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# Unpacking Green IT: A Review of the Existing Literature

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# Unpacking Green IT: A Review of the Existing Literature

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## ABSTRACT

Green IT is the latest manifestation of sustainable business practices. The decision surrounding whether or not to implement Green IT strategies, policies, and tools provides compelling challenges for organizations. While practitioners have been highly interested in this topic for a while, recently, there is also a growing interest on this topic among academicians. In this paper, we conduct a comprehensive review of both the practitioner and academic literature surrounding Green IT. By presenting the overlaps and differences between both perspectives, we aim to identify noticeable gaps in the current literature. By presenting research questions, we aid scholars in determining rigorous academic research directions of this phenomenon.

## Keywords

Green IT, literature review, environment

## INTRODUCTION

As firms react to the challenge of rising energy prices and other related impacts to their bottom lines, many find themselves facing increased pressure to reduce their carbon footprint, emissions, or other metrics as a result of pressures from political and social actors. Given this focus on reducing energy costs (at a minimum), one component of environmental friendliness is the phenomenon of Green IT. The EPA told Congress in 2007 that data centers in the U.S. used 61 billion kilowatt-hours in 2006 (1.5% of all the power used) at a cost of \$4.5 billion (InformationWeek, 9/2007). Both the EPA report and McKinsey (2008) among others, say that IT could reverse this trend significantly by enabling practices such as telecommuting and productive (non-wasteful) use of energy. Green IT is experiencing an exponential growth in terms of its relevance, and this is reflected in current events. In December 2009, Copenhagen, Denmark hosted the United Nations Climate Change Conference, and Green IT was a key topic of focus for the 192 members of the United Nations.

Given the focus on Green IT amongst practitioners, it is not a surprise that it is slowly becoming a topic of increasing importance amongst academics. Recently, the Information Systems discipline's premier conference, ICIS 2009, hosted a Green IT track for research papers. Even though Green IT is quickly becoming an important topic of study in the IS field, there is still a noticeable lack of published research in this area. Given the breadth of this topic, to further academic research on Green IT, it is important to identify the core areas that need investigation.

Our initial review suggests a few key areas that need examination in research surrounding Green IT. Firstly, there seems to be a *gap in an understanding of what is meant by Green IT*, which we believe is an important first step, before any rigorous academic research can be conducted on it. Further, Murray (2009) reports that public sector IT managers are deeply concerned over their ability to successfully implement Green IT. In that study, more than two-thirds of senior public sector IT managers expressed serious concerns about "their organizations' ability to meet the government's green IT targets". Murray's (2009) study seems to suggest that the *adoption/implementation of Green IT is often cumbersome*, and wrought with failures. Yet, failure to successfully adopt green IT policies can undermine an organization's efforts to meet governmental regulations, and therefore run the risk of severe penalties.

Given much of the challenges surrounding Green IT, we thus believe that rigorous scholarly work is required in the area of Green IT, in an effort to help practitioners address some of the areas highlighted above. The specific objective of this paper is to review the current literature on Green IT studies from both the academic and practitioner journals and publications in order to identify gaps that need to be filled with rigorous academic research.

## BACKGROUND OF GREEN IT

### Green Practices and Initiatives

Environmentally sound (or sustainable) practices can be traced back almost as far as a researcher would care to go. Perhaps the more important question is the motivation and the degree of emphasis at varying times in history, behind what are often called green practices. Some in the “green movement” would suggest that “green” is a reaction to the excesses resulting from the development of Western societies and the waste generated from that development. Rather than continuing to emphasize growth at any cost, the green movement suggests that the relationship between humans and their environment must not be taken for granted. Gradually, the ideas of sustainability and environmentally friendly practices evolved into what are now almost mainstream acceptance and usage by individuals and organizations. For purposes of our discussions in this paper, we also make a distinction between “green” and sustainable. “Green” usually means energy efficient and environmentally friendly and “sustainable means planning and investing in a technology infrastructure that serves the needs of today as well as the needs of tomorrow while conserving resources and saving money” (Pollack, 2008, p. 63).

As green practices became more and more common in organizations, at all levels, oil prices reached \$100 a barrel in January 2008. A “wake-up call” as popular usage has it, must have been heard in IT departments around the developed world.<sup>1</sup> As firms reacted individually to the challenge of escalating energy prices and other related impacts to their bottom lines, many also found themselves facing increased pressure to reduce their carbon footprint, emissions, or whatever other metric of choice was the focus for variety of regulatory, political, and social actors in their respective domains. Even firms that had not been adopting green practices as a consequence of a commitment to environmental and sustainable operations as part of their business, found themselves facing a whole new reality. They were now going to have to look at every aspect of their business with a “green lens” or face the consequences.

Given the focus on saving money on energy costs (at a minimum), Green IT could be seen as just a way to reduce what McKinsey research (2008) estimates will be three percent of worldwide greenhouse gas (GHG) emissions in 2020. Perhaps even more important, both the EPA report and McKinsey (among others), say that IT could reverse this trend significantly by enabling practices such as telecommuting and productive (non-wasteful) use of energy. Some, however, like Orsato (2006), suggest that green practices can be a source of competitive advantage. He suggests that by making the right choices, such as money spent on what he calls “eco-investments,” can transform a company. The framework he proposes for general green strategies can be applied to Green IT strategies as well—especially when Green IT strategies are aligned with the overall strategies of the organizations in which they are implemented.

### Green IT Definition and Relevance to the IS Discipline

According to Benbasat and Zmud (2003), the IS discipline should deal with “IT artifact and its immediate nomological net”. The IT artifact is defined as “the application of IT to enable or support some task(s) embedded within a structure(s) that itself is embedded within a context”. In the context of Green IT, the concept can be reframed as the application of IT to enable more environmentally friendly processes within organizations. Therefore, Green IT can be viewed as a specific kind of IT artifact and IS researchers need to understand how it can impact the organization, environment, and so on. Sidorova et al. (2008) define the IS discipline as “how IT systems are developed and how individuals, groups, organizations, and markets interact with IT”. Green IT can introduce environmentally friendly business processes to organizations and environmentally healthier products to markets.

A key question that can be raised is what is meant by Green IT. Murugesan (2008) suggests that Green IT is:

"the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment. Green IT also strives to achieve economic viability and improved system performance and use, while abiding by our social and ethical responsibilities. Thus, green IT includes the dimensions of environmental sustainability, the economics of energy efficiency, and the total cost of ownership, which includes the cost of disposal and recycling. It is the study and practice of using computing resources efficiently."

To understand and study Green IT comprehensively, we must consider that Green IT involves power consumption and management, manufacturing practices, data center design and operations, recycling and end-of-life concerns for computer

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<sup>1</sup> Our paper is focused on Green IT as practiced in highly industrialized nations; it does not seek to examine the challenges of IT practices, let alone Green IT practices, in developing countries.

equipment, total cost of ownership issues, both micro and macro-economic issues, systems performance and efficient systems use, and environmental, social, and ethical practices relating to IT acquisition, use, and disposal.

Thus, for this paper, we do not define Green IT as purely the hardware component of IT, but as an inclusive concept that goes beyond the working definition provided by Murugesan (2008). At this time, it is also important to make a distinction between Green IT and Green IS for the purpose of this paper. Watson et al. (2008) state that Green IT is mainly focused on energy efficiency and equipment utilization, whereas Green IS, in contrast, refers to the design and implementation of information systems that contribute to sustainable business processes. Our definition of Green IT includes the ideas of Murugesan's definition, but encompasses the technology, the human aspect, and the organizational mindset and culture concerning Green IS as well. In other words, we take a sociotechnical view of Green IT (Markus and Robey, 1988). Specifically, we categorize Green IT in two ways: 1) the initiatives that utilize IT infrastructure to change organizational processes and/or practices to improve energy efficiency and reduce the environmental impacts, and 2) environmentally healthier IT products and/or services.

## LITERATURE REVIEW

### Practitioner Literature

To get a sense of what is being discussed in the practitioner literature, we reviewed multiple practitioner-related journals, including *Communications of the ACM*, *CIO* and *PC World*. Additional articles that are relevant and useful for our study have also been included in this paper. We found that the first time the term "Green IT" appeared was in 2007 in the *CIO* magazine, so we consider 2007 as the start year of our literature search. Table 1 lists a sample of practitioner studies.

Journal/Conference	Reference	Topic/Research Question	Category	Conclusion
CACM	Kurp (2008)	News about green computing	Adoption choice (cost); Eco-Efficiency	Much of the green computing movement's focus is on data centers
CACM	CACM Staff (2007)	In Search of Greener Pastures	Adoption choice (social pressure)	Report predicts environmental pressures will force companies to find greener ways
CACM	CACM Staff (2007)	IBM allow owners to monitor mainframe power usage	Post Adoption (energy usage); Eco-Efficiency	IBM is going to report power consumption on servers
CIO	Overby (2007)	Introduction of new technology into data center	Adoption choice (cost and strategy); Eco-Efficiency	VistaPrint to save \$500,000 and cut emissions. Benefits go beyond saving money
CIO	Beach (2008)	Talk with Michael Dell about Green strategy	Adoption choice (strategy); Eco-Collaboration	Make green a strategic pillar of the firm
CIO	Burnham (2008)	Green IT budgets getting cut	Adoption choice (cost)	Economic crashes are bad for Green IT
CIO	Ricknäs (2009)	Greener profits	Adoption choice; Eco-Efficiency	European companies that are serious about green earned a 2% higher profit margin compared to others in the same industry
CIO	Rosenbaum (2007)	Editorial including comments on green business practices and sustainability	N/A	Comments on green practices and sustainability in editor's column in April 1, 2007 issue
CIO	Swanborg (2009)	Raytheon' Green IT strategy	Post Adoption; Eco-Efficiency	Raytheon project showed benefits for company and environment

CIO	West (2007)	Data center management, efficiency, cost management	Post Adoption; Eco-Efficiency	Good practices for managing data center costs
PC World	Perenson (2009)	Reduced power consumption in internal hard drives	Adoption choice (cost); Eco-Efficiency	Saving money and saving power (Western Digital Caviar GP)
PC World	Rebbapragada (2007)	Tips on a "green" office	Adoption choice (cost); Eco-Efficiency	How to save energy and money by good "green" practices
IEEE Computer Society	Murugesan (2008)	How to take advantage of Green IT	Adoption and post adoption; Eco-Efficiency, Innovation and Collaboration	Benefit, Holistic approach to green IT, how to use IT, enterprise Green IT strategy
Online	Mines (2007)	The strategies of Green IT supplier	Post Adoption	Phases Of Green IT Services Engagement and data warehouse solution

**Table 1. Practitioner Literature**

A search of “Green IT” done on a base of business literature yielded thousands of references. For the purposes of our review, obvious advertisements and editorials were eliminated from our analysis. We find what Mingay (2007), writing in a Gartner presentation presented at the World Economic Forum in Davos, Switzerland, called Green IT as a “new industry shock wave”. As Pollack (2008) says in a report on green and sustainable information technology oriented to education, “seldom does a day pass in which we don’t hear or read about sustainability or ‘going green’”. According to GreenerComputing.com (2008), energy efficiency is being used in one way or another to reduce environmental impacts and to cut costs, by at least sixty five percent of IT managers. However, the same survey indicates that forty percent of these managers are concerned about lack of top executive support. Ambivalence about the motivation for green initiatives in IT is evident; many organizations have a heightened awareness level but they may not be completely committed to Green IT beyond simple energy savings. Other organizations see the current challenge as an opportunity and see opportunities beyond cost savings as a result of implementing Green IT practices in their organizations.

The published literature from the practitioner side of information technology falls into four complementary categories (Murugesan, 2008): Green use, Green disposal, Green design, and Green manufacturing. These categories encompass areas of emphasis and activities such as:

- Designs and strategies for environmental sustainability including data center design and location (Cameron, 2009; Going Green with IT, 2008)
- Energy-efficient computing including power management and virtualization (Cloud computing and SaaS) (Big Blue Goes Green, 2007).
- Disposal and recycling practices that are responsible, sustainable, and comply with applicable regulatory requirements along with pollution prevention (Murugesan, 2008)
- Green metrics, assessment tools, and a methodology (ISO 14001) for effective use and practice.

Figure 1, a diagram from Siggins and Murphy (2009), sums up the information discussed in the practitioner literature. There are three orientations to adopt Green IT: eco-efficiency, eco-collaboration and eco-innovation.



**Figure 1. Three-sided Diagram of Green IT in Practitioner Literature**

Murugesan's four categories relate to the three-sided diagram from Siggins and Murphy: Green Use and Green Disposal relate to Eco-Efficiency, Green Design relates to Eco-Collaboration, and Green Manufacturing relates to Eco-Innovation. Therefore, these three factors are discussed throughout the practitioner literature, and Table 2 shows this breakdown.

Category	No. of Articles	%
Eco-Efficiency	9	69.23%
Eco-Innovation	1	7.69%
Eco-Collaboration	3	23.08%
Total Count	13	100%

*Note:* One article may belong to multiple categories.

**Table 2. Categories of Practitioner Literature**

**Academic Literature**

Our review of the literature began with a search of the six premier academic IS journals (*MIS Quarterly*, *Information Systems Research*, *Journal of MIS*, *Journal of the AIS*, *European Journal of Information Systems*, and *Information Systems Journal*). This search did not reveal any rigorous academic research on this topic. The search was then expanded by including other academic journals and conference proceedings, such as *MISQ Executive*, *AMCIS* (Americas Conference on Information Systems), *ICIS* (International Conference on Information Systems), and *PACIS* (Pacific Asia Conference on Information Systems). Additional studies from other conferences or sources were included if they were determined to be relevant and useful for our study. Table 3 shows a breakdown of the categories of the literature reviewed, and Table 4 shows a sample of academic studies<sup>2</sup>.

Category	No. of Articles	%
Benefit (cost and environment)	1	12.5%
Initiation	3	37.5%

<sup>2</sup> Here we only list the papers from IS literature. Relevant studies such as Jorgensen and Jorgensen (2009) are used in the discussion but not included in the table.

Framework for adopting Green IT	1	12.5%
Enterprise Green IT Strategy	3	37.5%
Total Count	8	100%

Note: One article may belong to multiple categories.

**Table 3. Categories of Academic Literature**

Journal/Conference	Reference	Topic/Research Question	Category	Conclusion
ACIS 2009	Molla et al (2008)	A Green IT Readiness Framework	Adoption choice;	Attitude, policy, practice, technology and governance are the five drivers that enable enterprises to deploy environmentally sustainable IT and IT processes
PACIS 2009	Sarkar and Young (2009)	Managerial attitude of Green IT	Adoption choice	Attitudes will be transformed into action when a sound model exists, supplemented with articulately designed long-term awareness programs
PACIS 2009	Vykoukal et al (2009)	Relationship between Green IT and Grid Technology	Adoption choice; Eco-Efficiency	Green IT (Grid technology) has economical and ecological benefits. It also increases the companies' competitiveness
PACIS 2009	Molla (2009)	Organizational motivation for Green IT	Adoption Choice; Eco-Efficiency, and Eco-Collaboration	A Green IT-Reach-Richness Matrix to classify Green IT strategies and initiatives
AMCIS 2009	Mann et al (2009)	The implementation framework of Green IT	Post Adoption	Three step implementation framework for Green IT
AMCIS 2009	Sayeed and Gill (2009)	Explore the implementation of Green IT measures	Post Adoption; Eco-Efficiency and Eco-Collaboration	By mobilizing their dynamic resources, the organizations are able to leverage Green IT implementation for strategic purposes
MISQ Executive	Weiss (2009)	UPS experience with Green IT	Post Adoption; Eco-Collaboration	Collaboration between IT and other business units at UPS to implement "green" and sustainable practices

**Table 4 Academic Literature**

By reviewing these papers, four categories of Green IT are identified (also refer to table 4)<sup>3</sup>:

#### 1. The Benefits of Green IT

There are two major categories of benefits: environmental and cost benefits.

<sup>3</sup> One paper may contain several categories of content.

For environmental benefits, Jørgensen and Jørgensen (2009) examine the potential environmental risks related to IT together with nanotechnology and biotechnology, and recommend future study of the relationship between technology and society, which implies that IT needs to be environmentally green.

Cost reduction is a major benefit of Green IT. For example, Hopper and Rice (2008) show how system-level optimizations of power consumption could be achieved, which in turn can lower the operating costs. In another study, Vykoukal et al (2009) argue that Green IT initiatives (Grid technology) have economical benefits for company.

## *2. Initiation (When to adopt Green IT)*

Molla et al (2008) evaluated the readiness of organizations' adoptions of Green IT. They find that there are five important factors of success in Green IT – attitude, policy, practice, technology and governance – which together determine if the organization is ready to adopt Green IT. The combination of these five factors is unique to each organization, and enables the organization to deploy environmentally sustainable IT and IT processes. Later, Molla (2009) develops a matrix to classify motivation in the adoption of Green IT. In another empirical study, Sarkar and Young (2009) find that the existence of an effective cost model and awareness programs surrounding Green IT will influence managerial attitudes towards Green IT.

## *3. Framework for adopting Green IT*

Mann et al. (2009) developed a three step implementation framework for Green IT: determine external and internal factors, determine the sophistication of the strategy, technology and processes, and measure sustainability of the proposed venture.

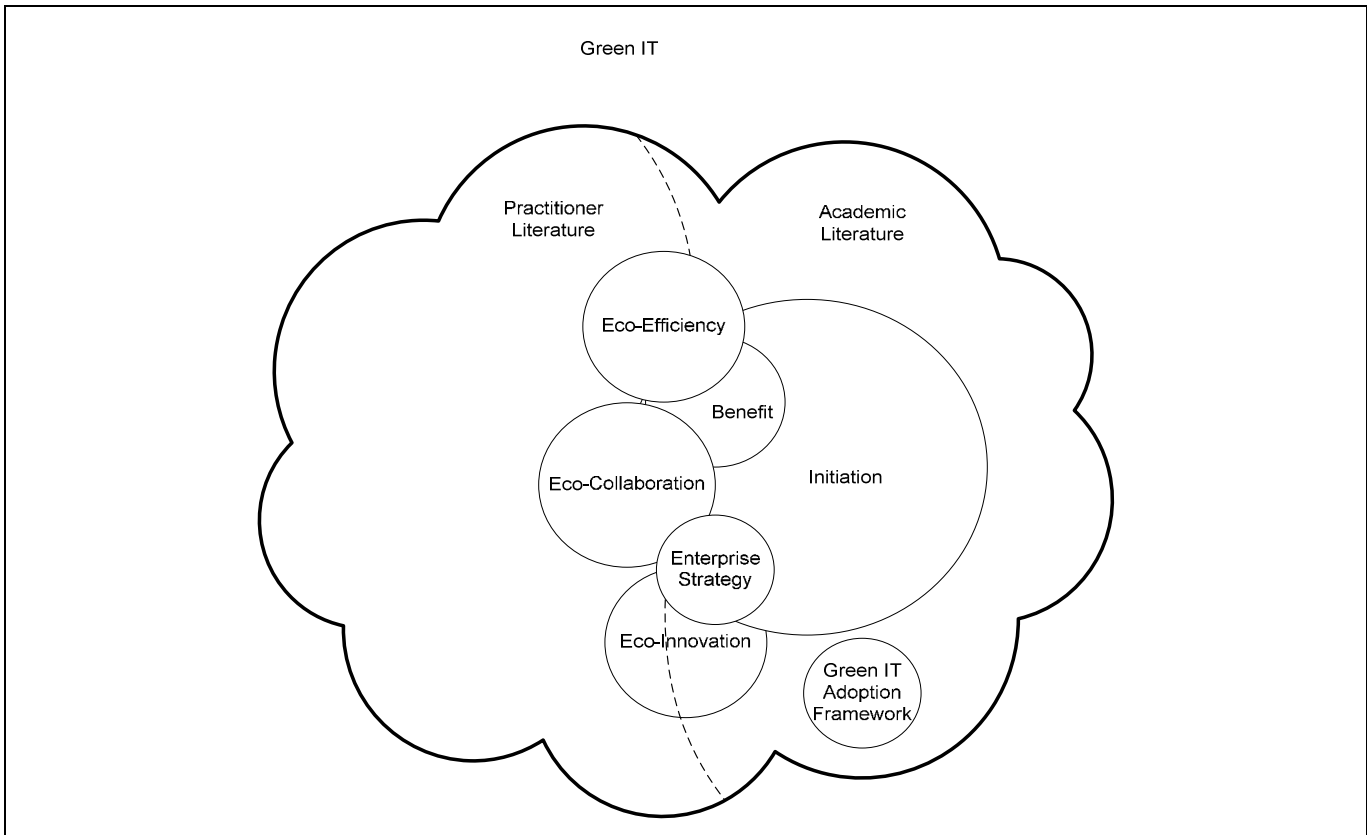
## *4. Enterprise Green IT Strategy*

Vykoukal et al. (2009) argue that Green IT can increase the companies' competitiveness. In another study, Sayeed and Gill (2009) show that by mobilizing their dynamic resources while implementing Green IT, organizations are able to take advantage of Green IT for strategic purposes. Although not closely related to Green IT, Weiss (2009) talk about how to use IT to reduce miles of travel and improve vehicle parts replacement “through a structured approach of gathering data, analyzing that data, and simplifying jobs.” Consistent with Molla (2009), IT can not only measure the energy being used but also reduce it.

## **ASSESSMENT OF CURRENT STATE OF GREEN IT RESEARCH**

After reviewing the content from the practitioner and academic literature, there appears to be many overlaps between them; both communities discuss the benefits of Green IT, provide recommendations as to when an organization should start to adopt Green IT, and how an organization should become “green” and the strategies to employ when making the green decision (refer to Figure 2).





**Figure 2. Focus and Overlap in the Reviewed Literature<sup>4</sup>**

Have we as IS researchers done a sufficient job of studying Green IT? To date, arguably, we have not. The reasons are as follows:

1. The number of papers we identified in our review of the research literature is limited. To be specific, no papers on Green IT have yet appeared in the six premier MIS journals.
2. Limited theories have been developed and applied relating to Green IT.
3. Few empirical studies of Green IT have been performed.

Thus, the academic research in Green IT is still immature, and we suggest the IS research community needs to focus more on this increasingly important topic.

### RESEARCH QUESTIONS FOR FUTURE STUDIES

Based on our review of the practitioner/academic research, we propose a total of three research questions that span the timeline of Green IT implementation/adoption. These three questions should receive the initial focus from the IS academics.

The beginning of the timeline concerns deciding whether or not to adopt the specific Green IT technology or process. Therefore, the first research question we propose is: “What are the motivational drivers *for a company to choose to begin Green IT adoption?*” Motivational drivers for the Green IT adoption decision are not evident in the literature reviewed. Prior research on Green IT initiation focused mainly on understanding when organizations are “ready” to adopt Green IT initiatives (Molla, 2009; Molla et al. 2008). While we agree that readiness is an important topic for Green IT research, organizations do not necessarily begin Green IT adoption when they are ready for it. Since only one study (Sarkar and Young, 2009) examines the factors which motivate organizations to adopt Green IT, this topic needs more attention in future research.

<sup>4</sup> Please note that the figure is to represent the overlap and interrelationship between practitioner literature and academic literature. The size of each circle does not represent the number of previous studies.

Following the understanding of the motivational drivers for adoption/implementation, the second research question that we propose is concerned with the adoption/implementation process: “*How should the firm manage the process of Green IT adoption?*” This question is especially critical since as we have discussed earlier, practitioner articles have repeatedly highlighted the challenges associated with successfully adopting and implementing Green IT.

Finally, after the adoption/implementation has been completed, there are still considerations to keep in mind. Given that the effects of Green IT adoption/implementation do not end when the "official" process has been completed, an important research question to address would be: “*What are the impacts (net benefits and risks) of the adoption of Green IT?*”

Research studies utilizing these three research questions will be effective in filling the gaps in the current body of literature determined by the literature review.

## CONCLUSIONS

In this paper, we reviewed the practitioner and academic literature for studies concerning the phenomenon of Green IT. The purpose of this review is to identify what the current status of Green IT research in the IS discipline is. We find that although the IS community is beginning to pay more attention to this important topic, more rigorous effort is needed to more fully understand the complexities of Green IT. We hope that our work will help researchers identify potential focuses in future studies.

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