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A Techno-Economic Perspective of Green IT Implementation in Europe and the US

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Abstract

The present paper investigated the implementation of environmentally responsible IT measures in ten American and nine European organizations. The environmentally responsible IT measures include the implementation of existing hardware and software technologies as well as organizational and managerial actions that aim to reduce environmental impacts of IT use. As a result, adoption of Green IT measures requires adjustments that may modify the physical IT infrastructure and various organizational processes. These adjustments to organizational processes in addition to the infrastructure are 'techno-economic' in nature. The term techno-economic denotes concurrent consideration of technological, social, and economic issues surrounding an innovation. We interviewed at least two executives in each of the organizations in our study to assess the extent of Green IT implementation. Based on the analysis of these interviews, we conclude that the techno-economic adjustments were necessary for widespread implementation of environmentally responsible IT measures.

Keywords: Green IT, Data Center Management, Energy Efficiency, Environmental Responsibility, Organizational Development, Corporate Strategy.

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Introduction

The present paper analyzes Green IT implementations in organizations from a 'techno-economic' perspective. The term techno economic, originating in sociology and evolutionary economics, posits that the study of certain technological changes must consider concomitant social and economic changes (Hull, Walsh, Green and McMeekin, 1999) as well. According to this perspective, the study of a technological change or innovation will result in a comprehensive understanding if the research focuses on the linkages among the technological, social and economic adjustments resulting from the implementation of the innovation. Therefore, the implementation of Green IT initiatives in organizations can be analyzed using the techno-economic perspective because environmentally responsible IT initiatives embody changes in organizational processes in addition to the physical IT infrastructure (Sayeed and Gill, 2008).

The present paper is organized as follows. A description of Green IT initiatives in organizations will be followed by a discussion of the techno-economic literature. A proposition on the relationship between Green IT and techno-economic considerations will be developed based on these discussions. The section on methodology will describe an empirical study to collect and analyze data to evaluate the proposition. Finally, the discussion and conclusions sections will provide the analysis of the collected data and directions for future research.

Green IT

Continued growth in the use of Information Technology (IT) for information processing by organizations has environmental consequences. As more and more paper based tasks migrate to electronic data processing, the demand for energy and material resources increases as well. In addition to information processing tasks related to data processing, pervasive use of IT in all facets of organizational operations (such as communication networks) requires further resources. Moreover, disposal of depreciated electronic equipment used in information processing tasks necessitates environmentally responsible handling processes. It is clear that as we continue to increasingly migrate toward a distributed, online, and electronic work environment, we affect the physical environment around us. Despite the significance of this issue, academic researchers in Information Systems (IS) have paid little or no attention to the relationship between IT use and environmental sustainability. IS practitioners, on the other hand, are very much aware of this issue (Brill, 2007). Moreover, the US government also has recently paid attention to the environmental impacts of IT use as indicated by a recent report from the Environmental Protection Agency report (2007). For the purposes of gauging environmental impacts, organizational activities that use IT can be very broadly categorized as: (1) data processing tasks performed by corporate data centers, and (2) all other non data center information processing tasks that require IT for support and execution. The issue of energy consumption by data centers has recently received the US Environmental Protection Agency's (EPA) attention (US EPA, 2007). We will first present environmental sustainability issues relevant to data center operations followed by all other non data center information processing tasks.

Many factors contribute to the growth in data center activities including the increased use of: electronic transactions, internet communications and entertainment, electronic medical records, satellite navigation, electronic shipment tracking, the internet to publish government documents, government regulations requiring digital records retention, digital provision of government services, high performance scientific computing, etc. A report published in August 2007 by the EPA in response to a request from Congress noted that the U.S. data centers are experiencing major growth through

increasing demand for data processing and storage capacities. Data centers consumed 61 billion kilowatt-hours (kWh) in 2006 accounting for $4.5 billion in cost and 1.5 percent of total U.S. electricity consumption. The report noted that corporate and government data centers have adopted and continue to adopt technological measures to reduce energy consumption. Despite these efficiency trends, the EPA estimates that national energy consumption by data centers will most likely increase to more than 100 billion kWh by 2011 accounting for $7.4 billion.

In addition to the data centers, IT supports day to day operations of present day enterprises ranging from end user information processing tasks to supply chain activities. Thus far, the EPA has not assessed the environmental impact of non data center activities. However, IT as a whole leaves a carbon footprint that is a combination of centralized and non-centralized data centers and non data center activities. "When it comes to emissions, ICT is on a par with aviation…… Yet these numbers look less frightening if,….., ICT's 'enabling effect' is taken into consideration…..ICT could help to reduce emission in other industries by 7.8 billion tons by 2020, or five times ICT's own footprint" (The Economist, 2008).

Although academic researchers have not addressed sustainability issues related to IT use, a considerable body of research has developed around the relationship between environmental sustainability and corporate strategy (e.g., Anderson and Bateman, 2000; Bansal and Roth, 2000; Florida, 1996; Marshall and Brown, 2003; Rugman and Verbeke, 1998; Russo and Fouts, 1997).

The Techno-Economic Considerations

The distinction between infrastructure and techno-economic changes is discussed by Carlota Perez (1983). Adoption of Green IT initiatives engenders changes that include techno-economic as well as infrastructure adjustments. Techno-economic adjustments pertain to managerial and organizational processes of a firm while infrastructure adjustments address the potential of the current technological state of the firm to accommodate future technological transitions. Examples of techno-economic adjustments include organizational design issues such as changes in the level of formalization, decentralization and complexity, among others. For example, implementation of flexible telecommuting and reorganization of workforce require techno-economic adjustments. On the other hand, examples of infrastructure adjustments include changes in physical processes, methods, techniques, and equipments in order to implement Green IT measures.

Two concepts are central ideas in techno-economic considerations. These are the 'Techno-Economic Network' (TEN) and the 'Techno-Economic Paradigm' (TEP). Callon (1991, 1992) originally developed the concept of TEN which is rooted in the field of sociology. TEN integrates the role of dynamic relationships among various actors in the society and the flow of intermediaries in promoting a specific technological innovation. The concept of TEN views the interaction among the actors as a critical factor in promoting and implementing an innovation.

The concept of TEP, on the other hand, is rooted in the writings of evolutionary economists such as Perez (1983) and Freeman (1987). TEP is concerned with explaining economic changes as a result of technological shifts. TEP analyzes the compatibility of the technological infrastructure with economic growth rate over the long run. As a specific technology evolves, the economic, social and institutional changes must be aligned to support the adoption of the technology. The focus of the TEP concept is on aligning organizational and economic linkages of a technology with its growth.

Based on the above discussion, we formulate the following proposition:

P1: The firms that include techno-economic considerations in the adoption of Green IT measures will be further along in their implementation efforts than the firms that do not include techno-economic considerations.

Research Methodology

We used a qualitative approach in our data gathering and analysis efforts. Qualitative methodology is appropriate for exploratory investigations (Chua, 1986; Lee 2009). For analyzing the data, we used inductive analysis (Bansal and Roth, 2000).

In order to investigate the TEN and TEP, we initially intensively interviewed eight Green IT evangelists who were based in the US and Europe. We identified them through internet based searches. The goals of our initial interviews were to: 1) construct a set of interview questions that would be useful for eliciting information from organizations that are implementing Green IT technologies and initiatives, and 2) identify appropriate executives in organizations who would provide us with reliable information regarding environmental impacts of IT use and their organizational initiatives. Our interviews with the Evangelists helped us prepare twenty six interview questions for the Chief Information Officer (CIO) which we refined during our interviews. All eight Green IT evangelists opined that, in addition to the CIO, the executive in charge of facilities and physical plants would be the person we would need to interview in practitioner organizations to collect appropriate information regarding the management of environmental impacts of IT use. Following are the questions for the CIOs interviewed in this study which we modified while interviewing other executives in the organizations.

1. Tell us about your company: revenue, number of employees, size of IT (number of servers and employees), IT centralized/decentralized, CIO reporting to CEO/CFO, type of company?
2. Is there an environmental /sustainability action plan in your company? If yes, does this action plan include Green IT (GIT)?
3. Is there a sustainability manager or an equivalent in your company?
4. Is GIT a corporate issue or just an IT issue?
5. Is there a restructuring of capital costs and operating costs as a result of GIT? If yes, does the restructuring involve the CFO or only the IT department and facilities/operations department?
6. Do you have any policy to encourage GIT to your users? If yes, what are the policies?
7. What is the size of your data centers? ___ sq ft, How many? ____Mid Tier; ____ Enterprise
8. Does GIT influence your purchasing/procurement decisions (e.g., buy Energy Star)?
9. What metrics are being used to measure power consumption in data centers? Do you plan to use these metrics for benchmarking purpose?
10. Have you set specific targets for data centers to be achieved by your GIT initiatives?
11. Which of the following GIT measures have you adopted? We used the list of the measures compiled by Sayeed and Gill (2008).
12. Do you consider GIT in your evaluation of outsourcing/collocation facilities?

13. When and under what circumstances did you adopt the GIT measures above?
14. Has the EPA played any role in your GIT adoption?
15. Do you think GIT measures impact your company's profitability/bottom line?
16. What are the broader organizational advantages of GIT beyond financial reasons?
17. Has GIT led to the redesign of your data centers or other physical facilities?
18. Did the implementation of GIT measures require or engender cooperation from other departments?
19. Has GIT influenced your human resource capabilities?
20. Does GIT have any impact on your firm's reputation?
21. Do you seek a leadership position on GIT within your industry?
22. What are the organizational barriers or resistance to GIT?
23. How committed are your upper management to GIT?
24. What role do you see standards or regulations having on adoption of GIT (innovation)?
25. Are you aware of any incentives from Federal/State governments or public utilities encouraging GIT?
26. Can you tell us how your organization's IT governance structure helps or hinders GIT? Any conflict with Sarbanes and Oxley Act?

Following our interviews with the Green IT evangelists, we contacted twenty organizations in the US. In ten of these organizations, we interviewed the CIO and the executive in charge of physical plants and operations. In three of these ten organizations, we also interviewed a third manager who was able to provide additional information regarding the data center operations and overall environmental initiatives. We did not include the remaining ten organizations in our data analysis of US organizations because six of these organizations declined our invitation altogether and we were able to interview the CIO only in the other four. Finally, we analyzed thirty one interviews in the US consisting of twenty three executives from ten practitioner organizations and eight Green IT evangelists from public and private sectors. All interviews were audio taped and transcribed. Moreover, both researchers took meticulous notes during the interviews. In general, each interview lasted from forty five to ninety minutes. We also consulted web sites of all the practitioner and evangelist organizations. In addition, we reviewed relevant documents and memos shared by the respondents. In Europe, we were able to interview at least two executives in each of the nine out of ten organizations we had approached.

Practitioner Organization	Business and Ownership	Size: Revenue and Number of Employees	Number of Data Centers (DC) and Servers	CIO Reporting to
Organization 1:	Manufacturing and media service; public	$482 million; >1000 employees	DC 2; 300 servers	COO
Organization 2:	Manufacturing; private	Revenue undisclosed; 250	DC: 1; 50-70 servers	CFO

		employees		
Organization 3:	Software; private	$115million; 320 employees	DC: 2; 120-140 servers	CFO
Organization 4:	Manufacturing and service; public	$1.2 billion; 3400 employees	DC: 25 600+ servers	CFO
Organization 5:	State university	$350 million budget; 4000+ employees	DC: 5; 350-400 servers	VP of Finance
Organization 6:	Manufacturing; public	$1.33 billion; 2700 employees	DC: multiple but exact number not disclosed; 800+ servers	CEO and VP of Business Development
Organization 7:	Electronic manufacturing; private	Revenue undisclosed; 120 employees	DC: 1; 65 servers	CEO and CFO
Organization 8:	Software; public	$3 billion; 8400 employees	DC: 9; number of servers not disclosed	CEO
Organization 9:	Software and storage devices; public	$2.8 billion; 7000 employees	DC: 6; 1,700+ servers	CFO
Organization 10:	Media; private	$500 million; 1200 employees	DC: 19; 1000+ servers	CEO

Table 1. US Organizations in the Study

Tables 1 and 2 display the profiles of the US and European organizations respectively.

We analyzed the data iteratively following Bansal and Roth's approach to inductive analysis. Our goal was to classify the extent of Green IT implementation in each of the nineteen organizations. The US based co-authors individually read the transcripts of the thirty one interviews in the US in addition to their own notes taken during the interviews. The European co-authors used analogous analysis procedure. Based on Lewin's (1947) three stage model of organizational development, we individually classified the nineteen practitioner organizations based on their Green IT initiatives and then conferred on the classification. Our agreement level was very high because we differed on the classification of only one organization which we resolved after a discussion. Following is a discussion of Lewin's three stage model.

Practitioner Organization	Business and Ownership	Size: Revenue and Number of Employees	Number of Data Centers (DC) and Servers	CIO Reporting to
Organization 1	Manufacturing; private	€320 million; 1,200 (up to 2,400 in Q4)	DC: 1 (535 sq. ft.) 30 servers	CEO
Organization 2	Manufacturing; public	€1,1 billion; 3,200 (worldwide €3,9 billion; 12,000)	DC: 1 (963 sq. ft.) – the biggest is outsourced to IBM 30 servers plus one for each production plant (10)	Corporate CFO
Organization 3	Energy; Public	€108 billion; 35,000 (worldwide 70,000)	DC: 4 (32,100 / 42,800 sq. ft.) 3,000 servers	COO
Organization 4	Pharmaceutical company; public	€500 million; 1,000 (worldwide €18 billion; 40,000)	DC: 1 (642 sq. ft.) Consolidation policy towards the UK DC (1000 m2, 605 independent servers)	CEO and Managing Director
Organization 5	Manufacturing; Private	€22 million; 60	DC: 1 (85.6 sq. ft.)	Managing Director
Organization 6	Manufacturing; Private	€10.5 million; 54	DC: 1 (535 sq. ft.)	Group Leader CEO
Organization 7	Energy; Public	€11,563 million; 1,580	DC: 2 350 servers	CEO
Organization 8	Software; private	€3 million; 50 (worldwide $7 million, 90)	DC: 1 (100 sq. ft.) (worldwide 2; 200 sq. ft.)	CEO
Organization 9	State university	€82,63 million; 688	DC: 2	Company Secretary and Rector

Table 2. European Organizations in the Study

We used a three stage model of organizational change to capture the extent of Green IT adoption in organizations. The three stages in the model are *unfreezing*, *changing* and *refreezing*. Figure 1 provides a graphical illustration of the three stage Green IT implementation process in practitioner organizations.

The implementation of Green IT initiatives begins with the *unfreezing* stage. This is when the organizations become aware of the environmental impacts of their IT operations and a formal or informal plan to implement Green IT initiatives and technologies starts to emerge. The organization is

gathering data and concurrently laying the foundation for a course of action to adopt Green IT measures at this stage. We observed that all ten US organizations in our study had reached this stage.

As organizations transition to the *changing* state, they begin to implement Green IT measures. However, they also continue data gathering and enhancing their awareness of the environmental initiatives. Based on the results of their data gathering, they may need to realign their Green IT plans. This realignment and continued information search is reflected in *feedback loop A*. Of the ten US organizations, those labeled 3, 4, 5, 7 and 10 have reached this stage while 6, 8 and 9 have progressed further.

In the third stage- *refreezing*, most if not all of the planned Green IT initiatives have been implemented. However, further alignment of the initiatives and information gathering continues. *Feedback loops B and C* depict the continued data gathering and alignment of Green IT initiatives. US organizations labeled 6, 8 and 9 have reached the refreezing state and the feedback loops.

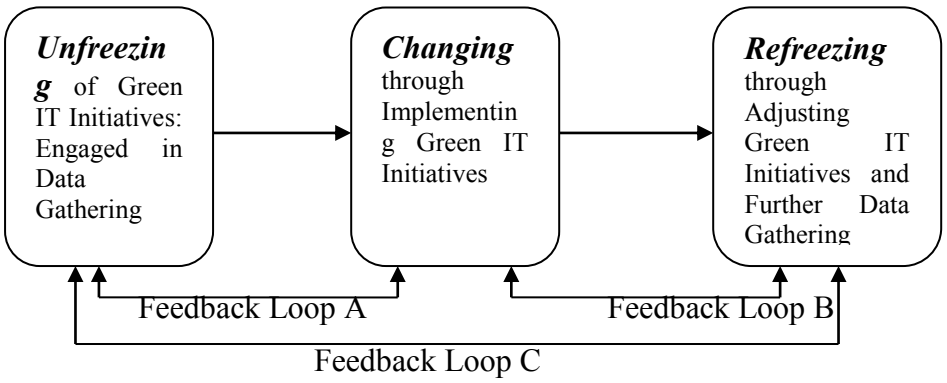
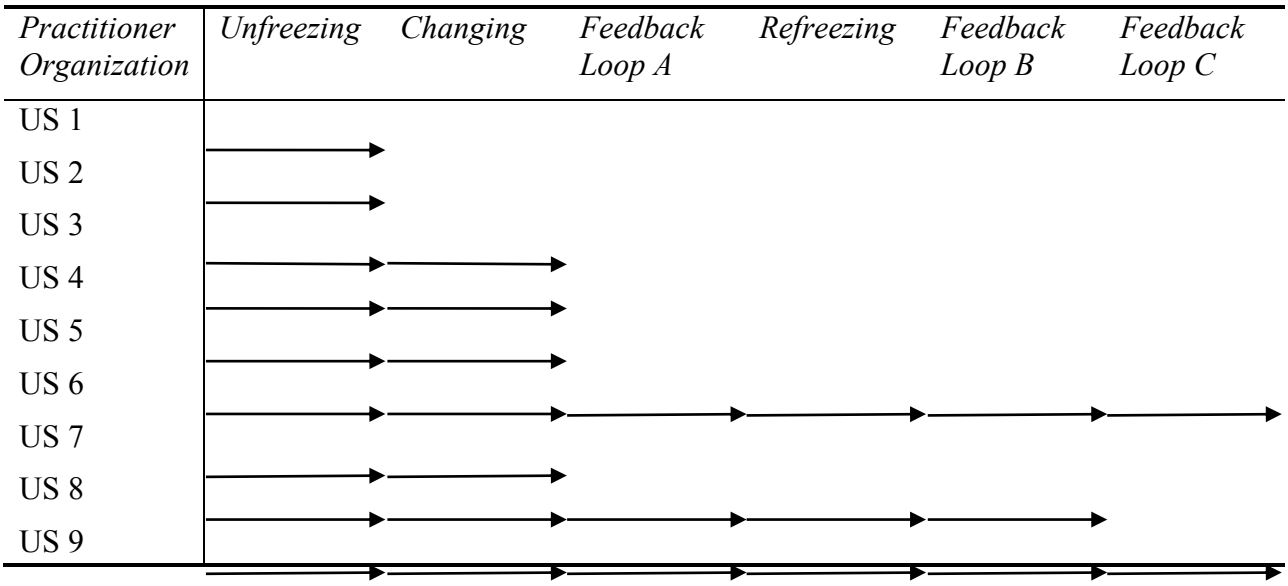


Figure 1. Lewin's Three Stage Model Adopted to Reflect the Extent of Green IT Implementation

Findings

Figures 2 illustrates the extent of Green IT implementation in the US and European organizations respectively.



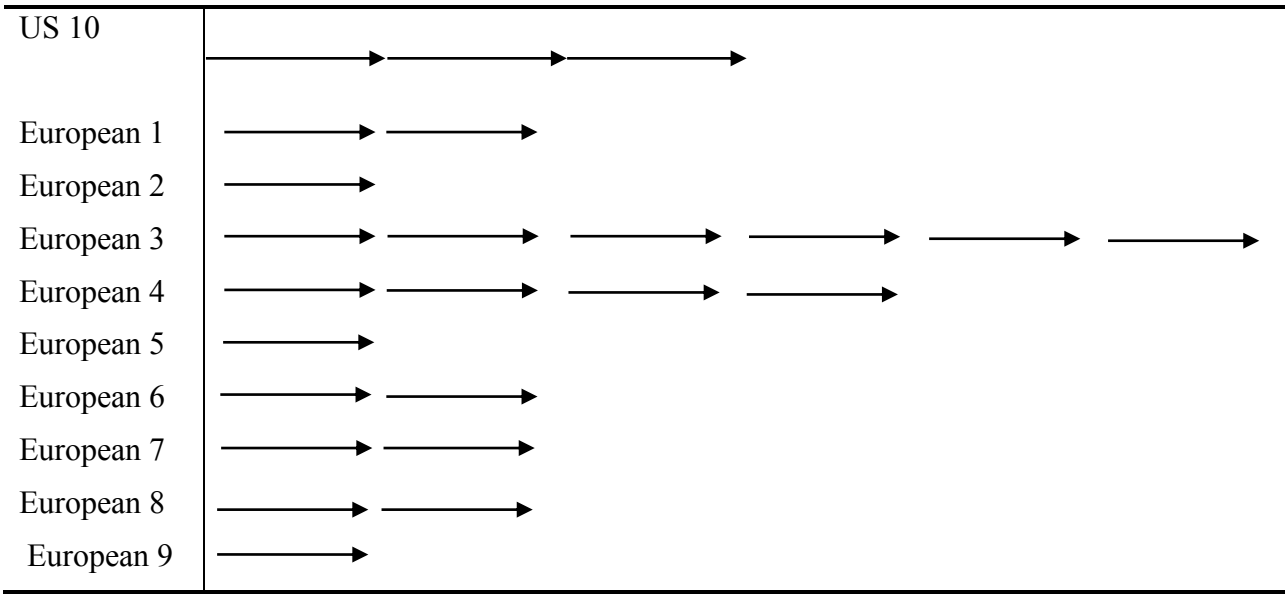


Figure 2. Extent of Green IT Implementation in US Organizations

US organizations 6 and 9 along with the European organization 3 demonstrate that they have completed all three phases and the feedback loops of the Green IT implementation model. US organization 8 and European organization 4 have completed all three phases but have not completed all the feedback loops. Following is a discussion of the US organizations 6, 8 and 9 followed by that of the European organizations 3 and 4.

US Organizations 6, 8 and 9

US organizations 6, 8 and 9 were further ahead, of the ten US organizations described above, in terms of their Green IT implementation practices.

Practitioner Organization 6 was developing a sustainability plan for the entire company. Moreover, they had designated a manager in charge of the initiative. The Green effort was mainly a worldwide corporate effort that was focused on the efficiency of facility utilization and had an acceptable ROI of two to three years. Data center efficiency, however, was on top of the list. Even though the company had implemented a measurement for data center efficiency of BTU/Sq. Ft., they had not set any goals. With respect to E-Waste, it was clear the company had already achieved refreezing. They had implemented an audit practice to account for proper disposal of all E-Waste. The company had applied and received local county Green certification and they had incorporated the LEED Green Building Rating System into their new facility design standards. In general, the company had implemented several infrastructure and techno-economic changes in data centers and the entire organization. Additionally, they were monitoring the impact of these changes such as energy efficiency in the data centers due to Virtualization and other infrastructure improvements. Our interview also revealed that the company had implemented *feedback loop A* for E-Waste, and *feedback loops B and C* for space and power efficiency utilization.

Practitioner Organization 8 had appointed a Director of Sustainability and was actively engaged in initiatives in the IT department, the data centers and the end user environment. The Green initiatives were undertaken with top level executive involvement and commitment. The company was using Green in their marketing activities. Following is an excerpt from the software maker's web site about a new product named Green Snapshot.

"(Name of the company) Green Snapshot gives you recommendations on how to save money by going Greener. It's all based on your (name of the software) data, so there's no extra work for you! With (name of the company) Green Snapshot, it's easy to:

- View a chart that estimates your biggest categories of carbon emissions based on your (software name) expenses with just a few clicks.
- Scroll through recommendations to help your business go Greener and save money. Each idea is clearly written, provides a description of how to take the action and offers links to key resources.
- Share your progress with your customers – give your Green customers a reason to keep coming back!"

In the *unfreezing* phase they had conducted surveys and measurements (using outside consultants) to determine areas of Green improvements in the entire company. They had also conducted a study to determine the company's carbon footprint which was broken down to: 51% - electricity use, 20% - commuting, 20% - direct marketing, and 8%- travel. A steering committee had set goals for carbon footprint reductions and delineated a course of action to make changes in appropriate corporate policies to implement Green initiatives. They had adopted all the LEED standards for new building construction. All of the infrastructure and techno-economic initiatives that were adopted were in the *refreezing* stage. They were developing software tools for their customers to set goals and monitor their own Green initiatives. The company desired to become a "good corporate citizen" and as part of *refreezing* they were setting up education programs for their employees. Employee participation was part of their *feedback loops A and B*. However, we did not detect a *feedback loop C* where their original plans were being modified as a result of their implementation of Green IT initiatives.

A corporation wide Green strategy was in place in Practitioner Organization 9 with comprehensive measurement of their Green initiatives. Following is an excerpt from the company's web site.

"…..we share in the global responsibility for protecting and preserving our environment today and for future generations by not only creating energy efficient products, but also by practicing good environmental stewardship.

Our approach to fighting growing power consumption is simple: subtract machines and disks from the power equation by using storage more efficiently. This strategy has many corollary benefits: it lowers complexity, people costs, support and service costs, while improving network efficiency and performance."

The company was the most advanced company according to the three stage model that we encountered among the ten practitioner organizations. They not only had fulfilled the planning, action, and results corresponding to *unfreezing*, *changing*, and *refreezing*, they also had in place all three *feedback loops*: *A, B,* and *C*. The VP of Physical Plants stated that their measured Power Usage Effectiveness (PUE) rating was at 1.37 with a goal of achieving a rating of 1.2. The CIO commented that the main driver for Green is "capitalism and not citizenship." With Green they felt they could reduce the cost of ownership and hence offer delivery services to their customers at affordable prices. The VP of Physical Plants emphasized that "Being Green was not a direct objective but rather a tactic to increase returns to their shareholders." This company was incorporating Green IT features in their product innovation process by adding environmentally beneficial features to their data storage products as well as their software.

European Organizations 3 and 4

European organizations 3 and 4 had implemented most of the Green IT initiatives.

European organization 3 was a subsidiary of a multinational corporation. The utility company had a sustainability plan called "Health, Safety and Environment" that dealt with power consumption and CO2 footprint. The company joined the "World Community Grid" that allows sharing of processing power accumulated during non peak periods. The company also adopted initiatives such as video conferencing in order to reduce the footprint resulting from personnel travel. Additionally, a program to stimulate green behavior among its customers was operational. The green initiatives encompassed all three feedback loops: A, B, and C. The firm bought Energy Star machines and implemented a check list for regulating future purchases, giving different weights to different factors according to their sourcing strategy. Furthermore, the organization was building a new data center designed to be one of the most modern and energy efficient in Italy. The CIO commented:

"To measure our consumption we use the Power Usage Effectiveness (PUE), calculating an annual average of our measures. The new data center will have an annual PUE lower than 1.2: this is a significant goal, if you consider that the most efficient data center in Italy currently has a PUE higher than 1.75."

Organization 4 was a multinational corporation with strong green focus: the company had an European sustainability plan and Green IT is an important component of this plan. Green IT was a part of the "Health Safety and Environment Impact Procedures" (HSE) of this company: every decision was made considering the environment and safety impact. They had three metrics to measure the effectiveness of their Green IT initiatives: percentage of server utilization, number of virtualized servers and power saving. The interview data did not indicate the presence of feedback loops B and C in this organization. The firm's top management was committed about Green IT policy. Following are some comments from CIO and VP Plants.

"Green IT belongs to a general corporate philosophy of environmental attention. Our green focus impacted various managerial choices."

"Now we are developing the biggest Italian pharmaceutical plant and it will be entirely paperless. The new refrigeration plant that we are going to setup has a zero CO2 footprint. Furthermore, we are thinking about a cloud computing solution for some services."

"Now our IT is centralized in the UK and we have an European and Italian policy for energy saving. This allowed us to get a 70% energy saving. The metrics we are using to measure our green IT initiatives are: percentage of server utilization, number of virtualized servers and power saving."

Discussion and Conclusions

Several insights can be drawn from the findings of the present investigation. First, the Green IT evangelists and their efforts to promote adoption of environmentally responsible IT measures indicate the existence of the TEN. The evangelists included public and private individuals who are engaged in promoting Green IT because of their personal gain or institutional affiliation.

Second, the organizations in the US as well as in Europe that are integrating techno-economic considerations in their Green IT implementation are further along than organizations who are viewing Green IT as an infrastructural issue only. In order for a widespread and effective implementation of Green IT, organizations need to align their organizational processes such as adopting LEED standards and video conferencing to reduce travel.

Third, techno-economic considerations necessitate data collection of various organizational activities. The more advanced adopters of Green IT initiatives collected data of carbon footprints beyond electricity consumption. These organizations view Green IT as a market force that can be harnessed to enhance their strategic position in addition to being a vehicle to respond to the societal need to be environmentally responsible.

Finally, future research should extend the qualitative research approach to quantitative techniques that would lead to conclusions with the ability to generalize the findings more widely than the current research.

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