

PAUL MOBBS

A practical guide to sustainable IT

Unit 5



This unit is one of 12 sections to a "A practical guide to sustainable IT", a hands-on guide to working with everyday technology in an environmentally conscious way. The guide has been written by environmental activist and ICT expert Paul Mobbs, and was commissioned by the Association for Progressive Communications (APC) with the support of the International Development Research Centre (IDRC). To download the full text of the guide, or any of the other units, please visit: greeningit.apc.org

A practical guide to sustainable IT

Author

Paul Mobbs

Copy-editing

Alan Finlay

Layout proofreading

Lori Nordstrom

Publication production

Karen Banks and Flavia Fascendini

Graphic design

Monocromo

info@monocromo.com.uy

Phone: +598 2 400 1685

Commissioned by the Association for Progressive Communications (APC).



Conducted with support from the International Development Research Centre (IDRC).



The views expressed in this publication are those of the individual authors and not necessarily those of APC or IDRC.

A practical guide to sustainable IT

Published by the Association for Progressive Communications (APC) with support from the International Development Research Centre (IDRC).

South Africa
2012

Creative Commons Attribution 3.0 Licence
<creativecommons.org/licenses/by-nc-nd/3.0/>
Some rights reserved.

DESKTOPS: PROGRAMS, PERIPHERALS AND GADGETS

When we talk of “computers”, most people will think of a desktop computer system, with a mouse, keyboard and video display screen. In the previous units we've looked at machine hardware and software. In this unit we'll look specifically at the influence of desktop computers on the sustainability of information technology. Surprisingly what we find is that the variable which has the greatest impact is not the machine – *it's the machine's user*.

The way we use desktop computer systems, and how we use and generate data, has a great effect on the ecological footprint of the system. For example, the programs we use, and how well we understand those programs and their functions, have an impact on the environment. Certain peripherals, such as printers, also have an impact as a result of the way we use them, and if we look at recent trends, it's the effects of information capture gadgets – such as digital cameras and sound recording – that are driving the storage capacity demand of IT. When we consider the wider global network of computers, the increasingly “virtual” nature of the relationships people maintain is driving the demands on network connections and data storage.

Over the next four units we'll examine the ecological effects of desktop computers and the ways we can tackle them. In this unit we'll look specifically at the issue of desktop computers; in the next we'll look at information storage and the measures we can use to keep, back-up and secure information; then we look at computer networks and how our use of data influences the efficiency of data movement and resource consumption; and finally we'll look at physical security and maintenance.

5.1. THE ROLE OF THE “USER” IN THE ECOLOGY OF INFORMATION TECHNOLOGY

In unit 2 we looked at the “ecology” of information technology; the effect that our demand for information systems has on the environment generally. There was a very important part missing from that analysis – *the user of the equipment*. When we think of desktop computers, an integral part of the system is the human user who sits in front of the computer. The type of job that they are doing, and how efficiently they work, affects how intensely the computer is utilised and how great the impact of that activity is.

There are many facts and figures about the impacts of computing in terms of emissions, but because they often consider different system boundaries, or because they are based on certain industries or activities, the results given vary widely. Often the units these impacts are measured in differ too, making direct comparisons difficult. For example, some give the emissions as an equivalent of elemental carbon (C), some the emissions of carbon dioxide (CO₂), and others give measurements adjusted to reflect the value of different greenhouse gases as an “equivalent” of carbon dioxide (CO₂eq).

To make comparing the impacts of using desktop systems less complex, we'll take rough figures from the range of information available to look at the scale of the impacts from different parts of a desktop computer system:

- Firstly, the *internet* - the energy used by the global digital networks that the computer is connected to. This is a difficult figure to find because it assumes certain things about the user of the system. To give a general figure, let's take the annual estimate for the internet's carbon emissions, 300 million tonnes of CO₂, and calculate that as an average figure for two billion internet users connecting for eight hours a day. **That gives a figure of around 0.05 kilos of carbon emitted per hour of use.**
- Secondly, *power consumption*. How much energy or carbon is produced for each unit of

electricity consumed² depends upon how efficient the power generation system is and the types of fuel it uses. Coal power plants generate around one kilo of carbon dioxide for each kilowatt-hour of power consumed, while natural gas produces around 0.44 kilos, and wind turbines about 0.01 kilos. Therefore, assuming a mix of fuels which give around 0.6 kilos per kilowatt-hour, and assuming the desktop system consumes an average 250 watts of power, **the PC emits around 0.15 kilos of carbon per hour of use.**

- Thirdly, *embodied energy*. How much energy it takes to manufacture a PC³ and how much greenhouse gases are released as a result vary widely. The results usually depend on what the researchers carrying out the work measure, and where they sourced their data. Let's apply a very broad rule, and assume that the total impact of the hardware is around 1½ times the impact of the power consumed, in which case **the embodied energy of the PC hardware is 0.23 kilos of carbon per hour of use.**
- Finally, *the computer user*. The computer user runs on food rather than electricity. In the most developed nations, where the average diet consists of a lot of processed and out-of-season fruit and vegetables, the amount of energy and carbon is much greater than in less developed states, where more local and basic foodstuffs are consumed. Research in the United States (US) puts the annual carbon emissions from the average diet at around 5,500 kilos of carbon per year.⁴ Other

1. Guardian Online (August 2010). What's the carbon footprint of... the internet? www.guardian.co.uk/environment/2010/aug/12/carbon-footprint-internet

2. Wikipedia, Comparison of life-cycle greenhouse-gas emissions.

en.wikipedia.org/wiki/Comparisons_of_life-cycle_greenhouse-gas_emissions

3. Kris De Decker (June 2009). The monster footprint of digital technology. www.lowtechmagazine.com/2009/06/embodied-energy-of-digital-technology.html

4. Brighter Planet (2010). The American Carbon Footprint: Understanding and reducing your food's impact on climate change. attachments.brighterplanet.com/press_items/local_copies/52/original/carbon_foodprint_wp.pdf

estimates put European dietary emissions at about half that figure, and in less developed states perhaps a quarter of the value in the US. Given that desktop computers dominate the business world in the US and Europe, let's take a figure for food emissions as somewhere between Europe and the US – 4,000 kilos of CO₂ per year. Therefore, averaged over a year, **the computer user emits 0.46 kilos of carbon per hour of use.**

While green IT guides often look at the carbon emitted by the system hardware, it's the system's "wetware"⁵ (the human component) that's also a significant source of carbon emissions. In the example above, the desktop computer system emitted half the carbon emissions of the food used to "fuel" the system user; if we had used the example of a laptop computer, the user might have emitted twenty times more than the computer system they were using. Yes, the efficiency of power generation and how we make our IT equipment is very important, but if we look at the factors which influence the use of IT then the role of the computer user is very important too.

As the computer user is a significant part of the process, it's important that our efforts to reduce energy and resource use include the needs of the computer operator. For example:

- *Training* – learning how to use all the features of the system allows us to more efficiently use the software on the machine, and helps us to work more fluidly;
- *Software and hardware* – if the computer can't easily run the software programs, or the operating system regularly crashes and requires rebooting, then that affects the efficiency of the computer user;

- *The use of networks* – if the user is overloaded by emails⁶ not directly related to their work, or are swamped with spam email, that affects the rate at which they can use the system; and
- *The way we create and manipulate files* – with a little training or practice we could minimise the resources our work required, increasing the efficiency with which we use the system.

One of the most important factors is data loss. Information is a resource, just like metals or other commodities. It costs time and energy to create the information we store on our computers, and in that process the emissions created by the computer user are as significant as the machine itself. The loss of data – especially if such losses are avoidable – represents a waste of energy and an excess of carbon emissions. Surveys on the causes of data loss⁷ show that hardware or system malfunctions account for 44% of data losses, human error 32%, software errors 14%, computer viruses 7%, and natural disasters⁷ – such as fire or flooding – only 3%. Another problem, when machines become clogged with files, is that we can lose track of data, and spend time on the computer blindly searching for something stored on the hard drive.

By avoiding data loss, or losing track of information and spending a lot of time searching, we can reduce the repetitious and unnecessary time spent searching for or recreating lost data. How we configure the operating system and programs we use, and how we run systems for backing up and data storage, can have an impact on the extent or likelihood of data loss.

5. Wikipedia, Wetware (brain). en.wikipedia.org/wiki/Wetware_(brain)

6. Guardian Online (October 2010). What's the carbon footprint of... email?
www.guardian.co.uk/environment/green-living-blog/2010/oct/21/carbon-footprint-email

7. For example, QASys (2009). Statistics About Leading Causes Of Data Loss.
www.aztecsystems.com/downloads/OASys_Protect_FAQ.pdf

5.2. MANAGING THE ENERGY USE OF DESKTOP SYSTEMS

Let's consider a more traditional approach to green IT – the energy and resources consumed by the desktop system. In section 4.4 we examined the power saving features of operating systems. Changing the way programs are executed or the system is configured can easily save 5% to 10% of the power consumed by a desktop machine – perhaps more if the system is switched into the most efficient power saving mode. Unlike laptops, desktop systems often have no power-saving features enabled by default – it requires the user to manually activate these features.

Of all the power-saving features, perhaps the most valuable is the *hibernate* or *sleep mode*. This is often used with laptops – for example when you close the lid the system is suspended into memory. For desktops it can save a large amount of power by configuring the system to switch to a power-saving state when you are away from the computer. There are two steps you should undertake to implement this:

- Configure the power management system to suspend (also called sleep) or hibernate the computer when you are away from it for a certain length of time. Of the two, hibernate is the most secure because it backs up any open programs to the hard disks rather than to the memory – unless the programs used have the option to “save a back-up copy” at regular intervals to prevent data loss. The downside is that restoring from hibernation takes longer than from suspend, and for that reason people avoid using it. How long you set before the machine automatically enters the suspend/hibernate mode depends upon your work patterns. Ideally set this to 20 to 30 minutes or less.
- A better option is to place an icon on the task bar or desktop that initiates suspend or hibernation when you click it. This is more predictable because you decide when the mode is activated, and if used routinely it will save more because the computer need not be inactive for a period before power saving is enabled. The default time limit in the power-saving configuration should still be set as a back-up, in case the user forgets to click the icon; but

putting an icon on the desktop allows more timely control over the power consumption.

Many people configure screen savers on their desktops. These were developed for use with old-style cathode ray tube (CRT) monitors in order to stop the screen's phosphor coating degrading through over use – and were useful because they prolonged the life of the CRT monitor. This feature is now redundant with the development of flat-screen monitors. Moreover, screen savers don't “save” energy. In fact, when they create complex animated or fast-moving images (for example, music visualisation software), they can use far more energy than a blank screen.

Even so, screen savers are important. Setting your screen saver to start after four or five minutes without any activity, and requiring a password to unlock it, is an effective security measure against casual intrusion on a computer system. As in the case of power saving, putting an icon on the desktop/task bar to lock the desktop enables the user to activate the screen saver when you leave the computer.

With newer flat-panel monitors, it's important to configure the system so it turns the display off when not in use. This is usually part of the power management configuration (recently manufactured CRT monitors have this feature too). After a certain period of idleness the display will be switched into standby mode, saving a large proportion of its power consumption. How long before the screen goes blank is set by a slider or list box in the power management menu. On most Linux systems, and some proprietary Windows applications, another important saving can be made by dimming the display brightness after a certain period of idleness – usually around ten or twenty seconds without movement of the mouse or pressing a key. This reduces the level of power consumed by the monitor's back light. This feature is also enabled from the power management menu (usually a check box to “dim display brightness”).

For both CRT and flat monitors the brightness of the monitor is also an issue. Brightness isn't usually a feature solely related to the workings of the monitor. It is influenced by the

relative contrast of the background we view the display against. For example, if there is a bright sunny window behind your monitor, or the sun shines across the monitor, it appears that the display is dimmer than it actually is. In these situations users are often tempted to turn up the brightness and that in turn will increase power consumption. A brighter monitor can also cause greater stress on the eyes of the user. Locating the monitor in a position where it is viewed against a darker background, and where bright lights or sun light do not shine directly across the surface of the screen, achieve the opposite: the monitor will appear to look brighter. This allows – the monitor brightness to be reduced, and that in turn can reduce the stress on the user's eyes.

Sometimes, particularly where the monitor is small, users can have problems reading the screen. In these cases they might turn up the contrast to increase the definition of the text on the screen, but it doesn't create a great improvement in readability. Where users have difficulty viewing what's on the screen, or with particular applications, the best solution is to experiment with the colour scheme. Particularly where the user's eye sight is poor, or they have a small colour blindness or sensitivity, changing the default colour scheme, and changing the font size of characters, can make a big difference to the readability of the display. As well as changing the general desktop theme or colour scheme, many applications allow you to vary their default colours to produce a more readable interface.

5.2.1. Peripherals, gadgets and power consumption

Assuming that power management is enabled, the machine suspends or hibernates when not in use, and video display power management has been optimised, the most significant remaining power usage is going to be the peripherals attached to the computer. Computer networks, especially with the development of broadband, are a problem because they're on all the time – we'll examine this in unit 7. We'll also look at printers in section 5.4 below. What remains are all those other devices which we plug into the machine – speakers, USB hard drives, cameras, scanners, web cams etc.

USB peripherals usually draw their power from the computer, and when the computer

shuts down/hibernates the power to the USB ports is cut. As a result they won't draw power when the machine is not in use. The exceptions are the yellow coloured “sleep and charge” USB ports included on more recent motherboards. These are intended to power/charge mobile phones and other devices, and keep the power turned on even when the machine has been put in a “soft” shut down (not turned off at the mains). When using USB hard drives and other similar devices, don't plug them in the yellow port or they will keep running even when the machine has powered down.

When the machine shuts down or goes into a suspend/hibernation mode, the power to devices which have their own power supply will not be cut. Ideally these devices should have their own internal electronics to monitor the activity of the machine and go into a standby mode when they receive no signal. Most new video displays and PC speakers have an “auto power on/off” feature and will turn on and off depending upon whether they receive a video/audio signal.

Of course all mains-powered devices, even if they power down with the system, are still drawing power in their stand-by mode. All recently manufactured devices should, when in stand-by mode, meet the requirement of the International Energy Agency's One-Watt Initiative.⁸ This requires that devices marketed after 2010 should have a maximum standby power demand of one watt, and after 2013 that figure should be halved. While it's not worth deliberately replacing peripherals for newer ones which include more efficient stand-by power supplies – *the power saved is negligible compared to the waste of embodied energy caused by discarding a functional device* – when you replace equipment ensure that it meets these new standards.

While we can minimise power use from peripherals, the most effective way of eliminating stand-by power consumption is to have the ability to switch off the entire installation by having easy access to the mains switch. This allows the user not only to shut down the computer, but also to isolate the power supplied to all its associated peripherals. It is also safer as it guards against the likelihood of power surges damaging

8. Wikipedia, One Watt Initiative. en.wikipedia.org/wiki/One_Watt_Initiative

Box 5.1.

Changing the desktop environment/configuration

On any desktop system, the size of the video display has a significant impact upon the power consumed by the system. As we saw in unit 3 when discussing video hardware and the AGP slot, the higher the resolution and colour depth of the display, the more data it requires to generate the display. In turn, the programs which create the graphical desktop and organise display data for other programs add to the demand on the system, and that increases with the scale of the display.

With Windows and MacOS you are locked into a single display system; while you can vary the theme of the desktop (e.g. in Windows 7 you can configure a display theme which looks like Windows XP) you can't change the nature of programs generating the display. With Gnu/Linux you are free to change the programs which generate user interface in order to change the amount of processing power required to generate the display and that can reduce power consumption.

Lightweight Linux distributions come with a lower power desktop environment already configured. General purpose distributions are usually configured with one of the more powerful desktop environments (usually Gnome or KDE) but can change the display environment if required. Often you can select which environment to use when you log into the system. The main effect of changing the user interface is to reduce the amount of processing power required to generate the display, reducing the amount of memory required for the display (which allows other programs to run faster). On older hardware this can significantly increase the performance of the system.

Usually the selection of which desktop environments are available is made when the system is installed. Depending upon which Linux distribution is used, other desktop environments can be loaded very quickly from online software repositories. The "heaviest" display manager is KDE, followed by Gnome. These are the standard desktops with most distributions and are optimised to provide a feature-rich desktop. XFCE is less resource hungry than Gnome, although it provides many of the same features. Finally LXDE is the lightest, and on older hardware it definitely improves the usability of the desktop. However, while XFCE/LXDE will work well with most applications, fast video programs or the animated content of web pages may not work well or at all.

Finally, with both Windows and Linux another way to squeeze some extra speed out of the system, or slightly reduce power consumption further, is to run the display hardware at a lower resolution. For example, most new high-definition (HD) displays are 1920 pixels wide and 1080 pixels high. If you're primarily carrying out office work or internet browsing on the machine, rather than playing video games or watching DVDs, you might be able to run the display at a lower setting to save processing power (e.g., 1280x1024, 1152x864 or 1024x768). You may also be able to reduce the colour depth of the display. Provided the video hardware can support the change without causing problems, the effect of reducing display resolution and colour depth is to free up memory and reduce the amount of power used by the video display electronics.

ing the equipment, or electrical faults causing fires while the machine is unattended. As outlined in section 3.4 and figure 3.8, the easiest way to isolate the system from the mains is to use a switched and surge-protected plug strip.

The machine and all its peripherals are plugged into the strip, and at the end of the day the user can shut down the system and then perform a “hard” shut down by disconnecting the power using a single switch.

5.3. PRINTING

There is a modern marketing myth, developed in the 1970s⁹ when the first word processors were available, that one day paper would be eliminated from offices by the development of better computer technology. In 1980, before the IT revolution swept across the office environment, world office paper consumption was 70-million tonnes a year; by 1997 it was almost 150-million tonnes. In Britain 120 billion pieces of paper are printed each year. The average British office worker prints 22 pages every working day and research suggests that 44% of this is easily avoidable and over 21% of this printed matter is disposed of before the end of the day.¹⁰

The paperless office hasn't arrived for many reasons. These are partly *technological* – not everyone uses computers well or feels comfortable reading from screens. They are also *psychological* – research shows that the physicality of paper is an important part of how we comprehend its content and mentally map that information. Perhaps most importantly, the change in the scale of office administration as part of the modern serviced economy has made the market for paper grow compared to the 1970s. It's this last point that is the least explored. Yes, the amount of office paper generated per person may have fallen with the advent of new technology; but as the global economy has grown, so the numbers involved in office and administration have grown too. The overall effect has been to eliminate the savings from new technology as more people use these technologies and generate a greater demand for paper.

From an ecological point of view, the debate over paper and printing also misses an important aspect of the technology of the printed word. *Not all printing is bad!* (see box 5.2). It takes a lot of energy to make paper, and a comparatively small amount to print information upon it. However, once printed, providing it is appropriately stored and cared for, that information can be available to anyone without investing further energy for years or decades. Digital information requires a computer system, powered up with electricity, in order to access the data, and more equipment to store that data securely. Each time it is accessed it requires energy, the longer it takes a person to read through the more energy is consumed, and if it is kept live online it requires a powerful server machine and network to hold it ready for access. Depending on the type of publication, there will inevitably come a point when it is more efficient to print information which will be required, in an unchanging form, for the long term – for example, libraries of books, technical information and important reports. Where information is short lived, or changes rapidly, or is only valid for a short period, then it is more suited to storage and viewing on digital media.

The two printer technologies in widespread use are laser and ink-jet printers. How you interpret the ecological impact of these two technologies is complex, and depends upon how much printing you do. There are some life-cycle studies of different printing technologies, but they do not produce a clear result

9. Business Week (June 1975). The Office of the Future. www.businessweek.com/technology/content/may2008/tc20080526_547942.htm

10. Global Action Plan (2007). An Inefficient Truth. www.it-energy.co.uk/pdf/GAP_An_Inefficient_Truth_Dec_2007.pdf

in terms of which is the better option.¹¹ While laser printers are cheaper to run for large volumes, and so have a lower energy expenditure per sheet printed, they can produce a larger volume of solid waste if they require replacement of the toner cartridge (refilling with toner powder is usually only an option on larger/more expensive laser printers). In contrast, while ink-jet printers produce less solid waste, they use more energy per sheet and can have a higher embodied energy because of the smaller volume of printing during their operating life.

If we look for some general rules and advice about printing, there are a number of ways we can maximise the efficiency of using printing or copying devices:

- Purely on the basis on the embodied energy of manufacturing, having a large number of users share a printer is more efficient than having a printer for individuals/small groups. The capital savings also means that buying a more expensive, more efficient printer, is cost effective for larger groups.
- Small laser printers which will duplex are now available. This means they print both sides of the sheet automatically. Even though they cost more, routinely double-sided print jobs will cut paper use and, due to the high price of paper, pay for itself fairly quickly. While you can print both sides by printing odd and even pages separately and reloading the paper, if there is a fault during the printing of the second side this can often waste paper – so a duplexing printer is the best option. Duplexing can be enabled from the printer configuration interface in order to reduce the amount of paper used in routine print operations; users can still print single-sided, but they must deliberately select this option before printing.
- Most word processors and other applications create documents from a standard template, and most allow the configuration of this template file to be edited. Editing the template can enable a specific set of printer settings in order to ensure the most efficient

use of paper and ink/toner. In addition, by minimising the size of the margins, and not using an excessively large font size, it is possible to increase the amount of information on the page.

- The use of ink or toner use can be minimised if the “draft” mode is used for printing – not only with draft documents, but for any publication that is not intended for formal use (memos, circulars, etc.). Again, this is something that must be set in the printer configuration menu on the operating system or software application.
- Most printer control software allows control over who has access to printers. Filtering which users have access can limit the use of more expensive/high quality machines, and allow general printing to be carried out from a cheaper-to-run general purpose printer which uses lower quality paper. This will save money and environmental impacts (for example, limiting access to printing on colour printers and allow all access for printing on the cheapest printer).
- On a plain printed page only 5% of the area is covered with ink/toner. If printing graphs or slides using solid blocks of colour, the amount of the paper covered is far higher. Using a hatched infill on graphs/images rather than solid colour especially when using ink-jet printers – reduces the amount of ink or toner required for printing documents significantly.
- Recycled paper requires half the energy, and produces less pollution, than using non-recycled paper. If possible, rather than bright-white paper which has to be chemically bleached to get it clean, using lower grade off-white paper will save more. While there are various various “sustainable forestry” certification schemes for paper, these products still use new rather than recycled pulp, which uses more energy and emits more pollution. Using 100% recycled paper, or paper with a majority of recycled pulp, is always the better option.
- Waste white office paper is worth more as a product for recycling, and is more efficiently recycled if it is segregated from other lower quality/coloured papers. If it is possible to organise a separate paper collection for higher

11. Fraunhofer IZM/PE Europe (2007). EuP Preparatory Studies “Imaging Equipment” (Lot 4). www.eup-network.de/fileadmin/user_upload/Produktgruppen/Lots/Final_Documents/Lot4_T5_Final_Report.pdf

Box 5.2.

Printing information is not necessarily a bad thing

Paper is a very energy-intensive product to manufacture. There are various estimates for how much energy it takes to produce, and the impact depends upon many variables – from whether the paper plant is run by coal or hydro-power, to how far the paper pulp is transported. For the sake of this comparison let's take a general figure of 10 kilo-Watt-hours per kilo of paper. The weight of a single A4 sheet of 80 gram per square metre paper is around five grams. The energy required to produce one A4 sheet is therefore 50 watt-hours.

For the sake of simplicity we'll ignore the embodied energy of the computer, and to balance that we'll ignore the energy used in printing. We'll also ignore the energy required to store and transmit the digital information. Let's assume it takes three minutes to read a single side of A4 paper. Let's also assume that the desktop computer consumes a quarter of a kilo-Watt, or 250 watt-hours of electricity. Therefore in a fifth of an hour, or 12 minutes, the computer will consume the same amount of energy as making a sheet of A4 paper. If reading a page every three minutes, the user is consuming a quarter of the energy reading from the screen than if they were reading from the paper – which is obviously better for the environment.

However, let's optimise this system. Let's assume the paper is double sided. That uses extra energy for printing, but not significantly more because much of the energy is contained in the paper itself. Reading from the screen will now take almost half the equivalent energy as

reading both sides of the paper. Now let's assume that three people read the information, sharing the same piece of paper and reading it one after another. They are now using the less energy reading the paper copy than it takes to read the information from the screen individually. And, of course, if ten people read it, then the paper version is using far less energy.

In reality the figures are not so simple. For example, if we were reading the information on a laptop computer, that uses a tenth of the power of a desktop system; you'd have to share the piece of double-sided paper between twenty-five to thirty people before the paper version was better than reading it on a laptop. Quite simply, we must “think before we print”. What we can say is that where often-used information is “static”, meaning it is infrequently revised or changed, it is probably better that this information is kept as a printed volume which people can pull from a shelf and read at any time. For example, reference materials and technical manuals. Where information is in “flux”, and in continually being updated, or it is only required for a single use by a few individuals, then online distribution is probably the best option. For example, news bulletins and memos/emails.

What this analysis shows is that there is no one simple solution when it comes to the ecological footprint of our decisions on the use of technology. It is the peculiar characteristics of the factors in each decision which determine what is the best option overall.

quality paper, segregate the collection of white waste printer/photocopier paper.

- Most digital photocopiers are little different in function to a laser printer, although they are usually more energy efficient than a laser printer when producing a large number of copies. For making a large number of multiple copies a photocopier is likely to be

more efficient than a laser printer. However, if you are routinely producing large print runs on a photocopier, getting the job produced by a conventional commercial printer using wet inks and a conventional printing press will be more efficient. Using conventional printing also allows a range of lower-quality/recycled papers to be used.

5.4. E-READERS

Print is no longer a purely paper-based medium. As well as traditional computer screens there are now a number of devices which are specifically designed to replace printed books. Unfortunately the ecological impacts of reading information on the latest tablet devices is a complex issue to interpret.¹² For example, while designed for reading print-based information, they are also capable of undertaking other tasks as well. It also requires information on the carbon footprint of the e-reader, and that is not always provided by the manufacturer. There are some studies, but they are often partisan. For example, one positive study¹³ of e-readers didn't consider the lending or resale of printed books to other readers when it calculated the impacts of e-books versus conventional books; another report¹⁴ more favourable to the print industry notes the uncertainty in the figures which underlie comparisons between print and e-books. Of course, with any electronic technology, the golden rule is always to maximise its use and keep it functioning for the longest time possible before replacing it – which appears to be the bottom line of almost all studies on the comparison between conventional and electronic books.

Another aspect of e-reader technology not often discussed is intellectual property and in particular the use of digital rights management to control the use of the devices and the files they contain. For example, Amazon's Kindle service allows books to be shared by up to six devices registered to the same Amazon account, but not *between* Amazon accounts. There is a facility to loan an e-book you have bought to another Amazon user, but only once, and only if the publisher permits it. One of the great features of the traditional printed book is that it can be shared freely by many people, and can be given/sold back to shops who will re-sell the book. The resale/recycling of second-hand books means that the impact per person of printing the book becomes progressively less as it is passed around. With e-readers the sharing of the data is usually blocked; on desktop systems equipped with e-reader software there is greater scope to share files, but only while the operating system permits that to take place. Consequently it's hard to minimise the resource impact of e-books by sharing the files between many readers.

Additionally, all the transactions of book download and loans are logged, and that potentially has an effect upon our privacy and freedom of thought.¹⁵ When you download files to the e-book reader from a service, the details of the book and the account are logged, and data is available to the company and its corporate partners to mine as a source for marketing or customer profiling; or by security services profiling members of the public from their online browsing habits. While intended for use by com-

12. Palmer, Brian (August 2010). Should You Ditch Your Books for an E-Reader? The Slate. www.slate.com/articles/health_and_science/the_green_lantern/2010/08/should_you_ditch_your_books_for_an_ereader.html

13. Cleantech Group (2009). The environmental impact of Amazon's Kindle. www.tkearth.com/downloads/thoughts_ereaders.pdf

14. Green Press Initiative (2011). Environmental Impacts of E-books. www.greenpressinitiative.org/documents/ebooks.pdf

15. EFF (2010). Digital Books and Your Rights: A Checklist for Readers. www.eff.org/wp/digital-books-and-your-rights

mercial interests, this same technology could enable control over public debate traditionally associated with more repressive states.

On certain services it is also possible for the service provider to read and manage the content of the e-reader device. For example, it is possible for the online services to delete books on

a device if there are rights issues about selling the book, meaning that a book could be digitally “banned” from e-readers by the service provider. Deletion of books on customers' e-readers without owner permission has happened on the Kindle service – perhaps ironically one of the books deleted was George Orwell's *1984*.¹⁶

5.5. FILES, FOLDERS AND ORGANISING DATA

As the speed of data networks has increased, and with the advent of downloadable TV and radio programmes, the amounts of data streaming into computers has grown exponentially. At the same time we have more digital capture devices – from mobile phones, to digital audio recorders, video/stills cameras, and image scanners for digitising images and printed materials – which routinely generate giga-bytes of data (see box 5.3). All of this data fills our own computers, and we're file sharing and emailing large quantities of it to friends and contacts via the internet – replicating multiple copies across computer networks and creating a greater demand for storage.

Once data has been downloaded to a computer, the next issue is how those files are organised. Again, the growing size of files has been driving the demand for larger hard drives on desktop computers. That's partly due to the downloading and editing of video, although the larger capacity of digital cameras and portable music players means that the data imported to the system are becoming ever larger as consumer gadgets store larger quantities of files. As the sources of data have grown, so the total number of files on a hard drive has increased substantially too. Perhaps a routine example of the growth in files would be saving a web page with all its associated formatting and image files which for websites with large amounts of advertising can produce 40 to 100 files along with the main HTML page file.

The traditional method of organising data is by using directories or folders, describing the types of file contained in the name of the folder – as shown in figure 5.1. As we work and create files it is important to store these in subdirectories/folders to hold them separately from

the mass of data held on the system. Ideally the folder name should identify the contents, but as time passes and as old files get shuffled around the system, keeping track of all these files, folders, names, and what they relate to becomes progressively harder.

The difficulty with this approach is that the directory names only have meaning to the human operator. They have no special meaning to the operating system, and may even be vague or confusing for other users too. Organising files into a directory tree also requires care and consistency. Without attention to the details of which files go where, important data can be lost in a sea of files and subdirectories very quickly. The point is the user can soon spend progressively longer periods of time searching for information – and that's because the design of the storage system does not match the complexity of the collection of information being held.

What has developed over the last decade are systems which enable us to catalogue the files on our computers with far more relevant data than a simple file or folder name. Just like web search engines, desktop search or indexing systems¹⁷ read the content of the users files and create an index of the information held. Of course the problem are those files which do not contain textual information that is intelligible by the machine – such as videos, sound files and

16. Johnson, Bobbie (July 2009). Why did Big Brother remove paid-for content from Amazon's Kindles?, Guardian Online. www.guardian.co.uk/technology/2009/jul/22/kindle-amazon-digital-rights

17. Wikipedia, Desktop search. en.wikipedia.org/wiki/Desktop_search

Box 5.3.

Digital cameras, mega-pixels and data overload

One example of the way the increasing data capacity of equipment is driving data storage is digital cameras. The obsessive selling point for all new digital cameras is the number of mega-pixels inside the image sensor: The higher the mega-pixels figure the better the images are assumed to be. This is not always the case since the true image quality is dependent upon the quality of the optics and the use of filtering and correction software to render a true image under different lighting conditions.

What has happened as the camera mega-pixel count has risen is that the file size of photographs has risen, but that doesn't necessarily translate into "better" photographs. If we look at the mega-pixel rating and the size of print that can be produced, most cameras are taking impractically large images. They are much higher resolution than commercial digital print machines (which usually operate at around 300 pixels per inch resolution); are far higher than can be displayed on the computer monitor (which operate at 75 to 150 pixels per inch); and are excessively higher than is required for producing everyday documents or web-based content (where images of a few hundred pixels square are often all that is required).

Buying a camera purely because it has more mega-pixels is once – it exceeds six to eight mega-pixels an excessive use of resources for most everyday purposes. Instead, by matching the resolution of the image to the application you

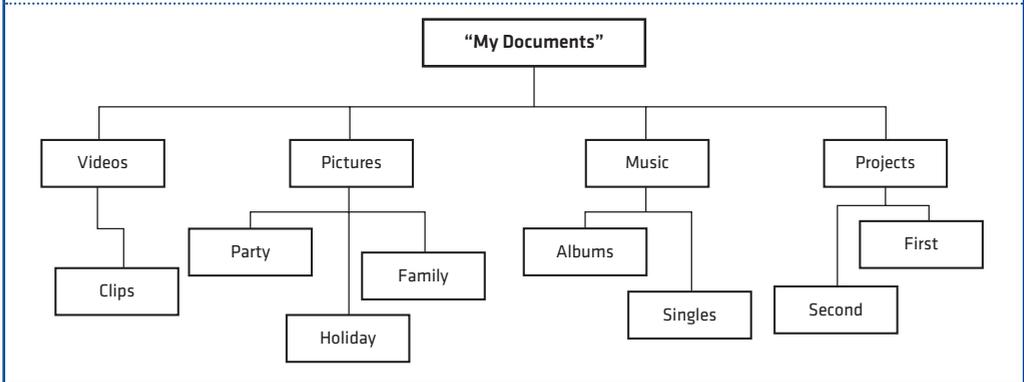
MP rating	Maximum print size
3	6.8x5.1 inches, 17x13cm
6	10x6.7 inches, 25.4x17cm
10	12.9x8.6 inches, 32.7x21.8cm
12	14.3x9.3 inches, 36.3x23.6cm
16	16.4x10.8 inches, 41.7x27.4cm

To calculate the relative size of the image take the pixels width and height and divide by the image resolution. E.g. a 3MP image with 2048x1536 pixels at 300 pixels per inch gives an image of 6.8x5.1 inches.

require the image for, you can produce smaller image files and as a result fit more images on the camera or the storage device where you keep the image files. If using a camera that has a high mega-pixel count, turning down the image resolution will reduce the size of the files produced without significantly affecting the image quality.

Figure 5.1.

A traditional directory tree



images. To standardise the organising of files on a computer, a collection of embedded labels called metadata¹⁸ (box 5.4) has been developed to describe the contents of each file. Rather like the track title and artist information used with MP3 music files, by labelling files across the system with information on their content it makes the job of locating and using the files/data stored on the system much easier. In practice describing the content using metadata produces more accurate results.

Most desktop operating systems have a desktop search/indexing system:¹⁹ *Windows Vista* and *Windows 7* come with *Windows Search*; Macintosh systems use an application called *Spotlight*; and Linux desktop environments usually have a search facility built-in, although many use dedicated search applications such as *Beagle*. In addition there are a variety of proprietary and free desktop search applications which can be installed. The benefit of a more sophisticated search system is not only its ability to index data. Most desktop search applications allow you greater control over the content and formatting of file metadata, making the management of metadata across the system far easier. Note that programs to import sound, image or video files often have metadata editing options too, and you should learn to use these when creating files in order to make indexing and finding files easier.

Finally, one of the problems about the large hard disks installed on many new desktop machines is the physical volume of data. The size of new hard drives, increasingly rated in terabytes (a terabyte is a million megabytes), allows users to fill up the storage system with files which are poorly organised, and, worst of all, which are not backed-up. The physical scale of the data stored can also make backing-up an even bigger headache. When considering the efficiency of desktop systems, having large amounts of files stored on the hard drive can complicate how we manage that data. For example the more files, the more effort the desktop indexing system has to expend in keeping track of those files, and that increases the processor power and drive space required to map the system. More problematically, in the event of a system failure, a drive full of superfluous data can hamper the recovery of more important files.

With larger hard drives the temptation is to allow data to stack-up on the system, rather than moving the important files to a back-up storage system and deleting the outdated/unwanted files. One of the most important skills to learn in organising the files on a computer system is to know when to delete them, or to move them onto other forms of data storage that are less demanding of power and resources. We'll examine this subject in detail in the next unit.

18. Wikipedia, Metadata. en.wikipedia.org/wiki/Metadata

19. Wikipedia: List of search engines. en.wikipedia.org/wiki/List_of_search_engines#Desktop_search_engines

Box 5.4.

Using metadata to label files

Metadata is often described as “data about data”. In addition to the image or textual information in a file, additional strings of information are used to identify the content of the file, when it was created, and copyright or other information on ownership. Almost all commonly used file formats support metadata in order to describe the content of the file and other statistics relevant to it. When creating images or capturing other data, many of the latest gadgets will automatically add metadata tags to describe the conditions/setting under which the data was processed and stored. For example, the type of metadata that people commonly see is the track and artists information displayed when playing MP3 music files; by labelling the sound file with text which identifies the music, the computer is able to order the files more logically when they are queued for playing.

The value of metadata is that by allowing the operating system to “know” what is inside the file it allows the search for files to be automated. For example, instead of searching the content of a file for keywords, which often will result in many false matches for common words, if the metadata contains a string of keywords which spe-

cifically describe the file, the system can present you with far more relevant results. Taking a minute or two to add metadata to a file can, over the period that the file is kept, save far more time when you are trying to manage hundreds or thousands of data files.

Most applications have a “properties” option, usually in the file menu, where you can add metadata labels. Figure 5.2 shows the properties menu from *OpenOffice* other applications are very similar. Usually there will be a default list of properties allowing a title, keywords and other comments to be defined (top box). It is also possible to define additional labels that provide a more narrow description of the content (bottom menu box) and which provide descriptions that are relevant to your own work.

In addition to providing information for desktop searching and indexing, many applications and online services now use metadata to configure imported/uploaded files – automatically inserting into the relevant fields the labels which describe the data. This makes uploading easier and also ensures that the labels used properly describe the content.

Figure 5.2.

Document properties



Box 5.5.

Check-list for desktop systems

- While the impacts of the machine are important, the time the user spends sitting in front of the machine is often more significant in terms of the ecological impacts – therefore improving our personal skills and methods of using the system is an ecological issue.
- Always configure the operating system's power management settings to minimise energy use, both by the machine and by the monitor attached to it.
- Besides configuring the shutdown of the monitor after a period of inactivity, if the function is available, configure the system to dim the brightness of the monitor when it is not actively in use.
- Operating systems that allow the configuration of a lightweight desktop environment, or the lowering of the display resolution, can be used for older hardware to increase the performance of the system and/or reduce energy consumption.
- Besides configuring suspend/sleep or hibernation when the machine has been left idle, include icons on the desktop to activate the suspend/hibernation function easily, or to lock the desktop when not in use.
- Try to use a monitor, speakers and USB devices which are able to power-down automatically when the machine hibernates or is shut down.
- On newer machines, try not to inadvertently plug USB peripherals into the yellow “sleep and charge” ports unless they require power when the machine is shut down.
- Use a printer that meets the demands you require. Ink-jet printers are better for low volume, but for higher volumes laser printers are better suited to the task and in most cases it is better to share a printer between multiple users rather than each user having their own printer.
- For information which is not time-sensitive or does not date quickly, and is to be widely shared, printing a hard copy on recycled paper for many people to read often requires less resources than each individual reading that information from a computer system.
- Where possible use 100% recycled paper, and ensure that white office paper is collected separately where a segregated collection can be arranged.
- For larger print runs a photocopier is usually more efficient than a laser printer; and for regular large print runs using the services of a commercial printer is more efficient than using a photocopier.
- Take care with data capture devices – such as digital cameras, scanners and sound recording applications – to store or encode the data at a quality or resolution that's compatible with the types of application – you require the data for. Storing excessively high-definition data requires far more hard drive space.
- To simplify finding or locating information on the computer, use an organised system of directories/subdirectories to hold the files, and also configure a desktop search/indexing system to make finding individual files easier and quicker.
- When creating documents or files, always try and complete the metadata properties provided with that file format to allow easier and more accurate indexing by desktop search systems.

A practical guide to sustainable IT

This practical guide to sustainable IT offers a detailed, hands-on introduction to thinking about sustainable computing holistically; starting with the choices you make when buying technology, the software and peripherals you use, through to how you store and work with information, manage your security, save power, and maintain and dispose of your old hardware. Suggestions and advice for policy makers are also included, along with some practical tips for internet service providers.

Written by IT expert and environmentalist Paul Mobbs, the purpose of the guide is to encourage ICT-for-development (ICTD) practitioners to begin using technology in an environmentally sound way. But its usefulness extends beyond this to everyday consumers of technology, whether in the home or office environment. We can all play our part, and the practice of sustainable computing will go a long way in helping to tackle the environmental crisis facing our planet.

This is also more than just a “how to” guide. Mobbs brings his specific perspective to the topic of sustainable IT, and the practical lessons learned here suggest a bigger picture of how we, as humans, need to live and interact in order to secure our future.

The guide is divided into 12 sections (or “units”), with each unit building thematically on the ones that have come before. They can be read consecutively, or separately. The “unit” approach allows the sections to be updated over time, extracted for use as resource guides in workshops, or shared easily with colleagues and friends.

The guide has been developed on behalf of the Association for Progressive Communications (APC), with funding support from the International Development Research Centre (www.idrc.ca). It is part of a APC’s GreeningIT initiative, which looks to promote an environmental consciousness amongst civil society groups using ICTs, and amongst the public generally. Other publications and research reports completed as part of the GreeningIT initiative can be downloaded at: greeningit.apc.org

