Socio-technical Systems Theory and Environmental Sustainability

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Abstract

This paper argues for the relevance and utility of socio-technical systems theory for designing solutions to the challenges we face from climate change and managing the impact of human activity on the environment. Socio-technical systems theory defines systems as a collection of messy, complex, problem-solving components. This paper identifies two elements of socio-technical systems theory most relevant to encouraging environmental sustainability. The first is the concept of a system goal and its impact on the activities of the system. The current goal of our global economy is ever increasing consumption. Therefore we need to redirect the goal towards environmentally sustainable development. The second element identified is the role of the feedback loop, which provides information that compares the actual outcome of the system to the desired system goal. This paper presents an example of effective feedback mechanisms, illustrated by the work of OPOWER, which offers energy efficiency and smart grid technology services. This paper argues that a socio-technical approach to the problem of environmental sustainability will lead to better outcomes. IS professionals therefore have a critical skill set, a fluency with socio-technical concepts as well as systems design, that can be applied to the creation of information systems in support of environmental sustainability.

Introduction

IS research is concerned with understanding the dynamics of people interacting with computing systems. It tries to explain the interaction of a complex set of social, political, organizational, economic, and technical factors and components. When studying such a multifaceted topic, academic research grounded in theory has greater power of explanation and analysis than anecdotal evidence. Theories and frameworks give us explanatory and predictive tools. They help untangle the dynamics of complex problems.

One of the most influential theories used in IS research is socio-technical systems theory. Hughes argues that "technological systems contain messy, complex, problem-solving components. They are both socially constructed and society shaping. Among the components in technological systems are physical artifacts, such as turbo-generators, transformers, and transmission lines in electric light and power systems. Technological systems also include organizations, such as manufacturing firms, utility companies, and investment banks, and they incorporate components usually labeled scientific, such as books, articles, and university teaching and research programs. Legislative artifacts, such as regulatory laws, can be part of technological systems," (Hughes, 1989, p. 51). The goal of socio-technical systems theory is to provide a nuanced mechanism for revealing the complexities within these systems.

The understanding that technological systems have an embedded social component is a central thesis of IS research. The premise of socio-technical systems theory is highly relevant to the work of important IS researchers such as Marcus (Marcus, 1983, p. 23), Orlikowski (Orlikowski, 1992, 2000; Orlikowski & Robey, 1991), and DeSanctis and Poole (DeSanctis & Poole, 1994).

The impact of human activities on the earth's environment can be understood by applying the framework of socio-technical systems theory. Environmental sustainability is widely recognized as a 'wicked' problem since global, social, technical, political, economic and cognitive factors all impact the use of natural resources. Wicked or complex problems have ill-defined, shifting definitions and multiple conflicting elements (Rittel & Webber, 1973). Solutions to wicked problems have arisen from approaches that incorporate the non-deterministic philosophy of socio-technical systems theory (Hasan & Dwyer, 2010). The next section gives a brief summary of the components of socio-technical systems theory and its relevance to environmental sustainability.
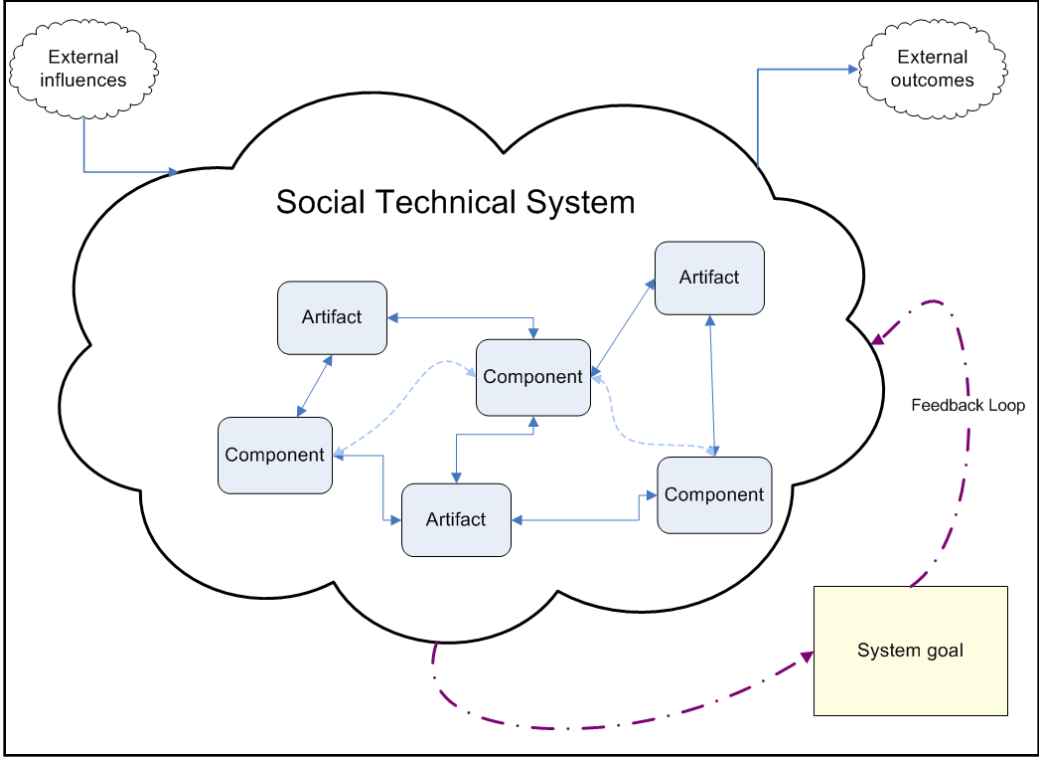
Figure 1: A model of a socio-technical system.

Overview of Socio-technical Systems Theory

Socio-technical systems theory evolved through the collaboration of historians and sociologists that focused on the history of science. This led to a new academic specialty, self described as "sociologists of technology," (Bijker, Hughes, & Pinch, 1989). IS researchers look at problems starting from the technology perspective, therefore they can consider themselves "technologists of society." There are many overlaps between the sociology of technology and IS research. What is critically important to the topic of this paper is the special skill set that IS brings, which is the

ability to inform the design and implementation of technology systems in support of environmental sustainability.

Socio-technical systems consist of components, which are social structures, and artifacts, which are technical elements that contribute directly or through other components to a common system goal. Figure 1 is a graphical representation of Hughes's description of social technical systems (Hughes, 1989). The system's boundary is depicted in the diagram with an irregular shape, representing the blurred borders of socio-technical systems.

Within the system are components and artifacts that interact. Technological systems are both socially constructed, and also help shape social structures. Guiding the overall behavior of the system is the system goal, for example, rapid response time across a communications network. Another important element is a feedback loop, which is a mechanism that enables actual output of the system is to be compared to the system goal. If there is a large gap between the output and the goal, the components and artifacts that make up the system needs to be revised.

An example that illustrates the relationship between system artifacts and system components is the impact of new communications technologies, such as e-mail, cell phones, and the internet, on the organizational structure of companies. For example, the type of communication technology has been found to affect the structure and success of virtual teams (Cramton, 2001).

An element of this theory to consider is the feedback loop, represented in Figure 1 as a dashed line. Hughes maintains that people within a technological system have a critical role, which is to complete the feedback loop by perceiving the gap between system performance and system goals. Hughes argues that it is only through this feedback loop that errors are caught and corrected, leading to improvement in system performance (Hughes, 1989).

Applying Socio-technical Systems Theory to Environmental Sustainability

The two components of socio-technical systems theory most relevant to the topic of this paper are the notion of a system goal, and the role of the feedback loop. We will first consider the relevance of the system goal to supporting environmental sustainability.

Socio-technical systems theory argues that the construction and operation of such a system is guided by a system goal. If we think of the global economy as one huge socio-technical system, complete with social, political, economic, and technical components, then what is the goal that guides the direction of the global economy?

Throughout the twentieth century, the cultural dominance of the United States greatly influenced the development of a global economy whose ultimate goal has been increased consumption (De Grazia, 2005). During the twentieth century, fundamental cultural concepts such as "standard of living," as well as the most frequently quoted economic statistic, GDP, were based on the value of growth and consumption (De Grazia, 2005; Stiglitz, Sen, & Fitoussi, 2009).

As long as governments and businesses measure "success" as increasing consumption, there is no room for consideration of sustainability, which instead values reuse and resource reduction. It

is like that old joke, "the operation was a success, but the patient died." Our economy and standard of living will "grow," but if this continues without consideration of consequences we will turn the earth into a wasteland.

There have been efforts to recalibrate economic goals to take into account damage to the environment. For example, the Commission on Measurement of Economic Performance and Social Progress (CMEPSP) was charged in 2008 by the President of the French Republic, Nicholas Sarkozy, to uncover the inherent limitations of the use of GDP as an indicator of economic performance and social progress. In addition, the Commission was asked to considering any additional factors that should be measured and included for future indicators of social progress, and to judge the feasibility of alternative measurement tools (Stiglitz, et al., 2009).

Another alternative measure of long term economic viability is the Goldman Sachs SUSTAIN Index (Ling, Forrest, Fox, & Feilhauer, 2007). Goldman Sachs provides investment banking and financial advisory services. For investors, Goldman Sachs uses tools and analysis methodologies to identify companies and industries expected to prosper in the future. Goldman Sachs has determined that traditional methods of evaluating the investment potential of companies is inadequate, because they do not take into account the expected impact of climate change on business markets. The Goldman Sachs SUSTAIN Index evaluates from 20 to 25 indicators related to sustainable energy usage, as well as corporate governance issues. Through their methodology they identify a number of companies in various industries, such as Johnson & Johnson, Monsanto, AXA Insurance, and HSBC, that they predict will prosper in an environment of rapid population growth and diminished natural resources (Ling, et al., 2007).

Enhancing Feedback Loops

The second component of socio-technical systems theory relevant to supporting environmental sustainability is the feedback loop. According to Hughes, the feedback loop plays a critical role in discovering the gap between the actual output of the system compared to the system goal. Through this feedback loop, the operation of the system can be modified to align the output more closely to the system goal.

The feedback loop brings information to a human agent, who then initiates changes to alter the system. Applying the feedback loop concept, reporting carbon emissions and energy consumption to consumers should lead to reduced energy use.

However, this deterministic model of a feedback loop often does not work. It depends on an over simplified interpretation of the individual as a rational actor who can make on the spot, cost benefit analyses and act accordingly (Simon, 1955). The failure of various energy incentives to make a dent in US energy consumption, as well as the ineffectiveness of public health warning over smoking and obesity demonstrates the inadequacy of this interpretation (Miller & Rollnick, 2002).

Therefore we cannot go forward with the understanding that the feedback loop within socio-technical systems is a deterministic force. The answer is not to keep blasting more energy

consumption information at consumers, because there is a real risk of emotional shutdown and withdrawal from the problem (Dwyer & Hasan, forthcoming).

Instead, we need to study examples where the feedback loop actually works, and develop a deeper understanding of the social forces that enable information to change behavior. A promising case study of improved communication of energy use leading to changes in behavior the case of OPOWER, a company providing energy efficiency consulting services.
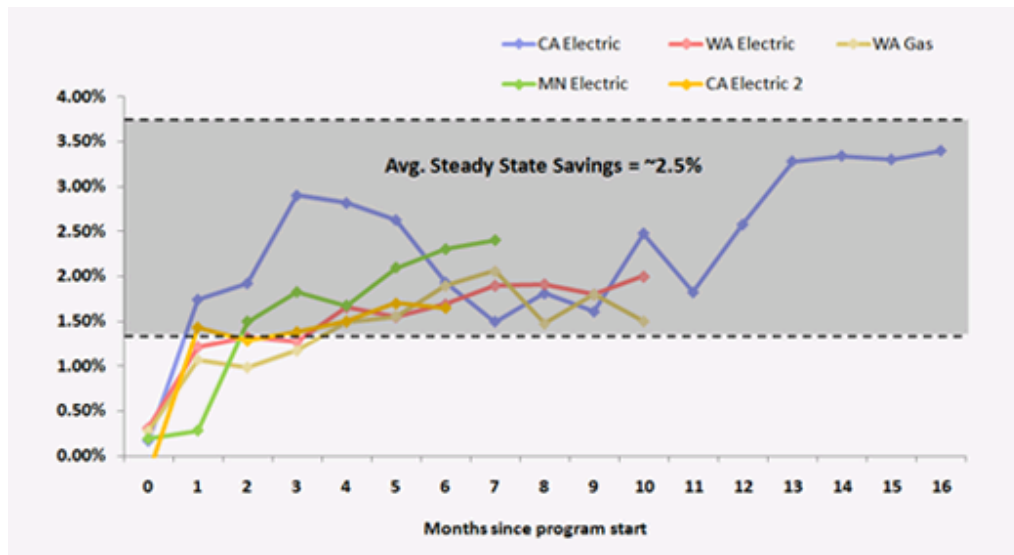

Figure 2: OPOWER chart of energy savings.

OPOWER (www.opower.com) was founded in 2007 by Dan Yates and Alex Laskey. The premise of the company was to use improved information collection, data mining, and data visualization methods to clearly communicate energy use patterns to utility companies and their customers. There results have been quite remarkable: OPOWER reports that "every utility that has implemented the OPOWER system has found it to be among the most powerful, and cost-effective programs in its efficiency portfolio," ("OPOWER Web Site," 2010). The chart presented in Figure 2 shows remarkable changes in energy use across five different utilities.

OPOWER functions by combining advanced data analytics with behavioral science, with the goal of creating more effective customer engagement. The OPOWER team combines software engineers, product specialists, behavioral scientists, and efficiency advocates.

OPOWER has found that the most powerful weapon in reducing energy use is communicating information about the energy usage of a customer's peers. In this case, social norms with regard to energy use are clearly presented, and have a powerful impact on behavior.
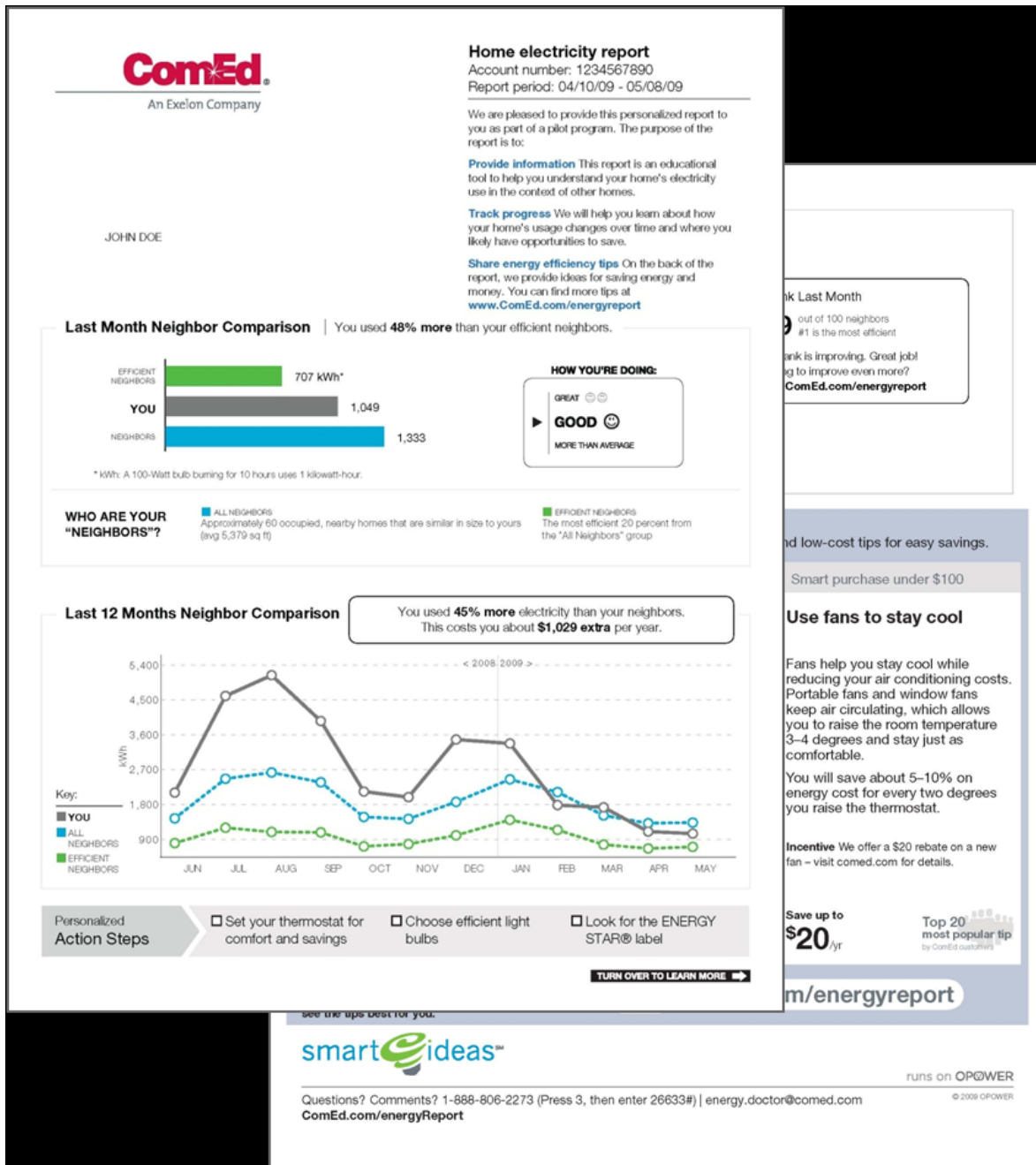
Figure 3: Example of OPOWER Home Energy Report .

The impact of social norms on behavior is an obvious by-product of our nature as social beings. What is less clear is how norms are set, and how they might influence behavior. The influence of norms, however, cannot be denied, even though norms act in almost invisible ways. For example, a study of privacy settings on social network sites within a college environment found the strongest predictor of a student's privacy settings were comparing the settings of their roommates (Lewis, Kaufman, & Christakis, 2008).

Figure 3 presents an image of the Home Energy Report provided by OPOWER. It shows a clear and visually compelling analysis of energy use patterns. First of all, customer energy use is compared to a similar set of "neighborhood peers," selected by family size, house size, or type of business if applicable. This way, people can compare energy use in a direct way, comparing apples to apples, not apples to oranges. The Energy Report also analyzes individual energy use patterns, and suggests possible causes for higher energy use, along with customized suggestions.

Customer ID: 1 Invoice #:	Double-Bottom line Electric Bill							Organization
Service Dates: July ▼ 2008 ▼				Environmental Impact				
Circuit #	Description	KWH	% Usage	CO_2 Equivalent	Methane	Carbon	Trees	$ Costs
1	Bath/Garage GFI plug	29.45	100%	45.21	949.39	201.84	0.11	4.12
2	Dryer	17.66	100%	27.10	569.20	121.01	0.07	2.47
3	Fridge & Answering machine	47.38	100%	72.72	1,527.18	324.67	0.18	6.63
5	Kitchen	106.14	100%	162.93	3,421.49	727.39	0.40	14.86
6	Clothes Washer	24.70	100%	37.92	796.36	169.30	0.09	3.46
7	Furnace / Air Conditioning	120.44	100%	184.88	3,882.39	825.38	0.45	16.86
8	Garbage Disposal	1.36	100%	2.09	43.83	9.32	0.01	0.19

Bill To:				
Synergy Conscious LLC HQ			Subtotal	241.18
			Tax	21.46
5071 Rodeo Circle, Antioch			Balance Due	262.64
94531, CA			Carbon Offset	11.47
USA			Optional Balance	274.11

Figure 4: Statement produced by EcoNexus of electricity use and carbon emissions.

Compare the OPOWER Home Energy Report to the well intentioned but incomprehensible statement from EcoNexus (www.energymon.com), displayed in Figure 4. This bill lists multiple data points for electrical usage (KWH) per circuit, along with measures of the environmental impact. This bill is large dose of information overload (Hiltz & Turoff, 1985), and offers no coherent measure of use patterns, or suggested steps for improvement. Since this statement is likely to make customer feel guilty about energy use, or angry about suggestions they stop using appliances, it can in the worst instance perversely encourage energy consumption.

Summary and Conclusion

Socio-technical systems theory has been an influential component of IS research for many years. It is especially helpful in untangling complex interconnected factors, and providing clearer explanations for confusing or contrary outcomes (Orlikowski, 1993). Given that socio-technical systems theory concerns itself with "messy, complex, problem-solving components," (Hughes, 1989, p. 51), and environmental sustainability is both a complex predicament, and "an urgent problem to address," (Watson, Boudreau, & Chen, 2010, p. 23), the application of socio-

technical systems theory to the design of information systems in support of environmental sustainability.

This paper identifies two components of socio-technical systems theory most relevant to encouraging environmental sustainability. The first is the concept of a system goal and its impact on the activities of the system. The way governments describe social goals, as well as the method by which progress is measured, both profoundly shape the structure of the global economy. We therefore need to radically shift the goal of the global economy away from ever increasing consumption to long term sustainability, and reinforce this with statistical measures that fully weigh the health of the planet as a factor affecting our standard of living.

The second component of socio-technical systems theory relevant to encouraging environmental sustainability is the role of the feedback loop. Through the illustrative case study of OPOWER, this paper shows how clear presentation of energy use can cause proven reductions in consumption patterns. However, it is critically important to consider how information is presented, rather than pushing masses of data, leading to confusion and indecision.

In conclusion, this paper presents an argument that a socio-technical approach to the problem of environmental sustainability will lead to better outcomes. Because the IS profession is grounded in both an understanding of socio-technical systems, as well as ways to inform the design of new technology, IS professionals have an important and singular role to play "in applying the transformative power of IS to create an environmentally sustainable society," (Watson, et al., 2010, p. 24).

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