intellect

High Tech: Low Carbon

The role of technology in tackling climate change

Foreword

HIGH TECH: LOW CARBON – THE ROLE OF TECHNOLOGY IN TACKLING CLIMATE CHANGE

The three most critical environmental challenges facing society today are climate change, resource degradation and pollution. At the heart of all three is energy efficiency and this is the area where the technology sector can make the most positive contribution.

This report looks at the role of technology in tackling climate change, the progress we have made to date and the significant challenges we, as a sector and stakeholder, face ahead.

The questions we are constantly asked by media, government and consumers focus on the energy efficiency of our products. What receive less attention are the beneficial environmental effects of technology across the whole economy, which are reducing energy consumption and emissions whilst improving productivity and competitiveness: a positive contribution that is too often forgotten or simply taken for granted.

In this report we look at both important areas.

Understanding where we are as a sector is vital if we are to take a lead in tackling climate change in the future. Intellect is therefore working with the University of Warwick to develop more systematic approaches to measuring our emissions. I also believe that the commitments we have identified will make a difference but can't be achieved alone. This report must help to kick-start further collaboration between industry, government and citizens.

Much good work has already been done by other organisations and companies, for instance, the CBI's Climate Change Task Force report 'Climate Change – everyone's business' is helping to set clear targets for UK business.

We have also initiated work with other partners outside the UK and a European version of this paper will be published by EICTA, the Brussels-based industry association representing the technology sector in Europe. A German version will also be published by BITKOM, our German counterpart and we intend to collaborate with both organisations in meeting our commitments.

We are only at the beginning of a long process in tackling climate change but we are building momentum. There is no doubt that technology has a positive role to play in meeting the challenge and this report makes it clear how we can do it.

John Higgins CBE
Intellect Director General

Executive Summary

HIGH TECH: LOW CARBON – THE ROLE OF TECHNOLOGY IN TACKLING CLIMATE CHANGE

Context

For the purposes of this document, the technology sector comprises the Information and Communications Technologies (ICT) and Consumer Electronics (CE) sectors, including defence and space-related IT. Collectively this sector now employs well over 1 million people and contributes around 10% of UK GDP – a greater share than the whole of agriculture (5.8%)[1] and all the automotive sectors (3.5%)[2] combined.

Introduction

The technology sector is a relatively new industry and has developed at extraordinary speed over the last few decades, and on a scale far beyond early predictions. It has evolved in response to the market pull of an environment where energy was not a major issue, where the sleeping giants of China and India were still snoozing, and where the kind of mass adoption we see today was no more than a pipe dream.

Technology now underpins most aspects of our daily lives and has transformed the way we interact with each other, the way we shop, access public services and run our businesses. But these developments come with associated costs: the vast majority of ICT and CE products and services use electricity, and as they become more and more pervasive, gross energy demand continues to rise.

In April 2007, Gartner estimated that the ICT sector was responsible for around 2% of global CO_2 emissions[3], approximately the same as the airline industry[4]. Moreover, the Energy Saving Trust[5] predicted that by 2020, 45% of domestic electricity will be consumed by ICT and CE products, in what they described as "a new ICE age"[6]. Both statements were accompanied by a barrage of press coverage emphasising the growing energy demand of our sector and its products.

But we are in a unique position – whilst on the one hand our products consume energy, on the other hand we provide technologies that help other sectors become more efficient. This report demonstrates that we understand and acknowledge the challenges we face, that we are working extremely hard to address them and are making good progress. It also explores the beneficial effects of our technologies, which enhance existing processes, enable new ways of working and transform behaviour, helping to create a lower-carbon economy.

This report is focused on energy efficiency, because energy efficiency is at the heart of the three biggest environmental problems that we now face: climate change, resource degradation and pollution

The report also emphasises the importance of the timely adoption of alternative, low carbon technologies in tackling climate change and sets out the actions that we will take as an industry to play our part.

This report is focused on energy efficiency, because energy efficiency is at the heart of the three biggest environmental problems that we now face: climate change, resource degradation and pollution. Energy efficiency reduces pollution and greenhouse gas emissions (in particular CO_2) and makes better use of limited resources. It is also an area where we as a sector can make the most substantial contribution.

1 Source – LANTRA
2 Source – SMMT (Society of Motor Manufacturers and Traders), website as at August 2007
3 Gartner Symposium/IT Expo, 26 April 2007 (http://www.gartner.com/it/page.jsp?id=503867)
4 These sectors are, however, of dramatically different size – the aviation industry contributes about 1 % of UK GDP and employs around 180,000 people; the ICT sector contributes 6.4% of UK GDP (ONS, 2006) and employs over five times as many people. Furthermore, atmospheric and other factors connected with aviation mean that the effect on climate change is between two and four times the emission level.
5 "The Ampere Strikes Back", Energy Saving Trust, July 2007
6 Information, Communications and Entertainment

On the one hand our products consume energy, on the other hand we provide technologies that help other sectors become more efficient

Part I Energy efficiency – problems and solutions for the technology sector

Energy efficiency measures that we implement will have to be robust enough to outweigh the kind of rapid growth and increasing proliferation that we have seen over the last decade and which look set to continue.

We start by addressing some of the challenges that we face regarding the energy use of our products and services. These include proliferation, standby (where energy is wasted when products are inactive), peripheral energy use (where only a fraction of the energy used is for core functions) and rapid obsolescence (where products are discarded and replaced at frequent intervals).

Most problems, including product inefficiency, standby and peripheral energy demand, relate to the "in-use" phase of a product's life, so most of the emphasis is on this stage of the lifecycle. However, the problem of rapid obsolescence is more of a design issue, so we also explore more holistic approaches like eco-design and voluntary agreements. Finally, to complete the picture, we also look at what we are doing to optimise efficiency in the manufacturing phase.

The boom in technology is both a benefit and a challenge: energy efficiency measures that we implement will have to be robust enough to outweigh the rapid growth and increasing proliferation that characterise our sector at the moment. This is challenging but achievable: in the ICT and CE sectors, orders of magnitude improvements in product efficiency are already a reality.

A quick look at some everyday devices like mobile phones, (now around 100 times more efficient than in 1990) demonstrates that dramatic efficiency improvements are being made over relatively short timescales. We are also tackling the problem of standby losses by reducing standby power consumption and by providing power management tools that turn devices off. Peripheral energy use is a problem which has not yet been solved, particularly in the data centre environment, but solutions do exist, and now need to be implemented.

The unprecedented speed of innovation within the technology sector has a downside – rapid obsolescence as products are superseded by new and better models. Besides the waste issue there is a significant energy impact. Eco-design in particular, and voluntary agreements to an extent, are providing some solutions and the technology industry is taking a leading role in such initiatives.

Technology businesses are also leading the field in manufacturing efficiency, as a result of internal corporate initiatives, intensive R&D, and the application of voluntary standards to business processes. A few brief examples from companies like Intel and Sharp illustrate some of the things the sector is doing to optimise efficiency in the manufacturing phase.

Part II What technology does for other sectors – enhance, enable and transform

Three classes of technology can contribute to an overall reduction in energy demand: enhancing technologies let us do what we do already, only more efficiently, enabling technologies produce evolutionary change in everyday processes, transforming technologies let us do different things altogether.

To date, attention has been focused on the energy requirements of ICT and CE devices themselves – for instance, the amount of energy used to operate a desktop computer or a TV. These impacts are easy to measure and analyse – hence all the media attention. However, we keep forgetting the beneficial effects of technology: the innovative, low-carbon, ICT-enabled applications that are being adopted in almost every industry sector, improving efficiency and at the same time, increasing productivity and competitiveness.

Often unnoticed, once they have been absorbed into everyday life, there are thousands of ways in which technology is being exploited to reduce energy demand across other sectors, such as energy generation and distribution, transport and manufacturing. Logistics technologies reduce vehicle miles, remote monitoring reduces travel, energy management tools turn off computers, sensors switch off lights, and advances like technological convergence and broadband change the way we do things and lead to de-materialisation[7], to new, low carbon, business models. We need to focus on these wider opportunities because although they are harder to measure and harder to understand and predict, they are the ones that have the potential to decouple economic growth from energy use.

We look in turn at technologies that enhance existing processes, technologies that enable new ways of working and technologies that transform what we do altogether.

Enhancing technologies make things better: they make us more efficient while allowing us to continue doing the things we normally do. Enhancing technologies include monitoring and analytical tools which enable users to identify when energy is being wasted. Logistics systems optimise the supply chain and streamline fleet operations and intelligent transport systems

7 De-materialisation means minimising the physical properties of a product or process.

improve vehicle efficiency. Smart building technologies minimise energy use and user management technologies intervene intelligently to minimise energy wastage.

Improving efficiency, however is not sufficient to achieve what we really need:- to decouple economic growth from energy use. Enabling technologies do have exactly that capability. This is because enabling technologies change the way we do things: they enable new processes, new ways of working.

Enabling technologies include energy-related applications that facilitate renewable generation and a whole series of technologies based on virtualisation, including in-silico testing and modelling and paperless office technologies.

Transforming technologies change fundamental behaviour and lead to the creation of new business models. Whereas enhancing technologies help the transport sector become more efficient: transforming technologies remove the need for transport altogether – or at least reduce it to a fraction. Transforming technologies do not just save energy, preserve resources and reduce waste, they change what we do, stimulate innovation and spawn new industries.

Transforming technologies include broadband (which has completely changed the telecoms market) and space-related technology. With access to solar reserves one billion times greater than those that reach the earth, space and satellite applications are truly disruptive technologies that offer dramatic potential for replacing traditional terrestrial processes with low energy alternatives.

Technologies that change behaviour as radically as the ones we have discussed above do, inevitably, involve considerable uncertainty. Moreover, energy demand may increase temporarily during transitions from one technology to another. It will take time and research to establish conclusively which technologies are the real winners.

Part III So why are our emissions still going up?

The core problem facing the technology sector is that whilst devices are getting more efficient, our gross energy demands are still rising.

The Market Transformation Programme (MTP)[8] states that electricity use by ICT equipment more than doubled between 2000 and 2005[9]. Yet we know that our products are getting more energy efficient. So why is this happening? What is preventing the downward trend in gross energy use that we all want to see?

We have already looked at issues like proliferation, standby losses and peripheral consumption. There is no doubt that these problems drive up energy use, but the usual suspects are not the only culprits. There are other, more complex and pervasive issues that either exacerbate existing problems, or act as barriers to developing and implementing solutions. These include procurement, policy and perverse incentives, user behaviour and carbon accountability.

Traditional procurement processes are often cited as a barrier to implementing energy efficient ICT, particularly in large organisations, where up-front costs can dominate decision making. Things are changing but not quickly enough. Policy measures can also have unforeseen consequences on energy use or may create split or "perverse" incentives.

User behaviour has a dramatic influence on the energy efficiency of ICT and CE products – firstly in purchasing preferences and secondly in actual use. Just like the efficiency of a car depends on the way it is driven, the efficiency of ICT equipment depends on the way it is used and this is true at every level, from businesses running huge data centres to the domestic consumer in a studio flat. We are providing interim solutions like power management tools, but there is still a long way to go.

These problems are actually symptoms of a bigger issue – what economists call the "market failure" in carbon. Market failure happens when the price of goods or services does not reflect the true cost to society – in this case, not factoring in the long term costs of carbon mitigation in the short term price of energy. The lack of carbon accountability means that there are no clear price signals to differentiate energy efficient products from cheaper but less environmentally friendly ones.

Part IV Why technology matters

The timely adoption of low carbon technologies is a critical success factor in tackling climate change.

MTP projections suggest that the rapid implementation and uptake of new energy-efficient technology can produce much greater energy savings than policy measures alone. In contrast to current trends, the energy demand of ICT and CE products could drop dramatically between now and 2020, given the right circumstances. Implicit in the MTP projections is an obvious

8 Part of the Department for Environment, Food and Rural Affairs – DEFRA
9 "Sustainable Products 2006 – Policy Analysis and Projections", Market Transformation Programme, 2006

Already, technology is helping businesses and individuals to do things in different ways, replacing traditional, high impact processes with low carbon, low-impact alternatives which are integrated into everyday life at an unprecedented speed

fact – the earlier those technologies are implemented, the better. This is because the longer we take to reduce emissions, the greater the accumulation of greenhouse gases in the atmosphere, and it is the concentration of those gases that influences climate change.

Recent work by the Tyndall Centre emphasises the problem of cumulative emissions. Their findings are bleak: achieving our target emissions reductions by 2050 will not prevent disastrous concentrations of CO_2 building up in the atmosphere unless the rate of abatement increases – soon, and dramatically. The early implementation of low carbon technologies will play a critical role here, so we must do everything we can to identify those technologies as quickly as possible, to accelerate their development and support their adoption.

Part V Commitments: what the technology sector needs to do

The issues covered in this report may be complex, but the actions are clear. We in the technology sector have a lot to do.

We need to develop a more systematic approach to monitoring and measuring the energy demand of our own products and services. We need to improve environmental performance within our own supply chain by sharing best practice. We need to stimulate and encourage behavioural change. Most importantly, we must find ways to identify those technologies that have the greatest potential to tackle climate change, and accelerate their development and adoption.

The technology sector is engaging with other partners such as the CBI to try and ensure that our activity complements the work being done in other industry sectors across the economy. We are working with the University of Warwick which is providing academic expertise to complement our business insights and being external to our sector, will also bring objectivity to the process. We are also working with our European counterparts, EICTA (the European ICT and CE industries association), and with INSEAD (a leading European business school) who will augment our work and broaden our perspectives.

Part VI Conclusions

In the long run, technology needs to be the central element of response strategies to climate change.

It is clear that there is considerable scope for improving the energy efficiency of ICT and CE products. However, it should also be clear that the technology sector has embraced the challenge of energy efficiency and is producing better, faster, lighter devices that use less and less energy. Moreover, we are taking a leading role in the development of alternative, low carbon technologies that will help to decouple economic growth from energy consumption.

Already, technology is helping businesses and individuals to do things in different ways, replacing traditional, high impact processes with low carbon, low-impact alternatives which are integrated into everyday life at an unprecedented speed. Technology does not just change the way we do things. It changes what we do, creating whole new business models and stimulating innovation.

But there are barriers to progress. Although the MTP shows that a wholesale adoption of best available technologies could dramatically reduce energy use, robust policy instruments are required to make this a reality and create the necessary market pull. Under current circumstances there is little incentive for individuals to seek out the most energy efficient products, or to change behaviour and adopt energy efficient lifestyles.

The recent publication "Avoiding Dangerous Climate Change" compiled by leading international scientists concludes that "In the long run, technology needs to be the central element of response strategies to climate change"[10]. We believe that there are two, interdependent solutions to the problem of climate change – the intelligent use of technology, and innovation.

However, this is not the time to sit back, relax and wait for technology to take care of it all: the low-carbon technologies that the new economy will rely on need active stimulation and support. And timing is a critical success factor, so we need to do everything we can to accelerate their development and adoption.

The important actions are clear. We need to understand the energy implications of our products and processes better, we need to spread best practice through our own supply chain, we need to stimulate behavioural change, and we need to identify the best low-carbon technologies and accelerate their development and implementation. The first two actions are up to us. The last two actions have to be shared with everybody.

10 Avoiding dangerous Climate Change, Ed. J Schellnhuber, Cambridge University Press 2007

Introduction

HIGH TECH: LOW CARBON – THE ROLE OF TECHNOLOGY IN TACKLING CLIMATE CHANGE

The technology sector is in a unique position. On the one hand, our products and services (whether consumer electronics devices, communications equipment or software) have an energy requirement, and we need to work hard to ensure that this is minimised. On the other hand, many of our products help other sectors work more efficiently and reduce their emissions

Global warming is at the top of the international political and business agenda and the UK Government is taking a leading role. Policy objectives are set out in the Energy White Paper, and the Climate Change Bill will be the instrument through which the UK aims to reduce its net carbon account by at least 60% from the 1990 baseline by 2050. These are accompanied by a plethora of government initiatives to reduce emissions and make business more accountable for their carbon, which include the Carbon Reduction Commitment, the Climate Change Levy and the Climate Change Agreements. In Brussels, the Energy Using Products Framework Directive was adopted in July 2005 and wider initiatives like the Sustainable Energy Europe Campaign and the EU Action Plan on Energy Efficiency are raising awareness and encouraging behavioural change. At a global level the UN Framework Convention on Climate Change (UNFCCC) continues to promote international cooperation in the reduction of greenhouse gas emissions.

However, responsibility extends beyond our politicians and policy makers: robust action is required by all of us to reduce our carbon footprint. In this respect the technology sector is in a unique position. On the one hand, our products and services (whether consumer electronics devices, communications equipment or software) have an energy requirement, and we need to work hard to ensure that this is minimised. On the other hand, many of our products help other sectors work more efficiently and reduce their emissions, and new technologies like broadband change the way people do things and lead towards alternative, low carbon, business models.

When we consider the technology sector in the context of energy efficiency, the current media focus is on reducing the energy use, and hence the emissions, associated with our products and services, and this is indeed a key priority for all in our sector. Incremental improvements in energy efficiency can achieve great advances – for instance, mobile phones use several orders of magnitude less energy than they did 15 years ago. However, we believe that we must do more than this if we are to have any chance of avoiding harmful climate change and achieving the 2020 and 2050 goals established by the UK government. As well as doing the same things more efficiently, we need to change what we do. Technology is a primary enabler of behavioural change, and as such can play a pivotal role in helping make the low carbon economy a reality.

We think that the opportunities for emissions reduction are currently underexploited, a position that is reinforced by a quick look at McKinsey's recent work on the Carbon Cost Curve[11] which demonstrates that between one-third and one-half of the reductions needed to achieve our 2050 targets are at nil or negative net cost. The problem is that these reduction opportunities – these "no-brainers" – are not being taken up and the obvious question is, why not?

We think that some of the answers are cultural and behavioural, and some stem from the lack of a market for carbon. We also believe that accelerating the development and adoption of low carbon technologies will be a critical factor in our success in achieving these targets, and the ultimate objective of tackling climate change. The sooner we reduce emissions, the more effect we have on cumulative CO_2, and as a result on the concentration of greenhouse gases in the atmosphere.

This report explores the role of technology in tackling climate change. Part I identifies some of the problems associated with our sector, such as product efficiency, standby and rapid obsolescence, explains how we are tackling them, and demonstrates that, contrary to perception, many of our practices and products lead the field in energy efficiency. Part II illustrates how ICT-enabled technologies help other sectors improve energy efficiency and looks at how new technologies are revolutionising the way we do things and replacing high-impact activities with virtual, low impact alternatives. Part III examines some of the barriers that might slow down our transition to a low carbon economy. Part IV emphasises the importance of developing and implementing new low carbon technologies as early as possible and Part V sets out the steps that we will take as a sector to help make this happen. The report concludes that there are two interdependent solutions to climate change – the intelligent use of technology and innovation, and that we all need to play a part in accelerating their adoption and development.

11 A Cost Curve for Greenhouse Gas Reduction – The McKinsey Quarterly, 2007 No. 1

Part I

Energy Efficiency Problems and Solutions for the Technology Sector

HIGH TECH: LOW CARBON – THE ROLE OF TECHNOLOGY IN TACKLING CLIMATE CHANGE

Energy efficiency measures that we implement will have to be robust enough to outweigh the kind of rapid growth and increasing proliferation that we have seen over the last decade and which look set to continue

Products and services

Technology now underpins most aspects of our daily lives as consumers and citizens, employees and employers and has transformed the way we interact with each other, the way we shop, access public services and run our businesses. But these developments come with associated costs – the vast majority of ICT products and services use electricity, and as they become more and more pervasive, the gross energy requirement continues to grow. In April 2007, Gartner estimated that the ICT sector was responsible for around 2% of global carbon dioxide emissions[12], approximately the same as the airline industry[13]. Moreover, the Energy Saving Trust[14] predicted that by 2020, 45% of domestic electricity usage will be consumed by ICT and consumer electronics products, in what they described as "a new ICE age"[15].

Both statements were accompanied by a barrage of press coverage emphasising the growing energy demand of our sector and its products. Criticisms of the sector focus on product inefficiency, design features that encourage users to leave items permanently switched on, lack of customer information and rapid obsolescence.

We believe these criticisms can be grouped into four areas:

- efficiency versus proliferation: the mass adoption of electronic devices both at work and at home means that products have to be much more efficient to counteract cumulative energy demand.
- standby, where energy is wasted when products are inactive.
- peripheral energy use, where only a fraction of the power consumption of a product is driving its core functions and the majority is used for peripheral activity (for instance, powering fans in computers)
- rapid obsolescence, where products are discarded and replaced at frequent intervals.

12 Gartner Symposium/IT Expo, 26 April 2007 (http://www.gartner.com/it/page.jsp?id=503867)
13 Although it is worth noting that the sectors are of dramatically different size – the aviation industry contributes about 1.1 % of UK GDP and employs around 180,000 people; the ICT sector alone contributes 6.4% of UK GDP (ONS, 2006) and employs over five times as many people. Furthermore, the true effect of aviation on climate change is between two and four times the emission level because of atmospheric factors.
14 "The Ampere Strikes Back", Energy Saving Trust, July 2007
15 Information, Communications and Entertainment

Most criticism, including product inefficiency, standby and peripheral use, relates to the "in-use" phase of a product's life, so most of the emphasis will be on how we are addressing these in-use energy efficiency issues. However, the fourth problem, rapid obsolescence, is more of a design phase issue, so we will also demonstrate the progress that is being made through eco-design and voluntary agreements. Finally, to complete the picture, we also look at what we are doing to optimise efficiency in the manufacturing phase.

Products in use

This section explores the in-use phase of products and what we are doing to improve efficiency. Although we do not yet use energy optimally as a sector, we are getting better all the time.

Efficiency versus proliferation

ICT and CE products are not in themselves large consumers of energy when compared for instance to a car or domestic heating system. However, they are pervasive, often duplicated within homes, and are in use for long stretches of time.

The MTP notes that the boom in technology is likely to grow and cites three underlying reasons: Moore's law* (computer technology continues to get faster, smaller, cheaper and better), Metcalfe's Law (which states that the value of a network is proportional to the square of the numbers using it and explains the popularity of the web and social networking technologies) and the autocatalytic nature of ICT (computers and associated technology actively contribute to the development of new improved components and products)[16]. This is both a benefit and a challenge for the technology sector – whilst we, like any sector, want to grow and sell more products and services, energy efficiency measures that we implement will have to be robust enough to outweigh the kind of rapid growth and increasing proliferation that we have seen over the last decade and which look set to continue.

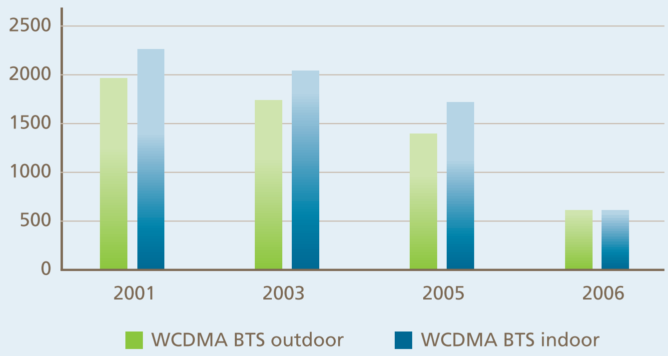
However, in the ICT and CE sectors, orders of magnitude improvements in efficiency are not just wishful thinking: they are already a reality in our products and systems. Mobile telephones have become around 100 times more energy efficient over the last 20 years and microprocessors (or chips) are achieving four-fold improvements in energy efficiency in just a year – and the trend looks likely to continue.

This suggests that we can expect to exceed the target set by the CBI Climate Change Task Force of a 30% improvement in the efficiency of electrical equipment by 2030[17]. In many cases this will be achieved before 2010. We do not have all the answers but the following examples demonstrate that we are making orders of magnitude improvements in efficiency over relatively short timescales right across the technology sector. We will start by looking at some familiar products: mobile phones, digital radios, computers and the all-important microprocessors* – or "chips". We are not ignoring the more problematic area of TVs but will look at this issue in more detail later in the document.

Mobile phones

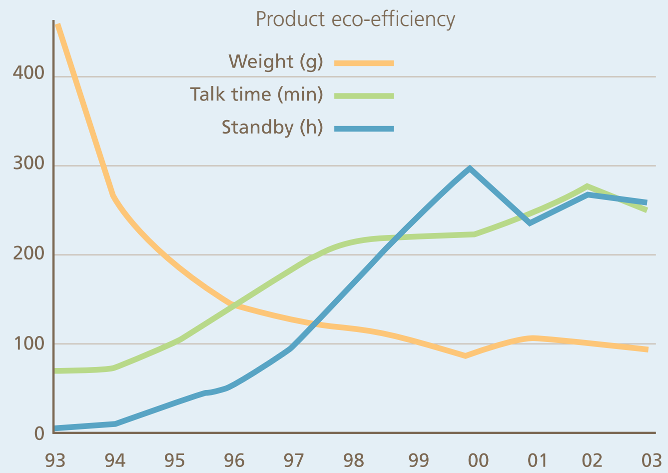
Since the early models in the 1980s, mobile phone efficiency has improved beyond all expectations. Anyone unwise enough to have left their mobile phone charging from their car battery overnight in 1990 would have had to jump-start their car in the morning – a situation that is hard to believe now. In 1990, mobile phones weighed between 500g and 1kg with about half an hour of use and minimal standby. Current models weigh below 100g, with 6-9 hours of call time and days of standby (weeks for basic models). Only ten years ago, making a call used tens of Watts (W)*, now it uses around 1W. As well as the efficiency of the phone itself, companies like Nokia have focused on the energy used by chargers (as we will see later) and on the energy efficiency of the base stations (the links between mobile devices and the network infrastructure, which consume the majority of energy in mobile networks). The energy demand of Nokia base stations[18] has dropped from around 2000W in 2001 to around 600W in 2006 and Nokia believes this trend is set to continue, enabled by rapid developments in technology.

Diagram 1: Energy use of base stations from 2001-2006 (Nokia)



Energy consumption calculated for reference configuration including three sector WCDMA base station with each sector with 20W output power and with capacity of 64 speech channels.

Diagram 2: Eco efficiency of mobile phones from 1993-2003 (Nokia)



16 Changing consumer lifestyles and their possible effect on future patterns of energy consumption", Market Transformation Programme, January 2006
17 Climate Change: Everyone's Business, CBI Climate Change Task Force, November 2007
18 Now Nokia Siemens Networks
* see glossary

Firstly, standby consumption has to be reduced so it is as low as possible, and secondly we need to make it easier to turn things off. We are making progress on both fronts

Radios

In consumer electronics, digital radio technology relies on a more powerful transformer to enable the digital signal to work reliably. Early digital radios required up to ten times more energy than their analogue predecessors[19] (30W rather than 3-4W) but current models use around 4-5W and the trend is downwards. Besides the better performance is the added advantage that at the broadcasting end, digital transmitters only need a fraction of the energy of analogue ones. Self-powered (wind-up) radios do not need batteries at all.

Computers

Computers are also becoming more energy efficient through the use of components that require less power and by the implementation of power management software to minimise energy consumption. Manufacturers are adopting both these approaches and one positive result is that power management options are now usually enabled as default. Almost 100% of computers now have a "deep sleep" or hibernate option, with very low power consumption but restoration of the full desktop within a few seconds. Apple, for instance, reports an 88% energy saving in sleep mode since the first Mac. Apple's Mini Mac uses only 25W when on, less than half the power of a conventional light bulb[20] and less than the 30W that many older computers consume even in standby or idle mode[21].

The Massachusetts Institute of Technology (MIT) and OLPC[22] initiative are developing the "$100 Laptop", a teaching aid and electronic book aimed at developing countries. It needs an order of magnitude less energy to run than a typical laptop, and can be powered by solar or human power (foot pump or pull string powered chargers).This model is not designed to replace current business offerings but it demonstrates what can be done with technology, willpower and – most importantly in this case – economies of scale in production.

Microprocessors

Microprocessors[23] (or chips), the core components hidden away inside every desktop, laptop and server, and also inside radios and electric toothbrushes, are the things that do all the work, whether it is managing data or telling the video when to record. Microprocessors produce heat that would destroy them quickly without fan-assisted cooling, which in turn requires power. It is therefore important to improve not only the energy efficiency of chips but also reduce the heat they emit.

Dramatic improvements have already been made through better chip design, with manufacturers like Intel, IBM and AMD competing fiercely on efficiency (see case study 1). IBM has produced a chip that enables users to "cap" maximum power usage[24], Intel's new processors have four cores (quad-core) and are equipped with thermal sensors that measure temperature and are capable of reducing or increasing cooling according to need. Another approach is "thermal throttling", where the chip slows down its processing speed if it is getting too hot. This saves energy but the primary function is for chip preservation and the processing speed is affected.

A chip is even being developed that converts heat to electricity. There is obvious scope for integrating these heat conversion chips into computing devices to harness the heat generated by processors and turn it into electricity to power fans or other cooling technologies or even illuminate the screen (see case study 2).

Printers and multifunctional devices

Other IT equipment is moving in the same direction as computers. Printers now have the ability to print duplex, multiple pages per sheet and at different toner densities, all of which allow energy use to be minimised (see case studies 3 and 19). That is in addition to the same kind of power management functions that are now standard in PCs. Improved energy efficiency in use and developments in toner manufacture and digital printer technologies are also delivering substantial energy savings. Moreover, printers are increasingly becoming multifunctional and incorporate scanning, photocopying and faxing functions – so one machine rather than three is on at any one time. Xerox has calculated that a single multifunctional printer, copier and fax replaces one copier, four smaller printers and a fax, and reduces the annual energy requirement from 1400kWh to 700kWh[25], a saving of 50%.

Multifunctional devices are not limited to printers – a multifunctional device is any hardware that combines a number of functions, and is usually the result of technological convergence and often, miniaturisation. Mobile phones with, for example, in-built cameras or email capabilities (like Blackberry or Nokia e-Series) are classic multifunctional devices. The obvious benefit of making a single appliance perform an increasing number of functions is that it takes up less space than conventional equipment, uses less energy, and creates less waste.

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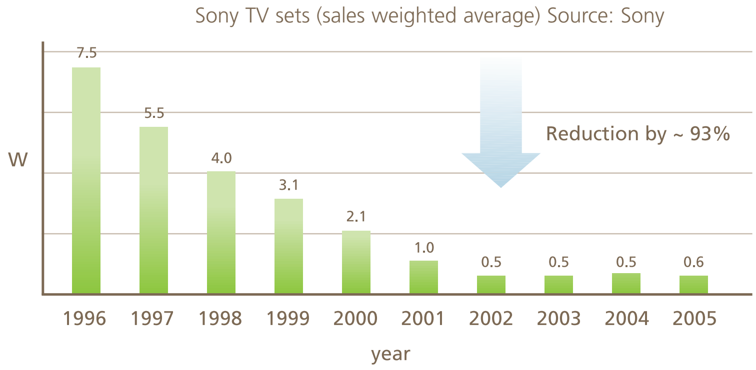
19 This was to some extent the result of the original product specifications developed by the relevant authorities, which did not prioritise energy efficiency.
20 Source: Apple Mac:
21 Monitoring Home Computers, Market Transformation Programme, 2007
22 One Laptop Per Child initiative, led by Nicholas Negroponte at MIT. The current version is retailing at around $175, so the $100 target has not yet been reached.
23 Often referred to simply as processors
24 Estimating power requirements of a server is difficult so usually firms have to arrange for more power than is necessary to be delivered into a data centre.
25 Source: Xerox 2006 report on global Citizenship, p 44. All products are energy star rated. Savings increase to 73% if the products being replaced are not energy star rated.

A TV would have to be on continual standby for nearly a month to use the same electricity as boiling a kettle

Diagram 3: TV Standby power consumption



Networks and infrastructures

ICT doesn't work in isolation – communications technology relies on networks, computing functions for businesses are backed up and stored in data centres. We already mentioned how mobile networks are becoming more efficient, and a new communications infrastructure is currently being implemented in the UK, known as the Next Generation Network. Thanks to developments in technology, the physical infrastructure will be simpler, with fewer moving parts, fewer electrical components, with lower maintenance requirements and fewer physical interventions. These new core and access networks will provide better performance with lower energy requirements.

Energy lost from inactive devices – the standby problem

Many electronics devices have a mode called standby. Technical definitions vary but for the purposes of this report we regard standby as an operating mode when the device is inactive but not actually off, or when the device is apparently turned off but is still drawing power from the mains[26]. In either case it continues to consume energy.

The standby problem is characterised by the cumulative effect that results when individual devices waste apparently negligible amounts of energy. The problem is that more and more devices are left almost permanently in standby, which means that they are constantly drawing power. Over time and multiplied by the many devices in the average home (now around 20, a five-fold increase since the 1970s)[27] this adds up to an extra £65 a year on the average domestic electricity bill. On a national scale it is enormous. For instance, mobile phone chargers draw less than 0.4W when idle (plugged in but not charging a phone)[28] and 3-5W when actively charging a battery[29], which seems negligible until it is multiplied by the UK's 65 million mobile phones[30]. Nokia estimates that two-thirds of the energy used by mobile phone handsets is due to chargers being left plugged in while idle[31].

The MTP states that "stand-by electricity consumption is a significant contributor to energy consumption in the UK[32]" and conservatively estimates the total in 2006 at around 7.2TWh[33].

Other estimates suggest that standby currently uses 7% of domestic electricity. However you look at it, far too much energy is being wasted.

Another form of standby power loss occurs through transformers or external power supply units (EPS/EPSU)[34]. The extra chunky plug on a mobile phone charger is a transformer, so is the black box between most laptops and the plug. Transformers are important for many ICT and CE products because they convert mains electricity into a stable, usable form for the appliance. Transformers continue to use energy whenever they are plugged in, even if the appliance is off, so either have to be unplugged or the power turned off at the socket. We are also tackling the additional issue of the conversion efficiency of transformers (see case study 7).

Tackling standby is not just a simple case of turning everything off at the switch: some devices like set top boxes need to be on standby to fulfil their functions (e.g. record programmes or download information during the night or whilst people are out). Therefore this issue has to be addressed on two levels. Firstly, standby consumption has to be reduced so it is as low as possible, and secondly we need to make it easier to turn things off. We are making progress on both fronts.

Reducing standby power consumption

Currently the average power consumption of a TV in standby mode is 2.6W, (with the best in class now 0.3W[35]) down from over 6W on average in 1995[36]. That means that a TV on standby for one hour uses less electricity than a 100W lightbulb does in two minutes, and it would have to be on continual standby for nearly a month to use the same electricity as boiling a kettle. The graph above shows how the industry has reduced TV standby power consumption by over 90% over the last ten years (see case study 10).

Attention is now focused on other CE devices like digital video recorders and set top boxes to ensure their standby doesn't exceed 1W. Many, including all those that carry the Energy Saving Trust's ESR[37] logo, already use less than 1.5W.

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26 Definition depends to some extent on the device in question. Mobile phones are different from TVs and radios, computers are different again. The MTP defines computer standby "when the computer has been shut down entirely, and appears off to the user, but is still drawing power from the mains supply". However, for the purposes of this report we include sleep modes like hibernate and similar low energy but non-off modes in our definition of standby, simply because this is the most widely perceived definition, even if it is not the correct one.
27 Energy Saving Trust reports – the Rise of the Machines (2006) and The Ampere Strikes Back (2007)
28 "How much energy do home electronics use?" Guardian newspaper, 12th April 2007 (note that 0.009kWh daily = a draw of 0.375W)
29 Intellect internal data, compiled by industry experts
30 HPA (Health Protection Agency) website – mobile telephony and health section, November 2007
31 Nokia CR Report 2006
32 Source – Market Transformation Programme, Product Overview: Energy, August 2006
33 Market Transformation Programme – BNXS36 Estimated UK standby electricity consumption 2006
34 Transformers that are charging devices for mobile phones, toothbrushes etc. are called EPSUs – External Power Supply Units, or EPS (External power supply) but not all transformers are EPSUs/ EPSs
35 Source: Sony – many models including KDL-40X3500 and KDL-40W3000 all have standby of 0.3W.
36 Source: Market Transformation Programme's WhatIf? Tool, published 15/11/07
37 Energy Saving Recommended (see Voluntary Agreements)

Just like a traditional fireplace, where up to 92% of the heat goes straight up the chimney not all the energy required to run a system is actually used productively

The energy requirement of mobile phone chargers is also diminishing; the average no-load[38] energy consumption of a Nokia charger in 2007 was 0.3W, with best in class around 0.03W. Nokia has set a target to reduce average no-load consumption by 50% and the no-load consumption of its best-in-class chargers to close to zero by 2010. Moreover, new Nokia phones will now alert users as soon as the phone is fully charged and even remind them to unplug the charger (see case study 6). Collective efforts by the industry to reduce standby losses include the EU Code of Conduct on Energy Efficiency of External Power Supplies[39].

Switching things off

For things that can – and should – be turned off, there are some excellent low-cost solutions such as "Smart Socket", "Bye-bye Standby®" or "Standby Buster®" which allow consumers to turn off a multitude of devices in one go through a wireless controlled master switch, for instance when going out. This solves the problem of having to crawl under furniture to get to inaccessible plugs and remembering to turn lots of different appliances off individually. It also provides a solution for those few devices that do not have an "off" switch. These devices also deal with the power consumption of transformers in external power supplies.

Another solution is emerging, although not yet in widespread use – solar power. Electronic calculators have relied on solar power for decades, and now an increasing range of electronic gadgets use solar cells to recharge batteries, obviating the need for external chargers[40].

There is, however, a potential problem that reducing standby down to levels that people consider insignificant will, ironically, make it more likely that devices will be left on standby permanently, thereby completely defeating the object. That is why we are promoting a combination of energy efficiency, automatic switches and, most importantly, education.

Peripheral energy use – spotlight on data centres

The problem of energy being used up for peripheral rather than core functions is a widespread issue not restricted to this sector. However it is a particular problem in complex, high-tech environments like data centres.

Just like a traditional fireplace, where up to 92% of the heat goes straight up the chimney[41] not all the energy required to run a system is actually used productively. The average desktop computer wastes nearly half the power delivered to it[42], primarily through power supply inefficiency and cooling fan demands[43]. In data centres, only around a quarter of power is actually used for core functions. We will explore the data centre environment in some detail because it provides an excellent illustration of the attrition caused by peripheral requirements on energy destined for a specific role. It is also a complex and problematic area that we will undoubtedly hear more about in the near future.

Problems

Data centres house the computing and communications equipment that businesses use to manage and organise their corporate data. A large data centre may cover the area of several football pitches and contain thousands of servers (computers). Data centres are estimated to use between 2.2 – 3.3% of the UK's total electricity[44] and the annual energy bill for a large corporate data centre frequently runs into millions of pounds.

Servers[45] (and the power supply units they rely on) not only generate heat but require a fixed temperature range[46] in order to operate reliably, so a large proportion (almost 50%) of the power requirement of data centres is actually for air conditioning and other peripheral functions: only around 50% reaches the servers. This means that data centres have a high fixed power demand even if the servers are doing nothing at all (see diagram 4). Moreover, around half of the power that actually reaches the servers is taken up by peripheral functions within them.

After all that, the energy used for core functions like data processing is often not used efficiently because machines are frequently run at low load, when they are least efficient[47].

38 When the charger is not charging the phone but is still left plugged into the mains, and drawing power.
39 Part of the EU Stand-by Initiative. For list of signatories and ToR see: http://re.jrc.cec.eu.int/energyefficiency/html/standby_initiative_External%20Power%20Supplies.htm
40 Mobile phones powered directly by solar panels are not yet readily available but the possibility is not too far away as new technology in electronic components is developing rapidly.
41 ests by Burley indicate 30% efficiency for flued living flame gas fires and 8% for flued decorative flame effect fire – see http://www.burley.co.uk/model_images/FluelessEfficiency.pdf
42 Climate Savers Computing Initiative home page, October 2007– see www.climatesaverscomputing.org
43 Power supply efficiency is only around 65% on models over 2 years old although manufacturers are working hard to improve this (see 80 PLUS, later in this paper) so it tends to be higher in recent models.
44 Source: Anson Wu, Market Transformation Programme figures based on projected 2007 server energy consumption as a proportion of 2006 total UK electricity consumption (excluding transport), updated from 2005 DUKES energy consumption
45 Actually the microprocessors that do the work inside them – see below
46 The range of operating temperature and humidity has recently been widened by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) standards: Sun has also produced servers that operate satisfactorily at higher temperatures.
47 The busier a server is the more efficiently it runs: it is most efficient when running at full capacity.

Although only 5% of data is mission critical, all data is frequently treated this way which requires unnecessary (and energy intensive) levels of redundancy

Diagram 5 shows how a server at zero load can use between 50% and 70% of the power it uses at maximum load – even though it is not doing anything[48].

Moreover, a percentage of the power actually used is also wasted for other reasons – businesses often massively over-provision hardware to cope with potential (but often non-existent) spikes in demand and regulations or certain business functions may require instant access to certain kinds of historical data. Although only 5% of data is said to be "mission critical", the approach is frequently to treat all data in this way and build in unnecessary (and energy intensive) levels of redundancy[49] and it is also true that obsolete data is sometimes stored almost indefinitely, perhaps because its life-expectancy is unknown or even because nobody understands its true function.

Diagram 4:: The high fixed power demand of the physical building – the data centre facility.

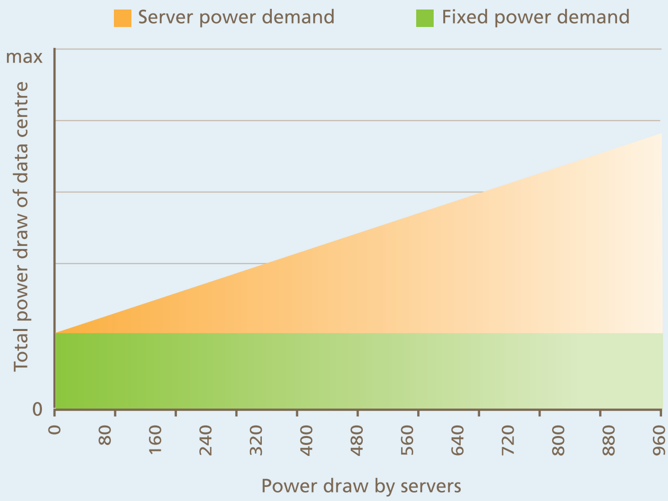
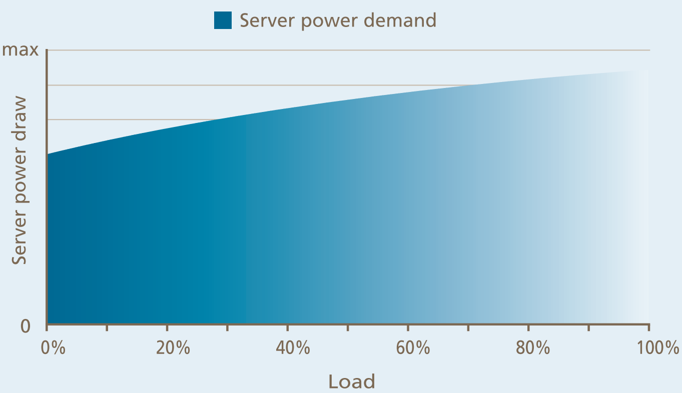


Diagram 5: The overall energy requirement of a server working at full load is not much more than that of a server at zero load.



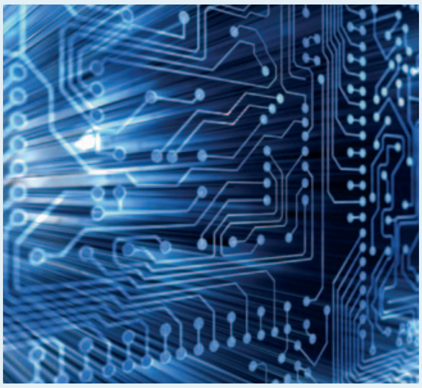
Other issues relate to infrastructure management – in some cases server function is not actively monitored and managed – so the less active servers (which require less cooling) are not differentiated from those running at capacity. Some cooling mechanisms are also sub-optimal. Poor asset management can even mean that servers that no longer have any function at all are simply left running instead of being switched off or reallocated. These are only a few items from a long list of data centre-related issues.

The overall number of data centres in the UK is growing fast, albeit not as fast as the data capacity, which is doubling approximately every 18 months. Along with this growth in demand there has been a trend of increasing processing power for a given chip size (in line with Moore's Law), so more and more technology is packed into the same physical space with two obvious consequences – an increase in overall power consumption (with demand surpassing supply in 40% of data centres[50]) and an increasing energy burden for cooling. The power consumption of data centres in the US, for instance, has doubled in the last five years[51].

Solutions

Energy management in data centres is a complex area which is attracting increasing scrutiny. Solutions already exist that can radically reduce energy use – even by orders of magnitude. These include improvements in hardware (particularly in processor efficiency), in data centre design, in facility management and in resource optimisation (for instance through virtualisation, which is discussed later). As mentioned above, new hardware, such as multi-core processors, offers greater capacity with reduced energy consumption and reduced heat generation: Managed hosting provider Memset revealed that in one year server hardware had become around three times more powerful whilst reducing energy consumption by about 40%, an increase in overall energy efficiency of around a factor of five[52].

48 Source: adapted from L. Newcombe, BCS Data Centre Specialist Group, see also Power Provisioning for a Warehouse Sized Computer, Google, June 2007
49 Source: adapted from L. Newcombe, BCS Data Centre Specialist Group, November 2007 pers. comm.
50 IDC Analyze the Future White Paper – HP Products Built to Protect the Environment, Feb 2007
51 EPA report to Congress on Server and Data Center Energy Efficiency, August 2007
52 This year's generation of Dell's PowerEdge servers using Intel's 2007 quad core architecture draw 176W with 2.8 times the processing power of 2006 models, which drew 280W.

Smart data centre management tools optimise heat and cooling – sophisticated analytical software monitors what the servers are doing and feeds that information to intelligent energy management systems. HP's Dynamic Smart Cooling system is an integrated approach to power management for data centres (see case study 5). IBM's Big Green and Cool Blue initiatives are alternative solutions. More recent approaches target the software applications themselves to minimise energy use .

• Thin client
Other approaches to reducing the energy requirement of data centres include thin client solutions where the computing functionality is held remotely and accessed online via desktop screens, removing the need for individual hard drives. This can reduce energy demand, particularly when combined with innovative server technologies. Thin client desktop products are less complex, cheaper, have longer life cycles and are less energy intensive to manufacture than PCs, so there are positive life-cycle implications. However, this business model is not suited to all applications and does not provide the totally location-independent, mobile working solutions that some people favour. Implementing these approaches may also require the installation of completely new terminals – and infrastructure – so can also involve waste implications[53].

• Grid computing
The emerging scenario of grid computing can also be an effective way of reducing data centre energy requirements. In grid computing, resources are effectively shared between different users, which allows economies of scale to be realised. Grid computing is most suitable for what is termed "high throughput computing" where the capacity of many different computers is combined to achieve large scalable tasks, from transaction processing (e.g. for banks) to highly complex mathematical modelling. Grid computing is effectively a form of virtualisation[54], where capacity is contracted as and when it is needed – in this case across a grid of interconnected facilities.

• Virtualisation
Virtualisation technologies can be applied to the whole data centre infrastructure. At a server level, virtualisation transforms the hardware resources into a functional virtual machine that runs its operating system and applications like a real computer. However, virtual machines can share hardware resources without interfering with each other[55]. This enables the consolidation of a number of virtual computers (or servers) onto one physical computer (or server), whilst maintaining the individual properties of each of those systems – so they behave exactly as though they are still on individual servers, although they are in fact all together. This kind of practice can achieve power savings well in excess of 50%[56].

• Consolidation
Virtualisation is one way of ensuring that workload is consolidated onto as few servers as possible. The enormous fixed energy demand of the data centre makes it vital to use that facility, and all its servers, to capacity. That does not mean that servers should be left cluttered with information that could be archived, but it does mean that if server capacity is not optimised then the result is energy waste on a colossal scale. There are some excellent examples of how data centre operators have made substantial energy savings through consolidation (see case study 11).

The concept of a green data centre is rapidly evolving... the most important message to take away is that a holistic approach is needed if data centre energy use is to be optimised

53 One approach is to turn existing PCs into thin clients at the point where they would have been upgraded.
54 The definition of virtualisation in a data centre context given here differs from the more general concept of virtualisation used later in this document, where it is a synonym for dematerialisation.
55 Source – VMware: www.vmware.com
56 Source – Memset

Eco-design is one approach that can help to solve the problem of obsolescence

The importance of consolidation is that it reduces the energy demand of the core function. This has a magnifying effect on overall savings because, as we saw earlier, the energy used to run the servers is only a fraction of the overall demand.

• Other initiatives
The current data centre environment is very energy intensive and few facilities use energy optimally. There is clearly much room for improvement. However, the concept of a green data centre is rapidly evolving and a number of initiatives are already underway such as the Green Grid. Other operations like the Grid Computing Now Knowledge Transfer Network are promoting the environmental benefits of grid computing, and the BCS DCSG (British Computer Society, Data Centre Specialist Group) is developing metrics that will enable meaningful comparisons to be made on data centre efficiency – an extremely difficult task given the complexity of the environment and the manifold constraints on operators and suppliers. They are also developing an open source simulation tool to allow operators to realise the potential savings offered by different technologies. On the European level, the industry is working with the European Commission and national energy agency experts on a European Code of Conduct for green data centres.

The most important message to take away is that a holistic approach is needed if data centre energy use is to be optimised – possibly even a complete re-design of the way data centres work. Data centres have evolved in a particular way, and piecemeal solutions are not the answer, although they can help in the short term. A comparison could be made to the water supply system in the UK where – absurdly – we use drinking water to flush the toilet. Due to physical infrastructure constraints, that is what we are stuck with, at least for the medium term. But in the data centre environment we can make radical changes to the whole architecture, and we are doing so.

Product design

A new approach to data centre architecture really sits within the product design phase, so this leads us on to design issues. We will now explore the design phase problem of obsolescence, and outline the ways we are addressing it, through eco-design and voluntary agreements.

Rapid obsolescence

The technology industry is evolving at an unprecedented rate, with new product and service innovations emerging all the time, new multifunctional devices and dramatic developments in software. However there is a serious downside to these rapid improvements in functionality: equally rapid obsolescence as products become outdated by newer developments, and even worse, incompatible with newer versions, driving a regular upgrade cycle. Some view this frequent renewal cycle as a fundamentally unsustainable business model. Not only does it create enormous quantities of waste but there is a significant energy impact at each end of the product's life cycle.

Limited product life is a particular problem for computers, which have relatively high energy and materials intensity* within the manufacturing process. One well-cited study suggests that 81% of the energy requirement of a desktop computer is absorbed in the manufacture and disposal stages, and only 19% during the in-use phase[57]. However, this conflicts with a study conducted for the European Commission DG Energy and Transport which found almost exactly the opposite – 84% of energy demand taken by the in-use phase as opposed to 16% by manufacture, distribution and disposal[58]. This is supported by other work by DG Environment and by the US Center for Clean Products and Clean Technologies, whose recently published "Electronics Environmental Benefits Calculator" asserts that under typical use conditions the main environment impacts associated with desktop PCs arise from the in-use phase[59]. A more detailed product energy analysis by Fujitsu provides a useful comparison of lifecycle energy demand for laptops and desktops (see case study 4).

It should be said that the rapid speed of development which accelerates obsolescence can also be an advantage because faster product cycles allow efficiency improvements, and even new technologies, to be implemented and adopted very quickly. We will explore this in more detail later.

Eco-design

Eco-design is one approach that can help to solve the problem of obsolescence. Eco-design takes account of environmental aspects during a product's development process. The EU's Framework Directive on Energy Using Products (EuP), implemented in July 2005[60], is primarily concerned with

57 Williams, E., "Energy Intensity of Computer manufacturing: hybrid assessment combining process and economic input-output methods", 2005, United Nations University, Tokyo (A desktop computer with a CRT monitor requires an estimated 1700MJ of energy for manufacture, and 260kg of fossil fuels, a ratio of fossil fuel to product weight of 11, an order of magnitude above the factor of 1-2 applicable to many other manufactured goods. The high energy intensity of manufacture, coupled with the relatively short life span, results in an annual energy burden of approximately 2,600MJ, about 1.3 times that of a refrigerator)
58 13571MJ as opposed to 2594MJ. Source: Preparatory studies for eco-design requirements of EuPs, Lot 3, Personal Computers (desktops and laptops) and computer monitors. IVF Industrial Research and Development Corporation, prepared for DG TREN.
59 University of Tennessee, launched April 2007, see: http://eerc.ra.utk.edu/ccpct/eebc/eebc.html
60 Directive 2005/32/EC – EuP
* see glossary

There is evidence that voluntary agreements have been more effective in improving energy efficiency than legislation

eco-design, because considering these issues during the design process is seen as a cost-effective way to reduce a product's negative environmental impact throughout its entire life cycle. Eco-design balances environmental considerations against functional, technical and economic ones and takes the whole product life cycle into account.

Eco-design includes the concept of life-cycle assessment, an area where technology companies have taken a leading role. Life-cycle assessment takes into account the energy used in the production and disposal of a product as well as during its working life, which can be very complicated to calculate for sophisticated, multi-component products with complex supply chains. It is particularly important in a sector where the energy involved in manufacture and disposal is substantial because it reflects the operational efficiency of the manufacturing process, provides transparency and allows meaningful comparisons to be made. If these are not taken into account, a situation could arise where a device that is marginally more efficient when in use could attain a better energy rating than one with a lower energy requirement over its lifecycle, and this could also skew manufacturing priorities to focus on energy efficiency in use rather than in production.

Eco-design has to consider the entire supply chain. This is an intensely complex process, particularly when it involves sophisticated products (see case study 13).

Voluntary agreements

One major driver for the design of more efficient products is voluntary agreements. Most, such as ENERGY STAR®, set minimum standards for energy efficiency and those products that comply can display an appropriate logo. Others have more specific scope, such as the EU Code of Conduct on Energy Efficiency of External Power Supplies (mentioned above) or the 80 PLUS programme which aims to improve the efficiency of the power supply to computers and servers to above 80%[61]. These standards may become more exacting over time to raise the benchmark and stimulate continuous improvement. Others, such as the Energy Saving Trust's ESR (Energy Saving Recommended) logo are relative measures, and will only apply, say to the top 20% of products, so they create a moving target for competing manufacturers[62].

Voluntary agreements do not just relate to product specifications – some, like the Climate Savers' Computing Initiative, set up by Intel, Google and the WWF and now supported by a large number of major players, provide a strategic goal for the industry in the medium and longer term – in this case a 50% reduction in the energy used by computers by 2010 – 54 million tonnes of CO_2[63]. Other voluntary agreements involve forms of standardisation – a group of mobile phone manufacturers has recently agreed to standardise the charging system for mobile phones so that in future all chargers will work from the same kind of USB connection[64]. Some aim to involve the whole supply chain: HP, IBM and Dell among others have developed an Electronic Industry Supplier Code of Conduct[65].

There is evidence that voluntary agreements have been more effective in improving energy efficiency than legislation, are more flexible and adaptable, can do it at far lower cost, and in a much shorter time[66].

ENERGY STAR | energy saving recommended | 80 PLUS

Eco-labelling

Users of ICT equipment are often unaware of the energy consumption of their devices, and how to activate the internal power management solutions that already exist. Whilst power-down settings are increasingly becoming defaults, there is still room for improvement, particularly in helping consumers distinguish products by their environmental credentials. One way to do this is through eco-labelling. An eco-label certifies that the product has met certain environmental standards.

Energy related eco-labels include the ENERGY STAR label or the Energy Saving Trust's Energy Saving Recommended (ESR) logo which are awarded to the most energy efficient devices - see above. There are a number of similar schemes which tend to be associated with a particular region or product set. Intellect is working with the Consumer Electronics Association of America to develop an online database comparing the energy use of a

61 See http://www.80plus.org/80what.htm
62 In the EU Energy Star only applies to ICT equipment, but ESR applies to a wide range of products. Energy Star is US based but is applied in the EU through a special EU/US agreement. Energy Star is now mandatory for many US government contracts.
63 See: http://www.climatesaverscomputing.org/, Climate Savers' home page as of November 2007
64 OMTP – Open Mobile Terminal Platform announcement, 17th September 2007
65 See http://www.eicc.info/
66 CEA (Consumer Electronics Association) research, April 2007
67 See Part V

wide range of electronic products[67] which is designed to complement existing resources.

An eco-labelling scheme for electronic devices (similar to the one that has been so successful for white goods like fridges) is desirable but will not happen overnight. There are several reasons for this – the rapid evolution of technology means that functions are changing all the time and any scheme will have to keep abreast of these changes to remain meaningful. Secondly the complexity of products, particularly multifunctional devices, means they may span different categories (after 30 years, a fridge is still a fridge but in around half that time a mobile phone has become a camera, a web-browser and a calendar, among other things). Thirdly, simple efficiency comparisons may be misleading unless life cycle considerations are included. All make this a complex area in which genuine comparisons are extremely hard to make and where there are few quick fixes.

Product manufacture

Although the energy efficiency of manufacturing processes within the technology sector has not been the focus of attention in the same way that our products have, to complete the picture we will now look at some of the things we are doing to optimise efficiency in the manufacturing phase.

Business processes

We have examined ways in which we are improving the energy efficiency of our products during both their use and their design phases, but as mentioned above, the energy requirement of any product also includes manufacture and disposal. The efficiency of manufacturing and other business processes are therefore essential.

The technology sector includes some of the greenest businesses on the planet, many of whom made environmental performance a priority decades ago. These are just a few examples:

- Sharp, a CE manufacturer, started its environmental programme back in 1971 and gradually incorporated green manufacturing into all core processes, covering products, factories and management. Sharp developed a green product guideline back in 1998, produced the first eco-flower[68] certified LCD TV in Europe and is spearheading a "Super Green" initiative that aims to ensure every activity has an environmental focus. Sharp opened its first "Super Green" Factory which uses solar power, with 100% water recycling and zero waste, at Kameyama in Japan (see case studies 8 and 9).
- Intel, a chip manufacturer, has reduced energy consumption in its operations by 20% per production unit over the last three years (equating to a saving of 160 million KWh in 2006) and has invested in Green Building technologies. Intel has had its first green building LEED[69] registered and has just enjoyed its 8th year running as Technology Market Sector Leader in the Dow Jones Sustainability Index.
- Toshiba has introduced a novel approach to product design through its Factor T eco-efficiency indicator, which is a simple but robust way to drive improvements in eco-design and product efficiency whilst taking into account improvements in performance and functionality (see case study 12).

Standards

Standards also play an important role and many ICT and CE manufacturers comply with the ISO14000 series which requires that a continuous improvement cycle is in place regarding environmental performance. Many are also registered with the European based EMAS (Eco-Management and Audit Scheme), a voluntary initiative that also recognises those organisations that go beyond minimum legal compliance and continuously improve their environmental performance. Technology businesses are also leading work by the European Association for Standardising Information and Communication Systems (ECMA International) to develop a standard to measure the energy efficiency of all ICT and CE products[70].

It is easy to focus on the obvious things and forget about the bigger picture. The Energy Saving Trust predicts a new ICE age of home entertainment with associated increases in electricity use. But how much energy is being saved by the reduction in production and distribution of CDs now that music can be downloaded? How much fuel is being saved by opting to download a film and watch it at home rather than driving to the nearest multiplex? How much petrol is being saved if people can socialise on Facebook once a week instead of travelling? At the moment, we simply do not know, but what we do know is that in each of these scenarios, a high-impact activity is being replaced by a low-impact one, and unless we look at the situation holistically, the figures do not give the whole picture.

The next section is all about looking at the bigger picture. We have examined the "direct energy effects of ICT"[71] – the energy requirements of ICT and CE devices themselves. These impacts are easy to measure, analyse and comment on – hence all the media attention. The important thing to remember is that these direct impacts can be dwarfed by the "indirect and systemic effects"[72] of ICT – the beneficial, innovative, low-carbon, ICT-enabled technologies that are being adopted in almost every industry sector.

We need to focus on exploiting those wider opportunities because although they are harder to measure, harder to understand and harder to predict, they are the ones that have the potential to decouple economic growth from energy use, and this is what we will now explore in Part II.

68 Eco-flower is an EU logo for computers, laptops and TVs with reduced environmental impact
69 Leadership in Energy and Environmental Design Green Building Rating
70 IBM chairs the TC38 technical committee, Intel chairs the Energy efficiency task group of this committee
71 Saving the Climate @ the speed of light – first roadmap for reduced CO_2 emissions in the EU and beyond: ETNO/WWF, 2007
72 Gartner terms these the second and third order benefits of ICT in relation to energy savings

Part II

Enhance, enable, transform: What technology does for other sectors

Three classes of technology can contribute to an overall reduction in energy demand:

- **enhancing technologies let us do what we do already, only more efficiently**
- **enabling technologies produce evolutionary changes in our everyday processes**
- **transforming technologies produce entirely new systems and let us do different things**

Part I of this report followed a current focus of media and political attention – the energy efficiency of our sector's products. But it is not realistic to view the technology sector in isolation without considering its wider role, because technology now underpins many – if not all – other sectors. This section therefore considers the broader effects of technology across the whole economy.

Often overlooked, perhaps because they cease to be noticed once they have been absorbed into everyday life, the technology sector's products and services enable other sectors to reduce their environmental impact significantly, in particular their energy use. Logistics technologies reduce vehicle miles and fleet sizes, remote monitoring and analysis reduce travel, energy management tools turn off computers automatically, sensors switch off lights, and advances like technological convergence and broadband change the way we do things and lead to the creation of new business models.

For the purpose of this report we have split these into three: what we call enhancing technologies – which help us to do the same things more efficiently, enabling technologies – which allow us to do things differently, and transforming technologies, which let us do different things altogether. We will look at each in turn.

Enhancing technologies

These technologies enhance existing processes; they make us more efficient while allowing us to continue doing the things we normally do. Enhancing technologies include monitoring and analytical tools, logistics, intelligent transport systems including tracking and telematics, smart building technologies and energy management systems, and technologies that manage user behaviour and intervene intelligently to minimise energy wastage.

Monitoring and analysis

Monitoring and analytical technologies do not in themselves save energy – it is the information they provide that facilitates energy saving. For instance, they enable users to identify usage patterns, map energy flows and pinpoint areas of wastage.

At a global level, remote sensing technologies provide reliable information without the need to transport research teams and equipment to target areas. On a national level, such technologies reduce energy losses by identifying leakages, blockages or other problems in major infrastructures such as pipelines or power grids, or provide patterns of usage that help utilities match supply to demand efficiently. At the level of individual businesses or households, applications like smart meters provide users with an intelligent analysis of their energy use, enabling them to identify areas of waste and take remedial action (see case study 29). Technologies vary in sophistication depending on their application – in major infrastructures or advanced facilities like data centres the monitoring and analytical applications are highly sophisticated to match this very complex environment.

Logistics

Intelligent software has transformed business and supply chain logistics: improving certainty, reducing shrinkage and saving money. Although in most cases cost reduction is the primary objective, energy efficiency has emerged as a major benefit. Logistics applications are not limited to keeping track of goods and materials but also apply to systems and business architectures. For instance, a recent development compares the carbon emissions of different system options so that the most energy efficient solution can be designed or selected (see case study 15).

A combination of logistics and tracking technologies provided by the technology sector like satellite and RFID vehicle tracking, improve certainty, reduce vehicle miles and enable fleet sizes to be minimised. Logistics applications like these have broad applications, from forestry to shipping (see case studies 22, 23 and 28).

Transport

The transport sector was responsible for around 27% of total UK CO_2 emissions in 2004[73] and is the only UK sector where emissions have risen since 1990 and are set to rise again by 2010. This makes transport a particular priority.

In addition to logistics and tracking technologies, the ICT sector provides a whole range of applications that reduce emissions. These include vehicle telematics, navigation tools like satnav, location finders and routers, advanced driver assistance systems like adaptive cruise control and ICT also provides the underlying infrastructure for demand management tools like road charging.

Vehicle telematics monitor driver behaviour and identify those in need of additional training, leading to improvements in fuel efficiency through better driving, and longer vehicle life. Insurers are now investigating the application of telematics for pay-as-you-drive insurance premiums to reduce vehicle miles.

Intelligent Transport Systems

Intelligent Transport Systems (ITS)[74] are tools that combine computers, databases, maps and sensors to assist drivers and improve transport infrastructure. They are particularly applicable to tackling congestion, and since the UK suffers the worst traffic congestion in Europe our road system is an ideal candidate for ITS. The European Commission has found that up to 50% of fuel consumption is caused by congestion and non-optimal driving behaviour[75] and is supporting the adoption of in-car ICT through its Intelligent Car Initiative because of the clear benefits in fuel efficiency.

ITS also include navigation tools such as satnav and dynamic route guidance systems, which incorporate real time factors like congestion or roadworks and take them into account in the information transmitted to users. Dynamic navigation depends on the immediate availability of accurate traffic information, so the integration of satellite, communications and software technologies is crucial. Once the preserve of the military, satellite navigation and timing technology is now a critical part of modern transport infrastructure, serves individual and professional users alike and is used for thousands of applications worldwide from navigating single cars to controlling large aircraft fleets.

Intelligent routing of road transport can cut fuel and emissions by 20-30%[76]. UPS for instance, reduces fuel consumption by using route planning software that minimises cross-traffic turns at intersections. This may seem trivial until you take into account their 88,000 vehicles and 15 million deliveries a day. Satellite monitoring reduces aircraft stacking, streamlines flight routing, and re-routes shipping to avoid adverse conditions, cutting journey times and emissions. The CBI estimates that inefficient use of airspace and infrastructure creates 73m tonnes of CO2, and that streamlining air traffic could cut fuel consumption by 12%[77].

Related transport technologies

ADAS (advanced driver assistance systems) are another form of ITS and include intelligent speed adaptation, adaptive cruise control and blind spot monitoring. They are primarily designed to improve safety but have an important side-benefit in smoothing traffic flow, with substantial reductions in emissions and journey times. Other approaches, such as software that monitors internal tyre pressure, help optimise fuel efficiency.

New applications and technologies are emerging all the time. One example is an amazing development in automotive software such as Lysanda's Eco-Log® system, a pioneering technology that calculates the true emissions of a moving vehicle, both the quantity and composition. This not only enables meaningful comparisons to be made between vehicles and acts as a means of authenticating efficiency claims by manufacturers, but it also provides intelligent feedback on the effects of different driver behaviour, enabling problems to be identified and addressed.

73 Source – UK Climate Change Programme 2006, Defra
74 Sometimes referred to as Integrated Transport Systems
75 EU Intelligent Car Initiative brochure
76 Case4space report, June 2006
77 Climate Change: Everyone's Business, CBI Climate Change Task Force, November 2007

Road charging

Road charging is an economic instrument[78] designed to reduce demand, particularly at peak times, and move passengers from private to public or shared transport. Current schemes are entirely ICT-enabled. The London Congestion Charging scheme has achieved a 20% reduction in emissions[79]. ICT also enables electronic public transport ticketing systems like the Oyster card, which speed up passenger transit through traditional station bottlenecks, make public transport options simpler and cheaper – and therefore more attractive – to the user, and moreover feed back passenger movement data which facilitates forward planning and helps to optimise the available capacity (see case study 20).

Smart Buildings

Energy use in buildings accounted for around half the UK's 150 million tonnes of carbon dioxide emissions in 2004, and the energy used to heat, light and run UK homes accounts for over half of that.

The UK government is taking a leading role in this area. Besides implementing the Energy Performance of Buildings Directive (which requires all publicly owned buildings to display actual energy usage), all new homes being built will comply with low and zero carbon standards. The objective is to foster technologies and innovation that will help drive down emissions from existing building stock. The government is introducing a combination of economic incentives and regulatory controls to help achieve this and aims to be the first country to set a timetable for delivering zero carbon homes[80].

There is scope for ICT and associated technologies to play a major role in achieving these aims through the application of smart building technologies. These include building and energy management systems, metering technologies, environmental sensors, lighting control systems, energy auditing and optimisation software, and communication networks[81].

Building and energy management systems

Building management systems (BMS) are automatic means of controlling building services in order to maintain a comfortable working environment with the minimum amount of waste. Sets of data, such as occupancy levels and space measurements, are combined with information from sensors both internally and externally. This information is processed by a central computer which adjusts the controls for temperature, ventilation and lighting to maintain optimum efficiency. This kind of technology has made thousands of buildings "intelligent", saving hundreds of thousands of tonnes of cumulative CO_2 emissions (see case study 26). It is anticipated that in the home, people will be able to run a BMS through their digital TV.

Energy management systems work in a similar way to BMS but may operate on a much larger scale – for instance across a large facility like a hospital, factory or even a town. They provide data on energy use and identify opportunities for power saving. Kodak recently implemented an energy management system across their entire New York site which is saving them several millions of dollars annually in energy costs (see case study 24).

Metering technologies include applications like smart meters – which monitor energy use in buildings intelligently and pinpoint areas of waste. Environmental sensors include photosensitive elements that detect the ambient light levels and switch off internal lighting when the external light entering the building is at a certain level. Other lighting control systems within buildings include time-switches and movement sensors.

Lighting

Although there is plenty of scope for energy reduction by switching lights off, lights do need to be on at least some of the time, so it is important to make them as efficient as possible. Artificial lighting accounts for around 19% of global electricity consumption[82] so improving the efficiency of lighting can have a major impact on emissions.

LEDs, or Light Emitting Diodes provide an alternative – even revolutionary – approach to lighting. Often referred to as "solid state" lighting, they are semiconductors that light up when a current of electricity is passed through them, are over four times as efficient as traditional incandescent bulbs, will reduce energy costs by around 75% and yet have similar brightness to halogen lights. LEDs also have very low thermal output, reducing the need for cooling in heat sensitive environments. The National Theatre is replacing its lighting with solid state alternatives which will not only provide dramatic visual enhancements but will reduce the energy needed to light the building by 70% and save around £100,000 per year in energy costs. Comparable savings are being made on a wider scale elsewhere (see case studies 25 and 27).

Finally, the Cinderella of smart building technology, particularly in the UK, is electricity generation through solar photovoltaics, which is currently poorly exploited yet has major potential for reducing reliance on fossil fuels, particularly for water heating.

78 A means of changing behaviour along the "polluter pays principle"
79 SBD – see http://www.sbd.co.uk
80 Bulding a Greener Future – towards Zero Carbon Development, DCLG Consultation, December 2006
81 Source: UK CEED – Future Scenarios, ICT-Enabled Environmentally Smart Buildings
82 LEDs Magazine, Aug 2007 (http://www.ledsmagazine.com/features/4/8/2)

Technologies managing user behaviour

Changing behaviour takes more than effort – it usually takes a long time – which is the one thing we do not have. So we are developing interim solutions that mitigate user behaviour, for instance by turning things off automatically. These save energy by detecting when things are not in use and switching them off automatically – a bit like a stingy parent following their profligate offspring round the house and turning things off, but less intrusive and far less irritating.

Sensors detect movement (or the lack of it) and turn things off, "Intelliplugs" detect when devices are not in use and switch themselves, and other connected devices, off, timers provide light for long enough to move through an area, and "Smart Sockets" enable power supply to devices to be controlled remotely. More sophisticated power-down technologies like 1E's Nightwatchman® software or Intel's new VPro processors operate at a network level. A number of emerging technologies are variations on this theme and provide intelligent intervention to reduce energy use (see case studies 14 and 21).

Intelligent intervention devices are physical gadgets or software applications that make some kind of "informed intervention" to minimise energy use. Some are bolt-on applications and others are fully integrated into products or processes. For instance, "Dynamic demand" reduces the energy demand of appliances like fridges in peak periods and could save 2M tonnes of CO_2 a year if fully implemented[83]. Another gadget reduces the energy demand of fridges by measuring the temperature of the food (instead of the traditional approach of measuring the air temperature). New applications are appearing all the time: the difficult thing is keeping track of them.

These are a few of the many ways in which technology can make existing processes more efficient:- in factories and manufacturing plants, in offices, in the home or when travelling in between. Many applications are so fully integrated into our daily lives that we scarcely know they are there.

Enabling technologies

Reducing the impact of existing processes and actions incrementally through improved efficiency can only do so much: it can negate the additional energy requirements from the increase in production associated with economic growth and from improved functionality resulting from product innovations, but it is not sufficient to achieve what we really need:- a complete decoupling of economic growth from energy use. Technologies that change the way we do things, which we call enabling technologies, do have exactly that capability, which is why they deserve a lot more attention. Enabling technologies include energy-related applications that facilitate renewable generation and a whole series of technologies based on virtualisation, including in-silico testing and modelling, paperless office technologies, and electronic paper.

Reducing the impact of existing processes and actions incrementally through improved efficiency is not sufficient to achieve what we really need:- a complete decoupling of economic growth from energy use

Clean tech and energy generation

The energy supply sector has the largest share of carbon dioxide emissions in the UK, at around 38%, mainly because of the inherent inefficiencies in generating and distributing electricity from raw materials.

Because of the huge scale of these processes, even a fractional improvement in efficiency will make a dramatic dent in UK emissions, and again, ICT related technologies have an important function. ICT is already delivering improved efficiencies at the point of generation, including renewable power, for instance in the optimisation of wind farm operation (see case study 34). ICT is also of growing importance to the optimal generation and distribution of network power. For instance, electricity generation in the UK is finely tuned to align with forecast demand (which in turn relies on satellites and weather-forecasting computing). Green energy sources like wind power tend to be intermittent and widely distributed, usually away from centres of population and there is an important balancing act involved to optimise the use of renewables within the grid without compromising the reliability of supply.

As energy generation from renwables increases, ICT will also be an important enabler of the major grid reconfiguration that will be needed to cope with a more distributed pattern of generation. Moreover, successful integration of microgeneration and other renewable outputs into the national grid will also depend on technology. ICT is also a key enabler at the user end – for instance when trying to combine or integrate different types of fuel source to produce a single output. Hybrid cars could not operate without sophisticated software to balance the power distribution.

Photovoltaics

The technology sector also manufactures and supplies solar-related technologies, both for the domestic and commercial markets. Light energy can be converted into electricity using solar cells or photovoltaics, which are usually based on silicon. More recently, thin-film* technology is being developed which may improve efficiency and reduce the materials needed for each cell. Solar power is one of the few clean energy sources that can get appliances off the grid altogether (as we saw above) and has few of the disadvantages of large scale wind or wave power which will require extension and to some extent reconfiguration of the national grid. Sadly, photovoltaics provide only about 1.8% of the energy supply in the UK, as opposed to 7% across the EU, so there is significant scope for improvement here, simply by implementing existing technology.

83 BERR, August 2007, Dynamic Demand – see: http://www.berr.gov.uk/files/file41011.pdf (see case study 16)
* see glossary

The technology sector not only manufactures the latest solar applications, but also provides the essential software interfaces that allow solar technologies to work in conjunction with other heating solutions in the home. Furthermore, the technology sector is pioneering the reclamation of discarded silicon from computer-based applications to be used in the solar heating sector, which is currently constrained by a global shortage of silicon (see case study 31).

Virtualisation

The technology sector has an amazing capacity for virtualisation. We see virtualisation as the de-materialisation[84] of physical processes through the application of technology. The benefit of virtualisation is that traditional, high impact and high energy processes are replaced by low impact, low carbon technologies. The virtual replacement (or proxy) for a physical process usually uses far less energy (often several orders of magnitude) but still enables people to achieve the same ends. The difference is the way they do it.

Some virtualisation technologies, such as broadband, have been so successful and are now so pervasive that they have changed fundamental behaviour and led to the creation of new business models. Travel replacement technologies are the most important, and widely quoted, applications of virtualisation, and this is unsurprising considering that transport contributes almost 30% of CO_2 emissions in the UK. We will look at broadband in the next section. In this section we explore in-silico modelling and electronic document technologies which are good examples of virtualisation.

In-silico testing and modelling

Computer aided (in-silico) modelling is not new – engineering, architecture and many forms of manufacturing have used computer aided design (CAD) for decades, which makes dramatic energy savings over physical modelling (and also enables increasingly optimal products to be designed and produced). In more recent years, the virtualisation of modelling and testing has moved into new areas, in particular into biotechnology. In this context in-silico modelling is effectively the computational simulation of experimental biology, where much early stage modelling can now be conducted entirely on a computer using specialised software.

In-silico modelling enables the virtualisation of energy intensive, expensive and sometimes controversial procedures and can work at both the molecular level and the organism level. A related application is the rapidly developing area of bio-informatics[85], literally the combination of biotechnology and informatics: the collection, collation and analysis of biological data. One example is the mapping and analysis of clinical data to improve the understanding of fundamental disease mechanisms and to identify biological markers. Bioinformatics is particularly important in genetics research, because of the large amount of complex data this research generates. The application of software to experimental biology has made possible what was previously a cumbersome and energy-intensive task.

Paperless office technologies

Paperless office technologies are now a reality, not a futuristic scenario. Electronic document management systems enable businesses to capture and store documents without ever needing to print them. They also provide automated document record management, for instance, logging and storing revisions and version control. Electronic documents can be stored remotely but still be accessible online from any location. The primary objectives for electronic document management are usually cost saving, access, security and compliance with records management standards, but clear environmental benefits are emerging. Electronic document management reduces the need for faxes, photocopiers and printers and shrinks space requirements (together with associated light and heating demands).

Document management also offers additional functionality over paper based systems because a single system can combine, process and manage different kinds of data. In Germany, for instance, Siemens provide a document management system for installations to report their CO_2 emissions which collates a whole range of different data into a CO_2 account that streamlines and automates the reporting procedure and helps to optimise emissions trading (see case study 33).

Electronic paper

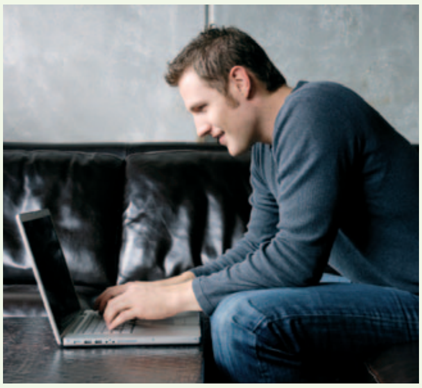
Many people are sceptical of the paperless office becoming a reality. Although there is a tendency not to store documents in printed form, they are often printed on demand and then thrown away, and maybe printed again when next needed. Paper is a major element in the life cycle assessment of any printer and the EPA estimates that it takes ten times more energy to manufacture a piece of paper than to create a print or copy[85], so this is a serious issue.

Electronic paper substitutes may provide the answer. Xerox, for example is developing an electronic reusable paper called Gyricon, a display material that has many of the properties of paper. It stores an image and is viewed in reflective light. Unlike conventional paper, however, it is electrically writeable and erasable. Although projected to cost somewhat more than a normal piece of paper, a sheet of electronic paper can be

Some technologies have become so pervasive that they do not just save energy, preserve resources and reduce waste, they also change fundamental behaviour and transform business processes

84 The definition of virtualisation is different in the data centre environment (see above). In this context, other terms include immaterialisation and e-materialisation. Some definitions differentiate these terms slightly.
85 First major achievement of bioinformatics was the creation of the database of genetic codesits for the whole human genome.
86 Source: Xerox 2006 Report on Global Citizenship

The benefit of virtualisation is that traditional, high impact and high energy processes are replaced by low impact, low carbon technologies



It is because we have broadband that companies have invested R&D in teleworking, mobile working and remote conferencing technologies

re-used thousands of times. This material has many potential applications in the field of information display (see case study 35).

Electronic reading, e-books and downloads

Accessing a newspaper through a PDA has been found to have 1/600th the energy impact of printing and distributing the physical version to the same reader[87]. As yet though, reading a large document through a miniaturised device may not seem a very attractive proposition, but the development of electronic books (e-books) is making virtual paper a reality. An e-book can either be purchased online and downloaded as a file or on disk, or borrowed through an online library. The content is protected using digital rights management (DRM) technology. Just like reading material, other online content such as music or video can be downloaded direct to disk, obviating the need for hardware, packaging or postage.

e-Commerce

e-Commerce developed as a viable alternative to traditional, paper-based processes. e-Banking has now become a way of life for many people, and more and more people are transacting online with government. The dematerialisation of processes like renewing a tax disc online saves energy, time and effort.

Electronic transactions are made feasible by authentication software such as a Digital Evidence Seal™ that validates communications, using special software that ensures transactions are secure and not vulnerable to interception, and by a broadband communications infrastructure, something we will look at later (see case study 30).

Transforming technologies – changing what we do

Some technologies have become so pervasive that they do not just save energy, preserve resources and reduce waste, they also change fundamental behaviour and transform business processes. Broadband access has transformed the telecoms marketplace and satellite technology is changing the nature of broadcasting and has spawned new industries like remote sensing.

In the previous section we explored how enhancing technologies are helping the transport sector become more efficient. Now we are going to look at technologies that remove the need for transport altogether – or at least reduce it to a fraction.

Broadband

Broadband underpins a huge range of other technological developments, all of which change the way we do things and the development and uptake of broadband is set to continue with the implementation of next generation networks – the UK's underlying communications infrastructure. It is because we have broadband that companies have invested R&D in teleworking, mobile working and remote conferencing technologies. Without the "fat pipe" there would not be much point.

The striking thing about broadband is the speed at which it has brought about dramatic behavioural change. Over the last five years it has developed from a leading edge technology into a mass-market must-have, enabling access to all kinds of online content from music to video. Those who adopted the technology rapidly adapted their way of working to take advantage of the flexibility it offered, and this change is demonstrated by the fact that 10% of workers in the UK now telework at least one day a week[88].

Teleworking

Teleworking is perhaps the most obvious way in which ICT can help improve energy efficiency and it is evident that it has a positive impact in reducing energy use even when rebound effects are taken into account. Rebound effects are the negative impacts of teleworking like increased home heating and lighting, opportunistic use of the car, staff moving further away from work because they have to travel there less frequently and potential duplication of hardware and office space. A recent survey by Flexibility.co.uk confirmed that teleworking does reduce emissions. For instance, BT's Workabout scheme[89] delivered an average reduction in travel of 193 miles a week per person.

Telemedicine is an important form of teleworking where expensive resources (like consultants) can be shared between locations and online support can be provided for patients who cannot travel.

"Homeshoring" and virtual call centres

ICT is often associated with off-shoring call centre functions to locations abroad to take advantage of cheaper labour costs. However, new technology is enabling "homeshoring[90]" where agents work flexible hours from home through a virtual call centre. The Co-Op Travel Group's Future Travel subsidiary has minimised its energy and travel requirements by establishing the largest virtual contact centre in the UK (see case study 37).

Virtual conferencing

Virtual conferencing has been made feasible by the availability of broadband infrastructure, and companies such as Microsoft, Cisco and HP (among others) have created 3-D

87 Toffel, M & Horvath, A, Environmental Implications of Wireless Technologies: News Delivery and Business Meetings, Environmental Science & Technology, 38(12) 2004, pp 17-24
88 Source: Broadband Stakeholder Group
89 UK CEED / Sustel case studies / Report – Is Teleworking Sustainable? 2004
90 Flexibility.co.uk – the online journal of flexible work

With access to sunshine reserves one billion times greater than those that reach the earth, space-related technologies are truly disruptive technologies that offer dramatic potential for replacing traditional terrestrial processes with low energy alternatives

videoconferencing suites that exactly mimic a round table meeting, so that remote attendees are brought together as though they are in the same room. Other companies like Thales have developed similar tools that enable collaborative team working for people dispersed geographically.

Refinements in virtual conferencing technologies provide flexible conferencing facilities where those involved need only join the meeting for the parts relevant to them, or be called to the meeting at short notice if particular expertise is required. Materials can be exchanged online and documents can be reviewed, amended and circulated in real time.

Now that virtual conferencing provides a viable alternative to a physical presence it has enormous scope for reducing travel, particularly long distance air travel. This is amply demonstrated at Vodafone where 5520 tonnes of CO_2 were saved in 2006 as a result of encouraging videoconferencing in place of travel. This was achieved by a combination of behavioural change and the provision of high-end equipment (see case studies 36, 38, 40 and 41).

On a larger scale, webinars are online seminars that are conducted live with audio and usually video, involving interaction between the speakers and moderator and the remote audience. In addition to the advantage over traditional conferences, which have a substantial energy impact because attendees frequently travel long distances, the content of most webinars stays accessible online after the event, so those unable to attend can review the outcomes without the need for printed conference proceedings.

Online conferencing does not have to use expensive, state-of the art facilities – one-to-one or small scale meetings can be conducted online with a basic broadband connection and a cheap digital camera, using web-conferencing facilities (such as Microsoft's NetMeeting or Yahoo Messenger) that are pre-installed on the operating systems of most PCs, or available to download. Documents can even be transferred using a virtual whiteboard. Low cost VOIP* technologies such as Skype are proving increasingly popular for one-to-one remote interaction. It is also possible to forget the video contact altogether – audio conferencing is a low cost, perfectly effective alternative for small meetings and participants can use the internet to access materials simultaneously. SustainIT's recent figures suggest that replacing physical conferencing with virtual conferencing could save over 2M tonnes of CO_2 per year[91]. At BT alone, replacing physical conferencing with teleconferencing saved 47,400 tonnes of CO_2 in one year[92].

One of the most exciting things about technologies like broadband is the incredible speed at which they become integrated into people's everyday lives, and how our behaviour changes as a result. For this reason we call them disruptive technologies. Disruptive technologies stimulate innovation, spawning a whole new array of industries and technologies. Broadband for example underpins new developments in wireless networking such as 3G, 4G and WIMAX (radio based bandwidth without the wires) which provide a seamless wireless networking environment and enable truly location independent working.

Space and satellite applications

With access to sunshine reserves one billion times greater than those that reach the earth, space-related technologies are truly disruptive technologies that offer dramatic potential for replacing traditional terrestrial processes with low energy alternatives.

Satellites are exceptionally energy efficient – a satellite launcher emits less CO_2 than a single transatlantic flight[93], and is a one-off cost – once the satellite is in orbit, it runs entirely on solar power. Moreover, at launch sites such as Kourou, the energy required to reform ethanol into hydrogen and oxygen and its refrigeration to liquid fuel is from a hydroelectric source and the ethanol is produced from sugar cane. Some materials are lost during launch (about 10% of a single aircraft by mass) but a rocket is only used in this way about once every 20 years.

Network Infrastructures

There is scope for achieving orders of magnitude energy savings by switching to satellite technology to perform terrestrial network infrastructure tasks, particularly in the communications field. Broadcasting is a good example of this: the current UK terrestrial TV broadcast system consumes more than 50MW and releases at least a quarter of a million tons of CO_2 per annum. A single satellite can provide all the UK's TV in HD format and releases zero CO_2 into the atmosphere. It is powered purely by sunlight. Even the uplink requirement is miniscule in comparison – far less than 1% of terrestrial demand. As satellite power and antenna size increase, future satellite systems (e.g. GEO and LEO) will also be able to provide broadband and mobile cost and performance comparable with terrestrial systems. They will provide a greener ICT network alternative for a wide range of service providers.

91 SustainIT – www.sustainIT.org
92 SustainIT case study, based on a sample of 4,900 BT staff, October 2004
93 Source, Case4Space, additional data provided from pers. comm., December 2007
* see glossary

Monitoring and remote sensing

Globally, earth observation by satellites such as those of EC/ESA's GMES[94] programme provide crucial data on earth system processes, environmental trends and compliance levels without the need for field surveys or piecemeal collation of individual data sets. It is also worth mentioning that all the climate change modelling, projections and predictions that form the basis for the whole debate, are reliant on the technology sector. In fact without the ICT sector we might not even understand what is going on – and it would certainly be difficult to have a global debate on the subject.

Space and satellite applications are enabling the rapid development of new technologies that in turn save energy, such as remote sensing and GIS (Geographic Information Systems). Remote sensing is a monitoring and analytical technology, usually, though not exclusively performed by satellites. Remote sensing provides reliable information on hard-to-access areas, for instance mountains, war zones, the polar regions and the oceans. GIS provide another means of analysing an area without having to visit it physically. GIS combine relational databases with spatial interpretation using computers and specialised software, and produce analysis either in the form of data or maps which can be queried.

In addition to the obvious benefits that satellite imaging and weather-forecasting computing have brought to industries like farming and fishing, other exciting developments in satellite technology include "smart services" which minimise the need for irrigation or fertilizers by monitoring and analysing ground conditions and crop requirements in real time (see case study 39).

Space-related technology has also produced ground breaking and universally adopted applications, including solar cells, fuel cells, large scale liquid hydrogen technology, and imaging algorithms.[95]

Trends: Integrated solutions, service provision and partnerships

It is important to note that solutions like flexible conferencing and telework rely not on one technology but on the integration of a number of different technologies. Broadband underpins flexible working technologies but these still rely on advanced virtual networks, on intelligent software and on sophisticated hardware. Mobile computing, for instance, is enabled by a combination of telecoms infrastructure including wireless networks and advanced hardware. Pretty much every low-impact alternative technology on offer relies on a combination of different, interdependent technologies. Moreover, many, if not most solutions are cross-sectoral, relying on engineering for instance, or biotechnology. We believe that the interoperation of different technologies will become increasingly important, increasingly pervasive – and increasingly invisible.

Over time, and as technology improves, airports could become teleconferencing hubs as well as travel hubs – and the virtual side of the joint offerings might gradually supplant the physical side

The concept of service provision is becoming increasingly important in the technology industry and is replacing traditional, more specific offerings like particular items of hardware or software. What this really means is that instead of a utility company selling gas, for instance, they sell the service of keeping people warm, so they take care of all domestic heating aspects including supply, efficiency and insulation. Document management services could be seen as an example within the technology sector.

This trend could have some very exciting – and environmentally beneficial – consequences, particularly if a partnership approach is adopted. If, for instance, a major airline went into partnership with a company offering state-of-the-art videoconferencing facilities like Cisco, between them they could offer a service to bring people together, either virtually, or physically. Over time, and as technology improves, airports could become teleconferencing hubs as well as travel hubs – and the virtual side of the joint offerings might gradually supplant the physical side.

94 European Community / European Space Agency Global Monitoring for the Environment and Security
95 Case4Space report, 2006

It will take time and research to establish conclusively which technologies are the real winners. Although we have long term solutions, in the short term we will have to rely on a combination of approaches

A word of caution – uncertainty, transitional technologies and legacy issues

Uncertainty

Disruptive technologies that change behaviour as radically as the ones we have discussed above do, inevitably, involve considerable uncertainty. It can often be difficult to predict the longer term consequences – after all, text messaging was never expected to be popular. Some models, like videoconferencing and teleworking, are robust and display clear and measurable energy savings – even allowing for "rebound" effects. There is also a clear environmental benefit from music and video downloads which do not require physical disks to be made, distributed, retailed, purchased, and re-distributed. Philips estimates that using video on demand instead of renting or buying physical disks could save around 120,000 tonnes of CO_2 a year across the EU (see case study 32).

However, in some areas the picture is more complex – for instance, online shopping may save a journey to a shopping centre but if the delivery system for online orders is inefficient, the process might not always save energy. It will take time and research to establish conclusively which technologies are the real winners. We are therefore delighted that the European Parliament's Science and Technology Options Assessment Panel (STOA) has recently decided to undertake an analysis on the impact ICT has with regard to improving the energy efficiency of other sectors. This third party work will complement these activities and provide additional insight into quantifying these hard-to-measure aspects.

In the meantime, we are not standing still – companies like Fujitsu are already developing methods to evaluate quantitatively how much particular IT applications reduce the overall environmental burden and their work on Environmentally Conscious Solutions is a good example of the effort being made by our sector to understand this complex area (see case study 18).

Transitional and early stage technologies

The technology sector is an immature sector, developing at a rapid pace, and changing all the time as new and better technologies are implemented and adopted. When technologies are in early stages of development they are often not at optimum energy efficiency – and this has been true of digital radios and of plasma* TVs, both of which are rapidly becoming much more energy efficient. Secondly, there are transitional phases when we are moving from one technology to another. A good example of this would be the transition from analogue to digital TV – better known as Digital Switchover. Whilst much existing stock is analogue, many people are using set top boxes to upgrade their existing TVs (entirely sensibly) rather than buy new digital versions. This effectively means that for those people, two devices are drawing power rather than one and will continue to do so until they eventually upgrade.

This is the result of two technologies running in parallel during a transitional phase. In the longer term the situation will improve but in the meantime there an additional energy burden. Much the same applies to the new multifunctional devices like the iPhone or the Nokia N95, which combine mobile phone, MP3 player, camera, email and much more, yet many people still retain four separate devices despite the fact that functionality is duplicated.

Legacy issues

There is also a closely related legacy problem. As with vehicles, the newest technologies are usually the most efficient, but unfortunately this does not mean that they will be adopted instantly. All products have a life expectancy and there is a natural "stock" turnover, so inevitably the majority of equipment in use will not be the latest model, and therefore to some extent the energy efficiency of most devices in use will be sub-optimal.

As we mentioned earlier, there is a difficult trade-off between retaining existing stock to extend its lifecycle, and upgrading earlier to new models in order to improve energy efficiency. This is particularly important when dealing with equipment with high materials or energy intensity of manufacture and it reinforces the need to take life cycle aspects into consideration when making these decisions. It means that although we have long term solutions, in the short term we will have to rely on a combination of approaches including education and careful management. After all, people are familiar with "retro-fitting" older buildings with additional insulation or double glazing to improve energy efficiency, and careful management can have a similar effect with electronic equipment.

* see glossary

Part III
So why are our emissions still going up?

HIGH TECH: LOW CARBON – THE ROLE OF TECHNOLOGY IN TACKLING CLIMATE CHANGE

The core problem facing us is that whilst devices are getting more efficient, the gross energy demands of our sector are still rising

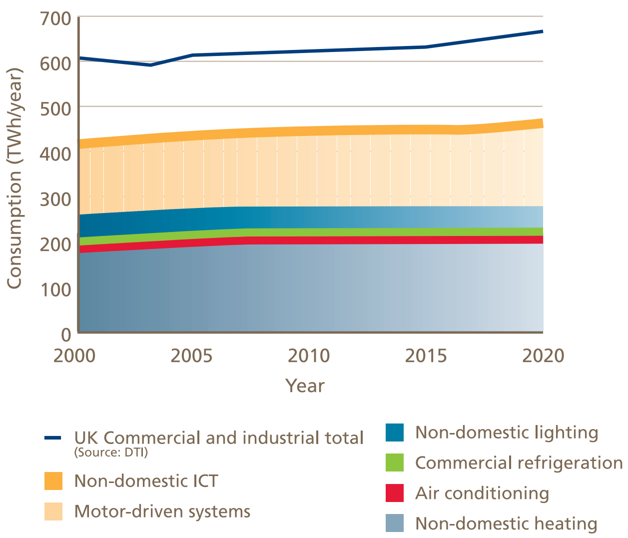
Sector Emissions and Trends

MTP figures state[96] that non-domestic electricity use by ICT equipment increased by nearly 70% between 2000 and 2005 and domestic consumption more than doubled, with growth set to continue, albeit at a slower rate. ICT products used over 25TWh of electricity in 2005. The figures for consumer electronics products look rather similar, with 2005 demand estimated at 17.5TWh and projected to rise to over 27TWh by 2010. Growth is mainly due to the increased proliferation of devices, and in the case of TVs, the tendency to buy models with larger screens.

To set this into context the MTP breakdown of energy use across the domestic and non domestic sectors is illustrated. This shows that on the one hand, ICT and CE only make up a tiny percentage of total energy use, but on the other hand, they are both predicted to grow.

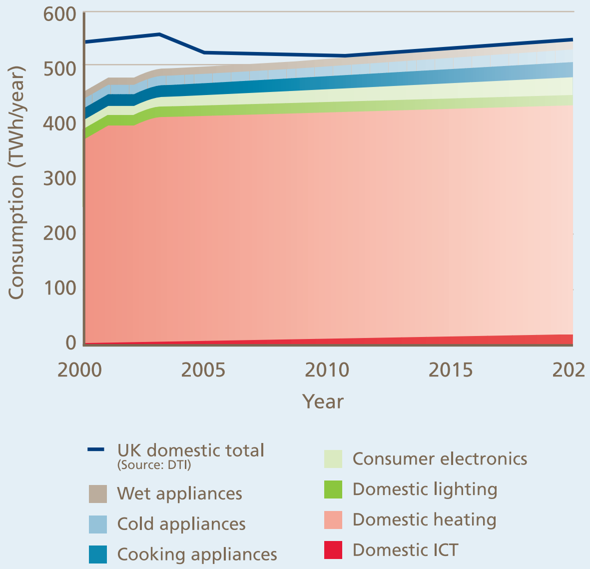
If energy use continues along these lines, then a quick back-of-the-envelope calculation based on the MTP's projections suggest that the energy use of ICT in 2050 could be around five times what it was in 2005 and the energy use of CE could be around six times what it was in 2005.

Diagram 6: MTP estimates and projections for non-domestic energy use. Note ICT share (thin orange band).



96 "Sustainable Products 2006 – Policy Analysis and Projections", Market Transformation Programme, 2006

Diagram 7: domestic energy use.



Source: MTP, Sustainable Products 2006, Policy Analysis and Projections

This means that the energy efficiency of devices will have to improve by roughly an order of magnitude to enable us to achieve our 2050 targets. That in itself may not be a problem; we have already demonstrated that our sector can, and will continue to, deliver orders of magnitude improvements in energy efficiency but there are other factors that have to be taken into account.

Issues and barriers

So why is this happening? What is preventing the downward trend in gross energy use that we all want to see? In Part I of this report we explored the issue of energy consumption across our products and services, and identified what we are doing to address efficiency issues. We know that our products and our manufacturing processes are getting more energy efficient, which should help counterbalance the increasing proliferation of devices. We also looked at energy loss through standby and peripheral consumption and identified some of the solutions we have provided to address these issues. We also explored potential problems that arise from transitional technologies.

There is no doubt that these all contribute to the upward slope of the MTP graphs, but there are other, more complex and pervasive issues that either exacerbate the problems we addressed above, or act as barriers to developing and implementing solutions. These include procurement, policy and perverse incentives, user behaviour and carbon accountability.

Procurement, policy and perverse incentives

Many believe that traditional procurement processes, particularly in large organisations, are a barrier to energy efficient ICT. For example, those who are responsible for facilities management (i.e. those who pay the electricity bill) are often not involved in purchasing ICT. As a result, energy efficiency has not been a criterion in purchasing decisions and the knock-on effect is that there is little incentive for suppliers to offer energy efficient solutions. In the public sector (the UK's largest ICT customer) mechanisms are in place to promote sustainable procurement but the National Audit Office identified a "gap between commitment and implementation" and identified a number of barriers including lack of leadership, lack of integration, decentralisation, ignorance and difficulty in balancing cost with sustainability[97]. The situation is changing for the better, but not quickly enough.

We have seen a plethora of policy measures to address climate change in the UK, and although it is clear that things are heading in the right direction, many observers think that policy instruments need to be stronger and implemented more quickly in order to drive the kind of changes needed. For instance, the Carbon Trust observes that "Without a more supportive policy framework it seems unlikely that the government's goal of putting the UK on a path to reducing its CO_2 emissions by 2050 will be realised"[98]. In addition to more positive initiatives, current approaches may need to be strengthened (e.g. to ensure that the next phase of the EU ETS operates more effectively than the previous one).

It is also important to ensure that existing policy measures are working as intended. Sometimes regulation has unforeseen consequences and may even create what the Carbon Trust terms "perverse incentives" which have side effects that encourage environmentally damaging behaviour. Traditionally, business mileage had to exceed a certain threshold to attract more favourable taxation status, encouraging those below that threshold to increase their use of the car in preference to other modes of transport. Within the ICT environment, the implementation of Sarbanes Oxley and MIFID[99] require financial services data to be stored in an instantly accessible form for a number of years which adds significantly to the energy burden of data centres because material that might be safely archived is held on active servers, with consequent, long term, energy requirements.

Perverse incentives are not restricted to the regulatory environment – there have been instances when organisations that power down their equipment and then restart it each morning are penalised by their energy provider because the restart creates a demand spike that moves them into the next tariff band – as a result they are charged more money for using less electricity.

User behaviour

User behaviour has a dramatic influence on the energy efficiency of ICT and CE products – firstly in purchasing preferences and secondly in actual use. Users include the domestic consumer buying a TV right up to government departments purchasing an ICT system with the help of specialist buyers and procurement guidelines – all of them are customers.

Customers can be the driving force behind innovation and product development because they provide the market "pull" for products and services. Manufacturers respond to, and to some extent try to anticipate, that demand. If energy efficiency drives demand, then energy efficiency will drive supply but this pattern is not yet evident. To date, the sector has had to rely on voluntary agreements within the industry to improve energy efficiency in the absence of customer demand.

97 National Audit Office, Sustainable Procurement in Central Government, September 2005
98 Innovation Report, The Carbon Trust
99 Markets in Financial Instruments Directive

The energy efficiency of devices will have to improve by roughly an order of magnitude to enable us to achieve our 2050 targets. That in itself may not be a problem; we have already demonstrated that our sector can, and will continue to, deliver orders of magnitude improvements in energy efficiency but there are other factors that have to be taken into account

People often bemoan the fact that ICT can be used to generate more printed matter than ever before, but it can also be used intelligently to run an entirely paperless office. Just like the efficiency of a car depends on the way it is driven, the efficiency of ICT equipment depends on the way it is used. This is true at every level, from businesses running huge data centres to the domestic consumer in a studio flat. Only the most profligate would leave a car running in the drive whilst they go inside to have lunch, or leave the oven on overnight with nothing cooking, but exactly this behaviour is common with ICT and CE equipment.

People often bemoan the fact that ICT can be used to generate more printed matter than ever before, but it can also be used intelligently to run an entirely paperless office

Part of the explanation is, paradoxically, that these devices are regarded as low-energy, so the consequences of leaving them on are perceived to be negligible. However, as we have already seen, the increasing penetration of ICT and CE equipment means that the cumulative effect is very significant.

Business users

Most computer equipment already has power-management features but evidence suggests that users are simply unaware of, or unwilling to activate, these options. A recent study[100] found that 53% of computers had the ability to activate system hibernate but this feature was only used in 3%, 86% had the ability to activate system standby but it was only used in 22% and 100% had the ability to switch off the hard disk but this option was only activated in 22%. In many cases, power management features set as default in IT equipment are actually disabled by the IT department or the end user.

Another study by the National Energy Foundation (NEF)[101] established that over 87% of employees have never been asked to shut down their PC at night by their employers and that at least 1.7 million PCs are habitually left on overnight and at the weekends, wasting 1.5 billion KWh of electricity per year, equivalent to 700,000 tonnes of CO_2. NEF also estimates that if all UK businesses shut down their PCs when not in use it would contribute 10% of the Government's Climate Change Levy target, and 40% of the energy efficiency targets set by the Carbon Trust. Shutting down the government's estimated two million PCs alone would save around 140,000 tonnes of CO_2 annually. There is clearly scope for better information and guidance.

The importance of customer behaviour is also demonstrated in energy intensive data centres, where the mission critical nature of the data means that all other factors rank as relatively immaterial on the priority scale. Until recently, there was little interest in energy efficiency and suppliers who invested R&D to offer energy-efficient data centre solutions[102] lost out. Things are changing, and energy efficiency has risen as a priority – but more because of limitations in supply than because of rising energy costs.

Domestic consumers

Recent work by Forrester Research in the US found that only 12% of adults would pay more for environmentally friendly CE products, 41% were concerned about the environment but did not believe they should pay more for green products, and 47% did not have concerns about the environment or global warming in particular[103]. So far there is little evidence that things are much better in the UK.

Consumers do not replace like-for-like when they buy new devices – they have every right to take advantage of the rapid pace of development and upgrade to more sophisticated products with enhanced performance. Most people buying new TVs will want larger screens, better definition and enhanced

100 Monitoring Home Computers, Market Transformation Programme 2007
101 Assessment for potential for energy savings from PC software management, 1E / NEF,
102 Cobalt might be seen as an example
103 In Search of Green Technology Consumers, Forrester Research Inc, December 2007

Over time it is likely that carbon will be traded just like copper or coffee. It is going to be very important, therefore, for companies to be able to account for their carbon just as they would account for any other physical asset, like hardware or building stock

sound quality. The problem is that as screen size increases, so does energy use. Contrary to popular belief, LCD*, CRT and Plasma TV screens are broadly similar in their energy requirement[104], varying by about 25%. It is the larger screen size that makes the difference, not the underlying technology.

Changes in user habits and in demographics are also having an effect on the power consumption of technology products. There is an increasing proliferation of entertainment equipment owned by children, with the economic influence of the young now being six times greater than it was in the 1950s[105].

Moreover, the number of households is set to increase with the trend towards smaller family units, each requiring its own set of devices, and the projected increase in affluence will increase spending on entertainment and labour saving devices and will reduce sensitivity to cost saving.

Carbon accountability

The issues discussed above are actually symptoms of a bigger problem – what economists call the "market failure" in carbon. In fact, the Stern Review states that "climate change is the greatest and widest-ranging market failure ever seen"[106]. Market failure happens when the price of goods or services does not reflect the true cost to society – in this case, not factoring in the long term costs of carbon mitigation in the short term price of energy. Our generation enjoys the benefits of cheap energy, the next generation pays the true price[107]. Currently, renewables and clean energy look expensive when compared to fossil fuel alternatives, and there are no clear price signals to differentiate energy efficient products from cheaper but less environmentally friendly ones. In the words of the Carbon Trust "Market pull mechanisms for low carbon technologies are weak in the absence of policy measures, because carbon emissions are an externality[108]".

The result is that there is little to encourage consumers to make energy efficient purchases, or to focus competition around energy efficiency. That means there is no incentive for firms to invest in low carbon technologies. Even where cost savings can be achieved they are not taken up "because the payback period is too long. Government and business must look for creative ways to bridge this gap."[109]

The conventional solution to market failure is of course to create a market for carbon through legislation and/or market instruments. This is the objective of the European Emissions Trading Scheme, which still has some way to go to achieve its intended effects. In the UK the Climate Change Levy, the Climate Change Agreements and the Carbon Reduction Commitment all, to some extent, help give carbon a value. The UK Government has even proposed the introduction of a national carbon budget. With the development of these schemes, carbon is increasingly becoming a commodity. Over time it is likely that carbon will be traded just like copper or coffee. It is going to be very important, therefore, for companies to be able to account for their carbon just as they would account for any other physical asset, like hardware or building stock.

Organisations like the Carbon Disclosure Project provide companies with a methodology and formal process to account for carbon and they also publish data on corporate emissions in order to catalyse activity and improve transparency. Investors and shareholders are already starting to take into account the carbon assets of companies and these may become important factors in terms of valuation and investment potential in the future.

Over time, carbon accounting is likely to become increasingly important on an individual level, and eventually the implementation of individual carbon accounts may allow the social cost of emissions to be added to the market price of energy. This will at last enable us to "see" the emissions implications of every action or purchase we make, if not with our eyes, then through our wallets. The difficulty will be in establishing how much more accountable we need to make carbon in order to send the right signals to consumers and businesses, and how to do this without unwelcome side effects like aggravating fuel poverty.

But carbon accounting is far from simple. The Carbon Trust's work in calculating the carbon footprint of relatively simple goods like crisps has only served to underline the enormity of the task, particularly for complex, multi-component goods like TVs. The Carbon Trust is currently working with the British Standards Institute to develop an open source methodology and standard for the calculation of embodied carbon in the supply chain.

104 Recent tests recorded the power draw of CRT, LCD and Plasma TVs as 0.0472, 0.0507 and 0.0583 W/cm2 of screen respectively, Market Transformation Programme, November 2007.
105 Changing Consumer Lifestyles and their possible effects on future patterns of energy consumption – Market Transformation Programme, 2006
106 Stern Review:- The Economics of Climate Change
107 Market failure usually results from imperfect competition such as monopolistic control or when externalities are involved. Externalities are additional costs (or benefits) borne by others not involved in the transaction.
108 Innovation Report, Carbon Trust
109 Climate Change: Everyone's Business, CBI Climate Change Task Force, November 2007
* see glossary

The emissions associated with the ICT industry may rise due the application of energy saving technologies across other sectors. If so it will be important to distinguish this "growth" in emissions, which is enabling larger reductions elsewhere, from real and less welcome increases. Such calculations are far from straightforward

There is a further complication: accountability for emission versus credit for carbon saved. This could be a particular issue in ICT applications, as this illustration shows.

Carbon accountability: A scenario

- A logistics software service is adopted by a transport provider.
- The new system will have an energy impact of its own because it will be run on computers, probably backed up on servers that run 24 hours a day.
- However, that software package enables the transport provider to cut his vehicle miles substantially, and reduce his emissions proportionally.
- Since carbon is accountable, the ICT sector takes on the small addition in emissions and the transport sector gets a much larger carbon credit.
- The overall result is positive – a reduction in gross energy requirement, but the ICT service provider is "punished" for providing the very service that made this possible. It is easy to see how issues will arise over who "owns" this carbon.

We can see that the emissions associated with the ICT industry may rise due the application of energy saving technologies across other sectors. If so it will be important to distinguish this "growth" in emissions, which is enabling larger reductions elsewhere, from real and less welcome increases. Such calculations are far from straightforward.

Despite these difficulties, making carbon accountable is a positive thing. It will help solve the problem of market failure. It will help drive demand for energy efficient products and services, it includes life cycle considerations and will iron out the kinds of perverse incentive that we identified in Part I. It will improve transparency, create a level playing field for energy efficient manufacturers and stimulate investment in low carbon technologies.

Part IV

Why technology matters

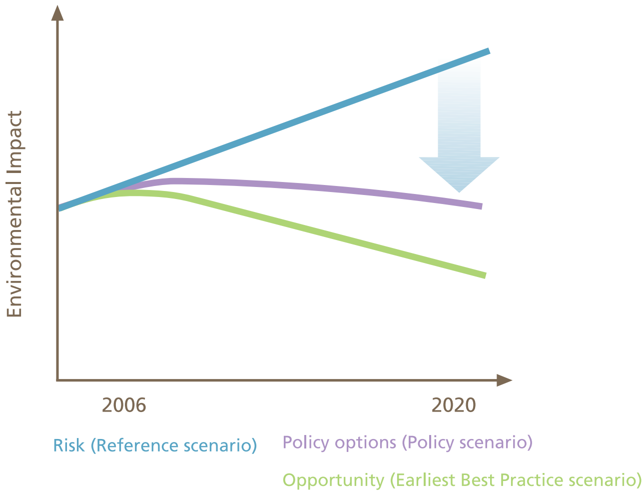
HIGH TECH: LOW CARBON – THE ROLE OF TECHNOLOGY IN TACKLING CLIMATE CHANGE

The timely adoption of low carbon technologies is a critical success factor in tackling climate change

Carbon reduction: Why technology is so important

In the previous section we looked at MTP charts which predicted that the energy consumption of ICT and CE would continue to grow up to 2020. But this is not the only picture.Those scenarios are based on the extrapolation of current trends. The MTP has also developed a different set of forecasts which set out energy predictions for three different scenarios – firstly a "risk" scenario based on current trends, secondly a "policy" scenario incorporating the implementation of energy saving policy measures, and thirdly an "earliest best practice" scenario, envisaging a situation where the most energy efficient technology is brought quickly to market, and adopted rapidly by consumers, encouraged by policy measures (see diagram). It is not anticipated that this scenario will be fully realised but it serves to illustrate the opportunities for energy savings given the right conditions.

Diagram 8: MTP Scenarios.



Source: Market Transformation Programme: Sustainable Products 2006: Policy Analysis and Projections

Much greater energy savings could be achieved by the rapid implementation and uptake of new technologies than by policy measures alone

Spotlight on TVs

TVs provide a good case study to examine in more detail. This area is complex and problematic, because improvements in energy efficiency are being neutralised by proliferation and by a tendency for people to upgrade to larger, more sophisticated models.

The MTP predicts that projected energy consumption of TVs in the UK is expected to rise from 9.6TWh in 2005 to over 19.3TWh in 2020. This is their "risk" scenario (a rough equivalent to business as usual). However, their figures suggest that, whilst policy measures could achieve a savings of 0.4TWh a year by 2010 ("policy" scenario), the universal adoption of TVs with best environmental performance would achieve much more dramatic savings of 2.5TWh and 11.5TWh per year by 2010 and 2020 respectively ("earliest best practice" scenario).

Because of the difficulty in predicting future performance of TV technologies in such a rapidly changing industry, the effects of "earliest best practice" are limited to improvements in stand-by and on-mode efficiency for plasma and LCD TVs, and do not include the energy saving potential of emerging technologies like OLEDs (organic LEDs)* and FED (Field Emission Display*) screens. This suggests to us that there may be further potential for energy saving than is envisaged by these figures. After all, ten years ago LCD screens seemed very radical – in ten years time it is likely that we will have moved on beyond plasma to another technology – and maybe even beyond that.

The important message in all this is that much greater energy savings could be achieved by the rapid implementation and uptake of new technologies than by policy measures alone. This position is strongly supported by the CBI's Climate Change Task Force who stated "Technology has a vital part to play in opening up sustainable solutions" whilst emphasising the important role of government in delivering supporting policy measures: "Ultimately, government has a critical role in determining how business and consumers can play their parts in tackling emissions…its policies on tax, regulation, planning innovation and public spending create the rules by which markets work".

The importance of timing: Early implementation of low carbon technologies

The MTP chart demonstrate clearly the importance of accelerating the adoption of the best, most energy efficient technologies in order to help meet our emissions reduction targets.

The rate of carbon abatement proposed by the UK government's Climate Change Bill may be enough to meet our 2050 targets but it is not enough to prevent disastrous levels of CO_2 accumulating in the atmosphere

Implicit in this is an obvious fact – the earlier those technologies are implemented, the better, irrespective of whether they are existing technologies that need to be fully implemented or pipeline technologies that need development and deployment.

Recent work by the Tyndall Centre for Climate Change presents some very alarming findings[110]. According to their calculations the rate of carbon abatement proposed by the UK government's Climate Change Bill may be enough to meet our 2050 targets but it is not enough to prevent disastrous levels of CO_2 accumulating in the atmosphere – levels over 600ppm, enough to make a temperature rise of 4°C a likely scenario.

110 Drinking in the Last Chance Saloon; Dr Kevin Anderson, Tyndall Centre for Climate Change, Presentation made at "Climate Frameworks: implications, opportunities and threats" a conference at the Royal Society, 14th November 2007.

* see glossary

It is the cumulative total of CO_2 emissions which matters (even more than hitting a particular target by a particular date) because it is the concentration of CO_2 (and other greenhouse gases) in the atmosphere that influences climate change

There are two further underlying issues that cannot be brushed under the carpet. Firstly, if we continue to ignore aviation, "the fastest growing carbon emissions source of any sector"[111] then all other sectors will have to reduce their emissions by closer to 90% than 60% to "balance the books". Secondly, if we take a global view, developed countries will need to transform themselves into true low-carbon economies in order to allow for the inevitable growth in developing countries. Again, a reduction much greater than 60% will be needed.

This will require some fairly radical changes both in technology and behaviour over the next few decades which emphasises even more strongly the importance of the timely application of those enabling and transforming technologies discussed earlier. A shift of this magnitude cannot be achieved by incremental improvements alone.

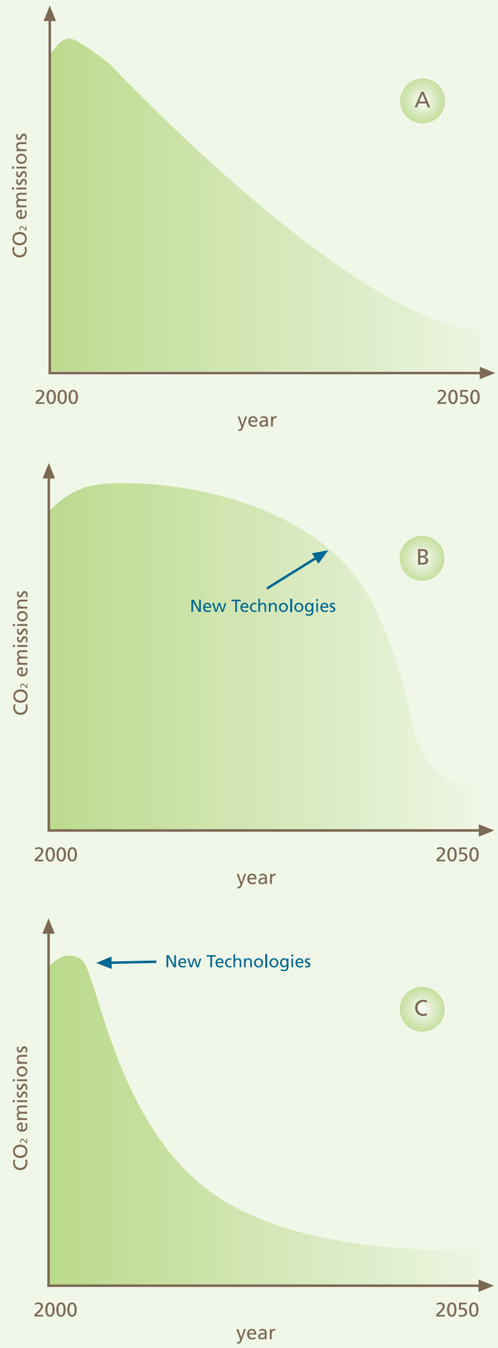
This is illustrated by the charts below[112]. They show three different scenarios for a reduction in emissions between 2000 and 2050 from current levels to the kind of level that might reflect a truly low carbon economy. When we talk about targets by particular dates, we often assume that there is a steady reduction in emissions over time. This kind of scenario is represented by chart A. In chart B, we achieve the same targets by 2050 but only at the last minute. In chart C the targets are also achieved, but dramatic savings are made at a much earlier point in time.

The substantial difference between the charts is the area under the curve which represents cumulative emissions between 2000 and 2050.

This is not a completely new approach – many models such as the elegant Wedges Model[113] are based around a cumulative concept (in that particular case, cumulative savings) but it is a very important concept to keep in mind because it is the cumulative total of CO_2 emissions which matters (even more than hitting a particular target by a particular date) because it is the concentration of CO_2 (and other greenhouse gases) in the atmosphere that influences climate change.

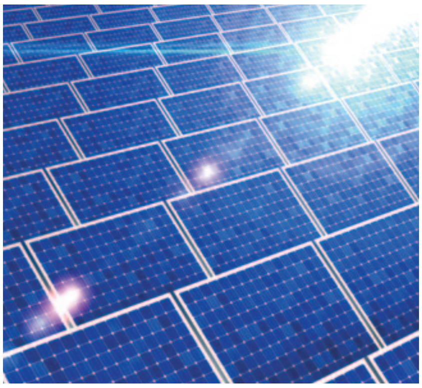
In this illustration cumulative emissions released into the atmosphere between now and our deadline are dramatically greater in scenario B – around twice as much – than in scenario C, despite the fact that in both scenarios the same target emission levels are achieved.

Diagram 8: Cumulative emissions: three scenarios



111 Source, Dr Kevin Anderson, as above.
112 These charts are loose adaptations of points made in: Drinking in the Last Chance Saloon; Dr Kevin Anderson, Tyndall Centre for Climate Change (See previous references)
113 The Wedges Model was developed at Princeton University by Robert Socolow.

The critical factor is timing. If new low-carbon technologies do not achieve full implementation until 2040 then we court disaster



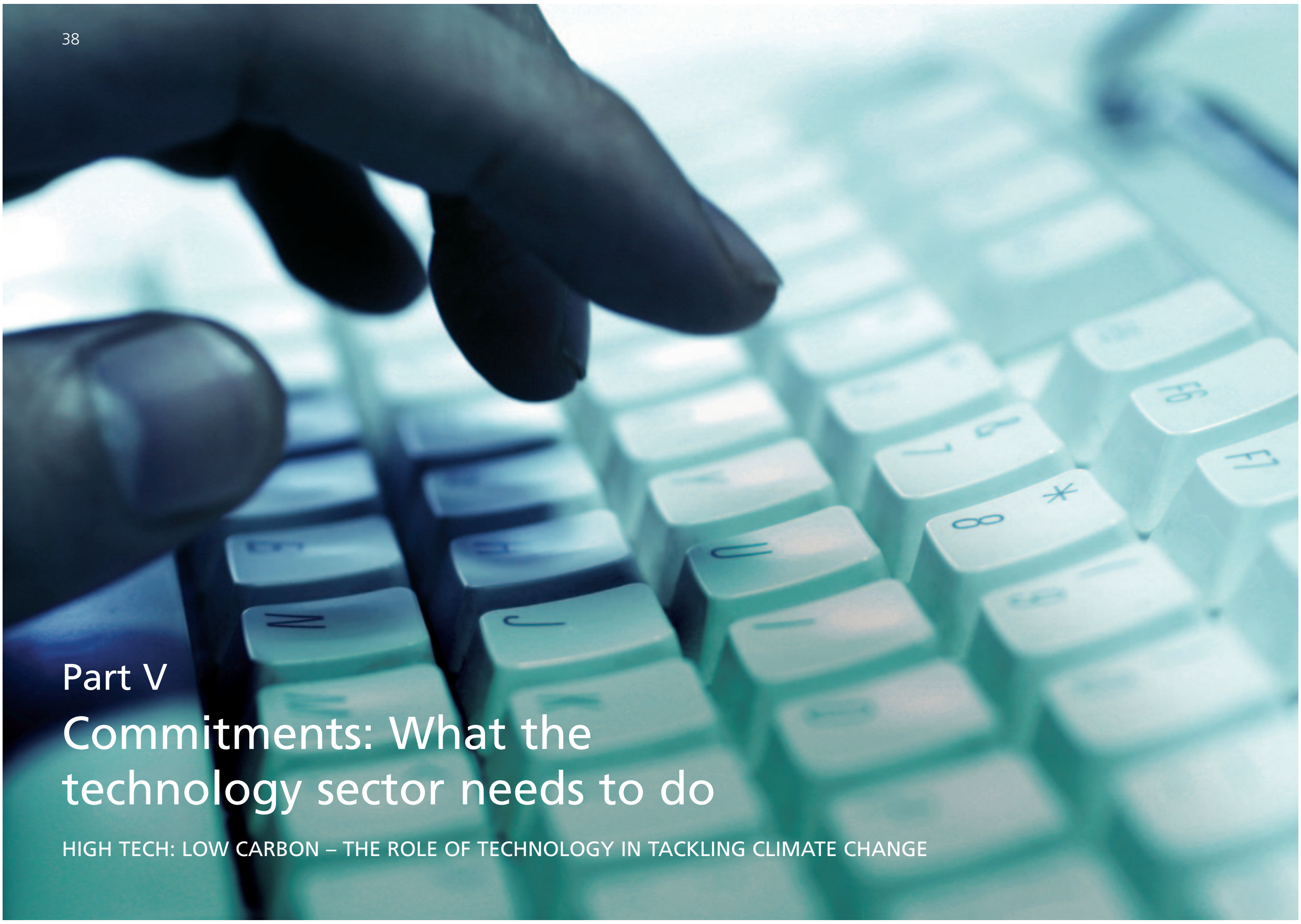
The charts also imply that changing the shape of the curve to achieve a steep downward trend in emissions will depend on some very big changes, both in energy supply and demand. This is where the application of technology is key, as indicated by the arrows. Moreover, the steep decline will only start once these replacement technologies are fully developed and achieve widespread adoption.

These technologies are by no means exclusively ICT-related; many will be based on engineering or biotechnology for instance. The critical factor emphasised here, however, is timing. If new low-carbon technologies do not achieve full implementation until 2040 then we get the kind of result illustrated by chart B – and court disaster. If they are implemented rapidly before 2020, then we get something that looks more like chart C. These are only hypothetical illustrations but they make the point that we need to implement changes as early as possible to have the greatest cumulative effect.

We must do everything we can, collectively and individually, to identify those technologies as early as possible, to accelerate their development and support their implementation and adoption. The UK government is providing unprecedented levels of support for innovation through schemes like the Competitiveness and Innovation Framework Programme and the creation of the Energy Technologies Institute, and specialist sources of venture capital, such as Carbon Trust Investments, are emerging alongside traditional offerings.

The European Commission supports similar approaches including the Environmental Technology Action Plan, backed up by funding under the Entrepreneurship and Innovation programme. However, many feel that more is needed; in the UK the CBI Task Force is calling for a more coherent approach to R&D from government and more support to stimulate and develop emerging solutions.

We must do everything we can, collectively and individually, to identify those technologies as early as possible, to accelerate their development and support their implementation and adoption



Part V

Commitments: What the technology sector needs to do

HIGH TECH: LOW CARBON – THE ROLE OF TECHNOLOGY IN TACKLING CLIMATE CHANGE

We need to understand the energy implications of our products and processes better, we need to stimulate and encourage behavioural change to drive demand for energy efficiency and we need to optimise efficiency through our supply chain. Some of this work is up to us but some has to be shared

In Part I of this report we looked at the energy efficiency of our products and services, across design, manufacture and use phases. We identified problems like standby and rapid obsolescence and explained what we are doing to address them. We have not solved all the problems and there is more that we can do as a sector to reduce our emissions.

In Part IV we looked at the crucial role that technology will play in a move to a low-carbon economy and the critical issue of timing. Again, there is more that we can do as a sector to help.

This section therefore sets out some specific actions that we in the technology sector need to take collectively. These actions split into four main areas:

A. monitoring and measuring the emissions generated by our own products and services

B. improving environmental performance throughout our own supply chain by sharing best practice

C. stimulating and encouraging behavioural change

D. identifying and accelerating the development of the best low carbon technologies

The first three are aimed squarely at addressing some of the problems we identified in part I. The fourth has a more strategic objective; helping to optimise the positive environmental effects of technology.

We will now look at each area in more detail.

A. Monitoring and measuring the emissions associated with our products

Improved data on the carbon footprint of the manufacture and use of ICT and CE equipment and services would inform current debate. It would also provide a solid platform of evidence to help us identify opportunities for carbon reduction and single out priority areas for improvement. Although many technology companies lead the field in measuring and monitoring the energy impacts of their products, (and even produce tools to facilitate this), there is a need for a more systematic approach across the sector.

We will therefore working with scientists and technology experts at the University of Warwick to develop a mechanism to help us quantify:

- energy use during manufacturing, whether in the UK or overseas;
- energy use related to transport and distribution of products and components;
- energy use related to ICT service provision;
- energy use of ICT and CE products during their in-use phase.

This will be a progressive process which will also help to underpin the actions we are undertaking in areas B, C and D.

B. Disseminating best practice through our supply chain – Who Cares Wins

A recent survey of Intellect members revealed that whilst energy efficiency is a key priority, many businesses, particularly SMEs, are unsure how to optimise their environmental performance and would welcome guidance and peer support. Intellect is therefore developing a programme for its members to share best practice on improving the energy efficiency of their business and manufacturing processes.

The principle behind this is one we share with the CBI – that there will be long term rewards for those companies who take a lead in implementing the green agenda. Therefore the programme will be run under the heading “Who Cares Wins”. Its objective will be to help members assess their environmental performance and implement improvements whilst maintaining their competitiveness.

This will be a progressive process which will also help to underpin the actions we are undertaking in areas B, C and D.

C. Stimulating and encouraging behavioural change

Changing behaviour is neither easy nor quick and the effort involved should not be underestimated. We cannot do everything but we can make a substantial contribution at the three stages of consumption:– purchasing, use and replacement.

1. Purchasing: we need to encourage consumers to buy the most energy efficient products and help drive competition around energy use aspects. While there are plenty of energy efficient products on the market, information comparing their environmental credentials could be much better. We are therefore building and launching a web-based tool that enables consumers to compare the energy efficiency and environmental credentials of a wide range of electronics products against their functionality and purchase price. This will complement existing online directories and catalogues.
2. Use: we need to improve the way that devices in the home or the office are used. The objective is to tackle the energy loss that results from equipment being left on or charging unnecessarily. This will involve two approaches:

a. We will continue to ensure that technology does as much as possible to optimise energy efficiency of devices, both when they are working, and particularly when idle for long periods of time.

b. We will help consumers help themselves – by providing better information regarding the amount of energy that electronic devices use in different operating modes, and how to use settings and appropriate operating modes (including “off”!) to minimise energy use.

3. Replacement: we need to do more to try and identify ways to break the “upgrade cycle” where improvements in energy efficiency are negated by proliferation or by a tendency to buy bigger and better. This is a more complex issue and we will take a more qualitative approach here, again in association with the University of Warwick, to explore perceptions and potential triggers.

D. Identifying and accelerating the development of the best low-carbon technologies

The Stern Review, the MTP and others have highlighted the potential for new technology to help us move to a low-carbon world. In our sector, there is a need to identify more clearly which have the most potential to reduce the overall carbon footprint of society if technological change were accelerated, or if existing or new technology was embodied more quickly. Two of the most problematic areas in terms of emissions reduction – transport and domestic energy use – will form the focus of activity: technology experts from both business and academia will work together to address the following issues:

- which technologies are available or coming onstream, that have the potential to deliver significant emissions reductions in a cost-effective way?
- which technologies have the most potential to be developed in the future to achieve the same objective over a longer timescale?
- which steps might be taken to accelerate the embodiment and development of new low-carbon technologies?

The detailed work programme will be finalised in the second half of 2008 and we expect to report back before the end of 2009.

Next steps

The technology sector is engaging with other partners to try and ensure that our activity complements the work being done in other industry sectors across the economy. For instance, in their recent report “Climate Change: Everyone’s Business” the CBI identified five clear areas for further work. Three of these directly involve the technology sector, so we will be co-ordinating activity on an ongoing basis.

We are working jointly with the University of Warwick who are providing academic expertise to complement our business insights and, being external to our sector, will also bring objectivity to the process.

We are also involving our European counterparts, EICTA (the European association for the ICT and CE sectors), and INSEAD who will augment our work and broaden our perspectives.

Conclusion

HIGH TECH: LOW CARBON – THE ROLE OF TECHNOLOGY IN TACKLING CLIMATE CHANGE

In the long run, technology needs to be the central element of response strategies to climate change

The technology sector is a new industry and has developed at extraordinary speed over the last few decades, and on a scale far beyond early predictions. It also developed in response to the market pull of an environment where energy was not a major issue, where the sleeping giants of China and India were still snoozing, and where the kind of mass adoption we see today was no more than a pipe dream. It is a relatively immature sector and it has a lot of work to do.

It is clear that there is considerable scope for improving the energy efficiency of ICT and CE products. 2% of global emissions is a lot of carbon, irrespective of our sector size, our contribution to GDP or anything else. We have to work on reducing "our 2%" just like every other sector has to work at reducing its own share of emissions. However, it should also be clear that the technology sector has embraced the challenge of energy efficiency and is producing better, faster, lighter devices that use less and less energy as the result of a continuous process of intensive research and development.

Improving energy efficiency through incremental improvements can have a substantial effect over time, but in reality it can only have limited benefits – for instance it can compensate for the increase in productivity through economic growth or improvements in functionality – but it cannot do enough. We need to do much, much, more in order to have any chance of achieving the kind of reduction in CO_2 emissions over the next 50 years that is required to stabilise climate change. So in addition to improving efficiency we have to find ways to completely decouple economic growth from energy consumption. This is not an either/or scenario – we have to do both.

The technology sector is taking a leading role in this sense – producing dramatic efficiency improvements in existing products and simultaneously taking a central role in the development of alternative, low carbon technologies. We already help businesses and individuals do things in different ways, improving efficiency, replacing traditional, high impact processes with low carbon, low-impact alternatives which are being integrated into everyday life at an unprecedented speed. New technologies do not just change the way we do things, however – they change what we do, they create whole new business models, stimulating innovation and spawning new industries and technologies.

But there are barriers to progress. Although the MTP's predictions illustrate the dramatic effect that a wholesale adoption of best available technologies could have on energy use, these are not realistic scenarios but illustrations of what could be achieved under the right conditions. Robust policy instruments are required before these scenarios can approach reality.

Under current circumstances there is little incentive for individuals to seek out energy efficient products, or to change behaviour and adopt energy efficient lifestyles. And the reason for this? It is partly a cultural and behavioural issue but the principal problem is that there is a market failure in carbon where the social costs of emissions are not added to the price of energy. The result is that there are no clear price signals to differentiate energy efficient products from cheaper but less environmentally friendly ones, to encourage consumers to make energy efficient purchases and to focus competition around energy efficiency.

Although this document covers some complex issues, the important actions emerge very clearly. We need to understand the energy implications of our products and processes better, we need to stimulate and encourage behavioural change to drive demand for energy efficiency and we need to optimise efficiency through our supply chain. Some of this work is up to us but some has to be shared.

We also need to identify and then accelerate the development of the best low carbon technologies because there are two solutions to the problem of climate change – the intelligent use of technology and innovation. This is not the time to sit back, relax and wait for new technologies to sort everything out for us – the low-carbon technologies that the new economy will rely on need active stimulation and support, whether they already exist or not. We need to do everything possible collectively to accelerate their development and adoption because timing is a critical success factor in avoiding the disastrous accumulation of atmospheric CO_2 that could result from further delay.

The recently published and well-researched book "Avoiding Dangerous Climate Change" takes an in-depth look at the scientific issues associated with climate change and presents the most recent findings from leading international scientists. It concludes that "In the long run, technology needs to be the central element of response strategies to climate change"[114]. We in the technology sector fully support that conclusion.

114 Avoiding dangerous Climate Change, Ed. J Schellnhuber, Cambridge University Press 2007

Appendix One

Case study summaries

Full case studies are available from our website: www.intellectuk.org/casestudies

These case studies are loosely organised to reflect the structure of the preceding text. The first section relates to Part I and includes improvements to our own products and services through all three phases of design, manufacture and use. The second section relates to Part II and covers enhancing, enabling and transforming technologies in turn. These categories are not definitive; many technologies apply to more than one category.

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Section one: Improvements to our own products and services in use, manufacture and design

1. AMD: PowerNow! Technology

AMD PowerNow! Technology is a power management solution integrated into AMD Opteron processors that helps to reduce CPU (central processing unit) power consumption in servers by 15% and up to 40% at idle. Correspondingly, this also lowers the electricity consumption of the cooling equipment. The result is increased performance by Watt because power and cooling requirements are reduced. Combined with other technologies, such as AMD CoolCore technology (which shuts off the flow of electricity to sections of the processor when not in use) energy consumption can be decreased even further. These systems should be implemented in as part of a holistic process of energy management– i.e. in data centers which have already been re-organised, i.e. unnecessary hardware removed, the system consolidated and virtualised.

2. Eneco: new chip technology

Eneco is developing a revolutionary solid state energy conversion/generation chip that will convert heat directly into electricity, or alternatively refrigerate down to -200 degrees C when electricity is applied. Based on principles of thermionic energy conversion, whereby the energy of a hot metal overcomes the electrostatic forces holding electrons to its surface, these free electrons then pass across a vacuum to a cold metal and in the process creates an electronic charge that can be harnessed. The result is a solid-state energy conversion chip that can operate at temperatures of up to 600°C and deliver absolute efficiencies (in terms of how much heat energy is converted to electricity) of between 20 and 30%. There is scope for chips replacing high end lithium ion and polymer batteries, but the major scope is in integrating the heat conversion chips into computing devices to harness the heat generated by processors and turn it into electricity to power fans or other cooling technologies.

3. EPSON: digitises textile printing

Traditional textile printing is a complex manufacturing process that requires several production steps before a fabric is printed and ready for use. Epson offers solutions, based on the patented micropiëzo print technology, that can be used to digitise the textile printing process. Digital printing eliminates several of the production steps required for traditional textile printing. The implementation of digital textile printing leads to significant reductions in energy and water use compared to traditional textile printing. By changing the traditional textile printing process to digital printing, energy reductions of 50% can be achieved, leading to savings in the area of 23.000 KWh per printer or 1,610,000kWh in total during 2007.

4. Fujitsu: life cycle energy requirements of laptop and desktop PCs

Fujitsu published details of life cycle assessment of a desktop and a laptop computer which found that the desktop used more energy during its in-use phase (4510MJ) than in the manufacturing and disposal phases (2416MJ and -432MJ) whilst the laptop's energy use was greater in the manufacturing and disposal phase (1655MJ and -19MJ) than the in-use phase (810MJ). Interestingly, this difference is a reflection of the lower energy requirement of the laptop in use – less than 20% of the desktop – and should not therefore be read as a negative aspect of laptops. It emphasises the importance of taking whole life energy use into account. In this case the total energy requirement of the laptop is less than half that of the desktop (2446MJ as opposed to 6504MJ).

Type of PC	Note-book	Desk-top	Note-book	Desk-top	Note-book	Desk-top	Note-book	Desk-top	Note-book	Desk-top	Note-book	Desk-top
Energy Input MJ	1650	2410	5	16	810	4510	-19	-432	1636	1994	2446	6504
	Manufacturing stage		Distribution/Sales stage		Usage Stage		Collection / recycling		Manufacturing, distr. & recyc.		Total energy	

Adapted from pp 41-42 of 2005 Fujitsu Group Sustainability Report: http://www.fujitsu.com/downloads/ECO/rep2005/2005report41-42-e.pdf

5. HP: Dynamic Smart Cooling

Dynamic Smart Cooling is an advanced hardware and software solution that continuously adjusts data centre air conditioning settings and directs cool air to where and when it is required. Real-time air temperature measurements are taken by a network of sensors deployed on the racks of servers. An associated development, Thermal Zone Mapping, provides a three dimensional model of exactly how much and where the data centre air conditioners are cooling. From this information, air conditioning can be re-arranged for optimal cooling. HP predicts that customers can reduce data centre cooling energy costs by up to 45% using dynamic smart cooling and thermal zone mapping. Cooling costs comprise on average around 50% of a data centre's energy use, so substantial energy (and cost) savings can be achieved this way. HP also provides a thermal assessment service which uses sophisticated modelling tools and techniques to determine the unique thermal conditions within a data centre. These are analysed and changes can then be implemented to optimise climactic conditions and maximise capacity.

6. Nokia: charger alerts

For convenience, some mobile phone users may keep their chargers plugged into the wall constantly. From an environmental angle, such behaviour is undesirable. The charger consumes power (so-called standby consumption) even when it is not charging. Nokia decided to introduce an "unplug your charger" alert to some of its phone models. This application detects when the battery is fully charged and alerts the user to remind her to unplug the charger. If the charger is plugged into the wall all the time, the resulting standby consumption could amount to 60% of the mobile phone's total lifetime energy consumption. Therefore, the "unplug your charger" alert may reduce the use-phase energy consumption of mobile phones by more than a half. Nokia believes that having the reminder in the mobile phone helps to make users more conscious about the standby electricity consumption of electrical devices at large. This consciousness, in turn, can inspire users to check their usage habits with devices other than the mobile phone. Thus, the "unplug your charger" reminder in the mobile phone can induce energy savings beyond mobile phone usage. It can also motivate the manufacturers of other devices that use re-chargeable batteries to implement the same technology.

7. NXP Semiconductors: power converter efficiencies

NXP has developed high efficiency power converters. These comprise a series of power controller integrated circuits that integrate the basic functionality of a power converter and additional IP to increase the efficiency of the converter. The result is a cost-effective power converter with increased overall efficiency and wide applications in consumer electronics and lighting. Specific products include the GreenChip and STARplug controller families. NXP has established a long term roadmap with regards to increasing the efficiency of power converters. The goal is to increase the efficiency at all loading levels from minimum to maximum load. The energy savings potential is estimated at 500TWh+ in 2010 and of 2000TWh+ in 2020.

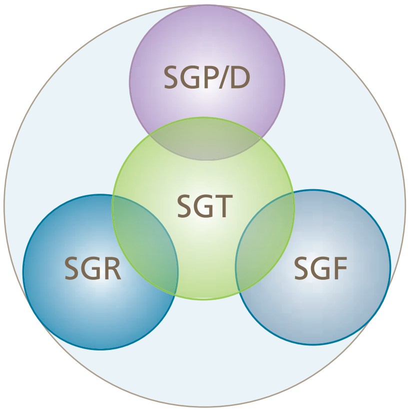
8. Sharp: Super Green initiatives

Sharp's objective is to balance its emissions by energy creating and energy saving technologies. This is being achieved through Sharp's Super Green initiative which is a combination of environmental best practice in five areas: products and devices, in technologies, in factories, in management and in recycling. The objective is to ensure that every aspect of Sharp's activity has an environmental focus. See diagram (source, Sharp).

SGT Super Green Technologies
Develop unique environmental technologies that contribute to environmental conservation.

SGR Super Green Recycling
Recycle used products to promote reuse of resources

SGM Super Green Management
Enhance environmental sustainability management



SGP/D Super Green Products and Devices
Create products and devices with high environmental performance

SGF Super Green Factories
Develop environmentally conscious factories that can be trusted by local communities.

9. Sharp: Super-Green Kameyama plant

Sharp's new Kameyama manufacturing plant in Japan has implemented Sharp's super green principles in its construction and function and was the company's first Super Green factory. The factory generates its own energy – 12 MW through LNG co-generation and 5 MW through solar panels and 1 MW from four environmentally friendly molten-carbonate fuel cells, the largest fuel cell system of its kind in Japan. It uses the waste heat generated for air conditioning, hot water supply or steam. 100% of the manufacturing process wastewater (up to 9,000 tonnes a day) is recycled and re-used. The factory generates zero waste. The Kameyama Plant was recognised for its outstanding environmental management by being chosen from among 125 applicants for the highest honor, the Sustainable Management Pearl Award, in the 2004 Japan Sustainable Management Awards.

10. Sony: best in class TV standby

Sony has reduced TV standby power consumption by over 90% over the last ten years. As of February 2007, all Sony BRAVIA LCD televisions sold in Europe achieved a standby power consumption below 1 Watt, while many models are below 0.3 Watts. Sony has also drastically reduced the power consumed in operating mode. TV producers historically ship their products in a bright picture mode most suitable for display in shops, but the brighter the picture settings, the higher the power consumption. Most customers do not modify the picture settings after purchase, so Sony now gives the user a choice of 'home' or 'shop' modes upon first switch-on. This results in a saving of more than 20% in power in operating mode and raises awareness among consumers about the fact that they can actively contribute to reducing power consumption of electronic products.

11. Sun: data centre consolidation

Sun is improving the efficiency of its data centres through a number of measures – consolidation, compression and more efficient design. By consolidating its multiple European datacentres into a single, UK facility, it has achieved an 80% space reduction and around 50% reduction in electrical power and cooling costs. High density design now enabled expansion to five times current capacity yet using only 15% of the original datacentre space. Improved server design means that Sun's servers can operate safely at higher temperatures – around 72° rather than 68° without harming reliability or performance. Each degree yields a 4% saving in cooling costs. On a worldwide level the move to new technology has enabled sun to reduce 267,000 square feet of data centre space to 133,000 and save around 4,100 tonnes of CO_2 per hear. The new design can cut power costs by as much as 66% whilst increasing processing power by around 450%.

12. Toshiba: Factor T

Toshiba has introduced a novel approach to product design through its Factor T eco-efficiency indicator which is a simple but robust way to drive improvements in eco-design and product efficiency whilst taking into account improvements in performance and functionality. The eco-efficiency of a product is defined as the product's value (in terms of quality, functionality, etc) divided by its environmental impact. The smaller the environmental impact and the higher the product value, the greater the eco-efficiency. The Factor T indicator is derived by comparing the eco-efficiency of a new product against the eco-efficiency of a benchmark product (in other words, by dividing the former by the latter). The greater the value, the more the eco-efficiency has improved. Factor T is a simple but robust way to drive improvements in eco-design and product efficiency without losing sight of improvements in functionality. For instance, the Factor T for Toshiba's Notebook PC Portego R500 was 5.1 between 2000 and 2007. This means that the eco-efficiency of that product has improved by a factor of 5 over the 2000 version of the notebook.

13. Xerox: designing for energy efficiency

Xerox follows a comprehensive approach to reducing product energy consumption. First, in the design phase, product teams evaluate the system as a whole as well as individual components to maximise energy efficiency. Second, during the customer use phase, features such as automatic power-saver modes lower the energy consumed. Finally, remanufacture and reuse programs do their part by requiring less energy than building new parts from raw materials. Together, these initiatives dramatically reduce the energy needs, generating cost savings for Xerox as well as for our customers – and notable benefits for the environment. Xerox has also developed a "secret e-Agent" used in the production of toner which reduces energy required in production by 22%, delivering 30mkWh of electricity savings by 2008. Xerox applies a systems approach to fuse technology and new electronics architectures to make its current products more energy efficient whilst enhancing functionality. Xerox is a Charter Partner in the Energy Star programme and the use of its several million energy star rated machines saved 1,000,000 MWh of energy in 2005 alone. A further 280,000MWh was saved by remanufacturing from re-used parts in the same year .

Section two: What the technology sector does for other sectors: Enhance, enable, transform

A: Enhancing technologies

14. 1E: Nightwatchman and Peterborough City Council

NightWatchman is a computer programme that enables computers that are left on but not in use to be switched of centrally, safely and remotely. Peterborough City Council has 4,500 staff and estimated that 30% of PCs were being left on when not in use, costing the authority between £40 and £60 per machine. Even after an education programme, machines were still being left on because staff found it hard to differentiate between stand-by and off-modes. The Authority recently implemented the NightWatchman software solution, supplied by 1E, across its entire ICT infrastructure. It achieved a return on investment within 3 months, cost savings of £50,000 per annum and a reduction of 250 tonnes of CO_2 emissions per annum.

15. Apsys: SIMLOG and system analysis

With much confusion over which system architecture has the least life cycle cost and lowest carbon emissions, Apsys has developed a new model. Over the last 15 years APSYS has developed and supplied an Integrated Logistic Support (ILS) software tool called SIMLOG. The main functions of SIMLOG are maintenance optimisation and life cycle cost (LCC) assessment. What makes this new module different is that it calculates the carbon emissions of a system and its maintenance and enables users to identify which system architecture and which maintenance options have the lowest carbon footprint and to select the most energy efficient option. Furthermore, it enables the carbon emissions for each option to be costed per tonne, and provides a metric for life cycle cost assessment.

16. Dynamic Demand: stabilising energy demand

"Dynamic demand" is an emerging technology that could reduce the amount of electricity used by appliances like fridges and freezers during peak periods through the intervention of small electronic controllers inside the goods. This development could provide a more stable and efficient grid, removing some of the barriers to more renewable electricity generation in the UK which is variable in nature. If fully integrated across the network savings could be in the region of two million tonnes of CO_2 emissions a year – the equivalent of taking over 665,000 cars off the road.

17. EDS: holistic infrastructure management

EDS takes a holistic approach to the whole ICT infrastructure. This includes designing the whole architecture with as much centralisation as possible to achieve economies of scale in power consumption, standardising hardware configurations, using low energy devices and optimising power management features, and remote management of PCs so that engineers and IT support staff do not have to travel to different sites to resolve user problems and install upgrades.

18. Fujitsu: Environmentally Conscious Solutions

Fujitsu Laboratories has developed a method for quantitatively evaluating on a per-environmental-factor basis, the environmental burden reduction effects of adopting particular software or IT service. Utilising this method, Fujitsu is certifying as Environmentally Conscious Solutions those software and IT services offerings that can achieve by their adoption environmental burden reductions of 15% or more (in CO_2 equivalent terms) and providing these solutions to their customers By the end of 2005 54 offerings had been certified. Fujitsu also participates in the IT solutions Working group of the Japan Forum on Eco-Efficiency and are involved in creating the ICT Environmental Efficiency Guidelines used to evaluate efforts to reduce environmental burdens through the adoption of IT services.

19. IBM: ICT-enabled office optimisation

ICT technologies create opportunities for companies to restructure their office environment so that the use of available office space is optimised, temporarily unused space can be divested and by this the energy consumption per employee and the total energy consumption reduced up to 50%. IBM transformed their office structures at 8 locations in Europe, replacing desktops with notebooks, stationary phones with cordless substitutes, and copy, print and fax facilities with pooled, multifunctional devices. This enables employees to be completely mobile within the building, using an open plan environment which improves flexibility and reduces space and energy requirements. Moreover by combining the office concept with new management concepts, such as working time flexibility, mobile working and home- or tele-working, further demonstrable reductions are possible.

20. IBM: road charging

An automatic road charging system implemented in Stockholm by IBM and partners has made a real impact by reducing traffic congestion and energy waste. Congestion was becoming a serious issue in Stockholm, and by 2005 commuting time had increased 18% on the previous year. A congestion charge was introduced in 2006 by the Swedish National Road Administration (SNRA) and the Stockholm City Council. The objective was not only to reduce congestion, but encourage ancillary benefits, such as improving public transport and alleviating environmental damage. The system implemented by IBM and its partners recognised, charged and received payment from vehicles as they passed control points on the way in or out of the Stockholm city center during weekday, rush hour times. The city implemented a free-flow roadside system using laser, camera and systems technology to seamlessly detect, identify and charge vehicles depending on which time of the day they were passing (with higher rates during the rush hours). By the end of the trial phase, traffic was down nearly 25% with an estimated reduction in CO_2 of 41,000 tonnes or 8-14% of the normal inner city emissions. Public transport schedules had to be redesigned to reflect the faster travel speed.

21. Intel: remote PC management

Intel's new VPro™ microprocessor technology has major implications for improving efficiency of networked PCs because it enables computers within a network to be managed remotely. This dramatically reduces distances travelled by IT support staff who no longer have to physically access the PC to deal with problems. Moreover, the new processor technology means that individual PCs can be managed even whilst they are switched off, so there is no longer any need to leave PCs on when not in use in order for upgrades or maintenance to be carried out by support staff, since this can now be done when the PCs are powered down. Intel recently implemented this technology for ING, a global provider of financial services, with 114,000 employees spread over 50 countries. In addition to dramatic cost reduction and more streamlined PC management, substantial energy savings were achieved.

22. Microlise: vehicle telematics and tracking

Microlise provides vehicle telematics technology that monitors how vehicles are being driven. In a recent project involving high density home delivery they were able to show a dramatic improvement in MPG through vehicle monitoring and driver training, and consequently a major reduction in carbon tonnage. Microlise also provides vehicle tracking software that monitors how efficiently vehicles are being utilised with a view to reducing fleet size. The improved certainty has enabled transport operations to be optimised, allowing vehicles to be taken off the road and reducing vehicle miles, by around 1 million km in one year for one of their customers.

23. Nokia: Logistics and Enterprise Resource Management

As a result of networking, digitalisation of structures and data and RFID applications, ICT plays an increasing role in rendering logistics processes more energy efficient. Stora Enso's wood logging areas in Finland are connected to pulp mills through an information system based on GSM, GPRS and GPS. The real-time information system contains the wood orders from pulp mills and the logging and transportation programs for each area. It takes as additional inputs the logged and hauled amounts of wood, sent to the system by forest entrepreneurs, and the coordinates of wood trucks from the truck drivers. Based on this information, the system performs real-time operational stock accounting, updates the logging program and devises transportation plans for wood trucks. It then sends the updated information to forest entrepreneurs and truck drivers. More efficient processes and optimised transport mean fewer empty drives and less waste of resources overall.

24. OSIsoft: Kodak Park

OSIsoft provide energy management technologies. Kodak Park in New York, USA operates like a small town, with two power plants, 150 buildings, 11,000 employees and covering 1300 acres. There was no central energy management system for the site and many of the buildings operated as silos. OSIsoft provided a single web-based portal for managing energy use across the entire site, which provided real-time data on energy use and consolidated all the different strands of data. It allowed engineers and energy managers to see what was going on, identify areas of waste and address them, then monitor the results and re-adjust if necessary. The system helped Kodak to optimise its energy assets, it identified opportunities for energy reduction and provided critical tools that enabled Kodak to meet their very aggressive energy reduction targets and make savings amounting to several million dollars annually. It also continues to identify new opportunities for energy saving.

25. Philips: LED lighting for the National Theatre

Philips and the National Theatre are implementing a programme to replace the landmark London Venue's lighting scheme with a state of the art, dynamic and energy efficient design. The first phase of the LED lighting solution provided by Philips will focus on the exterior and give the National Theatre a spectacular colour palette, illuminate new areas and provide a new video wall installation on the roof to replace the old dot "seefact" display. The second phase will concentrate on revitalising the internal lighting and improving efficiency, and there will be an ongoing programme of improvement as Philips continues to develop even more sophisticated lighting technology. The LED solution will not only improve a dramatic visual enhancement, it will also reduce the energy needed to light the building's iconic exterior by 70% and deliver estimated savings of £100,000 per year.

26. Siemens: smart buildings

In Vienna, Siemens building technologies has optimised the energy consumption of the "Brigittenau" indoor pool. The resulting improvements saved the pool operators over £140,000 a year. This industry–leading technology uses specialised algorithms to calculate the actual ventilation and heating requirements and has already been applied to optimise energy efficiency in thousands of buildings world-wide, including hospitals, banks, industrial sites and schools. In Germany, Siemens is a contracting partner for over 1600 buildings, producing savings of over £115million and almost 650,000 tonnes of CO_2 during the average contract term of ten years.

27. Siemens: lighting solutions for Budapest

Siemens has replaced the light bulbs in all of Budapest's 33,000 traffic lights with LEDs. The monthly instalments paid to Siemens are lower than the savings Budapest generates from reduced energy consumption and the elimination of traffic light maintenance.

28. Thales: Smart Container Shipping

Thales is currently developing a secure system of container tracking called Smart Container Shipping. Smart container systems are designed to impart intelligence to the container system which can then be used by shippers, owners and customs officials. The smart container is simply a standard container which has sensors, processing capability and communications devices that can interact with a central database over a communications network. The database will also incorporate external data such as cargo manifests and will be accessed through web browsers or manifests. The smart container will provide a tracking and tracing capability to monitor the location and movement of the container, it will protect the integrity of the container and identify whether it has been opened or interfered with in any way, it will monitor the contents – particularly high risk contents – and the content inventory and it will identify the container. The primary objective of this system is to minimise vulnerability to terrorist attack (currently there are opportunities for terrorists to insert unwelcome materials into containers at several stages) but there are a number of substantial environmental benefits, in particular increased efficiency resulting from improved certainty. Goods cannot be lost and shippers know with confidence the conditions under which the goods have been stored (such as ambient temperature, humidity etc), which reduces wastage, and container contents are simply scanned in so physical searches and other interventions are reduced.

29. Xerox: carbon footprint calculator

Xerox provide complete document management services for companies with the primary aim of reducing cost and improving efficiency. This process involves scrutinising, analysing and streamlining every aspect of document management. Within this service, Xerox help companies understand their document carbon footprint, using a unique carbon calculator tool that Xerox has developed with the Carbon Trust. The carbon calculator highlights the activities that are having the worst environmental effect so that companies can re-engineer processes if necessary. The carbon calculator also helps to show how intricately economics and sustainability are linked – if companies reduce their document carbon footprint, they will reap the associated rewards of significant cost savings and productivity gains. The key to integrating sustainability is to find mechanisms that not only contribute to overall environmental goals, but which are also commercially viable.

B: Enabling technologies

30. Evident Europe: Digital Evidence Seals™

Evident Europe provides Digital Evidence Seals™ that enable organisations to prove that digital data, documents and records have not been altered. An Evidence Seal™ is a simple piece of XML based data which is cryptographically appended to any digital data, over any digital medium. It proves, indisputably, over time which parties were involved, what the original information or data was and when the event happened. It provides independent validation, guarantees data integrity (as any changes to the original data are immediately verifiable), durability, transparency and portability. The key environmental benefit of Digital Evidence Seals is that they are a critical enabler of the paperless office. Traditionally, documents had to be printed in hard copy to be authenticated, and then stored securely. Now there is no need to do that, and documents can remain in electronic format indefinitely, without risk.

31. IBM: recycling silicon for solar power

IBM has developed an innovative new semiconductor wafer reclamation process which will enable 3 million wafers to be re-used annually. Semiconductor wafers are the thin discs of silicon used to imprint patterns that make finished semiconductor chips. The IBM process uses a specialised pattern removal technique to repurpose scrap semiconductor wafers into a form that can be used to manufacture silicon-based solar panels. The new process was awarded the "2007 most valuable pollution prevention award by the National Pollution Prevention Roundtable (NPPR) in the US. The process enables the Intellectual property from the wafer surface to be removed efficiently and hence allows the wafers to be reused. The solar industry is currently being held back by severe shortage of silicon, which is one of the primary materials needed to manufacture solar panels. Re-using silicon in this way helps to stimulate the growth of renewable energy solutions.

32. Philips: internet information and entertainment services

Philips provides a wide variety of third-party information and entertainment services through its easylog user interface. TV-based information can substitute paper-based versions and in particular the electronic delivery of entertainment content through Video on Demand (VOD) is substituting disc-based distribution (DVD), saving materials (paper, plastic, ink, etc.), plus the physical distribution of the DVDs via the stores to homes. Philips has estimated that in Europe people travel around 33 million km per year to buy or rent DVDs and that VOD can therefore reduce annual CO_2 emissions by around 6.6million kg. VOD also obviates the need to produce 2 million or so DVDs a year, a further saving of at least 181900kg of CO_2. Moreover, VOD does not require a DVD player which reduces the energy required for viewing over a physical video or DVD, a further saving of around 113.5 million kg of CO_2 emissions per year.

33. Siemens: document management systems and emissions trading

On January 1, 2005, the EU launched its emissions trading plan. Since then, installations with high CO_2 emissions may only produce as much CO_2 as is allocated in their certificates. If their emissions are higher, they must purchase additional certificates. Conversely, any plant that cuts CO_2 emissions below its allowance can sell its remaining credits. Once a year, about 1,850 companies in Germany must report their CO_2 emissions to the German Trading Emissions Authority (DEHSt). This is done via the Internet, with a document management system developed by Siemens together with partners. In a multistage process, the emissions data from the plant operator is first collected online and then checked by an expert assessor. The report is then sent, complete with an electronic signature, to state authorities. In order to prepare this report, companies can use Simeos, an emission management software package from Siemens. It combines data from measuring points, energy data management systems, financial accounting, and other company processes into a CO_2 account that helps to optimise emissions trading. The software also classifies the flow of energy and materials according to specific products and different forms of energy, providing rapid and easy identification of potential savings in energy and energy costs.

34. Siemens: intelligent algorithms for smart grids

Siemens "learning" algorithms maximise the power generated by wind farms by introducing cooperation among all wind turbines. The increase of power output is estimated at 1-5 percent. Siemens offshore wind farms are generally controlled remotely via ICT solutions and even defects can be detected and often repaired remotely by software applications.

35. Xerox: electronic reusable paper – Gyricon

Electronic reusable paper is a display material that has many of the properties of paper. It stores an image, is viewed in reflective light, has a wide viewing angle, is flexible, and is relatively inexpensive. Unlike conventional paper, however, it is electrically writeable and erasable. Although projected to cost somewhat more than a normal piece of paper, a sheet of electronic reusable paper could be re-used thousands of times. This material has many potential applications in the field of information display including digital books, low-power portable displays, wall-sized displays, and fold-up displays.

Electronic reusable paper utilises a display technology, invented at the Xerox Palo Alto Research Center (PARC), called "Gyricon." A Gyricon sheet is a thin layer of transparent plastic in which millions of small beads, somewhat like toner particles, are randomly dispersed. The beads, each contained in an oil-filled cavity, are free to rotate within those cavities. The beads are "bichromal," with hemispheres of two contrasting colors (e.g. black and white, red and white), and charged so they exhibit an electrical dipole. When voltage is applied to the surface of the sheet, the beads rotate to present one colored side to the viewer. Voltages can be applied to the surface to create images such as text and pictures. The image will persist until new voltage patterns are applied. There are many ways an image can be created in electronic reusable paper. For example, sheets can be fed into printer-like devices that will erase old images and create new images. Printer-like devices can be made so compact and inexpensive that you can imagine carrying one in a purse or briefcase at all times. One envisioned device, called a wand, could be pulled by hand across a sheet of electronic reusable paper to create an image. With a built-in input scanner, this wand becomes a hand-operated multi-function device – a printer, copier, fax, and scanner, all in one.

C: Transforming technologies

36. Cisco: TelePresence videoconferencing

Cisco TelePresence is a remote conferencing tool that makes a virtual meeting seem like a physical one, using state of the art technology with life-size images, high-definition video, and spatial audio. Users feel as if they are at the same table with remote participants, everyone communicates in real time, with no delay, catching every comment and every nuance of the conversation. The industry-leading high-definition video means that every expression and every gesture is now clearly visible, whether participants are meeting across town or across time zones. There are two different room systems for different applications: The Cisco TelePresence 3000 allows a meeting for 6 people per room, creating a "virtual table" for 12 participants in group meetings and small team interactions. The Cisco TelePresence 1000 has a unique design, allowing a small meeting for 2 per room or up to 4 at the virtual table, and is designed to be used in smaller spaces, such as executive offices, hotel lobbies, bank branches, retail stores, or doctors' offices – anywhere a one-on-one or small group conversation is needed.

37. Co-Op Travel Group, Future Travel: homeshoring

New technology is now enabling "homeshoring " where agents work flexible hours from home through a virtual call centre. The Co-Op Travel Group's Future Travel subsidiary is the largest virtual contact centre in the UK with 630 ABTA-certified home based staff. Besides a host of improvements in operating costs, quality of service and transparency, there are a number of positive side-effects including a reduction in energy requirements (because there are no central offices to heat and light), and staff travel is minimal. The "rebound" effects (see above under Teleworking) are also minimised because the majority of workers are already home-based, and now able to work productively, for instance whilst the children are at school.

38. HP: Virtual Collaboration System

Halo, HP's Virtual Collaboration System (VCS), offers a compelling alternative to traditional work and collaboration methods. The HP Halo Collaboration Studio is a precisely designed broadcast solution that enables remote teams to communicate in real-time in a face to face environment. The Halo Collaboration Studio allows for interactivity between teams and enhances business connections while visually reinforcing the sense that meeting participants are in the same room. It reduces CO_2 emissions by reducing the need to travel for team meetings.

39. Smart Services: changing agricultural practice

"Smart services" applications are an offshoot of satellite based remote sensing technology and have the potential to change agricultural practice for the better. They are based on a remote sensing application that monitors soils, assesses the fertiliser or water requirements according to its specific signature, and feeds this information live to a device in the tractor or sprayer that adjusts the flow of fertiliser or changes the irrigation plan accordingly.

40. Tandberg: videoconferencing solution for Vodafone

Vodafone recently implemented a move to videoconferencing in an effort to reduce air travel, using Tandberg as its supplier of videoconferencing tools. Vodafone has 200 globally connected videoconferencing units, all multi-connected and most using Internet Protocol. To ensure employee engagement in this policy, Vodafone implemented internal controls on employee travel (for instance, employees need to seek approval for travel in advance and state why their objectives cannot be achieved through videoconferencing) and marketed the policy clearly to staff. This has cut travel dramatically – travel between sites with videoconferencing facilities fell by 100 trips per month per site in 2006, facility utilisation was 85% during business hours and 5520 tonnes of CO_2 were saved as a result. There were also some interesting learning outcomes – multi-point facilities (videoconferencing suites where more than two units could participate simultaneously) proved essential and Vodafone gained a clearer understanding of when videoconferencing was an appropriate substitute for travel – and when it was not.

41. Thales: nuVa collaboration solutions

NuVa is a collaboration desk that allows teams of colleagues split geographically to work together and hold multi-way project meetings, using standard broadband connections to the internet. Collaboration tools will only be used regularly if they provide real benefits, are easy to use, non intrusive and make the users feel comfortable – it is not enough to provide faithful audio and video representation of the remote collaborator, support tools are also needed. Therefore the nuVa collaborative desktop includes a number of tools such as a synchronised document set for teams to use during their sessions. Benefits include improved staff efficiency, and better time management, reduced travel and improved multi-site and off site working, and reduced carbon footprint.

Appendix Two – Glossary

Field Emission Display	A Field Emission (FED) is a flat panel which works on a similar principle to a Cathode Ray Tube display but is only a few millimetres thick. Instead of a single electron gun it uses a large array of tiny electron emitters which bombard phosphor dots on the screen with electrons in order to emit light. FEDs are energy efficient and require less power than other flat screen technologies like LCD or plasma displays. They can also be cheaper to make.
LEDs – Light Emitting Diodes	A Light-Emitting Diode or LED is a semiconductor diode that emits light when charged with electricity. LEDs were originally red but they can emit light of different wavelengths depending on the materials used.
LCD – Liquid Crystal Display	Liquid Crystal Display or LCD is a flat panel display made from a layer of liquid crystal sandwiched between plastic or glass. This becomes opaque when electricity is passed through and images and characters become visible from the contrast between the transparent and opaque areas. LCD screens require relatively little power but do rely on backlighting to work.
Materials Intensity	Materials or energy intensity of manufacture means the amount of raw material or energy required in the manufacturing process. Computers have a high materials intensity of manufacture, requiring large quantities of raw materials and clean water.
Moore's Law	Moore's law states that the number of transistors that can be placed on an integrated circuit doubles approximately every two years. Effectively this means that the processing power of a chip increases exponentially. This has held for more than 50 years. Other capabilities of digital electronic devices are linked to Moore's Law – memory capacity, processing speed, resolution of digital cameras, all of which are improving at roughly exponential rates. Moore's law is a good analogy for the rapid pace of technological change we are witnessing today.
OLEDs	An organic light-emitting diode (OLED) is an LED whose electro luminescent layer is made up of a film of organic compounds. They can be used in computer or TV screens and require much less energy to function than LCD screens because they do not require a backlight.
Plasma screen	Plasma screens are flat panel screens used for large TV displays. Many tiny cells held between two glass panels hold a mixture of inert gases. This gas mixture is ionised by electric current which excites phosphors to emit light.
Processor	Processors, microprocessors or chips are programmable digital electronic components consisting of small crystals of silicon with many tiny transistors embedded in them.
Thin-Film technology	Thin films are layers of material ranging in thickness from several micrometers to less than a nanometer. They are being developed to reduce the cost of photovoltaic systems because they are cheaper to manufacture and have lower energy, material and handling costs. The technology is not fully developed.
VOIP	Voice Over Internet Protocol is a combination of software and hardware that allows people to use the internet to make telephone calls. This technology makes international calls very cheap as the cost is limited to the internet connection.
Watt/Watt-hour (W/Wh)	A Watt is a unit of power equal to one joule of energy per second. A Watt-hour is simply the amount of electrical energy used (or produced) when one Watt is used for one hour. A 60 Watt lightbulb if left on for one hour would use 60 Watt hours (60Wh). • kWh (kiloWatt Hour) = 1,000 Wh – a 1 bar electric heater on for an hour will use 1kWh • mWh (megaWatt Hour) = 1,000,000 Wh • gWh – (gigaWatt Hour) = 1,000,000,000 Watt hours or 1,000,000 kWh • tWh – (teraWatt Hour) = 1 billion kWh or 1,000 gWh. Sizewell B nuclear power station produced around 9TWh in the year ending March 2007.

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