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# Low Carbon Computing: a view to 2050 and beyond

(Executive Summary)

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# Low carbon computing: a view to 2050 and beyond

## Executive Summary

The UK is the first country in the world to introduce a legally binding framework for tackling climate change and the implications of this are likely to be far reaching for the public sector. Over the coming years targets will be set, carbon emission budgets agreed and strategies and plans announced: all with the overall goal of cutting the UK's emissions by 80% of 1990 levels, by 2050. What will this mean for the ICT sector, and in particular for those responsible for information services in higher and further education? This report sets out to explore how reducing greenhouse gases produced by ICT will play out in practice and what the future may hold.

The impact of ICT on the environment has both positive and negative aspects. For example, a video-conferencing service for a college may use electricity, but the overall environmental impact will be small compared to the carbon emissions created by travel. In-use electricity consumption is not the only concern. A systemic view of ICT takes into account, in a structured way, supply chain management and social and environmental factors. However, for the purpose of this report we class these wider concerns as part of the 'green' or 'sustainable' ICT agenda, for which JISC has already published work. This TechWatch report will therefore focus on so-called first and second order impacts: direct environmental impact of equipment and facilities and the impact of policies and process for control/use of equipment.

In line with much current thinking we use the term 'low carbon' to describe this primary focus on reducing greenhouse gas emissions, whilst acknowledging the difficulties inherent in this term. In addition, whilst TechWatch's remit is usually to scan the five- to ten-year horizon, this report takes a perspective over 30+ years. This reflects the long-term nature of current, primarily European horizon scanning, which will increasingly drive climate change abatement measures across national boundaries, and which already takes a view (albeit sketchy) to 2100. There is however a caveat with respect to outlying risk scenarios as technology is notoriously difficult to predict over such long timescales, not least because of the pace of change in materials development and so-called 'Black Swan' events.

**Summary**
Since the passing of the Climate Change Act, the UK Low Carbon Transition Plan has been published. This sets out strategic plans and targets that need to flow from the legal framework established in the Act. Of most relevance to HE is the section on the workplace (section 5) and, within that, plans for greenhouse gas reduction within the public sector. Whilst business workplaces in general will be expected to provide an overall reduction of about 13%, the public sector is expected to reduce by 30% of 1999/2000 levels by 2020. The TechWatch report explains that it is likely that data-intensive sectors such as tertiary education will probably find themselves facing even harsher targets and argues that the impetus will fall not only on reducing demand but also on generating supply. In summary, the report covers:

- best practice measures and standards for metrics (section 3)
- short term 'quick fixes' based on simple staff actions and/or low cost investment (section 4)
- longer term solutions that either represent a more costly investment, or are based on more experimental technologies (section 4)
- discussion of the factors that are likely to affect how these technologies develop in the future
- a first attempt at a Low Carbon ICT Roadmap, which puts these issues into a framework that also takes into account what is currently known about the targets associated with the Climate Change Act (section 6)
- a discussion of the factors and technologies that are likely to feature in the long-term plans and decisions that senior managers in tertiary education will need to make (section 5).

## Low Carbon ICT Roadmap (evolving)

| | Data centres | End user devices | Storage | Networks | Printers | Cross-sector planning and knowledge sharing: technology testing and data sharing; low carbon shared services; development of enterprise architectures to ensure that business processes and ICT are optimised for energy efficiency |
|---|---|---|---|---|---|---|
| **2009** | **Climate Change Act (CCA) comes into effect. Low Carbon Transition Plan published.** | | | | | |
| | **HEFCE consulting on HE's contribution to national carbon reduction plan and strategy for achieving this.** | | | | | |
| | * Basic benchmark of existing data centre performance<br>* Review with respect to EU Code of Conduct/BCS tools suite | * Use device's power management software<br>* Implement switch off policy for evenings and weekends<br>* Disable screen savers | * Undertake storage life cycle review<br>* Consolidate individual user disks | * Review equipment in light of EU Broadband Code of Conduct | * Make use of 'quick' wins such as recycled paper, lower weight paper, black/white printing, etc. | |
| **2010** | **April: introduction of Carbon Reduction Commitment (CRC) in public sector with "larger institutions" expected to participate in a test of the carbon allowance market mechanism. In this phase, carbon allowances will not be controlled. In tandem, by spring, all government departments to have produced their own carbon reduction plan.** | | | | | |
| | * Incorporate simple airflow 'fixes' such as sealing floor voids<br>* Consolidate servers and/or purchase more efficient equipment (e.g. blades, multi-core)<br>* Advanced power management<br>* Decommission unused servers<br>* Virtualise at server level<br>* Explore use of voltage conditioning equipment<br>* Explore potential for fresh air/liquid cooling<br>* Track shared services/JANET shared data centre developments<br>* Publication of JISC reports into academic uses of cloud computing (May) | * Instigate centrally controlled power management<br>* Buy Energy Star 5.0 rated PCs<br>* Buy most efficient power supplies (>80% efficient)<br>* Explore local advantages and disadvantages of thin clients, shared PCs, energy-efficient 'fat clients' and 'slim clients' | * De-duplicate data<br>* Virtualise storage disks<br>* Instigate information systems architecture with a view to expanding this to an EA. Include analysis of virtualisation, SAN, NAS, MAID and SSD | * Explore network consolidation, virtual LANs and speed rationalisation<br>* Proxying Support for Sleep Modes (ECMA) and automatic port and network shutdown equipment start to appear | * Develop and implement campus-wide print strategy to reduce overall printing levels<br>* Consolidation of print devices/use of MFDs | |
| **2011** | **First sale of carbon allowances takes place in April. Participants will have to purchase allowances, at a fixed price, to cover their forecast emissions for 2011/12.** | | | | | |
| | * Airflow modelling and redesign of data centres<br>* Investigate operating | | * Use of hybrid disks (SSDs and hard disks)<br>* Green RAID and similar | * Purchase equipment based on new standard: for energy efficient Ethernet | | |

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| | equipment at higher temperatures than recommended/optimum (preparing for new equipment operating guidelines from EU in 2012) | | technologies | (IEEE 802.3az) | | |
| **2013** | **Total amount of carbon allowances to be capped under the CRC and allowances are auctioned to determine a market price. Second phase of carbon budgets begins.** | | | | | |
| | * Fuel cells for UPS (hydrogen?)<br>* Explore possible DC power re-equip<br>* Possible introduction of 'adaptive' data centres | * OLED display monitors<br>* Power-efficient operating systems<br>* Many-core CPUs (with thermal load balancing)<br>* Thermionic co-power<br>* Zero-standby-dissipation technology | * Widespread use of dynamic power management | * Widespread use of centralised power management software | * Possible introduction of reusable paper | |
| **2018** | **All new public sector buildings to be 'zero carbon'. Third phase of carbon budgets begins.** | | | | | |
| **2020** | **Public sector to have cut greenhouse gas (GHG) emissions by 30% on 1999/2000 levels. 30% of all electricity to come from renewables.** | | | | | |
| | * Zero or very low power ICT through energy harvesting becomes available for data centres<br>*Data centres increasingly powered by renewable micro-generation | * Low power optical computing systems<br>* Zero or very low power ICT through energy harvesting for end user devices<br>* New display technologies such as field emission displays. | | | | |
| **2030** | **Low cost emission reductions from cuts in nitrous oxide and methane almost fully exploited. Bigger reductions to be made elsewhere.** | | | | | |
| **2050** | **>80% GHG reduction from 1990 levels. Virtually all electricity to come from a mix of renewable sources, nuclear or fossil fuels where emissions are captured and stored safely for the long term.** | | | | | |

Key

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| UK Low Carbon Transition Plan | | European Environment Agency | | HEFCE | |

**To 2050 and beyond**
The requirement for data centres has been growing rapidly over the last few years due to the growth in online services, changes in architecture (the rise of 'cloud computing', which moves applications into the data centre) and the more general growth of information and data storage requirements. Universities and colleges are particularly data rich organisations and within the sector there are also specialised applications such as equipment control systems and high performance computing which have their own operational challenges on top of those that are faced within a typical data centre. It is therefore vitally important when considering the long-term future of the institutional ICT infrastructure to think about the future of the data centre.

**Problems with the cloud**
Many in the computer industry argue that we are in the midst of a paradigm shift as computing moves away from desktop PCs and migrates to the Internet 'cloud'. While planning for lower carbon ICT will inevitably involve examining the potential of a move to the 'cloud' there are significant obstacles, particularly to commercial cloud provision, that HE as a sector needs to take account of:

- Legal issues connected to the protection of data that require it to be kept within UK jurisdiction.
- The greenhouse gas emissions associated with connecting to the cloud. Until very recently there has been little attention paid to making network equipment and associated protocols energy efficient. The move to the cloud will result in a consequent rise in network traffic as users seek to access their remote data and make use of software services, and this could be particularly energy inefficient.

The report notes other developments, such as adaptive data centres and nano data centres, as examples of alternative ways of thinking about the issues.

**Generating supply to feed demand**
When planning for the medium- to long-term (2020 to 2050 and beyond) universities may well have to give consideration not only to reducing their consumption of electricity, but also to generating their own supplies. This should partly be considered a defensive move: it is entirely possible that we will be entering an age when relying on the national grid to supply the amount of energy required by data-intensive HEIs might become limited. Alternatively, this could be considered to be a unique opportunity for universities and colleges to plan ahead, think 'outside the box' and provide leadership in new innovation.

**Universities and colleges on the smartgrid**
It is almost certain that there will be a complete re-development of the electricity supply process over the next 20 years. This is known as the smartgrid and the vision is of a convergence between the Internet and the energy supply. The Internet will be used to exchange telemetry data that will optimise how the electricity supply system is used and also allow individuals and small-scale generators to 'feed in' electricity from their own renewable supply operations. One of the implications of all this, for the individual HE/FE institution or perhaps even faculty, will be that of micro-generation. It is not impossible to envisage a future in which any new proposal to introduce substantial amounts of new equipment such as ICT will need to be accompanied by a parallel proposal to demonstrate where the electricity is to come from, and micro-generation is likely to be a key part of such proposals.

**Rethinking the options: renewable energy and the merits of a DC supply**
There is already interest in the creation of a cross-sector data centre infrastructure, with JANET currently developing a sector-wide strategy that will look at bringing its shared services model to the provision of highly efficient, scalable solutions. How much more sensible would it be, for example, to site such a shared national data centre infrastructure near a renewable energy source such as tidal power? Discussions over the local provision of electricity lead into the debate about

the form of power being generated for use by ICT and the report also examines the potential of using a DC rather than AC power supply.

**Mitigating and adapting: a two-pronged approach**
Finally, the report looks at the second phase of the European Commission's strategy for dealing with climate change: adaptation. The Stern Review argued that the economic costs of adapting to climate change (e.g. making buildings more resilient to storm damage, improving flood defences) would be higher than the costs of avoiding climate change and this logic has resulted in a primary focus on *mitigating* climate change, so as to reduce its overall impact. However, as global temperatures rise they will bring changes in weather patterns, rising sea levels and increased frequency and intensity of extreme weather events such as storms, floods, droughts and heat waves. Even if we were able to convert to a low carbon economy overnight there would still be impacts from the climate change we've already incurred, and some adaptation will be needed.

To date, the primary role for ICT in terms of adaptation is envisioned as a fundamental infrastructure that underpins much of the day-to-day work of an institution. As such its role is being increasingly included in high level strategic planning through techniques such as LEAN thinking and Enterprise Architecture. It is early days, but as these high level plans will soon need to incorporate adaptation planning it is clear that ICT has a role to play, for example as a communication tool for exchanging data, best practice etc. about adaptation, and as a backbone for 'smart' technologies incorporated into our built environment (e.g. heating monitoring and control through building sensors).

However the key role that ICT will play in adaptation has yet to be really defined. Predicting the future accurately is notoriously difficult and this is especially true for low carbon computing. Due to the urgency of climate change there is a huge level of interest in reducing energy across all sectors of the economy, with money and research time being poured into developing energy efficient technologies and researching new energy sources. This is an extremely fluid area and we can expect great strides to be made in the next few years.

**Key Recommendations:**

1. The TechWatch report identifies several key, early stage technologies for which there is little reliable energy efficiency data or where data does not 'translate' to the typical HE/FE environment. As a trusted cross-sector organisation JISC should consider funding activity that either generates data or pools data generated by others to ensure that learning and good practice is shared and built on.

2. More consideration needs to be given to the issues involved in a move towards shared services and third party 'cloud' services. Connections need to be made with the emerging government plans for G-Cloud and further detailed work needs to be commissioned into these areas.

3. Investigative work should be funded into the practical reality of a wholly DC-supplied data centre built near a source of renewable energy.