**green information systems**

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Sustainability requires information on the use, flows and destinies of energy, water, and materials including waste, along with monetary information on environment-related costs, earnings, and savings. Relevant and accurate data, information, metrics, and Key Performance Indicators (KPIs) are important key to support sustainable practices, this type of information is critical if we are to understand the causal relationships between the various actions that can be taken, and their impact on sustainable performance. The development of information systems that support this information need has led to the emergence of Green Information Systems (IS) as a field of research. Green IS refers to the design and implementation of information systems that contribute to sustainable business processes (Watson et al 2008). There is substantial potential for Green IS to bring together business processes, resource planning, direct and in-direct activities, and extended supply chains to effect positive changes across the entire activities of governments, organizations and individuals.

Within organisations, Green IS is the engine driving both the strategic and operational management of sustainability issues. Organisations pursuing a sustainability agenda will need to consider their Green IS to be a critical part of their operational IS (Watson, Boudreau, & Chen, 2010). As sustainable information is needed at both the macro and micro levels, it requires a multi-level approach that provides information and metrics that can drive high-level strategic corporate/regional sustainability plans (Curry, Guyon, Sheridan, & Donnellan, 2012) as well as low-level actions like improving the energy efficiency of an office worker, a server.

Green IS has been applied to a number of problems, from optimising logistical networks (Watson, Boudreau, Li, & Levis, 2010), to buildings, data centres (Curry, Hasan, White, & Melvin, 2012), and even cities. In order to understand how Green IS can enable transformations that improve sustainability it is important to perform a holistic systems-based impact analysis. Elliot provides an impact-oriented, transdisciplinary, multifaceted conceptual framework for business transformation (Elliot, 2011). Grounded in general systems theory, the framework categorizes the environment and five categories of stakeholders (Society, Government, Industry & Alliances, Organizations, Individuals & Groups in Organisations) as separate but interactive systems within a single ecosystem.  The framework can be used to understand the impact of Green IS in reducing environmental contamination, developing technology-enabled solutions, and generating sustainable business opportunities

## ENERGY INFORMATICS

The research field of Energy Informatics (Watson, Boudreau, & Chen, 2010), a sub-field of Green IS, recognizes the role that Information Systems can play in reducing energy consumption, and thus $CO_2$ emissions. Energy information systems are concerned with analysing, designing, and implementing systems to increase the efficiency of energy demand and supply systems. The core idea requires the collection and analysis of energy data sets to support optimization of energy.

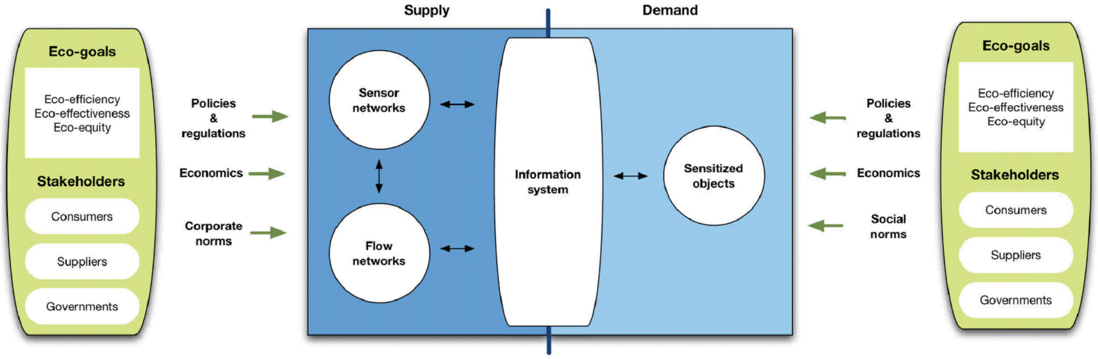


Figure 1 Energy Informatics Framework (Watson, Boudreau, & Chen, 2010)

The Energy Informatics Framework (Watson, Boudreau, & Chen, 2010), as illustrated in Figure 1, addresses the role of the information systems in the management and optimization of energy. The key components of the framework are:

***Supply and Demand:*** There are two parties to any energy consumption transaction: a supplier and a consumer. Both sides have a common need for information to manage the flow of the resources they deliver and consume.

***Energy System Technologies:*** Three types of technology are present in an intelligent energy system 1) *Flow network:* a set of connected transport components that supports the movement of continuous matter (e.g. electricity, oil, air, and water) or discrete objects (e.g. cars, packages, containers, and people) 2) *Sensor network:* a set of spatially distributed devices that reports the status of a physical item or environmental condition (e.g. air temperature, location of a mobile object) providing data that can be analysed to determine the optimum use of a flow network. 3) *Sensitized object:* a physical good that a consumer owns or manages and has the capability to sense and report data about its use (i.e. GPS in a car, smart appliance).

***Information System:*** An information system ties together the various elements to provide a complete solution. It has several important functions from collecting data from the sensor network and feeding them into flow optimization algorithms, to transmitting data to automated controllers in the flow network to dynamically change a network based on the output of the optimization algorithms.

***Key Stakeholders*** The three most critical stakeholders in typical energy supply/demand system suppliers, governments (regulators), and consumers.

***Eco-Goals:*** The sustainability literature has identified three broad sustainability goals, Eco-efficiency (competitively-priced and reducing ecological impacts and resource intensity), Eco-equity (social responsibility), and eco-effectiveness (working on the right products and services)

## FUTURE RESEARCH DIRECTIONS

Many organizations think sustainability requires a significant transformational change, yet the ultimate goal is to embed sustainability into business-as-usual activities. Improving sustainability performance (Donnellan, Sheridan, & Curry, 2011), especially through changing the way an organization operates, requires a number of practical steps which will include the need for a systematic approach for information-gathering and analysis (Curry, Hasan, Hassan, Herstand, & O'Riain, 2011).

While organisations are fighting a data deluge within their information systems (Cukier, 2010), there is a significant lack of data on sustainability concerns. A 2010 survey of more that 600 Chief Information Officers and Senior IT Managers highlighted that few organisations are performing well at measuring the effectiveness of their sustainability efforts (O'Flynn, 2010).

The paucity of sustainable information within organisations is a significant challenge and one that needs to be addressed if sustainable IT efforts are to deliver on their potential. Determining the granularity for effective sustainable data is not well understood and research is needed to define the appropriate level of usefulness (Watson, Boudreau, & Chen, 2010). The appropriateness of information will also be highly dependent on the Stakeholders and the task or decision at hand. Sustainable IT will need to be flexible to provide the appropriate level of information for the given situation.

Emerging next generation smart environments such as Smart Grids, Smart Cities, and Smart Enterprises are complex systems that require a complete and holistic knowledge of their operations for effective decision-making. Multiple information systems currently operate within these environments and real-time decision support will require a System of Systems (SoS) approach to provide a functional view of the entire environment to understand, optimize, and reinvent processes. The required system of systems will need to connect systems that cross organizational boundaries, come from multiple domains, (i.e. finance, manufacturing, facilities, IT, water, traffic, waste, etc.) and operate at different levels (i.e. region, district, neighborhood, building, business function, individual). These SoS pose many significant challenges, including the need for flexible mechanisms for information interoperability that require overcoming conceptual barriers (both syntax and semantic) and technological barriers. Overcoming these challenges will require rethinking the design and approach to interoperability of green information systems using decentralized information management approaches such as Semantic Web and Linked Data (Curry, 2012).

In addition to these technological challenges many other challenges exist for Green IS research, and Melville (Melville, 2010) has outlined these under six themes:

**Context:** How do the distinctive characteristics of the environmental sustainability context, such as values and altruism, affect intention to use and usage of information systems for environmental sustainability?

**Design:** What design approaches are effective for developing information systems that influence human actions about the natural environment.

**Causality:** What is the association between information systems and organizational and sustainability performance?

**New Business Models (e.g. cloud computing):** What is the association between IS and cloud computing from an efficiency and environmental perspective?

**Systems Approaches:** How can systems approaches shed light on organizational and environmental outcomes that result from the use of IS for environmental sustainability?

**Models/Metrics:** Multi-level models and metrics that encompass enterprise-wide sustainability initiatives

## BIBLIOGRAPHY


Cukier, K. (2010). A special report on managing information: Data, data everywhere. *The Economist*, *12*(8). doi:10.1038/nsmb0805-633

Curry, E. (2012). System of Systems Information Interoperability using a Linked Dataspace. *IEEE 7th International Conference on System of Systems Engineering (SOSE 2012)* (pp. 101–106).

Curry, E., Guyon, B., Sheridan, C., & Donnellan, B. (2012). Developing an Sustainable IT Capability: Lessons From Intel's Journey. *MIS Quarterly Executive*, *11*(2), 61–74.

Curry, E., Hasan, S., Hassan, U. ul, Herstand, M., & O'Riain, S. (2011). An Entity-Centric Approach To Green Information Systems. *Proceedings of the 19th European Conference on Information Systems (ECIS 2011)*. Helsinki, Finland.

Curry, E., Hasan, S., White, M., & Melvin, H. (2012). An Environmental Chargeback for Data Center and Cloud Computing Consumers. In J. Huusko, H. de Meer, S. Klingert, & A. Somov (Eds.), *First International Workshop on Energy-Efficient Data Centers* (pp. 117–128). Madrid, Spain: Springer.

Donnellan, B., Sheridan, C., & Curry, E. (2011). A Capability Maturity Framework for Sustainable Information and Communication Technology. *IEEE IT Professional*, *13*(1), 33–40. doi:10.1109/MITP.2011.2

Elliot, S. (2011). Transdisciplinary Perspectives on Environmental Sustainability: A Resource Base and Framework for IT-Enabled Business Transformation, *35*(1), 197–236.

Melville, N. P. (2010). Information Systems Innovation for Environmental Sustainability. *MIS Quarterly*, *34*(1), 1–21.

O'Flynn, A. (2010). Green IT: The Global Benchmark. Fujitsu.

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.

Watson, R. T., Boudreau, M.-C., Li, S., & Levis, J. (2010). Telematics at UPS: En route to Energy Informatics. *MIS Quarterly Executive*, *9*(1), 1–11.