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Reducing ICT-related Carbon Emissions: An Exemplar for Global Energy Policy?

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Abstract

While controversy swirls globally about carbon emissions and electricity use, the Information and Communications Technology (ICT) sector has achieved significant, positive results already, especially in the developed nations. Some central processing units have reduced power use by 90% or more, and data centers are achieving previously unimaginable results in decreasing the use of electrical power. Several of the leading approaches to this improvement, sometimes called "Green IT", are discussed, including E-waste mitigation, data center economies like virtualization and PUE improvement, telework and telepresence, smart grid devices, power management technologies, cloud computing, and dematerialization. In addition, several ICT power rating systems and return-on-investment methodologies are examined. Finally, as a brief example of a national agenda for ICT-specific focus on energy management, the case of Australia is described. Even though ICT represents only about 3–5% of the world's electrical use, its aggressive, successful, and continuing pursuit of reduced electricity use and lower carbon footprint is a model for other sectors.

Keywords

E-waste, Green IT, Dematerialization, Power management, Virtualization, Power unit effectiveness.

1. Reducing ICT-related Carbon Emissions: Is it an Exemplar for Global Energy Policy?

There are few global issues that have the visibility of the carbon emissions debate. Regions and nations are called to sign treaties, set goals and effect major reductions in CO_2 emissions along with reducing waste in electricity consumption. The problems are complex, but the Information and Communications Technology (ICT) sector is emerging as a worldwide exemplar of high achievement in reducing electricity use and the resulting CO_2 footprint. In recent years, there has been an extraordinary increase in awareness about lowering electricity requirements for computer equipment of all kinds. Dubbed "Green IT", the subject has crossed into nearly all segments of the economy. Many data centers must pass Energy Star standards or other strict regional, national or international requirements; manufacturers of main frames, PCs laptops, monitors, and servers are challenged as never before to make drastic reductions in their products' power usage; new buildings now conform to LEED requirements. How much of the world's electricity actually is allocated to ICT equipment? A decade ago there was a debate suggesting that ICT would soon consume over half of the world's electrical power. That has been proven to be an exaggeration and the number is now considered to be in the 3–5% range [1], but ICT has a much broader effect on the use of electricity, beyond hardware, servers, PCs and data centers; for example, systems management software affects applications like power distribution, the smart grid, intelligent transportation systems, management of medical records, and many more. This article will describe several of the more significant Green IT issues, the ones that seem to be receiving the greatest attention. It should be remembered that Moore's law aids ICT power calculations dramatically. For example, while automobiles achieved gas economies of 40% over the past three decades, some ICT equipment has achieved 2.8 million more instructions per Watt over the same period [2].

2. Calculating Savings

There are many summary measures which assess the aggregate yield on Green IT investments, like reduction of carbon emissions, lower electrical costs, data center efficiency, etc. I will briefly note three of them. In the report "*SMART 2020: Enabling the Low Carbon Economy in the Information Age*" [3], there are four categories described: smart grid savings of 230–480 million metric tons (MMT) of CO_2 and $15–35 million in energy and

fuel costs; more efficient road transportation (240 MMT, $65–115 billion; smart buildings (240–440 MMT, $40–50 billion) and travel substitution (70–130 MMT; $20–40 billion). Another recent estimate of potential worldwide savings through ICT was placed at a 15% reduction in global electrical demand, equal to 7.8 gigatons of CO_2 reduction, thereby reducing energy spending by $300 billion [4]. An IDC report, *Reducing Greenhouse Gases through Intense Use of ICT*, concluded that the potential savings through 2020 were 5.6 gigatons of CO_2. The sector allocations were: power 29.8%; buildings 28.1%; transport 28.0%; and industry 14.1% [5].

3. Rating Systems

The EPAs Energy Star rating, launched in 1992, has become a significant energy benchmark in dozens of countries for thousands of electrical products. Servers, laptops and gaming systems, just like refrigerators and blenders, advertise their Energy Star compliance. EPEAT (Electronic Product Environmental Assessment Tool), a system founded in the US Green Electronics Council, is among the most successful of the Green IT evaluation systems for specific devices, assessing their compliance with IEEE standards. EPEAT covers PCs, laptops, monitors, thin client devices and work stations and is used in over 40 countries worldwide. It evaluates over 2000 products manufactured by almost 50 firms. About a third of these products have achieved the coveted EPEAT Gold level. Results for EPEAT have been impressive. Here are some examples: savings in hazardous waste: 72 000 metric tons (MT); reduction in use of toxic materials: 1537 MT; reduction in solid waste: over 29 000 tons; reduced greenhouse gas emissions: 2 MMT; electricity savings: over 10 billion kilowatt hours (KWH) [6]. For data centers, as described below, the Power Unit Effectiveness (PUE) is the most widely used metric and the Green Grid, in association with Energy Star, Silicon Valley Leadership Group, Uptime Institute and other leadership groups, has proposed a modification of the PUE standards with four successively more complex rating categories. But there are risks involved in adopting the simpler approach to PUE. A center reporting under level 0, the least complicated, would possibly lose market share to a competitor who reported at level 3, the most comprehensive standard [7].

4. E-waste

The major contributor to the world's growing mountain of hazardous waste is E-waste, constituting about 70% of the hazardous total each year. E-waste is bulky, often dangerous, and is increasing at an alarming rate each year. Since 1980, over 25 billion devices such as televisions, computers, televisions, printers, etc. have been sold in the United States alone, generating several million tons of discarded electronic devices each year. Only a small amount, perhaps 15–20% is recycled [8]. While there are national statutes aimed at E-waste, many of the individual states in the US have established their own approaches for regulating disposal of computers, printers, monitors, gaming systems, television sets, video monitors, etc. Some regulations simply prohibit disposal of E-waste in municipal facilities but others are far more detailed, specifying requirements for transportation, disposal, recycling, etc. For example, in the state of New York, The Equipment Recycling and Reuse Act, passed in summer 2010, places the responsibility for recycling on the manufacturers for "implementing and maintaining an acceptance program for discarded waste" [9]. In October, 2010, the US Congress began hearings on a bill that would stop American recyclers from dumping E-waste in developing countries [10]. There are many international programs, like the e-Stewards Electronic Recycling Certification, that set standards for high levels of E-waste control. Redemtech TCM Centre, of Surrey, UK, became the first European company to win the e-Stewards certification [11].

5. Data Centers

The data center is where the most ICT-related electricity is used and some lifecycle estimates put the additional expense of ICT power and cooling at roughly equal to half the cost of computer hardware itself. For large computers the IBM z10 main frame, introduced in 2008, provides an example of design upgrades that reduce power usage considerably. This IBM redesign effort cost $1.5 billion, and the z10 specifications promised a reduction of 85% compared with a large group of servers with equal computing capacity [12]. This large investment in Green IT by IBM is not only an indication of stewardship of the environment–a phrase found in many of the largest computer manufactures advertisements–it also helps the bottom line. But servers are becoming more cost effective too. Even relatively small server concentrations in data centers are significantly increasing their productivity and lowering power usage.

One of the best-known yardsticks for analyzing overall data center performance is Power Unit Effectiveness (PUE), a measurement unit that is relatively simple in concept. A perfect PUE score of 1 would mean that every watt of power expended in the data center is going toward ICT equipment, like servers, mainframes, monitors, cooling systems, air conditioners, generators, batteries, lighting, pumps, etc. A score of 2 means that only half the power expended is utilized for ICT tasks. The PUE measures only electrical power so when other sources contribute to the mix like natural gas, steam, diesel, chilled water, etc., the results can seem to be better than they really are. Average PUE scores are in

the 1.9 area or higher but there have been some reports of near-perfect results. Google claims to be in the 1.2 range for all its centers but a recent report of results at Yahoo's Lockport, New York, data center, the Compute Coop, is an amazing 1.08. The Yahoo center's efficient design was facilitated by a $9.9 million grant from the US Department of Energy. Some of its characteristics: the design is a series of long, narrow rows (hence the name "coop", as in chicken coop), allowing easy air flow; and hydro-electric power provided by the state's power authority. Also the site is a cold climate area so the net effect is that only 1% of Compute Coop's total electrical consumption is required for cooling. The facility cost about $150 million but is expected to save Yahoo over $100 million in power costs over the next fifteen years [13]. Recently Capgemini's Merlin data center in Surry, UK, also claimed a PUE of 1.08. In the U.S., Energy Star is now involved in certification of data centers after establishing qualifications for servers in 2009. Qualifying centers must be in the top 25% of EPA's energy performance scale. And the European Union has published *2010 Best Practices for the EU Code of Conduct on Data Centres*, a detailed manual describing best practices for the operation of data centers in its 27 nations [14].

6. Virtualization

Any discussion of data center energy savings has to include virtualization, a group of techniques that have led to efficiencies in the management of servers through higher levels of utilization, lower overall energy expense and space savings. In addition, virtualization can lower costs through intelligent allocation of virtual machines, better automation of data center tasks, resource reclamation of underutilized CPU or storage and serving other potential business users [15]. In the United States, a recent study by CDW found that 77% of government agencies are already implementing virtualization techniques and 90% of them are finding them beneficial [16]. In the past, individual servers, sometimes thousands of them in one data center, were using only 5 to 15% capacity, waiting for work, so to speak. But over a million servers had been virtualized by 2008 and, by one estimate, the combination of virtualization of servers and storage plus improving air flow could alone reduce data center operating costs by half and save over 8 billion KWH of electricity annually [17]. In the low-PUE centers now online, the server or mainframe utilization rates are drastically higher than in the pre-virtualization days.

7. Telework and Telepresence

Perhaps the least understood element in Green IT measurements is the contribution of telework to energy savings [18]. At one end of the estimation scale are the optimists like technology writer Kate Lister who says, "If the 40% of employees who could work from home did so half of the time (approximately the national average) it would reduce Gulf Oil dependence by almost 60% and save Americans $40 billion at the pumps" [19]. But there are some reports that question the savings from working from home. A recent UK study found that the typical teleworker generates a third more CO_2 over a year than an office worker [20]. Telework is generally regarded as both a productivity enhancer and a differentiator in recruiting employees, although the private sector has been more actively using it than the public sector [21]. Companies like IBM, Microsoft, Sun Microsystems, Bank of America, Procter and Gamble, and Cisco have been teleworking for decades and have also claimed significant additional savings in real estate; that is, releasing buildings and offices because the work is being done at home or client site. Nearly half of IBM's workforce of over 300 000 teleworks [22]. While teleworks' benefits are not easy to document, the business case for telepresence, the use of technology to hold meetings and other work sessions normally requiring travel is easier. A new report concludes that large companies (over $1 billion in annual sales) in the US and UK alone can achieve system-wide financial benefits of close to $20 billion within a decade, plus saving millions of tons of CO_2 emissions. In addition there are other benefits like "air travel, improving productivity, and better work-life balance" [23].

8. Cloud Computing

Cloud computing is both a metaphor and an indicator of the significance of Green IT. Every time an organization shifts a workload of storage or processing to the cloud they are reducing their overall electricity usage, since the massive new data centers used for cloud services are all striving, like the Yahoo and Capgemini facilities mentioned above, to reduce power usage drastically. Major reductions in cost are achieved in the cloud, too. Shelton Waggoner, Associate Vice Chancellor and CIO at UC Berkeley, says that savings on the cloud for can be of the order of 90% for large volumes of storage– from $30 per month per GB to $2.20 per month–and also nearly that much for servers: "A common metric for an efficiently run organization is 140 servers per administrator. At scale, many cloud providers are now reaching ratios of more than 1000 servers per administrator, or a seven-fold improvement. The key in both situations is that the solution requires scale – scale of design, scale of use, and (reverse) scale of cost per unit" [24]. The cloud is not without problems, despite the large numbers of organizations that are moving storage and processing to it. The greatest concern is data security, but that is frequently dealt with by a triage of applications so that some of the highest risk activities stay in the organization's cloud and are not dispersed.

9. The Electronic Grid

Another significant expenditure partly related to Green IT will be from power providers preparing the electronic grid infrastructure. A study from Pike Research stated that these purchases will grow from $10 billion today to $35 billion in 2013. The report estimates total investment in this field worldwide to be in the $200 billion range from 2008 through 2015. In addition, investments in the "smart grid" are also expected to soar. A Pike Research spokesman says: "Smart meters are currently the highest-profile component of the Smart Grid, but they are really just the tip of the iceberg…our analysis shows that utilities will find the best return-on-investment, and therefore will devote the majority of their capital budgets, to grid infrastructure projects including transmission upgrades, substation automation, and distribution automation" [25]. In the United Kingdom, for example, the government is committed to a 20 year program to install smart meters in 27 million homes, and aiming to achieve net benefits of over $US 20 million [26].

9.1 Power Management Technologies

Energy-saving technologies at the microprocessor level are also widely available in laptops and hand-held devices as well as PCs and larger machines. Examples are AMD's Cool'n'Quiet and Intel's Speed Step. Improvements can be aimed at the entire processor, or in specific areas. Even finer levels of energy saving are possible through deactivating internal circuitry within processors as with the Intel Core and AMD Cool Core product line. Not surprisingly, the energy stakes are high for laptops and PCs, with the number of them now in use approaching 2 billion worldwide. The Climate Savers Computing Initiative, a group of dozens of cooperating PC and laptop manufacturers, has set significant goals for leveraging PC power management systems. Noting that a PC in idle state draws 60 W of power but only 5 W in a lower energy state, the organization's recommended tools take advantage of the potential gains in using equipment only when directly needed through employment of energy management tools from Energy Star and others. One estimate of annual savings worldwide through power savings from laptops and PCs is $US 50 billion [27].

9.2 An Example of National Approach: Australia's Green IT Agenda

For a national case study, Australia is a good example of Green IT applications. The country is especially sensitive to energy conservation, and has generated a wide variety of government-led approaches to squeeze maximum electrical savings from Green IT. These are summarized in the Australia Information Industry Association's recently published *ICT's Role in the Low Carbon Economy* [28]. It gives a detailed list of national policy approaches to harness ICT for delivering energy-related economic, environmental, and social benefits as described in the Copenhagen Climate Change Summit, where developed countries, like Australia, pledged up to $100 billion per year by 2010, for activities that include leveraging ICT-produced power reductions. Specifically, Australia is aiming at seven areas where ICT can directly contribute to reduced power use: ICT Industry (savings in data centers, national broadband network, smart grid); Energy Production and Distribution (smart grid); Transportation (standardized transportation communication channels); Health (electronic health records, telemedicine); Industrial Processes (process control systems improvements); Building Management (power management systems); Education (e-learning-based transportation savings). Another part of the report is also very helpful: a new listing of about twenty other new Green IT-related resources worldwide.

10. Dematerialization

Finally, Green IT also includes some of the most obvious examples of dematerialization, the atoms-for-bits swap, where physical goods like first-class mail, movies, newspapers, songs, CDs, books, income tax filings, checks, etc. (atoms), are shifted to the Internet (bits). Savings due to dematerialization are sometimes included in the cases described earlier, but the following examples are useful to define the order of magnitude involved. The manufacture of 100 tons of paper requires over 3000 KWH; and reading a newspaper from the newsstand represents as much as 140 times the CO_2 required as reading it online [29].

11. Summary

A close observer of the progress of Green IT would find it easy to conclude that the movement has truly galvanized the ICT community worldwide, especially in the most visible applications, like End User Computing (PCs, laptops, printers, etc.) and Enterprise Computing (data centers, servers, telecom, etc.), perhaps as no other effort has for a long time. Hardware and software, servers, cooler units, UPS, data centers, and all the other areas where ICT is active, seem to have gone completely green in several parts of the world, especially in the developed nations. The next frontier, exemplified the electronic grid and the accompanying smart grid devices, is already here, and as cloud computing and other major power-saving opportunities become commonplace, there will undoubtedly be more ways to save on ICT-dedicated power. Some of the claims for the business effects like two recent Pike Consulting reports claiming that by 2015 the market for Green Telecom worldwide will be $US 122 billion and Green data centers $US 40 billion [30]

may be speculative. What is clear, though, is that even though it is only 3–5% of the total global power usage, ICT is more than doing its share to reduce costs, usage, and emissions–an exemplar for many other sectors.

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