National Statistics, 2007. *Population estimates for UK, England and Wales, Scotland and Northern Ireland - current datasets*. Table 1 United Kingdom. Table 4 England. 21 August 2008. [Online] Available at: http://www.statistics.gov.uk/statbase/Product.asp?vlnk=15106 [Accessed 31 December 2008].

Oliver, R., 2005. Ten more years of educational technologies in education: How far have we travelled? *Australian Educational Computing*, 20(1): 18–23.

Pamlin, D. (ed.), 2002. *Sustainability at the Speed of Light*. Stockholm: World Wildlife Fund for Nature.

Park, J. & Roome, N. (eds), 2002. *The Ecology of the New Economy: Sustainable Transformation of Global Information, Communications and Electronics Industries*. Sheffield: Greenleaf Publishing.

Parliament, 2008. *Climate Change Bill [HL] 2007–08*. Bills and Legislation homepage. [Online] Available at: http://services.parliament.uk/bills/2007-08/climatechangehl.html [Accessed 7 November 2008].

People and Planet, 2006. *Going Green. How UK universities can improve their environmental performance and help stop climate chaos*. [Online] Available at: http://peopleandplanet.org/gogreen/report.php [Accessed 10 November 2008].

People and Planet, 2008. *The Green League*. [Online] Available at: http://peopleandplanet.org/greenleague [Accessed 21 October 2008].

Platt, M., 2002. *Microsoft Architecture Overview*, 2002. Article for Microsoft Corporation. [Online] Available at: http://msdn2.microsoft.com/en-gb/architecture/ms978007.aspx [Accessed 28 March 2008.]

Prompt, 2008. *Next-Generation Internet to reduce global warming (Green NGI)*. [Online] Available at: http://www.promptinc.org/documents/NGI_release_en_v2.pdf [Accessed 31 December 2008].

Ramsay, D., 2008. *UC San Diego's GreenLight Project to Improve Energy Efficiency of Computing.*. Press Release, 28 July 2008. [Online] Available at: http://ucsdnews.ucsd.edu/newsrel/science/07-08GreenLightProj.asp [Accessed 11 August 2008].

Riley, P., 2008. Personal Communication between Phil Riley, Energy Manager, University of Sheffield and Lisa Hopkinson. 11 June 2008.

Roy, R., Potter, S., Yarrow, K. & Smith, M., 2005. www3.open.ac.uk/events/3/2005331_47403_o1.pdf, Final Report, Milton Keynes: Open University Design Innovation Group, March. (Report DIG-08).

Ruiz, Y. & Walling, A., 2005. Home-based working using communication technologies. *Labour Market Trends*, 113 (10), 2005, pp.417–426. [Online] Available at: www.statistics.gov.uk/CCI/article.asp?ID=1284&Pos=1&ColRank=2&Rank=624 [Accessed 21 October 2008].

Schulz, G., 2007. *Business Benefits of Data Footprint Reduction*. StorageIO Group, 15 July 2007. Available at: www.storageio.com/Reports/StorageIO_WP_071507.pdf [Accessed 5 August 2008].

Schulz, G., 2008. *Maid 2.0 – Energy Savings Without Performance Compromises*. StorageIO Group, 2 January 2008. Available at: www.storageio.com/Reports/StorageIO_WP_Dec11_2007.pdf [Accessed 13 August 2008].

Smith, A., 2008. Personal communication between Andrew Smith, Head of Estates and Sustainable Development, HEFCE and Lisa Hopkinson. 14 August 2008.

SUSTEL, 2004. *Is Teleworking Sustainable? – An Analysis of its Economic, Environmental and Social Impacts.* UK Centre for Economic and Environmental Development, Peterborough, 2004. Available at: www.sustel.org [Accessed 28 April 2008].

Toplass, S., 2008. [Discussion procurement] Personal Communication between Simon Toplass, Head of Consortium, North East Universities Procurement Group (NEUPG) and Lisa Hopkinson, SUSTEIT, February 2008.

US Environment Protection Agency (USEPA), 2007a. *Report to Congress on Server and Data Center Energy Efficiency*. August 2007. [Online] Available at: www.energystar.gov/index.cfm?c=prod_development.server_efficiency_study [Accessed 23 June 2008].

US Environment Protection Agency (USEPA), 2007b. *ENERGY STAR® Specification Framework for Enterprise Computer Servers.* [Online] Available at: www.energystar.gov/index.cfm?c=new_specs.enterprise_servers [Accessed 23 June 2008].

US Green Electronics Council, 2008. Environmental Benefits of 2007 EPEAT Purchasing. May 2008. [Online] Available at: www.epeat.net/Docs/EnvironmentalBenefits2007.pdf [Accessed: 29 October 2008].

US Green Electronics Council, undated. EPEAT criteria. [Online] Available at: www.greenelectronicscouncil.org/epeat/criteria.htm [Accessed 3 October 2008].

VHK, 2005. *Methodology Study Eco-design of Energy-using Products. (MEEUP). Product Cases Report.* Final report to the European Commission, November 2005. [Online] Available at: www.vhknet.com/download/MEEUP_ProductCases_fin.pdf [Accessed 15 May 2008].

Williams, E., 2003. Environmental impacts in the production of personal computers. In: Kuehr, R. & Williams, E., eds, *Computers and the Environment. Understanding and Managing the Impacts.* Netherlands: Kluwer Academic Publishers and United Nations University.

Williams, E., 2004. Energy intensity of computer manufacturing: hybrid assessment combining process and economic input-output methods. *Environ. Sci. Technol.*, 2004, 38, 6166–6174.

Williams, E., 2008. Personal communication. 13 November 2008.

Wilsden, J. (ed.), 2001. *Digital Futures*. London: Earthscan.

Worrall, B., 2008. A Green Budget Line. *Forbes*, 28 July 2008. Available at: www.forbes.com/technology/2008/07/27/sun-energy-crisis-tech-cio-cx_rw_0728sun.html [accessed 11 August 2008].

Wyse, 2007. Review of Technologies. Paper for SCHOMS Getting VFM from Printing and Copying project. June 2007. Available at: www.lboro.ac.uk/mediaservices/ex/schoms/printing/outcomes/tech.html [accessed October 2008].

Sustainable ICT in Further and Higher Education

Further information about JISC:
Web: www.jisc.ac.uk
Email: info@jisc.ac.uk
Tel: +44 (0)117 33 10789

Document Nº: 508
Version 1.1 January 2009