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A Proposed Framework for Improving IT Utilization in the Energy Industry

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***Abstract*—**The purpose of this study is to suggest direction for future study of the energy-IT industry that will be used for framework to increase IT utilization in the energy industry. Recently, Green IT is a becoming global issue because of global environmental pollution. Also, IT roles in energy industry are becoming more important. However, the related studies were IT industry oriented that is not sufficient to make plan for Green energy. Therefore, after analyzing existing studies related to Green energy and Green IT, re-categorization for Green energy-IT industry was suggested. Direction of framework is based on energy industry that enable to link between energy and IT. The results of this study suggest comprehensive insight to Green energy-IT industry. Thus it is able to provide useful implications and guidelines to increase IT utilization in the energy industry.

***Keywords*—**Energy-IT Industry, Green Energy, Green IT, IT Utilization

I. Introduction

BECAUSE of global environmental pollution, such as energy exhaustion and global warming, Green IT is becoming a global issue. The IT industry, in particular, is considered an industry with high energy consumption and CO_2 emissions. Therefore, Green IT and Green energy are becoming focus on research subjects. It is necessary to promote the growth of green living in order to reduce carbon emissions and resolve the economic crisis. This growth of green living could change the national paradigm to a green code. However, the concept of Green IT is recent and there is no clear definition. Thus, each industry or country has a different definition depending on their position. In addition, even though Green energy and Green IT industry is converged between Green energy and IT industry, recent studies are only focus on IT industry that needs to study energy industry point of view. Therefore, this is a beginning stage so it needs to be studied in order to be defined. To enable the efficiency of conversion of IT and energy industry concepts, the scope and categories of Green IT and energy were reviewed through a literature review and trend analysis.

This study analyzes related industry trends on energy savings in the IT industry and energy savings through the use of IT and proposes direction for future categorization methods and frameworks for improving IT utilization. It will contribute to the foundation for energy and the Green IT policy for industry.

This paper consists of five parts. Chapter 2 explains a trend review of Green IT, energy, and the research approach. Chapter 3 explains categorization of Green IT and energy to understand categorization for improving IT utilization in the energy industry. In chapter 4, re-categorization and the proposed future direction of framework for the energy-IT industry provides solutions regarding which parts need to be converged. Finally, chapter 5 describes suggests future direction to study.

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II. Theoretical Background

A. Review of Green IT

Green IT is compound word and refers to the environment and IT. It can refer to either "Green of IT" or "Green by IT." However, there is no precise definition. Green IT also refers to energy-saving IT equipment and decreasing CO_2 emissions because of the recent global climate change and high oil prices [1]. According to the Danish Ministry of Science, Technology, and Innovation, Green IT can be defined as the use of IT in an efficient and environmentally friendly manner[2]. Also, Green IT in Japan focuses on either energy-saving IT equipment and systems or an energy-efficient society by IT[3]. Murugesan has defined Green IT as environmentally sound IT that can achieve total environmental sustainability from the IT side and make IT greener throughout its entire lifecycle; it refers to green design, green manufacturing, green use, and green disposal[4]. According to the Gartner's report, Green IT is an optimal use of information for managing the environmental sustainability of enterprise operations and the supply chain, as well as that of its products, services and resources, throughout their life cycles [5]. Even though the definition of Green IT varies depending on the country, research institute, or researcher, it is similar in a broad sense.

B. Review of Energy and Green Energy

Energy is divided into two classes: fossil fuel and non-coal energy. Fossil fuel includes coal, petroleum, and natural gas, while non-coal energy includes nuclear energy, natural energy, and waste energy. Before the 18th century, many nations were dependent upon wind power and hydropower, but switched to coal after the Industrial Revolution. In the 20th century, petroleum and natural gas were the principal sources of energy. Nevertheless, solar, tidal, and geothermal sources have been

receiving greater attention because of resource exhaustion and global warming. In other words, the world must save energy and develop alternative energy sources for times of energy scarcity.

Therefore, Green energy has been introduced. This energy is new and renewable, is cleaner than fossil fuels, and has improved energy efficiency. The Green energy aims to diminish green house gases or non-exhausting energy sources. It is likely that Green energy will become a powerful energy source in the future. Green energy can promote the improvement of efficiency in other industries, and create jobs and greater incomes for individuals[6], [7].

C. Research approach

The purpose of this study is to suggest categorization for utilizing IT in making the energy industry green. When discussing re-conceptualization or a new concept, defining the scope of the research or concept should be done first[8]. Currently, there is no clear definition of Green IT and the energy industry. Therefore, through the theoretical reviews of Green energy and the IT industry, this study will suggest future directions for the energy and IT industries. For this purpose, this study will analyze recent research on Green IT and Green energy. Data from government reports and research institutions that concentrate on Green IT and energy will also be analyzed. This study is significant in that a variety of research was analyzed in the point of context analysis that explains the overall idea of Green IT and energy.

A total 35 academic dissertations, government reports, and research papers were selected for this research, including 'Green IT,' 'Green ICT,' 'sustainable energy,' and 'Green energy.' These papers consist of 9 academic dissertations, 11 papers from government, and 15 papers from research institute. In particular, the scope and strategy of Green IT and the definition of the energy industry were analyzed. Most of these documents tend to be government documents and research institute documents, because the concept of Green IT and Green energy is fairly new. Therefore, various research papers are expected to come out when Green energy industry are activated.

III. Analysis of Existing Study

A. Categorization of Green IT

In the previous chapter, definitions of Green IT were reviewed. The definitions of Green IT are diverse, and vary according to research institution, industry, and country. In this way, the categorization of Green IT also varied according to researcher and research institution. In order for the IT and energy industries to be developed efficiently, the categorization of Green IT must be reviewed. Therefore, the various scopes and strategies of Green IT were analyzed.

Type I: Categorization based on roles of IT

Green IT can be categorized into two types based on the roles of IT. These categories include 'Green of IT' and 'Green by IT' [9]. 'Green of IT' means making the IT industry green, while 'Green by IT' means making activities green by using IT. There was other similar category. Lee proposes that the scope of the Green IT strategy could be categorized into 'Promoting Green IT in the IT industry' and 'Utilizing IT for making the energy industry green based on IT utilization in the energy industry' [10]. Table I presents the details of each category. The categorization based on aspect of IT industry presents power management of IT products. While aspect of utilizing IT for energy industry includes increasing energy efficiency and developing new, renewable, Green energy. These categories can propose promoting strategies for one aspect of the industry by separating energy issues in the IT industry from issues of the energy industry.

TABLE I
Category Based on Roles

	Categorization	Details of strategy
Lee HyeJung 2008	Green of IT	- Reduce electric power usage by developing low-power IT products - Reduction of CO2 emissions in IT industry
	Green by IT	- Reduction of energy and resource consumption by using IT products - Minimization of CO_2 emissions by using sensor networks
Lee EunMin 2008	Promoting green IT in the IT industry	- Power management of IT products - Developing low-power IT products
	Utilizing IT for making the energy industry green	- Low consumption of energy - The development of Green energy

Type II: Categorization by industry lifecycle

The studies of type 2 divide Green IT strategy based on industry lifecycle.

First, the scope of applying Green IT can be divided into the following stages: production, consumption, and distribution[10]. Each stage has its main activity. Production includes the reduction of using hazardous substances when manufacturing IT products. The consumption stage considers improving energy efficiency. Moreover, the recycling of IT products is the main activity of the distribution stage. According to this categorization, only the consumption stage is related to the energy industry. It implies that this category was mainly about IT industry issues. Green IT is the main subject in this category.

This characteristic is similar to that presented in Murugesan's study. Fig. 1 presents Murugesan's cycle of Green IT[4].

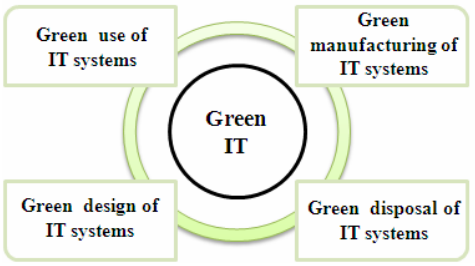

Fig. 1 Holistic approach to Green IT

He proposed a holistic approach to green IT. It consists of green use, green disposal, green design, and green manufacturing of IT systems. The 'Green use' stage refers to reducing energy consumption of IT-related products and systems by using them in environmentally friendly ways. 'Green disposal' means reusing old computers and properly recycling IT-related products and other electronic equipment. 'Green design' is related to the design of energy-efficient and environmentally friendly computers, servers, and cooling equipment. Finally, 'Green manufacturing' includes manufacturing the electronic products and other associated subsystems with minimal or no impact on the environment. According to categorization, the 'Green use' and 'Green design' steps are related to the energy industry. However, the subjects related to energy issues are limited to reducing energy consumption.

Fig. 2 presents another Green IT categorization based on the product lifecycle[11]. This categorization explains the support of IT in all processes of the product lifecycle, like the introduction of system, consumption, upgrades, replacement, and disposal. Each stage includes activity related to environment. In other words, making all the process related to product environmental-friendly, reducing total costs, improving the management process, reducing risk, and increasing flexibility in business process are the main goals. This category is distinct in that activities are related to business process and management issues.

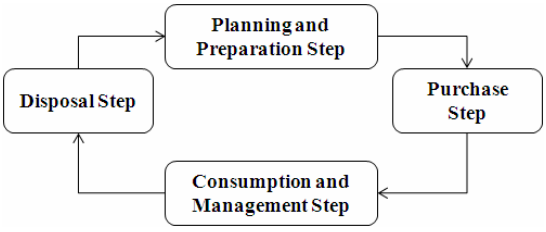

Fig. 2 Categorization of Green IT based on Product Lifecycle

There is the cycle of Green IT as it relates to the energy industry[12]. This categorization categorizes the scope of Green IT and energy into the following categories: energy design, energy PCD (PCD: Production, Conservation, Distribution), and energy consumption. This categorization is useful to reify the effects of IT on energy consumption.

In the energy design stage, energy supply system plans for the entire lifecycle (regarding energy-intensive products, smart buildings, services, and processes) are developed. The PCD stage refers to energy production, conservation, and the distribution sector. This stage represents the connection between energy supply and consumption. The main issues in this stage include increasing the efficiency of the energy production process, intelligent metering, energy-network management, and so on. Finally, the efficiency of energy consumption can be improved in the energy consumption stage. In this stage, developing sensor and data systems is the main strategy. This categorization classified the activities based on energy industry. However, the classification of the energy industry is vague. Therefore, the lifecycle should be developed with clear categorization by the energy industry.

B. Category of Energy

There are many ways to classify the energy industry. The first part of this section reviews the basic categories and focuses on four aspects of energy classification: property, resource, consumption, and cycle. The second part of this section reviews the cases of Japan and Korea, which exhibit the law of supply and demand and possible to growth of energy.

Energy can be categorized by its form. First, energy can be categorized by its property, such as external energy, internal energy, thermal energy, mechanical energy, chemical energy, or nuclear energy. Each energy property has a unique characteristic and is able to convert to another form of energy [13]. Second, energy resources can be categorized according to whether they are solid, liquid, gas, hydropower, nuclear energy, electronic power, solar power, biomass, wind power, ocean energy, or geothermal energy. In particular, coal, petroleum, and natural gas are called fossil fuels[13]. Third, there is the categorization by consumption; there is depletable energy and renewable energy. Depletable energy, such as coal, gas, or oil, includes energy that, once consumed, cannot be replaced. However, renewable energy, such as wind power, hydropower, and geothermal energy, are naturally renewable; that is, they can continue to be used. The last method of categorization is related to the energy cycle. From resource to final consumption, energy can be divided into primary, secondary, and final energy. Primary energy is energy that is not converted. This type includes fossil fuel, hydropower, nuclear power, and solar power, as they must be processed to use the energy. Secondary energy involves the conversion from primary energy to final energy. Final energy is the useful energy that is provided to the consumer, such as thermal energy, and solar energy.

The categorization of energy also varies according to the policies of each country. According to Japan's Ministry of Economy, Trade, and Industry, they classified energy by Supply and Demand. Japan presented Green IT as a way to save energy. As a result of growing concerns about global warming caused by IT development, Japan proposed a 'Green IT Initiative'. These are materialized through the promotion of 'Cool Earth 50' [3], [14]. According to the Cool Earth program, energy can be classified supply, demand, and cross sectional.

On the other hand, the Korean government categorized energy by its growth power. They focused on nine energy areas

to select for growth in the energy industry for the Green energy strategy. Usually, energy facilities can be used for more than 10 years after they are first installed. Therefore, the Green energy industry is hard to maintain and only the domestic market that exports to related industries should be attempted first. Because of limited resources and manpower, selection and concentration are necessary to export industrialization. Therefore, the Korean government selected solar energy, wind power, LED, power IT, hydrogen fuel cells, GTL and CTL, IGCC, CCS, and energy storage as focus areas that need special care. Among these, solar energy, wind power, LED, and power IT focus

<table>
<tr><th colspan="2" rowspan="3"></th><th colspan="3">The aspect of IT industry</th><th colspan="3">The aspect of Energy industry</th></tr>
<tr><th colspan="3">Green of IT</th><th colspan="3">Green by IT</th></tr>
<tr><th>Production</th><th>Consumption</th><th>Distribution</th><th>Production</th><th>Consumption</th><th>Distribution</th></tr>
<tr><td rowspan="3">Fossil Fuels</td><td>Petroleum</td><td rowspan="3">Business process improvement</td><td rowspan="3">Carbon measurement and optimization</td><td rowspan="7">Developing Integrated remote control system, Servers (Including OS) and Storage</td><td rowspan="7">Developing of high efficiency power technology and computer modeling</td><td rowspan="3">Data collection and consumption management by IT</td><td rowspan="3">Detection technology of energy lose</td></tr>
<tr><td>Coal</td></tr>
<tr><td>Natural Gas</td></tr>
<tr><td rowspan="6">New & Renewable Energy</td><td>Hydro Power</td><td rowspan="6">Development IT products which is operated by Renewable Energy (ex:u-IT solar cells technology)</td><td rowspan="6">Simulation of energy cycling</td><td rowspan="6">Integrated energy-Demand management System</td><td rowspan="6">Integration management of alternative energy source</td></tr>
<tr><td>Nuclear Energy</td></tr>
<tr><td>Wind Power</td></tr>
<tr><td>Hydrogen Fuel Cell</td></tr>
<tr><td>Bio Energy</td></tr>
<tr><td>Solar Energy</td></tr>
<tr><td>Electric Power</td><td>Electric Energy</td><td>Automation of power devices</td><td>Recycling of IT products</td><td>Home and building energy management system</td><td>AMI(Auto Metering-Infra Structure)</td></tr>
</table>

Fig. 3 Re-categorized of Green IT and Energy Industry

on industrialization that rapidly grows in the world market or related industries based in the nation. Moreover, the other areas are focused on research and development for planning future power growth[14].

IV. Future Framework for Energy and the IT Industry

A. Result of Analysis

Existing categorizations of the IT and energy industries were reviewed. Based on previous studies, it was discovered that there was no category that focused on the Green energy industry.

Therefore, an analytical framework is proposed to increase IT utilization in the energy industry. Fig. 3 presents a comprehensive categorization method, which is re-conceptualized based on existing studies related to green IT and Green energy. It shows detailed activities for each step.

First, green IT was categorized based on the scope of IT: 'Green of IT' or 'Green by IT.' This is because issues of the IT industry needs to must be separated from those of the energy industry related to environmental issues. After that, the category was subdivided into production, consumption, and distribution steps to derive specific strategies for each step. Fig. 4 presents the categorization criteria of green IT. In this categorization, planning, design, and manufacturing steps were included in the production step. In this manner, energy consumption and purchase steps were included in the consumption step. In addition, disposal and energy supply were included in the distribution step. Even though these categories seem different, they have things in common. Thus, the category was subdivided based on common characteristics.

		Stage of Cycle				
		Production		Consumption		Distribution
E. M. Lee(2008)	The scope of Green IT	Production		Consumption		Distribution
Murugesan(2008)	Holistic approach to Green IT	Green Design	Green Manufacturing	Green Use		Green Disposal
IBM Korea(2008)	Categorization of Green IT based on Product Lifecycle	Planning and Preparation Step		Purchas	Consumption and Management Step	Disposal Step
K. B. Lee(2008)	Cycle of Energy Industry	Energy Design	Energy Production	Energy Consumption		Energy Distribution

Fig. 4 Common Stage of IT-Energy Cycle

After subdividing the IT section, the energy industry section was categorized based on energy source. The energy section was separated into three parts: fossil fuels, new and renewable energy, and electric power. The details regarding the energy criteria will be explained in further detail in the next chapter.

This comprehensive categorization shows the activities associated with each specific step. However, existing categories have limitations in their application to the energy industry. As previously mentioned, the categories were mainly focused on the IT industry. Even though they included the energy section, the subjects were limited. Therefore, a new framework needs to be developed based on the energy industry to utilize IT in the energy industry.

B. Direction for Future Framework

One of the objectives of this paper is to present the direction of a framework for the Green energy industry. To accomplish this objective, the framework based on the energy industry was proposed.

Energy section can be separated into three parts. First, energy criteria can be divided by resource and consumption. In particular, fossil fuels and new and renewable energy are regarded as a primary category. Fossil fuels are traditional and main energy source for several decades that definitely include. In addition, fossil fuels are limited and it causes environmental pollution. In contrast, among new and renewable energy subcategories, hydropower, nuclear energy, wind power, hydrogen fuel cells, bio energy, and solar energy were selected because those resources are considered as high-growth. This new and renewable energy is regarded as solutions for an energy crisis [15].

After dividing by characteristics of energy, political importance and prospects of growth were considered for framework. According to the Korea government, they selected those energies for Green energy strategy that need to focus on research and development. Also, global company such as IBM, Intel and Google are promoting Green IT solution related to alternative energy and Green energy[16]. Then, electric power is also included in the main category, because Green IT is main issues these days and partly related to energy industry. That means IT industry consumes a lot of energy.

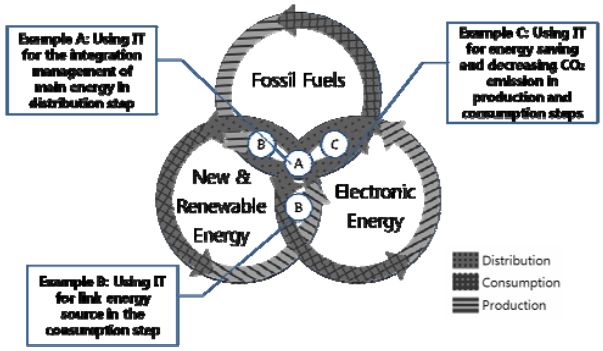

Fig. 5 Proposed Framework for IT Utilization in Energy Industry

Even though electric power is not a primary source of energy, it is still important to Green IT and energy; thus, it is included in this main category.

As a result of analysis, a guideline of new framework for energy industry was proposed. This framework is based on energy resource, and converged with lifecycle of energy. In other words, finding a convergence area among energy resources and common step of energy-cycle were focused. As Fig. 5 shows, an analysis of the energy industry should focus on the convergence era. Analyzing the convergence enable to the development and appropriate strategy and technology for Green energy.

IV. Conclusion

The growth of the energy industry with IT is becoming a main issue, according to energy exhaustion and global warming. Although Green energy and Green IT become a biggest issue and it is part of energy industry, recent studies are only IT point of view. For this purpose, after the definition and classification of Green IT and energy industries were reviewed and re-categorized from the energy perspective, we set up the framework. Therefore, this study suggests direction of IT uses in the energy industry through the analysis of the concepts and scopes in Green IT and energy industry. The advantage of this

framework is convergence between energy resource and lifecycle of energy. Compare to previous study, this study focus on energy industry that this helps to find a convergence area of energy resources and energy cycle that have to develop. It is useful to reveal solutions regarding which part needs to efficiently converge with IT to use IT for the energy industry. Then using IT product or IT system can be used properly to link among energy source. Thus, new information technologies for connection area should be developed.

However, there is a limitation of this study. The concept of converging energy and the IT industry is new; therefore, there are not enough documents to review. Nevertheless, the proposed direction for framework is based on IT that is different from existing categorization of the energy industry, so it has the potential to positively affect the energy industry.

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