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Abstract

This paper addresses the need for a comprehensive, practice-oriented Green IS framework. The study conducted a systematic integrative review of research and practitioner literatures in concert with a cross-sectional field study in order to achieve its objective of building such a framework. This research began in September 2009 and ended in September 2010; thus, the paper incorporates up-to-date findings from academic and practitioner studies and articles, and is informed by insights from leading IT professionals in public and private sector organisations. The Green IS framework presented herein is based on six core concepts or categories: the first of these is Business and IS Strategy, which, in turn, underpins the People; Energy Efficiency; Dematerialisation; Waste and Recycling; and Green Operations categories. This paper argues that if each of these five areas are addressed comprehensively by practitioners, then lower organisational Greenhouse Gas (GHG) emissions will result. The paper concludes that while the direct effects of Green IT are being realised by a growing number of organisations, the enabling effects of Green IS are proving more elusive. There is much then that research and practice needs to do if 2020 GHG emissions offset targets are to become a reality.

Keywords: Green IT, Green IS, Green Strategy, Field Study, GHG, Emissions Reductions.

1 Introduction

Economic growth is associated with the rapid increase in greenhouse gas (GHG) emissions (Brock and Taylor, 2005). It is well-recognised that information technologies (IT) and information systems (IS) have enabled recent economic growth (Jorgenson and Stiroh, 1999) and have had direct and enabling effects on the increase in GHG emissions (OECD, 2009a,b). In 2007, it was estimated that IT accounted for 2% of global GHG emissions (Gartner, 2007); in 2009, that figure rose to 3%; by 2020 IT-based GHG emissions will double to 6% (Fujitsu, 2010). However, while IT is argued to be part of the problem, it is also considered to be part of the solution, as it is increasingly argued that Green IT and Green IS can help lower GHG emissions: (a) directly through the replacement of energy inefficient IT architectures with Green IT and (b) and indirectly by enabling GHG emissions reductions across business processes and society (Butler, 2011; Watson, Boudreau, and Chen, 2010; GeSI, 2008; OECD, 2009a,b). The Smart 2020 Report (GeSI, 2008) estimates that the combined direct effects of Green IT and the enabling effects of Green IS can, potentially, offset emissions in other areas of social and economic activity by at least 15%, while some put the offset factor higher (cf. Fujitsu, 2010).

In the year that the SMART 2020 Report was jointly published by The Climate Group and the Global eSustainability Initiative (GeSI, 2008), Green IT did not rank highly on the corporate agenda, as the costs associated with the transition to Green IT architectures were viewed as being problematic for business and IT executives (Cooter, 2008). By 2010, a survey of 1,000 CEOs carried out by Accenture for the United Nations Global Compact reports that an overwhelming 93% CEOs saw sustainability as being "critical to the future success of their business", while 96% believed that sustainability should be engrained in the strategy and operations of their company; (Accenture, 2010, p. 12). However, a recent study on the adoption and use of Green IT and IS in the USA, UK, Australia and India did more than question the progress being made towards achieving 2020 GHG offsets, it argued, based on its findings, that there was no hope of doing so (Fujitsu, 2010). Support for this argument comes from the Carbon Disclosure Project (CDP) which studied the performance of the top 100 global companies with respect to GHG emissions reductions in 2009 and 2010 and discovered a chasm between the reductions in GHG emissions and those actually achieved (Carbon Disclosure Project, 2009, 2010). Thus, Mindy S. Lubber, President of Coalition for Environmentally Responsible Economies (CERES) argues that "Companies must produce tangible results that put us on a truly sustainable path. For climate change, that means a 50 percent improvement in energy efficiency and a 25 percent lower carbon footprint by 2020" (CERES, 2010, p. 4).

Recent IS journal contributions in this area have reviewed extant studies in the IS and cognate disciplines in order to set the agenda for future investigations and to provide theoretical foundations for such research (Jenkin, Webster, and McShane, 2010; Melville, 2010; and Watson et al., 2010; Butler et al., 2010). Such studies are, however, contemporaneous with several papers on Green IT/IS appearing in conference proceedings at ICIS, ECIS and IFIP 8.2 and 8.3. While several papers present high-level theoretical perspectives (e.g. Melville, 2010; and Watson et al. 2010) or frameworks (Jenkin et al. 2010), others provide theoretically informed empirical studies on several aspects of either Green IT (Bengtsson and Agerfalk, 2011; Hedwig et al. 2009; Molla et al. 2009) or Green IS (Butler, 2011; Hasan et al., 2009) or both (Butler et al. 2010; Chen et al. 2009; Pitt et al. 2010). As comprehensive as this collective body of research is in terms of its scope, an integrative practical perspective is required if academic rigour is to be balanced with practical relevance in terms of the contribution of IS research. This will be particularly important if what is arguably the most vital of sustainability objectives, i.e. GHG emissions reductions, are to be met (OECD, 2009a; GeSI, 2008). Thus, the objective of this paper is provide a practice-based Green IS framework based on (a) a systematic integrative literature review of research and practitioner literatures (Cooper, 1998) and (b) a concurrent cross-sectional field study (Lillis and Mundy, 2005). The second section of this paper presents therefore presents this study's research design.

2 Research Design and Method

This research study on Green IS involves a qualitative design that incorporates a cross-sectional field study (Lillis and Mundy, 2005) with a systematic review of extant research and practitioner literatures (Cooper, 1998). In the process of conducting the literature review, the research team gathered over 500 academic articles, monographs, industry, and government reports. This includes the findings of academic research across several disciplines viz. institutional perspectives in sociology, organization theory, economics, business and management, climate science, law, information systems, computer science, and engineering. Business and practitioner journal articles, EU and OECD reports, industry association reports, newspaper and web articles, were also gathered and analysed. The cross-sectional field study method involves limited-depth investigations of a phenomenon at a purposively selected selection of field sites (Lillis and Mundy, 2005). This approach was adopted in order to maximise the scope and depth of practitioner perspectives on the use of Green IT and IS for environmental sustainability, with an emphasis on lowering GHG emissions. Lillis and Mundy (2005) argue that this approach lies somewhere between in-depth cases and broad-based surveys. Data gathering in the field study was carried out through attendance at two industry-based conferences in London (Green IT Expo 2009 and Government ICT Goes Green Conference 2010) and one in Brussels (ICT4EE 2010); data was also gathered at the IBM Smart Cities Seminar 2010 in Dublin. All conference presentations were digitally recorded (25 hours) and transcribed, as well as Q&A sessions, which the researcher participated in. Informal and formal follow up interviews were conducted with purposively selected key informants at all conferences. Extensive field memos were also taken and/or digitally recorded. Data analysis involved the use of constant comparative analysis and rigorous coding procedures and the use of field research memos (cf. Patton, 1990).

3 Towards a Practical Framework for Assessing Progress to Sustainability

This paper's conceptual framework is first presented (see Figure 1). This model emerged in several iterations from the literature review and data gathered from the field study. The framework posits that in order to be effective, a Green Business and IS Strategy will be underpinned by unique configurations of people, processes and Green IT (cf. Keen, 1993). Green IT is conceptualised as energy efficient or otherwise environmentally sustainable computer, networking and telecommunications hardware; also included in this schema are energy-efficient system and application software. Thus, this paper conceptualises a Green IS as constituting particular configurations of people, processes and Green IT (cf. Chen et al. 2009). While the aforementioned direct effects arise out of the design and use of Green IT in organisations, the enabling effects are derived from the application and use by people, of Green IT to make business, organisational, or social processes environmentally sustainable. A Green IS would typically focus on one or either of the following processes or areas of activity: (a) Energy efficiency (cf. Watson et al., 2010; Hedwig et al. 2009); (b) Dematerialisation (GeSI, 2008); (c) Waste and recycling (Zoeteman et al., 2009); and (d) Green operations (cf. Donnelly, 2006). Perhaps the most important element of such a Green IS would be committed people (cf. Bengtsson and Agerfalk, 2011; Unhelkar and Dickens, 2008). However, as Butler and McGovern (2009) point out, it is unlikely that any one Green IS incorporates or supports all of these processes or activities; nevertheless, enterprise Green IS appear to be an emergent phenomenon. The remainder of this section explores the core concepts and framework elements.

3.1 Green Business and IT Strategy

The concept of the Green business strategy is not new (cf. Hart, 1997); however, the incidence of organisations adopting such strategies is on the rise (Field, 2008). Take, for example that the Harvard Business Review recently published a collection of articles on Green Business Strategy (HBR, 2007).

These studies illustrate the influence of a range of stakeholders, public and private, in shaping Green organisational strategies (cf. Field, 2008; Olson, 2008). The incidence of organisations adopting Green business and IS/IT strategies also appears to be on the increase (Chen et al., 2010; Symantec, 2009). However, only 30% of companies reported having actually implemented a Green IT strategy (Symantec, 2009), with 97% discussing the adoption of a Green IT strategy. Thus, the findings of recent academic surveys provide support that Green IT strategies are on the increase. Nevertheless, the consensus of CIO's from 143 organisations in Australia, New Zealand and the US is "that their organisations lack an adequate level of readiness for Green IT" (Molla, et al., 2009, p. 1). The IT manufacturing and telecommunications sectors appear to be best prepared to execute such strategies (cf. Butler, 2011; GeSI, 2008; OECD, 2009a,b); however, governments and public sector organisations also appear to be active in formulating Green business and IT strategies, particularly where GHG reductions are concerned (OECD, 2009b). It is clear from the literature and from the findings of this field study that the same key issues appear to be associated with the design and implementation of Green business and IS strategies as traditional business and IT strategy viz. organisational culture, capabilities, leadership, social and stakeholder relationships, and linkages with industry associations and standards (cf. HBR, 2007; Heslin and Ochoa, 2008; Jenkin et al., 2010; Melville, 2010; Molla et al., 2009; Ryan, 2008; Olson, 2008; Unhelkar and Dickens, 2008).

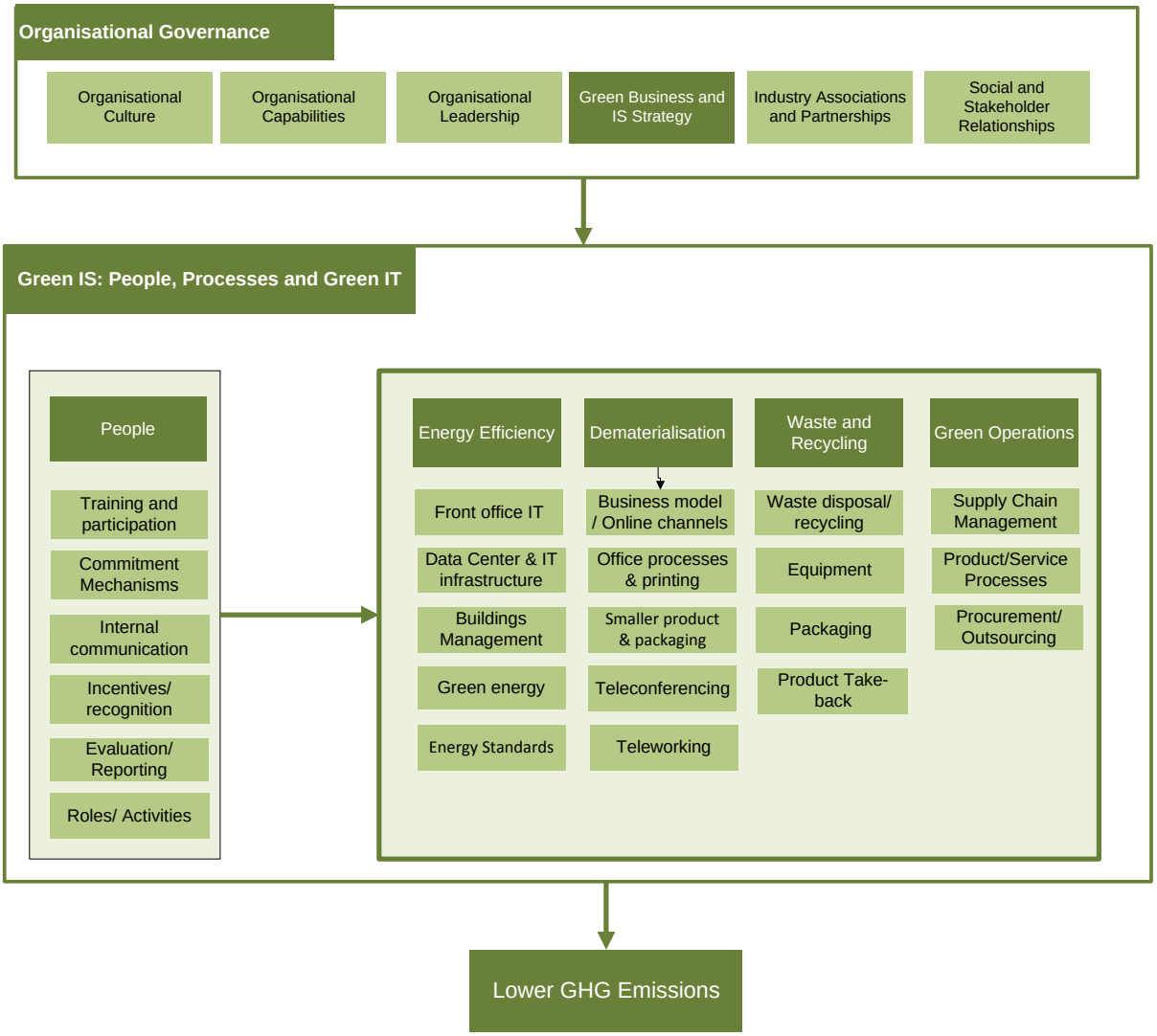

Figure 1 A Practical Framework for Geen IS: From Strategy to Lower GHG Emissions

While overviews of Green business and IS strategy are to be found in corporate sustainability reports (Melville, 2010), detailed descriptions of strategies are thin on the ground. One of the most ambitious and well-regarded business and IS strategy is the UK public sector's Greening Government ICT Strategy (cf. OECD, 2009b). Findings from the field study revealed that in Great Britain and Ireland, government departments and public sector organisations account for over 35% of IT-based GHG emissions. In he UK, total emissions from the public sector stands at 10.2 million tonnes GHG, while total business activities total 72.4 million tonnes (of a grand total of 480.9 for the entire economy). In 2008, the British Cabinet Office published its strategy for the Greening of Government ICT, which attempts to make IT use across the all government and public sector organisations carbon neutral by 2012, and carbon neutral across the entire IT lifecycle by 2020 (Cabinet Office, 2008). Over 100 public sector organizations are participating in the execution of this policy. New structures, roles and leadership initiatives were put in place to help public sector organisations make the transition to carbon neutral entities. In addition, the UK Government's Chief Information Officer/Chief Technology Officer Council developed a Green ICT Scorecard with which to evaluate the environmental performance of government departments, agencies, and so on, using 32 key indicators, including 18 IT-related action points. Areas covered include: Green Policy; Governance of Policies; Energy Efficiency; Waste Management; Supplier Management; Procurement (including IT outsourcing); Buildings and energy management; and Staff behaviours. Engagement and linkages with industry associations, consultancy firms and IT service providers, standards bodies and the broader community of stakeholders were established. In order to implement strategy, public sector organisations have produced Green ICT Action Plans setting down measures for improving the energy consumption of their IT infrastructures, thereby lowering related GHG emissions. Individual UK government organisations reported on progress in achieving these goals at the Greening Government ICT Conference 2010, while the UK government publishes annual progress reports (cf. Cabinet Office, 2009). The findings of the field study indicate that the application of the direct effects of Green IT to reduce GHG emissions has shown a measure of success; there was also evidence of the impact of the enabling effects Green IS across such key areas building energy management, IT infrastructure, data centre management, and in logistics and transport. The findings indicate that there are valuable lessons for public and private sector organisations in designing Green business and IS strategy here. Significantly, there is strong evidence in support of the above conceptual and practical framework, the chief elements of which are now discussed.

3.2 People and Green IS

The importance of the people dimension in the formulation of corporate strategy well accepted, particularly where the alignment of business and IT strategies are concerned (Keen, 1993). This finding also applies to the formulation of Green business strategy (Field, 2008; Hart, 1997; HBR, 2007; Heslin and Ochoa, 2008). As Unhelkar and Dickens (2008) point out "a corporate green ICT strategy needs to consider all three significant components of any strategy: people, processes, and technologies." These points are echoed across recent IS studies on the issue (cf. Bengtsson and Agerfalk, 2011; Melville, 2010; Molla, et al. 2009; Petrini and Pozzebon, 2009; Watson et al., 2010).

The practical question that begs an answer here is "what are the special people-based considerations that need to be given to the execution of a Green business and IS strategy over and above those concerned with traditional business and IS strategy?" Data gathered from the field study provides an indication. In an unscripted talk on his experiences, in helping implement Green business and IT strategies in over 33 organisations, to business and IT professionals at the Green IT Expo conference, Ben Murray of Carbon Smart stated that: "I would argue that all of those technical and all of those management decisions and actions will come to nothing if the people in your organisation are not on board. It's the people who decide whether or not they are going to get on a plane, it's the people who decide whether or not to go into business class or economy, it's the people who decide whether or not to turn the lights on when they are in a room when there is in fact enough natural light, it's the people who will turn the heating and the cooling on at the same time, it's the people who make procurement

decisions, it's the people who leave PCs on at night or when they go off on holiday." In communicating the need for sustainability outside of the organisation, Murray emphasised "whether it's talking to customers and sealing a deal, or making decisions about procurement and costs issues, whether it's about talking to local communities or other people who have an influence over the value of your brand, it's your staff that is going to be out there and it is they who will be taking the reputation of your brand with them. If they are engaged fully and positively in a sustainability issue, they are going to take that out to everyone who they talk to." Having reviewed the literature extensively, this practical advice provides the best insight into the need for grassroots involvement. However, there is a substantial body of cumulative IS research on the benefits of user participation in IS development (cf. Cavaye, 1995); on the commitment required of stakeholders (Butler, 2003); and on the factors that impact success in IS implementation (Kwon and Zmud, 1987). Hence, this paper argues that training and user participation, instituting mechanism for employee buy-in or commitment; internal communication; incentives and employee recognition; staff evaluation and reporting; and the institution of new roles and activities are required to be considered as important elements of the people dimension. This came across quite strongly from UK public sector strategy documents and in data gathered from IT practitioners. However, as Murray points out, different tactics will need to be applied in different organisations.

3.3 Energy Efficiency

It is clear from the literature review and the field study that the chief rationale behind the introduction of Green IT artefacts is energy efficiency (Murugesan, 2008). Hence, the inclusion of front office IT and data centre and IT infrastructure elements under this conceptual heading, rather than Green operations. The same justification applies to building management systems, Green and renewable energy sources, and energy standards.

Greening the Front Office: In its simplest form Green IT involves the minimisation of energy consumption associated with IT use (Murugesan, 2008). At front office level, energy savings are to be realised through actions as elementary as powering-off desktop computers and other IT peripherals when not in use, particularly during off-peak office hours i.e. night time and weekends (Ryan, 2008). Many refer to this as the 'low hanging fruit', as such actions, while relatively simple can prove highly cost effective (Jenkins et al., 2010). 1E's PC Energy Report (1E, 2009) estimates that a typical UK firm with 10,000 computers wastes £168,000 annually on energy costs as a result of staff failing to power-off computers when leaving their workstations at the end of every day. Significantly, IE is a vendor of NightWatchman, one of several Green IS that helps organisations power manage their front-office computers. Relatedly, using energy efficiency standards such as Energy Star and EPEAT to make purchasing decisions on office computers is also central to optimising the energy efficiency of the IT infrastructure in any organisation (Pratt, 2008; Melville, 2010; OECD, 2009b). Evidence gathered from the field study indicates that there is an increasing use of energy efficient PCs, laptops and notebooks in private and public sector organisations. There is mixed evidence on the use of Green IS such as NightWatchman, as organisations are fearful of losing critical data in forced shutdowns. Many are employing strategies where users are segmented according to computing needs. Take, for example, that Windows policies are used to apply/enable energy management standards on desktops, where stringent policies are being applied to ordinary users, while users of mission critical applications are generally excluded. Wake-on-Lan is also in widespread use to enable vital updates and security patches. Increasingly, however, organisations are moving to low energy thin clients and desktop virtualisation solutions.

Data Centre and IT Infrastructures: Data centres are, and will continue to be, a major source of IT-related GHG emissions by organisations (Ryan, 2008). Accordingly they have received much attention in the practitioner literature and are the subject of a variety of standards and best practice (cf. OECD, 2009b; Hedwig, et al. 2009). Take for example, The Green Grid which promotes user-centric models, metrics for data centres, and the adoption of energy efficiency standards, processes, and efficient

server and related technologies. The Green Grid's influence on data centre practice is manifested in the widespread use of the Power Usage Effectiveness (PUE) and Data Centre Efficiency (DCE) metrics for benchmarking the energy efficiency of data centres. Likewise, the European Union also publishes and promotes the EU Code of Conduct on Data Centres viz. the "Code of Conduct is a voluntary commitment of individual companies, which own data centers (owners/operators), with the aim of reducing energy consumption (against a BaU scenario) through the adoption of best practices leading to agreed energy saving targets in a defined timescale." [1] Best practices for data centre design and operation are also researched and published by the Lawrence Berkeley National Laboratory in the US. The findings of the study indicates that the Green Grid Guidelines and the EU Code of Conduct are being applied by practitioners. PUE benchmarking aside, US organisations tend to adopt the former, while EU public and private sector organisations favour the latter. Evidence from the field study is instructive on the need for such standards. Andy Lawrence, Research Director for Eco-Efficient IT, 451 Group argues that "The problem out there is that most servers and disks out there are operating at absurdly low levels of utilisation – 5-15% and I have heard some people say it's 1-3%, so that means that a server spends most of its time 3-5% busy or maybe 10%. But of course it's being powered at 70%, and then it's carrying an overhead of cooling and power distribution. So, huge amounts of power are effectively going into servers, the same on storage, that's just doing nothing." A practical example comes from University of Westminster, which was running 150+ software applications on 150 servers in two data centres. In 2009, a combination of server consolidation and virtualisation (VMWare) saw the same number of applications running on 35 servers. The university plans to reduce the number of servers to 5 (energy efficient multi-core processors) through consolidation and virtualisation and operate just 1 data centre at a capital cost of £100,000. Organisations are also running their data centres at higher operating temperatures as they are replacing old servers, routers and telecommunications equipment. Take, for example, Strato AG, which according to René Wienholtz has 73 % lower energy consumption/heat dissipation and a 60 % saving of space by consolidating and virtualising from 100 to 42 servers (operating up to 90% load) and doubling storage capacity from 24 to 51 TB. Upgrading its operating system to Solaris 10 and code optimisation of its applications also helped reduce energy consumption. Airflow optimisation, rack configuration, increasing operating temperature also brought improvements. Strato also purchases all of its energy from hydroelectric sources. Returning to the UK public sector, evidence gathered there indicates that application consolation is being planned in conjunction with a cloud computing or G-cloud to lower energy costs and cut GHG emissions.

Building Management Systems: Energy management of buildings assumed greater prominence when a recent United Nations report Buildings and Climate Change reported that between 30-40% of all primary energy is used in buildings management (Sinha, 2009). Thus, a comprehensive Green business and IS strategy cannot afford to ignore the potential energy savings and GHG abatement opportunities associated with buildings management and buildings maintenance. To bring about the necessary reductions Smart buildings will use IT to micro-manage heating, lighting and ventilation and minimising energy use (GeSI, 2008); indeed, it Cisco Systems is leading the way in an IT context. In a general context, there has been a growth in building management system (BMS) software offering in the marketplace; however, such systems differ greatly in scope, features and functions. There are two rival environmental standards for buildings globally: the US Leadership in Energy and Environmental Design (LEED) Standard, which is a Green Building Rating System developed by the U.S. Green Building Council, and the UK's BREEAM (BRE Environmental Assessment Method), which is argued to be the leading and most widely used standard globally, due to the existence of UK and International versions. Major US corporations are implementing LEED in the construction of offices and manufacturing facilities and new data centres. Indeed, the Lawrence Berkeley National Labs (LBNL) drew on LEED to arrive at its 'Environmental Performance Criteria (EPC) Guide for Data Centers '. Recently, the BREEAM standard was extended to cover data centres.

[1] http://re.jrc.ec.europa.eu/energyefficiency/pdf/CoC%20DC%2020Nov2009/Paolo%20Bertoldi.pdf.

Green Energy and Standards: Green or renewable energy is a relatively new phenomenon for business organisations. However, there is increasing evidence that organisations are seeking to obtain electrical energy from renewable sources (Pratt, 2008). New Green energy and related standards have also been put in place, while existing standards such as the ISO 14000 series have been evolved (OECD, 2009a). Evidence from the field study indicates that organisations are increasingly building their IT facilities near renewable sources (Pratt, 2008; Melville, 2010). Significantly, Green IS have also play a key role in the design and implementation of Smart Grids (cf. GeSI, 2008; Watson et al. 2010). Hence, much applied research is being conducted in this area globally, albeit in related fields such as computer science and electrical engineering, as indicated by the data gathered at the European Commission's ICT4EE (ICT for Energy Efficiency) Conference in 2010.

3.4 Dematerialisation

Dematerialisation – the minimisation of the use and production of material objects - is integral to a sustainable environment and Green IT is playing a crucial role in enabling dematerialisation across the enterprise and society (GeSI, 2008). The underlying rationale is that a reduction in material usage lessens the impact of economic activity on the natural environment (Melville, 2010).

Business Models/On-line Channels: Both the public and private sectors now offset GHG emissions by conducting business-customer activities or business-business activities online. The UK public sector positions its provision of online services accordingly (cf. Cabinet Office, 2008, 2009). This appears to be a common theme across the developed world (OECD, 2009a,b). However, the notion that e-commerce and e-business bring efficiencies (albeit economic) has been a central tenet of the IS field for some time.

Office Processes & Printing: Dematerialisation in an office context involves switch from hardcopy to soft- or e-documents, chiefly by avoiding print operations by staff (Pratt, 2008). Take, for example, the use of duplex printers and double-sided printing where hardcopy cannot be avoided (Jenkins et al., 2010). As with Jenkins et al. (2010), the findings of this study indicate that this is primarily a behavioural issue for many staff. One which can be resolved using stringent Green printing policies and centralising printers. Several organisations reported that eliminating personal printers and centralising printing facilities led to a significant reduction in paper and printing costs.

Smaller Product and Packaging: This is a relatively new development which is increasingly being regulated, reported upon and monitored, due to its contribution to GHG emissions and other environmental effects (CERES, 2010). Jenkins et al. (2010) indicate a role for IS in the design of IT packaging, while Butler and McGovern (2009) report that Green IS are being used by organisations to monitor and report on such issues. At a practical level, this study found that organisations such as Leeds City Council in the UK mandate that computers and other IT artefacts are shipped to them in pallets rather than individual boxes. IT manufacturers such as US storage solution provider EMC^2 ship their goods to customers on pallets or with the minimum of packaging.

Tele-conferencing and Tele-working: Minimising carbon emissions associated with employee travel whether through tele-working, tele- and video-conferencing is now commonplace (cf. CERES, 2010). "By effectively managing the technological options for conferencing — including Net conferencing with built-in video, VoIP, and virtual project collaboration software — a company can provide a flexible base for its employees to communicate without impacting the environment through increased office space or travel" (Ryan, 2008, P. 8-9). This is becoming a key reporting issue for organisations in their corporate sustainability reports and data from the field study indicates that public and private organisations are pursuing both tele-conferencing and tele-working/tele-commuting with a degree of enthusiasm. The latter involves remote access to existing IS using tried and tested internet technologies such as VPN. The corporate sustainability reports of many leading IT manufacturers now contain references to the substitution of tele-conferencing solutions for corporate travel, with significant savings being reported. In the UK Government and other public sector organisations a

move to 'New Ways of Working' includes the wide-spread use of tele-working; Bristol City Council, for example, estimates that moving over 20% of staff to home working will result in a saving of 11 Kg of CO_2 per employee per day.

3.5 Waste and Recycling

The related concepts of waste and recycling is covered by national international regulations such as the WEEE Directive which obliges producers to take responsibility for their electrical products at the end of their lifecycle. Organisations are being measured and are required to report on issues such as waste *disposal/recycling*, *equipment*, *packaging* and *product take-back* (cf. Hojsik et al. 2008). Presently, several Green IS are on the market to help manage compliance with such regulations and to gather data for accurate reporting (Butler and McGovern, 2009). SAP has arguably the most comprehensive portfolio of IS solutions that target these elements in the framework (see http://www.sap.com/solutions/executiveview/sustainability/sustainability-map/index.epx). At a practical level, this study found that public sector organisations in the UK are extending the life of their IT assets to reduce waste, while some Local Authorities such as Bristol City Council are refurbishing personal computers for use in socially disadvantaged communities. This latter approach is congruent with the council's On-line Channel Strategy to lower GHG emissions by enabling clients to engage in on-line transactions, rather than travel to service centres.

3.6 Green Operations

Lowering GHG emissions associated with business and manufacturing operations and supply chains will, *ceterus paribus*, depend on the enabling effect of Green IS (cf. Butler and McGovern, 2009; Chen et al. 2010; Jenkin et al. 2010; Watson et al. 2010).

Supply Chain Management (SCM): It is clear from Melville's (2010) recent analysis that Green IS have not as yet materialised to provide comprehensive automating and informating capabilities in this area. The reference to SAP's solutions above indicates that this IS provider has a comprehensive portfolio of environmental modules, e.g. the logistics management module helps (a) reduce inventory and increase asset utilization across the logistics network thereby reducing GHG emissions; (b) makes the supply chain more visible and therefore highlight weak points; and (c) helps reduce GHG emissions and mileage with optimized transport routes. However, as Butler and McGovern (2009) indicate, much will rely on the data being captured. The IT sector appears to be leading the way in terms of the use of IS to capture and track GHG emissions. Take, for example, that Electronics Industry Citizenship Coalition (EICC) Carbon Reporting System is an on-line system that permits organisations in the electronics industry to calculate their GHG and share that data with other companies in the industry. Delegates at the ICT4EE Conference 2010 were informed that the Global e-Sustainability Initiative and the EICC were collaborating with Achilles Information Ltd. to advance the ongoing development of a Green IS called E-TASC to address the complex issue of corporate responsibility in global supply chains. E-TASC was deployed by the EICC and GeSI in late 2007; to date it has more than 270 subscribers who use E-TASC to administer Self-Assessment Questionnaires (SAQ) for suppliers. Clearly, much work will have to be done to deliver the type of sophisticated IS functionality require to make the supply chain truly transparent with respect to GHG emissions.

Product/Service Operations and Environmental Management Systems (EMS): Many organisations look to Environmental Management Systems (EMS) to help make their business and production/service processes sustainable. Most adhere to the ISO 14000 standards series: e.g. ISO 14001 and ISO 14004 provide requirements and guidelines for environmental management systems (EMS). The ISO 14064 standard covers GHG accounting and verification. These are not Green IS, although there are software solution to help manage and document the process towards certification. There are however product Life Cycle Assessment (LCA) Tools that are based on this standards and which enable sustainable product stewardship (cf. Butler and McGovern, 2009). A recent analysis by

Verdantix identified CA Technologies, CarbonSystems, Enablon, Enviance, Hara, IHS, ProcessMAP, SAP, TRIRIGA and Verisae as the 10 leading vendors of carbon and energy management software (see http://www.verdantix.com/). Little is known about the capabilities of such Green IS; however, Tesco has adopted CA's ecoSoftware to help it halve its GHG emissions by 2020.

Procurement/IT Outsourcing: Green IS for SCM address general procurement issues in a manufacturing context. This section highlights the procurement of Green IT and Green IT outsourcing. Ryan (2008) identifies the basic criteria for the procurement of IT equipment as EPEAT certification. Ryan reports that an Executive Order was issued by President Bush in 2007 requiring all US federal agencies to purchase only EPEAT-certified artefacts. However, the OECD (2009b) reports that Energy Star is also in widespread use to evaluate IT offerings. Evidence gathered in the field research component of this study indicates that public sector organisations in the UK apply stringent procurement criteria on IT suppliers, including Energy Star and EPEAT, down to the sources of metals used in printed circuit boards and components. In terms of IT outsourcing, the Brown-Wilson Group (2009) Green Outsourcing Survey found that 87% of IT outsourcing vendors were not delivering on agreed energy efficiency measures. It is unsurprising then that 82% of companies using outsourcing strategies were impatient with vendors' responses to calls for Green initiatives. Hence, Doug Farquhar, Sustainable Outsourcing Lead with Capgemini UK, argues that outsourcing Service Level Agreements with IT outsources should cover a range of issues and answer such questions as 'Which mines and from what countries do the substances contained IT artefacts originate?' and 'What emissions reductions have IT manufacturers obtained in the production and supply chains?' The UK's Environment Agency is regarded as an exemplar in the use of such approaches by many in the UK. While such issues have become the subject of IS research (cf. Babin and Nicholson, 2009), much more is required in this area as the trend to outsourcing or cloud computing continues.

4 Conclusions

This study articulates a comprehensive, practical framework for Green IS. However, the depth of the study was limited by its breadth, in that more was omitted in the drafting of this article than included in the final version. Nevertheless, it does provide insights into the current state of practice, or lack of it, in the provision by vendors of enterprise wide Green IS that addresses all of the factors considered here. While a small number of vendors such as SAP promote their environmental software applications, rigorous research/impartial evaluation of such solutions are warranted to verify the claims made (cf. Butler and McGovern, 2009; Butler, 2011). Feedback from IT practitioners indicates that caution is also required when it comes to the adoption of building management systems (BMS) and carbon reporting software, as a return on these investments rarely materialise. More, it is argued, can be achieved using a power meter and a spreadsheet. Nevertheless, large corporations are apparently gathering huge volumes of data in order to report on their GHG emissions—direct and indirect, including those of their suppliers. Without a comprehensive, auditable enterprise-wide Green IS, the accuracy of much of these GHG accounts is questionable. In the absence of a monolithic Green IS, what may be required is an integrative IS based on open, extensible industry standards for data transfer from the disparate systems that collect GHG emissions-related data on office and operations facilities, data centres, and the supply chain. It is clear from my research that the fruit that were out of reach 2-3 years ago are now low hanging and are ready to be picked. Thin client/desktop virtualisation, low power notebooks and netbooks, server consolidation and virtualisation, and a highly competitive power management software market, all mean that the direct effects of Green IT can be realised in full. It is the leveraging enabling effects of Green IS that now pose a challenge for IS research and practice, as this involves behavioural change in individual actors and related process-wide change in organisations and across society. In conclusion, the Green IS Framework and the findings of this study could be applied by practitioners to evaluate their progress across the key areas where the direct effects of Green IT and the enabling effects of Green IS can be realised towards making their organisations environmentally sustainable and in reducing GHG emissions.

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