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Information Systems Solutions for Environmental Sustainability: How Can We Do More?

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Abstract:

We contend that too few information systems (IS) academics engage in impactful research that offers solutions to global warming despite the fact that climate change is one of the most critical challenges facing this generation. Climate change is a major threat to global sustainability in the 21st century. Unfortunately, from submissions of our call for papers presenting IS solutions for environmental sustainability, we found only one paper worthy of publication. Given that IS have been the major force for productivity increases in the last half-century, we suggest that IS scholars should immerse themselves in creating solutions for environmental problems. Moreover, information is a perquisite for assessing the state of the environment and making appropriate decisions to ameliorate identified problems. Indeed, the IS scholarly community needs to help create a sustainable society. While there is an emerging body of IS scholarship under the banner of green IS, we strongly believe that we need to step up these efforts. Our experience indicates that the emergence of green IS as an academic discipline is still by far too slow relative to the needs of society. Too few people are working on green IS given its importance, and fewer still are publishing papers about IS solutions that could contribute to dealing with climate change. In this editorial, we speculate on some reasons for why and explore how the IS discipline can grasp the opportunity to contribute to one of the most important societal challenges of our time. We identify the major barriers that we assert curtail the involvement of IS scholars in green IS research; namely, incentives misalignment, the low status of practice science, data analysis poverty, identification of research scope, and research methods. We discuss each barrier and propose solutions for them.

Keywords: Solutions, Green IS, Climate Change, Design Science, Internet of Things.

1 Introduction

Most scholars from all disciplines, including IS, acknowledge that we need to act on climate change. Since 1988, the world's environmental scientists on the Intergovernmental Panel on Climate Change (IPCC, 2014) have provided multiple and clear scientific reports on the state of knowledge on climate change. The evidence shows that we are rapidly approaching the tipping point beyond which we cannot reverse the effects of global warming and other massive environmental shifts, such as rising sea levels, dramatically expanding droughts, ocean acidification, and loss of biodiversity. In 1992, the Rio Earth Summit devised the UN Framework Convention on Climate Change (UNFCCC, 2015) to drive the international political response to climate change. Annual meetings of the Conference of the Parties (COP) promote action aimed to stabilize atmospheric concentrations of greenhouse gases (GHGs) and avoid "dangerous anthropogenic interference with the climate system" (IPCC, 2014, p. 11). In September 2000, the largest gathering of world leaders in history adopted the UN Millennium Development Goals (UN, 2000), which committed their nations to a new global partnership to act on extreme poverty, promote gender equality and environmental sustainability, and enshrine the basic human rights of each person on the planet to health, education, shelter, and security. The international momentum for tackling these grand challenges, COP21, continued with a near-universal representation from 195 member countries of the UN (UNFCCC, 2015) in Paris 2015 to work on a legally binding agreement on climate to keep global warming below 2°C.

Joining the grand challenges movement, in 2014, the Association for Information Systems' (AIS) council formed a task force to develop a proposal for an AIS grand vision to address the risks and side effects associated with ICT such as privacy, cyber-attacks, global warming, and sustainability. Led by then AIS president (2015-2016) Jae Kyu Lee, the AIS instigated the Bright ICT Initiative (Lee, 2015) to create several high-impact and high-visibility research opportunities for the IS community in line with the Millennium Development Goals.

Motivated by our responsibility to use our IS knowledge and skills to help create a more sustainable society, as editors of this special issue of *JAIS,* we called for papers oriented towards IS solutions for environmental sustainability. We received only nine papers and ultimately accepted only one as both relevant for the special issue and suitable for *JAIS*. A significant gap between the global need to solve problems associated with climate change and what IS scholars are prepared to do seems to exist, at least when it comes to publishing in prestigious journals such as *JAIS*, despite the potential contribution that IS knowledge and skills could make to this grand challenge identified in the Bright ICT Initiative.

In this introductory editorial to the special issue, we comment on the accumulated body of green IS literature and identify some key gaps that we believe might explain IS scholars' lack of engagement in green IS research. In particular, in Section 3, we focus on barriers. We first discuss the lack of incentives for IS scholars to engage in solution-focused investigations. As we identify other barriers/challenges that face those who are motivated to investigate the potential ways that IS can contribute to environmental sustainability projects, we refer to the example published in this special issue in Section 4. In Section 5, we conclude with some suggestions on the way forward.

2 Background

Environmental sustainability is the emerging dominant challenge of the 21st century, and organizations and researchers must combine to react to this new challenge (Watson et al., 2012). As the Climate Reality Project (established in July 2011 after the joining of the two environmental groups, The Alliance for Climate Protection and The Climate Project, both of which Al Gore founded in 2006) notes, "no one discipline has all the answers and no one discipline has all the questions". Nevertheless, it is difficult to imagine solutions to environmental challenges without a substantial IS component. The efforts of the UN Environment Program (UNEP), the IPCC, and UNFCCC demonstrate the determination of a global response that promotes the sustainability-dominant logic of a green economy as a new engine of growth. There is even an emerging consensus among "ecological economists" that the reductions needed to avoid catastrophic climate change are radically incompatible with the continued "economic growth", even with "efficiency" gains from new "technology" (Alexander, 2015). Similarly, Sarkis, Koo, and Watson (2013) emphasize the need to find a synergistic win-win relationship between economic growth and environmental sustainability.

One needs more and better quality data are to assess the state of the environment, make appropriate decisions to ameliorate identified problems, and analyze the efficacy of the different initiatives. Given that information systems have been the major force for productivity increases in the last half-century (Devaraj &

Kohli, 2000; Stiroh, 2002; Dedrick, Gurbaxani, & Kraemer, 2003; Barua et al., 2010), it is appropriate that IS scholars immerse themselves in creating solutions for environmental problems. Indeed, given the immensity of the ecological problems we face, IS scholarly community at large needs to help create a sustainable society (Watson, Boudreau, & Chen, 2010, Malhotra, Melville, & Watson, 2013; vom Brocke, Watson, Dwyer, Elliot, & Melville, 2013). Such engagement requires IS scholars to keep in mind the ultimate goal of solving significant societal problems related to environmental degradation (Becker, vom Brocke, Heddier, & Seidel, 2015).

Thus, several issues arise, such as the position of the community of IS scholars along this research trajectory, the extent to which the Bright ICT Initiative provides a viable way forward, the body of knowledge created so far with green IS scholarship, and the barriers that might limit more IS scholars from engaging in solving this critical problem.

2.1 Calls to Action for IS Scholars to Tackle Grand Societal Challenges

Calls for tackling grand societal challenges in the IS discipline are not new. vom Brocke, Stein, Hofmann, and Tumbas (2015) quote publications on these themes in the 1980s and 1990s, and recent panel discussions have occurred at the European Conference on Information Systems (ECIS) in 2006 and the International Conference on Information Systems (ICIS) in 2011. Such summons for action typically reiterate the message that solutions call for transdisciplinary and interdisciplinary efforts to which diverse disciplines, including IS, must contribute (e.g., vom Brocke et al., 2015).

With rapid environmental degradation and increasing social costs, we have also witnessed data's increasing volume. Data's ever-increasing volume and variety has exacerbated scientific specialization and knowledge fragmentation (Sidlauskas et al., 2010; Hampton & Parker, 2011). However, the complexity of the environmental challenges we face today demands solutions that transcend traditional disciplinary boundaries (Carpenter et al., 2009), which the Intergovernmental Panel on Climate Change (IPCC), International Geosphere-Biosphere Program (IGBP), International Human Dimensions Program on Global Environmental Change (IHDP), and Future Earth (www.futureearth.org) have recognized (Lynch et al., 2015).

In discussing the AIS's Bright ICT Initiative launched under his presidency, Lee (2015) brings to the attention of IS scholars the fifteen global challenges that the Millennium Project identifies as a foundation for investigating Bright ICT initiative. In particular, vom Brocke et al. (2015, p. ix) note that "energy shortage and climate change are among these global challenges, and we must determine how IS can help to mitigate and adapt to climate change". The complexity of "wicked" problems, such as climate change, can be overwhelming because diversity among both the interpretations of the scientific evidence and the viability of possible solutions exists (Kazlauskas & Hasan, 2009).

Winter and Butler (2011) advise that IS scholars must "develop the practice of articulating and engaging large-scale, broad scope problems" or "grand challenges (p. 100). However, they also warn that envisioning grand challenges involves difficult strategies and approaches for increasing the "impact" of IS research. Similarly, Eymann et al. (2015) see the need to inspire researchers so that "the underlying idea of grand challenges is to focus on ambitious research objectives that harness science, technology, and innovation to solve important national or global problems that have the potential to capture the public's imagination". They also suggest grand challenges speaks the current language of science policy and, hence, plays an increasingly important role for allocating public and private research funds.

Focusing on environmental challenges, Watson et al. (2010), Melville (2010), and Elliot (2011) advocate that the IS discipline has both the responsibility and the historic chance to demonstrate societal value by contributing to solutions that lessen the negative environmental effects of people's behavior. For example, the "energy informatics" discipline (Watson et al., 2010) has arisen to investigate the design and use of information systems to improve energy efficiency through sensor networks in both businesses and private lives. Information systems can also play a major role in facilitating sustainability transformations in organizations of various types (Seidel, Recker, & vom Brocke, 2013). IS researchers need to leverage this knowledge in contributing to grand societal challenges (vom Brocke et al., 2013).

2.2 Building the Green IS Body of Knowledge

One way that AIS might advance the emergence of a body of knowledge on IS topics is through special interest groups (SIGs), which connect like-minded individuals in to affect or produce solutions in specific knowledge areas. The AIS SIG SIGGreen was set up to guide the growth of the green IS body of knowledge and provide a focus for environmentally responsible activities, where IS can really make a difference. It was

inspired by calls to arms in groundbreaking green IS papers. Watson et al. (2010, p. 23) say "we need to demonstrate how the transformative power of IS can be leveraged to create an ecologically sustainable society", and Melville (2010, p. 1) observes "the critical role that IS can play in shaping beliefs about the environment, in enabling and transforming sustainable processes and practices in organizations, and in improving environmental and economic performance".

Since the initial awareness-raising papers, an increasing number of conference tracks, special issues, and workshops have addressed the questions of how we can reduce the negative impact of IT on the environment (green IT) and how IS can contribute to the eco-sustainability of businesses and society (green IS) (Molla & Abareshi, 2012). Special issues of journals, conference tracks, and workshops can help to build a coherent body of knowledge emerging in a discipline. Addressing global climate change, however, requires far more than a few special issues and a few workshops. It requires a sustained effort by many scholars and, from time to time, a consolidated and synthesized review of the accumulated literature.

The editorial of the special issue of *MIS Quarterly* on information systems and environmental sustainability (Malhotra et al., 2013) analyzed 23 green IS papers published between 2008 and 2013 to examine to what extent IS research had gone beyond conceptualizing, analyzing, and designing green IS and contributed solutions that mitigate climate change. They found that all of the 23 studies focused on the "conceptualize" and "analyze" stages of research; they found little research on the "design" and "impact" dimensions.

To discern if the IS discipline has progressed in researching these latter dimensions, we reviewed the green IS literature published since Malhotra et al. (2013): that is, from 2013 to 2016. To identify the papers, we first searched all issues of the Association of Information Systems (AIS) basket of eight journals (*European Journal of Information Systems, Information Systems Journal, Information Systems Research, Journal of AIS, Journal of Information Technology, Journal of MIS, Journal of Strategic Information Systems, and MIS Quarterly*). We identified eight journal papers (see Appendix). We adapted Malhotra et al.'s (2013, p. 1266) framework to map the eight papers into their four categories: "conceptualize (review papers, conceptual frameworks, etc.), analyze (case studies, ethnographic analyses, quantitative empirical analyses, hermeneutics, etc.), design oriented (design science), or impact oriented (implementation and sustainability impacts using action research, in vivo real-time approaches, etc.)". Figure 1 displays the result. We critically summarize the papers in the appendix.

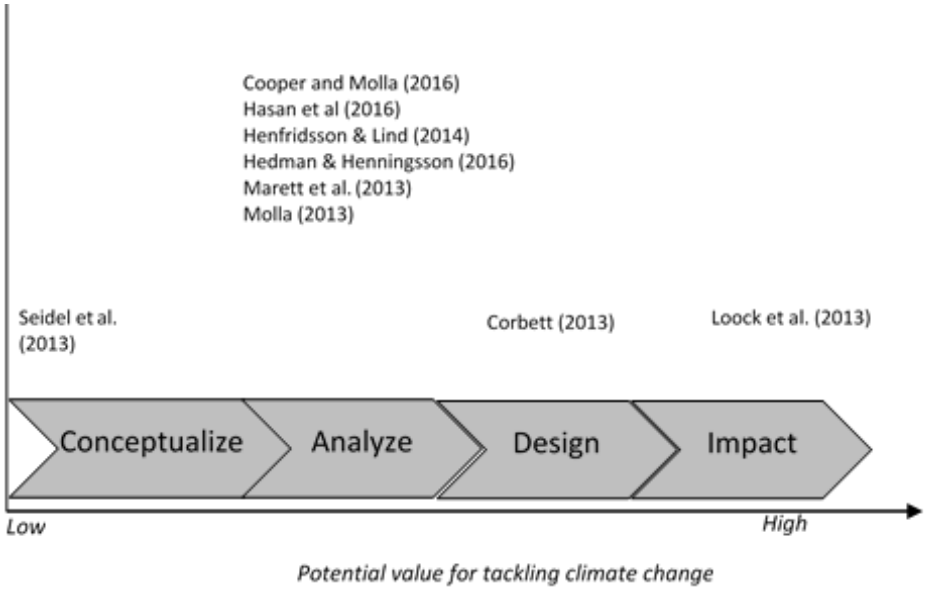

Figure 1. The State of Green IS Research since Malhotra et al. (2013)

3 Barriers to Green IS Research

A major research gap seems to exist between what is needed to solve problems associated with climate change and what IS scholars have done despite the huge potential contribution of IS knowledge and skills. The low number of IS papers published in the green IS design and impact value space (Malhotra et al.,

2013) suggests that research in these domains is challenging both in its conduct and publication. To explore why, we discuss the nature of the barriers and causes of this gap in Sections 3.1 to 3.5

3.1 Barrier: Incentives Misalignment

IS scholars, like most humans, are influenced by incentives related to the interrelated imperatives of employment, tenure, promotions, recognition, funding, and prestige. The traditional currency of the IS academic community is "hits" in prestigious journals and the h-index. Simple counts of publications in prestigious research journals and citations are critical for promotion and tenure in many universities, while their "real impact" on problems that matter seems to count for little in promotion and tenure decisions (vom Brocke et al., 2013). Moreover, as we later show, projects that address such problems are often more difficult to conduct in that they require new sources of data and more innovative methods, which are a disincentive for a promotion- and tenure-driven academic.

Publication and citations counts remain almost totally insensitive to societal needs, and only those IS scholars with an environmentally active bent will research issues related to societal grand challenges without regard for traditional incentives. Given the current university ranking systems, it would be idealistic, but unlikely, if provosts, deans, and promotion and tenure committees singled out for special rewards those who tackled society's most important problems. The existing promotion and tenure system encourages researchers to address topics and use methodologies that result in "quick" hits regardless of how well it benefits society. Citations are also a flawed measure because they reflect an approach that emphasizes quantity and not the creation of social value. Thus, the incentive system for academics does not align with the needs of society and practice.

In addition to promotion and tenure, funding is also an incentive that often depends on applicants' publication record and citations. We note Eymann et al.'s (2015) observation that the policies of research funding bodies have begun to change to favor submissions that address grand societal challenges. Furthermore, the UK Research Excellence Fund now explicitly assesses the societal impact of research in its reviews (Schubert, Andersen, & Kilian, 2015). If universities widely implemented such policies, they could realign the incentive model towards green IS research.

Meanwhile, two problems seem to exist with the current publication-counting regime1) the greater importance placed on publications in academic journals as opposed to those in practitioner outlets and 2) the reluctance of academic journals' editors and reviewers, at least in IS, to value papers that focus on solutions rather than theory. Changes in these two areas would also provide new incentives for solution oriented green IS research.

The incentive system for academics does not align with the needs of practice. Publications in prestigious research journals are critical for promotion and tenure, but their "impact" on practice seems to count for little (vom Brocke et al. 2013). The scholarly IS discipline still focuses far too much, in our view, on its identity, foundational theory, scientific rigor, and contribution to theory and not sufficiently on relevance. The IS discipline's motto seems to be: "who cares whether it flies, as long as it is publishable". However, one might find it interesting that, during the last 20 years, researchers (in physics, chemistry, and medicine) that have invented new methods have received more Nobel awards than those that have published new theories (Greenwald, 2012).

3.2 Barrier: The Low Status of Practice Science

IS does not have a well-established, strong tradition of valuing practice science. Editors of the top IS journals have been understandably concerned with the IS discipline's reputation. In spite of the occasional calls for more balance, editors place more emphasis on methodological rigor than societal relevance. In common with other social science disciplines, IS sometimes falls victim to the malaise of "physics envy" in that it wants to be as "scientific" as the natural sciences, which use precisely defined constructs, tight quantitative measures, and precise causal explanations (Thomas & Wilson, 2011). Even in a more realistic social sciences tradition, many widely believe that practical atheoretical research is not legitimate in an academic discipline.

Over 25 years ago, Orlikowski and Baroudi (1991) observed that the philosophical assumptions about the nature of valid evidence and the phenomena of interest to IS researchers drew on the natural science tradition in a way that may not always be appropriate for inquiring into the relationships between information technology and organizations. They argue that the dominant research perspective in IS

research is not well equipped to deal with situated interactions over time as is the case in problems of practice.

3.3 Barrier: Data Analysis Poverty

Data are the key to solving many problems. They enable one to understand a situation and evaluate alternatives. Thus, a lack of data can hinder IS research, which might explain the paucity of applicable green IS research. However, this data poverty should soon change: the rise of the concept and application of "big data" has already begun to open new opportunities for mining growing sources of available data relevant to a problem for innovative analysis and modeling of solutions.

Clarke (2016) sees the current euphoria for big data and data analytics as a sequel to the enthusiasm for data warehousing and data mining in the 1990s. The Internet of things is creating an opportunity for one to collect and analyze unprecedented amounts of big data. One can embed information systems into physical objects to make them smarter and uniquely identifiable and controllable via the Internet. As Kranz, Kolbe, Koo, and Boudreau (2015) note: "Sensor and actuator networks are integrated with the physical electricity grid infrastructure to so-called cyber physical systems with the aim of increasing reliability, efficiency, and environmental sustainability" (p. 13). Different streams of IS research, such as decision analytics, design science, security and privacy, human-computer interaction, service science, economics of IS, and technology acceptance can contribute to analyzing, designing, or improving smart-energy innovations and to regulating and designing energy markets (Kranz et al., 2015).

Currently, the security, healthcare, transport, and energy sectors] use 30 million sensors, and, worldwide, the number of these sensors has grown by 30 percent annually (McKinsey & Company, 2011). However, to benefit from these sensors, one needs to be able to use the data they produce. Jetzek, Avital, and Andersen (2014) studied the case of Opower, a pioneer in using and transforming data to encourage a behavioral change among households that resulted in a substantial reduction in energy consumption by customers.

Research has categorized information value-chain activities into two groups: knowledge derivation and decision making (Sharma, Mithas, & Kankanhalli, 2014). Firms now collect data from social media and sensors to supplement their internal data sources (Chen, Chiang, & Storey, 2012). However, using such varied data sources is not straightforward. We need to address a range of data-quality and credibility issues. Appropriate data-management, data-preparation, and knowledge-management are essential (Abbasi, Sarker, & Chiang, 2016). Discovering, integrating, and interpreting these various multi-modal physical-cyber-social streams of big data to provide timely, accurate, and reliable insights and actionable knowledge are among the key challenges we currently face (Barnaghi, Sheth, & Henson, 2013).

The major challenge for society is to shift from fossil fuels to renewables to reduce carbon emissions. This shift requires a smart grid that can efficiently route electricity:

> *from both concentrated and distributed generators, to the final consumer with high reliability, security, and quality of supply standards. A smart gird is expected to be the implementation of a kind of Internet in which an energy packet is managed similarly to a data packet—across routers and gateways which autonomously can decide the best pathway for the packet to reach its destination with the highest integrity levels.* (Vermesan & Friess, 2015, p. 41)

Smart meters that report real-time consumption of each consumer and that one can control remotely are critical to the smart grid's success. Smart metering will enable grid operators to analyze real-time energy generation and consumption to maintain grid stability. The intermittency of renewables, such as solar and wind, makes real-time data analysis essential for incorporating renewable energy into the grid (Initiative for Global Environmental Leadership, 2014). For instance, Alliander (the Dutch utility provider) uses in-memory analytics to keep the grid running at peak efficiency, which increases profits and reduces negative environmental impact. Alliander used to optimize the grid only once a year, and it took 10 weeks to do so. However, Alliander now optimizes the grid every month, and it requires only three days to complete (Initiative for Global Environmental Leadership, 2014).

Because each type of household appliance (e.g., a fridge) has a unique signature, it is has recently become possible to attach a sensor to the electricity supply and report its use[1]. One could combine this sensing

[1] For example: https://sense.com/2016februarycampaign.html?utm_source=GDN&utm_medium=115726659088&gclid=CPH3qrbm1MwCFVYdgQodo3cE7w

capability with remote device controllers and a real-time pricing data stream to enable householders to minimize their electricity costs. We expect that, over the next few years, the opportunity will arise to escape the current poverty of data to enable a rich analysis of electricity consumption behavior by a variety of parties, such as utility companies, appliance manufacturers, and IS scholars.

Seidel, Recker, and vom Brocke (2013) argue that the literature largely lacks knowledge about the use of information systems in sustainability transformations in organizations (see Elliot, 2011; Melville, 2010; Watson et al., 2010). As such, they suggest empirical research as a suitable strategy to develop insights. The primary role of information systems in sustainability transformation is to create action possibilities for sensemaking, and sustainably practicing and creating these affordances is a key transformative power that IS can provide to organizations to become sustainable (Seidel et al., 2013).

3.4 Barrier: Identification of the Proper Research Scope

As the paper published in this special issue exemplifies, IS research is ideally suited to creating targeted solutions where one can process data, either already available or potentially collected from sensors, into information that can support decision making for more sustainable practices at many levels. In contrast, there are many problems of environmental sustainability that one cannot solve with such targeted solutions and that need a broader multi-disciplinary or multi-faceted perspective. The trans-disciplinary nature of IS could have a role here (Elliot, 2011).

Supporting a multi-disciplinary scope, Ahmed (2010) argues that we need to consider the major crises humanity faces today (climate change, energy crisis, food insecurity, economic instability, international terrorism, and militarism) as part of the same ailing system. He believes these major crises share the same root causes, and, in order to solve them, we must consider their complex interactions. He explains most of the current research on global crises focus on one area and exclude others. The reluctance of experts to look outside their own discipline explains why there is so much disagreement and misunderstanding about particular crises. Hence, he proposes an interdisciplinary approach to solving grand challenges that humanity faces today.

Winter and Butler (2011) examine the holistic multi-disciplinary nature of grand challenges from an IS researchers' perspective. They suggest that grand challenges are socially constructed boundary objects that can enable one to span disciplines. They claim that:

> *IS research is undervalued, at least in part, because as a community we fail to engage the full range and scale of problems to which our work and knowledge is relevant. Rather than scoping problems for study that are familiar and tractable, we must develop the ability to seek out and engage critical problems, even when they are unfamiliar and significantly exceed the capabilities of any one individual or research team.* (Winter & Butler, 2011, p. 99)

IS scholars can contribute to these solutions by developing and promoting the application of suitable IS at all levels. When data are the core of solving most problems, IS is a component of most solutions.

As we note above, the infrastructure is being created to generate large volumes of real-time data, and the IS discipline has the particular competency to analyze such data. We understand how to manage large data sets, merge data streams, and analyze and mine data. We will likely need to develop deeper skills in real-time data stream analysis, but IS scholars have the conceptual foundations for adding this capability to their repertoire. Thus, we have the opportunity to provide interdisciplinary teams with data-analytic skills. For example, some IS scholars now work with engineering faculty to jointly tackle managing energy demand for a campus (e.g., Lawrence et al., 2012). The engineers understand a building's physical systems, such as HVACs, but do not have the skills to handle and analyze large volumes of data.

3.5 Barrier: Research Methods

We note in Section 3.1 that many IS scholars assume that all quality research must have a theoretical contribution before the journal will publish it, which we disagree with on the grounds that it precludes publishing atheoretical or theory application papers that report on important novel IS solutions that make major contributions to grand challenges. We now revisit this issue and examine the methods that we recommend IS researchers engaged in solution-oriented research adopt.

First, we emphasis that one should not confuse the concept of a solution in IS research with the concept of a solution in computer science or software engineering where the predominant research method involves producing a novel system or an innovative algorithm (Nunamaker, Chen, & Purdin, 1990). A contribution

could be applying IS theory or expertise to innovative beneficial practice (Lee, Thomas, & Baskerville, 2015), particularly in areas with significant unresolved environmental or societal problems.

Second, we observe that one popular approach to publishing solution-oriented research in our top journals is to reframe its product as *theory*. We can resolve the lack of theory in IS research by introducing a new type of theory for design and action (Gregor, 2006). This claim provides a basis for the legitimacy of design science, which may provide a suitable choice of method for solution-oriented projects (Hevner, March, Park, & Ram, 2004). Peffers et al. (2007) provide a six-step framework to guide the researcher who takes this path. This framework includes both "demonstration of the solution" and "evolution of theory and reflection" as two steps of the method. However, many critiques of design science argue that, when applying a design science method, one needs to present, explain, and justify the evolution of a theory requirement. We question the efficacy of these requirements. We argue that a legitimate contribution to the IS body of knowledge, where appropriate, could be evidence on how the solution helps to make meaningful progress towards a particular grand societal challenge. If design science gauges its value purely on its theoretical contributions, then it fails society just as surely as other theory-absolutism approaches. We need a practice science to create novel practices by following scientific principles.

For instance, Recker (2016) defines the core building blocks for a design theory that specifies a class of green IS that allow organizations to perform environmentally sustainable work practices and make environmentally sustainable decisions. Recker builds his design theory on two kernel theories: the belief-action-outcome framework (to examine how organizational behaviors are formed) and affordance theory (to understand how technology can influence organizational behaviors).

Third, action research (Baskerville & Wood-Harper, 2002; Davison, Martinsons, & Kock, 2004) provides a relevant methodology for projects that meet the objectives of both research and practice. Engaged scholarship (Mathiassen & Nielsen, 2008; Van de Ven, 2004) provides a similar tradition. McKay and Marshall (2001) eloquently describe the intention of action research to identify the separate agendas of the practical problem and the research. The researcher is responsible for designing mechanisms whereby the practice and research agendas inform each other as each works toward fulfilling their separate goals. Action researchers, while concerned with improving practice, recognize that one needs a research contribution, separate from the practical solution, for academic publication. The question remains as to whether journal reviewers and editors will accept atheoretical research contributions.

Fourth, we propose that an IS practice or solution science that engages with practice should not require theory building to be acceptable for publication in IS journals if this type of research starts with a problem and puts theories to work to solve the problem. IS could follow the medical tradition of translational research where one tests discoveries generated in the laboratory in human trials, the results of which journals report and then hospitals and communities adopt as best practice.

4 Presenting an Example of Solution-focused Green IS Research

In accepting papers for this special issue, we kept in mind the conflict of our intended focus on solutions-oriented research and that *JAIS* "encourages theory based multi- or inter-disciplinary research" (AIS, n.d.). The single accepted paper, entitled "Providing Utility to Utilities: The Value of Information Systems Enabled Flexibility in Electricity Consumption", presents an IS response to a core problem in mitigating climate change; namely, overcoming the limitations of fluctuating supply with renewable energy sources. The paper has a theoretical basis in real options theory, but it is also very much solution-focused in that it uses a design science approach. The problem is a classic IS challenge of converting data into information to support decision making—in this case, short-term consumer compensation—based on calculating the economic value of time shifting electric loads using historical spot price data from the electricity exchange.

The published paper demonstrates applying theory to solve a problem. It also implicitly highlights the purpose of theory, which is not an end but rather a means to solve problems. Society judges a discipline not by its theories but by the problems it solves. IS is becalmed in a sea of theories, and maybe climate change can be the motivating force to propel it out of the doldrums.

The shift from fossil fuels to intermittent renewables is not just a smart grid problem. It also requires designing new organizational structures to handle the variability of solar and wind power. For example, one could address the undersupply problem by a demand-response market (Watson, Lawrence, Boudreau, & Johnsen, 2013) that is based on buying and selling options to consume electricity. Similarly, one could design a production rights market to handle the oversupply problem. Both solutions require an

understanding of market design (Roth, 2008) and IS because such markets will need to be distributed, real-time, electronic, and inhabited by intelligent agents. One can apply IS theories (e.g., Malone, Yates, & Benjamin, 1989) related to real-time electronic markets in this situation, and the study of such markets should appeal to those in the IS and economics area.

The shift to a sustainable society will require adopting new behaviors, such as decision making that considers environmental impact. The IS scholarly community has considerable experience in building behavioral-based theories related to adopting new behaviors and using information in decision making.

To achieve a sustainable society, humanity needs to make technological changes (e.g., renewable power generation) and behavioral shifts (e.g., greener life style). The complexity of the required technological change will require processing vast amounts of data, and information will play a key role in driving the necessary behavioral shifts. IS scholars have many opportunities to apply their theoretical and practical knowledge to solve critical problems.

5 IS as a Solutions Science: An Agenda for the Future

In this editorial, we argue that few IS scholars seems to be conducting research on topics in green IS because journals are reluctant to publish papers that report solutions rather than theories. However, given the global importance of environmental sustainability, the IS discipline has an obligation to make a tangible contribution to one of the most important grand challenges of our time. We urgently need solution-oriented studies that show how one can leverage the transformative power of IS to mitigate negative environmental impacts (vom Brocke et al., 2013). A focus on outcomes extends the traditional relevance and rigor debate to applying theories. IS scholars should apply their knowledge, skills, and experiences to solve problems that really matter.

We recommend that green IS strategically asserts itself as problem oriented, which most scholars in this area advocate. Global climate change is a pressing problem, and we need to apply current IS theories now to address this significant threat. Our journals are full of theories, but they create little value if they are only of interest to other IS researchers. We need to apply the theories we have. We need to also recognize that solutions often require multiple theories; therefore, it would be more beneficial to start with a significant problem and pertinent empirical facts than with a particular theory.

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Appendix

Green IS Research (2013-2016)

As we describe in Section 2.2, we searched all issues of the Association of Information Systems (AIS) basket of eight journals (*European Journal of Information Systems, Information Systems Journal, Information Systems Research, Journal of AIS, Journal of Information Technology, Journal of MIS, Journal of Strategic Information Systems, and MIS Quarterly*) published since the *MISQ* special issue on information systems and environmental sustainability in 2013. The results of this search revealed that, except for two papers (e.g., Corbett (2013) and one paper published in the special issue (Loock et al. 2013)), the few green IS papers accepted for top journals were conceptual or analytical in nature. In Table A1, we critically overview each paper and indicate where the research might go if it focused more on solutions.

Table A1. Green IS Research (2013-2016)

Reference	Focus and critique	Future direction
Cooper and Molla (2016)	This paper's central thesis is that IS departments can enhance the success of environmentally driven IS-enabled change when they develop their ability to learn and effectively use sustainable IS knowledge to transform unsustainable organizational and social practices. The core research activity reported is the development of a model where sustainable IS triggers, knowledge exposure, and prior experience influence IS-environmental absorptive capacity, which, in turn, contributes to the level of environmentally sustainable IS assimilation and to the cost saving, operational performance, and reputation of organizations. In addition to its theoretical contribution, the paper advises that IS departments should pay attention to developing IS-environmental absorptive capacity and not assume that their existing knowledge and skill sets are sufficient to provide the IS-enabled change.	In the paper's conclusion, the author's acknowledge that the ultimate outcome of leveraging IS for environmental sustainability should be its contribution to the quality of the environment, which they do not test empirically because it is an area of multiple complexities. The causes of environmental outcomes are ambiguous and deciding what to measure is rarely straightforward. Further, differing views exist about what constitutes desirable environmental outcomes and metrics.
Corbett (2013)	This paper investigates how to design and develop carbon management systems (CMS) that persuade employees to develop pro-environmental behavior. It identifies eight new design principles including two related to task support; namely, commitment and personal learning. Commitment relates to a CMS's ability to enable users to make specific commitments to change. Personal learning is the system's ability to support the accumulation of individual knowledge about the subject of the persuasion (e.g., carbon footprints in the case of CMS). It is not surprising, however, that the research shows how contextual factors in organizations may lead to different persuasive design principles.	The author suggests four areas for future research: defining and operationalizing the dependent variable, testing and refining the theory linking relationships between system design principles, organizational context, and individuals' behaviors vis-a-vis the environment, applying these concepts to other applications of green IS and further investigating cross-over and boundary-spanning CMS. Note, however, that these suggestions focus on theory rather than solutions. However, because human behavior is such a major factor in mitigating climate change, practical solutions could come from applying the identified design principles in persuasive system development.
Hasan, Smith, & Finnegan (2016)	The paper proposes that the role of IS in climate change adaptation should be a topic of green IS (in addition to the role of IS in climate change mitigation). It argues that, although we should not stop mitigation efforts, we are already feeling the effects of climate change and must find ways to adapt. It reports action research that shows that activities of adaptation can be complex with long time horizons and involve the linking of huge disparate data repositories to provide information to support both crisis and chronic impacts of climate change.	An opportunity exists for the findings of this paper to inspire further research into the design of IS solutions that support activities of adapting to climate change. Moreover, it shows that IS scholars can contribute to climate change mitigation and adaptation and to other global challenges with their expertise in managing and integrating complex data sets and developing interactive simulation and modeling applications for decision support with a solutions focus.

Table A1. Green IS Research (2013-2016)

Henfridsson & Lind (2014)	This research addresses the problem: what is the process by which the micro-strategizing of actors from a variety of organizational subcommunities contribute to realize strategy contents as they use IS to implement a sustainability strategy? The paper contributes a new process model to the IS strategy literature by incorporating the case commitment to be "green, safe, and connected".	Future research and practice could focus on implementing strategies using the process model reported in the paper to determine whether it leads to improved environmental outcomes and solutions.
Hedman & Henningsson (2016)	This paper uses a case study to show that organizations take their green IS initiatives through a bottom-up process in which environmentally concerned individuals identify issues and become green IS champions and promote green IS to the organization. They also found that organizations endorse green IS if: 1) it agrees with their organizational agenda and 2) it is in their existing resource and cognitive limitations. The paper presents an integrated model of how green IS becomes part of the sustainability process and relates to the overall firm strategy.	One area of investigation is to examine how generally successful the bottom-up solution is to corporate sustainability where dedicated champions lead green IS.
Loock, Staake, & Thiesse (2013)	This paper in the *MISQ* special issues uses field experiments to study the role of information systems in encouraging and affecting more energy efficient behavior in households.	The editors suggest that this work could be a "potential accelerant is to encourage green IS researchers to foster a community within and outside the IS scholarly community on this topic" (Malhotra et al., 2013 p. 1271).
Marett, Otondo, & Taylor (2013)	This paper in the *MISQ* special issue analyzes the underlying factors for successful and sustained use of green IS in the trucking industry.	The editors suggest that from this work "there are two critical aspects of future IS research. First, to learn how to create accurate systems for pricing environmental damage so that externalized costs can be fairly internalized. Second, we need to investigate how the presentation of information can influence perceptions in favor of valid environmental sustainability actions." (Malhotra et al., 2013 p. 1269).
Seidel et al. (2013)	This paper in the *MISQ* special issue presents "a theoretical framework based on the affordances view to suggest characteristics of Green IS that enables organizational transformation. They highlight the key affordances of Green IS that present an organization with a set of options for transformation." (Malhotra et al., 2013, p. 1266).	The editors suggest that this work "stimulates us to pose two critical questions. First, how do we identify the case or cases that reveal eco-effective affordances and their corresponding transformational power? Second, beyond observing best practice, how do we to apply theory and design science to rise above the incrementalism of eco-efficiency to create radical changes the promote eco-effectiveness? IS research would gain much in stature if it could be an active change agent rather than a passive reporter of what practice has discerned. Of greater importance, it would contribute to solving one of our most pressing problems." (Malhotra et al., 2013, p. 1268).

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