

The Application of Green Informatization Framework and a Case Study

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Abstract

Global energy consumption and the related to CO₂ emissions have increased very rapidly in the last half century and are expected to continue to grow over the next fifty years. The energy consumption associated with Information Communication Technology (ICT) is increasing, and massive numbers of disposable ICT equipment are released into the environment every year. As the need for green (i.e., environment-friendly and energy-efficient) information technology (IT) is evident, we have defined the concept of green informatization and developed a framework to assess the maturity level for an organization's green information systems-related efforts. To promote the growth of green IT, it will be important to articulate how sustainable IT can be developed and implemented within an organization. To this end, we present a case for sustainable IT - 'green informatization'.

Keywords: Green IT, Information Sustainability, IT Assessment

I. INTRODUCTION

Global energy consumption and the related to CO₂ emissions have increased very rapidly in the last half century and are expected to continue to grow over the next fifty years [Goswami, 2007]. The Organization for Economic Co-operation and Development [OECD, 2008] has reported that some private sector leaders are being encouraged by stakeholder and consumer demands for "green" innovations and products, as eco-innovation and the wider use of eco-efficient techniques not only improves environmental performance, but also raises economic productivity. The information technology industry is no exception to this trend. The energy consumption associated with Information Communication Technology is increasing, and massive numbers of disposable ICT equipment are released into the environment every year [Mingay, 2007]. This has been problematic with regard to the increase in CO₂ levels and the toxicity of chemical components that are potentially lethal to both humans and ecosystems. Green IT is the optimal use of information and communication technology for achieving the environmental sustainability of enterprise operations, products, services and resources throughout the product life cycle [Mingay, 2007]. The benefits of Green IT range from cost effectiveness to fulfillment of corporate social responsibilities and long-term sustainability. Nonetheless, most companies lack both the motivation and the concrete plans to use green technology because they fail to understand the

inefficiency of their current state with regard to the greenness of their information systems, and it is difficult to clearly present this in monetary terms [i.e., Return on Investment, ROI].

II. GREEN INFORMATIZATION ASSESSMENT FRAMEWORK

In an attempt to address the lack of concrete plans and in order to maximize motivation, we first defined the concept of green informatization and developed a framework to assess the maturity level for an organization's green information systems-related efforts. We developed the Green Informatization Assessment Framework (GIAF) in order to clearly and fairly evaluate green informatization in organizations [Park et al., 2009]. Based on this framework, we also developed a questionnaire which we used to assess the green informatization level of a Korean university. Finally, this paper makes recommendations for improving the levels of green informatization and for making progress toward eco-friendly information systems.

Green Informatization Maturity Model

The maturity level of green informatization is determined by the degrees of two critical decision factors: environmental sustainability and IT capability, as shown in Figure 1. Each axis represents a different perspective toward green informatization, and each perspective area makes a unique contribution (Table 1).

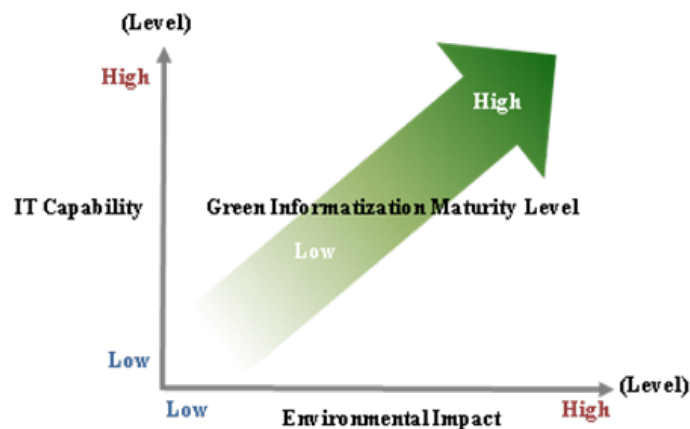


Figure 1: Critical Decision Factors of Green Informatization Maturity Level

The maturity level of green informatization develops as information systems increase in energy efficiency and become less hazardous to the outdoor environment and to indoor users. These green informatization efforts are simultaneously and interactively implemented in the dimensions of IT capability - strategy, infrastructure, and effectiveness (Figure 1 and Table 1). Current information systems cannot be 'green' without consideration of their total environmental impact, and green informatization should also be reflected effectively in all operating areas of the information system (IT capability).

Table 1: Main Activities within Critical Decision Factors				
Critical Decision Factors		IT Capability		
		Strategy	Organization & Infrastructure	Effectiveness
Environmental Sustainability	Energy Efficiency	Energy reducing planning in an information system	Energy efficient IT facilities	Energy cost reduction
	Exterior environment sustainability	IT resource management planning	IT devices made of environmentally safe raw material	Industrial waste reduction
	Interior environment sustainability	IT environment Improvement planning	No heat, No noise devices	<ul style="list-style-type: none"> •Work efficiency •Corporate Image Improvement

Green Informatization Maturity Phase

Green informatization maturity phases are the evolutionary stages of information systems (IS) that lead to environmental sustainability. From low to high levels in green informatization (GI), each level corresponds to distinct phases, green informatization maturity phases, connected with ongoing IT performance in both environmental sustainability and IT capability areas (Figure 2). Establishing the maturity stages of IS for green informatization and environmental sustainability is a very important part of the pursuit of green informatization, since enterprises can use the stages to set up clear and far-reaching goals to realize successful green informatization by following its evolutionary attributes. Furthermore, these evolving stages also serve as evaluation stages, enabling enterprises to identify their present state and to measure their progress in implementing green informatization.

The improvement stages of IS performance for environmental sustainability were divided into three steps: initial personal green informatization, task-oriented green informatization, and enterprise-integrated green informatization. In order to represent the development of IT capability in green informatization, our improvement stages were based on Leem and Kim[2004]’s five-stage improvement model. The main reason we chose to follow Leem and Kim’s work was that the improvement model reflects continuous enhancement of IS performance as an integrated and holistic view, unlike other improvement models focusing on limited parts of IS. Moreover, since green informatization maturity phases should reflect the developmental changes of IT capability corresponding to their environmental impacts, we designed each developmental stage by taking into consideration the three domains of environmental impact on ICT(first-order effects, second-order effects, and third-order effects), so that the stages satisfy environmental sustainability.

In the Green Informatization Maturity Phase, each IT capability factor can be part of more than one maturity phase according to the degree of environmental sustainability of each IT capability

factor. As described above, the total green informatization maturity level of an enterprise is determined by considering the balance of each IT capability factor. This can be interpreted to mean that all components of IT capability in an enterprise ideally develop harmoniously. Therefore, a high degree of maturity in one specific IT part is meaningless in the holistic view, and the total balance of environmental sustainability factors in all IT capability factors should be measured in order to understand the degree of maturity of the whole IT system's green informatization.

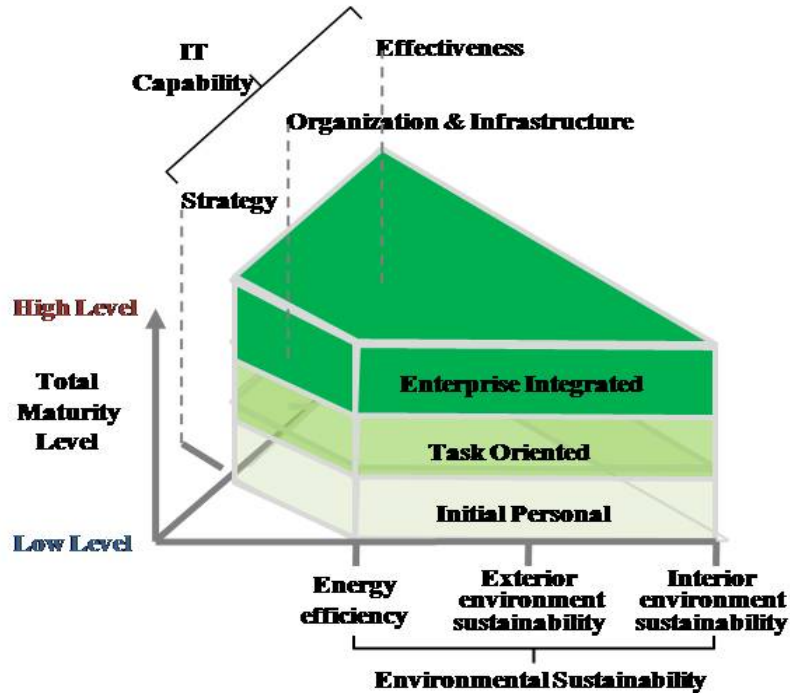


Figure 2: Green Informatization Maturity Phase

Initial Personal Green Informatization

'Initial Personal' green informatization is the initial phase of green informatization in organizations. At this level, green IT facilities are not considered for introduction, but most green informatization processes are implemented within each individual's voluntary practices. Generally speaking, the main activities at this step are simple energy reduction functions such as using 'hibernation' and 'screen saver' modes and tuning off the monitor when it is not in use. Without applying visible green IT facilities to the current non-'green' information system, energy consumption can be decreased by personal users' small behavioral changes [IBM, 2007].

Task-Oriented Green Informatization

'Task-Oriented' Green Informatization is an intermediate phase in which awareness of the environmental impacts caused by information systems is improving and practical Green IT facilities are mainly established in data centers. In contrast to the Initial Personal stage, an organization partly considers green informatization in specific tasks such as managing the data center or in IT operation process servers. In the mid- and long-term views, enterprises can be tempted to consume considerable energy upgrading to green informatization, but this would not be an effective way to improve work spaces or, for that matter, the outdoor environment.

Enterprise-Integrated Green Informatization

'Enterprise-Integrated' Green Informatization is an objective phase in which all information system facilities are converted to green IT devices. Green informatization at this level is well-managed by a special department or by the IT department as a whole. Most importantly, the short- or long-term IT strategies are established to support or build an integrated 'green' information system. At this level, IT and business organizations are able to manage both the energy cost reduction of direct effects and the working environment and corporate image improvement of indirect effects through persistent cost-benefit or ROI calculation.

Green Informatization Assessment Indices

With an increased focus on the enhancement of IT capability corresponding to environmental sustainability, Green Informatization Assessment Indices derived from the critical decision factors in green informatization (GI) can provide a balanced improvement process. Each index's critical success factors (CSFs) are measurable so that enterprises can know their Green Informatization Maturity Phase (GIMP) score on each index. Green informatization assessment indices are broken down into five fields: Green Informatization Strategy, Green Informatization Support, Green Informatization Equipment, Green Informatization Practice, and Green Informatization Achievement. GI Strategy is drawn from the "strategy" critical decision factor, GI Support and GI Equipment from "infrastructure," GI Practice and GI Achievement from "effectiveness." Each assessment index is comprised of characteristic decision factors by maturity phase (Table 2).

Understanding the current GI status is very important for properly implementing green information systems. Based on the study of green informatization and its maturity phases, we suggest a Green Informatization Assessment Framework (GIAF) for evaluating the current GI phase in an organization [Park et al., 2009]. Systematic analysis of the present GI status in an organization can be the first step in establishing further direction for green informatization.

GIAF follows the methodology of Evaluation Indices of Industrial Informatization (EIII) [Leem and Kim, 2004]. Similar to EIII, GIAF can be divided into three sections: Development, Measurement, and Interpretation of the three development stages (Figure 3). The development stage involves the development of GIMP and assessment indices as well as detailed measurement criteria. The measurement stage determines the detailed method for assessment. In the interpretation stage, the last stage of GIAF, the assessment data are analyzed to give the final score

Table 2: Decision factors for improvement phase of GI performance

Classification	CSFs	Initial Personal	Task oriented	Enterprise Integrated
Strategy	Investment plan	No or low level plan	Short-term construction	Mid/long-term
	Energy reduction plan	Informally performed	Specific IT equipment plan	Enterprise energy
	Related to CSR	No	Limited connection with	Close and active
Support	GI organization	No	Performed by IT	Specialized and
	GI rules and procedures	Basic GI rules limited personal behavior	GI rules including equipment area	Settlement of GI governance
	GI mind	Lack of recognition	Expansion of GI mind	High level of GI mind
Equipment	Hardware	Lack of introducing green IT facilities	Partly introducing green IT facilities (i.e. data center)for a core part	Applying Green IT facilities to all parts of an information system
	Software			
	Data centers			
Practice	Support	Low (at most 30%) compliance and	Medium (at most 70%) compliance and availability	High (at least 90%) compliance and
	Equipment			
Achievement	Energy reduction	No GI effectiveness directly	Partly accomplishment	Entirely attained
	Corporate image			

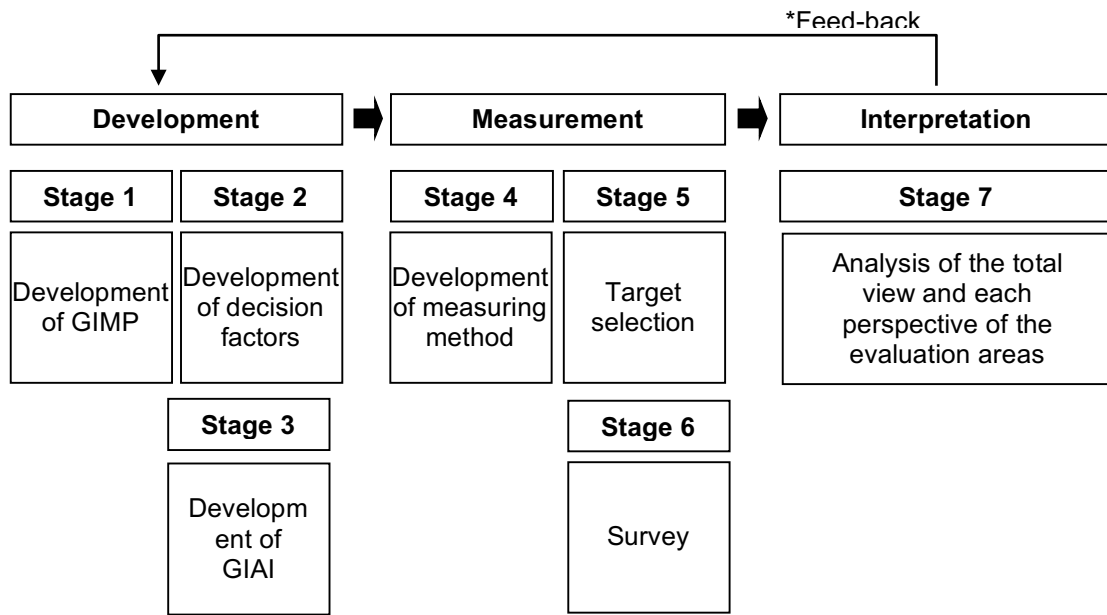


Figure 3: Flow Diagram of Green Informatization Assessment Framework

III. CASE STUDY

In order to verify the adoptability and practicality of the proposed integrated evaluation system, a case study was performed. Using the completed questionnaire, we conducted a survey to assess the GI status of a major Korean university using the measurable items in all five fields of GI performance in December 2018. We forwarded advance questionnaires to IT executives at the university via e-mail and followed up with in-person interviews with the IT manger or CIO. The information collected indicated that the university can be expected to reduce its energy consumption.

Table 5: Main and detailed indices of GIAF	
Green Informatization Assessment Indices (Weights)	Detailed Index (Weights)
Strategy (0.103)	Investment Plan (0.225) Energy Reduction Plan (0.454) Corporate Social Responsibility (0.321)
Support (0.261)	Organization (0.115) Rules and System (0.405) Mind (0.408)
Equipment (0.286)	Hardware (0.282) Data Center (0.482) Software (0.176) Network (0.060)
Practice (0.216)	Support System Aspect (0.250) Equipment Aspect (0.750)
Achievement (0.134)	Electric Power Consumption (0.714) Image Improvement (0.143) Work Efficiency Elevation (0.143)

The survey and interview results show that the university is stagnant at the 'Task-Oriented' GI level on GIMP, as evidenced by obtaining near 50 points on the total score. This result reflects that the university still needs to recognize the importance of GI. Also, the fact that the subject of the evaluation is a public organization with an advanced green campus program suggests that the university should consider seriously the environmental impacts of IT related to the social responsibility of public organizations.

The total score in Figure 5 shows that the universities obtained a high score on equipment, whereas they received low scores for strategy. In order to advance to a higher level of GI, universities would need to establish a clear strategy and vision of GI for their information systems and should promote GI policies and rules from the level of top-management. Compared to the previous study (Park et al., 2009), the awareness and implementation for green informatization has not improved much.

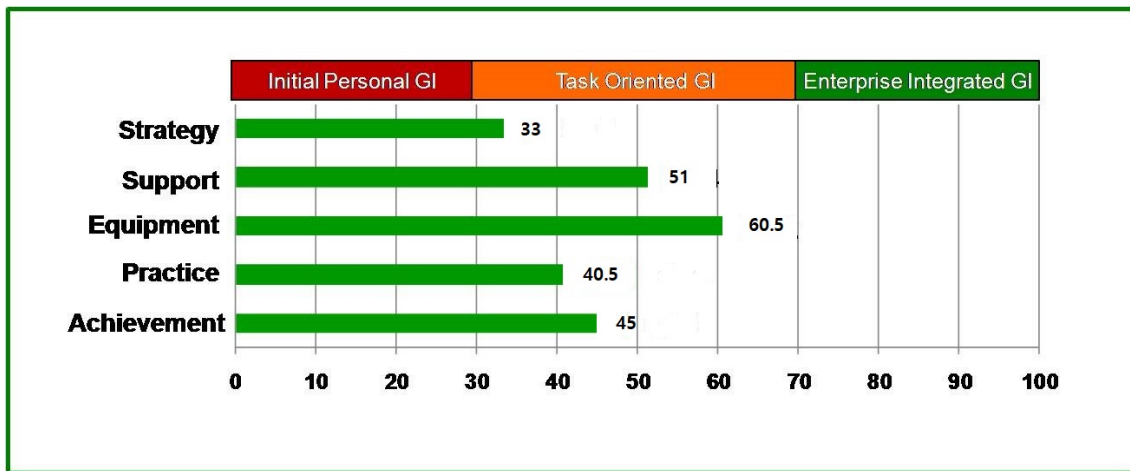


Figure 4: Green Informatization Results by Category

Although the university has not set up specified rules and procedures regarding eco-friendly IT equipment, purchasing and installing green IT items is announced in its groupware. Commonly, all managers whom we interviewed concurred that it will be necessary to move to green IT, but they thought that the environmental impacts of the IT department were of only secondary importance. In order for an enterprise to advance to a higher level of GI support, the performance of green informatization should not be limited to the IT department but should be connected to the other departments which are related to the social responsibility of the enterprise. Also, various support systems should be implemented to support efficient installation, and use of green IT and educational programs should be provided to improve users' consciousness about eco-friendly information systems.

Regarding the network, although the university survey stated that it prefers to buy low volume and high performance network products that enable them to reduce operational costs, they do not consider whether those network devices are comprised of eco-friendly raw materials. The university scored low when evaluated on the availability of GI support and processes for GI. On the other hand, the university generally showed a relatively high degree of availability of GI equipment. In particular, the availability of hardware (including PCs and network devices) is greater than 75%. This demonstrates that the university as a whole obtains a high degree of hardware utilization. However, software categories show a relatively lower level of success, achieving less than 50% availability. Therefore, these results indicate that the universities should gradually extend the availability of hardware to all areas of their information systems, and that all users' attitudes towards GI be improved.

VI. CONCLUSION

In order to improve green informatization (GI) performance, this paper has attempted to diagnose current GI levels compared to previous studies, identify the deficiencies of the current status, and to use this information to help universities and industry advance to the next level. To this end, we defined the concept of GI, developed a framework to assess Green Informatization Maturity Phases (GIMP), and developed the Green Informatization Assessment Framework (GI AF). We used a case study of a major university' GI levels to illustrate our method. What distinguishes this result from previous studies is that this paper revealed the importance of green IT strategy, support, equipment, practice, and achievement.

Note GI could have a positive effect on institutional image as the sustainability has become a key measure of university innovation. To attain the 'Enterprise Integrated GI' level in the GI achievement area, green informatization should be driven as the comprehensive perspective of 'greening' over the entire information system, involving both the work environment and the outdoor environment. Also, it is necessary to monitor green informatization progress frequently and to improve information systems, in order to achieve visible effectiveness of GI.

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