

Emergent Solutions for Global Climate Change: Lessons from Green IS Research

Catherine Dwyer
Pace University
cdwyer@pace.edu

Helen Hasan
University of Wollongong
hasan@uow.edu.au

Accepted for publication at: *The International Journal of Social and Organizational Dynamics in Information Technology*

Abstract

In the emerging field of Green IT/IS, a figure of 2% is often quoted as the percentage of environmentally harmful emissions attributed to the use of IT and the IT industry. The term ‘Green IT’ is now part of our vocabulary recognizing the problem of IT as a polluter and the responsibility of IT professionals to do something about it. On the other hand there is a counter argument that in IT and IS we have the potential and opportunity to positively influence the global environmental future – in other words, develop Green IS to reduce the other 98%. Historically, the value added by IS has been its ability to realign and reinvent business processes in support of productivity and efficiency. Given the urgent need for progress on Climate Change, we argue it is the duty of IS academics, researchers, and practitioners to reorient IS, and develop new IS practices that optimize processes in support of sustainable outcomes. This argument is supported by the proven ability of IS to transform business processes. In this paper we describe the Climate Change problem as an example of a ‘wicked problem,’ and argue that IS research has often demonstrated that imposed, top down solutions are ineffective for highly complex problems. In contrast, bottom up, emergent solutions have been shown to have more promise for creating real change. This paper reviews and reports Green IS research to

make a case for a multifaceted approach to the climate change problem, with the suggestion that the IS experience may inform global approaches to finding bottom-up, emergent solutions to climate change.

Keywords

Sustainability, Climate Change, Green IS, socio-technical systems

Introduction

Wicked or complex problems have ill-defined, shifting definitions and conflicting elements that belie solution although some resolution is possible through a holistic perspective (Rittel & Webber, 1973). IS research often frames complex problems in terms of interconnected economic, social, and technical components. This framing is largely based on sociotechnical systems theory.

Sociotechnical systems theory envisions large technological systems as complex, messy problem solving systems with ill-defined boundaries (Hughes, 1989). These systems contain technical elements, called artefacts, that contribute directly or through other components to a common system goal, and components, which are social structures that represent work-flow processes, as well as attitudes and habits in the use of technical artefacts. There is a double social component to these systems: technology artefacts are socially constructed, in that they are designed and built by people and organizations (Orlikowski, 1992). These systems also help shape social and organizational structures, by offering technological affordances that encourage certain actions, and constraints that discourage others (Markus & Silver, 2008).

An important understanding of IS through sociotechnical systems theory is that the role of technology is non-deterministic – in other words, there are no magic inputs, levers, or incentives that will guarantee a certain outcome (DeSanctis & Poole, 1994).

Relying upon sociotechnical understanding of systems, much IS research, such as the analysis of failed Enterprise Resource Management systems within distributed organizations, shows that complex, ‘wicked’ problems do not respond to simple levers and incentives applied via top-down solutions. On the other hand, bottom-up emergent processes, though less politically acceptable, have demonstrated a higher level of success.

As an example of a failed top down approach, consider the Copenhagen Summit on Climate Change, COP15. It is generally agreed that the summit fell short of expectations. At COP15, so many contradictory demands were apparent that it is doubtful whether it produced many useful outcomes.

While an accord was reached, it was reported that the “Copenhagen deal falters as just 20 countries of 192 sign up to declare their climate change strategies”¹. We therefore ask: is it possible to have a one-size fits all solution to a complex or wicked problem such as climate change, which has inherent contradictions?

As anticipated from previous efforts, the Copenhagen Accord focuses on targets and measures for Green-House Gas (GHG) emissions to keep global temperature increases below 2 degrees Celsius as recommended by the science. This approach implies schemes, audits, incentives, compliance, regulations etc that are difficult enough to implement at national levels let alone internationally. In this paper we refer to this as the top-down approach. The Accord does go on to emphasize the special needs of vulnerable island nations and least developed countries. Tackling climate change at the local we refer to as a bottom-up approach.

¹ <http://www.guardian.co.uk/environment/copenhagen>

The first paragraph of the Copenhagen Accord declares a “strong political will to combat climate change in accordance with the principle of common but differentiated responsibilities and respective capabilities”. This statement reveals the inherent contradiction between what can be done in common at the top global level and the different realities at the bottom local level. This paper aims to take a balanced view of how to deal with this and other contradictions inherent to climate change challenges. It should be noted that, while the authors represent two ‘western’ developed countries, there are different imperatives and contradiction both within and between these countries.

In this paper we articulate through examples why we believe that high-level global meetings and accords will inevitably fall short of expectation because of the inherent contradictions. We bring the IS experience of lessons learnt from many systems failures to demonstrate that top-down solutions, although desirable and useful, are rarely the most promising way to approach highly complex problems. In contrast, bottom-up emergent processes, while less politically acceptable, contain the potential for effective, lasting change. As evidence for this we will describe large scale, top-down Green IT research and contrast it with the bottom-up work of the authors and others. We use this to make a case for a multifaceted approach to the climate change problem in respect of our discipline of IS and suggest that this IS insight may inform all aspects of the climate change debate.

Background

Problem solving approaches can be described as top-down (ordered) v bottom-up (unordered – emergent). Wicked or complex problems are difficult to solve due to incomplete, contradictory, or changing requirements that are often overlooked or

misinterpreted. Moreover, because of complex interdependencies, the effort to solve one aspect of a wicked problem may reveal or create other problems. Wicked problems do not respond to top-down solutions. This is not unlike the record of failures of IS projects in large distributed organizations who try to implement enterprise systems. While certainly challenging and difficult, some resolution for wicked problems is possible through a holistic perspective (Rittel & Webber, 1973).

Here are some examples that illustrate the inherent contradictions that make up the climate change problem:

- The phenomenon known as “carbon leakage,” where a decline in emissions from a developed country leads to an increase in emissions from a country with weaker environmental standards. For example, while China is now the world’s largest producer of CO₂, this is in part due to the energy requirements of production of goods bound for US and European markets (Pan, Phillips, & Chen, 2008)
- The US Energy Independence and Security Act will require that incandescent bulbs be replaced by more efficient bulbs, such as Compact Florescent Lamps (CFLs). However, CFLs have mercury and cannot be safely disposed of through conventional waste disposal methods
- A transition in the US from gasoline to electric vehicles could **increase** CO₂ emissions, because half of US electricity is produced by coal
- The use of corn and other commodities as feedstock for biofuel reduces the amount of farmland available for food, broadly limiting the supply, and thus raising the cost of many food products

- Water, a scarce resource in itself, is essential to the production of energy, and energy is essential to the production of clean water (Jones, 2008).
- On March 31, 2010 President Obama announced an expansion of US offshore drilling, in part to entice legislative support for a US climate bill. Three weeks later an offshore drilling platform in the Gulf of Mexico exploded and began spewing millions of gallons of oil, damaging any public support for more offshore drilling, therefore making US climate legislation much less likely (Weisman, 2010).
- In Australia, the government's attempt to introduce a bill for an Energy Trading Scheme (ETS) through a hostile upper house has had to incorporate so many amendments to appease the coal industry that it is now probably too weak to be worth the effort.

Information systems success and failure have been much discussed in the IS literature for many years, and many authors have posited structural, cultural and social reasons for such failures (DeLone & McLean, 1992; Fortune & Peters, 2005; Lyytinen & Hirschheim, 1987; Sauer, 1993; Warne, 2002).

IS thus has credentials in this space, understanding the pitfalls of top-down design. It is interesting to note that the largest information system ever, the Internet, grew through an emergent process, and it is Global yet has a bundle of contradictions (security versus openness etc).

The Two Directions of Green IT and Green IS

Watson, Boudreau and Chen (2010) argue the IS community must take a new direction in support of sustainable development. Watson et al. call for "IS researchers,

educators, journal editors, and association leaders to demonstrate how the transformative power of IS can be leveraged to create an ecologically sustainable society,” (p. 23).

Watson et al. describe this direction as having two elements: ‘Green IT,’ and ‘Green IS.’ Green IT concerns itself with the environmental impact of the data center, and running technology in general. Applications of Green IT include reducing the energy consumption of data centers, reducing the impact of electronic waste, and adoption of technology use habits that minimize the ecological footprint of the IT business sector.

Watson et al. argue that focusing on the efficiency of the data center, while important, is too narrow a role for IS professionals. A more expansive approach is suggested, called ‘Green IS,’ which is the design and development of information systems in support of sustainable business processes. Green IS encourages the application of information systems thinking and skills to initiatives across all functions of the organization, from logistics, to waste management, to communicating consumption information to customers (Watson, et al., 2010).

The Green IT/IS literature is just emerging and taking two paths. The first path, related to support of Green IT, is traditionally top-down, survey-based that looks for common trends, relationships, and measures from a large homogenous cohort of respondents. This is useful for setting targets for energy use reductions, treatment of e-waste in organizations, industries etc and applies to mainstream Green IT with a limited agenda e.g. to reduce the Carbon Footprint of IT in specific area.

The second path is more bottom-up and situated - focused not only on reducing the impact of IT but on the ways information systems can be used to help everyone reduce their carbon footprint in a cost effective and socially acceptable manner. Green IS solutions depend on an “understanding of ecological problems as systemically interconnected and interdependent,” (Watson, et al., 2010, p. 25). Here is a brief summary of the research done following these two approaches.

Top-down research and what it contributes

Initial Green IT studies are empirical survey and interview research establishing basic entities in the field and relationships between them. This has been useful in scoping the area although limited to those entities prescribed by the researchers. Elliot (2007) identified competitive, legal and social responsibility dimensions of motivational elements influencing Green IT within organizations. Sayeed and Gill (2008) identified through a series of interviews by that the main reasons given for supporting Green IT were cost cutting and energy conservation. An empirical study by Kuo and Dick (2009) suggests that Green IT efforts are motivated by employees’ sense of social responsibility within organizations that have the capability to adapt rather than by issues of economics and technologies. Molla (2008) developed a Green IT Adoption Model that identifies economic, regulatory and ethical drivers of Green IT. Elliot and Binney’s work (2008) suggests the influence of government reporting, regulation and customer demand are potential drivers for Green IT and found that responsiveness to staff concerns and client requirements were also led to engagement with Green IT (Elliot & Binney, 2008). Molla, Pittayachawan, and Corbitt (2009) have produced comparative data on Green IT and organizational sustainability. They identified energy efficiency and cost cutting as the

primary consideration of US organizations, whereas organizations in Australia and New Zealand seem to be primarily motivated by environmental considerations.

Other studies concern the positive impact of Green IT on social, environmental and economic indicators in organizational systems (Caldille & Parmigiani, 2004; Velte, Velte, & Elsenpeter, 2008), in e-business (Yi & Thomas, 2007) and across the supply chain (Rao & Holt, 2005). A cross organizational consultancy study by Phillipson (2009) is developing a Green IT Readiness Index, a measure of the level of maturity of an organization's usage of Green IT in five key areas: End User Efficiencies, Enterprise IT Efficiencies, Lifecycle and Procurement, Measuring and Monitoring, and Enabling the Business. This draws on the concept of e-readiness indicators (Berthon, Leyland, & Berthon, 2008; A. Molla & Licker, 2005).

Bottom-up research exploring theoretical frameworks for Green IS

An emerging collection of IS research is using existing models in light of local experience to develop new frameworks applicable to Green IS studies. We view this as a bottom-up endeavor. Fernandez et al (2008) developed an innovative project management framework to support and coordinate a project to extract oil from green algae. Chen et al. (2008) have developed an insightful conceptual model that clarifies the roles of IS in the pursuit of ecological sustainability. They aim to show how, under different institutional pressures, IS can be leveraged to achieve eco-efficiency through automating, eco-equity through information flows and eco-effectiveness through organizational transformations. Daly and Butler (2009) take an IS perspective using Institutional Theory to derive theoretical propositions which specify the effect that

regulatory, normative and cultural-cognitive elements have in shaping environmental responsibility in organizations.

Bottom-up research exploring localized Green IT practice

Papers from the Workshop on Ubiquitous Sustainability (Hasbrouck, Igoe, Mankoff, & Woodruff, 2007) presented emerging practices through which technologies are able to align with environmental values. Many of the papers presented ways of designing innovative but often quite simple systems to influence behavior towards greener activities. These included ways to sense and display energy consumption and other carbon emitting events in the home (Brush, 2007; LeBlanc, 2007; Stringer, et al., 2007), at the office (Bray, 2007) and in the town (Hooker, 2007; Ljungblad, 2007). Greener actions and uses of technologies were shown to increase by providing information incorporated in stories (Oehlberg, Aipperspach, & Jeffery, 2007) and by playing games (Millecevic, 2007).

These bottom-up approaches contrast with top-down traditional empirical research, which looked to establish global entities and generalized relationships between them. This paradigm is similar to efforts towards global agreement on measures and targets determined from top-down processes such as COP15. The bottom-up research recognizes the complexity of the area and either moves to a more abstract level to create theory-based frameworks, or more practical localized IT based activities that influence individual or group behaviors.

Our proposition is that the top-down approach taken by the politicians in Copenhagen – the goal of simple, globally applicable solutions – is probably inherently impossible to achieve because of all the conflicting local demands. We also recognize

that a local bottom-up approach is a real challenge at the global level due to conflicting requirements – the issues of fairness, of assessing progress, of using carrots and sticks, maybe letting people set their own targets and programs as long as these are open, approved and monitored.

The case for a multifaceted approach to the problem of climate change

Progress requires solutions that embrace the contradictions of both top-down and bottom-up approaches. For example, the artist Michael Singer brilliantly engages the community bottom-up by applying design to top-down infrastructure for environmental projects. Singer’s designs turn waste processing and energy generation facilities into beautiful additions to a community (Singer, 2010). Figure 1 is a picture of a Solid Waste Transfer and Recycling Facility Singer designed for Phoenix, Arizona in 1993. It received national attention and won numerous design awards, transforming an “out of sight, out of mind” facility into an attractive part component of the city landscape. This innovative design for a waste facility created political capital that allowed Phoenix to develop other environmental projects in cooperation with, rather than in conflict with their citizens (Singer, Cruz, & Bregman, 2007).

[INSERT FIGURE 1 HERE]

One bottom-up contribution from Green IS can come from is the viral power of networked advocacy using social media tools, as demonstrated by the election of Barack Obama (Lutz, 2009), and the rapid solicitation of donations in response to the January 2010 earthquake in Haiti (Bunz, 2010).

Social media's power is being noted as an agent of political and social change. A survey indicated that 62% of Americans polled believe they can influence business decisions by voicing opinions via new media (Loechner, 2010). An example of social media's application for climate change advocacy is the use of Twitter to promote Earth Hour (<https://www.myearthhour.org/home>), a global orchestrated event where people turn off their lights for one hour. The Earth Hour event was #9 on the list of top news events for Twitter for 2009 (Chowdhury, 2010), (see Figure 2).

[INSERT FIGURE 2 HERE]

While bottom-up approaches are finding traction and influence among individuals and communities, we recognize that many parts of the sustainability puzzle also need to be addressed from the government or systems level perspective. As we have already discussed socio-technical systems are complex and if only parts of a system are assessed for their environmental impact, the system as a whole may not be environmentally responsible. One company may change its own processes to lower its environmental impact but may in doing so push that impact along the supply chain to its suppliers or customers. For example, a manufacturer may replace hardcopy manuals of its products with electronic ones only to find that customers then print these out, often in multiple copies. In Australia some local governments legislate against using hosed water for cleaning cars and hard surface only to find that people are using alternative chemical means or power-driven devices that are quite environmentally harmful.

Supporting sustainability requires a considerable recalibration of economic incentives at the systems level. Currently, the economics of energy reward decisions that

minimize lowest first cost rather than total life cycle costs of an investment. For example, while the initial cost of coal is dramatically less than solar energy, the full impacts of burning coal are quite substantial. Coal emits more CO₂ relative to its energy density than other fuels, and leaves behind mounds of toxic ash that pollutes ground water (Kosugi, et al., 2009). As long as coal's environmental damage is treated by energy markets as an economic externality, meaning something outside the expected costs for a transaction, then decisions will be made on the basis that fossil fuel is cheaper than renewable sources. This issue may be best tackled at national government levels by emissions trading schemes or carbon taxes.

The complexity of a life cycle cost analysis is certainly not something consumers can perform in their head as they make purchasing decisions or businesses determine with any certainty as they undertake forward planning measures. Despite attempts at calculations of carbon footprints or other measures, the "real" environmental cost of one choice over another is too complex to boil down to a single number and rarely are these related to economic costs either in the long or short term. In the end individuals and organizations make decisions on criteria that make sense to them.

The theory of bounded rationality (Simon, 1955) argues that the ability to make fully informed decisions is limited by both the knowledge and computational capacity of the person making the decision. Instead, research by social scientists suggest that when people face complex problems they apply heuristics, a particularly bottom-up process, that derive from culture and social norms (Carey & Burkell, 2009). This suggests that addressing culture and social norms will have the greatest impact on influencing people to take environmental impact into account when choosing products or consuming

energy. This implies that we need ways to understand and to influence behavior in complex socio-technical systems and to look for evidence of efforts that change attitudes and behaviors. We now report on two recent Green IS studies, one in Australia and one in the US, that provides some of this evidence.

Bottom-up Studies to Gather Perceptions and Attitudes: Eliciting the Perceptions of IS Professionals

Threats to the sustainability of the planet are the concern of everyone and meeting these threats is more than just doing the science, reducing waste and creating alternative sources of energies. Much of the progress may come from understanding the diverse needs, opinions and attitudes of people everywhere and having the leadership, political and public support to coordinate multiple solutions at global, national and local levels.

This study aims to increase the understanding of how IT and IS professionals perceive the confusing array of elements in the challenges posed by climate change and how they could use their particular skills and knowledge to be part of the solution. A Q-method study was used to gather and analyze the subjective views of a group of IS professionals on this question:

Which technologies, systems and applications offer the greatest opportunity in solving problems concerned with the environment?

Q-method is particularly suitable for the study of topics having complex ramifications that are not yet well understood. It can uncover the *range* of views, attitudes, opinions, understandings, and experiences on a specific topic of investigation, as opposed to most methods that offer one composite view (Brown, 1986). A Q-sample

of 20 to 50 participants has the ability to produce meaningful results i.e. provide an accurate picture of the range of views on a topic (McKeown & Thomas, 1988).

Although a comprehensive report of this study is not yet published, it is used here to illustrate the value of conducting such studies to draw out the human motivations that can be leveraged to find new solutions to complex problems and be more aware of how these will work in practice where green initiatives require public support. To conduct this study, we put together a multi-disciplinary reference group of 20 participants from among academic staff and graduate students at our university who were familiar with IS and/or ICT and concerned with green issues. The study is summarized as follows:

Phase 1: the Q-Concourse: A sets of statements, representing all possible views on the topic that the group could imagine, were elucidated through several meetings of the participants and through circulating the growing sets of statement by email. By this evolutionary process, duplicate statements were eliminated and the wording of some clarified. Examples of the 35 statements collected on the topic are shown in Table 1.

Phase 2. the Q-Sorts: The individuals who participated in the concourse, together with three other IS academic staff, were invited to do the sort making a total of 23 participants. Each participant was given a set of numbered cards containing all 35 statements and is asked to rank them all on the grid shown in Figure 3 as follows:

Rank these statements on the way you would prioritize these technologies, systems, initiatives, processes etc for implementation taking into account both their positive impact on the environment (reduction in

carbon foot-print etc) and their ease of implementation (cost, acceptance etc)
i.e. their position as “low hanging fruit”.

[INSERT FIGURE 3 HERE]

A factor analysis was performed using standard Q-method software on the set of 23 sorts. This gives Factors that are clusters of those participants who appear to hold similar views in their ranking of the statements, particularly the few statements ranked highest and lowest.

Here a 2-Factor solution emerged as follows:

Seven participants fell on Factor 1 which placed *Telecommuting* and *Teleconferencing* as top choices for technologies with positive impact on the environment and practicalities of implementation. Their lowest ranked choice was RFIDs and other embedded devices.

Factor 2 was a confounded Factor and so really consists of 2 Factors with opposing views. 5 participants fell on Factor 2a which gave the following statements high ranking: *systems for optimization of CO₂ emissions; long-term monitoring of climate to quantify the changes; long-term predictions of capturing carbon from atmosphere and storing it; optimization technologies for efficiencies of systems (transport etc); and global and regional climate modeling*. This group ranked the statement *visualization of information* the lowest. 1 person on Factor 2b (a mature aged undergraduate student) had the completely opposite ranking, i.e. their top choice was *visualization of information*.

In contrast to the Factors, Table 1 shows consensus statements that most participants ranked as a priority.

[INSERT TABLE 1 HERE]

This study shows that, even within a relatively small specialized group, there are contradictory but legitimate views on where our profession could begin our assault on the problem of climate change.

Eliciting the perceptions of US undergraduate students

This section describes a project to develop sustainability curriculum for US undergraduates. Since the US is the world's largest consumer of energy (Smil, 2006, p. 11), US consumers, when considered in aggregate, are one of the world's biggest sources of CO₂ emissions. Surveys of American attitudes towards the environment reveal a great deal of ambivalence. While a survey by ecoAmerica shows 77% of Americans worry about the environment a great amount (Guns, 2006), there is much less alarm about climate change, with just 26% expressing concern for this issue in an October 2009 survey (Jones, 2009). US energy use is roughly 40% higher than prosperous EU countries. If US consumers adopted energy use patterns more in line with EU habits, this would reduce carbon emissions by at least 2.5 GT of CO₂ per year.

What methods can be employed to reduce US energy consumption? One insight may come from research efforts, primarily by health professionals, to identify factors that influence positive change away from self-destructive behavior such as smoking cigarettes or drug use. Clinical psychologists and other health professionals have found that if individuals express ambivalent attitudes towards self-destructive behavior, its consequences, or steps needed to alter that behavior, this ambivalence will acts as a

powerful impediment to change (Miller & Rollnick, 2002). While people whose behavior can damage their health often agree that change is important, they show substantial resistance when called upon to modify their lifestyle. An important finding is that, paradoxically, exposure to increasingly negative consequences can prevent change by immobilizing the person, or even make the behavior worse (Miller & Rollnick, 2002, p. 17). Instead, “constructive behavior change seems to arise when the person connects it with something of intrinsic value, something important, something cherished,” (Miller & Rollnick, 2002, p. 12).

While it may seem outrageous to compare people not committed to recycling, or the environment with those who are addicted to drugs, the underlying role issues of ambivalence and obstacles to change are quite similar. The pivotal role of ambivalence with respect to sustainability was the main finding of a three year Green IS project to develop sustainability curriculum materials for US undergraduates. Developing techniques to combat ambivalence, and avoiding anxiety provoking methods when discussing climate change were found to be the most effective way to encourage progress in sustainable behavior.

These materials were included as coursework for an Introduction to Computing class, taught in seven sections over a three year span by the same instructor. Students completed a pre- and post-course survey regarding their sustainability attitudes and behaviors, with measures adapted from the New Environmental Paradigm (NEP), (Dunlap, Liere, Mertig, & Jones, 2000), and Environmentally Responsible Behavior (ERB), (Smith-Sebasto & D'Costa, 1995). Table 2 displays the distribution of students who participated in the study. Three sections of the course were taught in Fall 2008, two

sections were taught in Fall 2009, and two sections were taught in Spring 2010. A total of 166 students took the pre-course survey, and 139 students took the post-course survey.

[INSERT TABLE 2 HERE]

The curriculum material introduces sustainability issues with three modules. The first module consists of Excel exercises using data from the US Department of Energy (EIA, 2009). The second module contains sustainability reading assignments and online discussion. The third module is a group project developing a Web site focused on a sustainability topic, such as solar power, wind power, electric vehicles, 'green' construction, and how colleges can go green.

The instructor found that sustainability attitudes moved along a continuum from denial, to ambivalence, to agency and self-efficacy. Early in the project it became clear that emotional or distressing content about climate change blocked engagement with the complexities of sustainability. More effective outcomes came when positive benefits of sustainable behavior were emphasized, such as lower expenses, simpler lifestyle choices, and opportunities for careers in 'green' jobs.

Measures from the NEP were used to capture three clusters of attitudes towards sustainability, that we label here as “**Denial**,” “**Anxiety/Ambivalence**,” and “**Agency/Self-Efficacy**.” Each measure is a seven point semantic differential scale, from 1 (Strongly Disagree) to 7 (Strongly Agree). The measures for these attitudes are as follows:

- **Denial:** “The so-called ecological crisis facing humankind has been greatly exaggerated.”

- **Anxiety/Ambivalence:** “When humans interfere with nature it often produces disastrous consequences.”
- **Agency/Self-Efficacy:** “We must take stronger measures to conserve our nation’s resources.”

Pre-course results show the Denial cluster was the most influential attitude (see Tables 3 and 4). It significantly correlated with 11 out of 14 measures, influencing actions *against* environmentally responsible behavior. The Anxiety/Ambivalence cluster was the less *t* influential in the pre-course surveys, significantly correlating with only seven out of 14 measures. Despite a relatively high mean of 4.964, it was weakly predictive of environmentally responsible behavior. Just like the negative effect of anxiety on the ability of people to change their smoking habits, in pre-course results anxiety about the environment did not result in strong support for sustainability. The Agency/Self-Efficacy cluster was more influential in the pre-course survey with respect to supporting pro-environmental behavior. It had the highest mean for all three measures, with a value of 5.762. It significantly correlated with seven out of 14 measures.

[INSERT TABLE 3 HERE]

Post-course results show an increase in the positive influence of both the Anxiety/Ambivalence and the Agency/Self-Efficacy clusters, and a sharp decrease in the negative influence of the Denial cluster (from 11 down to 4). The Anxiety/Ambivalence cluster significantly correlates with nine measures, up from seven in the pre-course survey. The Agency/Self-Efficacy cluster has nine significant correlations in the post-course survey, up from seven in the pre-course survey.

These results illustrate that motivating people for change is a complex process, with outcomes that seem counter-intuitive. For example, students reporting high levels of anxiety about sustainability were rather tepid about recycling, with only 22% reporting they always recycle. Here we see anxiety blocking engagement with sustainable lifestyle changes. The negative effect of anxiety has to become more widely recognized and countered, because the media portrays climate change as a version of the apocalypse. Discussions with disaster themes interfere with encouraging pro-sustainable behaviors. In contrast, our work found that curriculum materials that focused on the pragmatic necessity and benefits derived from sustainability had a more positive impact on promoting pro-environmental behavior.

[INSERT TABLE 4 HERE]

Summary and Conclusion

This paper has presented evidence from the emerging Green IS literature that a top-down approach, though of some value, is limited when faced with a complex issue such as climate change where so many contradictory demands are apparent. We argue that the IS experience in studying the intrinsic contradictions within socio-technical systems provides a valuable mechanism for revealing the interconnected nature of the Climate Change problem. In this paper, we focused on two examples of bottom-up solutions to addressing climate change. This approach recognizes the complexity of the problem, and favors practical localized activities that recognize and influence individual or group behaviors allowing the emergence of solutions appropriate to the local context. Like many failed IS projects, the decision making at the 2009 Copenhagen Summit on Climate Change appeared to be predominantly top-down with a desire for globally acceptable objectives, targets and measures. The Copenhagen Accord does hints at

broader approaches, in one of its decisions to “pursue various approaches, including opportunities to use markets, to enhance the cost effectiveness of, and to promote mitigation actions”.

The two main studies described in this paper demonstrate how people can have legitimate but conflicting attitudes and views on how to combat climate change and what may be the relationship between these attitudes and actual behaviors. This is important both in the way individuals act in regard to their own impacts on the environment and in their collective influence through advocacy on government decision.

In this paper we question whether Global Summits with too much focus on uniform agreement are inherently doomed to fall short of expectations. We propose that Green IS research should make a case for a multifaceted approach to the climate change problem, including bottom-up solutions through our domains of IT and IS particularly through the use of social media. This may not lead to one uniform solution but rather suggest we do make a useful contribution through research into some of the assumptions on relationships between attitudes, behaviors and outcomes.

References

- Berthon, P., Leyland, P., & Berthon, J. P. (2008). E-Relationships for e-Readiness: Trust & Cultural Values in International eB2B. *Industrial Marketing Management*, 37, 83-91.
- Bray, R. (2007). *Informative Smart Green Office Buildings*. Paper presented at the Workshop in conjunction with the Ninth International Conference on Ubiquitous Computing (UbiComp 2007), Innsbruck, Austria.
- Brown, S. R. (1986). Q technique and method: Principles and procedures. In W. D. Berry & M. S. Lewis-Beck (Eds.), *New tools for social scientists: Advances and applications in research methods* (pp. 57-76). Beverly Hills, CA: Sage.
- Brush, A. J. B. (2007). *Did you leave the Calendar on?: Exploring trade-offs between availability and consumption in the home*. Paper presented at the Ninth International Conference on Ubiquitous Computing (UbiComp 2007), Innsbruck, Austria.
- Bunz, M. (2010). In Haiti earthquake coverage, social media gives victim a voice. *guardian.co.uk*. Retrieved from <http://www.guardian.co.uk/media/pda/2010/jan/14/socialnetworking-haiti>
- Caldille, A., & Parmigiani, M. (2004). Management Information System - tool for corporate sustainability. *Journal of Business Ethics*, 55(2), 159-171.
- Carey, R., & Burkell, J. (2009). A Heuristics Approach to Understanding Privacy-protecting Behaviors in Digital Social Environments. In I. Kerr, V. Steeves & C. Lucock (Eds.), *Lessons From the Identity Trail*. New York: Oxford University Press.

- Chen, A. J. W., Boudreau, M. C., & Watson, R. T. (2008). Information systems and ecological sustainability. *Journal of Systems and Information Technology*, 10(3), 186-201.
- Chowdhury, A. (2010). Top Twitter Trends of 2009 Retrieved February 6, 2010, from <http://blog.twitter.com/2009/12/top-twitter-trends-of-2009.html>
- Daly, M., & Butler, T. (2009). *Environmental Sustainability and Green IT: An Institutional Perspective*. Paper presented at the European Conference on Information Systems (ECIS2009), Verona, Italy.
- DeLone, W. H., & McLean, E. R. (1992). Information Systems Success: The Quest for the Dependent Variable. *Information Systems Research*, 3(1).
- DeSanctis, G., & Poole, M. S. (1994). Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory. *Organization Science*, 5(2), 121-147.
- Dunlap, R., Liere, K. V., Mertig, A., & Jones, R. E. (2000). Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. *Journal of Social Issues*, 56(3), 425-442.
- EIA. (2009, November 30). The Energy Information Administration Retrieved December 3, 2009, from <http://www.eia.doe.gov/>
- Elliot, S. (2007). *Environmentally Sustainable ICT: A Critical Topic for IS Research?* Paper presented at the Pacific Asia Conference on Information Systems (PACIS 2007), Auckland, New Zealand.
- Elliot, S., & Binney, D. (2008). *Environmentally Sustainable ICT: Developing Corporate Capabilities and an Industry-Relevant IS Research Agenda*. Paper presented at the Pacific Asia Conference on Information Systems (PACIS 2008), Suzhou, People's Republic of China.
- Fernandez, W., Bergvall-Kareborn, B., Djordjevic, M., Lovegrove, K., Fernandez, V. J., & Talent, M. (2008). *How IS Design can Contribute to Major Climate Mitigation Projects*. Paper presented at the Information Systems Foundations Conference (ISF 2008), Canberra, Australia.
- Fortune, J., & Peters, G. (2005). *Information systems: achieving success by avoiding failure*. Chichester, UK: Wiley.
- Guns, B. (2006). The American Environmental Values Survey, February 6, 2010, from http://ecoamerica.typepad.com/blog/files/ecoAmerica_AEVS_Report.pdf
- Hasbrouck, J., Igoe, T., Mankoff, J., & Woodruff, A. (2007). *Ubiquitous Sustainability: Technologies for Green Value*. Paper presented at the Ninth International Conference on Ubiquitous Computing (UbiComp 2007) Innsbruck, Austria.
- Hooker, B., Gave, W., Steed, A., Bowers, J. (2007). *The Pollution e-Sign*. Paper presented at the Workshop in conjunction with Ninth International Conference on Ubiquitous Computing (UbiComp 2007) Innsbruck, Austria.
- Hughes, T. (1989). The Evolution of Large Technological Systems. In W. Bijker, T. Hughes & T. Pinch (Eds.), *The Social Construction of Technological Systems* (pp. 51-87). Cambridge, MA: The MIT Press.
- Jones, M. (2009). World concerns about climate change dwindle: survey. *Reuters*, (December 6). Retrieved from <http://www.reuters.com/article/idUSTRE5B50FS20091206>
- Jones, W. D. (2008). How Much Water Does It Take to Make Electricity? *IEEE Spectrum*, (April). Retrieved from <http://spectrum.ieee.org/energy/environment/how-much-water-does-it-take-to-make-electricity>
- Kosugi, T., Tokimatsu, K., Kurosawa, A., Itsubo, N., Yagita, H., & Sakagami, M. (2009). Internalization of the external costs of global environmental damage in an integrated assessment model *Energy Policy*, 37(7), 2664-2678.
- Kuo, B., & Dick, G. (2009). The greening of organisational IT: what makes a difference? *Australasian Journal of Information Systems*, 16(2).
- LeBlanc, J. (2007). *Device-level Power consumption Monitoring*. Paper presented at the Workshop in conjunction with the Ninth International Conference on Ubiquitous Computing (UbiComp 2007), Innsbruck, Austria.
- Ljungblad, S. (2007). *Everyday Visualization to Support a Sustainable Development*. Paper presented at the Workshop in conjunction with the Ninth International Conference on Ubiquitous Computing (UbiComp 2007) Innsbruck, Austria.
- Loechner, J. (2010). American Consumers Want A Dialog With Business. *Research Brief From the Center for Media Research* Retrieved February 6, 2010, from http://www.mediapost.com/publications/?fa=Articles.showArticle&art_aid=120756
- Lutz, M. (2009). The Social Pulpit: Barack Obama's Social Media Toolkit. *Edelman Insights* Retrieved February 6, 2010, from <http://www.edelman.com/image/insights/content/social%20pulpit%20-%20barack%20obamas%20social%20media%20toolkit%201.09.pdf>
- Lyytinen, K., & Hirschheim, R. (1987). Information Systems Failures - A Survey and Classification of the Empirical Literature. *Oxford Surveys in Information Technology*, 4, 257-309.

- Markus, M. L., & Silver, M. S. (2008). A Foundation for the Study of IT Effects: A New Look at DeSanctis and Poole's Concepts of Structural Features and Spirit. *Journal of the Association for Information Systems*, 9(10).
- McKeown, B., & Thomas, D. (1988). *Q methodology: Quantitative applications in the social sciences*. Beverly Hills, CA: Sage Publications.
- Millecevic, M. (2007). *Imaginary To Dos: Three initiatives for personal environmental explorations*. Paper presented at the Workshop in conjunction with the Ninth International Conference on Ubiquitous Computing (UbiComp 2007) Innsbruck, Austria.
- Miller, W. R., & Rollnick, S. (2002). *Motivational Interviewing: Preparing People for Change* (Second ed.). New York: The Guilford Press.
- Molla, A. (2008). *GITAM: A Model for the Adoption of Green IT*. Paper presented at the Australasian Conference on Information Systems (ACIS 2008), Christchurch, New Zealand.
- Molla, A., & Licker, P. (2005). Perceived e-readiness factors in e-commerce adoption and empirical investigation in a developing country. *International Journal of Electronic Commerce*, 10(1), 83-110.
- Molla, A., Pittayachawan, S., Corbitt, B. (2009). Green IT Diffusion: An International Comparison. *Green IT Working Paper Series*, from <http://greenit.bf.rmit.edu.au/>
- Oehlberg, L., Aipperspach, R., & Jeffery, S. (2007). *Sustainability through Meaning; providing information to promote meaningful products*. Paper presented at the Workshop in conjunction with the Ninth International Conference on Ubiquitous Computing (UbiComp 2007) Innsbruck, Austria.
- Orlikowski, W. (1992). The Duality of Technology: Rethinking the concept of Technology in Organizations. *Organization Science*, 3(3), 398-427.
- Pan, J., Phillips, J., & Chen, Y. (2008). China's balance of emissions embodied in trade: approaches to measurement and allocating international responsibility. *Oxford Review of Economic Policy*, 24(2), 354-376.
- Phillipson, G. (2009). Green IT in Australia. Retrieved from <http://www.connectionresearch.com.au/greenitresearch.htm>
- Rao, O., & Holt, D. (2005). So Green Supply Chains lead to competitiveness and economic performance. *International Journal of Operations and Production Management*, 14(9), 898-916.
- Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4(2), 155-169.
- Sauer, C. (1993). *Why Information Systems Fail: A Case Study Approach*: Alfred Waller.
- Sayed, L., & Gill, S. (2008). *An Exploratory Study on Environmental Sustainability and IT Use*. Paper presented at the America's Conference on Information Systems (AMCIS 2008), San Francisco, CA.
- Simon, H. (1955). A Behavioral Model of Rational Choice. *The Quarterly Journal of Economics*, LXII, 99-118.
- Singer, M. (2010). Michael Singer - Artist Retrieved February 6, 2010, from <http://www.michaelsinger.com/>
- Singer, M., Cruz, R. J., & Bregman, J. (2007). Infrastructure and Community: How Can We Live With What Sustains Us? Retrieved February 6, 2010, from http://www.edf.org/documents/7182_Infrastructure_and_Community.pdf
- Smil, V. (2006). Energy at the Crossroads. *OECD Global Science Forum*. Retrieved from <http://www.oecd.org/dataoecd/52/25/36760950.pdf>
- Smith-Sebasto, N. J., & D'Costa, A. (1995). Designing a Likert-Type Scale to Predict Environmentally Responsible Behavior in Undergraduate Students: A Multistep Process. *Journal of Environmental Education*, 27(1), 14-20.
- Stringer, M., Fitzpatrick, G., Chalmers, D., Harris, E., Krishna, R., & Haarlander, M. (2007). *Kuckuck: Exploring ways of Sensing and Displaying Energy Consumption levels in the home*. Paper presented at the Workshop in conjunction with the Ninth International Conference on Ubiquitous Computing (UbiComp 2007) Innsbruck, Austria.
- Velte, T., Velte, A., & Elsenpeter, R. (2008). *Green IT: reduce your information system's environmental impact while adding to the bottom line* New York: McGraw Hill.
- Warne, L. (2002). Conflict and Politics and Information Systems Failure: A Challenge for Information Systems Professionals and Researchers. In S. Clarke (Ed.), *Socio-Technical and Human Cognition Elements of Information Systems*. Hershey, PA: Idea Group.
- Watson, R. T., Boudreau, M.-C., & Chen, A. J. (2010). Information Systems and Environmentally Sustainable Development: Energy Informatics and New Directions for the IS Community. *MIS Quarterly*, 34(1), 23-38.
- Weisman, J. (2010). Disaster Dims Odds of Energy Bill Compromise *The Wall Street Journal*, (May 5). Retrieved from <http://online.wsj.com/article/SB10001424052748704866204575224582701608508.html>

Yi, L., & Thomas, H. R. (2007). A review of research on the environmental impact of e-business and ICT.
Environment International, 33(6), 841-849.