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A practical guide to sustainable IT

Unit 2

APC

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THE ECOLOGY OF INFORMATION TECHNOLOGY

This unit examines the way in which our use of information systems interacts with the human environment. It encourages you to think about the context in which we use computers and the internet, how our choices effect the wider environment, and more importantly how global economic and environmental issues are inextricably tied to our use of information technology. This not only includes the direct impacts of power consumption, or the mining of minerals, but also the changes to the economy that have resulted from the greater technological development and mechanisation of what I call the “human system” – the complex and interlinked network of interactions that we have created for ourselves.

2.1. TOOLS, TECHNOLOGY AND HUMAN DEVELOPMENT

You cannot look at the "ecology" of information technology without reflecting upon the human system which has created these devices. Information and communications technology are part of the human development story. The trends which have created our modern day world are at work in the reasons why we created these technologies, and are behind the explosive growth in their use around the world.

As information and communications technologies have become more widespread, especially consumer-oriented technologies such as mobile phones, they have become "invisible". They have become such an everyday part of people's lives that we blindly accept they are there. In fact, we only understand their significance to our lives when the electronic device, or the information network it connects to, breaks down. The implicit association of these technologies with a "modern" lifestyle has in turn become a driver for their adoption in less developed states. The rapid adoption of information technology has not only enabled greater economic development, it has arguably brought with it social and political change as people have used these same media as a conduit for political expression – for example, the events of the *Arab Spring*.[1]

Computers and information systems are tools – human-made technologies intended to extend our biological capabilities. We might invest our lives in them, commit our most secret facts and thoughts to them, and rely upon them to organise our work and social lives, but if we are to understand how information systems operate then we have to examine them as we would any other aspect of human society; and that means looking at the role of these tools in the human system, and how that in turn relates to the global environment that humanity is a part of.

Like other tools made by the human species, technology extends the physical and/or mental capabilities of its user, achieving practical actions which they ordinarily would be unable to accomplish. The difference with information systems compared to, for example, a hammer, is the advanced level of complexity required to create and use these tools. If we're considering how "sustainable" information technology is then this inherent complexity[2] has significant implications for the ecological footprint of the technology, and also its future viability.

2.1.1. Convergence

The importance of programmable electronics has been the ability for one electrical device to serve many different purposes. By varying the software program, the electronic hardware can perform a wide variety of complex operations. As a result, not only have digital electronics made the production of technical or consumer goods simpler and cheaper, what we increasingly find is that different kinds of technology are *converging*[3] into a single device – removing the need to have separate devices to achieve those same functions. That may seem environmentally beneficial – having one device instead of many; but what has happened is that their success has led to their adoption by an ever greater part of the global population, and so over the last two decades the material and energy footprint of IT has steadily grown – today its carbon footprint is of a similar scale to that of the global air transport industry.

The clearest example of technological convergence is the smart phone. This is a telephone with a video display screen and digital camera built in, capable of playing music radio, television and radio. Most importantly, backing-up these various functions is a powerful computer able to interact with the internet via communications networks – allowing all the information stored or captured on the device to be shared and additional information downloaded. As a result we are no longer restricted to communicating with spoken words; we can converse in text, images, and video – or even in the machine instructions

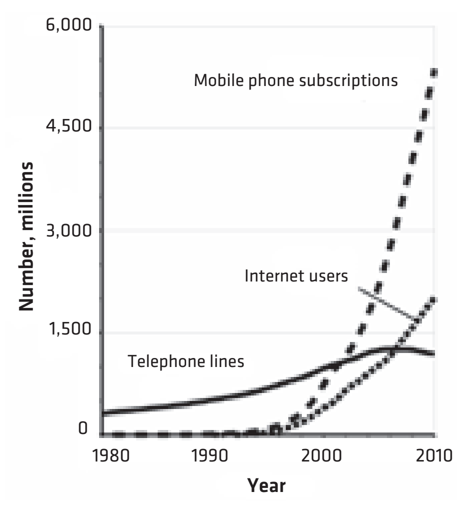
1. For a detailed exploration of the role of social media in recent protest movements see Mason, Paul (2012). Why It's Kicking Off Everywhere: The New Global Revolutions. Verso Books. ISBN 9781-8446-7851-8.

2. Wikipedia, Complexity. en.wikipedia.org/wiki/Complexity

3. Wikipedia, Convergence (telecommunications). en.wikipedia.org/wiki/Convergence_(telecommunications)

Figure 2.1.

Global growth in communications technology



(or language) required to manipulate the networks we are connected to. As shown in figure 2.1,[4] the global growth in the new digital communications services has been exponential for the last three decades.

This same kind of transition took place forty years ago, but then as a result of the electronics revolution created by the technological advance from thermionic valves to the transistor. This not only made the systems cheaper, it allowed the devices to be smaller and more mobile, meaning they could be used in ways they hadn't been used before. For example, the pocket transistor radio or cassette player used pre-existing technologies, but in a way which created a new mass market for electrical goods. Today, it's the switch from analogue transistors to digital microprocessors that is achieving the same revolutionary transformation of consumer behaviour.

2.1.2. Human tools are based on rocks

Within the growing ecological footprint of information technology one of the most important limiting trends is the reliance of human systems on ever-rarer materials. To understand the significance of this we have to go back to the very first human technology: rocks.

In our ancient history the first human tools were made of stone, and stone is perhaps one of the most plentiful resources on the planet. Wood, plant matter and animal tissue were equally important resources, but little of this material has survived. For perhaps two to two-and-a-half million years humans relied upon stone tools[5] to support their daily activities. The reason that the Stone Age ended was not that we ran out of rocks, it was that we found something which was more useful than stone: metals.[6] Metals are also made from rocks – metal ores[7] – but these rocks are far less plentiful as a proportion of all the stones available. This meant that in ancient societies metals had very high price, and were only used for very special applications.

What eliminated the rarity of metals was industrialisation, and more importantly the early use of fossil fuels to power the furnaces which made metals. Before the eighteenth century the limitation on metal production, even where the rocks it is produced from were plentiful, was the amount of wood required to fire the furnaces to produce pure metal. In short, the limitation was the quality and scale of the energy available to smelt the ores, not just the minerals resources available to produce metals. This restriction, known as the Law of the minimum,[8] applies to all other living organisms on the planet too – and in that sense today's technological society is no different from our ancient arboreal past.

In ecological terms, the limiting factor is time – and the shift to coal allowed the human economy to escape the restrictions imposed by nature. Wood represents stored solar energy, and that takes time to grow and mature, and so metal production was constrained by the sustainable limits of local wood production. For that reason coal has been used in metal production since the time of the Ancient Greeks.[9] Coal represents thousands of years of stored solar energy, meaning it has a higher energy density than wood and so produces

4. Information sourced from the World Bank's global indicators dataset. data.worldbank.org/topic

5. Wikipedia, Stone Age. en.wikipedia.org/wiki/Stone_age
6. Wikipedia, Metallurgy. en.wikipedia.org/wiki/Metallurgy
7. Wikipedia, Ore. en.wikipedia.org/wiki/Ore
8. Wikipedia, Liebig's Law of the Minimum. en.wikipedia.org/wiki/Liebig's_law_of_the_minimum
9. Wikipedia, The history of coal mining. en.wikipedia.org/wiki/History_of_coal_mining

more heat for the same weight of fuel. While the coal is easily accessible and reasonably priced, this allows metals to be produced on a much larger scale than when wood was the only fuel source.

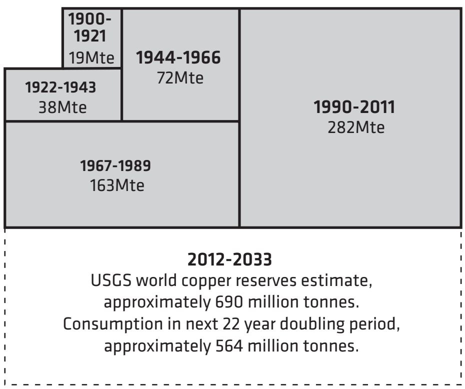
What allowed the Industrial Revolution to take off in the second half of the eighteenth century was the interaction of the technology of coal production and the improved technology of metal production. As metal technology improved we see the development of the first steam engines. The first major application of the steam engine was pumping water from mines, which allowed both greater metal and coal production from deeper mines – and it was this self-sustaining process which drove the Industrial Revolution.

2.2. GROWTH, CONSUMPTION AND RESOURCES

The effect of the information and communications revolution and its interaction with digital electronics has a direct parallel with effects of industrialisation on the use of metals. Independently the elements which make up the technology – computers, communications lines and digital information – existed well before the recent growth of electronic networks. It was only when these technologies were brought together, at prices affordable in a mass market, that the power of the network generated its own self-sustaining growth. It's not just that these trends allowed people to do pre-existing jobs more easily; the process created wholly new applications which caused the level of consumption, and the economy as a whole, to grow. Like the step change in energy and resource use 250 years ago with industrialisation, or the first use of metals over 7,000 years before that, the information and communications revolution is creating a fundamental change in the organisation of human society.

Figure 2.2.

Growth in world copper consumption, and future projections



2.2.1. Copper - an indicator of technological development and sustainability

As noted above, advances in human technology consume comparatively rarer metals.[10] Of these, copper provides one of the best case studies of the importance of minerals to the global economy, but also the fragility of that global system due to the natural constraints on human resource consumption. Copper is one of the most important minerals in the technological economy. It's important for micro-electronics, although the bulk of annual consumption is for electric cables, pipes and metal alloys. For example, a quarter of the weight of a mobile phone is made of metal,[11] and up to half of that could be copper.

As the world economy grows, so the amount of copper demanded by the world economy grows too. Copper has been in use for at least 7,500 years, but more than 95% of all copper ever mined and smelted into metal has been extracted since 1900.[12] Despite the fact that copper is one of the most recycled metals, and per-

10. Paul Mobbs/Free Range Network (2011). The Limits to Technology. www.fraw.org.uk/fwd?wslimits

11. U.S. Geological Survey (July 2006). Recycled Cell Phones A Treasure Trove of Valuable Metals, USGS Fact Sheet 2006 3097. pubs.usgs.gov/fs/2006/3097/fs2006-3097.pdf

12. U.S. Geological Survey, Copper Statistics and Information. minerals.usgs.gov/minerals/pubs/commodity/copper/

haps 75% of the copper ever mined by humanity is still in use, in 2011 around 16 million tonnes of new copper were produced from mines around the world. This is because as society becomes more technological, and especially as many developing countries begin to build power and telecommunications infrastructures, the demand for copper continues to grow year on year. As with many natural resources, the amount of copper in the top kilometre of the earth's crust is huge (around 900,000,000,000,000 tonnes, or 5-million years worth of production) but only a tiny fraction of these reserves is economically viable to extract. According to the information from the US Geological Survey (USGS), which studies the global availability of the most important minerals, the amount of copper available in the future is around 690-million tonnes.

In figure 2.1, the growth in mobile phones, like the rest of the economy, is an exponential curve. Any exponential trend has a characteristic called the "doubling time", a fixed period of time in which the quantity will double. Copper is interesting because its growth over the last century is a well-defined exponential curve with a doubling time of about 22 years. As shown in figure 2.2, we can draw boxes to illustrate how the amounts of copper consumed by the world economy grow with each period of doubling time – from around 19 million tonnes in the first 22 years of the last century, to about 280 million tonnes in the period which is just ending.

The issue for our future use of copper, and the viability of the technologies which depend on the metal, is that the next 22-year doubling period will consume about four-fifths of the remaining copper resource identified by the USGS. However, the production of minerals can't carry on at a constant rate. As the best reserves are used up first, so it becomes progressively harder to find and produce what remains, and more expensive. It is argued that rather than continuing to rise, as the quality of copper ore falls production will reach a peak and then decline.[13] What this means is that, as they have done for the last decade or so, average copper prices are likely to keep rising as the economy demands more of the metal – and that will impact upon our use of information technology in the years to come.

13. Wikipedia, Peak copper. en.wikipedia.org/wiki/Peak_copper

2.2.2. The limits to growth

Copper is not the only limitation on our sustainable use of information technology, and is not the only useful indicator of the state of human technological sustainability. Forty years ago, a group of scientists produced a study which forecast that there were "limits to growth"[14]. This caused great controversy at the time, and since then many politicians and economists have claimed that the projections were erroneous. However, not only does more recent research show that the forecasts are still largely correct when we use the latest data,[15] other work has shown that those who objected to the limits to growth hypothesis were wrong on a number of points.[16] At a recent conference to mark the fortieth anniversary[17] of the publication of The Limits to Growth, various scientists presented work showing that the projections of our future sustainability made in the 1970s are still largely correct today. If we are to avoid this outcome then we must seek a radical change in the way that human society produces and uses goods, and manages the unwanted materials from industrial processes.

As noted earlier, energy is an important part of our ability to produce raw materials. What's also important is price, as this affects the price of commodities generally. Over the last half of the twentieth century the price of energy and mineral resources was at an all time low, but in the first decade of the twenty-first century, both energy and mineral prices have been constantly rising. This, it is argued, is a symptom of the ecological limits predicted in The Limits to Growth. For example, oil production data shows that, since 2005, global oil production

14. Wikipedia, "The Limits to Growth". en.wikipedia.org/wiki/The_Limits_to_Growth

15. Graham Turner (June 2008). A Comparison of the Limits to Growth with Thirty Years of Reality, Commonwealth Scientific and Industrial Research Organisation (CSIRO). www.csiro.au/files/files/plje.pdf

16. Ugo Bardi (2011). The Limits to Growth Revisited. Springer, ISBN 9781-4419-9415-8.

17. Smithsonian Institute/MIT (March 2012). Perspectives on Limits to Growth: Challenges to Building a Sustainable Planet. si.edu/consortia/limitstogrowth2012 View the conference presentations on the YouTube playlist at www.youtube.com/watch?v=ZiG3I5DaPrE&feature=list_related&playnext=1&list=SP2817969CA87E5B47

has reached a plateau.[18] This is a warning of the imminent arrival of a longer-term decline in production, and the economic difficulties that this will create – as hizghlighted by the French Prime Minister in April 2011, when told the National Assembly of France that global oil production had reached a peak and that this would have serious implications for the future of the global economy.[19]

Information technology will be an important part of how humanity adapts to the restrictions imposed by the limits to growth. That process begins when we accept that we must adapt our personal use of technology to work within these limits.

As a priority we must learn to extend the life of our electronic goods. Making goods last two or three times longer creates a proportionate reduction in the demand for the materials from which they are made, and the energy used to produce the raw materials and assemble the components. To extend the life of existing equipment, or remove the need to buy new more powerful equipment, we have to look at the size and complexity of the software and data that are used on the machine. By making the size of the software programs and the movements of data smaller and less repetitive, it is possible to provide the services that we require using less powerful electronics and it reduces the amount of energy used by equipment.

2.3. THE LIFE-CYCLE IMPACTS OF INFORMATION TECHNOLOGY

The ever-greater use of IT is taking place within a finite environmental system – which means our technology must also have finite limits.[20] To understand the sustainability of computers and information appliances we must look at the life-cycle of the devices themselves: from the source of raw materials they are made out of; through the production process; their use by the consumer; and finally their disposal.[21] This will give us the information we require to redesign the products, and the systems which produce them, to shift from a linear to a cyclical system of resource use as shown in figure 2.3. This represents a challenge to many aspects of the way our industrial systems work today. For example, shifting away from the maximisation of production and short product lives and instead designing goods to have a longer life and be easily repairable.

2.3.1. Measuring what goes into the system

In order to make sense of this complex system, we need more precise information on what each product contains. This is produced by carrying out a life-cycle assessment[22] (LCA) of the product. Not only is the composition of the product measured, but also the energy, pollution and waste production that results from raw materials production, manufacturing and use. The availability of this data generally would enable policy makers and companies to tackle the problematic features of industrialisation more easily. Perhaps more importantly for the users of technology, it enables the consumer to preferentially buy goods which meet their demands for higher environmental standards (see box 2.2).

The life-cycle assessment studies carried out over the last decade or so have given us the first snapshot of the energy and resource footprint of IT (see box 2.1). By studying the whole ecological footprint, it has put the impacts of the consumer in context with the impact of the industries creating these goods, and this has focussed the ecological agenda upon the manufacturers. That in turn has allowed academics and campaigners to concentrate on the process-

18. Wikipedia, Peak oil. en.wikipedia.org/wiki/Peak_oil

19.Matthieu Auzanneau, Le Monde (April 2011), Petroleum blog,, 8th (in French). Fillon: la production de pétrole "ne peut que décroître"! (in French) petrole.blog.lemonde.fr/2011/04/08/fillon-la-production-de-petrole-%C2%AB-ne-peut-que-decroitre-%C2%BB

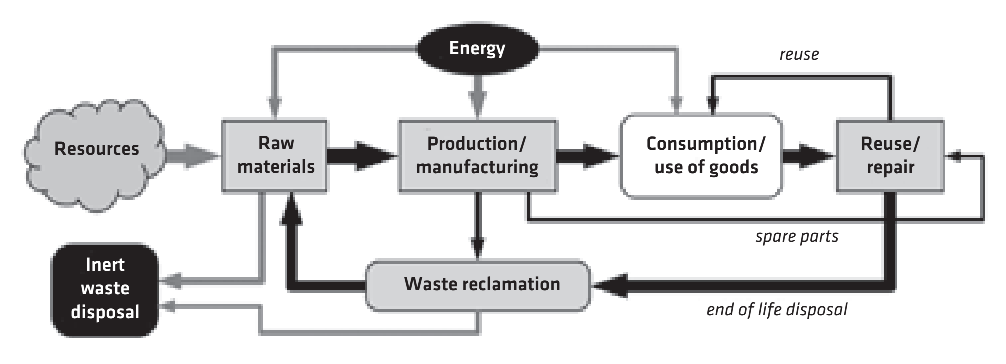
20.Wikipedia, Limits to Growth. en.wikipedia.org/wiki/Limits_to_growth

21.Leonard, Annie (2010). The Story of Electronics. www.storyofelectronics.org

22.Wikipedia, Life-cycle assessment. en.wikipedia.org/wiki/Life-cycle_assessment

Figure 2.3.

Ecological design and cyclical resource use



es which produce these goods in an attempt to apply greater pressure for change.[23]

With the rising concern about climate change there is an increasing focus on the amount of electricity that IT consumes. The more gadgets we have, especially mobile devices that require charging, the greater the demand for electricity around the globe.[24] Though we might focus on the direct use of electricity by IT – because that's the part of the system we can easily measure – in terms of the overall life-cycle of these devices more energy will have been used during their production (for example, see the figures for Apple computers shown in figure 3.1). As the level of direct energy use by electrical goods has reduced, so the energy consumed during production has become more significant.[25] For example, the memory chip in a laptop computer can take more energy to produce than the laptop itself will consumer over its three-yearservice life.[26] Another example are video display screens where, although the older glass cathode ray tube (CRT) displays consume more electricity while in use, the newer flat panel displays require as much or more energy to be expended during production.[27]

2.3.2. The importance of the embodied energy of equipment

The latest digital electronics require some of the rarest metals on earth, and this has increased the energy demand required to produce the devices. That's partly due to the energy invested in producing rarer resources, but also because of the high purity demanded by the semiconductor industry. The laws of physics require that to make something purer through refining you have to use more and more energy to remove progressively more of the unwanted impurities. The metals used to make microchips must be extremely pure as any impurities affect the conductive qualities and speed of the chip.

For those concerned about the ecological impact of the machines they use, this embodied energy[28] (the energy used to make the device and all the raw materials it contains) is rarely measured or reported by equipment manufacturers. To put that into perspective with regard to other technologies, weight-for-weight, the amount of fos-

23.Leonard, Annie (2007). The Story of Stuff. www.storyof-stuff.org/movies-all/story-of-stuff/

24.International Energy Agency. (2009) Gadgets and Gigawatts, OECD/IEA, Paris. Gadgets and Gigawatts Summary. www.iea.org/Textbase/npsum/Gigawatts2009SUM.pdf

25.Williams, E., Ayres, R., Heller, M. (2002). The 1.7 Kilogram Microchip: Energy and Material Use in the Production of Semiconductor Devices, Environmental Science and Technology, 36(24) p5504-5510. www.it-environment.org/publications/1.7%20kg%20microchip.pdf

26.de Decker, K. The monster footprint of digital technology, Low Tech Magazine, June 16th 2009. www.lowtechmagazine.com/2009/06/embodied-energy-of-digital-technology.html

27.Socolof, M., Overly, J., Geibig, J. (2005) Environmental life-cycle impacts of CRT and LCD desktop computer displays, Journal of Cleaner Production, 13 p.1281-1294.

28.Wikipedia, Embodied energy. en.wikipedia.org/wiki/Embodied_energy

Box 2.1.

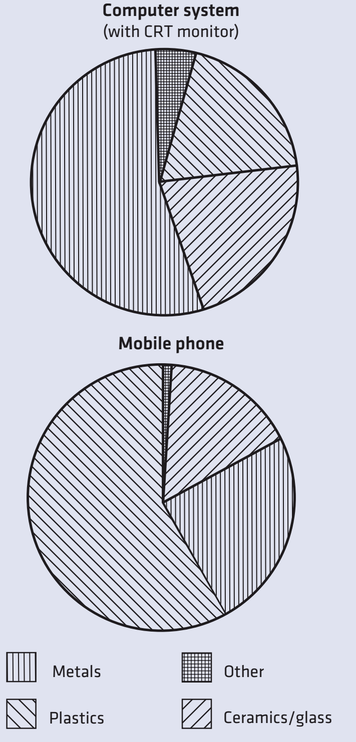
The resource footprint of consumer electronics

Computers, mobile phones and other digital electronics are a modern treasure-trove of rare and exotic substances. For example, a quarter of the weight of a mobile phone is made of metals; about half of that is copper, and the rest is mostly aluminium, tin, iron, silver, and gold – as well as minute quantities of platinum, palladium, barium, hafnium, indium, gallium and rare earth metals. You also get metals cropping up in unexpected places, such as the 2 or 3 kilos of lead in the glass of old TVs and computer monitors, or the gold which coats many of the connectors inside our IT equipment.

The diagram on the right shows the relative composition of a computer system (with old-style glass CRT monitor) and a mobile phone. There is little detailed information on the composition of most digital appliances, although that situation is improving with the introduction of life-cycle analysis reporting.

Figure 2.4.

Composition (by weight) of a typical computer system and mobile phone



By their nature, devices that rely on extremely pure materials, engineered at microscopic levels of detail, require far more energy to create than "old fashioned" analogue devices. Digital electronics might be more efficient or require less energy during their operational lives, but as they demand more energy during their production they are often no more efficient overall when we look at their life-cycle impacts. For example, a life-cycle study of a 2-gram 32 mega-byte DRAM memory chip estimated that 1,600 grams fossil fuels, 72 grams of chemicals, 32,000 grams water, and 700 grams of gases (mainly nitrogen) were used during its production; and the production of silicon wafers from quartz used 160 times the energy required for ordinary silicon metal. That means the laptop in which this chip would have been installed would use less energy during its working life than was required to manufacture its memory chip.

Note also that carbon dioxide from energy use is not the only significant greenhouse gas produced by semiconductor production. For example, nitrogen trifluoride is an etchant used in the production of silicon chips and LCD displays, and although released in very small quantities it is 17,000 times more potent as a contributor to the greenhouse effect than carbon dioxide.

At the heart of most digital equipment is the motherboard. This is a large printed circuit board mounted with chips and other system components and connectors which link it to other parts of the system using wires and ribbon cables. The motherboard is most easily seen inside a desktop computer.

When you look at a computer motherboard, most visible is the aluminium in the cooling fins/heat sinks on the microprocessor and other high-power heat-producing chips. The circuit board itself is clad in a thin layer of copper. The various connectors on the board are made of iron, copper and tin alloys, often with a gold layer of electroplating to enhance the conductivity of the mechanical connections. The small round components are capacitors, manufactured using titanium, barium and sometimes other rarer metals. Some of the minute devices on the board are also capacitors, but their small size means they contain much higher quality and rarer materials such as niobium or tantalum minerals extracted from the ore coltan which is associated with the blood metals trade in Africa.

The board itself, and most of the connectors, are made from laminated materials or thermoplastic resins which are made from oil. Most of these components are fixed to the board with solder made from alloys containing tin, copper, silver, bismuth, indium, zinc, antimony and some other metals. Many circuit boards are also given protective lacquer coating, made from oil-based resins, to prevent moisture corroding the circuit board or its components.

sil fuels required to produce a computer chip are 600 times greater than the weight of the chip; by comparison the fossil fuels required to produce a car are only one to two times its weight, and for an aluminium can around four to five times.[29]

Another aspect of the limited supply of these critical materials is that, as scarcity makes prices rise, the shortage of supply is an incentive to their illicit production. Unlike conventional agricultural resources, where supply can be drawn from a wide area and can shift with the global market, mineral resources can only be produced where they are found. Similar to the issue of oil and the Middle East, as pressure is put on global mineral resources, it is a handful of states who are becoming the focus of the world's trade in high-tech minerals. As a result of the problems with supply, some governments are arguing for strategic policies to protect these "critical raw materials"[30] to ensure the world has access to these resources in the future.

For example, an important metal in the production of miniaturised digital electronics is tantalum. Half of the world's tantalum supply is mined in Australia, and it is produced as a by-product of other metal-mining operations in many states, but between 1% and 10% may be mined illegally in central Africa. This trade in turn supplies the finance that perpetuates the armed conflict[31] in these areas, and the human rights abuses thatare the result.[32] While it may soon be possible to buy equipment which is accredited as "blood metal" free, the basic laws of economics mean that everyone is benefiting indirectly as a result of this illicit trade. By increasing supply within are tight market, it lowers the price of these resources for all. The only way to address the issue of conflict resources is to have a globally policed system which is able to accredit the trade in all resources.

The debate over green IT shows the value of life-cycle analysis, and also demonstrates the complexity of how we must manage the transition towards more sustainable industrial processes. Some of the leading hardware manufacturers are now commissioning reports on the impacts of their activities – and life-cycle analysis is a key part of providing this information. But while life-cycle assessment allows us to look at the impacts created by our demand for certain goods, for those whose work or lives have become dependent upon these technologies, it can also throw up some problematic questions on the impacts implicit in their use of technology. Knowing that the activities which you undertake on a daily basis require the expenditure of such resources puts our individual lifestyles under a critical microscope. Although the scope and standards of life-cycle analysis reports vary, if we utilise what information is available (see box 2.2) we can make better purchasing decisions, and so begin to address the impacts created by our demands for these technologies.

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29. Arizona State University (undated). Life Cycle Assessment of IT hardware. www.it-environment.org/about%20project%20-%20LCA%20of%20IT%20hardware.html

30. European Commission (2010) Critical raw materials for the EU, CEC. ec.europa.eu/enterprise/policies/raw-materials/files/docs/report_en.pdf

31. Global Witness (2009) Faced with a Gun, What Can You Do? www.globalwitness.org/media_library_get.php/980/1277197135/report_en_final.pdf

32. Sourt, C. The Congo's Blood Metals, The Guardian, Friday 26th December 2008 www.guardian.co.uk/commentisfree/2008/dec/25/congo-coltan

2.4. IS INFORMATION TECHNOLOGY SUSTAINABLE?

The answer to that question is both "yes" and "no". Under its current design, the way we build and utilise information systems is completely unsustainable for many different reasons. In part that's linked to the unsustainability of the human system in general, as described in *The Limits to Growth*. However, that's not to say that we couldn't address many of the present problems with IT to keep these technologies functioning in the future. The difficulty is that doing so will require the structure of the IT industry, and the products it designs and markets, to change to a wholly different model of working – and, without consumer and legislative encouragement, that is likely to result in both a cultural and economic resistance from the industry as it exists today.

The bottom line of sustainability is the ability of a system to keep functioning – and on that simple analysis information technology has a number of serious problems which need to be addressed. Some relate to the supply of minerals, while others, such as energy consumption, are implicit in the nature of the materials involved in the process. There are ways to address many of these issues. However, they're not "business as usual", which is why it requires a major institutional and ethical change within the information and communications technology (ICT) industry. As consumers of these goods we have a role to play in this process; partly by lobbying for better reporting and environmental standards, but also by changing our own practices to minimise the impacts of the work we carry out using these technologies.

To make the diminishing stock of raw materials last longer we need to extend the life of all electrical goods. At present digital electronics is only achieving a fraction of the lifetime that could be achieve if they were designed for a longer life. The difficulty for the electronics industry is that longer life will lead to lower turnover, and that in turn means that the nations who have specialised in the mass production of electrical goods will grow more slowly. Another great step forward would be designing devices in ways that maximise recycling and reuse, and to remove as much of the toxic content of electrical goods as possible, so that the end-of-life reclamation of IT equipment does not create intractable toxic waste residues.

While making gadgets last longer has an impact on manufacturers, perhaps the greatest impact will be upon the software community. They too focus on short product lifetimes, planned obsolescence and restricting backwards compatibility to ensure that users must upgrade. However, this "culture of obsolescence is predominantly the preserve of the proprietary software industry. The most sustainable lifecycle for IT involves the use of open standards and open intellectual property. This enables a progression of development rather than continual reinvention, and is far more likely to lead to extended lifetimes because the pressures to continually upgrade are not so great. For this reason the free and open-source software movement, and fledgling open-source hardware movement, offer a greater potential to develop a more sustainable IT industry in the future – and we need to work to support them, both as users and if possible developers.

In the end, this is a design issue; it is a matter of how we choose to build human systems. If we respect the physical boundaries to the natural world and work within these limits then we can make a truly sustainable culture. The difficulty is that in recognising these limits globally we must begin the process by first applying these limits to ourselves.

Box 2.2.

Sustainability check-list

The initial concerns about the use of IT were related to energy consumption, and were initially addressed through the labelling of more efficient goods – such as the US Environmental Protection Agency's (EPA) Energy Star logo. As the ecological issues related to IT have become more numerous, there are various standards which have been developed to accredit goods which are made to a higher environmental standard:

USEPA/DoE Energy Start Program

The longest-running energy-labelling scheme for both commercial and domestic appliances (including PC hardware), the scheme provides both audits/labels for products as well as accrediting and giving awards for excellence by organisations. It's significant amongst schemes because it puts as much emphasis on the domestic use of hardware as it does on large corporate installations. As well as product labels, their website provides a series of downloadable guides on different aspects of energy efficiency and reducing energy consumption. For more information see the website: www.energystar.gov

Electronic Product Environmental Assessment Tool (EPEAT)

This is an accreditation tool for electrical equipment managed by the Green Electronics Council. It maintains an online database of products that have been accredited using various environmental criteria, awarding each either a gold, silver or bronze classification. While there has been criticism of this scheme because it doesn't evaluate more radical measures – such as the elimination of common PVC (polyvinyl chloride) and flame-retardant plastics – it is currently the main labelling scheme used by most IT equipment manufacturers. To access the products database and learn more about the scheme see the website: www.epeat.net

Restriction of Hazardous Substances Directive (RoHS)

This is a European law introduced in 2006 which seeks to restrict the use of certain metal and flame-retardant compounds in all consumer goods. Goods produced or marketed in the European Union (EU) have to meet these standards. While there is no specific logo for goods, those which are compliant have "RoHS" printed on the packaging or on the body of the product. The RoHS legislation has recently been merged with the EU-wide controls under the Waste Electrical and Electronic Equipment Directive (WEEE) – this is discussed in detail in unit 9. By being WEEE compliant you not only tackle some of the toxics issues, but you help to simplify the way that the waste industry collects and processes the equipment at the end of its life.

Greenpeace Guide to Greener Electronics

This is the most wide-ranging rating scheme for electronics, based on energy use, carbon emissions, the use of recycled materials and the management of chemical hazards. As well as the general report, Greenpeace produces a "report card" for each major hardware manufacturer detailing their performance generally, and which products meet Greenpeace's reporting criteria. For more information see: www.greenpeace.org/rankingguide

In addition to the above sources, you can often find more in the "environmental reporting" or "corporate social responsibility" of most IT equipment manufacturers' websites.

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

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