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Analyzing Convergence of IT and Energy Industry Based on Social System Framework

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***Abstract*—**The purpose of this study is to analyze Green IT industry in major developed countries and to suggest overall directions for IT-Energy convergence industry. Recently, IT industry is pointed out as a problem such as environmental pollution, energy exhaustion, and high energy consumption. Therefore, Green IT gets focused which concerns as solution of these problems. However, since it is a beginning stage of this convergence area, there are only a few studies of IT-Energy convergence industry. According to this, this study examined the major developed countries in terms of institution arrangements, resources, markets and companies based on Van de Ven(1999)'s social system framework that shows relationship among key components of industrial infrastructure. Subsequently, the direction of the future study of convergence on IT and Energy industry is proposed.

***Keywords*—**Green IT, Energy industry, Convergence, Social System Framework.

I. Introduction

RECENTLY, introduction of Green IT(Information Technology) is becoming more important because environmental crisis and exhaustion of energy issues are raised. Especially, IT industry is indicated as a high consumption of energy and CO2 emissions. So, it began to focus on reduction of energy consumption of IT industry and solving energy problem by applying for IT [1]. This called Green IT, which means using IT for improving energy efficiency and solving environmental problems. Gartner, a worldwide IT research and advisory firm, pointed out Green IT is global issues and one of strategic technologies [2]. For example, most of developed countries are promoting a convergence of IT and Energy industry. Also, Korea government decided to the national vision for green growth and tries to solve the environmental problem and to ensure the national competitiveness by promoting convergence on high level of IT infra and energy industry [3]. Even though Korea has high level of IT infrastructure, convergence on IT-Energy industry is early stage [3]. For this reason, there is no certain concept or definition of green IT, and no strategy for promoting green IT across energy industry.

Therefore, the purpose of this study is to review the concept of Green IT and examine the scope and trends of convergence on IT and Energy industry through literature review. And then, this study aims to drawn implications to countries that such as Korea, which has an early stage of IT-Energy convergence industry, by analyzing the case of leading countries. For this, the research applied Van de ven(1997)' s social system framework to analyze main developed countries regarding main components of industrial infrastructure[4]. Research of Green IT has been increased, but most of them are only trend reports that studies with comprehensive analysis are insufficient. Therefore, at this point the result of this study by using social system framework is significant on providing comprehensive insight about Green IT and Convergence.

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II. Theoretical Background

A. Overview of Green IT

Lately, many key issues arising from globalization of world industries are the impact of economic activities on the environment and threats to sustainable development [5]. These issues are usually referred to as Green IT .Green IT was originated from Green Computing. The Goal of existing IT was to reinvigorates competitiveness, while purpose of Green IT is 3P (people, planet, prosperity) which means sustainable development [5]. Green IT is called Sustainable IT in U.S. and Europe usually, but there is no clear definition; Green IT, a compound word of environment and Information Technology, has the concept which includes 'environmental activity in IT industry' and 'environmental activity of Using IT' [6]. The practical implementation of Green IT can be divided to production, demand, distribution and disposal [1]. Since IT industry is regard to high energy consumption industry, major developed counties are focused on energy efficiency augmentation. With this point of view, they make meetings and groups for discussing and practicing Green IT. And also, global IT enterprises promote green IT because of Strengthened national restrictions for environment.

B. Trend of Convergence on IT and Energy Industry

As previously stated, the high energy consumption of the IT devices is the problem. While the information society is processing, it is going to increase energy consumption of IT product which is spread in industry rapidly [7], [8]. However, I can consider in a positive side that IT can bring the innovation of energy efficiency all over industry include IT industry. For this reason, IT-Energy convergence sector of Green IT field stand out in bold relief. Currently, each major developed country is promoting policies which they can perform preferentially, which consider to amalgamate area of various industries. There are a lot of energy field which can fuse into

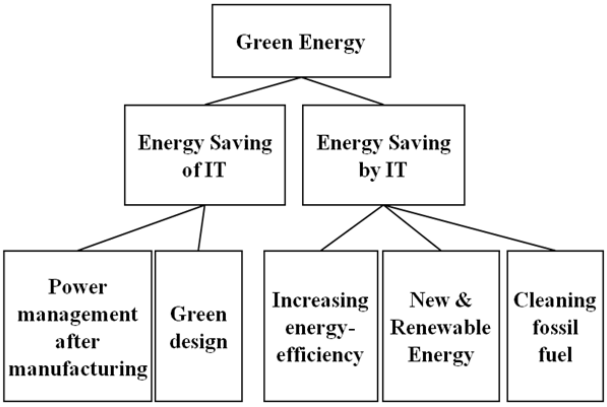

Fig. 1 Categorization of IT-Energy convergence industry

IT such as The field of reducing CO2, developing new & renewable energy through IT, cleaning fossil fuel, developing power IT, saving energy resource, increasing efficiency of building and so on. According to EIA report, Energy Technology Perspectives 2008, When Green energy use, it is expected to maintain on the same level which is emitted CO2 from 2005 to 2050. That means it achieve a 50 percent of goal of reducing CO2. [9] As previously stated, Green IT can be divided to many filed. The following Fig. 1[6] shows the categories which are promoted in fields of IT-Energy convergence industry. As shown above picture, Green IT can be classified under 'Energy saving of IT' and 'Energy saving by IT'. For instance, energy saving of IT industry includes power management of IT product; And Energy saving by IT which is just initiated includes energy efficiency augmentation, new & renewable development, cleaning energy. Accordingly, we can confirm converging many industries related of energy, which it should need to fuse IT and energy industry.

C. The Social System Frameworks for Emerging Industry

When the industry merged with other industry, there are obstacles because of its discontinuous rupturing effects on existing paradigm [10]. So it needs to find dissonant components of industry. Thus, in this study we applied Van de Ven(1999)'s social system framework to compare leading countries case of convergence on IT and Energy industry[3]. This framework is useful to explain the necessary components to settle new industry such as IT- Energy convergence industry. Fig. 2 shows social-system framework that incorporate relationship among key components of industrial infrastructure [3], [10]. It provides an augmented view of an industry and focuses on relationship among key components.

This framework of industry includes following: Institutional arrangements, Resources endowments, Market Consumption, Proprietary activities. Institutional arrangements include governance, industry rules, and regulation. And resources endowment is regarding basic resources necessary to support proprietary instrumental activities. Market means market creation and consumer demand and Proprietary activities refers technological development function by company.

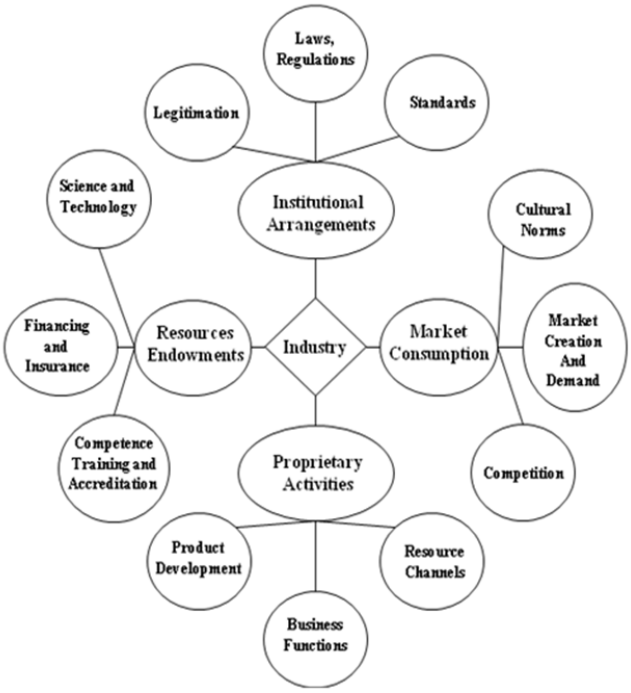

Fig. 2 An augmented view of and industry feature space

In this study, we adjust these factors to fit the industrial characteristics. Based on these components, we can conduct comprehensive analysis on IT-Energy convergence case of each country. Through this analysis, Strategic guidelines for initial level on convergence of IT and Energy industry can be drawn.

III. Case Analysis

A. The Case Analysis of Convergence on IT and Energy Industry

This paragraph explains energy policies, volunteer systems, and present condition of the world's major developed countries. Then, analyze IT-Energy convergence industry based on Social system framework of Van de Ven(1997). Finally, it derives implication to revitalizes IT-Energy convergence industry through compares USA, Japan, EU that are driven the industry with Korea. Table I presented summary of case analysis of IT in energy industry of Leading Countries (U.S., Japan, E.U, Korea)

Case 1.United States

The U.S. is taking up a positive movement to energy efficiencies through IT technologies in the enterprises perspective. Global IT-service conglomerates (IBM, Intel, AMD, Sun Microsystems, HP and etc.) constituted the 'Green Grid Project' forum to operate the energy-driven data center effectively. [11] In addition, other enterprises such as Google, Intel and others present the CSCI (Climate Savers Computing Initiative) project to reduce power energy consumed by IT equipments and carbon emissions, and then take action in practice. [12] In 2007, CTOs and mangers at the IT-service

TABLE I
CASE ANALYSIS OF IT IN ENERGY INDUSTRY OF LEADING COUNTRIES

Symbol	U.S.	Japan	European Union	Korea
Key Policies	· CCTP · CEIDS · Green New Deal	· Cool Earth · New IT evolution strategy · Green IT Initiative	· Framework Program · SET Plan	· National energy master plan · Standby 2010 · New IT Strategy · Green growth
The Cause and Purpose of promotion	· Power efficiency augmentation · Greener datacenter · Creating business opportunity	· New growth motivation · Solving environment problems · Constructing entire lifecycle of product	· Securing economic leadership · Improving economic growth and business opportunity	· Improving economic growth and industrial competitiveness
The main stream	· Movement to energy efficiencies through IT in the perspective of enterprises.	· Movement to Associate government and enterprise	· Movement to Associate structure of Europe countries	· Movement to Associate government and enterprise
The supporting system and Related program	· Energy Star program · IntelliGrid project · Green Computer Summit · Green Grid Project · CSCI	· Top Runner program · Green IT Project · Green IT promote committee	· EuP · BUSMOD project · CRISP · Triple Twenty · IT Work program	· Comprehensive countermeasures for promoting Power IT · Energy vision 2030 · Green energy policy committee · National energy committee
Status of Market and Technology	· IBM- Project Big green project · HP- Greener Datacenter · SUN- Greener Datacenter · Dell- Low power PC · EMC- Integration of storage resource · Intel- Low power CPU and environmental datacenter · AMD-Low power and heat processing product · Google- Power efficiency datacenter	· Hitachi – Cool center 50 · NEC- Real IT Cool Project · Fujitsu – Green Policy Innovation · Sony- Power saving Technology of personal PC · EMS(Energy Management System)	· Nokia Siemens Network- Energy efficiency solution · Alcatel-Lucent – eco-sustainability strategy · Phillips- ecovision4 · Nokia-Founding environmental base station	· Samsung - Using environmental materials and certificate system · LG Electronics- Using environmental materials and certificate system · KT- Green IDC · LG CNS-Investing IT in new & renewable energy

enterprises in the U.S. are trying to actively hold enterprise-based consortiums, announcing 'Green Computing Summit' and etc., on the purpose of proliferation of eco-friendly computing in the world [13]. On the other side, they are making an effort to raise efficiencies of energy in the point of each enterprise. IBM substantiated the policy of eco-friendly energy shortening; announcing the 'Big Green Project' and HP also develops solutions for the power reduction in data centers and the maximization of making full use of spaces [14]. Additionally, Sun Microsystems endeavor to produce energy-reducing chips, presenting the strategies about 'Go Green, Go Save' [14].

Following are main activities on the view of nations through cooperation between conglomerates and the government. CCPT is trying to promote improvement of energy efficiencies with market mechanisms and setting target technologies for coping with changes of climates [15] Moreover, there is an on-going project called 'IntelliGrid' for the smart power networks, proceeding on CEID (Consortium for Electric Infrastructure in a Digital Society), which is constituted in ERRI (Electric Power Research Institute) to the convergence of power energy and IT technologies [16].

Case 2.Japan

Japan has been making attempts in the parts of environment and energy for a long time in the government's perspective. Based on these, there are some characteristics on a recent global issue, called 'Green ICT [17]', such as takeoff of economic growth with establishment and promotion of various policies and visions in the long term about it.

Department of Economics and Industries announced the 'Green IT Initiative' policy [18] which is compatible with both environment protection and economic growth, and set to 'Green Project' in 2008. They also presented the plan for 'Cool Earth Energy Innovation Technologies' to deal with global warming with incorporation of 'Green IT Promotion Council', which consists of nongovernmental and governmental organizations. Moreover, they are required for the needs of development of innovative technologies to actualize 'Invitation to Cool Earth 50', set up the medium- and long-term road map, which is under the government, and promote the map [19] The

road map includes technologies, the level of development of technologies and the time when it become commercialized, as well as 21 innovative technologies. There are some main enterprises in the convergence of IT and energy, which are Hitachi Group, NEC, Fujitsu, and so on. With utilizing IT technologies, those enterprises suggest energy-reducing platforms, control software, installation service under the purpose of reducing energy.

Case 3. European Union

The remarkable strategies on the convergence of IT-energy industries in EU focus on improvement of the EU-centered energy efficiencies. The related joint development researches have begun based on FP started from 1984[20]. Especially, researches on intelligent power networks for the energy efficiency with IT have been done from FP5 (1998-2002) to FP6 (2002-2006) [21]. They have additionally researched on IT-based distributed information for the effective management of power networks, performing the two projects across the incorporation between large conglomerates and governments, which are BUSMOD (Business models for distributed power generation) and CRISP (Critical Infrastructure for Sustainable Power) project. These activities help improving the applicability of energy in the energy-based industries, widely-spreading IT across the whole stages of the energy life cycle in FP7 (2007-2013) [21].

Meanwhile, there are efforts to help joint research system to go smoothly with each government. Taking 'Green ICT' actions in the real world, England contributes to the construction of pertinent environments and organized the group called 'Green ICT Delivery Group'. Denmark, in the government's point of view, also is propelling the strategies, announcing the plan for 'Green ICT Action' and proposing initiatives.

Case 4. *Korea*

In Korea, compared with other countries, the lack of recognition on the climatic changes and saving energy makes it difficult and delayed to deal with 'Green IT'. However, as rising as problems in Korea, which are the 10th CO2 emission rate and the 1st growth rate so as to expect to be included in the mandatory reduction list, they show prompt reactions to reduce energy, setting up governmental policies and voluntary enlistment [22]. Korea government fulfills atmospheric power reduction programs called 'Standby Korea 2010' from 2005. Additionally, they chose Green IT as development strategies and suggested the aim called 'New IT Strategy' that they would be willing to increase the energy efficiency rate of IT products to 20%. Furthermore, the government precedes the IT promotion countermeasures with respect to 'Power Energy', which is compatible with IT and the existing power energy technologies, based on IT infrastructures as the strong point[23].

Nevertheless, these efforts do not meet the fully requirements, compared with activities in advanced countries, as researches on the convergence of IT and energy is not widely-spread in a variety of industries. In the enterprises perspectives, Samsung and LG Electronics enforce the eco-friendly certification system in practice and KT also builds the Greed IDC to reduce energy-consuming and to help preventing from global warming

IV. Analysis Results and Implications

A. Analysis Results

In this study, Existence of each component based on social system framework was checked. If there were certain factor, positive score were given. Components of structure of industry were adjusted considering characteristic of IT-Energy convergence industry. Fig. 3 shows results of analysis. Description of the results is following.

Factor \ Country			U.S.	JAPAN	European Union	KOREA
Institutional Arrangements	System or restriction		X	O	O	X
	Program		O	O	O	O
	Organization		X	X	X	X
Resources Endowments	Investment		O	O	O	X
	Technology	Energy	O	O	O	X
		IT	O	O	X	O
	Human Resource		O	O	O	X
Market Consumption	Demand		O	O	O	O
	Market creation		X	O	O	X
	Competition		O	O	O	X
Proprietary Activities	Leading Company		O	O	X	X
	Development of new technology		O	X	O	X
	Affiliation		O	X	O	X

Fig. 3 Analysis result of IT-Energy convergence industry

1. U.S.

The strengths of United States were compared to other countries are the area of resources and business activities due to market competition among global companies. Effect of the IT-energy convergence is very low because of the energy and IT connections are only focused on the power. However, through the well managed IT infrastructure, IT and data center power lead force to the green ICT. Nevertheless, the government's activities show weaknesses of policies and regulations because of marker led policies.

2. Japan

In case of Japan, from the early stage, the government controlled Green IT strategy which focused on the energy efficiency. So, the well-organized feature could be seen in maintaining resource and programs of market and policy supporting in Japan industry. Moreover, because well-known Japanese IT companies have executed IT business actively, government and business cooperation are successfully making effort for growth of Green IT industry. However, alliance of

companies and technical development has been seen as weakness. The effort of technical development has been conducted respectively, however, the technical development in IT & energy convergence and alliance have not been conducted so making the Japanese companies has been turned over to the American Company.

3. European Union

The regulatory system of EU is well maintained since each participating countries are joint research of the IT policy. The size of the market and unique environment of each country are strength point but there are not enough IT infrastructures and lack of the market leader is weakness point. This is because the property of EU is based on combined with multi-country system; therefore it is hard to find company which is representative EU in shortly.

4. Korea

However, Korea has the strengths of IT infrastructure development compared to other countries. It is the possibility of the existence of the various programs can be found. Compare to other countries, the Green IT policy in Korea revealed many limitations. Even though Korea government struggles to solve these problems, it is only a beginning stage that regulations and policies are still weak. In addition, the lack of recognition of the energy industry that low investment makes problems of secure the energy resources. Therefore, although they have demand for services, there is no investment for IT-energy convergence industry. However, Korea has the strengths of IT infrastructure development compared to other countries. It is the possibility of the existence of the various programs can be found.

B. Implications

This paper carry out study on comparing the IT-Energy convergence industry of the leading countries based on Van de van. And Implications for developing of the IT-Energy convergence industry are drawn as follows.

1. Implication for Institutional Arrangements

As a result of analysis, we ascertained that EU and Japan are well maintained on institutional. In EU case, they have the entire life cycling regulation, which includes production, demand, distribution and disposal. Especially, from the demand side, they are operating EUP(Eco-design requirements for Energy using Product) for energy efficiency augmentation. In Japan, they are managing regulations which IT and the energy related systematically with green IT propulsion of governmental leading. Therefore, it is necessary to settle up the IT-Energy convergence industry in beginning time that promoting of governmental leading like Japan and instituting entire life cycling regulation like EU. On the other hand, when we oversee all major developed countries, any countries do not have institutions which manage IT-Energy convergence industry specially. They are just having an institution dedicated to each industry-specific organization. It requires establishments of professional institution to develop the combined industry of IT - Energy. So it is strongly necessary to found the agency which specifies this field for the growth.

2. Implication for Resource Endowments

In the aspect of resource, U.S. and Japan have more advantage then other countries. For the United States, they have many technologies because of a lot of the enterprise-wide effort. Also, Japan regard the IT-Energy convergence industry as basis of national development, which they are trying to effort making program such as new IT evolution strategy, Green IT initiative so on. As these result of effort, they were expected to lead a field of energy efficiency technology. Therefore, we could confirm that the technology development was supported by a national and that convergence which institutional prompted, effectively confirmed.

3. Implication for Market Consumption

In the aspect of market, as the interest reducing Co2 and using energy effectiveness increase, we confirmed on demand of IT-Energy industry. It should keep Cross-country competition up. Especially, EU and Japan are trying to dominate market by taking the initiative in Convergence of IT and energy industry throughout energy effectiveness which use IT and network construction. Accordingly, size and the demand of the IT-Energy convergence industry is expected to grow rapidly by competition in the convergence of IT-Energy industry.

4. Implication for Proprietary Activities

In field of instrument, The United States led green IT of the global enterprise actively. Certainly, it is essential to compete with the active participation of companies for growth of the industry. In case of the United States, there are the technology development and alliances with many global companies. This should be necessary for the growth of the IT-Energy convergence industry and industrial competitiveness in near future to make program which were participate enterprise by a national leading. Furthermore, it is also required system which induce competition between corporate.

5. Implication for Korea IT-Energy Convergence Industry

Compare to the other three leading countries, Korea has been, so far reluctant to energy reducing and efficiency. As a result, Korea is now way back in the line of the light of a key technology and institution, market, enterprise. Therefore, Korea needs to benchmark the leading countries to have competence in the IT-Energy convergence industry. Especially, Japan is suitable country to benchmark, because Korea's government-control green IT strategy is similar to Japan. In addition, it is necessary for system to examine EU closely which has well maintained system on cycling of production, demand, distribution and disposal, and also it is required for securing the competitiveness of market to investigate the progress status of American global company. Although Korea is just starting of the IT-Energy convergence industry, if Korea which has strong IT infrastructure is ready for push forward it

systematically they could lead the IT-Energy convergence industry.

V. Conclusion

According to global environmental pollution problems, the growth of energy industry with IT is becoming main issues among the main developed countries. Especially as IT industry is pointed out regarding high energy consumption and CO2 emissions, it began to focus on convergence of IT and Energy industry effectively. Therefore, this study has been drawn implications for countries in early stage of convergence of IT-Energy convergence. For this, this study analyzed cases of main countries in terms of institution arrangements, resources, markets and companies based on Van de Ven(1999)'s social system framework. In conclusion, propositions for IT-Energy convergence of this study are follows.

First of all, if the level of IT-energy is in early stage, government policy and regulatory system must be established first. As in case of Japan, The promoting by government can establish the foundation of the industry systematically. Also, to revitalize of industry through market competition making business support system should be consider like U.S. case. Namely, it has been confirmed necessity of special organizations for managing IT-Energy convergence. And like in case of Korea, if IT infra already has been established, the possibility of cooperation between IT infra and existing energy technologies should be examined before focus on developing new technology.

This study has significance of being the initial research for areas of IT-Energy convergence and guidelines for countries with interests in green IT. Nevertheless, there were limits to In-depth analysis of each components of industry because this study examined overall structure of industry of multiple cases. So In-depth study on each components of industry is remains as future research projects.

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