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Strategic Priority of Green ICT Policy in Korea: Applying Analytic Hierarchy Process

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***Abstract*—**This study considers priorities of primary goals to increase policy efficiency of Green ICT. Recently several studies have been published that address how IT is linked to climate change. However, most of the previous studies are limited to Green ICT industrial statute and policy directions. This paper present Green ICT policy making processes systematically. As a result of the analysis of Korean Green ICT policy, the following emerged as important to accomplish for Green ICT policy: eco-friendliness, technology evolution, economic efficiency, energy efficiency, and stable supply of energy. This is an initial study analyzing Green ICT policy, which provides an academic framework that can be used a guideline to establish Green ICT policy.

***Keywords*—**AHP(Analytic Hierarchy Process), Case Study, Green ICT, Policy Priority

I. Introduction

GLOBAL environmental problems due to climate change are affecting directly many countries' energy and industrial policies. It is estimated that the consumption of energy will be about 15,064 million TOE (Ton Oil Equivalent) worldwide in 2020. Also, the Korean energy consumption rate is increasing, on average, 2.8% annually, which will be 27,480 million TOE by 2013[7]. As energy consumption is increasing, serious environmental disruption is occurring. Therefore, many countries are establishing Green ICT(Information Communication Technology) policies which increase energy efficiency due to correspondence climate change. Therefore, the Korean government needs to have a master plan and action plan which includes the development of alternative energy sources and strategies for efficient energy use in IT.

The purpose of this study is to derive a direction of Green ICT policy through ordering the priorities among the main goals. The most of previous studies regarding energy policy are focused on energy supply and price regulation. However, recent studies are emerging regarding the energy consumption paradigm, based on newly changed IT practices. At this point, this study can be a preliminary study regarding policy direction of Green ICT based on a new paradigm. This study provides the relative quantitative importance among goals for Korean Green ICT policy by applying the AHP (Analystic Hierarchy Process). Therefore, this study can be used as an initial model to accomplish reasonable policy, providing an academic framework. The significance of this study is that it provides a basic research model.

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II. Theoretical Background

A. Decision Making of Policy Priority

'Setting Priorities' is determining the relative importance among variables. It is important in policy making to use limited resources efficiently; and the link between the policy and practice can be enhanced[18]. The analysis of external factors of the correlation among policies is necessary to draw priorities in policymaking. For this reason, most of the previous studies used deductive methods, which can explain efficiently the complexity of the policymaking process[13]. Other studies used for policy making include factor analysis. Factor analysis uses many variables regarding social, economic, and political issues. The empirical variables from this method are used in many different research papers[9].

Most of the studies related to priorities in policymaking focus on the effects of policymaking. However, this study is a precedent for systemic policymaking, which makes it different than any previous studies. Therefore, the purpose of this study is to maximize the adoption effect of the beginning stages of Green ICT.

B. Definition of Green ICT

Green ICT means Green by ICT and Green of ICT. Gartner defines Green ICT as "Encompassing environmentally sustainable IT and the use of IT to contribute to environment preservation.[6]" The Danish Ministry of Science Technology and Innovation defines it as "more environmentally friendly utilization of IT and the use of sustainable IT.[3]" OECD defined Green ICT as "ICT to reduce environmental load and ICT for using as a promoter to relieve social environment influence," and Ministry of Economy, Trade and Industry in Japan defined it as "Saving in ICT-related energy consumption and energy conservation through the use of ICT.[11]" As shown above, the definitions of this concept are different. However, this study defines Green ICT as "reduction of energy consumption and pollution of environment through IT."

III. Research Model and Methodology

A. Principle Constructs

The Korean government established a basic law on green growth that promotes low carbon and green growth[10]. To achieve this goal successfully, it must be set up precisely, and the priorities should be drawn up based on a detailed evaluation of standards. Therefore, this study examines the main variables based on the goal of promoting green growth and strategy. These variables are economic efficiency, energy efficiency, technology evolution, stable supply of energy, and eco-friendliness. The definitions of these variables from previous studies are shown below.

First, Cho (2007) defined economic efficiency as, how the economical goal of organization is achieved through many activities.[17] Including economic variables can prevent redundant investment and can reduce waste of the budget. In this way, we can achieve the goal of economic efficiency. Thus, this can achieve the goal of economic efficiency[2].

Second, energy efficiency is defined as by reducing present consumption of energy achieving the goal of both economics and environment[14]. If energy efficiency is not included in research of policy making, it is possible that correct policymaking will be difficult later[4]. That is why this study included the variable of energy efficiency.

Third, Lim (2008) defines eco-friendliness as, without damaging the natural environment, humanity, and social life, but creating harmony with the natural environment and composing a pleasant environment. He claimed that evaluation of eco-friendliness is necessary for making a standard to preserve the natural environment[1].

Fourth, Miller and Morris (1999) emphasized the importance of technology strategy, because of the importance of providing new value to customers and ensuring competitiveness throughout the needs of the market[15].

The last variable is stable supply of energy. Yoon (2003) claimed that for economic growth the stable supply of energy is necessary. Therefore, a stable supply of energy becomes an important principle for energy policy making [13].

B. Research Model

This study adopted the AHP model for making optimal decisions regarding priorities. This model is useful when setting up the relative importance of evaluation criteria. The AHP only takes two elements to compare at each point of comparison, so the accuracy of decision making can be increased. After that, to judge the relative importance among variables, the method uses a 1:1 comparison. Through these procedures, quantity and quality of variables can be evaluated.

Fig. 1 shows 4 levels of adopting the procedure of the AHP. The first level sets up the problems for decision making; the second collects data of rating items for decision making; the third estimates the relative weight of rating evaluation criteria; and the fourth orders the relative weight of rating items. Variables of this study were selected as hierarchical, with 5 basic goals and 10 details, as shown in Fig. 2.

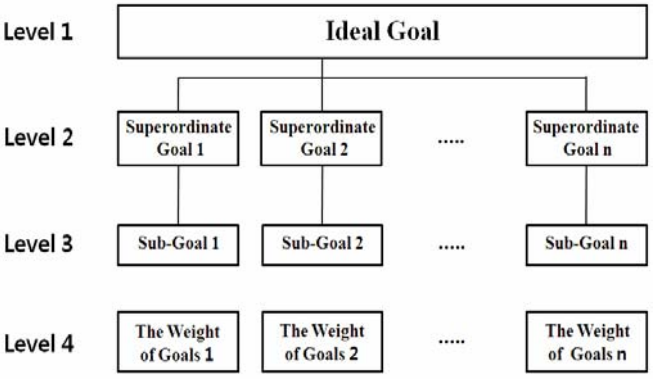

Fig. 1 AHP Structural Model

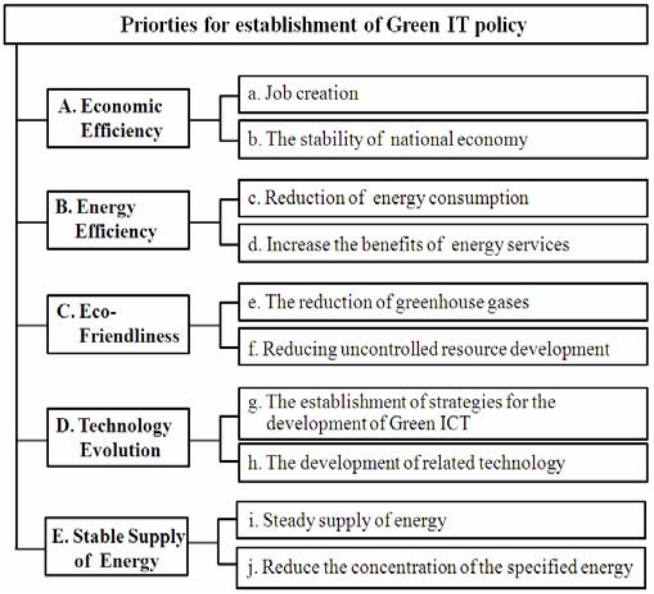

Fig. 2 Research Model and Key Factors

C. Methods

Generally, the evaluation of the relative importance of variables which use AHP is performed by an expert in the field, the final decision maker. As the research suggests, as part of a goal set by the government, it conducted a survey aimed at senior officials who are responsible for the establishment of domestic Green ICT policy. A total of 20 questionnaires were distributed and 18 of them were retrieved. Ultimately, 13 questionnaires were analyzed after excluding five responses that showed a problem with consistency. In order to prioritize potential concerns when the policy is applied, here we evaluate the relative importance among variables based on the hierarchy described in Fig 2.

IV. Data Analysis and Results

A. Weight Evaluation Using AHP Method

First, it is assumed that the assessed value of α_{ij} is drawn when A_i and A_j are compared one-to-one using the AHP. Then, the value α_{ij} can also be interpreted in the comparison matrix. α_{ij} is always positive. If A_i is greater (or less) than A_j, it is

$\alpha_{ij}>1$($\alpha_{ij}<1$).Since the same objects receive equivalent appraisal, $\alpha_{ij(i=j)}$ is equal to one. Moreover, A_j receives $1/\alpha_{ij}$ evaluation of A_i; therefore, α_{ji} is the reciprocal of $1/\alpha_{ij}$. If all of the above is taken into account, the comparison matrix A always results in the following formula[8].

$$A = \begin{bmatrix} 1 & \alpha_{12} & \alpha_{13} \\ 1/\alpha_{12} & 1 & \alpha_{23} \\ 1/\alpha_{13} & 1/\alpha_{23} & 1 \end{bmatrix}$$

Based on the matrix A, the points of each item were marked. Next, it will be explained about one of the data from the survey. First, Table I shows the respondents' given scores of relative importance by comparing variables and sum of columns. After the points marked, each cell divided by sum of the rows.

TABLE I
WEIGHT VALUE FOR EACH VARIABLE

	A	B	C	D	E
A	1	2	2	2	3
B	1/2	1	1/2	1/3	2
C	1/2	2	1	1/2	2
D	1/2	3	2	1	3
E	1/3	1/2	1/2	1/3	1
Sum of Columns	2.8333	8.5000	6.0000	4.1667	11.0000

Next step is to find sum of rows, then divide it to the total number of variables, which is 5, to get the average. This average is the weight of the variable. As shown in Table II, the priority of variables are drawn as A>D>C>B>E.

TABLE II
COMPARATIVE ANALYSIS OF AVERAGE WEIGHT

	A	B	C	D	E	Sum of Rows	Average (Weight)
A	0.3529	0.2353	0.3333	0.4800	0.2727	1.6743	0.3349
B	0.1765	0.1176	0.0833	0.0800	0.1818	0.6393	0.1279
C	0.1765	0.2353	0.1667	0.1200	0.1818	0.8802	0.1760
D	0.1765	0.3529	0.3333	0.2400	0.2727	1.3755	0.2751
E	0.1176	0.0588	0.0833	0.0800	0.0909	0.4307	0.0861

To verify reliability of the average, we need to get a CI(Consistency Index). For this, using comparison matix(A) and the weight of the variables(P) calculate the λp

$$AP = \begin{bmatrix} 1.0000 & 2.0000 & 2.0000 & 2.0000 & 3.0000 \\ 0.5000 & 1.0000 & 0.5000 & 0.3333 & 2.0000 \\ 0.5000 & 2.0000 & 1.0000 & 0.5000 & 2.0000 \\ 0.5000 & 3.0000 & 2.0000 & 1.0000 & 3.0000 \\ 0.3333 & 0.5000 & 0.5000 & 0.3333 & 1.0000 \end{bmatrix} * \begin{bmatrix} 0.3349 \\ 0.1279 \\ 0.1760 \\ 0.2751 \\ 0.0861 \end{bmatrix} = \begin{bmatrix} 1.7513 \\ 0.6473 \\ 0.9090 \\ 1.4366 \\ 0.4414 \end{bmatrix}$$

Sum of the rows divided by the weight of each variable then combined of their sum to find λ_{max}. After that it divided by the number of variables to find CI for using λ_{max}.

$$\lambda_{max} = \frac{1}{5}\left(\frac{1.6743}{0.3349} + \frac{0.6393}{0.1279} + \frac{0.8802}{0.1760} + \frac{1.3755}{0.2751} + \frac{0.4307}{0.0861}\right) = 5.1605$$

$$CI = \frac{(\lambda_{max} - n)}{n-1} = \frac{(5.1605 - 5)}{5-1} = 0.0401$$

After that, CI needs to be divided by RI(Random Index) to calculate CR(Consystency Ratio). If n = 5, RI is 1.12. If CR is less than 0.1, then this study assumes that the value is consistent.

$$CR = \frac{CI}{RI} = \frac{0.0401}{1.12} = 0.0358$$

This study decides the priority by evaluating many different samples based on the equation above. Among all the samples, we selected some samples, which is less than 0.1 CR, then the result to calculate the geometric mean for the weight value is the final weight for each variable.

B. Analysis of Results

After the comparison of priority among variables, the ranked order was eco-friendliness, technology evolution, economy efficiency, energy efficiency, and stable supply of energy, as in Table III. Eco-friendliness is drawn as a primary concern because of increase of CO_2 emission in the IT industry and environmental pollution caused by energy consumption.

Technology evolution was selected as the second greatest concern because of a far-fetching ripple effect of Green ICT. ICT not only increases energy efficiency, but also helps attain international competitiveness of its related technology. The expectation that economic depression may recede with eco-friendliness and technology evolution combined, set economic efficiency at the third place.

The fourth priority is energy efficiency that focuses on reducing indiscreet energy consumption and providing high-quality service. Lastly, the fifth concern is stable and ongoing energy supply through the above practice.

After derived priorities of super-ordinate goals, we also measured the priorities of subsequent goals. With regard to economic efficiency, job creation and general economic stability were the sub-goals. The result showed that economic stability took more importance than job creation. Job creation was regarded as relatively less important was due to the awareness that economic stability generates jobs.

Reduction in energy consumption and increase in service benefit are the sub-goals for energy efficiency. It turned out that the two goals share the same significance. These results are attributed to few survey samples and ambiguous criteria of energy efficiency caused by unsettled Green ICT.

As for eco-friendliness, diminution of greenhouse gases and cessation of indiscreet development of resources were the sub-goals. It was shown that the problems of greenhouse gases

were taken more seriously than those of resource development. In times of environmental disruption due to universal rise of greenhouse gases, it is no wonder that people are now more conscious of domestic environmental issues and ways to deal with them.

In terms of technology evolution, strategic establishment of Green ICT technological development and advancement of new growth engines of its related technology are the sub-goals. It was found that the latter played a more central role than the former. This occurrence adds to the value of attaining national competitiveness through the convergence of IT and energy.

From the perspective a stable supply of energy, stable supply of energy and reduction of the concentration of the specified energy are set up as sub-goals. As a result, the stable supply of energy was evaluated as important. The main reasons are in order to reduce the effects from change of international oil prices on Korean economics, which increase of necessity of a system for stable supply of energy.

Like above, this study set up the priority of sub-goals by adopting the weight of goals from the main goal. As a result, reduction of greenhouse gases came out as the first priority for policy making of Green ICT. And then, in the following order of priority came, development of relative technology, growth power, general economical growth, development of technology for green ICT policymaking, and expanding job market. These relationships between each variable and the research results can be drawn as in Fig.3.

TABLE III
FINAL WEIGHTS AND POLICY PRIORITY

Superordinate Goals (Weight) (CR =0.0798)	Sub-Goals	Weight (CR =0.0)	Total Weight
A. Economic Efficiency (0.1721)	a. Job Creation	0.1875	0.0323
	b. Stability of National Economy	0.8125	0.1398
B. Energy Efficiency (0.0642)	c. Reduction of Energy Consumption	0.5000	0.0321
	d. Increase the Benefits of Energy Services	0.5000	0.0321
C. Eco-Friendliness (0.4908)	e. Reduction of Greenhouse Gases	0.9517	0.4671
	f. Reducing Uncontrolled Resource Development	0.0483	0.0237
D. Technology Evolution (0.2514)	g. Establishment of Strategies for the Development of Green ICT	0.1875	0.0471
	h. Development of Related Technology	0.8125	0.2043
E. Stable Supply of Energy (0.0215)	i. Steady Supply of Energy	0.7869	0.0169
	j. Reduce the Concentration of the Specified Energy	0.2131	0.0046

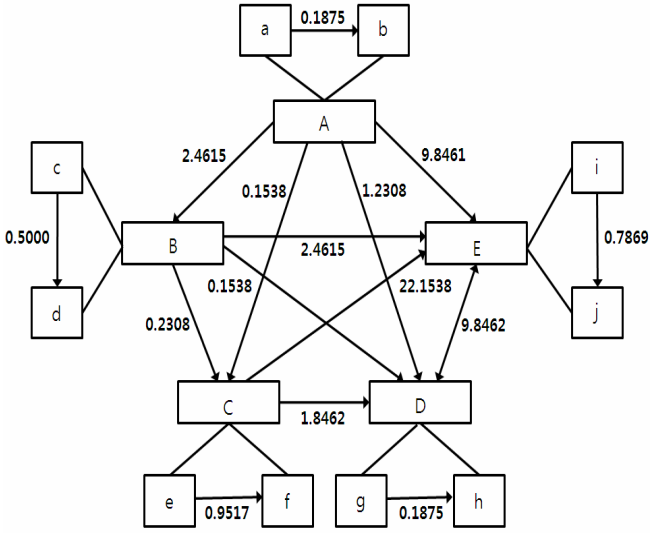

Fig. 3 Results of AHP Analysis

V. Conclusion and Discussion

Due to global warming, Green ICT is necessary to find solutions to environment and energy issues. Therefore, this study analyzed the priority of goals which need to be achieved for Green ICT policymaking in Korea. To analyze these goals, this study adopted the AHP for 5 main goals of policymaking. The goals came out in this order of priority: eco-friendliness, technology evolution, economic efficiency, energy efficiency, and stable supply of energy. The reason why eco-friendliness was the top priority is that it is the core priority in policymaking for the solution to pollution. And, international competitiveness is necessary in order to develop the technology of Green ICT policy. This can bring growth in the IT and energy industries and the national economy too.

The limitation of this study is that the survey experts in Green ICT are lacking. Therefore, the variable of energy efficiency emerged at the same level as the sub-goal's priority. And, there are no objective indicators for evaluation of effects from Green ICT policy. However, this study has significance as the base research for Green ICT policy making. If the market of related Green ICT technology continues to grow, many different studies regarding different perspectives of policy making can come out. Comprehensive and detailed performance indicators and studies for energy efficiency could be revealed from interviews with many different experts.

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