Green information systems & technologies – this generation and beyond: Introduction to the special issue

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1 Introduction

Individuals, organizations, communities, and nations are all under pressures to determine how humans can survive as our environment continues to degrade. How we currently live, in both developed and emerging economies, consumes more resources than nature can provide. How we utilize these resources is also altering our environment in directions, that some fear, are irreversible. Global climate change; water, mineral, energy, and land resource scarcities; biodiversity decline; acid rain; hazardous and toxic substance poisoning; and many other environmental ills will influence how we live and survive in both the short- and long-term. These concerns require us to reconsider how we produce, consume, and use products, services, and technology. Sustainability requires considering both the needs of this generation and future generations. In this special issue we begin with setting this environmental sustainability foundation for the remainder of the papers by including a fundamental issues article by Rajendra Kumar Pachauri (2013), Chairman of the Intergovernmental Panel on Climate Change (IPCC, the Nobel Peace Prize winning organization).

Within organizations, businesses have encountered pressures to alter their institutional perspectives. New

norms will require organizations and individuals to re-evaluate activities and functions so that future generations can survive and, with hope, thrive. The sustainability of organizations and their greening will be necessary to help address environmental burdens, but it will not be easy. Green growth, the decoupling of economic growth from environmental burden and even providing a synergistic win-win relationship between economic growth and environmental improvement, is a nascent policy mantra (Vazquez-Brust and Sarkis 2012).

Within commerce and the organization, greening supply chains, operations, strategy, human resources, marketing, and technology are all current efforts to help industry manage these environmental and social pressures. Some of these fields have been investigating these greening issues for decades and have developed a relatively mature research agenda. Information systems (IS) and Information Technology (IT) management have had sporadic developments and research investigation in greening and sustainability. The participation of IS and IT researchers and their voice in this literature has been lacking. Noting this gap, in the past few years, Green IS and IT¹ have become more prominent practical concerns with concerted research effort (Jenkin et al. 2011).

Green IS refers to improving the flow and management of information, while Green IT refers more to the hardware and other infrastructure that can be better managed and designed from an environmental perspective (Sarkis and Zhu 2008). Evidence of this greening prominence has included calls for research and investigation on this topic in the top IS and IT journals and by major IS and IT professional societies. Special

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¹ We distinguish between IS and IT and thus Green IS and Green IT. An IS is an integrated and cooperating set of people, processes, software, and information technologies to support individual, organizational, or societal goals (Watson et al. 2010).

interest groups (SIGs) on Green IS and IT have increased the voice of socially conscious academics as this community continues to grow. These research investigations are just commencing. Arguably the IS and IT community has to play ‘catch-up’ with many other parts of the academic and practitioner community when it comes to greening and sustainability issues. Part of making this progress will require both introspection into our field and collaboration with external, interdisciplinary practice, theory, and developments.

Raising the consciousness and attempting to tackle difficult to answer questions are the reasons for the call for research on this topic, with theory and use-inspired research as major underlying foundations. Implications for policy makers, managers, and organizations all need to be made. There is no more important and socially relevant research that we, IS and IT researchers, can encounter and need to pursue.

To help further the research agenda on greening IS and IT we offer this special issue for focused research. In this introductory editorial we provide an overview of some of the current practical and theoretical concerns facing the use of IS to create green solution and the greening of IT. We also identify future opportunities for investigation, while also including a perspective on how the field needs to progress. We then provide an overview of the papers in this special issue and what important questions are asked, answered, and contemplation for future research.

2 IS and IT influence on the environment

Over the past two decades, environmental pressures and concerns from a variety of stakeholders have motivated both researchers and practitioners to investigate corporate greening solutions. The growth and importance of greening and environmental sustainability has not gone unnoticed by industry, government, institutions, and their stakeholders. While environmental sustainability has received attention amongst practitioners, Green IS and IT have just started to display their unique practical contributions, both negative and positive, to the environment. Green IS and IT will necessarily include both infrastructural and organizational aspects of environmental technology. Expanding the focus to environmental sustainability includes considering its integrated nature and sets of systems (including people, processes, software, and information technologies) to support individual, organizational, environmental, and social goals, and may need more nuanced investigation and consideration.

Surprisingly, while industries, corporations, and IS units have acknowledged the importance of environmental issues, the academic community has provided limited contribution to

the burgeoning knowledge in sustainability with Green IS and IT. The critical role of both Green IS and IT and general greening through goods and services manufacture is visible to consumers, but it is also embedded in the life cycles of materials, manufacturing systems, and public infrastructure.

Information in general, and IS and IT systems in particular, can play an important control role through support of environmental management systems, life cycle analysis, and design of environment practices. Organizationally, IS and IT managers and technologists’ basic awareness of greening organizations is a potential starting point on the role of IS and IT in greening efforts. Along with awareness and readiness, the need for organizational leverage of IS capacities is also needed. The life cycle of the IT infrastructure itself, not just the information flow, whether it is in production, delivery, use or end-of-life, has significant environmental implications.

These dimensions of Green IS and IT can be studied at the operational or strategic levels. Examples of the scope and depth of Green IS and IT practice and research are now briefly overviewed.

2.1 Prevalence and influence of green information systems and technologies in organizations

Green IS and IT can have broad and varied influence, whether it is intra- or inter-organizational, and at multiple levels. For example, at broad inter-organizational levels, green value chain investigation shows that IS and IT can cause both environmental degradation and environmental improvement opportunities (Sarkis and Zhu 2008). At the individual level, Green IS and IT can also have an environmental impact. For example, the use of IS and IT can encourage individuals to make more sustainable behavioral choices (Ijab et al. 2010).

Organizational information systems can be separated into four basic types of systems, transaction processing, decision support, management information and executive support systems. Transaction processing systems (TPS) are focused at the operational level of an organization and deal with real-time and very short-term information requirements. Management information systems (MIS) and decision support systems (DSS) are typically focused at the middle management (tactical planning) level of an organization. Executive information systems (EIS) focus on the needs and requirements of upper management and aiding them to focus on strategic management of the organization. Information is typically aggregated from the lower level systems and summarized in longer-term perspectives ranging into years and focusing on non-routine type decisions (Laudon and Laudon 2010). From this hierarchical and managerial perspective, various IS requirements from an environmental perspective can be mapped across functions. One such summary of the various types of IS within an organization and across functions with examples of how they support the greening of organizations is summarized

in Table 1. Many of these items are appertained examples in later sections.

Not only is there an issue of how IS can help organizational and cross-organizational practices, but the environmental implications of hardware, software, and databases and their infrastructure and operations can be quite extensive. IT itself may cause substantial negative ecological footprints and needs to be managed accordingly. For example a greater need for energy and materials may be required. While an average desktop personal computer and monitor requires ten times its weight in water, fossil fuels, and chemicals as material and resource inputs (e.g., implementing virtualization servers, improvement in cooling systems, recycling of hardware, e-wasting management, green procurement policy for software and hardware) (Sayeed and Gill 2008). Large quantities of energy, materials, and chemicals are consumed during the production phase, not all of which will be contained in the final products.

Environmental software to support green IS and IT management range from auditing and managing emissions to analyzing energy and minimizing waste. More recent aspects of software systems include the utilization of Life-Cycle-Analysis (LCA), which goes beyond the organizational

boundaries. Design for environment (DfE) databases also play a role, which may integrate supplier and vendor data and processes. The management of hardware, software, and its usage is critical to organizational greening. Many additional examples exist concerning the roles and influence of Green IS and IT. Some of these are now discussed as issues and research that might be completed in this area. They are not meant to be exhaustive and represent some of what we, the special issue guest editors, feel are important and emergent issues in Green IS and IT.

2.2 Enterprise resource planning (ERP) systems and green IS and IT

Environmental management information systems (EMIS) include hardware, software, people, procedures, and tasks that manage environmental information and support environmental and other managers for managing environmental issues within and between organizations. The integration of ERP with more advanced environmental IS tools is a relatively novel issue (Eun et al. 2009). EMIS have typically been designed as stand-alone, isolated, software tools such as waste administration packages. Integration and adequate co-

Table 1 Summary of information system management levels and greening applications by organizational function

Managerial decision level	Strategic level	Managerial level	Operational level	
Functional area	Executive Support Systems (ESS)	Decision Support Systems (DSS)	Management Information Systems (MIS)	Transaction Processing Systems (TPS)
Engineering and design	New Product Requirements, Environmental Liability Issues	Justification Models for designs; Design for Environment (DFE) decision tools	Life Cycle Analysis (LCA) inventory data	Environmental product and process performance information
Procurement	Due diligence merger information, Superfund liability information	Supplier Selection decision models with Environmental factors	Reports concerning environmental performance of suppliers	Updating inventory of environmentally sensitive material
Manufacturing and production	Global, yearly emissions changes, environmental technology information	Disassembly production planning tools	Daily, weekly hazardous wastes generated from processes for Toxics Release Inventory (TRI) reporting	Email reminders of permit thresholds
Sales and marketing	Green consumer market development systems	Forecasting tools for green product requirements	Information on different green promotion successes	Daily sales of environmentally sensitive materials
Logistics	Long term data and plans for transportation fleets	Simulation tools for transportation and energy planning and network design	Reports on daily and weekly fuel usage.	Amount of packaging returns for day and scheduling of reclaimed materials
Finance	Shareholder value percentage for socially responsible funds	Capital budgeting DSS tools integrating environmental factors	Financial environmental budget reports	Daily transactions of greenhouse gas emissions permits
Accounting	Social and environmental report structure and standards	Environmental balanced scorecard system	Internal and external environmental audit information	Daily recording information on environmental accounting data
Human resources	Environmental and safety requirements in union negotiations	Personnel selection for environmental programs	Environmental training records	Updating Material Safety Data Sheet (MSDS) forms

operation of environmental and ERP functionality requires an emphasis in their common base: the physical flow model. Environmental harm directly connected to production is related to physical flows entering and leaving the production process.

The functionality of an ERP system will include various managerial and functional decision levels. For example operational level data registration addressing missing environmental data; integrating tactical managerial level environmental information, such as material safety data sheets, life cycle inventories, waste and energy balances; and strategically include data that can be used for statements about the future environmental management system, planning environmental investments or to predict liabilities. ERP systems need integration of mass and energy-flow models for effective integration. This integration is necessary since business process models are required for systems analysis and design approaches for implementing enterprise-wide information systems.

With this evolution of ERP systems as green IS and IT arrive, there are concerns on whether developmental and acceptance models need adjustment. For example, user input and user satisfaction of implementing these enterprise-wide systems may require a larger stakeholder sphere. The technical aspects of some environmental data acquisition may require integrating real-time information with emergency response issues that can be managed by an ERP system. Overall, whether systems can be agile enough to incorporate green IS and IT requirements is a technical and developmental concern for further research and development.

2.3 Green IS and IT and the value chain

From the systemic perspective of the organization, activities begin with procurement and in-bound logistics functions that introduce materials and services into the organization. These materials are transported from various vendors. The policies for selection of vendors, including transportation and delivery services, are a central issue for purchasing agents. The selection of material, services, and suppliers is a key purchasing function that can critically influence the greening of an organization and its supply chain. Relationships with suppliers, including environmentally-oriented selection, development, and management of suppliers, are all part of greening the procurement function. These materials are then stored, or services utilized, and may be managed under the auspices of the purchasing function. Managing this environmental information flow is an important part of green IS and IT. Environmental supply chain management embodied material and information flow both up and down the supply chain pursuing reduction, recycling, reuse and the substitution of materials (Zhu and Sarkis 2004; Hervani et al. 2005). From the IS perspective mobile technologies development and application

may be necessary for monitoring and data acquisition of environmental and sustainability performance throughout the purchasing and vendor management activities, which would include social and environmental auditing of supply chain activities.

There are both technical and managerial research concerns that need investigation in this field. The development and implementation of inter-organizational IS systems and diffusion can be investigated using various organizational theories (see Sarkis et al. 2011 for a review of organizational theories applied to environmental supply chain management issues). From a broader supplier perspective, the extended producer lifecycle practices for IT equipment also require suppliers (e.g. reverse logistics service providers) who can aid in extending the life of IT hardware.

2.4 Cloud computing and organizational sustainability

Cloud computing is the use of software and computing services by enterprises that are available through distributed online (Internet) systems. Cloud computing could lead to a potential reduction in worldwide data center and dispersed IT usage and energy expenditures. It may also help maximize power usage efficiency, improve recycling efforts, lower carbon and gas emissions, and minimize water usage in cooling the remaining centers. Large U.S. companies that use cloud computing can achieve energy savings and displace of millions barrels of oil (McKendrick 2011). IBM argues that pooling of software and technology in the ‘cloud’ allows organizations to maximize resources operate its IT systems with the most efficient infrastructure possible. Cloud computing has resulted in 73 % less power than traditional desktops and laptops (IBM 2009). Cloud computing can help organizations improve their Green IS and IT effects by providing a shared and on-demand infrastructure with virtualization capabilities (Scott and Watson 2012). Thus, with the centralization of information technology and software systems through the Internet, cloud computing can arguably add to the flexibilities and efficiencies of information system operations.

Investigating the true savings still requires research and investigation. Optimal cloud computing designs for efficiency, peak scheduling, capacity management, and service delivery are all managerial and technical topics that can be investigated. Local, regional, network, and even global data need to be evaluated to determine whether these savings occur systematically, or whether environmental burdens are just shifted.

2.5 Green IS and IT governance

Effective IS governance allocates decision rights and establishes the accountability framework for IS decisions to ensure

alignment with strategic objectives. Green IS and IT governance can be defined as an operating model that describes the administration of Green IS and IT initiatives. Green IS and IT governance specifies the decision rights and accountability framework to encourage environmentally desirable behavior in the sourcing, use, and disposal of IT. To achieve this, roles, responsibilities, accountability, and control for Green IS and IT initiatives need to be clearly established (Schmidt and Kolbe 2011). Green IS and IT are typically isolated and compartmentalized to few domains of the IS department. The coordination of Green IS and IT is completed by extending job responsibilities (e.g., data center, sustainability department). The CIO may have primary authority over these activities.

Centralization and decentralization of IT activities and governance design are issues that can be investigated. For example, centralization is coordinated by a designated Green IS and IT manager. Decentralization is coordinated by a designated Green IS and IT committee throughout the various business units of the company. The most effective governance design in this particular situation could be investigated. Additional dimensions of governance may include how employees are incentivized for Green IS and IT management; the integration of environmental policies into CIO and IS management practice is another dimensions that could be investigated. How IS and IT governance practices relate to greening organizations overall requires investigating organizational behavior aspects of greening IS and IT. Environmental policy development and management is an especially important part of governance issues. For example, ISO 14000 certification requires an effective policy perspective. Investigating how green IS and IT policy are integrated into the ISO 14000 process can be a direction of investigation.

2.6 Green IS and IT evaluation and the balanced scorecard

The many dimensions of green IS and IT management require that control and performance evaluation systems needs to be carefully designed. One popular approach is the Balanced Scorecard (BSC), which is a strategic management framework for aligning business objectives with the vision of an organization (Kaplan and Norton 1992). The BSC has been widely used in both the IS and sustainability area. The IS department can translate the BSC for more specific evaluation of the IS function. The BSC approach has also been applied to sustainability in order to ascertain that environmental concerns are integrated into corporate strategies and performance measures, (Figge et al. 2002). The integrative approach considers BSC as an effective tool to balance environmental and social management systems with business economic performance thus addressing the three pillars of sustainability – planet,

people, and profit (Molla et al. 2009b). A Green IT Balanced Scorecard can aid in alignment of technologies and business with the natural environment in order to measure the performance of IT with environmental aspects (as part of performance evaluation and governance, as well). In a Green IT BSC, the four original perspectives can be reinterpreted as financial perspective, stakeholder orientation, future orientation, and process orientation (Wati and Koo 2011).

The investigation of these types of strategic, financial, and accounting management tools and how they can be developed for green IS and IT practice is an important area for investigation. Linking these measures to inter-organizational (value chain) and multiple stakeholders are important dimensions of green IS and IT research directions.

2.7 Green IS and IT value and investment

Similar to green growth at national policy levels seeking win-win opportunities, researchers and practitioners in organizations have an opportunity to tackle environmental issues while improving their productivity, reducing costs, and enhancing benefits. However, this organizational level win-win goal is not an easy task. The lack of environmental skills, knowledge, and consciousness has resulted in many forms of waste, unused resources, energy inefficiency, and pollution from IT operations (Watson et al. 2010). One dimension of how the greening of IS and IT can add business value is by limiting these costs and inefficiencies. Additional business value adding dimensions include revenue generation, risk mitigation, business continuity, and image and reputational benefits (Sarkis 2012).

Examples of these value adding characteristics abound. Cost reduction from environmental efficiencies can be accrued through energy savings and dematerialization. Organizations may realize extra revenue through Green IS and IT practices by developing new technologies and systems that can manage the environmental operations of organizations. To operate effectively and with little conflict with stakeholders, organizations need to develop their ‘license to operate.’ This objective is a risk mitigation concern focused on minimizing organizational risk that might be associated with business continuity and reputational management dimensions. Business continuity, for an IT manufacturer or user, may deal with issues ranging from energy requirements to rare (unsustainable) materials used in manufacture of IT products. Image and reputational issues for IT manufacturers or organizations whose products and services are used in environmentally distressful ways can cause them to have difficulties in attracting consumers and employees.

Many of the fundamental benefits of Green IS and IT occur at individual and organizational levels. Individually and organizationally, traditional IS success and IT value factors such as use, satisfaction, performance, and economic value associated with Green IS and IT investment (Scott and Watson 2012) may be found. These benefits may also be accrued when companies

integrate previously implemented environmental or social responsibility management systems with general management systems of organizations (Simon et al. 2012). Previously dispersed ‘islands of environmental excellence’ for IS have existed, integrating these systems can result in synergistic value. General greening strategies, routines, policy, and process characteristics can also extend beyond organizational boundaries across internal and external value chains can add complexity.

Given these benefits and costs it would be worthwhile for organizations to determine which outcomes are positive and how to manage their Green IS and IT initiatives. Green IS and IT can support systems, products, processes that use less energy, recycle and reuse materials, reduce waste, water, and pollution, preserve natural resources, and finally achieve environmental sustainability. Thereby, Green IS for environmental sustainability as IS-enabled organizational practices and processes can improve environmental and economic performance. Integrating IS with management control and financial systems, such as by evaluating performance (e.g., the Balanced Scorecard, (Wati and Koo 2011); and multidimensional supplier evaluation systems (Bai et al. 2012)) can be beneficial in evaluating green IS and IT value propositions. These efforts start to address the development and implementation of information systems that contribute to sustainable business processes (Watson et al. 2010).

In this business and sustainability integration environment, management and research questions still linger including “what should we do?” and “how do we do it?”, among the first questions organizations need to ask.

3 Green IS and IT research: A social science or a solution science?

Much of the academic work schools of business and management of IS, especially in the most influential journals in this field, focuses greatly on a social sciences and theory based approaches to addressing issues. The question remains on whether Green IS and IT should also be focused only on traditional IS research paradigm of social science research. Green IS and IT research, to be effective in the short and long-term, will need to break the mold to stimulate solution-based research.

In our observation, the problem is that we need research that can take giant steps towards solving global warming, climate change, and other pervasive environmental issues. It is not clear where and when this research will occur. Incremental, baby steps can then fill in the gaps created by the giant steps. Unfortunately, for IS and IT research, and maybe academic work (serious, robust, theoretical) in general, it is very difficult to take these giant steps.

We, as IS researchers, need to take this opportunity to play a major role in solving the problems faced by this and future generations. IS researchers need to partner with and utilize IS practitioner knowledge, which will play a major role similar to the productivity improvement work associated with the past five decades of IS and IT research.

We know that IS and IT serves a purpose, but questions remain. Will research or practice in IS and IT have enough impact to change human behavior and general organizational/economic practice to truly influence global warming? There is skepticism in our community, and even amongst ourselves that incremental influence and research is the best we can do or expedite solving some of society’s most pressing environmental concerns.

IS research may have ‘missed the boat’ when it decided to become a social science rather than a solution science and settled on incremental influence. A clarion call is needed for solutions to solve this critical and ‘wicked’ problem of human influences on natural systems. Given the crises that are being faced, a practical question for our IS and IT community is whether theory can come after we focus on solving the problem, assuming we can.

In our field’s brief history, much of the early work in IT (first) and IS (second) on environmental issues was in the technology driven area of study, for example with IEEE and its symposia in the 1990s. Engineers and industry practitioners mostly drove this research. The core IS academic journals, until recently, have not focused on environmental sustainability. Can we join with industry researchers and practitioners to be able to focus on solutions? How do we convince ourselves, and even this journal, and this special issue that solution sciences are what is needed? Is theory and academic publication enough, working with engineers and applied IS researchers, and practitioners is needed. The lead time for academia and academic journals may be too long to influence practice, especially when a problem such as globally warming needs urgent attention.

There is a question on whether IS academics and researchers care enough and need to be missionary in our push to get IS scholars and the IS community involved in solving the most important problem of our time. A basic question is whether academic researchers should be cold and critical, or caring, compassionate and driven to find solutions. This concern is not only true for our discipline, but all academic disciplines.

We are unsure if what we provide here are giant steps or baby steps. Whether the work is traditional or solutions based. We will leave that up to the reader. The papers did undergo significant and rigorous review, as any journal would require. If the reader finds an article that can influence their organization, family member, friends, or community to rethink their behavior or adopt a certain practice, then share this information. If this research sparks the reader’s interest, become

involved, do your own research, develop insights and spread the message, it is too important not to be heard by our research community and its stakeholders.

4 Summary of the special issue

We now review and provide an outline of this special issue, which we saw as a way to incorporate global issues into the debate and research. International efforts, inter-organizational concerns, and the environment as a global entity are all underlying reasons for this focus. We also sought to expand and incorporate various research methodologies including theoretical approaches (conceptual or theory building), empirical studies encompassing broad-based surveys, case studies, technical research modeling, quantitative and analytical techniques. Linking this work with engineering, economics, and social sciences was an initial goal. We received dozens of papers for consideration and after a rigorous review process ended up with an important policy paper focusing on one of man's greatest environmental challenges, global climate change, and eight quality papers on Green IS and IT research.

Our special issue opening paper, "Climate Change Challenges for the US and the World", as mentioned earlier in this editorial, is from Dr. Rajendra Kumar Pachauri (2013). This paper sets the stage by providing significant environmental and social information related to global climate change. There are many choice points available to America and the world that are identified in this article. Although quite general from a policy and socio-cultural perspective, the roles of technology and information is not far from the surface of the basic tenets of this paper. In fact, it is information systems and technology that will be needed as vehicles to help us address these issues. The data and information presented in this paper ranges from centuries, to days and years. Also, it is clear that environmental, economic, and social information are needed to manage such a complex issue. This information needs to be acquired, developed, and managed at multiple levels. Although many of the research papers in this special issue focus on carbon emissions, energy, and other environmental information exemplified in this first paper by Pachauri, one of the most vital points made in this paper is that information and technology should not replace action, but support thoughtful action. Most cogently, we should not wait for catastrophic failures to occur, but use information and technology act before systemic catastrophes occur.

The second paper, "Identifying IT sustainability performance drivers: Instrument validation and development" by Molla (2013), sets the foundation for environmentally sustainable IT performance (eSITP). This paper provides a good idea of the current exploratory nature of much work in the Green IS and IT field. That is, we are at the stage of developing theory, instrumentation, and scales to help understand the field, but

also to guide future research. They identify drivers and outcomes nomologically and test their research model using an empirical survey of 133 IT firms. The model relies on various environmental forces, some of which are unique to IS and IT and institutional forces that cause adoption of various practices within an organization. The four green internal practices that are managed by their eSITP performance measures include eco-learning, eco-process, eco-brand, and eco-value governance. These are all important organizational strategies and routines (leading indicators), which result in various ecological and economic outcomes. Using rigorous statistical methodologies they confirm the validity of their constructs and relationships. Of course, these are initial steps in understanding how performance and control measures for Green IS and IT should be developed, but it is an important step for eventual business case and organizational development of green systems.

Having a framework for theoretical and academic development from a performance monitoring perspective, as in the second paper, can be enhanced with practical architectures for environmental performance monitoring, as in evident in this special issue's third paper, "Towards a Reference Architecture for Fuel-based Carbon Management Systems in the Logistics Industry" by Iacob et al. (2013). The authors provide a creative model to help gather and monitor information about the carbon footprints of transportation and logistics activities. The architecture design is meant to collect and evaluate both real time and aggregate information for energy consumption via computers installed in vehicles, which forms the core of the system. It is meant to be integrated with larger logistics information and management systems. They tested their model using real-time data and validated and implemented the architecture through a prototype. This paper represents an initial and exemplary information and decision support carbon management system. The linkage to broader carbon management systems for data gathering, validation, monitoring, and eventual improvement is a necessary operational step for the many corporate, national, and international carbon emissions goals that have been and will be emerging over the past and future decades.

In trying to further understand how gathering and using information for environmental sustainability, the fourth paper, "Using information systems to improve energy efficiency: Investigating the relationship between smart metering and electricity demand management" by Corbett (2013), investigates improvement of energy usage. Corbett (2013), integrates advance information systems (e.g., energy informatics) using historical data from 500 U.S. electricity generating utility companies. This fourth paper in our special issue sequence exemplifies a third research method to help investigate Green IS issues. Where the second paper utilized primary data collection in a broad-based survey and the third paper used a specific case study, this paper is able to investigate theoretical

hypotheses using secondary, and publicly available, data. The results were also significant showing that IS-enabled information processing capacities of smart meters are positively associated with energy efficiency improvement. That is, this paper integrates both the information technology and information itself as important resources for managing organizational and community sustainability.

In our special issue we travel from a large country (the U.S.) and big companies (electrical utility companies) in the previous paper to a small country (New Zealand) and small manufacturing companies. Using primary data from a multi-case study evaluation, this paper by Coffey et al. (2013) titled “Small business in a small country: attitudes to “Green” IT,” investigates motivators and barriers to green IT practices by small and medium companies. Similar to the second paper of this special issue by Molla (2013), various organizational greening practices are investigated, but this investigation is from a more qualitative perspective. Actual practices and inputs from various managers are analyzed on nine dimensions including internal and external forces influencing Green IS and IT management. They show that these small firms, which is as also possibly true for large firms, are still at the early stages requiring education and awareness raising on green issues, including green IT, to occur before substantial and more mature practices such as environmental reporting can be implemented, which is ranked as the lowest priority item. This paper provides additional evidence that substantial development and understanding of Green IT is needed.

Gräuler et al. (2013), building on the issue of sustainability reporting, which is not a high priority item for the small companies in the previous paper, describe a forward thinking investigation. Their paper, “Understanding the beliefs, actions and outcomes of sustainability reporting: An experimental approach” investigates online sustainability reporting, which can be a common instrument for corporate sustainability communication. The authors propose a model based on the theory of belief-action-outcome and investigate empirically ‘before reading’, ‘during reading’, and ‘after reading’ the online sustainable reports through three phases. The results indicate that sophisticated sustainable reports that satisfy the reader’s expectations have a significant influence on corporate image and the readers’ actions (i.e., buying and recommending products). Thus, reputational effects can be managed through well-designed information and electronic communications. Gathering the information for these reports and disseminating it are critical organizational IS processes that require the joint efforts of a number of departments within organizations. The interesting experimental methodology in this paper exemplifies the multiple methodological approaches that will be necessary to make sense of Green IS and IT and its influence internally and externally.

“Green practices-IS alignment and environmental performance: The mediating effects of coordination” by Ryoo and

Koo (2013), again revisits the practices and performance relationship that was introduced in portions of Molla’s (2013) paper in this special issue. This paper investigates the effects of green practices and IS alignment toward environmental performance and the mediation effects of green practices of manufacturing and marketing coordination. Thus, it starts to evaluate the coordination efforts of different disciplines, considering the more holistic, systemic concerns that most organizations need to face with greening and sustainability. Coordination theory plays an important internal role especially as it is applied to the manufacturing context. Their findings show that the green practices-IS alignment has an indirect effect on environmental performance via both green practices-manufacturing and marketing coordination. These mediations show that the green IS relationship is organizationally and managerially complex. An additional mediation between environmental and economic performance further exemplifies the complexities in valuations and benefits of such practices. Unlike Molla (2013), the performance relationships are not separate, but closely interrelated, further supporting the theory that doing good (through greening and environmental performance) means doing well financially. There is strong support in this paper for the ecological modernization theory (Zhu et al. 2012; Sarkis and Cordeiro 2012) argument that technological practices can result in organizational ‘win-win’ occurrences. These types of findings will only further support making the ‘business case’ for organizations who wish to green their IS and IT practices in a systemic broad intra-organizational perspective.

The final two papers of this special issue build on the notion of investing and making the business case (justification) for green IS and IT. The first of these two papers titled “Investment in Information Systems: A contribution towards sustainability” by Hertel and Wiesent (2013), focuses on the financial risk and uncertainty aspects of investing in Green IS and IT to help in organizational energy efficiency. Energy efficiency, as mentioned in the papers by Jacob et al. (2013) and Corbett (2013), is critical to reducing carbon emissions and resource depletion. In this paper by Hertel and Wiesent (2013), an optimization model utilizing net present value approaches will be attractive to financial decision makers who would be comfortable with the quantitative rigor for this analysis. The authors develop this model to determine the optimal degree of investment when integrating a risk and return decision calculus. The results demonstrated IS investments in energy efficiency, which can reduce a company’s dependence on uncertain energy prices minimizing (hedging) the risk of price fluctuations in the energy market.

The final paper builds on the investment from more than just risk and return, but starts to incorporate more strategic factors, and thus the title of the paper by Bai and Sarkis (2013), “Green information technology strategic justification and evaluation.” Although focusing on the development and application of a quantitative formal modeling approach, Bai

and Sarkis (2013) focus on many of the intangible and less direct benefits associated with green IS and IT investments. Using ecological modernization theory as the major driver for their ‘win-win’ argument they utilize fuzzy and multiple criteria approaches to arrive at their decision. Although the technique can help rank various green IS and IT decisions, they do not necessarily argue that there is always an optimal answer, and the outcome is heavily dependent on various fuzzy and perceptual valuations as well, which is what most strategic justifications and making the business case requires.

As can be seen in many of the articles in this special issue, there is a focus on how to convince organizations to adopt various practices. It may be a sign of where the research and practices are at this time, given that significantly more work is needed before green IS and IT starts to make a difference. We trust that these papers contribute to a foundation that requires many giant steps to address the world’s environmental issues. We aren’t blinded to the fact that we are still completing only incremental work at this time, but building the foundation is necessary so giant leaps can be made. We feel that these papers contribute to our knowledge and understanding of the theory and the practice. We also believe that the readership will find insightful results and analysis from which they can build upon and practice.

5 Conclusion

We are happy to finally arrive at the completion of this special issue which has been in the works for many years, as an idea, then as a proposal, and then finally as a real product and service to the community. We are grateful to a broad variety of contributors and support. We would first like to thank and acknowledge the support from R. Ramesh and H. Raghav Rao, *Information Systems Frontiers*’ editors-in-chief. We are grateful to our team of reviewers and guest editorial board who provided excellent and constructive feedback on the submitted manuscripts. We also wish to thank the Springer staff who helped us with managing the review and publishing process. Finally we wish to thank the authors of these papers and those who submitted their research for consideration.

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