Analysis of Eco-Efficiency and Its Improvement in Healthcare Sector of Korea

Jong-Ryool KIM

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Approved by Eui-Chan JEON, Advisor

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by

Jong-Ryool KIM

Approved ----------
Seokkyu LEE, Chair of the committee

Approved ----------
Kwangyim KIM, Member of dissertation committee

Approved ----------
Jungkyu KANG, Member of dissertation committee

Approved ----------
Hana KIM, Member of dissertation committee

Approved ----------
Eui-Chan JEON, Advisor

Abstract

Human beings have achieved modern material abundance through economic growth thanks to the use of fossil energy, but the consequential environmental pollution and climate changes are worsening every year. To cope with those problems, all sector's participation into various actions for reduction including hospitals, public institutions, schools, accommodation services, is very pivotal. The healthcare sector among them is a particularly important player that provides medical services for the treatment and prevention of diseases. It is necessary for the healthcare sector to fulfill its social responsibility and role in environmental crisis these days as a responsible member in our society. In the healthcare sector, the hospital is a place where patients and staff live 24 hours a day, consuming large quantities of energy and water, generating various forms of hazardous medical waste, and using chemicals, heavy metals, and radioactive isotopes. Also, it has the characteristic of the mutual influence between the resident population and a large number of floating population in the building. It often causes severe contamination by various pathogens that spread to society, for example, the MERS-CoV outbreak in 2015 in Korea.

To effectively disseminate environmental management in the healthcare sector, the Korean government has made various policy efforts such as voluntary agreements with large hospitals for environmental management, greenhouse gases and energy target

management system, and environmental information disclosure system. Compared with those efforts, the studies or research conducted by the government, industry, academia, and institutes are insufficient, which could assess the current status and effectiveness of environmental management in the healthcare sector. Thus, the eco-efficiency of the healthcare sector was determined in this study to support the dissemination of environmental management in the healthcare sector of Korea, and the results of the analysis were used to find ways to improve eco-efficiency and support policy.

The input-oriented BCC model of DEA (Data Envelopment Analysis) was used to evaluate the eco-efficiency in the hospitals. Four input variables such as water use, energy consumption, waste generation, and hazardous chemicals usage were applied as environmental load variables, and the sales and the number of patients of hospitals were used as economic data of output variables. The eco-efficiency for 21 hospitals was evaluated from 2012 to 2015 and the average score of eco-efficiency in 2015 was 0.940. Twelve hospitals, 57% of those evaluated, had an eco-efficiency score of 1. Six hospitals had lower scores than the average. Except for the twelve hospitals with an eco-efficiency score of 1, the nine hospitals that scored lower than 1 had potentials for improvement. There was a large potential for improvement by reducing their input variables. To improve eco-efficiency in 2015, possible input reductions were calculated for water use by 8% point, energy use by 9% point, waste generation by 10% point, and hazardous chemicals usage by 24% point.

Next, an analysis using AHP (Analytic Hierarchy Process) and IPA (Importance-Performance Analysis) was conducted to find ways to encourage environmental management in the healthcare sector. Questionnaires were circulated to investigate hospital staff's response to the support factors for promoting environmental management and the difference of importance and performance of those factors. This was intended to identify the effective factors for promoting environmental management in hospitals. 13 factors were selected among 20 items from the Environmental Information Disclosure System in the healthcare sector. The 'current status' (3 items) and 'investment and technology introduction' factors (4 items) were excluded because they overlapped with the company overview and quantitative items in the publicly information disclosed system.

The IPA results revealed that there were two factors in the first quadrant (maintenance area or keep up the good work), three factors in the second quadrant (concentrated here area), four factors in the third quadrant (low priority area), and four factors in the fourth quadrant (possible overkill area). To effectively disseminate environmental management in the healthcare sector, it was necessary, first of all, to concentrate and improve three support factors in the second quadrant, which had high importance but low performance. The three support factors in the second area were 'establishment of vision and strategy of environmental management', 'organization of task team for environmental management and task assignment', and 'management of greenhouse gas emissions and its reduction activity'. In the third

quadrant (low priority area), the four support factors which were low importance and low performance and needed continuous improvement, were 'guideline and compliance of green purchasing', 'investment in new and renewable energy and the introduction of technology', 'publication of environmental report and disclosure', and 'response to stakeholder's request for environmental information'.

In-depth interviews with six experts were conducted through email and face-to-face meetings. Those six experts who took part in this interview were from environmental policy institute, consulting company, university, and hospitals. They suggested ways to improve policies for supporting environmental management in the healthcare sector. The result of the interviews suggested that, first and foremost, governmental efforts to strongly encourage CEO and staff members to take interests in the field of environmental management, and motivation on the necessity of the related activities, were of the utmost importance to promote environmental management in the healthcare sector. Because the main purpose of the healthcare sector is the treatment of patients, environmental management of a hospital was recognized as incidental works regarding business management, currently handled by the facility management team. In order for environmental management to be recognized as a key managerial factor, that is worthy enough to be in a decision-maker's mind, to be more promoted and advanced, it was analyzed that the top manager's interest, his or her strong support, establishment of dedicated task force or department, and operation of non-standing committee in charge were important factors.

With regards to other detailed support factors for environmental management, it was found that implementation of new programs such as 'guidelines and compliance of green purchasing' was most challenging, posing a far greater difficulty than establishing the program itself. In this case, it was suggested that the Ministry of Environment was necessary to cooperate closely with relevant authority, the Ministry of Health and Welfare, for encouraging participation in green purchasing through development and provision of incentives to participating hospitals. In the 'publication of the environmental report and disclosure', it was suggested that a project to support the publication of the environmental report should be provided first to a leading group such as hospitals participating in the eco-friendly hospital network. The environmental report could contribute to increasing a hospital's reputation through information dissemination and also enhance public awareness of environmental issues in the healthcare sector. Thus, the government needs to take into consideration these aspects in promoting environmental reporting in hospitals.

Regarding medical waste management, water use, energy consumption, and GHG emissions, efforts were needed to ensure that hospital employees, patients, caregivers, and other stakeholders should be engaged and interested in environmental management through education, training, and a wide range of campaigns. Besides, it was necessary to define and share the best practices of environmental management in leading hospitals, to create right conditions for spreading sound environmental management in the healthcare sector.

This study could be very meaningful to suggest improvement and action directions through comparative analysis of eco-efficiency by DEA in the healthcare sector, although it was hard to evaluate the eco-efficiency concerning direct target quantity. In addition, through surveys of hospital staff and interviews with experts, this study tried to overcome the qualitative limitations of DEA analysis and to suggest directions for effective measures and policy support for promoting environmental management in the healthcare sector of Korea. However, for a more quantitative analysis, it was necessary to make correct measurement and comparison of actual implementing efforts for a long-term period with a continuous accumulation of related data, which was the limitation of this study.

Keywords: Environmental Management (EM), Eco-Efficiency, Data Envelopment Analysis (DEA), Analytic Hierarchy Process (AHP), Importance-Performance Analysis (IPA)

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List of Abbreviations

AHP	Analytic Hierarchy Process
DEA	Data Envelopment Analysis
DMU	Decision-Making Unit
EIDS	Environmental Information Disclosure System
EM	Environmental Management
ETS	Emission Trading System
GETMS	Greenhouse Gas and Energy Target Management System
GHG	Greenhouse Gas
HCWH	Health Care Without Harm
HEED	Leadership in Energy and Environmental Design
IPA	Importance - Performance Analysis
KEITI	Korea Environmental Industry and Technology Institute
MOE	Ministry of Environment
MOU	Memorandum of Understanding
NDC	Nationally Determined Contribution
UNFCCC	United Nation Framework Convention on Climate Change
US EPA	US Environmental Protection Agency
VA	Voluntary Agreement
WBCSD	World Business Council for Sustainable Development
WHO	World Health Organization

Chapter 1. Introduction

1.1 Research Background and Objective

Mankind has achieved modern material abundance thanks to the great use of natural resources including fossil fuels, but the resulting environmental pollution and climate change are also worsening every year. In order to fight against these negative impacts, the global, national and domestic societies have exerted a great deal of effort together for making our world better.

To work against climate change, the Paris Agreement under the United Nation Framework Convention on Climate Change (UNFCCC) came to effect on 4th November 2016. It was intended for holding the increases in the global average temperature to well below 2 ℃ and pursuing efforts to limit the temperature increase to 1.5 ℃ above pre-industrial levels. Starting in the year 2020, all nations should establish and undertake their Nationally Determined Contributions (NDC) to respond to climate change globally, based on equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances (UNFCCC, 2015).

In order to cope with such environmental problems including climate change, all sectors' participation in action is paramount, not only from the manufacturing industry but also from social sectors, which cover

public and social services such as public institutions, schools, hospitals, and accommodation service. However, in the field of public and social services, environmental management (EM), so far, has not been well emphasized compared to the manufacturing industry. These sectors have characteristics that directly affect people's lives. Hence, there is a strong demand for active promotion of EM in those fields. The healthcare sector among social services plays an especially important role because of its undoubtedly strong influence on patients and their families.

According to Korea Statistics, every Korean citizens visited the hospital an average of 26.6 times in 2011 (KOSIS, 2016). There were 89,919 of healthcare facilities scattered about the country such as hospitals, clinic, dentist, public health center, and drug stores as of 2016, according to Korea Health Insurance Review & Assessment Service (KHIRA, 2017). Among them, large general hospitals with more than 100 beds numbered 341 nationwide.

According to WHO report, about 24% of global disease burden and about 33% of child disease under the age of 5 were attributable to avoidable environmental exposures (WHO, 2006). Hospitals were essential players in the healthcare sector that provided medical services such as treatment and prevention of diseases. It is necessary to fulfill their social responsibility and role in environmental crisis these days (Kang, 2015). The hospital is where patients and staff live 24 hours a day, using a lot of energy, chemicals, heavy metals, and radioactive isotopes and producing various forms of waste. Also, it has a mutual influence on the resident population and the floating population in the

building and it often causes a serious problem with various pathogens, for example, the MERS-CoV (Middle East respiratory syndrome coronavirus) outbreak from 20 May to 23 December of 2015 in Korea.

The Ministry of Environment (MOE) in Korea has been conducting the voluntary agreement (VA) with the large general hospitals, university hospitals or superior general hospitals since 2013 in order to promote EM in the healthcare sector. The EM is a management that fulfills social and ethical responsibilities while minimizing greenhouse gas (GHG) emissions and environmental pollution by the reduction and efficient use of resources and energy in business activities (Kang, 2014). Ten leading hospitals such as Kyungbuk National University hospital and Daegu Patima hospital signed Memorandum of Understandings (MOUs) for the first time in 2013. Eleven more hospitals in 2014 such as Mokdong hospital of Ewha Women's University and Kochang hospital, nine hospitals in 2015 such as the National Central Medical Center and Myungji St. Mary hospital, and six hospitals in 2016 followed with their own MOUs. As of the end of 2016, a total of 44 hospitals participated in voluntary agreements for EM. After concluding VA, hospitals have used the title of 'green hospital' for publicity. The MOE provided them financial support up to 10 million KRW for EM consulting, the establishment of eco-friendly hospital network in domestic and global level, and sharing of best practices and solutions to the problem facing EM.

In addition to VA, the MOE has operated the Environmental Information Disclosure System (EIDS) to raise the voluntary commitment for the environment by industry and business sectors, to

promote their environmental communications with people, and to establish the environmental management basis for the society. It was expected to contribute to building and spreading out an autonomous EM culture across the whole society. Since 2010, the EIDS has been gradually rolled out as a pilot project in green companies by the MOE in Korea. Those participating companies in EM received various benefits from the government. From 2012, in accordance with the provisions of Article 16.8 and 16.9 of the Environmental Technology and Environmental Industry Support Act, the EIDS was expanded to central government agencies, local governments, universities, public and local corporations and energy target management companies, including green companies. By the end of 2015, a total of 1,216 companies and organizations have participated in EIDS, including 78 hospitals and related public institutions from the healthcare sector.

In this regard, although the government continuously exerted its efforts to promote EM in the healthcare sector, the study or research by the government, industry, academia, and institutes which could assess the current status and effectiveness of EM in the healthcare field, are at a standstill. Also, its progress of EM in hospitals is still in its infancy stage.

Thus, it is meaningful to review the evaluation tools that can diagnose the current state of EM in the healthcare sector. Through this study, practical strategies and support policies needed for healthcare sector can be derived. This study could contribute to building a solid groundwork for disseminating EM in the healthcare sector. In this study, the concept of eco-efficiency was applied as a criterion for

evaluating EM in the healthcare sector. Eco-efficiency is a concept that maximizes economic value by minimizing environmental burden in the entire business process. It can provide the tool for analysis of both performances of environmental improvement and economic value increased such as total sales or total cost savings (WBCSD, 2000). The outcome of EM can be deemed to have the same value as the enhancement of eco-efficiency. In this study, the current situation in the healthcare sector was diagnosed through the analysis of eco-efficiency. Based upon it, the potentials for improvement were suggested to enhance eco-efficiency in the healthcare sector. Through the comparative analysis of present policies, the effectiveness of policies for EM was examined. Policy tools were suggested for encouraging adoption of EM in the healthcare sector.

In order to disseminate EM in the healthcare sector, the healthcare sector itself also needs to establish an in-depth strategy for promoting its own EM, while it is an important influencing factor that government provides practical incentives to the healthcare sector. In this regard, a survey on the status of EM in the healthcare sector was conducted for hospital staffs in-charge. In addition, interviews and consultations with experts on EM in the healthcare sector were carried out to find out how to implement effective support strategy and policy. This study will, therefore, contribute to diffusing EM in the healthcare sector and consequently enhancing the effectiveness of environmental policy, including reduction of environmental risk by hazardous wastes and chemicals and countermeasures against climate change which has gradually been posing more severe issues in recent years.

1.2 Research Method and Procedure

The purpose of this study was to evaluate the status of EM in the healthcare sector and to develop practical strategies and supporting policies for the introduction and dissemination of EM in the healthcare sector. For this objective, the level of eco-efficiency of the hospitals compared to each other, assessed to support the diffusion of EM in the healthcare sector, and the results from the assessment were analyzed to find ways to improve eco-efficiency and policy support. The detailed research method and procedure of this study was as follows.

First of all, the current status of EM in the healthcare sector was analyzed through reviews of cases of EM in domestic and overseas areas, related previous research and literature reviews.

Second, the eco-efficiency was evaluated to measure the level of EM in the healthcare sector in Korea by Data Envelopment Analysis (DEA) and to suggest policy measures to improve eco-efficiency. DEA was developed to represent a nonlinear programming, which was extended to the ratio model with the relative efficiency concept (Jung and Kim, 2011). In particular, the DEA identified the Decision-Making Units (DMUs), evaluating targets such as government, hospital, company, programs, and policy measures to be evaluated in the analysis process as efficient and inefficient units. It had advantages to provide information on the reference set and potential improvement that should be set as an example for inefficient units to be efficient. Therefore, it has been widely used not only as a measure of efficiency but also as a

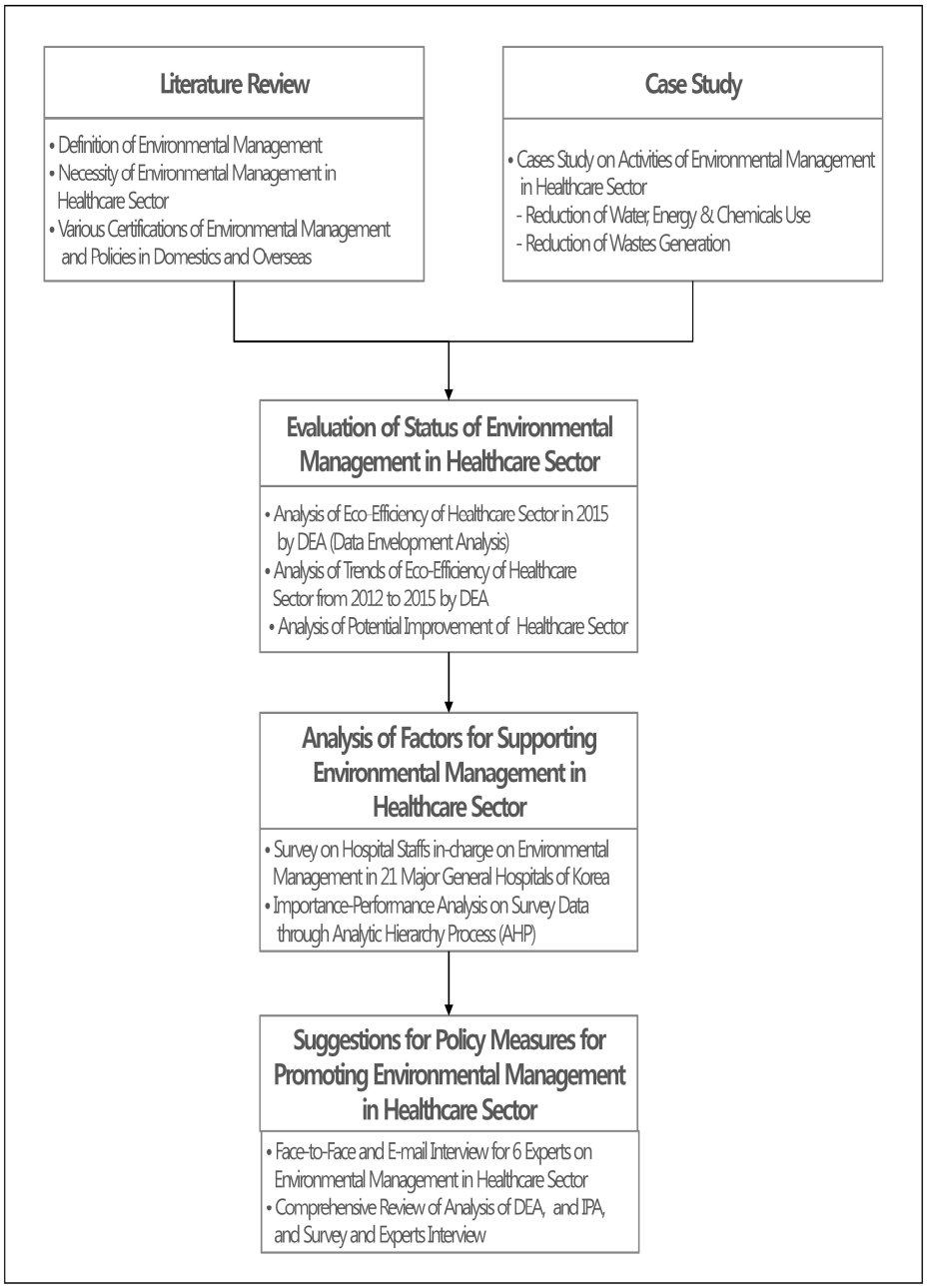
tool for setting goals for analysis and improvement of inefficiency. The subjects of this study were 21 hospitals, in which their information was open to public through the environmental information disclosure system. The variables for eco-efficiency evaluation were selected as mandatory open items, quantifying health information such as total amount of sales, the number of patients, and the quantity of water and energy use in the healthcare field of the environmental information disclosure system (see in <Table 1>). Frontier Analyst 4.0, which provides in-depth analysis and graphics compared to other data envelopment analysis software, was used for eco-efficiency analysis.

In this study, the input-oriented model was applied because it aimed to minimize the environmental load while maintaining economic value. The BCC model (Banker, Charnes, and Cooper, 1984) that excludes the effect of the scale, was used because the scale change of hospital was limited in its management activity. As of 2015, the relative eco-efficiency of 21 hospitals was assessed and the potential improvement of low eco-efficient hospitals was calculated. In addition, this study investigated possible ways according to environmental variables and suggested the measures that those hospitals with low eco-efficiency could adopt for enhancing their eco-efficiencies in the future.

Next, in order to elaborate policy support measures for promoting EM in hospitals, the Importance-Performance Analysis (IPA) was carried out using survey results from 21 hospitals. The IPA is a very useful analytical method that can save time and cost because it derives the

research result easily and quickly, using the matrix through the average values of the evaluation attributes without using the highly difficult statistical method. The questionnaire was circulated to hospital staff in-charge of EM in hospitals and they were asked for importance and performance on quantitative and qualitative items among twenty items, which were open to the public. Then, the levels of importance of each item for promoting EM and levels of performance of each item for enhancing the outcome of current hospital business activities were investigated. The matrix of IPA revealed support factors of policy to be promoted first for hospitals.

Finally, the direction of government policy for promoting diffusion of EM in the healthcare sector was presented by combining the results of experts' opinions and surveys of the hospital staffs in charge. See the research procedure at <Figure 1>.



<Figure 1> Research Procedure

Chapter 2. Theoretical Review of Environmental Management in Healthcare Sector

2.1 Environmental Management and Its Necessity in Healthcare Sector

2.1.1 Definition of Environmental Management

Environmental management (EM) refers to management that fulfills social and ethical responsibilities while minimizing GHG emissions and environmental pollution while saving and efficiently utilizing resources and energy in management activities (Kang, 2014). Thus, EM is not only a concept of environmental efficiency that maximizes output compared to input (resource or energy), but also a new concept of non-financial performances such as social and ethical responsibility of company in its society (MOE, 2017).

These days human beings are experiencing global climate change and environmental pollution episodes and as in turn have become more sensitive to their environmental problems than ever before. Also, as a group of conscious consumers, they monitor industry and business activities through a variety of media and demand them to be accountable for EM in all processes from production to distribution and consumption.

In addition, EM was recognized as one of the important factors that created competitive advantage among companies. These days EM became a practical strategy because it has pursued environmental sustainability and economic profitability simultaneously (Jang and Han, 2006). In this regard, many large companies such as Samsung, POSCO, LG, Hyundai Motors, Toyota, and IBM, have promoted EM in order to increase their environmental performances, enhance the company's status and reputation to the public and secure customers' loyalty. There were many empirical studies that the corporate environmental performance positively affected financial performances of the companies as well as firm values in factors such as stock price, stock returns, growth, profitability, and sales of the firm (Kweon et al., 2015; Kim, 2014; Lee et al., 2012a; Moon and Kim, 2006; Jang and Han, 2006). Particularly, in the manufacturing industry, the importance of promoting EM has been emphasized due to the price rise of raw materials, the strengthening of international environmental regulations, and the importance of the environmental industry as a new business opportunity. In 2007, the Mckinsey Quarterly surveyed the representatives of major companies around the world and found that more than the half of the respondents felt that EM could strengthen their competitiveness. According to the report of the Mckinsey & Company in July 2014, the high-sustainability companies did better and grew greatly from $ 1 at the beginning of 1993 to $22.6 by the end of 2010, compared with $1 in 1993 to $15.40 for low-sustainability companies. They found a significant correlation (95% to 99% confidence level) between resource

efficiency and financial performance in companies (Mckinsey, 2014).

However, in the field of public and social services, EM still has not been strongly emphasized compared to the manufacturing industry. Recently the need for the quick and aggressive introduction of EM is gradually increasing because these services have characteristics that directly affect our daily life. In particular, it can act as a positive factor for disseminating EM to society as a whole through communication with customers who use that service, as well as the business itself providing its service. In addition, buildings for public and social services such as hospitals, hotels, and schools, were expected to have a greater contribution to mitigation of climate change due to energy savings through the promotion of EM. The hardware that provides the most public and social services was the building. It used energy a lot more than those of commercial and residential sectors and manufacturing industry. Most of the research results showed that the potential for GHG reduction from buildings of public and social services was significantly higher than that from buildings of the manufacturing sector. 34% of the energy consumption depended on the living patterns of the users in the building (Brown et al., 2008).

Above all, it was required to establish the system and strategy for EM in order to sustain EM in their business and services. As shown in <Table 1>, four aspects were important for EM; Environmental system and strategy, EM activities, Resources and energy, and GHG and environmental pollution (KEITI, 2012).

<Table 1> Framework for Environmental Management in Korea

Category		Details
Environmental System & Strategy	Strategy & Goal	• Establishing formalized environmental strategies and goals • Chief executive involvement • Connecting with existing management plans • Establishing action plan & goals for achieving the vision, etc.
	System	• Designating officially environmental management personnel and department • Clear assignment by staff and department • Establishing evaluation processes such as monitoring procedure and period
Environmental Management Activities	Green Procurement	• Developing green purchasing guidelines and setting goals • Personnel education and establishment of green procurement system • Establishing green procurement training and cooperation with partner companies
	Environmental Service	• Development of environmental service • Expanding the proportion of environmental services among all services
	Education & Training	• Regular environmental management education and training • Development of environmental management education curriculum
	Certificate & Agreement	• Strengthening capacity and competencies through acquisition of external environmental certifications
Resources & Energy	Resource Efficiency	• Measurement and efficiency analysis of water and raw materials use • Continuous improvement analysis
	Energy Efficiency	• Measurement & efficiency analysis of energy use • Continuous improvement analysis
GHG & Environmental Pollution	Management of GHG	• Establishment of GHG inventory and management of emissions
	Control of Environment Pollution	• Waste, pollutant discharge, indoor environmental management, etc. • Development of internal guidelines and manuals

2.1.2 Necessity for Environmental Management in Healthcare Sector

The healthcare sector was one of the major buyers and one of the great sources of pollutants at the same time. The numerous purchase included a lot of pharmaceuticals, food, electricity, water, paper and office supplies. Also, it generated a variety of pollutions such as air emissions, wastewater effluents, medical wastes including infectious, pathogenic and chemical wastes, and municipal solid waste. If not properly managed, they would cause serious environmental pollution and adverse effects on human health. About 75-90% of the total wastes were general waste, generated by administrative, housekeeping and maintenance functions. However, the remaining 10-25% of waste including infectious, pathologic and chemical wastes, were hazardous and could create a variety of serious health risks (IFC, 2003).

In Korea, the amount of medical waste generated consistently increased by about 15% annually over last 10 years from 2006-2015. In 2015, a total of 61,728 healthcare facilities, including 361 large general hospitals, generated 203,261 tons of waste annually, which consisted of 73.8% of general waste and 26.2% of hazardous, chemical, clinical and infectious wastes (MOE, 2016a). Most of the medical wastes (95.3% in 2013) were incinerated. The cost for incineration was about 600~800 thousand KRW per ton, which was 4 ~5 times more expensive than that of municipal wastes (MOE, 2015). Regarding energy use, in the United States, the healthcare facilities ranked second only to

manufacturing facilities in electricity use per square foot (ESC, 2007).

In particular, hospital seems to be important in the healthcare sector because it is regarded as a representative of a variety of categories such as drugstore, health center, and health agencies in the healthcare sector. Trust from people is also the cornerstone of a hospital's public image and expectations so that the hospital is requested to fulfill their social responsibilities and roles in addressing environmental problems. In Korea, environmental policies such as greenhouse gas and energy target management system, environmental information disclosure system, and emission trading system, include the healthcare sector in its implementation. In this regard, the promotion of EM in the healthcare sector becomes more important. The healthcare sector needs to adopt EM to satisfy internal needs or incentives and external requests.

The internal needs for EM in the healthcare sector are categorized as three. First, EM helps to reduce administrative cost in the healthcare sector. The increase of the administrative costs in the healthcare sector was a pressing factor for business management. Proper treatment of medical waste and wastewater, and the amount of energy use were among the major elements of hospital costs and they also had significant potential for environmental impacts. Therefore, reducing those pollutions cut costs and improved their performances. Most hospitals introducing EM in Korea had a goal of reducing administrative costs (Kang, 2015).

Second, there was a need for a new strategy for service differentiation in order to be competitive among hospitals (Kang, 2015). Hospitals would like to use various certificates as tools for high quality

of healthcare and for their publicity, which meant that EM was one of differentiated strategy for raising public interest or awareness on their hospitals.

Third, good EM in hospitals went hand in hand with the improvement of safety and environment, service quality, cost savings and improvement of staff and patient's health protection. Many studies showed that best environmental practices brought positive impacts and benefits to patients, their family, and staffs, in addition to the hospital itself as shown in the summary of benefits of best EM in the healthcare sector at <Table 2>.

There are three external factors. First, governments regulated hospitals to reduce their impacts on the environment. In addition to direct control for medical waste by government, there were various environment policies such as reduction of GHG emissions and energy use, inclusion in emission trading system and information disclosure.

Second, there was a growing demand by the public for the healthcare sector to fulfill their social responsibilities. As the age of the healthcare consumer increases, they are likely to consider the social responsibility activities of hospital to be important when choosing hospitals (Lee et al., 2012b). At the end of 2016 in Korea, the elderly above age 65 numbered 6.45 million, consisting of 12.7% of health insurance members and they spent a monthly average of 328,599 KRW on medical costs, which was 3.1 times higher than the average and was 38.7% of total medical costs spent in 2016 in Korea (KHIRAS, 2017). Therefore, to increase their profit, hospitals considered the trend and preference of patients as an important factor.

Third, as the standard of living of people improves, the level of service of the healthcare sector is also increasing, and the physical environment of healthcare facilities was considered as an important part of the healthcare service experience.

<Table 2> Summary of Benefits of Best Environmental Management in Healthcare Sector

Category	Details
Safety Benefits	• Better handling of hazardous and toxic materials • Awareness raising of the staff and patients • Better and safer waste management • Reduction of the number of accidents and injuries (e.g. needles)
Economic Benefits	• Improvement of efficiency (technological, energetic, building and staff, reduction of losses) • Cost reduction (e.g. energy prices are and will continue increasing in the future, high costs of waste disposal) • Improvement of management practices (e.g. green purchasing) • Reduced turnover and higher productivity of staff
Environmental Benefits	• Reduction of CO_2 emissions • Better resources management • Water shortage abatement • Reduction of air pollution • Climate change mitigation (e.g. a big amount of electricity is gained from oil or coals)
Health and Social Benefits for Staff and Patients	• Improvement of health impact (e.g. air quality) • Decreased length of stay in hospital • Nosocomial infection reduction • Awareness raising (e.g. training) • Motivation increase through involvement of staff

* *Source*: SBA (2011), retrieved from Home Page (http://www.sba-int.ch)

2.2 Status of Environmental Management in Healthcare Sector

2.2.1 Trends of Environmental Management Overseas

EM of the healthcare sector has been actively promoted in the United States. In 1994, the US Environmental Protection Agency (US EPA) found that the incineration of hospital wastes released about 140 times more toxic substances such as dioxin and furan than the incineration of general hazardous wastes (Seo et al., 2010). In 1996, the EPA designated medical waste incineration as one of leading sources of dioxin, one of the most potent carcinogens. To respond to this serious problem, 28 organizations formed the coalition Health Care Without Harm (HCWH). HCWH's areas of work include sustainable healthcare waste management, green building, the substitution of hazardous chemicals used in hospitals with safer alternatives, reduction of health care's climate footprint and working with the health sector to advocate for a healthy climate (HCWH Home page).

In 2006, the US EPA, with American Hospital Association and Health Care Without Harm, co-established H2E (Hospitals for Healthy Environment) for promoting EM in the healthcare sector. The H2E has provided healthcare experts and hospital staff with information and education on environmentally friendly medical service, and checklists and questionnaires for EM of the healthcare sector (Seo et al., 2010). In addition, the US Green Building Council (USGBC) and the US Department of Energy (DOE) iterated on energy intensity in the

healthcare sector and worked together to improve the LEED-HC program (Leadership in Energy and Environmental Design for Heath Care). The LEED-HC's evaluation areas consist of 7 categories and a total score of 110; Sustainable Site, Water Efficiency, Energy & Atmosphere, Material & Resources, Indoor Environmental Quality, Integrative Design / Innovation and Design Process, and Regional Priority. The details were in <Table 3>. LEED was graded as four types based on final score; Certified (40 to 49), Silver (50 to 59), Gold (60 to 69), and Platinum (80 or more) (Kang et al, 2010).

<Table 3> Evaluation Criteria for the Certificate of LEED-HC in USA

Category	Details
Sustainable Site	• Construction activity pollution prevention • Environmental site assessment
Water Efficiency	• Water use reduction—20% reduction • Minimize potable water use for medical equipment cooling
Energy& Atmosphere	• Fundamental commissioning of building energy systems • Minimum energy performance • Fundamental refrigerant management
Material& Resource	• Storage and collection of recyclables • PBT source reduction—Mercury
Indoor Environmental Quality	• Minimum indoor air quality performance • Environmental tobacco smoke control • Hazardous material removal or encapsulation
Integrative Design/ Innovation and Design Process	• Integrated project planning and design

* *Source:* retrieved from Home Page (http://www.usgbc.org)

In Japan, Eco-Action 21 (Environmental Activity Evaluation Program), an environmental certification for small and medium enterprises (SMEs), has been certified to drive EM in the healthcare sector by the Ministry of Environment of the Japanese Government. Unlike other certification systems for EM, Eco-Action 21 has a direct evaluation index on actual inputs and emissions. It was a requirement to make environmental reports and disclose information through the Eco-Action 21 secretariat. Eco-Action 21 has supported education, seminar, and consulting to encourage continuous implementation through systematic environmental improvement program and induced program participating companies into the system. Since the introduction in 2004, non-manufacturing sector accounted for 76% of total certificates (MOE, 2017).

In Australia, Green Star certification, which operates for the development of an environmentally-friendly construction industry by the GBCA (Green Building Council for Australia) since 2003, is leading the EM in the healthcare sector. Green Star has categorized buildings into 9 types, including healthcare. The detailed criteria for evaluation consisted of 9 areas: Management, Indoor Environmental Quality, Energy, Transport, Water, Materials, Land Use & Ecology, Emissions, and Innovation. In particular, the criteria of indoor environment quality was characterized by more detailed evaluation items, compared to the US LEED-HC (Kang et al, 2010). See the details at <Table 4>.

In Europe, the Eco-Management and Audit Scheme (EMAS) as the representative of EM certification was introduced in 1993 and extended to the healthcare sector from general enterprise-oriented EM system.

<Table 4> Evaluation Criteria for the Certificate of Green Star-Healthcare in Australia

Category	Details
Management	Green Star accredited professional Commissioning-clauses Building tuning, Building guides Independent commissioning agent Environmental management Waste management Building management systems Maintainability Construction indoor air quality plan Sustainable procurement guide
Indoor Environment Quality	Ventilation rates, Air change effectiveness CO2 monitoring and control and VOC monitoring Daylight Thermal comfort Hazardous materials Internal noise levels Volatile organic compounds Formaldehyde minimization Mould prevention Daylight glare control, Electric lighting levels High frequency ballasts External views Individual thermal comfort control Exhaust riser Air distribution systems Outdoor pollutant source control Places of respite
Energy	Energy-conditional requirement GHG emissions Energy-sub-metering Peak energy demand reducing Light zoning, Car park ventilation Efficient external lighting

<Table 4> Evaluation Criteria for the Certificate of Green Star-Healthcare in Australia (Continued)

Category	Details
Transport	Provision of car parking Fuel efficiency transport Cyclists facilities, Commuting mass transport Transport design and planning
Water	Occupant amenity water Water meters Landscape irrigation Heat rejection water, Fire system water Portable water use for equipment
Materials	Recycling waste storage Building reuse Recycled-content & reused products and materials Concrete, Steel, PVC minimization Sustainable timber Design for disassembly Dematerialization, Flooring, Joinery
Land Use&Ecology	Ecology-conditional requirement Topsoil, Reuse of land Reclaimed contaminated land Change of ecological value
Emissions	Refrigerant ODP (ozone depleting product) Refrigerant GWP, and leaks Insulant ODP Watercourse pollution Discharge to sewer, Legionella Light pollution, Trade waste pollution
Innovation	Innovative strategies and technologies Exceeding Green Star benchmarks Environmental design initiatives

* *Source :* retrieved from Home Page (http://www.gbca.org.au)

As shown in <Table 5>, the healthcare sector can establish the EM system, its management status and improvement plan through EMAS certificate (MOE, 2011). As of October 2016, a total of 3,943 organizations have been certified by the EMAS in Europe, since the introduction in 1993. Among them, the non-manufacturing sector accounted for more than 37% (MOE 2011).

<Table 5> Evaluation Criteria for the Certificate of EMAS in Europe

Category	Details
Overview	General information, main business activities, structure of organization management
Environmental Management System	Environmental policy, environmental goal, environmental management organization, environmental management implementation method, etc.
Status of Environmental Management	[Direct loads] Air, water, waste, chemical, resource, energy usage and their management
	[Indirect loads] Product management, facility investment, service, supplier environment management, etc.
Plan for Environmental Improvement	Goal of environmental performance improvement and its implementing plan
Environmental Data	Emissions of pollutions, quantity of waste generated, energy usage, and resource usage, noise and etc.
Compliance of Environmental Regulation	Status of compliance with environmental laws and regulations
Certificates	Name and number of certifications, date certified

* *Source* : retrieved from Home Page (http://ec.europa.eu/environment/emas)

In the UK, the BREEAM, Building Research Establishment Environmental Assessment Method, has operated since 1990 for the first of its kind of program in the world. It is a system for assessing the environmental performance of new and existing buildings. There are several types of BREEAM for different types of buildings, including courts, schools, industrial, office, retail, prisons, multi-residential and data center. For the healthcare sector, BREEAM Healthcare has been used. BREEAM assessment includes 10 criteria; ① maintenance, ② health and wellbeing ③ energy, ④ transport, ⑤ water, ⑥ materials, ⑦ waste, ⑧ land use and ecology, ⑨ pollution and ⑩ innovation. BREEAM Healthcare has similar characteristics with LEED in the USA. In the case of hospitals, the number of evaluation items is higher or equal to that of an office building in all evaluation areas (Kang et al., 2010).

Finally, the World Health Organization (WHO) initiated the International Network of Health Promoting Hospitals and Health Services (HPH) to put into action the WHO principles of health promotion, which concerns patients, staff, community, and the environment of hospitals and health services (WHO, 2016). One of the three missions of the HPH was better health gain by improving the relationship between hospitals/health services, the community and the environment. To address climate change in the health sector, the WHO collaborated with HCWH to publish the discussion paper on 'Healthy Hospitals, Healthy Planet, Healthy People'. This paper focused on health sector's action for climate change, arguing that 'the health sector can

play a leadership role in mitigating climate change′ and suggested seven elements of a climate-friendly hospital; ① energy efficiency, ② green building design, ③ alternative energy generation, ④ transportation, ⑤ food, ⑥ waste, and ⑦ water (HCWH Home page). In addition, HCWH has worked hard globally to help the health sector worldwide reduce its environmental footprint, and become a community base for sustainability and a leader in the global movement for environmental health and justice. the HCWH now is a broad-based international coalition of hundreds of organizations in 52 countries (HCWH, 2017).

2.2.2 Policies for Promoting Environmental Management in Healthcare Sector in Korea

There were four government-led policies for promoting EM or indirectly contributing to EM in the healthcare sector in Korea. The Voluntary Agreement (VA) with government, Environmental Information Disclosure System (EIDS), the Greenhouse Gas & Energy Target Management System (GETMS) and Emission Trading System (ETS) were as follows.

The first approach directly targeting the healthcare sector was a VA between the government and healthcare sector. From 2011, the Korean MOE took several initiatives, which included developing guidelines for EM of public and service sector including healthcare sector, holding seminars and workshops for building their capacities, sharing best

practices in the healthcare sector, supporting the establishment of domestic environmental hospital networks and organizing expert meetings. Those measures helped to promote EM in the healthcare sector. From 2013, the MOE started to conclude a voluntary agreement between the government and hospitals for EM. The signing ceremony of the memorandum of understanding (MOU) for EM between the Minister of MOE and CEOs of large hospitals drew a lot of attention from the press and public. Ten hospitals such as Kyungbuk National University hospital and Daegu Patima hospital signed the MOUs for the first time in 2013. In 2014, eleven hospitals such as Mok-dong hospital of Ewha Women's University and Kochang hospital, nine hospitals in 2015 such as the National Central Medical Center and Myung-ji St. Mary hospital, and six hospitals in 2016 followed these MOUs. As of the end of 2016, total 44 hospitals participated in voluntary agreement for EM. Hospitals with VA have a possibility to get a title of 'green hospital' for their publicities. They also got a financial support up to 10 million KRW from the MOE for EM consulting and the MOE helped to establish green hospital network in domestic and global level, to share best practices, and to provide the expert advice or solution for the problem facing in EM.

The second measure was the Environmental Information Disclosure System (EIDS). The EIDS was a regulation introduced for indirectly promoting EM by the MOE in Korea on April 28, 2011, after three year-pilot periods. The EIDS has three objectives; ① To enhance the willingness of participating companies and agencies to voluntarily

promote EM, ② To promote environmental communication with the public and strengthen monitoring on their environmental impacts by stakeholders, customers, and business partners, and ③ To increase financial investment for eco-friendly companies from financial institutions and investors (Hwang, 2011; KEITI, 2016). From January of 2012, green enterprises, central and local governments, public agencies, private and public universities, large general hospitals and companies having significant environmental effects, should disclose environmental information such as their business overview, major plan and activity for EM, resources savings and pollutants reductions, and outcome from EM, according to the provision of Article 16.8 and 16.9 of 'Environmental Technology and Environmental Industry Support Act'. The number of companies or agencies subject to the EIDS was 1,216 with 8,720 business sites in 2015. For healthcare sector, there were total 78 with 21 hospitals and 57 public agencies related health. The detailed items of environmental information to be disclosed by the healthcare sector were shown in <Table 6>.

The third was the Greenhouse Gas and Energy Target Management System (GETMS). The GETMS was a direct regulation under the Framework Act on Low Carbon Green Growth. Companies and facilities with high levels of GHG emissions and energy consumption were subject to meet their annual GHG reduction target, set up by the relevant governments. The GETMS was introduced in 2010 in order to contribute to achieving national mid-term GHG mitigation target such as 30% reduction below 2020 BAU levels (GIR, 2017). As the end of 2016,

total 346 companies and facilities complied with this regulation. As one type of building sector, six hospitals including large general hospitals such as Yangsan Busan University hospital and Gwa-cheon Gil hospital, have been regulated under the GETMS and tried to make efforts to save energy for GHG emissions reduction.

The fourth was the Emission Trading System (ETS) in the healthcare sector. Korea introduced the ETS on January 1, 2015, in accordance with the Act on the Allocation and Trading of GHG Emission Permits. Companies emitting above 125,000 ton-CO_{2eq} annually or business unit with 25,000 ton-CO_{2eq} annual should comply with the ETS. They got allowable permits of GHG emissions from the government based on recent three year-average emissions by grandfathering for the first period, 2015-2017. They should comply with their permitted emissions through selling or purchasing permits emitted from others. From period II in 2018-2020, the government planned to reduce 3% of total allowable permits compared to Period I. The price of KAU (Korean Allowance Unit) traded on 12 May 2017 was 20,500 KRW. Four hospitals including Kangnam St. Mary's hospital, Samsung hospital, Hyundai Asan hospital and Seoul National University hospital were subject to the ETS from 2015 to now. Therefore, those hospitals should keep up with their allowed emission levels.

<Table 6> Items of Environmental Information Disclosure System in Korea

Category	Item	Mandatory/ Voluntary
1. Current Status	1. Sales	Mandatory
	2. Number of patients	Mandatory
	3. Records of environmental award-winning and agreement	Voluntary
2. Green Management Strategy	4. Environmental management strategy and policy	Voluntary
	5. Environmental management organization and its task	Mandatory
	6. Operation of green purchase guidelines	Voluntary
3. Resource/ Energy	7. Investments in raw material/water/energy –saving, introduction of technology	Voluntary
	8. Water usage	Mandatory
	9. Energy usage	Mandatory
	10. Investment in new renewable energy, introduction of technology	Voluntary
4. GHG/ Environmental Pollution	11. GHG mitigation investment and introduction of technology	Voluntary
	12. Level of GHG management and emissions,	Voluntary
	13. Investments in environmental pollutants reduction, introduction of technology	Voluntary
	14. Pollution/ harmful chemical control & monitoring system	Voluntary
	15. Emissions of water pollutants	Voluntary
	16. Waste amount	Mandatory
	17. Harmful chemical usage	Mandatory
5. Social/Ethical Responsibility	18. Violation of internal/external environmental laws and regulations on environmental pollutants, products, and services	Mandatory
	19. Publication of environmental(sustainable) report	Voluntary
	20. Response to stakeholder's request for environmental information	Voluntary

Source: retrieved from Home Page (http://www.env-info.kr)

2.2.3 Status of Environmental Management in Healthcare Sector in Korea

In Korea, the number of health facilities was 89,919 in 2016. Most of them were clinics, dentist, oriental clinics and drug stores at <Table 7>. There were 3,283 hospitals. Large general hospitals with more than 300 beds were 43, including university hospitals. According to the medical service act in Korea, the hospital should be equipped with 30 patient beds while general hospitals with at least 100 beds. Superior general hospitals, designated by the Ministry of Health and Welfare, should be equipped with more than 300 beds with no less than 20 specialized departments.

<Table 7> Statistics of Health-related Sector of Korea in 2016

Total	Superior General Hospital	General Hospital	Hospital	Clinics	Dentist	Oriental Clinics	Health Center	Drug Store
89,919	43	298	2,942	30,292	17,246	14,150	3,505	21,443

Source; KHIRAS, as of end of 2016

According to a study on green health in domestic hospitals by Korean Institute of Hospital Management in 2010, only 6.5% of hospitals established Green Team with objectives of planning and implementing for EM in the hospital. However, use of energy efficient product was 73.9% and education of their staffs on waste separate disposal and

energy saving was 76.1% (Lee, 2011). This implied that EM in hospitals focused on short-term activities for gaining short-term performances, instead of more systematic approach.

However, thanks to government policies, healthcare sector these days in Korea has been also pursuing EM through establishment of tasking team and strategy, and various eco-friendly activities. Hospitals participating in VA had achieved a lot of cost savings through reduction of energy and water consumption. <Table 8> showed the progress of MOUs from 2013 to 2015.

<Table 8> Progress of Hospitals with Voluntary Agreement for Environmental Management in Korea

Year	Voluntary agreement and its progress
2013 (1st)	• 10 MOUs with Kyungbook University Hospital, Yonsei University Hospitals and etc • Electricity saving 2,010 MWh/year, water saving 155,910 ton/year, GHG reduction 5,305 tCO_2/year and its cost saving of 1,300 M. KRW.
2014 (2nd)	• 11 MOUs with Kochang Hospital, New Korea Hospital • Electricity saving 1,516 MWh/year, water saving 47,482 ton/year, GHG reduction 1,277 tCO_2/year and its cost saving 500 M. KRW.
2015 (3rd)	• 9 MOUs with Myungji St. Mary's Hospital, Sungji Hospital • Electricity saving 6,178 MWh/year, GHG reduction 3,188tCO_2 /year and its cost saving 900 M. KRW.
2016 (4th)	• 14 MOUs with Catholic Incheon St. Mary's Hospital, Ulsan University Hospital and etc. • Through environmental management, enhanced support for eco-friendly medical service in essential aspect

Source: MOE (2016b)

In addition, there were several cases of the voluntary introduction of environmental-friendly building when they rebuilt or renovated, although Korea government did not provide the certificate of green building for the hospital. Some small and medium-sized hospitals also implemented voluntarily various EM activities such as environmental education for their staff, campaign for energy savings and purchase of local foods. Also, because it was difficult to construct new building due to large financial burden, small and medium hospitals were likely to use a strategy to partially improve the physical environment such as the installation of an indoor garden, indoor remodeling for inflow of natural light, and provision of resting spots (Kang, 2015). Another characteristic of EM led by individual hospitals was the strategy of strengthening their internal capacity of staffs rather than improving their physical environment. They believed that their staff's awareness of environment helped to contribute to improving their performance in business aspects.

Especially, Green hospital located in Jungrang-gu, Seoul, Korea was famous for green services, such as free medical service to the elder, volunteering to clean neighbors, and holding green bazaar to the local community. They hold every year green bazzar with the local environmental NGOs. This event has continued from the opening of the Green hospital in 2003 up to now for the 14^{th} event in 2017. It has the purpose to share, donate, exchange clothes, books, foods and talents, and to help the low-income elderly through donation of its proceeds (Green hospital, 2017)

<Table 9> Examples of Environmental Management Practices in Korean Hospitals

Hospital	Activities for environmental management
Hospital A	• Employees' volunteer activities on community service for a certain period of time • Promotion of environmental hormone education and environmental hormone-free campaign for patients, people, and community • Remodeling and providing resting space for community with inflow of natural light, garden, and shelter in hospital
Hospital B	• Establishment of the green management committee under the CEO of hospital, and its continued implementation and activities • Establish the Eco-plus team dedicated to environmental management to establish an annual plan for environmental management, educate hospital staff, and promote eco-friendly affairs
Hospital C	• First holding the proclamation ceremony for environmental management with the slogan "Eco Green Hospital" in 2008 and its implementation • Improvement of indoor air quality by various activities such as declaration event for stop-smoking, smoking-free hospital campaign
Hospital D	• 90% or more mandatory purchase of green products. • Operating employee training and education related to green procurement
Hospital E	• Operating plant factory that cultivates clean vegetable such as lettuce, chicory, etc. on the first floor, so that it enables patients to experience plants and to be relaxed • Most of the harvested vegetables are used as organic food sources for their patients.

Source: MOE (2011), retrieved from Home Page (http://www.env-info.kr)

<Table 10> Practical Actions for Environmental Management from Business Aspect

Category	Details
Strategy and Goals	• Environmental management check • Unit level management • Leading response on government policies • GHG & energy target management • Improving campaign participation
System	• Creating EM organization and job rules • Reducing waste by improving energy management • Putting name tag of lighting switches for turning off • Training for the training of experts in each field • Promoting environmental awareness by employees & staff
Green Purchasing	• Guidelines for eco-friendly purchasing • Reducing the cost of disposable consumables • Establishing a process for purchasing energy efficient products • Signed eco-friendly food service agreement • SCM management (selection of supplies for saving)
Eco-friendly Service	• Creating environment-friendly spaces • Improved noise, installed silencer • Providing health education and environment-related education • Expanding medical academy in hospital • Expanding eco-friendly treatment programs • Improving local environment and social contribution activities • Providing environment-related experience programs for patients and visitors
Communication	• Post-hospital activities on Home pages • Hospital environment marketing UCC video production • Establishing EM marketing strategy

Source: MOE (2011), retrieved from Home Page (http://www.env-info.kr)

<Table 11> Practical Actions for Environmental Management from Facility Management Aspect

Category		Details
Energy Management	LED	• LED replacement for operating room lights • LED illumination adjustment • Selection of proper LED installation location
	Boiler	• Boiler air ratio adjustment • Boiler steam pressure adjustment
	Chiller-Heater	• Adjusting air ratio of absorption chiller-heater
	Air Conditioner	• Installing air conditioner inverter
	Temperature Management	• Proper temperature setting • Central supply room temperature double check
	Installation	• Lobby heat curtain installation • External shade • Installing outdoor shade • Attaching heat insulation film to window
	Energy Source	• Introduction of new and renewable energy
	Standby Power Management	• Installing computer screen saver • Operation management of cold/ warm water purifier • Medical equipment standby power management
Water Management		• Installation of water purifier • Installation of sewage meters • Construction of water leak management system • Sterilizer cooling water recycling
Waste Management		• Recycling rate improvement plan • Introduction of food waste reduction facility • Install an interest-picking cart to increase recycling rates • Leading the funeral market green culture

Source: MOE (2011), retrieved from Home Page (http://www.env-info.kr)

2.2.4 Good Practices for Promoting Environmental Management in Healthcare Facilities in Korea

In this study, the improvement cases of real hospitals by environmental load variables, which were used as input variables, were examined so as to find out a method for enhancing the eco-efficiency and to provide information for inefficient hospitals. Generally, efficient hospitals carried out measurement and collection of data of energy, water, chemicals uses, and waste generation. Based on data, hospitals have carried out reduction activities through the introduction of related saving facilities and their CEOs, employee, inpatients and visitors participated in various activities of implementation of EM.

(1) Water

In the case of hospitals, water use for sanitation management of patients and staffs was considerable, and it has been shown that the introduction of water-saving devices and equipment helps to reduce water use. Water-saving devices such as automatic faucets, water pressure regulators, and high-efficiency toilets, and water reuse facilities such as storm water tanks and heavy water taps were increasingly installed due to the government regulation and cost saving. In addition, water use was monitored by the floor or by building, and a water-saving campaign helped to reduce water consumption in daily life. The example of water saving activities in hospitals in Korea was shown in <Table 12>.

<Table 12> Examples of Water Saving Activities in Hospitals

Hospital	Method of savings	Outcome
Hospital F	• Water savings through the installation of water saving devices at sinks, cleaning sinks, toilet valves, urinal valves, sewage disposers, shower head and water saving faucets	Annual 8,101 ton water saving
Hospital G	• Replacement of old equipment and installation of water saving devices	73 M. KRW cost reduction due to water saving
Hospital H	• Educating staff by department for water reduction through training materials based on water waste case • Reducing tap water use by groundwater supply as an alternative for washing or watering plant and garden	Annual 188,308㎥ water saving
Hospital I	• Installation of non-power automatic water drop • Recycle Equipment Coolant	30% reduction in annual usage

Source: MOE (2016b), retrieved from Home Page (http://www.env-info.kr)

(2) Energy

The hospital is a typical large energy user, in particular with the patients and the staff during 24 hours every day in 365 days. The energy consumption such as ventilation or heating and cooling is enormous. Therefore, it is essential to carry out energy management.

In the case of the newly constructed hospital, investments were being made in the introduction of resources saving facilities and energy efficiency in building. On the other hand, in the existing buildings, the introduction of energy-saving products such as LED and energy efficient boiler or cooling system, installation of renewable energy such as solar and wind power, analysis of energy usage and reduction activities were being promoted. In addition, energy saving activities every day such as temperature control of air conditioner, power saving of office equipment, use of public transportation and bicycle were also carried out (<Table 13>).

<Table 13> Examples of Energy Saving Activities in Hospitals

Hospital	Method of savings	Outcome
Hospital J	• Introduction of solar power generation facility - Installed on the rooftop to reduce the radiating heat on the roof and to improve the efficiency of cooling • Human body detection sensor, LED light fixture installed	Annual 126 MWh electricity saving
Hospital K	• Establishment of Energy saving TF to reduce energy use through identification of the main causes and establishment of improvement plan such as facilities improvement	After 3 months, TF achieved 11% reduction of electricity consumption

Source: MOE (2016b), retrieved from Home Page (http://www.env-info.kr)

<Table 13> Examples of Energy Saving Activities in Hospitals (continued from previous)

Hospital	Method of savings	Outcome
Hospital L	• Exchange Fluorescent lamp with LED	Annual 34,725 kWh electricity saving
Hospital M	• Installation of IoT (Internet of Things) based watt-hour meter • Real-time monitoring with mobile and PC and effective power peak management	9.6 TOE saving of electricity per year
Hospital N	• Exchange Fluorescent lamp with LED • High-efficiency heat pump replacement • Establishment of Air-conditioning central control system	57 M. KRW cost saving due to energy saving

Source: MOE (2016b), retrieved from Home Page (http://www.env-info.kr)

(3) Waste

Medical wastes in Korea were largely incinerated but its disposal cost by incineration was expensive 4~5 times higher than general municipal solid wastes. In addition, during the transportation and treatment of medical waste, there was fear of infection problems. Therefore, there was a great need to separate proper collection of medical wastes that can be recycled or incinerated. Many hospitals are purchasing reusable products, reducing packaging, purchasing necessary items in large quantities, and carrying out activities in various aspects such as food waste reduction activities to reduce waste generation (<Table 14>).

<Table 14> Examples of Waste Reduction Activities in Hospitals

Hospital	Method of reductions	Outcome
Hospital O	• Segregation of general domestic waste and medical waste since August 2016, - Education & training of the nursing department and medical waste person after understanding current situation - Expansion of education to other departments	5,033 ton reduction of medical waste
Hospital P	• Campaign of Wednesday as no food day to reduce food waste • Posting the graph of amount of daily food waste on the restaurant	35.3% reduction of food waste since campaign
Hospital Q	• Increased the number of collection of medical waste from 4 times to 5 times per week • Installation of general municipal waste collection box • Campaign of no food waste 3 days per week	Reduction of average 990 kg of food waste per month
Hospital R	• Replacement of environmentally friendly contrast medium scan bag • Medical waste conservation activities and rewards	More than 40% annual reduction of medical waste

Source: MOE (2016b), retrieved from Home Page (http://www.env-info.kr)

(4) Chemicals

Regarding chemicals management in hospitals, EM activities through proper management, provision of toxic chemical substances list, and material safety and health data, were being promoted mainly rather than the reduction of toxic chemicals usage itself. This was that the use of hazardous chemicals was an essential element in maintaining the main business in the field of healthcare. So, there was little room for improvement in terms of eco-efficiency by reduction of chemicals uses.

2.3 Literature Review of Environmental Management in Healthcare Sector

In the preliminary studies on EM in the healthcare sector, the main topic of research in Korea was to find strategic implications for promoting EM in the healthcare sector, while overseas studies were largely about the awareness of the risks of wastes in the healthcare sector and their management methods.

The main prior researches related to EM in the healthcare sector were summarized as follows.

First, Kang et al. (2010) presented important factors for introducing environmentally-friendly hospitals in Korea through consideration of accreditation criteria of environment-friendly hospitals in the USA, the UK, and Australia. The study pointed out six factors as critical for settling environmentally-friendly hospitals in Korea; ① CEO's interest & support, ② education and training for staff for the change of their awareness, ③ emphasis on efficient renovation of existing facilities rather than new facilities, ④ accumulation of data through quantification and verification, ⑤ establishing goals and action plans of eco-friendly hospitals and managing performance, and ⑥ establishing eco-friendly procurement program.

Seo et al. (2010) investigated the present status and future of environmentally-friendly green hospitals through surveys on 46 teaching hospitals in order to provide a good guide for establishing green hospitals. Survey result showed that most hospitals were found to have

a very low eco-friendly status in environmental policy, resource management, manpower and technology related to environment-friendly services, except for recycling and waste management and environmental services for the elder. Encouraging the CEO's and staff's participation for EM, setting up environment-friendly goals and strategies, educating employees on the eco-friendly hospital, utilizing environmentally friendly technology, and introducing generally environmental-friendly buildings were advised as the practical action items.

Lee (2011) suggested the necessity of development of green policies for hospitals because hospitals would face regulations such as introduction of the emission trading system and carbon tax. Through the analysis of domestic and overseas hospitals, hospitals were advised to introduce green hospital building and to participate in PVC Free-Hospital, and the government was recommended to provide the healthcare sector with policy and financial support, guideline and information for green healthcare and introduction of certification of eco-friendly medical service.

Kang (2013) presented the improvement points of the EIDS in hospitals and advised hospitals on countermeasures based on literature review and 41 hospitals' data of the Korean ENV-INFO system. The study pointed out six items for improvement of EIDS in hospitals; ① enlargement of citizen participation, ② upgrade of company overview, ③ clear definition of items, ④ unification of measurement unit, ⑤ close verification, ⑥ creation of standards for additional information. The hospitals were advised to respond to the reliability enhancement of data,

reorganization strategy and green management system, accumulation of water and energy saving data, GHG reduction plan, the introduction of green purchase guidelines, and digital publication of the environmental report.

Kim and Kang (2014) applied the green management evaluation criteria for health and medical services, which was developed by the government to 44 hospitals and found out the general strategies and improvement directions needed for the EM certification of hospitals. In order to acquire EM certification, it was necessary to raise awareness and change vision, strategy and goal of hospital CEO and employees. The reset of the assessment, adjustment of additional points and weights, creation of certification grades and adjustment of additional points were suggested for the improvement of green evaluation system.

Daschner and Dettenkofer (1997) argued that maintaining hygiene, reducing environmental pollution, and minimizing cost by reducing the consumption of limited resources was a major challenge for hospitals. The reduction of hospital waste, the control of pollution and toxic emissions, the unnecessary disinfection procedures and the avoidance of disposable products, and the implementation of energy and water saving technologies have been proposed as hospital-based environmental protection strategies.

Douglas and Meltzer (2004) proposed the establishment of EM system as an approach to solving environmental problems in hospitals. As a result of the case study on the development of EM system and the environmental performance of regional hospitals in the UK, the

environmental performance of the hospital was substantially improved through the implementation of EM. It was also suggested that EM require an integrated approach rather than a separate quality, health, and safety system.

Chaerula et al. (2007) proposed the hospital waste management system to minimize public health risks based on a case study in developing countries. It was argued that waste disposal, as well as disposal of infected wastes, should be properly performed by hospital management before disposal of hospital waste.

Alhumoud et al. (2007) studied for the necessity of hospital waste management through the study of hazardous wastes in Kuwait. Approximately 30% of Kuwait's hazardous wastes were discharged from medical wastes, and the need for organizational training for the awareness of waste management procedures and hazardousness of hospital wastes was suggested. The previous studies were summarized in <Table 15>.

<Table 15> Previous Studies on Environmental Management in Healthcare Sector

Researcher		Year	Main topic
Korea	Kang et al.	2010	• Study of important principles for introducing eco-friendly medical service, compared with the criteria of overseas eco-friendly hospital certification
	Seo et al.	2010	• Provision of implementation strategy for establishing eco-friendly hospitals through surveys of actual condition of hospitals
	Lee	2011	• Introduced green buildings and eco-friendly medical services through case studies of hospitals
	Kang	2013	• Improvement of environmental information disclosure system and response plan of hospital through analysis of hospital data
	Kim and Kang	2014	• Developed improvement direction of green management criteria for health and medical service'
Overseas	Daschner and Dettenkofer	1997	• Suggested hospital's environmental protection strategy to reduce pollution and resources consumption
	Douglas and Meltzer	2004	• Proved that the EM positively affected the environmental performance of the hospital
	Chaerula et al.	2007	• Presented the importance of waste segregation by hospital management through case study in Jakarta, Indonesia
	Alhumoud et al.	2007	• Suggested organizational training needed to raise awareness of waste disposal and hazardous risks of hospital waste in Kuwait

Chapter 3. Methodology of Analysis of Eco-Efficiency Using DEA and IPA

3.1 Eco-Efficiency and Constructing DEA Model

3.1.1 Eco-Efficiency

The eco-efficiency was first proposed by the World Business Council for Sustainable Development (WBCSD) in 1992. Since Johannesburg Summit in 2002, the eco-efficiency has been an important action agenda for sustainable development and many researchers have been actively conducting studies to evaluate and realize eco-efficiency in various fields such as international organizations, countries, and industries. According to the WBCSD definition (WBCSD, 2000), the eco-efficiency is achieved through the delivery of "competitively priced goods and services that satisfy human needs and bring quality of life while progressively reducing environmental impacts of goods and resource intensity throughout the entire life-cycle to a level at least in line with the Earth's estimated carrying capacity."

Therefore, the expression of eco-efficiency was combined concept of the eco from economic and ecological value, and the efficiency from optimization of resource use (Kim, 2014). Based on the above definition and concept, the WBSCD has used eco-efficiency as a continuously

evolving concept and value and was the economic value-added divided by environmental damage as follows at Equation (1) (Kim, 2014).

$$Eco-Efficiency = \frac{Economic\ Value-Added}{Environmental\ \ Damage} \quad (1)$$

The eco-efficiency can measure the extent of sustainable growth, considering both environmental and economic aspects together through the reduction in environmental impacts and the increase in economic value added. In other words, using less resources and energy to produce a product or service and discharging less pollutants, surely brings greater benefit in the long run (Cho, 2014).

Above all, one of the great remarkable characteristics of eco-efficiency was to present goals as the form of indicators that must be achieved by countries, businesses, and individuals. The eco-efficiency has been increasingly applied to make it easier to use in the decision-making stage by providing a comprehensive measure of environmental and economic performance compared with other efficiency indicators (Jung et al, 2007; Kim, 2009)

The international organizations such as OECD, UNEP, and UNCSD recommended eco-efficiency to be used as a tool for achieving sustainable development in various policies or measures. Many countries also adopted the eco-efficiency as a promising policy tool for sustainable development. Business and industry sectors recognized the eco-efficiency as an opportunity to eliminate the risks of corporate management activities and to find additional savings, and they are working actively

to realize them in the market. In companies, the eco-efficiency application was mainly being conducted on products or processes and their efficient management through comparison and evaluation of eco-efficiency with various alternatives was largely carried out focusing on reference products or standard processes (Jung et al. 2007).

3.1.2 Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a method of measuring the relative efficiency of DMUs with multiple inputs and outputs and it results in one integrated input-output ratio, a mathematically optimal weighted ratio, that corresponds to overall performance instead of multiple individual input-output ratios (Nyhan and Martin, 1999). Since DEA was developed by Charnes, Cooper & Rhodes (1978), it has been a special application of linear programming and the most representative methodology to evaluate the relative efficiencies of a set of entities called DMUs (Decision-Making Units) (Nyhan and Martin, 1999). There are several good characteristics of DEA compared to others such as simple ration analysis and regression analysis.

First, DEA is a non-parametric approach (Zhou et al., 2008). It does not require any prior assumptions on the functional relationships between inputs and outputs of DMUs. DEA empirically derives the weights between input variables and performance variables based on decision rule of maximum weight for desirable outcomes or minimum

weight for unfavorable one.

Second, DEA gives us a great flexibility in data selection. It is possible to evaluate efficiency from different units of input-output variables because it is measured by considering the input-output ratio between variables. It does not matter that input variable is quantity and output variable is monetary. So as to compare the same variable, however, a unit of the same variable in different measurement periods or different DMUs should be same for their comparisons (Kim and Choi, 2009). For example, as company A used 10 ㎥ of water per month and company B consumed 1000 ℓ of water per month, the unit of water consumption should be same as the expression of ㎥ (or ℓ) like 1 ㎥ in company B, instead of 1000 ℓ. Efficiency can be assessed in both monetary and non-monetary data, or multiple inputs and dependent performance measures (output, quality, and outcome) simultaneously, which were difficult to derive a single efficiency parameter.

Third, DEA has been, therefore, rapidly used by operation research and management science researchers, economists, government institutes and experts from various areas, including airlines companies, hospitals, army, libraries, schools, universities, banks, insurance companies, energy facilities and a variety of business (Jung and Kim, 2011). DEA provides various ways for measuring the efficiency of DMUs in public programs to improve their planning and control of their activities. It constructs a reference set by linking given data to a line or plane, and within the reference sets, its main means is to compare and analyze relative efficiency between DMUs. DEA can assess the level of relative

efficiency of DMU, analyzing and comparing those of other DMUs within a group where there are multiple inputs and outputs. DEA provides the efficiency frontier of an efficient DMU after comparing the efficient score of others. In other words, efficiency can be measured by comparing input and output variables observed from all DMUs, and relative efficiency is constructed through comparisons with other DMUs' efficiency scores.

Fourth, DEA has the advantage of distinguishing DMUs between efficient and inefficient one. It provides information about the potential improvement that should be saved at the input, or be produced more at the output in order to change from inefficient to efficient. Based on the reference set, DEA provides a calculation of the amount of resources or performances to be efficient. Since the reference set has the same combination of variables, it suggests the direction for inefficient DMUs to improve efficiency in their business activities where current production structure is maintained (Jung, et al., 2004).

3.1.3 Constructing DEA Model

Generally, there are two models of DEA frequently used; CCR model (Charnes, Cooper and Rhodes, 1978) and BCC model (Banker, Charnes and Cooper, 1984). The original model proposed by Charnes et al. (1978) was the CCR (Charnes, Cooper and Rhodes initials). The CCR model assumes a Constant Return to Scale (CRS) with regard to input and the

CCR ratio comprehends both technical and scale inefficiencies via the optimal value of the ratio form (Banker, Charnes and Cooper, 1984). In this regard, CCR has the disadvantage of not being able to distinguish between scale efficiency and pure technical efficiency (Cho, 2014). A separation into technical and scale inefficiencies was made by Banker, Charnes and Cooper (BCC, 1984) and this BCC model assumed the Variable Return to Scale (VRS).

For CCR model, suppose that we have the production possibility set satisfying free disposability, *P(x,y),* expressed as Equation (2). Here are a set of J DMUs, j=1, ⋯,J. and

$x_m^j (m = 1, 2, \cdots, M)$, $y_n^j (n = 1, 2, \cdots, N) > 0$, represent input and output data for DMU_j (Charnes et al., 1978).

$$P(x,y) = (x_1, \cdots, x_M, y_1, \cdots, y_N) \mid x_m \geq x_m^j (m = 1, 2, \cdots, M); \quad (2)$$
$$y_n \leq y_n^j (n = 1, 2, \cdots, N);$$
$$(j = 1, 2, \cdots, J)$$

That is, if x_m^j and y_n^j can be possibly producible, free disposability means that all production possibility set satisfying $x_m \geq x_m^j$, $y_n \leq y_n^j$ can be produced for any x_m and y_n. If the production possibility set was supposed as convexity, a variable return to scale such as Equation (3) is derived.

$$P(x,y) = (x_1,\cdots,x_M, y_1,\cdots,y_N) \mid x_m \geq \sum_{j=1}^{J} \lambda^j x_m^j \ (m=1,2,\cdots,M); \quad (3)$$
$$y_n \leq \sum_{j=1}^{J} \lambda^j y_n^j \ (n=1,2,\cdots,N);$$
$$\sum_{j=1}^{J} \lambda^j = 1, \lambda^j \geq 0 \ (j=1,2,\cdots,J)$$

If any (x_a, y_a) and (x_b, y_b) are the production possibility set, convexity means $\lambda(x_a, y_a) + (1-\lambda)(x_b, y_b)$ is also producible assuming λ with condition $\sum_{j=1}^{J} \lambda^j = 1, \lambda^j \geq 0$. It means that the production possibility set is constituted by the points that are combined with the linear interpolation among DMUs. In addition, because the sum of λ^j with condition $\sum_{j=1}^{J} \lambda^j = 1, \lambda^j \geq 0$ is always 1, only a linear interpolated set between DMUs is possible.

If DMU_k is supposed to locate within the production possibility set, the efficiency of DMU_k as a goal is the rate at which the output level can be fixed when input the level is minimized as much as possible. So the input-oriented CCR model can be expressed as Equation (4).

$$\theta^{k*} = \min \theta^k \quad (4)$$
$$s.t.$$
$$\theta^k x_m^k \geq \sum_{j=1}^{J} \lambda^j x_m^j \ (m=1,2,\cdots,M);$$
$$y_n^k \leq \sum_{j=1}^{J} \lambda^j y_n^j \ (n=1,2,\cdots,N);$$
$$\lambda^j \geq 0 \ (j=1,2,\cdots,J)$$

In Equation (4), input-oriented CCR model implies that all variables are positive and output should be positive within the production possibility set although input is significantly reduced. This becomes the goal of DMU_k to reduce input as much as possible without deviating from the production possibility set. Also, because it is reduced by multiplying by real same number, all input variables for the analysis of the k^{th} DMU are searched for, which is a common ratio value that can be reduced by the same ratio. θ^{k*} is optimal solution for making θ^k minimizing at the k^{th} DMU while satisfying the constraint in Equation (4).

The CCR model appears linear as a linear function assuming a constant return to scale (Lee et al., 2012). The efficiency under the assumption of constant return to scale is divided into the efficiency of variable return to scale and the scale efficiency. The efficiency under the variable return to scale is defined as the pure technical efficiency, excluding the scale inefficiency from the overall general efficiency. However, in many cases, the scale or size of organization management has the disadvantage of not being able to distinguish between the scale efficiency and the pure technical efficiency, as it can affect efficiency evaluation (Lim, 2009).

Addressing this problem, Banker et al. (1984) proposed a method for estimating the scale profitability and developed the BCC (Banker, Charnes and Cooper initial) model. The input BCC model for the production possibility set satisfying variable returns to scale is shown in Equation (5) (Banker et al., 1984).

$$\theta^{k*} = \min\theta^{k} \quad (5)$$
$$s.t.$$
$$\theta^{k} x_m^k \geq \sum_{j=1}^{J} \lambda^j x_m^j \, (m = 1, 2, \cdots, M);$$
$$y_n^k \leq \sum_{j=1}^{J} \lambda^j y_n^j \, (n = 1, 2, \cdots, N);$$
$$\sum_{j=1}^{J} \lambda^j = 1;$$
$$\lambda^j \geq 0 \, (j = 1, 2, \cdots, J)$$

Equation (5) is added to the constraint under invariant-scale returns with $\sum_{j=1}^{n} \lambda_j = 1$, which does not allow infinitely expanding or decreasing the point where the DMUs are combined into a linear production possibility set.

The BCC model assumes a variable return to scale depending on the size and is mixed with a combination of increasing the return to scale and decreasing the return to scale. In other words, it is a model created by the logic of economics that the initial rise of input in early stage decreases at a certain point later (Kim et al., 2015). In particular, the BCC model can measure the pure technical efficiency, excluding the effects of scale. Therefore, this study applied the input- oriented BCC model because the size change of hospitals is a constraint factor.

DEA provides solutions of θ^{k*}, λ^{j*}, s^{-*}, s^{+*} for inefficient DMUs through efficiency analysis and also provides information on how inefficient DMUs can be benchmarked to be efficient (Nyhand and Martin, 1999).

$$\theta^{k*} x_m^k - s_m^{-*} = \sum_{j=1}^{J} \lambda^{j*} x_m^j \, (m = 1, 2, \cdots, M) \tag{6a}$$

$$y_n^k - s_n^{+*} = \sum_{j=1}^{J} \lambda^{j*} y_n^j \, (n = 1, 2, \cdots, N) \tag{6b}$$

Equation (6a) and (6b) are derived by substituting the optimal solution $(\theta^{k*}, \lambda^{j*}, s^{-*}, s^{+*})$ into the constraint of efficiency using the input-oriented CCR model (Lee et al., 2012).

In order to be efficient, the input of DMUk should be reduced to the same ratio and then be further reduced by the marginality. The final transformed values, $(\theta^{k*} x_m^k - s_m^{-*},\ y_n^k - s_n^{+*})$, are called the reference set of DMU_k, and all points, belonging to the reference set, are strongly efficient. The reference set provides information on what points should be changed based on which specific evaluation unit is to be efficient. In particular, the reference set has a similar input variable to other DMUs, thus providing a direction that can improve current efficiency (Jung et al., 2004).

In the DEA, the efficiency score of the most efficient DMU is expressed as 1 of comparative value, while the efficiency scores of other DMUs are less than 1. However, where there are many DMUs with an efficiency score of 1, there is a problem that they can not be compared with each other. The method to solve this problem is a super - efficiency analysis model (Kim and Khoe, 2012). The super - efficiency analysis was proposed to compare the relative superiority between the

DMUs on the efficient frontier. It was frequently used as a supplementary tool for understanding comparative efficiency among the most efficient DMUs (Cho, 2014).

In order to evaluate the super - efficiency analysis of a DMU, it is necessary to set up a production possibility set, excluding the target DMU, and to evaluate the efficiency of the point of view for production possibility set (Lee et al., 2012). The larger score of the super - efficiency, the greater the contribution to the expansion of the production change. In other words, the larger the value of the super - efficiency, the greater influence is in determining the production change, and the DMU with the super - efficiency is relatively the most efficient one. This condition can be expressed by the input CCR super - efficiency model as shown in Equation (7).

$$\theta^{k*} = \min\theta^k - \epsilon\left(\sum_{m=1}^{M} s_m^- + \sum_{n=1}^{N} s_n^+\right) \quad (7)$$

$$s.t.$$

$$\theta^k x_m^k = \sum_{j=1, j\neq k}^{J} \lambda^j x_m^j + s_m^- \, (m = 1, 2, \cdots, M);$$

$$y_n^k = \sum_{j=1, j\neq k}^{J} \lambda^j y_n^j - s_n^+ \, (n = 1, 2, \cdots, N);$$

$$\lambda^j \geq 0 \, (j = 1, 2, \cdots, J);$$

$$s_m^- \geq 0 \, (m = 1, 2, \cdots, M);$$

$$s_n^+ \geq 0 \, (n = 1, 2, \cdots, N)$$

3.2 Data and Method for DEA Evaluation

3.2.1 Data for DEA Evaluation

The data in this study was collected from 21 hospitals, which participated in the program of Environmental Information Disclosure System (EIDS) under the Ministry of Environment of Korea during 2012-2015.

The EIDS was the initiative program by the Ministry of Environment for promoting EM system to various business and public sector through mandatory disclosure of EM information to the public under the Environmental Technology Development and Environmental Industry Act. In order to ensure the homogeneity of data from total 78 hospitals and health-related institutes, only 21 hospitals that provided medical care and related sales, were assessed for eco-efficiency, excluding 57 health related agencies such as Korea Red Cross and Korea Veterans Welfare Corporation.

The quantitative items among 20 elements in this study were used, which should be disclosed by the law as mandatory information to the public. As the input variables, four environmental variables such as water use, energy consumption, waste generation and use of hazardous chemical substances were used. The total amount of sales and a total number of patients of the year were used as output variables, which were economic value-added variables. See the details at <Table 16>.

<Table 16> Variables for Evaluating Eco-Efficiency in Hospitals

Category		Unit	Details
Environmental Damage Variables	Water	ton	The quantity of water use yearly
	Energy	TOE	Total energy consumption yearly such as electricity, gasoline and etc
	Waste	ton	Total amount of waste generated yearly
	Chemicals	kg	Total amount of hazardous chemicals used yearly
Economic Value-added Variables	Sales	Mil. won	Total amount of sales yearly
	Patients	Person	Total number of patients yearly

3.2.2 Method of Assessment of Eco-Efficiency by DEA

Although two models would be considered based on output performance and input performance, the input based model was adopted in this study to assess eco-efficiency in hospitals because it aimed at maintaining the economic value and minimizing the environmental burden.

Second, the input-oriented BCC model was more adequate because

the scale change of hospitals was constrained factor and the BCC model can measure pure technical efficiency, excluding the effects of scale.

Third, the characteristics of highly eco-efficient hospitals was analyzed and potential improvement in the hospitals with low eco-efficiency were measured.

Fourth, a super-efficiency analysis was conducted among the highly eco-efficient hospitals. The super-efficiency analysis was a model to compare relative advantage when there were many efficient objects with an eco-efficiency score of 1. The super-efficiency analysis was conducted as a complementary and post-treatment rather than as a substitute for DEA (Lim et al., 2008; Per et al., 1993). On the other hand, information for improving eco-efficiency in low-efficient hospitals was derived.

Fifth, eco-efficiency was evaluated by applying data from 4 years from 2012 to 2015 at the same time to analyze changes in eco-efficiency by year in hospitals. The data used were from the Environmental Information Disclosure System in consideration of the safety of data acquisition and reliability of data itself. Specific data were shown in <Table 17> to <Table 20>.

Finally, the data envelope analysis is a type of linear programming, and if only the principles constituting the problem are understood, the actual computation is measured using a program developed to analyze the linear programming method (Lee et al., 2012). In this study, eco - efficiency was evaluated using Frontier Analyst as a DEA program.

<Table 17> Data of Six Variables from 21 Hospitals in 2015

Hospital	Water (ton)	Energy (TOE)	Waste (ton)	Chemicals (kg)	Sales (M.won)	Patients (person)
H01[1)]	8,811	283	68	27	10,450	124,107
H02	291,220	6,586	2,192	8,118	264,535	246,241
H03	139,360	5,451	984	460	152,380	166,512
H04	267,343	5,359	1,215	24,494	211,768	913,765
H05	132,853	3,174	467	367	64,398	92,805
H06	320,840	6,751	1,114	25,739	284,263	351,207
H07	28,980	680	103	1,814	18,496	136,429
H08	15,000	701	59	2,087	4,969	61,328
H09	461,282	14,476	3,857	15,876	557,574	418,911
H10	1,000,039	30,494	7,833	34,564	934,905	562,725
H11	1,025,677	23,541	4,247	51,280	867,141	621,138
H12	250,218	7,601	1,103	29,574	284,333	353,571
H13	342,879	5,766	1,326	6,182	268,380	326,590
H14	306,575	9,916	1,539	8,269	311,468	1,214,742
H15	158,641	4,064	838	2,359	121,991	449,007
H16	366,833	6,560	1,324	1,939	348,334	1,520,590
H17	407,997	8,480	1,531	181	301,256	405,040
H18	202,507	4,146	1,180	47	156,609	777,613
H19	76,776	1,603	534	2,007	94,239	165,225
H20	76,123	1,469	380	2,830	72,886	127,252
H21	139,035	2,382	2,043	3,629	131,806	165,615

1) In this study, 'H', which was 'Hospital', was indicated because some information (number of patients, sales etc.) were business secrets and protected by the law not to open to public.

<Table 18> Data of Six Variables from 21 Hospitals in 2014

Hospital	Water (ton)	Energy (TOE)	Waste (ton)	Chemicals (kg)	Sales (M.won)	Patients (person)
H01	8,865	287	66	27.22	9,575	113,715
H02	314,269	6,746	2,322	8,119.31	265,055	254,838
H03	119,670	5,110	895	438.17	136,144	162,470
H04	280,568	4,711	1,061	21,772.44	195,480	888,156
H05	144,130	3,164	481	428.19	74,180	464,678
H06	321,966	6,138	1,104	33,565.85	275,984	351,206
H07	31,241	659	79	1,900.55	18,293	138,801
H08	14,800	744	51	1,900.55	5,357	66,701
H09	473,913	13,817	4,133	13,426.34	493,645	390,274
H10	925,459	31,918	8,054	38,773.09	1,061,225	672,163
H11	970,612	21,671	4,703	47,840.40	827,961	621,635
H12	230,041	6,983	957	25,310.46	246,168	325,447
H13	341,502	5,736	1,291	7,180.37	256,585	327,822
H14	301,688	9,897	1,513	7,801.79	297,485	1,236,407
H15	157,508	3,914	809	2,449.40	113,150	737,146
H16	325,301	6,630	980	1,784.43	337,573	1,489,223
H17	411,273	8,142	1,504	816.47	289,853	402,680
H18	182,783	3,834	1,161	92.53	140,850	786,747
H19	73,016	1,597	542	2,054.99	93,202	167,199
H20	73,851	1,418	339	2,775.99	66,849	113,766
H21	140,808	2,513	372	3,628.74	132,751	176,063

<Table 19> Data of Six Variables from 21 Hospitals in 2013

Hospital	Water (ton)	Energy (TOE)	Waste (ton)	Chemicals (kg)	Sales (M.won)	Patients (person)
H01	8,029	273	62	27	8,683	66,193
H02	308,208	7,250	2,771	8,074	276,297	1,194,812
H03	119,869	4,987	898	556	108,845	426,648
H04	286,663	4,909	1,008	20,865	182,002	824,518
H05	146,384	3,378	670	674	75,778	505,132
H06	333,727	6,401	1,169	27,460	267,049	1,164,848
H07	30,862	688	72	1,860	16,172	131,367
H08	13,149	805	50	1,860	5,321	68,409
H09	525,360	13,373	3,443	11,267	426,231	1,575,750
H10	997,369	22,310	5,148	46,896	782,290	2,800,784
H11	395,131	12,163	3,182	44,727	383,815	46,752
H12	220,885	7,059	910	25,401	217,058	868,767
H13	323,433	6,329	1,207	6,477	247,336	327,031
H14	300,874	9,320	1,387	5,443	280,628	1,228,678
H15	153,996	3,917	750	2,722	100,551	655,066
H16	311,964	6,408	752	2,226	315,569	1,416,201
H17	430,890	7,883	1,687	4,082	270,024	379,202
H18	192,370	3,964	1,122	118	138,928	689,821
H19	72,912	1,739	529	2,049	92,900	163,834
H20	75,806	1,560	138	2,177	66,082	120,109
H21	146,973	2,701	385	3,692	125,433	174,727

<Table 20> Data of Six Variables from 21 Hospitals in 2012

Hospital	Water (ton)	Energy (TOE)	Waste (ton)	Chemicals (kg)	Sales (M.won)	Patients (person)
H01	8,760	281	61	36	7,659	62,830
H02	340,094	7,143	1,974	8,528	268,547	1,194,736
H03	119,187	4,499	609	907	97,813	357,181
H04	270,052	4,983	957	23,587	171,176	848,648
H05	154,797	3,340	696	846	71,331	506,523
H06	349,163	6,535	901	31,859	265,330	1,148,492
H07	26,504	658	89	1,724	16,098	125,606
H08	12,997	780	51	1,724	4,765	64,847
H09	420,332	10,242	2,992	9,253	387,638	1,471,829
H10	1,017,140	21,846	6,185	51,480	759,350	2,751,238
H11	396,076	11,835	3,007	58,978	325,512	46,962
H12	220,151	6,779	920	21,137	201,714	820,959
H13	326,081	6,158	1,169	6,368	453,302	1,922,494
H14	304,885	8,399	1,349	5,443	248,521	1,260,091
H15	145,980	3,677	644	2,722	93,470	608,935
H16	322,702	6,586	650	1,983	292,394	1,408,000
H17	423,675	6,524	1,569	3,629	247,608	350,499
H18	181,413	3,898	1,049	61	128,355	716,954
H19	83,175	1,807	541	2,341	87,246	162,155
H20	78,721	1,500	128	2,177	62,426	120,803
H21	148,921	2,742	295	4,264	121,929	644,430

3.3 Method for Identifying Effective Factors for Promoting Environmental Management Using AHP and IPA

3.3.1 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a method to solve multi-criteria complex problems by combining subjective judgment and system approach in problem analysis. It is a method to solve problems by summing up human judgment rationally (Park, 2012). The AHP was developed by Professor Saaty in the 1970's to improve inefficiency of expert's decision-making on priority scales with tangible and intangible measurements. It is primarily used when evaluating, selecting and predicting decisions, or when deciding on the priorities of the alternatives. The AHP is used in both individual and group decision-making by business, industry, and governments and is particularly applicable to complex large-scale multiparty multi-criteria decision problems (Saaty, 2008).

The AHP can be calculated by integrating the relative evaluation information by the pairwise comparison with the pairwise comparison matrix A and by using the main eigenvector corresponding to the maximum eigenvalue of the pairwise comparison matrix A. (Park, 2012).

The eigenvalues of the n × n matrix A and the eigenvectors thereof in Equation (8)

$$u = \begin{pmatrix} u_1 \\ u_2 \\ \cdots \\ u_n \end{pmatrix} \tag{8}$$

The scalar λ and vector u satisfy $Au = \lambda u$.

λ is the solution of $|A - \lambda I| = 0$ in eigen equation of $A - \lambda I(I\,is\,unit$ and here λ is the n-th order algebraic equation, usually having n roots, which is called the eigenvalue of A. The largest eigenvalue is $\lambda_{\max}$, the maximum eigenvalue. Once determined $\lambda_{\max}$ by the determinant, the solution to this is the eigenvector for u.

For example, as shown in Equation (9), the main eigenvector is the solution of vector u and $\lambda_{\max}$ is considered as the final solution, when the other solution does not meet $u = 0$.

$$Au = \lambda_{\max} u \;\Rightarrow\; (A - \lambda_{\max} I)u = 0 \tag{9}$$

The first characteristic of AHP is that the evaluation is based on the comparative evaluation of the pairwise comparisons. The first thing to be done in performing the AHP is to review the constituents of the decision items that are pending and to hierarchize these factors. Many of these structured alternatives are analyzed on the basis of multiple evaluators and multi-faceted evaluations. Based on the evaluator's

knowledge, experience, and intuition, this process provides comprehensive answers to decision-making by simultaneously considering both quantitative and qualitative factors. That is the AHP, performed by relative evaluation through pair comparison. In decision-making, you should look for a pairwise comparison between each factor in level 2 (the evaluation criteria) and each factor in level 3 (alternatives). Pairwise comparisons can be extended to different levels depending on the level of comparison, but to what extent of expansion of the steps will depend on each research problem (Cho, 2014). For example, the result of the comparison between the selection factors i and j is as follows using the parameter (a reasonable real number whose size is greater than 1).

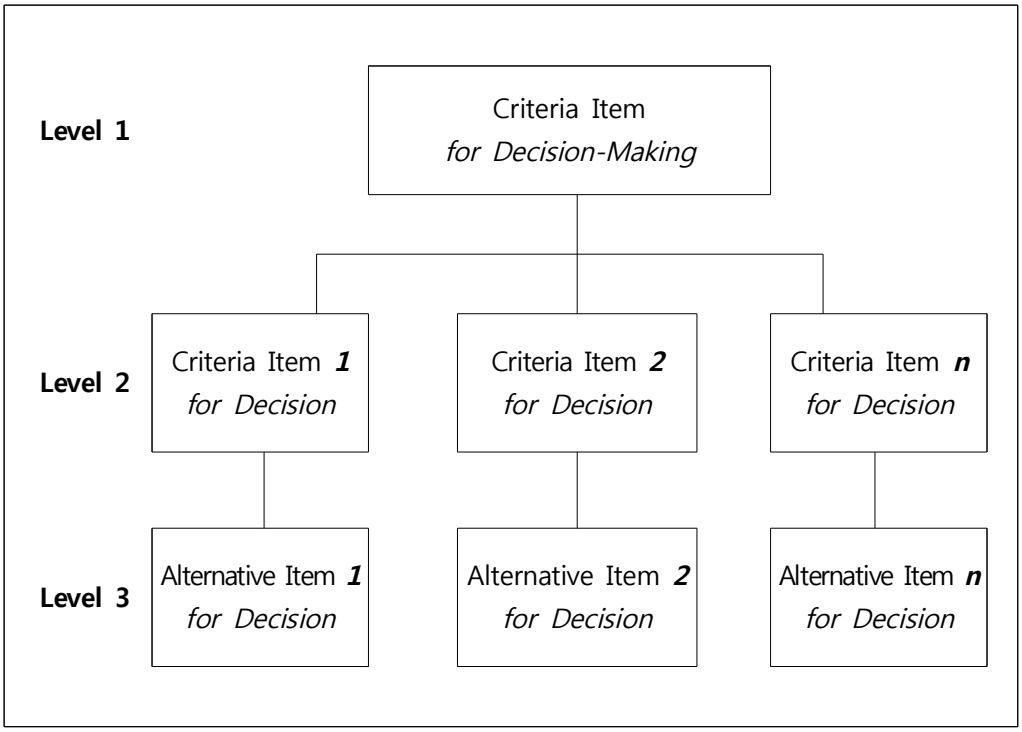
- If h is better than i, $a_{hi} = \theta$
- If i is worse than h, $a_{ih} = 1/\theta$

As a second feature, the AHP compares the two items among various items so that the evaluation items can be grasped in a hierarchical structure based on a certain logic (Shin et al., 2012). Unstructured decisions can be layered and categorized at different levels, and problems can be systematized by integrating elements at similar levels, such as evaluation criteria and alternative objects to be evaluated.

As a final feature, the AHP method results in a consistency index (CI) of the respondent in the merging process according to the 1 : 1 comparison result per element, and is expressed as Equation (10).

$$C.I. = \frac{\lambda_{\max} - n}{n-1} \tag{10}$$

Generally, if the consistency index is less than 0.1, the consistency of the pairwise comparison matrix is considered to be good and reliable. Generally, the consistency of the degree-of-pair comparison matrix is considered good, and this pairwise comparison matrix is defined as reliable. Here, the figure of 0.1 was an empirical figure (Saaty, 1980).



<Figure 2> General Structure of Hierarchy for AHP

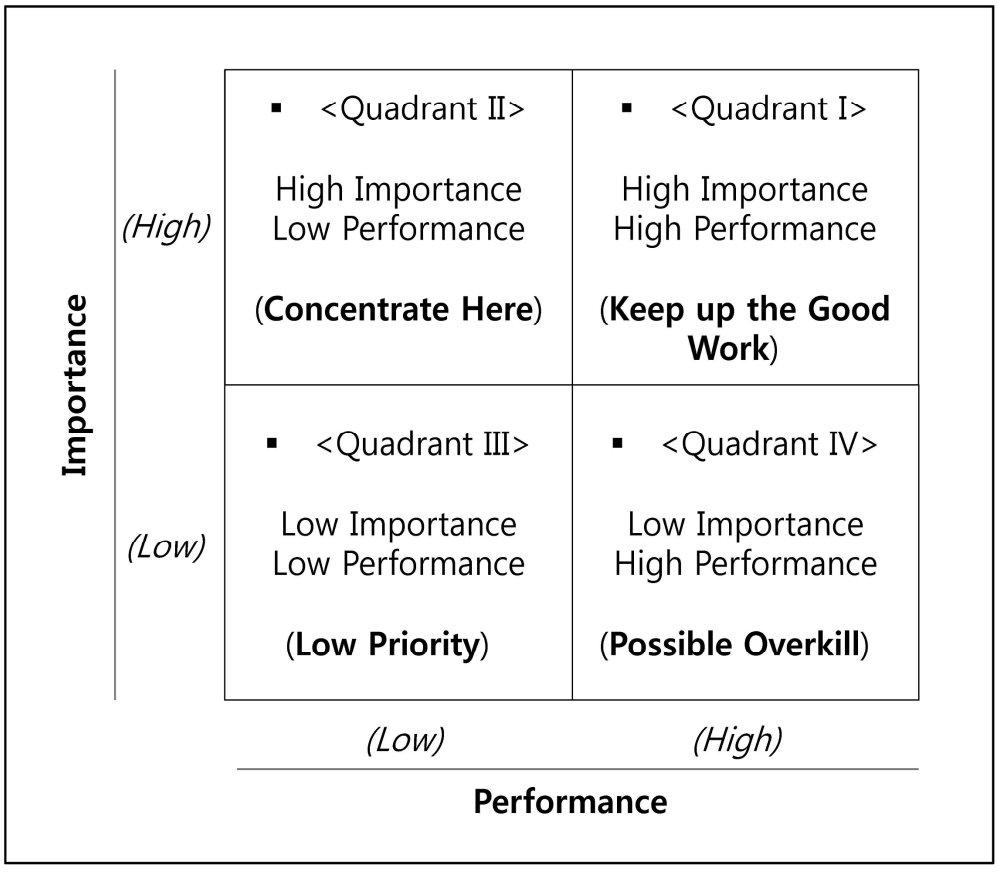
3.3.2 Importance-Performance Analysis

The Importance-Performance Analysis (IPA) is a technique developed in the marketing field to analyze how consumers perceive the importance and performance or satisfaction of the main attributes of the analyzed object (Martilla and James, 1977). The IPA method was designed to take both the performance level and the importance level apart from the basic method that used only a single item when determining the priority (Choi et al., 2016). In the IPA method, two aspects of the importance and the performance of analyzed elements were used to create a quadrant and the scores of the importance and performance of each element at the same time (see <Figure 3>). In the quadrant, the mean values or median values of each attributes were obtained by taking the importance as the vertical axis and the performance as the horizontal axis, so that each analyzing object was placed in the quadrant.

The first quadrant was the area where the importance and performance are all high as 'keep up the good work'. The second quadrant was the 'concentrate here' area, which has high importance but a relatively low performance. The third area was a 'low priority' area with low importance and low performance. The fourth area was a region with low importance but high performance, where the respondents do not think it is important but perform well even to the point of 'possible overkill'.

Based on their location of items, priority was likely to be determined.

Generally, items located in the second quadrant were priority for improvement with 'concentrate here' (Kim et al., 2012; Kim et al., 2015).



<Figure 3> Importance-Performance Analysis Matrix

3.4 Survey and Interview for Review of Analysis Result and Suggestion

3.4.1 Survey for Analyzing Effective Support Factors by IPA

To find out effective policy measure and support policy, survey for hospital staff in charge of environmental issues was carried out. In this study, the information open to the public was set as those of possible effective support factors, excluding the company outline items (3 items) and the 'investment and technology introduction' items (4 items) that overlapped with other quantitative items among the public disclosure items of EIDS in the healthcare sector. 13 out of 20 items of the EIDS were used as the support factors. The selection factor as the upper level of concept of support factor was structured as EM (purchasing) system, resource and energy, GHG and environmental pollution, and social and ethical responsibility. The selection and support factors for promoting EM in the healthcare sector were in <Table 21>.

A questionnaire survey was conducted to evaluate the importance of the support factors for promotion of EM in hospitals using a 5-point scale criteria. The form of questionnaire was shown in <Appendix 2>. The questionnaire survey was conducted to hospital staffs of 21 hospitals evaluated in this study and of 30 hospitals participating in the eco-friendly hospital network. The survey method was e-mail directed to those 51 staffs in charge of environmental matters.

Based on the collected questionnaires survey using a 5-point Likert scale (1: not at all~5: very much), the analysis for finding support factors for diffusion of EM was carried out. Based on the results of the performance and the importance analysis, the Importance-Performance matrix was created using SPSS Statistics 18.0. The X-axis for performance and the Y-axis for importance were set up and the average numbers of importance and performance were used to vertical and horizontal lines of means.

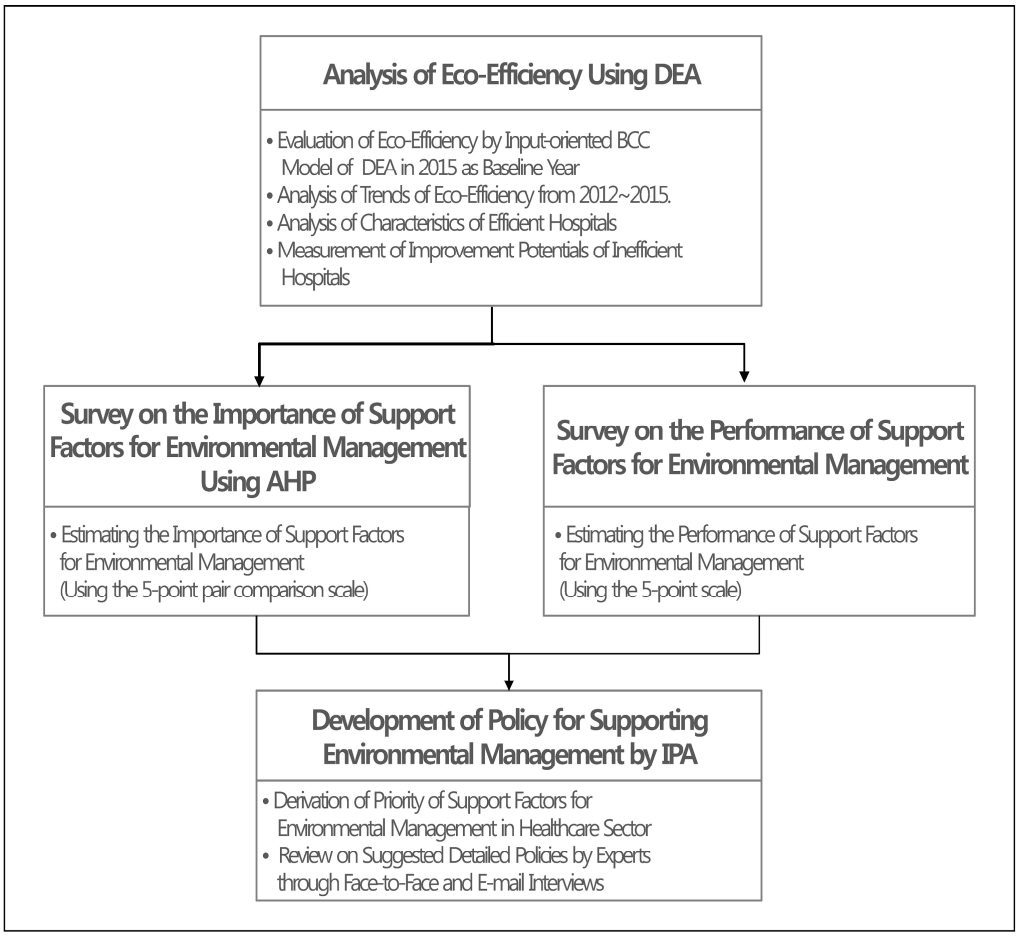
3.4.2 Expert Interview for Review of Analysis Result and Suggestion for Diffusing Environmental Management in Healthcare Sector

After the analysis of DEA and IPA based on survey, interview with experts was conducted to suggest direction of effective environmental policy or measure for supporting diffusion of EM in the healthcare sector. Total six experts were interviewed from policy institute, consulting company, academia, and hospital. The interview was conducted through e-mail and face-to-face meeting. The form for experts' interview was in <Appendix 3>.

The schematic flow of this study was shown in <Figure 4>.

<Table 21> Hierarchy Structure of Selection and Support Factors to Promote Environment Management in Healthcare Sector

Selection factor	Support factor
Environmental Management(Purchasing) System	1. Establishment of vision and strategy of environmental management
	2. Organization of a task team for environmental management and tasks assignment
	3. Guideline and compliance of green purchasing
Resources·Energy	1. Management of water use management and reduction activity
	2. Management of energy use and reduction activity
	3. Investment in new and renewable energy and introduction of technology
GHG·Environmental Pollution	1. Management of GHG emissions and its reduction activity
	2. Management of emissions of water pollutants and its reduction activity
	3. Management of waste generation and its reduction activity
	4. Management of the use of hazardous chemicals and its reduction activity
Social·Ethical Responsibility	1. Compliance with environmental laws and regulation in domestic and overseas
	2. Publication of environmental report and disclosure
	3. Response to stakeholder's request for environmental information



<Figure 4> Diagram of Research Procedure

Chapter 4. Results of Analysis of Eco-Efficiency and Discussion for Its Improvement

4.1 Evaluation of Eco-Efficiency in Hospitals with DEA

4.1.1 Result of Assessment of Eco-Efficiency in 2015

In this study, the input BCC model among DEA methods was used to evaluate eco-efficiency of hospitals. The results of the eco-efficiency analysis in 2015 were shown in <Table 22>. The average of eco-efficiency scores of 21 hospitals was 0.940. The number of eco-efficiency score 1, was 12 hospitals, 57% of the total. They were evaluated to be operated efficiently in terms of business environmental management. On the other hand, six hospitals had lower scores than the average.

H11, H12, H14, and H17 were hospitals participating in the GETMS. Due to government regulation, their scores of eco-efficiency were 1, which meant that their hospitals were efficiently operated. This suggested that legal obligation contributed to effectively improving their eco-efficiencies respectively.

On the other hand, except for H17, which was applied to both of the GETMS and VA, the scores of H02 and H05 hospitals that participated in the VA of EM were 0.847 and 0.630 respectively and two were needed to improve their eco-efficiency, suggesting that voluntary approach was not sufficient for meeting their goals of MOU for EM.

<Table 22> Eco-Efficiencies of 21 Hospitals in 2015

Hospital	Score of eco-efficiency	Remarks
H01	1.000	-
H02	0.847	VA*(2013)
H03	1.000	-
H04	0.816	-
H05	0.630	VA(2015)
H06	0.975	-
H07	0.951	-
H08	1.000	-
H09	1.000	-
H10	1.000	-
H11	1.000	GETMS*
H12	1.000	GETMS
H13	0.867	-
H14	1.000	GETMS
H15	0.737	-
H16	1.000	-
H17	1.000	VA(2014), GETMS
H18	1.000	-
H19	1.000	-
H20	0.928	-
H21	0.981	-
Average	0.940	-

* *VA : Voluntary Agreement, GETMS: GHG & Energy Target Management System*

4.1.2 Analysis of Trends from 2012 to 2015

This study evaluated the change of eco-efficiency from 2012 to 2015 in order to analyze the trend of eco-efficiency. In order to secure the objectivity of the evaluation, the growth rate of the producer price (or service) was applied to hospital sales which were influenced by the inflation rate. When looking at changes in eco-efficiency over time, it was needed to evaluate data of all years at the same time. The evaluation result of eco-efficiencies from 2012 to 2015 was shown in <Table 23>.

The result of the evaluation showed that the average eco-efficiency score in 2014 was the highest at 0.933, while it was the lowest at 0.830 in 2012. The average of eco-efficiency scores rose from 2012 to 2014 but dropped slightly by 3% in 2015. This difference in average scores indicated a change in the eco-efficiency of ineffectively assessed hospitals versus an efficiently assessed hospital. The gradual increase in the average scores suggested that the eco-efficiency of less efficiently evaluated hospitals was improved.

Four hospitals of H11, H12, H14, and H17, which participated in government regulation of the GETMS, showed their scores of eco-efficiency gradually increasing from 2012 to 2015. In particular, H11, H12, and H17 were inefficient in 2012 as first year, but the implementation of GETMS contributed to the high improvement of their eco-efficiency with score 1 in 2015. As mentioned above, it strongly meant that the GETMS had a positive impact on improving eco-efficiency in hospitals.

<Table 23> Eco-Efficiencies of 21 Hospitals from 2012 to 2015

Hospital	Year / Eco-efficiency				Remarks
	2012	2013	2014	2015	
H01	1.000	1.000	1.000	1.000	-
H02	0.770	0.866	0.785	0.819	VA(2013)
H03	0.760	0.870	1.000	1.000	-
H04	0.715	0.722	0.797	0.761	-
H05	0.630	0.675	0.814	0.570	VA(2015)
H06	0.816	0.815	0.864	0.826	-
H07	0.830	1.000	0.982	0.771	-
H08	0.997	1.000	1.000	0.905	-
H09	0.905	0.829	0.897	1.000	-
H10	0.993	1.000	1.000	0.918	-
H11	0.592	0.824	1.000	1.000	GETMS
H12	0.663	0.927	0.961	1.000	GETMS
H13	1.000	0.757	0.842	0.867	-
H14	0.703	0.904	0.936	0.946	GETMS
H15	0.646	0.857	0.958	0.681	-
H16	1.000	1.000	1.000	1.000	-
H17	0.643	0.657	0.881	1.000	VA(2014), GETMS
H18	1.000	0.932	1.000	1.000	-
H19	0.770	1.000	1.000	1.000	-
H20	1.000	1.000	0.879	0.898	-
H21	1.000	0.909	1.000	0.978	-
Average	0.830	0.883	0.933	0.902	-

Although two hospitals, H02 and H05, participated in voluntary measure as VA, their eco-efficiencies were not improved and were even worse. This suggested that voluntary measure was insufficient to ensure continuous action and implementation and had the limitation of its effect without proper corrective measure such as strict monitoring, reporting, and feedback system.

The statistics of variance on the average differences of the eco-efficiency scores showed statistically significance with 5% significance level in <Table 24>.

<Table 24> Statistics of Variances of Eco-Efficiency Scores

Sum of square	Degree of freedom	Sum of squares	P-Value
0.272	1.000	0.091	0.0001

In this study, the degree of inefficiency in the eco-efficiency evaluation was evaluated by using Profiling technique. The Profiling technique was to evaluate the partial efficiency of the hospital with the same output variable based on each input variable. In other words, this method analyzed the inefficiency of environmental load variable to the overall eco-efficiency and provided useful information to improve the eco-efficiency of the hospital through intensive management of inefficient environmental load variables (Christopher, 1996).

Thus, the eco-efficiencies of four environmental load variables were determined by the Profiling technique as shown in <Table 25> to

<Table 28>. As a result, the average eco-efficiency scores of environmental load variables were 0.762 for water use, 0.754 for energy use and 0.532 for waste generation in 2015. The high scores of water use and energy consumption meant that they were managed well, compared to waste generation. On the other hand, the use of hazardous chemicals was the lowest score of 0.323. This suggested that the management of the hazardous chemicals usage in hospitals was not performed properly.

<Table 25> Eco-Efficiency of 'Water Use' Variable from 2012 to 2015

Hospital	Year / Eco-efficiency				Remarks
	2012	2013	2014	2015	
H01	0.917	1.000	0.978	1.000	-
H02	0.770	0.866	0.694	0.738	VA(2013)
H03	0.734	0.829	0.907	0.867	-
H04	0.655	0.614	0.668	0.744	-
H05	0.630	0.664	0.609	0.373	VA(2015)
H06	0.736	0.774	0.717	0.732	-
H07	0.508	0.444	0.496	0.530	-
H08	0.618	0.613	0.543	0.535	-
H09	0.905	0.829	0.871	1.000	-
H10	0.956	1.000	1.000	0.800	-
H11	0.592	0.820	0.738	0.723	GETMS
H12	0.663	0.927	0.891	0.939	GETMS
H13	1.000	0.647	0.626	0.644	-
H14	0.686	0.904	0.936	0.946	GETMS
H15	0.646	0.857	0.958	0.681	-
H16	0.729	0.989	1.000	0.931	-
H17	0.422	0.534	0.594	0.615	VA(2014), GETMS
H18	0.625	0.728	0.889	0.792	-
H19	0.770	1.000	0.990	0.939	-
H20	0.587	0.688	0.704	0.734	-
H21	0.676	0.687	0.750	0.744	-
Average	0.706	0.782	0.789	0.762	-

<Table 26> Eco-Efficiency of 'Energy Use' Variable from 2012 to 2015

Hospital	Year / Eco-efficiency				Remarks
	2012	2013	2014	2015	
H01	0.972	1.000	0.980	1.000	-
H02	0.729	0.733	0.740	0.747	VA(2013)
H03	0.411	0.416	0.479	0.501	-
H04	0.710	0.721	0.797	0.744	-
H05	0.599	0.591	0.573	0.355	VA(2015)
H06	0.784	0.804	0.849	0.786	-
H07	0.577	0.556	0.634	0.611	-
H08	0.350	0.340	0.367	0.389	-
H09	0.799	0.710	0.813	0.899	-
H10	0.993	1.000	1.000	0.849	-
H11	0.377	0.656	1.000	0.974	GETMS
H12	0.416	0.584	0.662	0.699	GETMS
H13	1.000	0.745	0.842	0.867	-
H14	0.476	0.580	0.569	0.589	GETMS
H15	0.508	0.682	0.776	0.553	-
H16	0.680	0.953	0.970	1.000	-
H17	0.526	0.656	0.674	0.665	VA(2014), GETMS
H18	0.569	0.713	0.851	0.777	-
H19	0.722	0.931	1.000	0.995	-
H20	0.651	0.758	0.832	0.859	-
H21	0.723	0.841	0.947	0.978	-
Average	0.646	0.713	0.779	0.754	-

<Table 27> Eco-Efficiency of 'Waste Generation' Variable from 2012 to 2015

Hospital	Year / Eco-efficiency				Remarks
	2012	2013	2014	2015	
H01	0.876	0.885	0.980	1.000	-
H02	0.326	0.237	0.266	0.278	VA(2013)
H03	0.381	0.291	0.341	0.346	-
H04	0.472	0.441	0.445	0.409	-
H05	0.389	0.403	0.516	0.285	VA(2015)
H06	0.700	0.541	0.584	0.589	-
H07	0.801	1.000	0.963	0.734	-
H08	0.980	1.000	0.980	0.847	-
H09	0.449	0.490	0.455	0.585	-
H10	0.807	1.000	1.000	0.702	-
H11	0.252	0.378	0.863	1.000	GETMS
H12	0.483	0.560	0.598	0.595	GETMS
H13	1.000	0.484	0.463	0.466	-
H14	0.431	0.480	0.460	0.469	GETMS
H15	0.434	0.465	0.485	0.333	-
H16	1.000	1.000	1.000	0.815	-
H17	0.349	0.379	0.451	0.455	VA(2014), GETMS
H18	0.313	0.328	0.361	0.351	-
H19	0.341	0.386	0.372	0.377	-
H20	1.000	1.000	0.406	0.395	-
H21	1.000	0.738	0.799	0.143	-
Average	0.609	0.595	0.609	0.532	-

<Table 28> Eco-Efficiency of 'Chemical Use' Variable from 2012 to 2015

Hospital	Year / Eco-efficiency				Remarks
	2012	2013	2014	2015	
H01	0.750	1.000	0.992	1.000	-
H02	0.131	0.142	0.019	0.018	VA(2013)
H03	0.043	0.074	0.101	0.101	-
H04	0.010	0.011	0.017	0.019	-
H05	0.046	0.057	0.087	0.094	VA(2015)
H06	0.033	0.039	0.005	0.006	-
H07	0.016	0.015	0.015	0.015	-
H08	0.016	0.015	0.014	0.013	-
H09	0.507	0.746	0.716	0.791	-
H10	0.877	1.000	1.000	0.918	-
H11	0.025	0.095	0.560	0.552	GETMS
H12	0.015	0.018	0.005	0.006	GETMS
H13	1.000	0.021	0.200	0.024	-
H14	0.225	0.222	0.164	0.156	GETMS
H15	0.015	0.016	0.019	0.018	-
H16	0.800	0.724	1.000	1.000	-
H17	0.038	0.039	0.213	1.000	VA(2014), GETMS
H18	0.740	0.382	0.749	1.000	-
H19	0.016	0.019	0.019	0.019	-
H20	0.016	0.016	0.013	0.013	-
H21	0.010	0.012	0.012	0.012	-
Average	0.254	0.222	0.282	0.323	-

4.1.3 Analysis of Characteristics and Contributing Factors in High Eco-Efficiency Hospitals

The frequency of reference in high eco-efficient hospital was analyzed as shown in <Table 29>, in order to examine the characteristics of highly eco-efficient hospitals. There were six hospitals that showed the reference set among the eco-efficient hospitals. A hospital with a high eco-efficiency, represented by a reference set, would be used as a benchmark when the low eco-efficient hospital started to improve eco-efficiency.

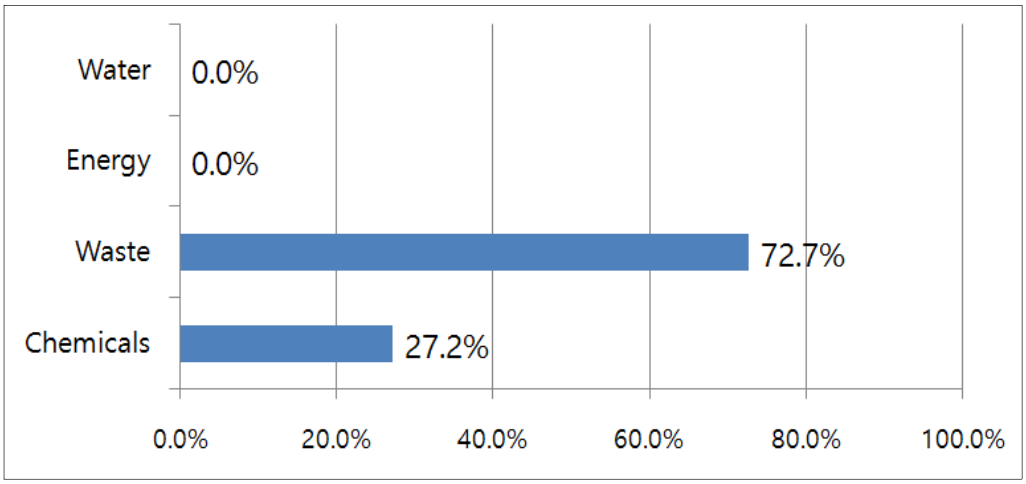
<Table 29> Frequency of Reference in High Eco-Efficient Hospitals

High efficient hospital	The frequency of reference	Hospitals referred
H16	9	H02, H04, H05, H06, H07, H13, H15, H20, H21
H01	6	H04, H05, H06, H07, H15, H20
H19	6	H02, H04, H13, H15, H20, H21
H14	2	H04, H15
H09	1	H05
H17	1	H02

For analyzing the characteristics of hospitals evaluated as efficient, the contribution of the variables to eco-efficiency evaluation was

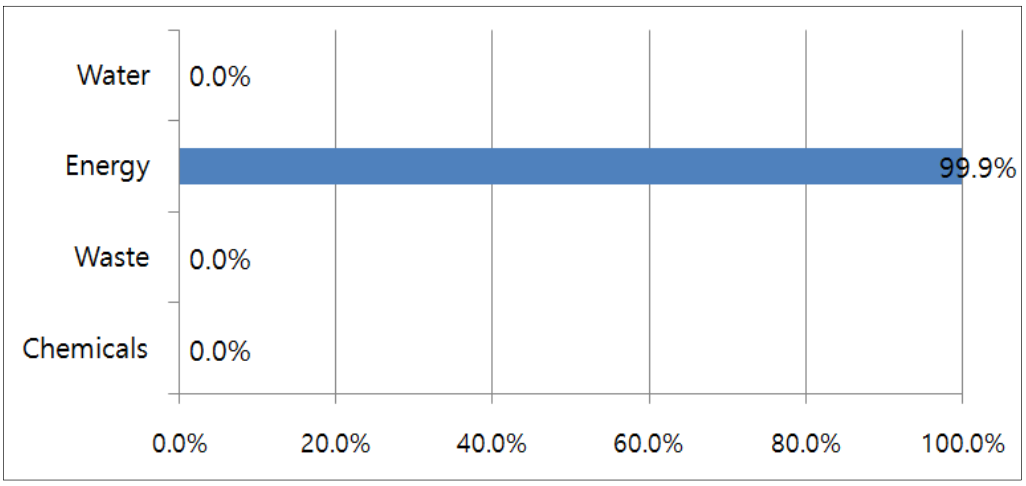
examined in the study. This indicated the extent to which variables contributed to achieving the eco-efficiency score of 1, and hospitals with low eco-efficiency could provide information on the proportion of those variables when referring to these hospitals to increase eco-efficiency.

In the case of H16, which had 9 frequencies of reference, waste generation and use of hazardous chemicals were found to be high as shown in <Figure 5>.

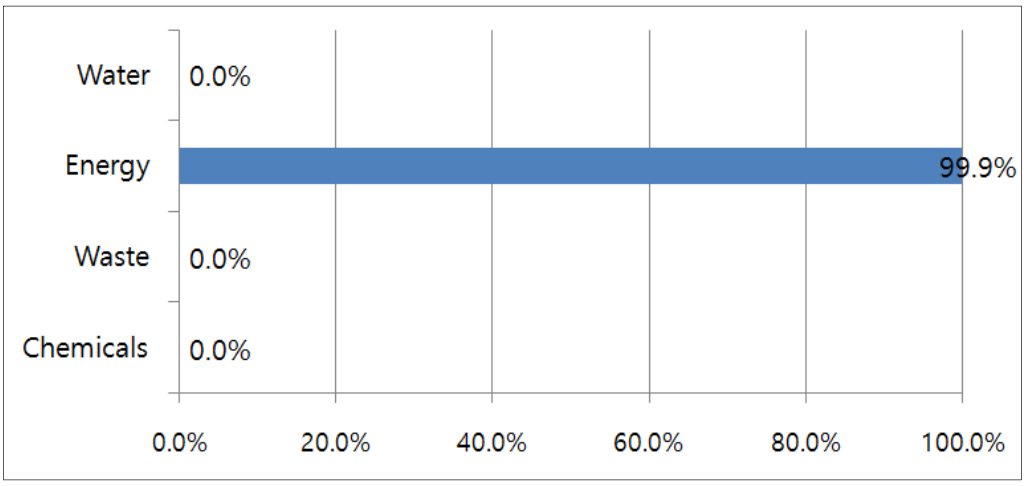


<Figure 5> Output Contributions by Variables in H16

In the case of H01 and H19 at <Figure 6> and <Figure 7>, which showed six frequencies of reference, energy consumption was found to be high with 99.9%. In other words, these two hospitals were found to have relatively higher eco-efficiency scores because they managed energy use more efficiently than others with lower eco-efficiency score.



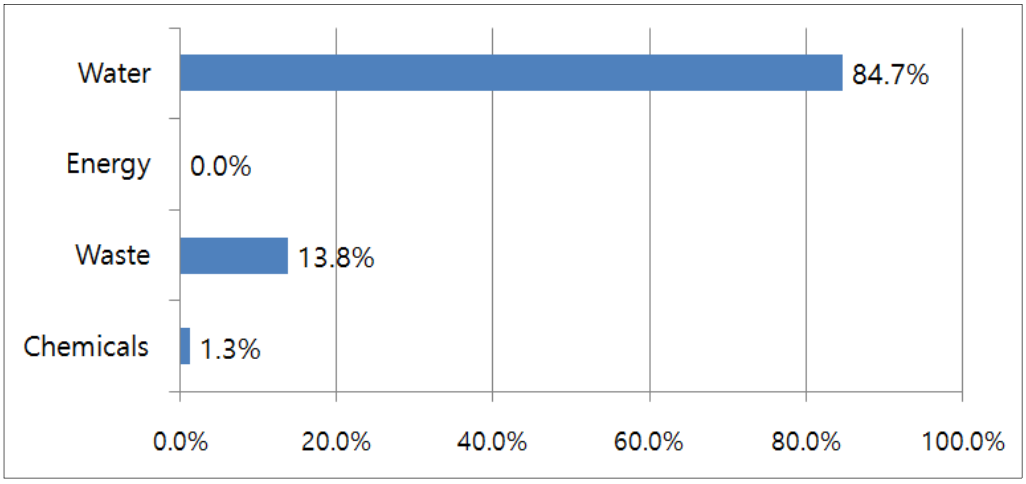
<Figure 6> Output Contributions by Variables in H01



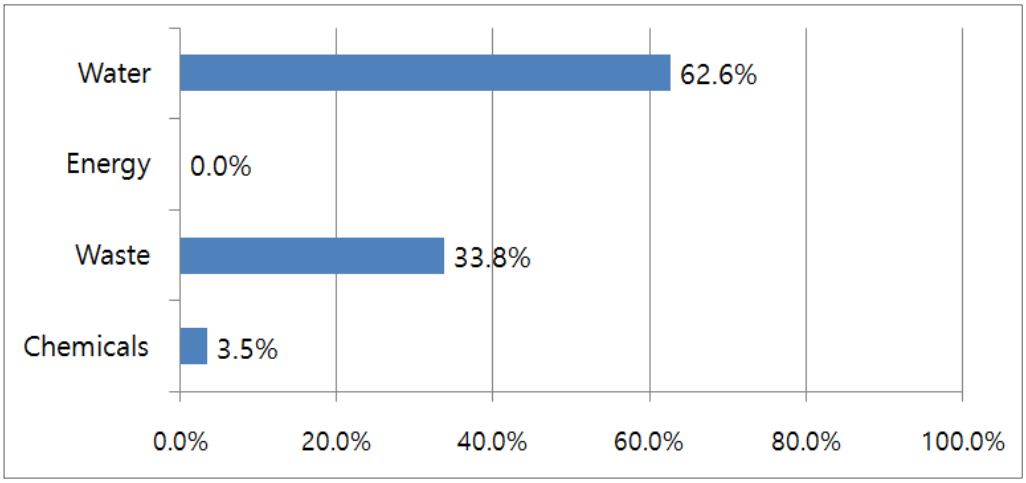
<Figure 7> Output Contributions by Variables in H19

In the case of H14 and H09, it was found that water consumption, waste generation, and use of hazardous chemicals were major sources of contribution (<Figure 8> and <Figure 9>). In particular, the contribution of water use to H14 was 84.7%, which was considerably higher than

the contribution of other variables, so that it indicated that water use was managed efficiently.



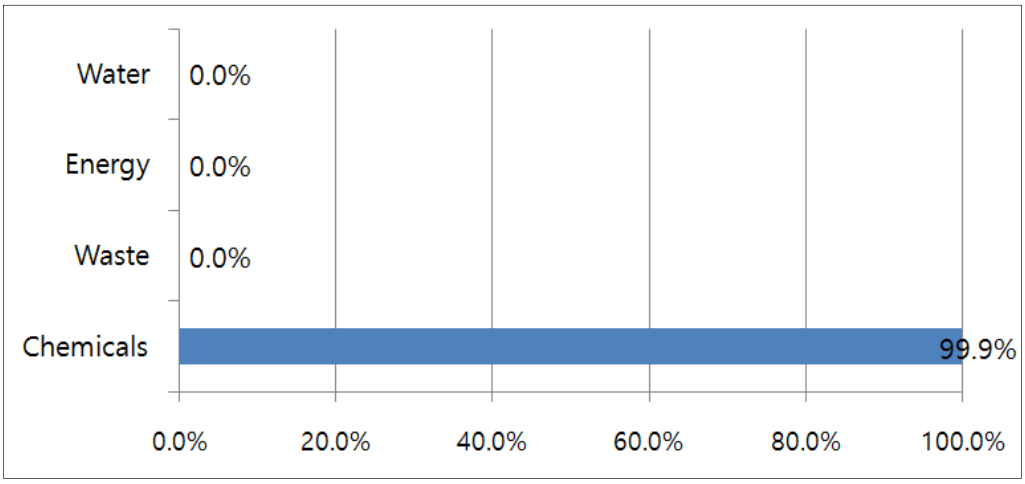
<Figure 8> Output Contributions by Variables in H14



<Figure 9> Output Contributions by Variables in H09

Finally, H17 had a high contribution by the use of hazardous

chemicals in <Figure 10> and H02, which had H17 as a reference set, could be improved by benchmarking related variable in above <Table 29>.



<Figure 10> Output Contributions by Variables in H17

4.1.4 Analysis of Super Eco-Efficiency in High Efficient Hospitals

Where there are many DMUs with an efficiency score of 1, the solution for comparing with those efficient DMUs is a super - efficiency analysis. The super-efficiency analysis was intended to compare the relative superiority between the efficient frontiers. It is a supplementary method for understanding comparative efficiency among the most efficient DMUs (Cho, 2014).

Above twelve hospitals with the eco-efficiency score of 1 were efficiently evaluated and no further ranking information could be derived.

Therefore, this study overcomes these limitations by evaluating the most influential and efficient hospitals through the super-efficiency analysis.

Super-efficiency analysis showed that three hospitals, H1, H10, H16, and H18 were most efficient at <Table 30>. There were the potential improvements in remaining 8 hospitals.

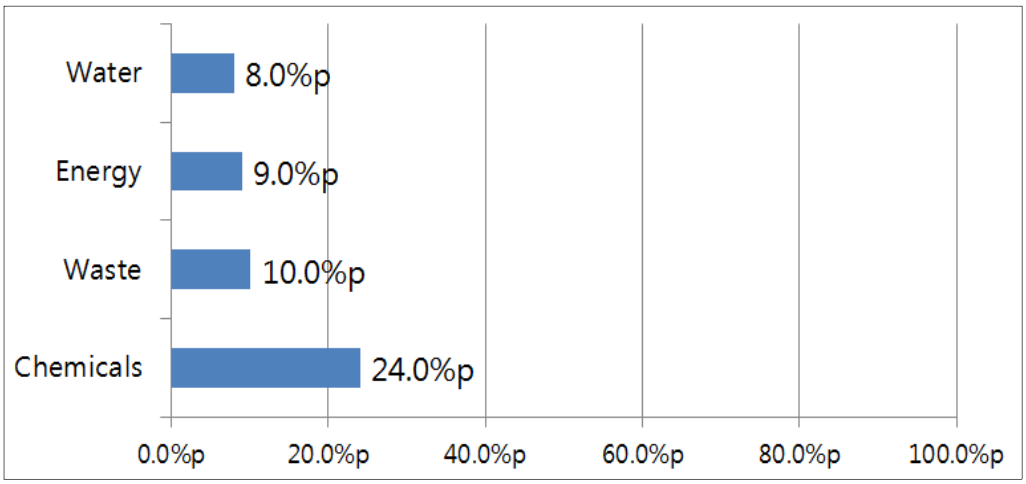
<Table 30> Analysis of Super Eco-Efficiency in 2015

Hospital	Super Eco-Efficiency	Remarks
H01	1.000	-
H03	0.123	-
H08	0.115	-
H09	0.126	-
H10	1.000	-
H11	0.167	GETMS
H12	0.114	GETMS
H14	0.104	GETMS
H16	1.000	-
H17	0.815	VA(2014), GETMS
H18	1.000	-
H19	0.122	-

4.2 Improvement of Eco-Efficiency in Hospitals

DEA evaluated the relative efficiency of inputs used in common and output produced using them for groups with the same characteristics. In addition, it was possible to obtain an alternative for inefficiently evaluated DMU to improve eco-efficiency by benchmarking efficient DMU in the same group. To this end, DEA derived efficient reference set from the same group. It was used as benchmarking set, providing a realizable potential improvement to efficiently improve inefficient DMU, such as the degree and the cause of inefficiency, the type and quantity of the input, and the type and amount of the output. This information provided important improvement points to improve eco-efficiency and enabled the achievement of eco-efficiency score 1 through adjustment of variables.

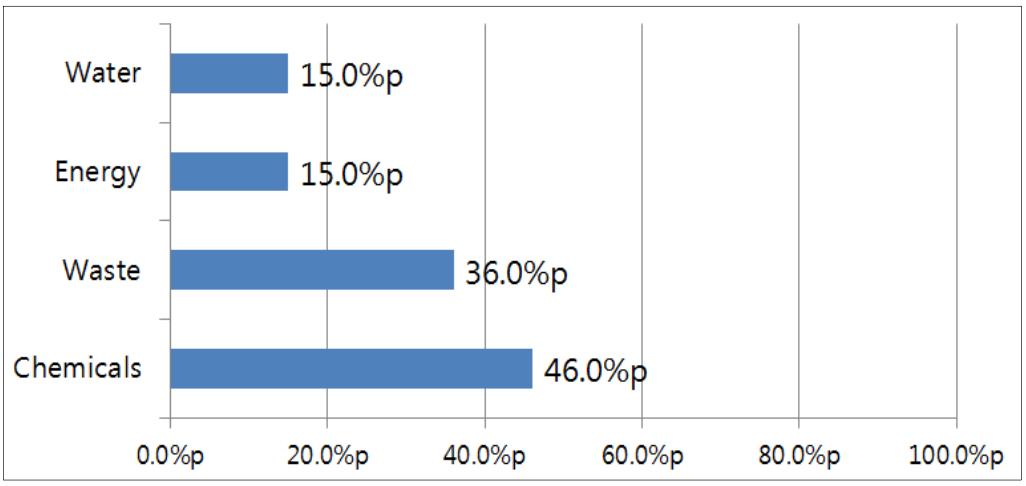
Through this process, the potential improvement in this study was evaluated for hospitals with low eco-efficiency scores. The analysis of the potential improvements by inefficient 9 hospitals was shown at <Figure 11>. They needed to reduce water use by 8% point, energy consumption by 9% point, waste generation by 10% point, and hazardous chemicals use by 24% point in 2015, compared to the reference set of efficient hospitals. The potential improvement was estimated by analyzing the actual production conditions and processes of the hospitals having the same production conditions and processes and there was a room for reducing the amount of resources uses and waste generations through potential improvement by each environmental load variables.



<Figure 11> Potential Improvement by Variables in 2015

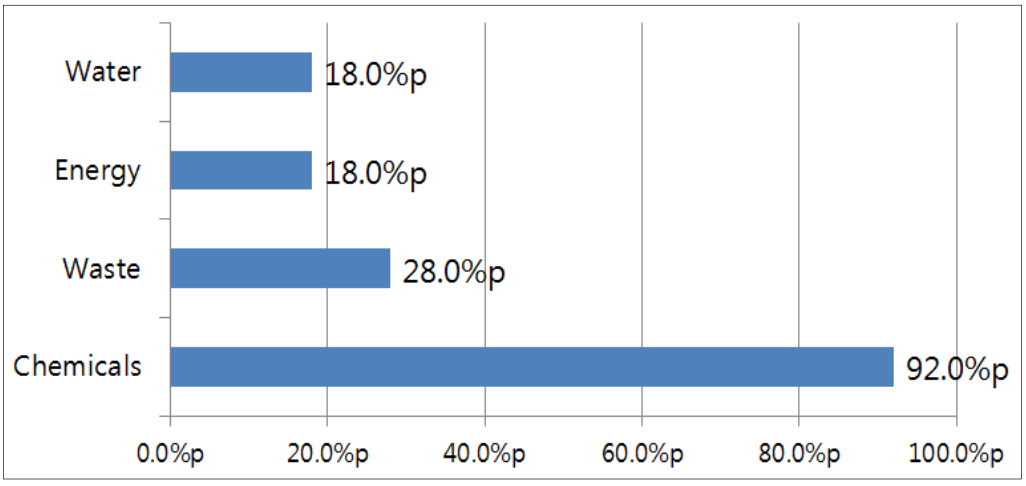
The eco-efficiency scores of chemicals use variable among those of environmental load variables was the lowest previously from <Table 25> to <Table 28> and the potential for improvement was the highest, indicating that active management of chemicals use was strongly recommended in hospitals.

As shown in <Figure 12>, H02 should reduce water consumption by 15% point, energy consumption by 15% point, waste generation by 36% point, and hazardous chemical use by 46% point. Especially, the potential improvements by waste generations and hazardous chemical uses are large, and it was analyzed that intensive effort for their improvement was needed.



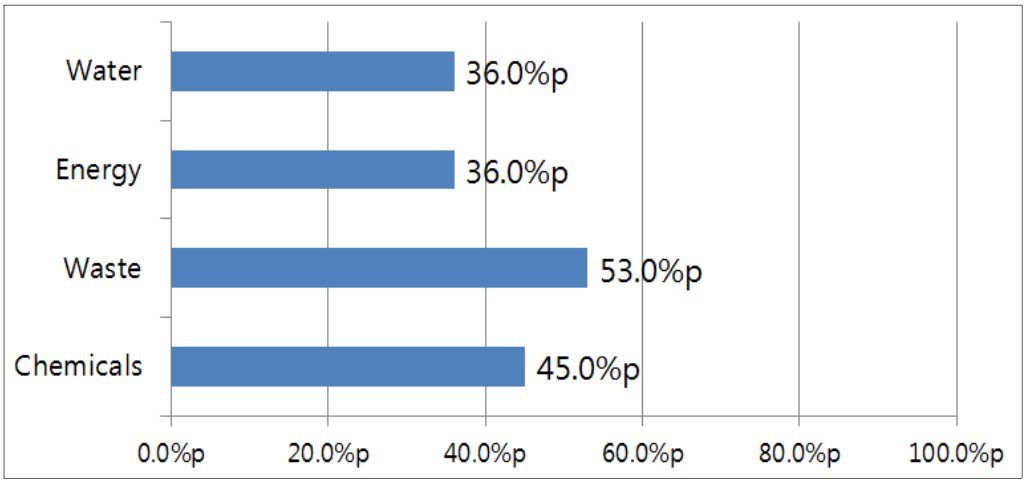
<Figure 12> Potential Improvement by Variables in H02

Next, H04 was advised to reduce by 18% point of water use, 18% point of energy use, 28% point of waste generation and 92% point of hazardous chemical use as shown in <Figure 13>. Especially, the potential by hazardous chemicals uses was considerably high, and it indicated that chemicals use needed intensive efforts for improvement.



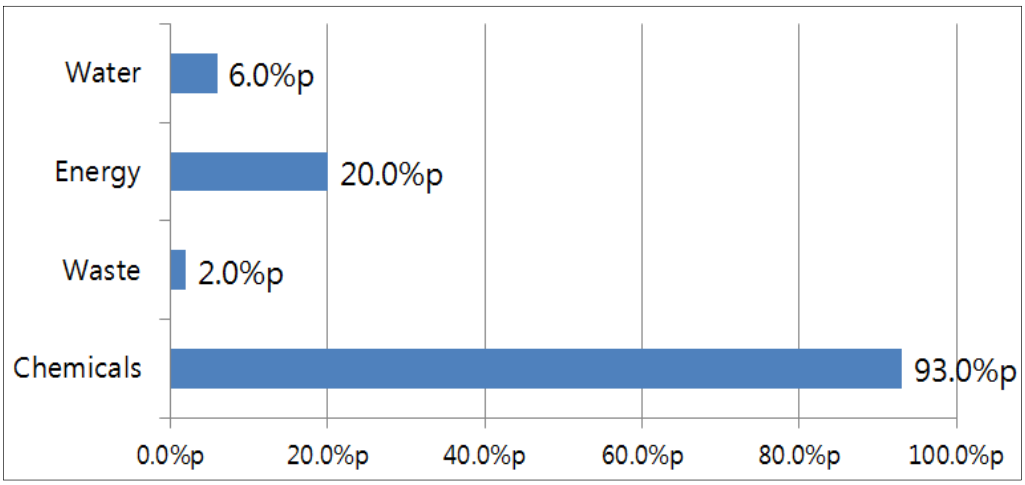
<Figure 13> Potential Improvement by Variables in H04

H05 was needed to reduce water consumption by 36% point, energy consumption by 36% point, waste generation by 53% point, and hazardous chemical use by 45% point in order to improve its eco-efficiency at <Figure 14>.



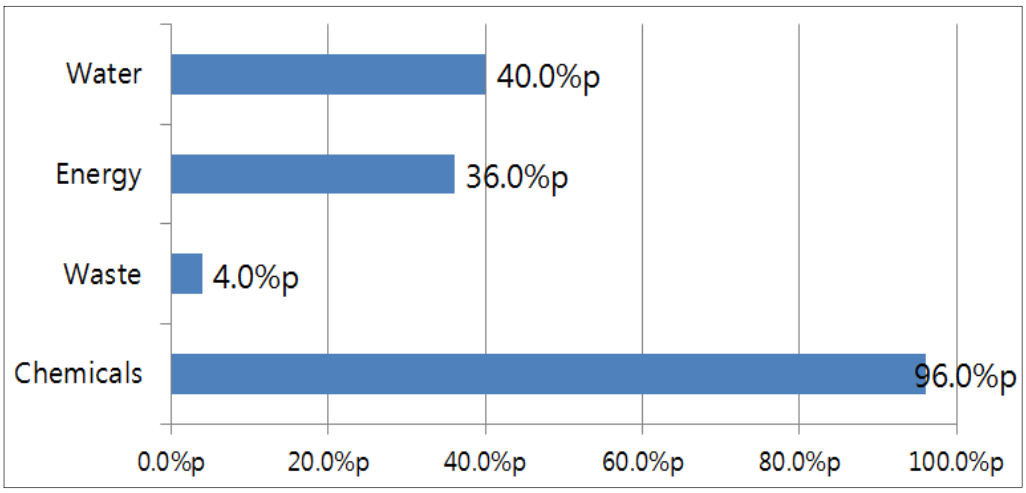
<Figure 14> Potential Improvement by Variables in H05

H06 from <Figure 15> needed to reduce water consumption by 6% point, energy consumption by 20% point, waste generation by 2% point, and toxic chemical use by 93% point. This was similar to the previous H04 trend, and effort to reduce the use of hazardous chemicals was more urgent than other variables in order to improve inefficiency.



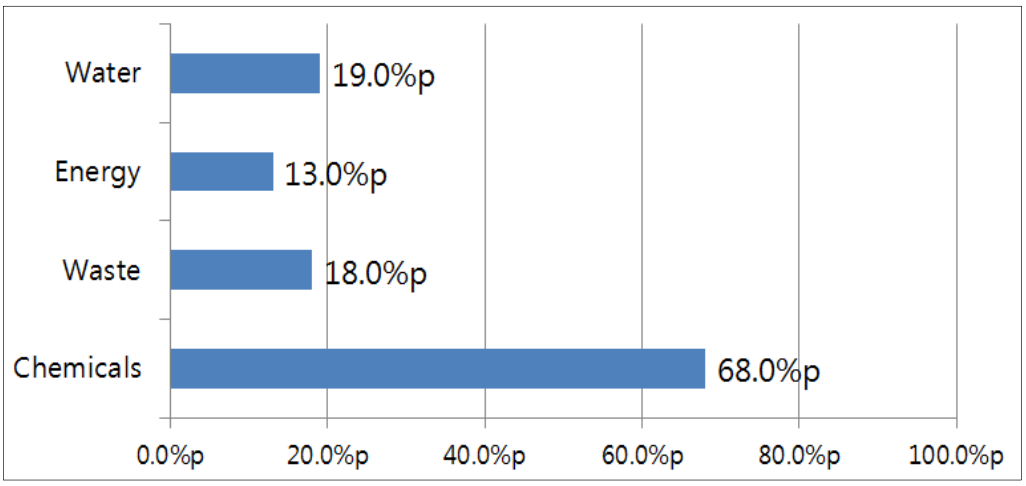
<Figure 15> Potential Improvement by Variables in H06

H07 at <Figure 16> was required to reduce water use by 40% point, energy use by 36% point, waste generation by 4% point, and hazardous chemical use by 96% point respectively. H07 showed a relatively large improvement in the use of hazardous chemicals among other environmental input variables and it was analyzed that efforts to reduce a large amount of chemicals use and efficient management measures were urgently needed.



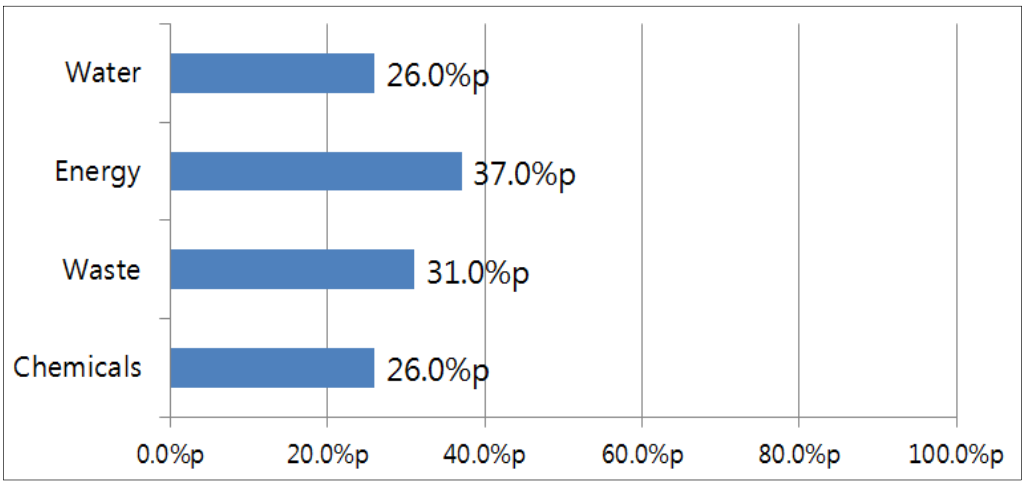
<Figure 16> Potential Improvement by Variables in H07

At <Figure 17>, H13 was required to save water consumption by 19% point, energy use by 13% point, waste generation by 18% point, and hazardous chemical use by 68% point respectively. In particular, it was analyzed that the most important measure needed for the hazardous chemical use, considering that potential improvements by chemicals variable was the largest compared to others.



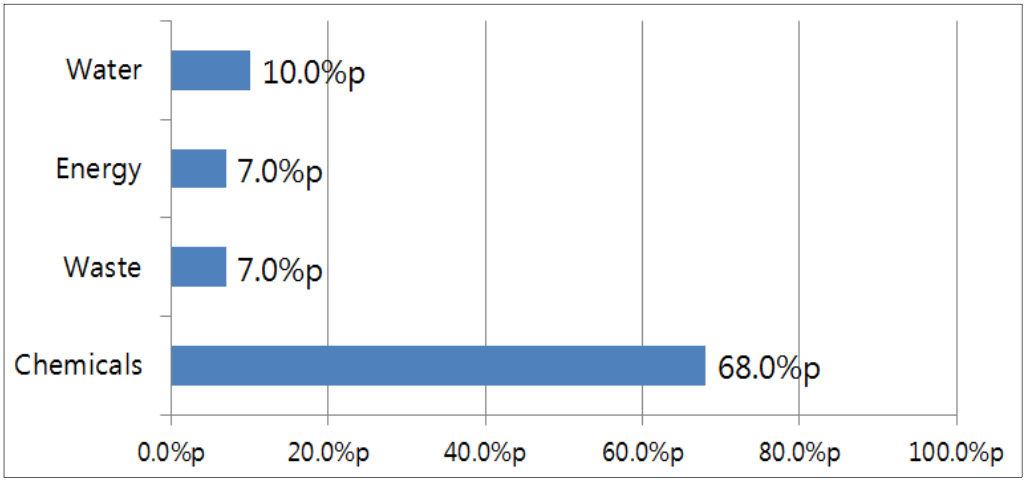
<Figure 17> Potential Improvement by Variables in H13

H15 was needed reduction of 26% point of water use, 37% point of energy use, 31% point of waste generation, and 26% point of hazardous chemical usage in <Figure 18>.



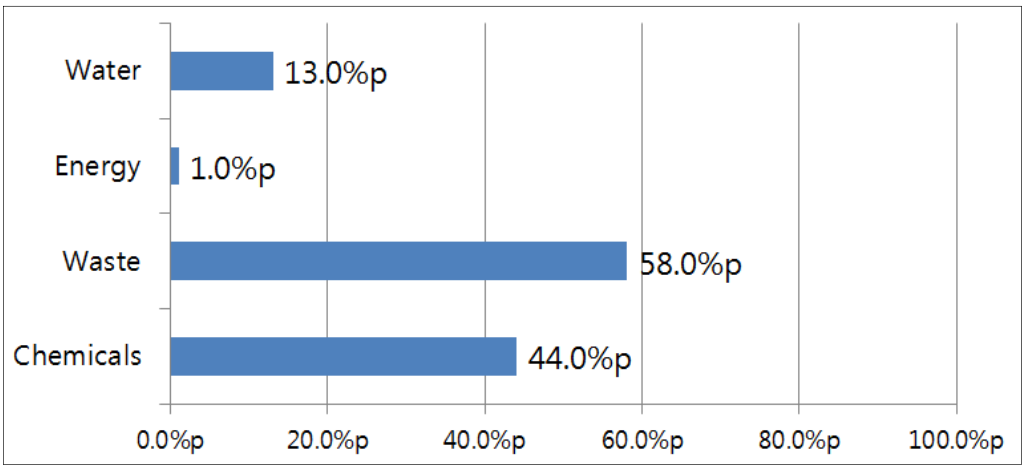
<Figure 18> Potential Improvement by Variables in H15

For being efficient H20 at <Figure 19>, it was necessary to reduce water use by 10% point, energy use by 7% point, waste generations by 7% point, and hazardous chemical use by 68% point respectively. It was analyzed that the improvement potential of hazardous chemicals was relatively larger than other environmental load variables such as H04, H06, H07 and H13, and efforts to reduce the use of hazardous chemicals were required.



<Figure 19> Potential Improvement by Variables in H20

Lastly, H21 was required to adjust the reduction of water use by 13% point, energy use by 1% point, waste generation by 58% point, and hazardous chemical use by 44% point respectively at <Figure 20>. Based on the potential for improvement, energy use was well managed internally, but it was analyzed that two variables of waste generations and the use of toxic chemicals were needed to be managed intensively because they were operated inefficiently.



<Figure 20> Potential Improvement by Variables in H21

By analyzing the potential improvements of hospitals with low eco-efficiency scores, each hospital could identify their input variables to be improved to get a higher score of eco-efficiency. In addition, more substantial alternatives will be reviewed and adjusted to achieve an eco-efficiency score of 1.

4.3 Effective Support Factors for Improving Environmental Management with IPA

4.3.1 Analysis of Importance for Promoting Environmental Management in Healthcare sector

Of the total 51 questionnaires, 33 were collected, and the four questionnaires with a consistency ratio of more than 0.1 were rejected, resulting in a total of 29 questionnaires.

As a result of the questionnaire survey to support EM in the healthcare sector, the results of the importance analysis by selection factors were shown in <Table 31>. As a result of the weighting analysis, 'resource and energy management and reduction activities' was the most important selection factor among other four factors. 'Environmental management (purchasing) system', 'GHG, environmental pollution management and reduction activity', and 'compliance with social and ethical responsibility' were evaluated respectively based on their relative importances.

<Table 31> Analysis of Importance of Selection Factors

Selection factor	Score	Ranking
Environmental Management(Purchasing) System	0.290	2
Resource & Energy	0.315	1
GHG·Environmental Pollution	0.283	3
Social·Ethical Responsibility	0.113	4

As a result of the weighting analysis of the importance of establishment of environmental management (purchasing) system, the organization of a task team and task assignment for implementing EM was the first priority compared to the establishment of vision and strategy and guideline and compliance of green purchasing (<Table 32>). This implied that the implementation of EM required in-charge staff and organization and it was more important than macro approaches such as vision, strategy, and guidelines.

<Table 32> Analysis of Importance of Establishment of Environmental Management (Purchasing) System

Support factor	Score	Ranking
Establishment of vision and strategy of environmental management	0.370	2
Organization of a task team for environmental management and tasks assignment	0.427	1
Guideline and compliance of green purchasing	0.203	3

As a result of the weighting analysis of the importance of support factors of resource and energy management and reduction activity, 'management of energy use and reduction activity' and 'management of water use and reduction activity' were found to be important (<Table 33>). They were more important than new investment in new and renewable energy facilities and it implied that more efficient management of existing facilities and employee activities were important.

<Table 33> Analysis of Importance of Support Factors for Resource and Energy Management and Reduction Activities

Support factor	Score	Ranking
Management of water use management and reduction activity	0.386	2
Management of energy use and reduction activity	0.463	1
Investment in new and renewable energy and introduction of technology	0.151	3

As a result of the weighting analysis of importance for selecting GHG and environmental pollution management and reduction activities, 'management of GHG emissions and reduction activity' was the most important among the four factors at <Table 34>. The relative importance was analyzed in the order of 'management of use of hazardous chemicals and reduction activity', 'management of waste generation and reduction activity', and 'management of emissions of

water pollutants and reduction activity'.

As a result of weighting analysis of the importance for selecting social and ethical responsibility, 'compliance with environmental laws and regulation in domestic and overseas' seemed to be of the highest importance, compared to other two factors at <Table 35>. With regard to the business aspect, EM activity was recognized as an important factor in preventing accidents through compliance with relevant laws, such as the management of harmful chemical substances. Publication of environmental report and disclosure in the hospital was the second important, which was more important than a response to stakeholders' request for information. This implied indirectly that unilateral communication was preferred by the hospital because it was an easier approach without listening to stakeholders' voices.

<Table 34> Analysis of Importance of Support Factors for GHG and Pollution Management and Reduction Activities

Support factor	Score	Ranking
Management of GHG emissions and its reduction activity	0.320	1
Management of emissions of water pollutants and its reduction activity	0.194	4
Management of waste generation and its reduction activity	0.234	3
Management of use of hazardous chemicals and its reduction activity	0.252	2

<Table 35> Analysis of Importance of Support Factors for Social and Ethical Responsibility

Support factor	Score	Ranking
compliance with environmental laws and regulation in domestic and overseas	0.552	1
Publication of environmental report and disclosure	0.263	2
Response to stakeholder's request for environmental information	0.185	3

The result of the combined weighting analysis of selection factors and support factors was derived in <Table 36>. As a result of the integrated weighting analysis, 'management of energy use and reduction activity' was analyzed as the most important factor for supporting EM. Besides energy factor, 1) the establishment of vision and strategy of EM, 2) organization of a task team for EM and tasks assignment, 3) management of water use and reduction activity, and 4) management of GHG emissions and reduction activity showed respectively higher than the average of 0.077. This suggested that they were the important support factors for promoting EM in the healthcare sector.

<Table 36> Comprehensive Result of Combined Weighting Analysis of Importance of Selection Factors and Support Factors

Selection factor	Support factor	Score	Ranking
Environmental Management(Purchasing) System	1. Establishment of vision and strategy of environmental management	0.107	4
	2. Organization of a task team for environmental management and tasks assignment	0.124	2
	3. Guideline and compliance of green purchasing	0.059	9
Resources·Energy	1. Management of water use management and reduction activity	0.122	3
	2. Management of energy use and reduction activity	0.146	1
	3. Investment in new and renewable energy and introduction of technology	0.048	11
GHG·Environmental Pollution	1. Management of GHG emissions and its reduction activity	0.091	5
	2. Management of emissions of water pollutants and its reduction activity	0.055	10
	3. Management of waste generation and its reduction activity	0.066	7
	4. Management of use of hazardous chemicals and its reduction activity	0.071	6
Social·Ethical Responsibility	1. compliance with environmental laws and regulation in domestic and overseas	0.062	8
	2. Publication of environmental report and disclosure	0.030	12
	3. Response to stakeholder's request for environmental information	0.021	13
Average		0.077	-

4.3.2 Analysis of Performance for Promoting Environmental Management in Healthcare Sector

The result of analysis of performance for IPA was shown in <Table 37>. As a result of analysis of performance according to the support factors, it was found that 'compliance with environmental laws and regulation in domestic and overseas', 'management of waste generation and its reduction activity', 'management of energy use and reduction activity', and 'management of water use management and reduction activity' showed higher performance with 4.20, 4.10, 4.10 and 4.00 respectively, which were higher than the average of 3.75.

On the other hand, 'investment in new and renewable energy and introduction of technology', 'publication of environmental report and disclosure', 'organization of task team for EM and tasks assignment', 'response to stakeholder's request for environmental information' and 'guideline and compliance of green purchasing' were evaluated as lower in performance analysis and turned out to be support factors.

Detailed quantitative EM factors such as water consumption, energy consumption, water pollutants, waste generation, and use of hazardous chemicals were managed and promoted efficiently in each hospital. On the other hand, qualitative activities of EM were analyzed to be inefficiently implemented.

<Table 37> Analysis of Performance of Support Factors

Support factor	Score	Ranking
1. Establishment of vision and strategy of environmental management	3.60	9
2. Organization of a task team for environmental management and tasks assignment	3.50	11
3. Guideline and compliance of green purchasing	3.70	7
4. Management of water use management and reduction activity	4.00	4
5. Management of energy use and reduction activity	4.10	2
6. Investment in new and renewable energy and introduction of technology	3.30	12
7. Management of GHG emissions and its reduction activity	3.70	7
8. Management of emissions of water pollutants and its reduction activity	3.80	5
9. Management of waste generation and its reduction activity	4.10	2
10. Management of use of hazardous chemicals and its reduction activity	3.80	5
11. Compliance with environmental laws and regulation in domestic and overseas	4.20	1
12. Publication of environmental report and disclosure	3.30	12
13. Response to stakeholder's request for environmental information	3.60	9
Average	3.75	-

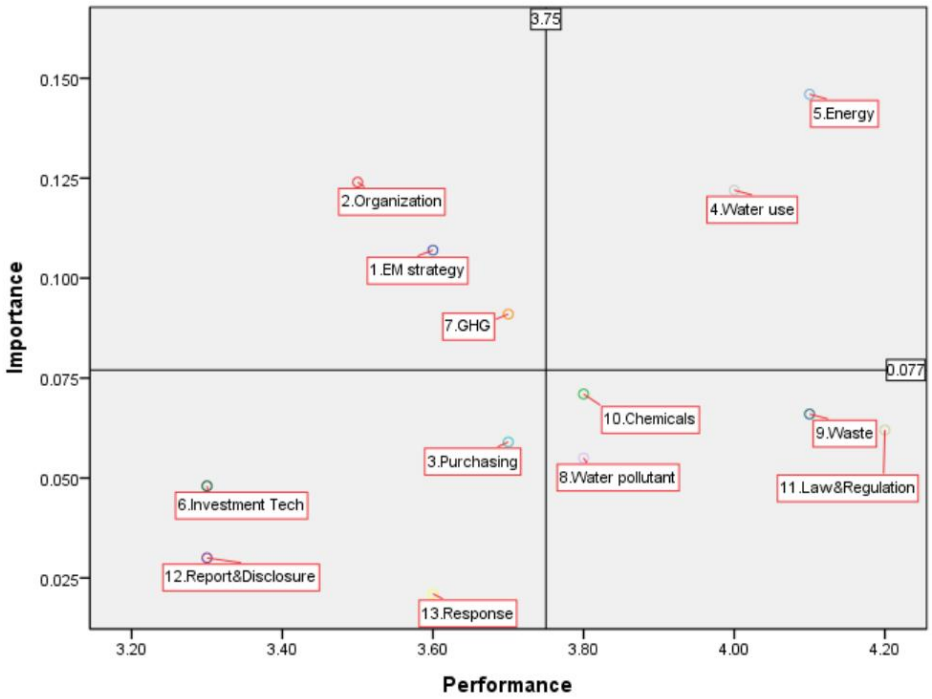
4.3.3 Matrix of Importance-Performance Analysis

The matrix of IPA was derived using SPSS Statistics 18.0 based on the aforementioned results of analysis of importance and performance. The result of IPA matrix was shown in <Figure 21>

The first quadrant (maintenance area or 'keep up the good work') means the area where the importance and the performance are both high and the current state needs to be maintained continuously. 'Management of water use management and reduction activity' and 'management of energy use and reduction activity' were located in the first quadrant for keeping up the good work.

The second quadrant ('concentrate here' area) should be implemented by establishing a key promotion strategy for supporting factors distributed in areas of high importance but low performance. In order to improve low performance for higher performance, it needs to concentrate on this area. 'Establishment of vision and strategy of EM, 'organization of a task team for EM and tasks assignment' and 'management of GHG emissions and its reduction activity' were included in the second quadrant.

The third quadrant ('low priority' area) is a low level of both importance and performance and it needs to be reviewed as improvement items. 'Guideline and compliance of green purchasing', 'investment in new and renewable energy and introduction of technology', 'publication of environmental report and disclosure', and 'response to stakeholder's request for environmental information' were categorized in the 3rd area.



① Establishment of vision and strategy of environmental management
② Organization of a task team for environmental management and tasks assignment
③ Guideline and compliance of green purchasing
④ Management of water use management and reduction activity
⑤ Management of energy use and reduction activity
⑥ Investment in new and renewable energy and introduction of technology
⑦ Management of GHG emissions and its reduction activity
⑧ Management of emissions of water pollutants and its reduction activity
⑨ Management of waste generation and its reduction activity
⑩ Management of use of hazardous chemicals and its reduction activity
⑪ Compliance with environmental laws and regulation in domestic and overseas
⑫ Publication of environmental report and disclosure
⑬ Response to stakeholder's request for environmental information

<Figure 21> Result of IPA Matrix

In the fourth quadrant ('possible overkill' area), the importance is low but the performance is high, which also implies that the concentration of policy input or support is higher than the actual necessity. Therefore, it needs to discard unnecessary work or reduce policy support. In this category, 'Management of emissions of water pollutants and its reduction activity', 'management of waste generation and its reduction activity', 'management of use of hazardous chemicals and its reduction activity, and 'compliance with environmental laws and regulation in domestic and overseas' were included.

Compared with the results between analysis of eco-efficiency of environmental input variables and IPA analysis in 2015, it was found that water use (0.762) and energy use (0.754), which were higher eco-efficiency scores than the average, showed both higher importance and higher performance, locating in the fourth quadrant.

On the other hand, the eco-efficiency scores of waste (0.532) and hazardous chemicals (0.323) were lower than the average and their importance levels were also lower than the average. This implied that they were likely to be inefficient because hospitals did not manage them well relatively compared to energy and water. In particular, waste generation and hazardous chemical use were highly done in terms of performance level and this implied that it was necessary to adjust or raise the level of the reduction goals of hospitals through effective interventions in order to be more efficient.

4.4 Expert Interview for Disseminating Environmental Management in Healthcare Sector

4.4.1 Method of Interview and Types of Experts for Interviewing

In-depth interviews with six experts were conducted after completion of IPA based on questionnaires by hospital staff. This interview intended to suggest environmental policy for supporting diffusion of EM in the healthcare sector. A total six of experts were interviewed, including one expert from an environmental policy institute, one from a consulting company for EM, two from academia, one from the hospital, and one former CEO of the hospital as shown in <Table 38>.

E-mail interviews were conducted for five experts, A and C to E, after providing them the result of IPA matrix. After that, a face-to-face interview was carried out for two experts, B and F, in order to summarize the complete interview results. Specifically, a face-to-face meeting with expert B was to acquire the problems and supplementary questions found in email interviews. The form for experts' interview was in <Appendix 3>. The questions in the written interview were prepared based on the environmental management support factors presented above so that it can be linked with the previous IPA result.

<Table 38> Interviewed Experts for Promoting Environmental Management in Healthcare Sector

Expert	Experts' activities on environment in the hospital
Expert A (Hospital)	• M.D. & Professor, department of physician & anesthesiology, University hospital • Leading campaign on greening operation room of university hospital (e.g. separate discharge of medical wastes in operation room) • Lecture on importance of separate discharge of medical waste and green hospital
Expert B (Hospital)	• M.D. founder & CEO of occupational hospital in Seoul • Social activist for democracy and ethical and social responsibilities of doctor and hospital
Expert C (Consulting Company)	• Managing Director of consulting company • Environmental management expert, working for environmental consulting for more than 15 years • Consultation for the environment-friendly hospital support project with MOE since 2013
Expert D (University)	• Professor, health administration and hospital management specialist • Interested in eco-friendly hospital and writing related papers and book (eco-friendly hospital) • Member of evaluation committee for environment-friendly hospitals by MOE
Expert E (University)	• Professor, the medical school of University, serving as the secretary general of University hospital • Expert on public health and environmental health • Board member of Korea Society for environment-friendly hospital
Expert F (Policy Institute)	• Director, working for promoting environmental management in industry & service area at environmental institute • Board member of environment-friendly hospital society, environmental management society and environmental policy society • Planning and promotion of eco-friendly hospital project with the MOE since 2013

4.4.2. Summary of Expert Opinions for Disseminating Environmental Management in Healthcare Sector

Six experts generally agreed upon the necessity of enhancing awareness of all members including the CEO of the hospital, on the importance of eco-friendly hospital. They also iterated on continuous supports from the government for their various activities such as consulting, education, casebook publication of best practices, provision of common environmental information report and incentives for green purchasing. See the summary of experts' opinion at <Table 39>.

<Table 39> Summary of Experts' Opinions for Disseminating Environmental Management in Healthcare Sector

Expert	Summary of comments
Expert A (Hospital)	• Need continuous training for top hospital manager • Required establishment of green team or green committee in hospital with above 200 beds • Need incentives for implementing green purchasing
Expert B (Hospital)	• Need the organization of a response team such as a non-standing green or planning committee, composed of representatives of each sector and ensure its activity and provide the committee members with various incentives • Communication and participation with all staffs, including the CEO and continuous education for raising their awareness • Voluntary service and social responsibility to play a responsible role at individual and organizational levels in their community

Expert	Summary of comments
Expert C (Consulting Company)	• Hold a regular forum for top managers to raise their awareness and motivate them for eco-friendly hospitals • Support to publish and distribute casebook or leaflet of best practices for reducing water and energy usage • Consulting and educational support for hospital staffs to improve their problems of violated cases on medical waste treatment in the last 3 years • Support to publish common white paper on eco-friendly hospitals, which will be used for a group of leading eco-friendly hospitals
Expert D (University)	• Need to share the clear vision and strategic direction with CEO and all employees in order to spread widely environmental management in hospital • Need to develop incentives or consult with the Ministry of Health and Welfare to promote implementation of green purchasing guideline • Thoroughly managing hazardous chemicals so as not to affect the environment, society and people, is most important, while reducing the amount of its use is also important.
Expert E (University)	• In-charge organization and budget related to implementation of environmental management are essential factors for environment-friendly hospitals • Continuous efforts to reduce the use of hazardous chemicals and to use appropriate alternative through research & analysis • Need to support voluntary participation in environmental management of hospitals
Expert F (Policy Institute)	• Organization of task team dedicated to environmental management in-charge is essentially necessary and if not so, non-standing committee will be useful measure • Training for staffs and publication of practices materials on medical waste separation • Support a leading group of eco-friendly hospitals for publishing environmental report

4.4.3. Expert Opinions on Effective Support Factors for Encouraging Environmental Management in Healthcare Sector

In the 'Establishment of vision and strategy of environmental management', it was suggested that it was the most proactive common element to promote environmental management. In particular, it was necessary to share related vision and strategy among the CEO and all employees and it was necessary to induce relevant activities to be included in management strategy.

In the 'Organization of task team for environmental management and task assignment', it was suggested that it was difficult to organize a team to be responsible for environmental management because the team in charge of the facility in the hospital mainly handled environmental issues such as the supply of water, heating and cooling, and treatment of medical waste. In this context, experts suggested that EM be effectively expanded to the hospitals equipped with administrative systems in large medical institutions or big general hospitals, instead of small and medium hospitals. On the other hand, for small and medium hospitals, it was better to utilize a non-standing committee or temporary task force organized by the CEO, which helped to make decisions on environmental management throughout hospital.

In the case of 'Guideline and compliance of green purchasing', government incentive was most essential to implementing green guidelines because there was no incentives managed by the supervising authority. Therefore, it was suggested that the MOE was needed to

cooperate closely with the Ministry of Health and Welfare for promoting green purchasing in hospitals.

Regarding the 'Management of waste generation and its reduction activities', it was found that thorough management and supervision was necessary considering the hazard of medical waste. In particular, it was necessary to induce all stakeholder of the hospital to be careful and to implement through thorough education and campaign on the separated collection of medical waste to hospital staff, caregivers, and patients. On the other hand, it was suggested that counter-measures should be taken to prevent recurrence through training, consulting and education for solving the problems of medical waste disposal in hospitals that occurred in the previous 3 years.

With respect to 'Management of use of hazardous chemicals and its reduction activity', various hazardous substances were used in hospitals and found to be well managed due to various strict regulations. While the efforts to reduce toxic chemicals were also important, it was most important to reduce harmful substances affecting the environment, society, and people through thorough and strict controlling management, as it was suggested. In addition, government R&D projects were needed to reduce the quantity of harmful substances used in various hospital processes and to support research and analysis to use substitutable materials.

In the 'Publication of environmental report and disclosure', it was suggested that a project to support the publication of the environmental report for the hospital should be provided firstly to a leading group such

as hospitals participating in the eco-friendly hospital network. The environmental report could be used for hospitals as the means of their promotion and increase of their reputation, but also contribute to enhancing general public awareness on environmental issues in the healthcare sector. So, when the government designs support policy for environmental report in the healthcare sector, it is necessary to consider the two aspects above.

In the quantitative items such as water use, energy use, GHG emission, water pollutant and their reduction activities, they seemed well managed, compared with other items. However, efforts were needed to ensure that all employees and hospital users should be engaged and interested in the pursuit of continuous and diverse programs such as campaigns, training, and distribution of promotional materials. In addition, it showed that it was necessary to support the publication and dissemination of best practices through leaflet, seminar, and casebook for each hospital to create conditions for sharing and spreading environmental management activities in the healthcare sector.

Finally, in order to spread EM in the healthcare sector, it was important that CEOs were required to raise their understanding of environmental management and to be interested and motivated in environmental issues. To this end, it was necessary for the government to hold a CEOs forum on environmental management in the healthcare sector regularly and to exert efforts to make them recognize its necessity.

4.5 Discussion for Encouraging Environmental Management in Healthcare Sector

4.5.1 Evaluation of Eco-Efficiency in Hospitals

The input-oriented BCC model of DEA was used in this study to evaluate the eco-efficiency in the hospitals. The eco-efficiency for 21 hospitals was evaluated from 2012 to 2015 and the average eco-efficiency in 2015 was evaluated as 0.940.

Notably, four hospitals which participated in the GETMS for meeting the government regulation, had their eco-efficiency scoress of 1. It implied that a legal requirement had the effective impact on improving eco-efficiency. In addition, the scores of eco-efficiency from 2012 to 2015 were gradually increasing and these differences were shown as statistically significance.

On the other hand, the eco-efficiency scores of the two hospitals participating in the VA were lower than the average and seemed inefficient. Moreover, from the analysis of eco-efficiency change from 2012 to 2015, the eco-efficiency scores were even decreased, indicating that the VA was not effective in terms of eco-efficiency. These results suggested that the VA was not designed on the basis of overall diagnosis in the environmental management activities of hospitals. Hospitals participating in the VA tended to concentrated on a single environmental factor that could easily achieve short-term results such

as energy use and water use.

From this point of view, it is necessary to support the overall improvement through the detailed diagnosis of the environmental management status rather than the supporting short-term performances in hospitals. In the case of the GETMS policy, which is a legal regulation, it does not focus on one-year short-term achievement, but instead it enables continuous measurement and monitoring every year for continuous improvement. The governmental regulation was considered to be the cause of the improvement. On the other hands, for the VA to be a more solid policy, it is necessary to establish conditions in the MOUs for measuring and monitoring their environmental performances and reporting them to the public and the government through publication of annual performance report. It can help to enable continuous monitoring of performance in VA hospitals and VA would turn to be effective measures.

In addition to the analysis of BCC Model, the analysis by the CCR model was conducted in Appendix 1. The scale effect on the eco-efficiency of Korean hospitals was analyzed and it was found that the scale efficiency was lower than the eco-efficiency evaluation score of BCC model in 5 hospitals. The eco-efficiency of the hospital is affected mainly by the inefficiency of the pure technical efficiency rather than the size effect. In Korea, there is a room for improvement of the environmental management on its own without changing the size of the hospital.

4.5.2 Possible Ways to Improve Eco-Efficiency in Hospitals

Nine hospitals were estimated for potential improvement. There was a large potential for improvement by reducing their input variables. To improve eco-efficiency in 2015, possible input reduction were calculated for water use by 8% point, energy consumption by 9% point, waste generation by 10% point and hazardous chemicals use by 24 % point.

In this study, the improvement cases of actual hospitals by environmental load variables, which were used as input variables, were examined so as to find a method for enhancing eco-efficiency and to provide information for inefficient hospitals.

In the case of water use, it has been shown that a introduction of water saving devices and equipment helped to reduce water use. Water-saving devices such as automatic faucets, water pressure regulators, and high-efficiency toilets, and water reuse facilities such as storm water tanks and heavy water taps were generally installed. In the case of energy use, introduction of energy-saving products such as LED lights and energy efficient boiler or cooling system, installation of renewable energy such as solar and wind power, analysis of energy usage and reduction activities were promoted. In the case of waste, reduction could be achieved by purchasing reusable products, reducing packaging, purchasing necessary items in large quantities, reducing food waste, and participating in environmental management. Finally, in the case of hazardous chemical usage, activities through proper management, provision of toxic chemical substances list, and material safety and

health data, were being promoted mainly rather than reduction of a toxic chemical usage itself.

Above all, in order to achieve environmental performance through environmental management activities, it is necessary to diagnose the current environmental management status and establish a systematic environmental management system. Prior to applying the above-mentioned eco-efficiency enhancement measures, the government should first consider the system that diagnoses the current status of the environmental management of hospitals and suggests ways to improve them. It will be necessary to provide a concrete diagnosis and improvement plan for environmental improvement such as the establishment of an environmental management system, resource, energy, and waste reduction, and indoor air quality improvement. In this way, it is possible to draw out the issues to be improved first in terms of eco-efficiency and environmental management promotion process, and it can become a setting to spread environmental management efficiently.

4.5.3 Effective Support Factors to Disseminating Environmental Management in Healthcare Sector

To gain insights into the current status of EM in the healthcare sector, the questionnaires were circulated to investigate hospital staff's response to the 13 support factors for environmental management and the difference of importance and performance of those factors. This was

intended to identify the factors that are most effective for the promotion of environmental management in hospitals.

As a result of the analysis of the importance of support factors, 'management of energy use and reduction activity' was analyzed as the most critical factor for supporting EM. Besides energy factor, the establishment of vision and strategy of EM, organization of a task team for EM and tasks assignment, management of water use and reduction activity, and management of GHG emissions and reduction activity showed respectively higher than average value. Especially, in the 'the establishment of vision and strategy of EM' and 'management of GHG emissions and reduction activity', it is defined as an autonomous item under the current environmental information disclosure policy. Given the international environmental regulations and domestic environmental issues, it is necessary to update the system regularly by revising the standard for public items and finding new public items.

As a result of analysis of performance according to the support factors, it was found that 'compliance with environmental laws and regulation in domestic and overseas', 'management of waste generation and its reduction activity', 'management of energy use and reduction activity', and 'management of water use management and reduction activity' showed higher performance.

Finally, the matrix of the IPA revealed that 'establishment of vision and strategy of environmental management', 'organization of task team for environmental management and task assignment', and 'management of greenhouse gas emissions and its reduction activity' are important

factors to be supported first for spreading environmental management. Considering the fact that the contents supported by the government through voluntary agreements in the field of health care are focused on quantitative achievements such as water usage and energy use, we will check and support the basis for promoting environmental management.

4.5.4 Expert Suggestion for Diffusing Environmental Management in Healthcare Sector

In-depth interviews with experts were conducted by email and face-to-face meetings. The experts were drawn from an environmental policy institution, a consulting company, academia, and hospitals, who suggested ways to improve policy to effectively support environmental management in the healthcare sector. The result of the interviews suggested that government efforts to provide CEO and staff with interest and motivation in the necessity of environmental management were most necessary to promote environmental management in the healthcare sector. Because the main purpose of healthcare sector was to provide medical treatment for patients, environmental management in the hospitals could mean extra workload, which is currently handled by the facility management team. In order for environmental management to be acknowledged as one of the key factors for successful management of healthcare providing facilities at an advanced level, it was found that establishment of the task force or non-standing committees in charge was crucial.

Above all, the biggest driving force for the diffusion of environmental management in hospitals is the interest of the CEO of hospital. In order to raise the interest of the environment-friendly hospitals, it will be necessary firstly to establish a communication forum such as the CEO forum at the government level and to include the individual hospital in the activities of environment-friendly hospitals. The "environmental management CEO Academy" centered on regional and leader-level personnel is needed. In addition, voluntary agreements based on current hospital interest are also important and hospitals can exchange their practical implementations with working staff levels. It helps create a good culture for supporting and sharing best practices for better EM.

4.5.5 Direction for Better Environmental Management in Healthcare Sector

The hospital is an institution that provides comprehensive medical care such as prevention, treatment, rehabilitation, and health promotion while performing diagnosis and treatment of patients. Fundamentally, the main purpose of medical institutions lies in the protection of human life and the sustainability of health promotion.

However, the hospital has many environmental risks such as chemicals that can pollute the environment of the community, and it also accounts for a considerable amount of GHG emissions, which are the primary causes of climate change. Climate change resulted in an

increase in average temperature, increased heat days, and precipitation during the summer months, bringing sunstroke, respiratory infections, and cardiovascular disease to our society. Infectious diseases such as food and insect-borne disease have also been increasing recently, indicating that climate warming has a great impact.

Therefore, hospitals can devise and introduce the most environmentally friendly methods for building construction and operation and maintenance of buildings. Hospitals will be able to have sustainability in management by contributing to energy conservation and countermeasures against climate change, as well as making efforts to add value to the environment and human health when providing medical services. So, hospitals will be able to promote public health by continually reducing their environmental burdens and ultimately eliminating environmental factors caused by the disease.

Also, it is a good starting step that hospitals establish strategies and vision for environmental management for human health and environmental problems, and make efforts to spread environmental management to society. Regarding environmental sustainability in hospitals, the Health Research and Educational Trust provided very useful guide to help the leaders of hospitals explore options and understand the steps for sustainability. The HCRE suggested six steps for environmental sustainability in hospitals; ① Make the commitment, ② Create a structure for supporting environmental sustainability, ③ Support and finance environmental sustainability, ④ Set goals and measure, report, and evaluate change, ⑤ Celebrate and share success,

and ⑥ Continue to assess and identify new opportunities (HRET, 2014).

By understanding the importance of EM in the healthcare sector, hospitals can help improve community health, build their public image, save facility operating cost, and improve financial performance. Thus, healthcare sector can add efforts to foster eco-friendly regional and national economies and contribute to sustainability for the nation and society through eco-friendly practices and EM.

Chapter 5. Conclusion

5.1 Summary of Study

Human beings have achieved modern material abundance through economic growth thanks to the use of fossil energy, but the consequential environmental pollution and climate changes are worsening every year. In order to cope with those problems, all sector's participation in various actions for reduction including hospitals, public institutions, schools, accommodation services, is very important. However, in the field of public and social services, EM has not been strongly emphasized compared to conventional industries such as the manufacturing industry. These sectors have characteristics that directly affect people's lives. Hence, there is a strong demand for active promotion of EM in those fields. Among them, the healthcare sector is an especially important player that provides medical services for treatment and prevention of diseases for the wellbeing of citizens. It is necessary to fulfill its social responsibility and role in environmental crisis these days as one of responsible members in our society. In the healthcare sector, the hospital is the place where patients and staff live 24 hours a day, consume larger quantities of energy and water, generate various forms of hazardous medical waste, and use chemicals, heavy metals, and radioactive isotopes. Also, it has a mutual influence between

the resident population and a large floating population in the building. It often causes serious contamination by various pathogens that spread to our society.

In order to disseminate EM in the healthcare sector, the Korean government has made various policy efforts such as VA for EM with large hospitals, the GETMS, and the EIDS. Compared with the level of various attempts made by the government, the studies or research by the government agencies, industry and academia, which could assess the current status and effectiveness of EM in the healthcare sector, are currently insufficient. In this study, the eco-efficiency of the healthcare sector was assessed to support the dissemination of EM in the healthcare sector of Korea, and the results of the analysis were used to find ways to improve eco-efficiency and to suggest effective support policy. The result of this study was summarized as follows.

5.1.1 Evaluation of Eco-Efficiency in the Healthcare Sector

In this study, the input-oriented BCC model of DEA was used to evaluate eco-efficiency in hospitals. In order to evaluate eco-efficiency, four input variables such as water use, energy consumption, waste generation, and hazardous chemicals usage were applied as environmental load variables. The sales and the number of patients in hospitals were used as economic variables.

The eco-efficiency for 21 hospitals was evaluated from 2012 to 2015

and the average score of eco-efficiency in 2015 was 0.940. Twelve hospitals, 57% of those evaluated, had an eco-efficiency score of 1. Six hospitals had a lower index than the average. Especially, four hospitals which participated in government regulation of the GETMS, had an eco-efficiency score of 1 and a legal requirement had an effective impact on improving eco-efficiency. In addition, the scores of eco-efficiency from 2012 to 2015 gradually increased and these differences showed statistical significance. On the other hand, except for the 12 hospitals with an eco-efficiency score of 1, nine hospitals that scored lower than 1, had potential for improvement. There was a large potential for improvement by reducing their input variables. To improve eco-efficiency in 2015, possible input reductions were calculated for water use by 8%, energy use by 9%, waste generation by 10%, and hazardous chemicals use by 24 %.

5.1.2 Analysis of Factors to Disseminating Environmental Management in Healthcare Sector

To gain insights into the current status of EM in the healthcare sector, questionnaires were circulated to investigate hospital staff's responses to the supporting factors for environmental management and the difference of importance and performance of those factors. This was intended to identify the factors that are most effective for the promotion of environmental management in hospitals. The support factors used in

this study were 13 among 20 items from the environmental information disclosure system in the healthcare sector. The 'current status' (3 items) and 'investment and technology introduction' factors (4 items) were excluded because they overlapped with the company overview and quantitative items in the publicly disclosed system.

As a result of the analysis of the importance of support factors, 'management of energy use and reduction activity' was analyzed as the most critical factor for supporting EM. Besides energy factor, the establishment of vision and strategy of EM, organization of a task team for EM and tasks assignment, management of water use and reduction activity, and management of GHG emissions and reduction activity each showed higher than the average value of 0.077. This was analyzed that they were considered as support factors for promoting EM in the healthcare sector.

As a result of analysis of performance according to the support factors, it was found that 'compliance with environmental laws and regulation in domestic and overseas', 'management of waste generation and its reduction activity', 'management of energy use and reduction activity', and 'management of water use management and reduction activity' showed higher performance. On the other hand, 'investment in new and renewable energy and introduction of technology', 'publication of environmental report and disclosure', 'organization of task team for EM and tasks assignment', 'response to stakeholder's request for environmental information' and 'guideline and compliance of green purchasing' were evaluated as lower performance and turned out to be

factors requiring government support.

Finally, the IPA matrix revealed that there were two support factors in the first quadrant (maintenance area or keep up the good work), three factors in the second quadrant (concentrated here area), four factors in the third quadrant (low priority area), and four factors in the fourth quadrant (possible overkill area). In order to disseminate environmental management in the healthcare sector, it was necessary, first of all, to concentrate and improve three support factors in the second quadrant, which had high importance but low performance. Those three factors were 'establishment of vision and strategy of environmental management', 'organization of task team for environmental management and task assignment', and 'management of greenhouse gas emissions and its reduction activity'. In addition, the four support factors in the third quadrant which had low importance and low performance and needed continuous improvement were 'guideline and compliance of green purchasing', 'investment in new and renewable energy and introduction of technology', 'publication of environmental report and disclosure', and 'response to stakeholder's request for environmental information'.

5.1.3 Strategy and Implementation Method for Actively Disseminating Environmental Management in Healthcare Sector

In-depth interviews with six experts were conducted by email and

face-to-face meetings. Six experts consisted of one from a environmental policy institution, one from a consulting company, two from academia, and two from hospitals, who suggested ways to improve policy for effectively supporting environmental management in the healthcare sector. The result of the interviews suggested that governmental efforts to provide CEO and staff with interests in and motivation on the necessity of environmental management, were the most necessary to promote environmental management in the healthcare sector. Because the main purpose of the healthcare sector is to provide medical treatment for patients, environmental management in the hospitals could mean extra workload, currently handled by the facility management team. In order for environmental management to be recognized as a key managerial factor that is worthy enough to be in the decision maker's mind, to be more promoted and advanced, it was analyzed that top manager's interest, his or her strong support, and the establishment of the task force or non-standing committee in charge were found to be crucial.

With regards to other detailed support factors for environmental management, it was found that implementation of new programs such as 'guidelines and compliance of green purchasing' was most challenging, posing a far greater difficulty than establishing the program itself. In this case, it was suggested that the Ministry of Environment was required to cooperate closely with the Ministry of Health and Welfare for encouraging participation in green purchasing through development and provision of incentives to participating hospitals. In the 'publication of the environmental

report and disclosure', it was suggested that a project to support the publication of the environmental report should be provided firstly to a leading group such as hospitals participating in the eco-friendly hospital network. The environmental report could contribute to increasing a hospital's reputation through information dissemination and also to enhancing public awareness on environmental issues. Therefore, the government should take into consideration these aspects in promoting environmental reporting in hospitals.

Including items such as medical waste management, water use, energy use and GHG emissions, efforts were needed to ensure that all employees and hospital users should be engaged and interested in the environmental management through education, training, and campaigns. In addition, it was necessary to define and share the best practices of environmental management in leading hospitals, to create good conditions for effectively spreading environmental management in the healthcare sector.

5.2 Limitations of Study and Future Research

Although this study is somewhat difficult for the subjects to evaluate absolute value of eco-efficiency expressed by direct target quantity in the healthcare sector, it is very persuasive as a way to rank the overall eco-efficiency of the hospitals through comparative analysis of the hospitals in the healthcare sector. In addition, it can be very useful that the result of analysis can be useful information for low eco-efficient hospitals to conduct their business management by benchmarking high eco-efficient hospitals and setting up the potential improvement.

The details are as follows. First, the results of eco-efficiency evaluation using DEA do not mean absolute eco-efficiency in the management of hospitals, but they are the result of relative comparison between hospitals having similar production structures. Therefore, the cause of inefficiency can be specifically provided. Through improving inefficiency, the hospital could pursue highly eco-efficient practices when fulfilling their original purpose. This is crucial in that these highly effective eco-efficient structures will open a platform for hospitals to pursue higher profits and lowered environmental burdens all at ones.

Second, it is meaningful not only to analyze the potential improvement through the evaluation of eco-efficiency but also to examine the applicable cases to improve eco-efficiency. Interviews with hospital staffs and experts were conducted to review actual practice case and to provide practical suggestions for encouraging their participation in EM in the healthcare sector.

On the other hand, while the theoretical analysis and the practical application of eco-efficiency evaluation are becoming more prevalent, this study has some limitations on research approach and the access to data.

First, the additional design of the research model, that can reflect the qualitative and qualitative aspects of the eco-efficiency evaluation of the hospital, is needed. In this study, the eco-efficiency of a hospital is evaluated as part of the quantitative performance of individual hospitals, which does not show all of the performance produced by the hospital being evaluated. Therefore, it is necessary to consider the qualitative aspects along with the quantitative aspects of a hospital, which will contribute to evaluating actual performance of a hospital and to suggest ways to improve eco-efficiency. In addition, in this study, the public open items in the EIDS were used to secure the objectivity of evaluation, but this also included considerable problems in objectivity. For instance, sales variable used as on of the output variables in this study had some limitations in presenting overarching view of hospital's overall performance. While sales or gross revenues in hospital consisted of patient revenues, non-patient revenues and extraordinary income (Yang and Jang, 2013), the value of sales in this study did not distinguish those differences. Hence, it is necessary to enhance the efficiency of evaluation by diversifying the input and output variables in the future.

Second is a methodological limit of DEA. The results of the eco-efficiency evaluation of this study might not be able to provide efficiency based on the absolute target or standard, but rather focuses

on delivering insights into efficiency or inefficiency level in Korean hospitals from the relative analysis point of view. Therefore, the hospitals evaluated with an eco-efficiency score of 1 also have the structural limitations that could have inefficiency in terms of business management.

Third, because the importance of eco-efficiency evaluation variables will vary depending on the type of industry or scale, it is necessary to study the weight of variables in order to reflect real importance in the evaluation process.

Regarding future research, the study can be expanded to investigate patients, caregivers or other stakeholders' responses to EM, which will help healthcare sector to introduce practical action program for their participations in daily practice in hospitals. Also, the study with various variables in the input and the output, which can better reflect overall performances with greater accuracy in the long periods, can bring optimal practical suggestions to healthcare sector and government in the field of assesment of eco-efficiency and promotion of environment management.

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Appendix

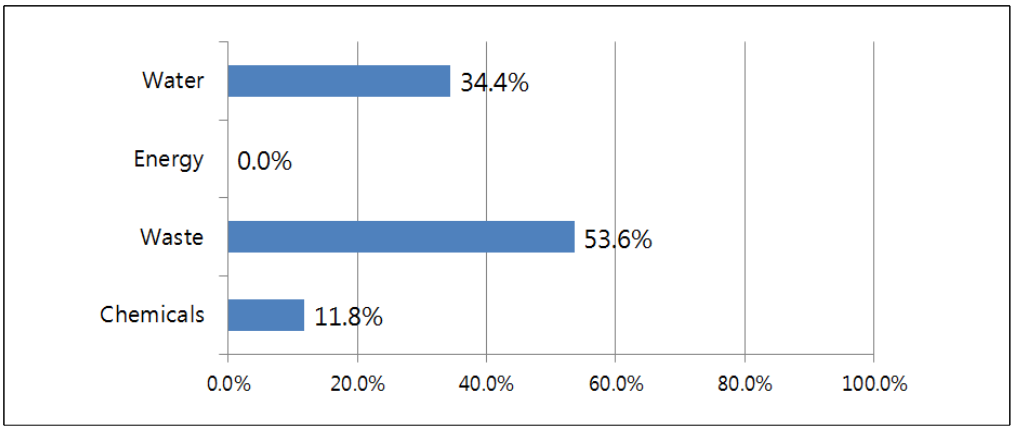
<Appendix 1> Evaluation of Eco-Efficiency Using CCR model of DEA

1. Result of Assessment of Eco-Efficiency in 2015

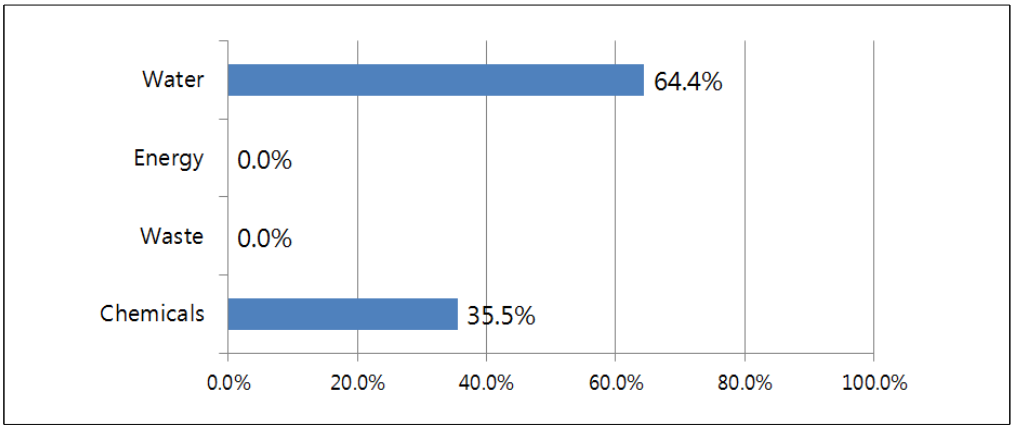
Hospital	Eco-efficiency (CCR)	Remarks
H01	1.000	-
H02	0.740	VA(2013)
H03	1.000	-
H04	0.828	-
H05	0.600	VA(2015)
H06	0.970	-
H07	1.000	-
H08	0.868	-
H09	0.985	-
H10	0.762	-
H11	0.813	GETMS
H12	1.000	GETMS
H13	0.857	-
H14	1.000	GETMS
H15	0.709	-
H16	1.000	-
H17	1.000	VA(2014), GETMS
H18	1.000	-
H19	1.000	-
H20	1.000	-
H21	0.898	-
Average	0.906	-

* *VA : Voluntary agreement, GETMS: GHG and Energy Target Management System*

2. Result of Assessment of Eco-Efficiency in 2015



<Output Contributions by Variables in H01>



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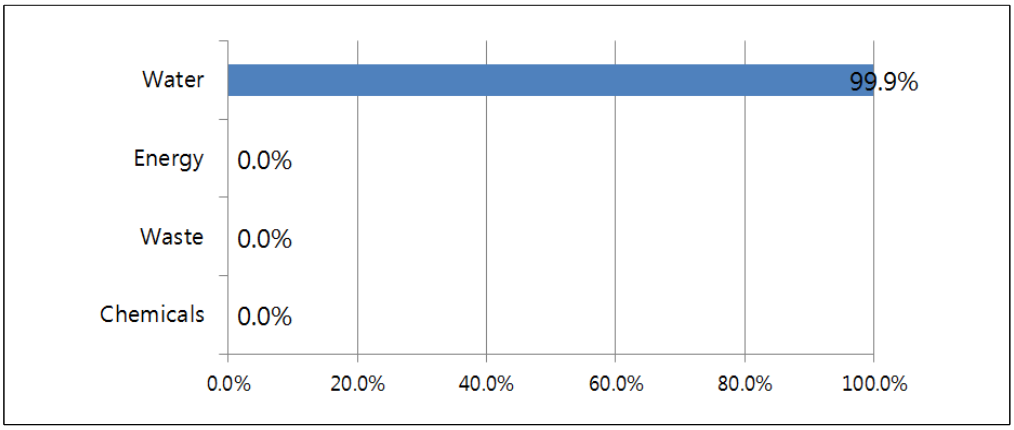

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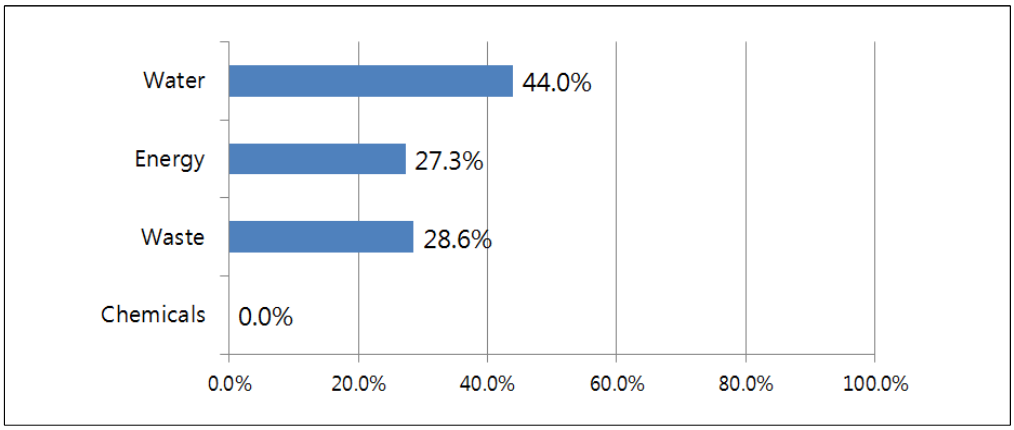

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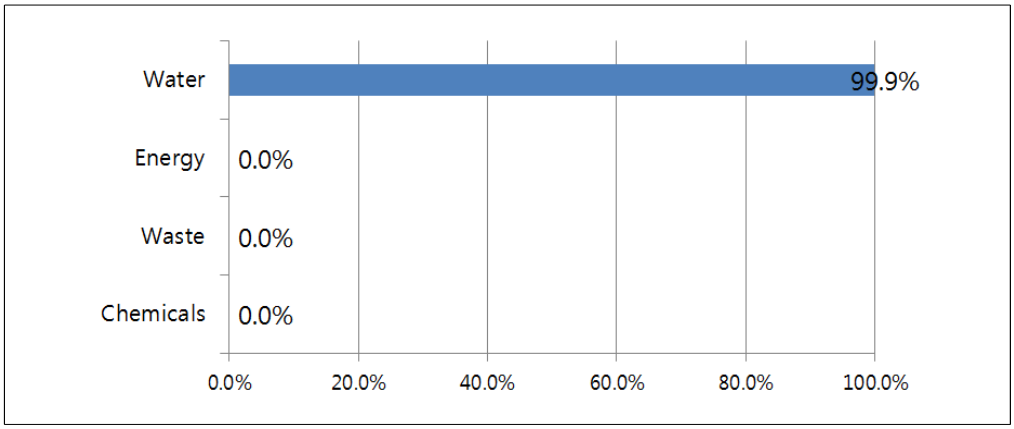

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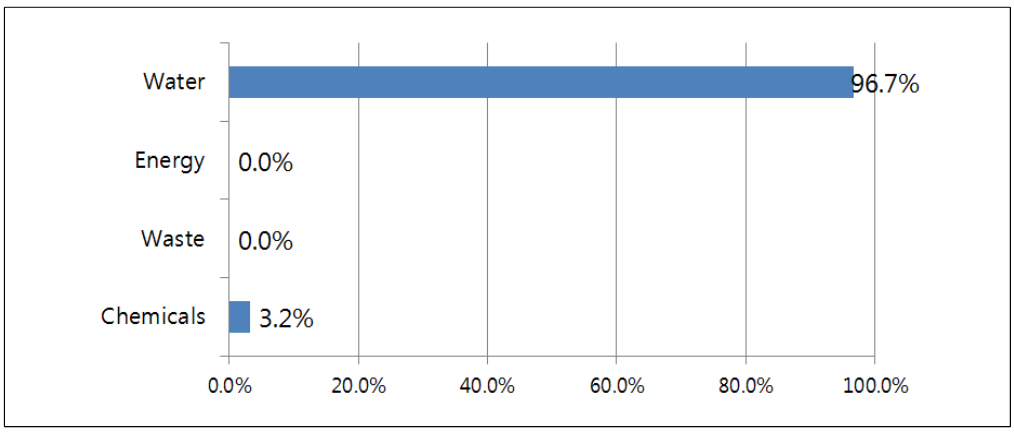

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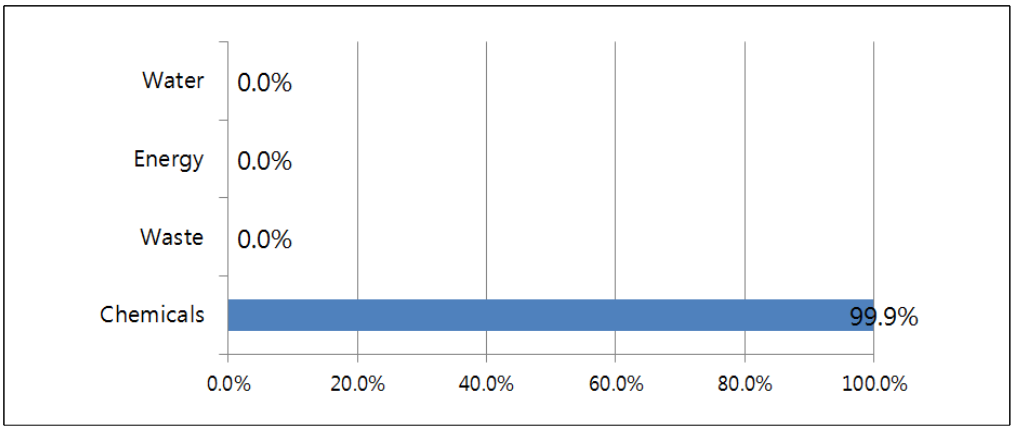

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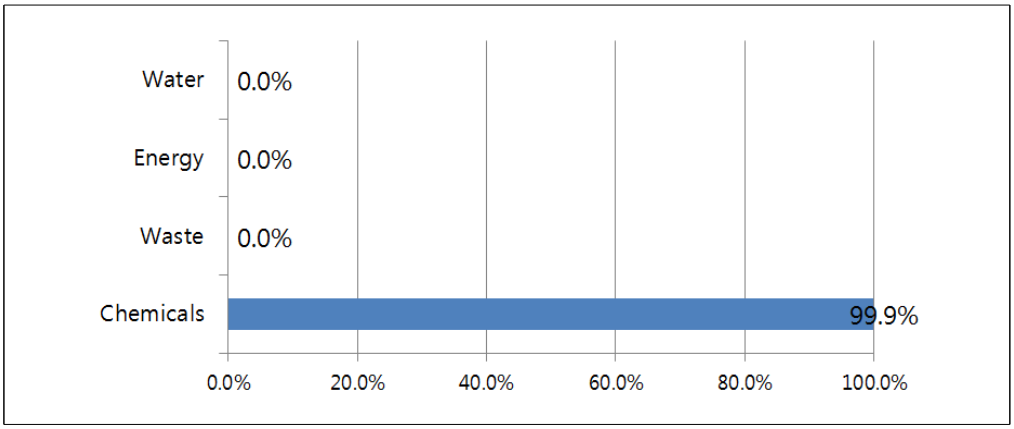

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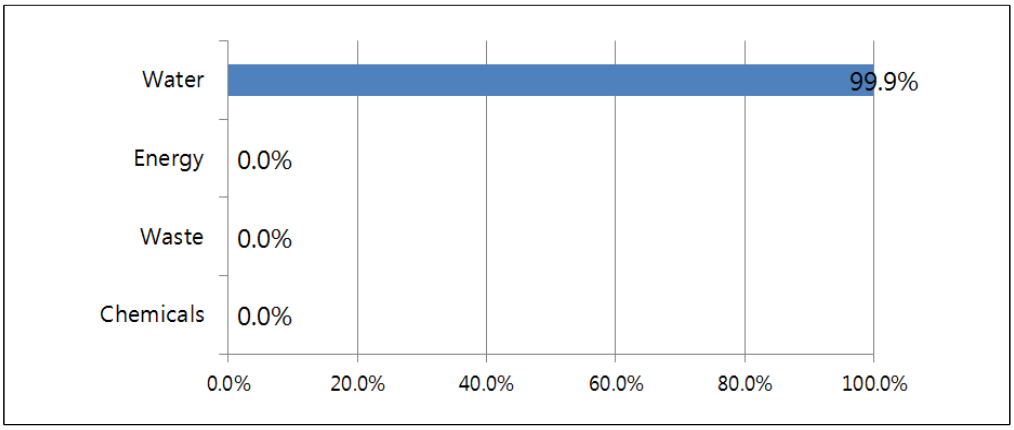
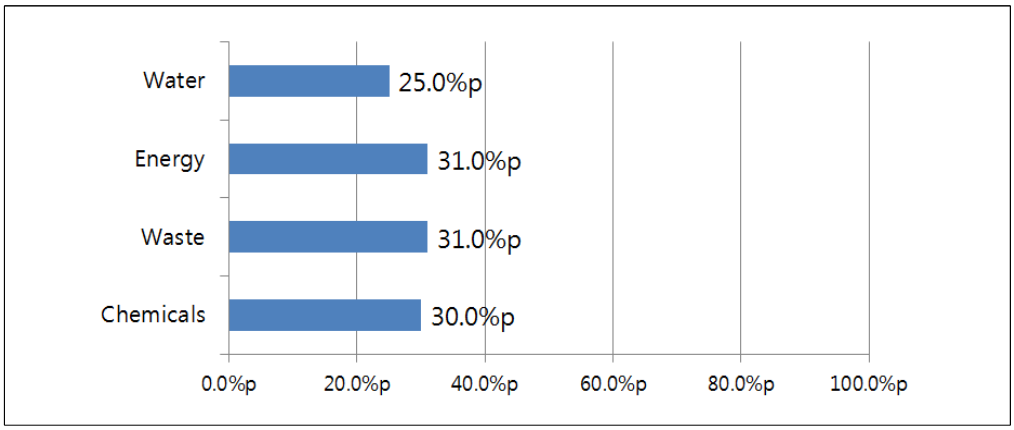


<Output Contributions by Variables in H19>

3. Potential Improvements in Low Eco-Efficient Hospitals



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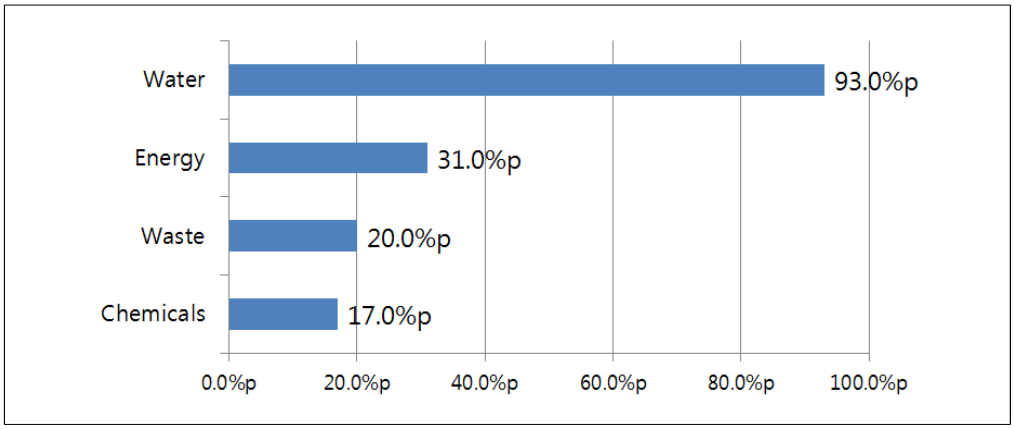
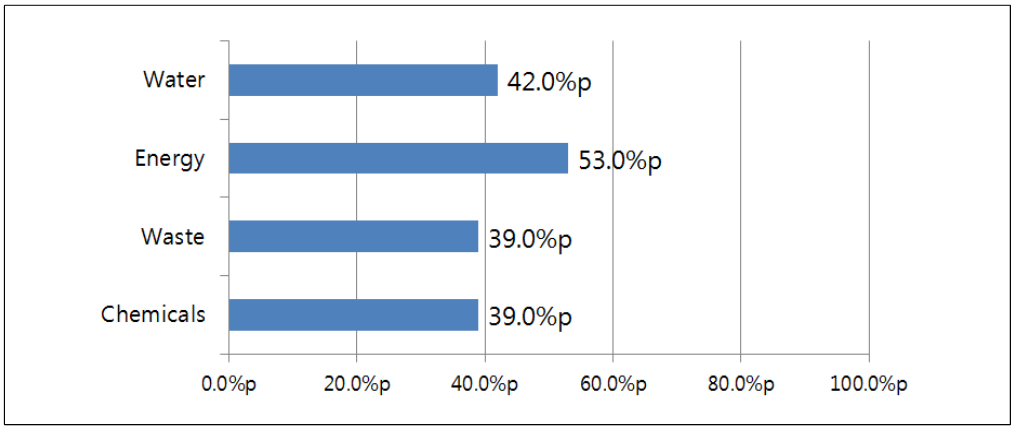
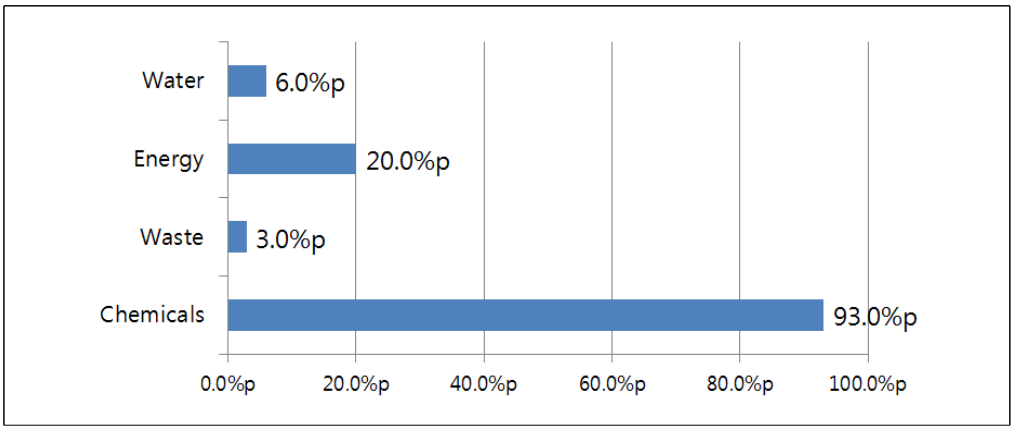


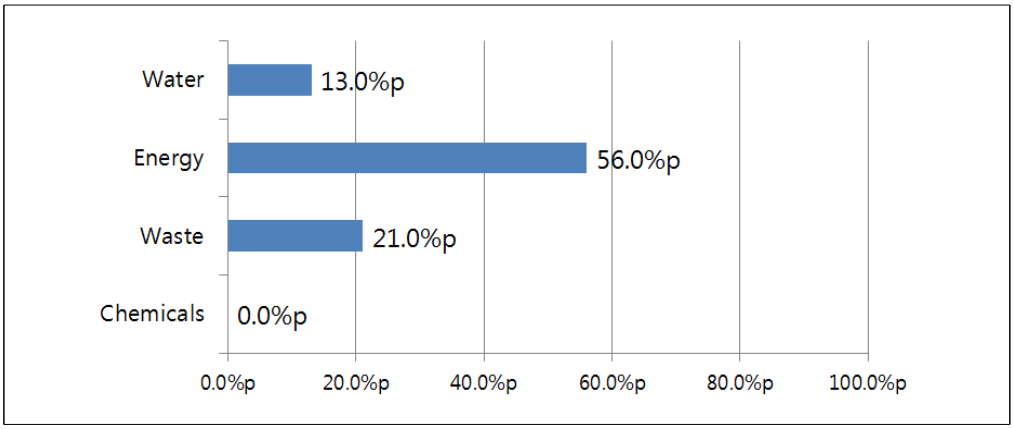
<Potential Improvement by Variables in H04>



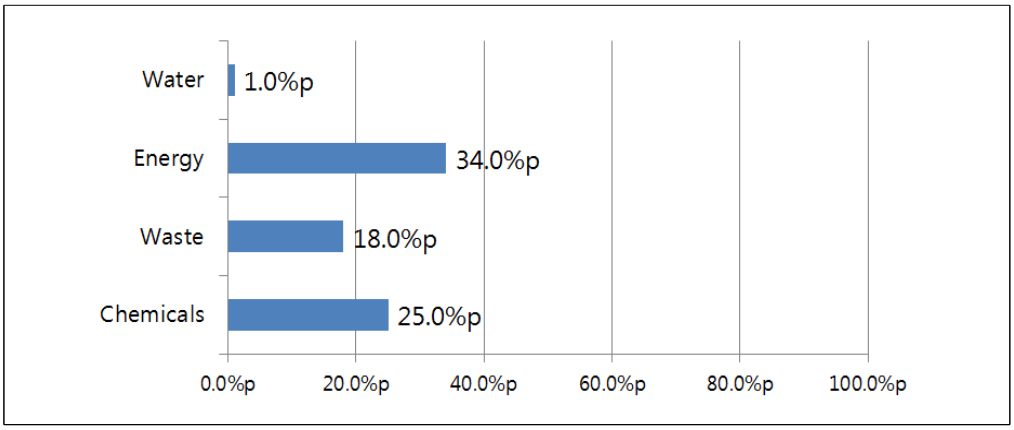
<Potential Improvement by Variables in H05>



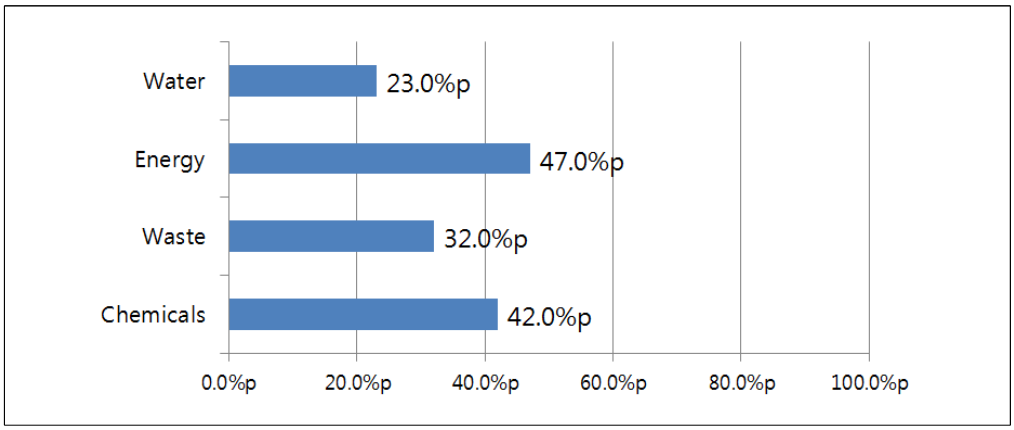
<Potential Improvement by Variables in H06>



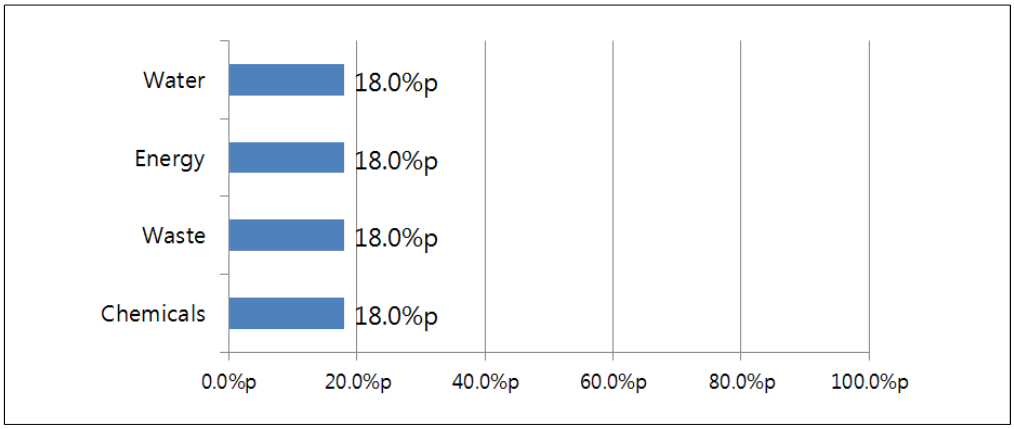
<Potential Improvement by Variables in H08>



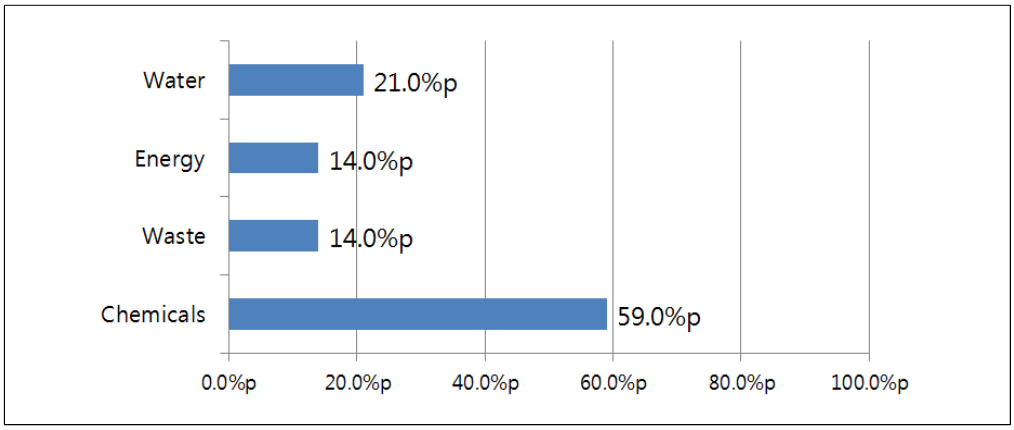
<Potential Improvement by Variables in H09>



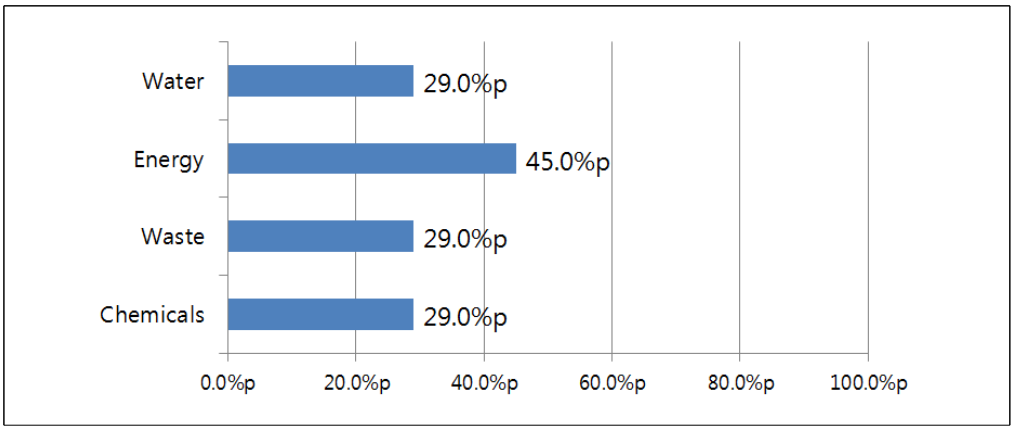
<Potential Improvement by Variables in H10>



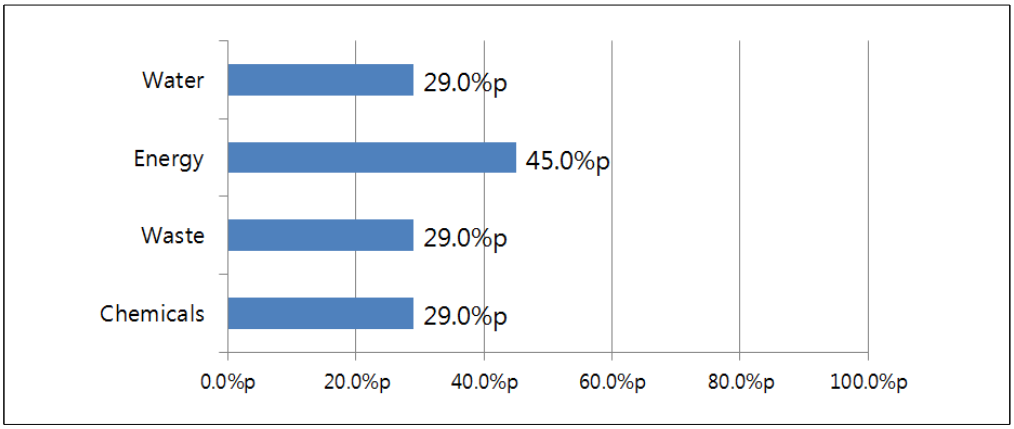
<Potential Improvement by Variables in H11>



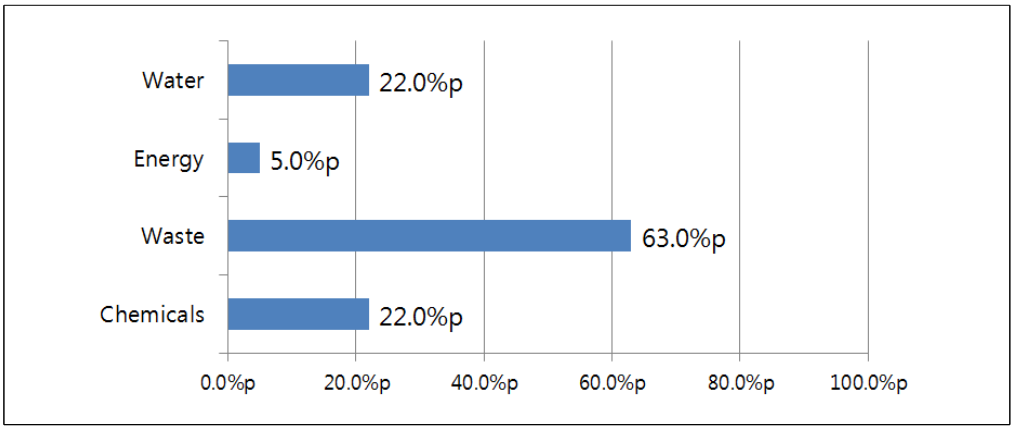
<Potential Improvement by Variables in H13>



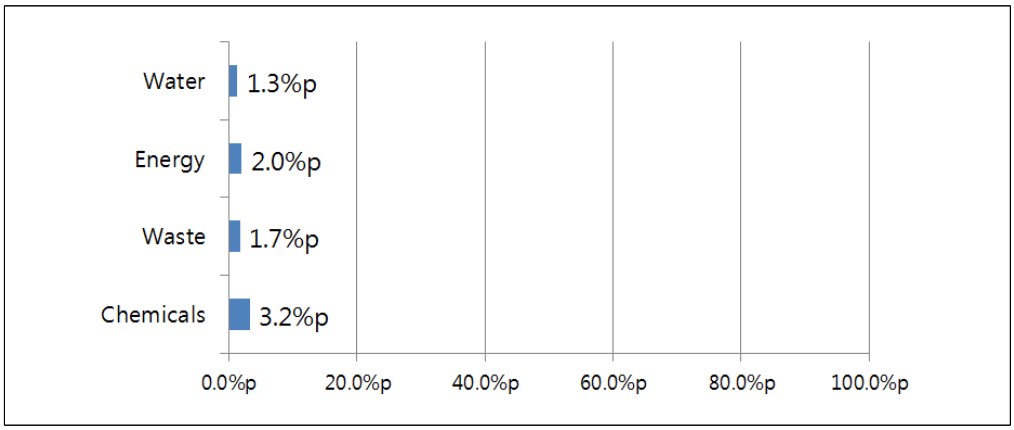
<Potential Improvement by Variables in H15>



<Potential Improvement by Variables in H20>



<Potential Improvement by Variables in H21>



<Potential Improvement by Variables in 2015>

<Appendix 2> Questionnaire of Survey for Importance-Performance Analysis

보건의료 분야의 환경경영 확산 지원방안 도출을 위한 중요도-성취도 조사

본 조사는 환경부에서 시행중인 환경정보공개제도 항목을 활용하여 보건의료 분야의 핵심인 병원의 환경경영 확산 지원 방안을 도출하기 위하여 실시되는 조사입니다. 특히, 중요도(Importance)에 있어 본 조사는 변수 간 비교를 통해 상대적인 중요도가 산출되기 때문에 일관된 응답이 중요하오니 유의하여 답변을 해주시기 부탁드립니다.

보건의료 분야의 핵심인 병원에서 환경경영이 확산되기 위하여 필요하다고 생각되는 객관적인 지원 요인을 파악하기 위하여, 귀하께서 알고 계시거나 생각하는 바에 따라 응답해주시길 부탁드립니다. 동 설문지는 연구 목적으로만 사용되며 익명으로 통계 처리후 폐기될 예정이니 솔직한 답변을 부탁드립니다.

바쁘신 중에도 귀한 시간을 내시어 본 조사에 응답을 해주신 귀하께 진심으로 감사드립니다. 향후 조사결과가 궁금하시면 아래 연락처로 연락주시면, 조사결과를 공유해 드리겠습니다.

- 연 구 자 :
- 전화번호 :
- 이 메 일 :

응답자	성 명	
	소 속	
	연락처	

(중요성 조사) 다음 환경정보공개제도 항목 중 병원의 **환경경영 확산을 위한 주요 관리지표**로서 중요한 정도를 표시하여 주십시오. 아래 비교되는 좌·우 두 항목중 중요하다고 생각하는 쪽의 중요도를 한군데에 표시하여 주시기 바랍니다.

<선정요인별>

항목	절대 중요	아주 중요	중요	약간 중요	동등	약간 중요	중요	아주 중요	절대 중요	항목
환경경영(구매) 시스템 구축	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	● 3	○ 4	○ 5	자원·에너지 관리 및 저감활동
환경경영(구매) 시스템 구축	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	온실가스·환경오염 관리 및 저감활동
환경경영(구매) 시스템 구축	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	사회윤리적 책임 준수
자원·에너지 관리 및 저감활동	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	온실가스·환경오염 관리 및 저감활동
자원·에너지 관리 및 절감활동	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	사회윤리적 책임 준수
온실가스·환경오염 관리 및 저감활동	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	사회윤리적 책임 준수

<환경경영(구매)시스템 지원요인별>

항목	절대 중요	아주 중요	중요	약간 중요	동등	약간 중요	중요	아주 중요	절대 중요	항목
환경경영 비전 및 전략 수립	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	환경경영 전담조직 구성 및 업무분장
환경경영 비전 및 전략 수립	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	녹색구매 지침 보유 및 준수
환경경영 전담조직 구성 및 업무분장	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	녹색구매 지침 보유 및 준수

<자원·에너지 지원요인별>

항목	절대중요	아주중요	중요	약간중요	동등	약간중요	중요	아주중요	절대중요	항목
용수 사용량 관리 및 절감활동 추진	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	에너지 사용량 관리 및 절감활동 추진
용수 사용량 관리 및 절감활동 추진	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	신재생 에너지 투자 및 기술도입
에너지 사용량 관리 및 절감활동 추진	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	신재생 에너지 투자 및 기술도입

<온실가스·환경오염 지원요인별>

항목	절대중요	아주중요	중요	약간중요	동등	약간중요	중요	아주중요	절대중요	항목
온실가스 배출량 관리 및 저감활동 추진	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	수질오염물질 배출량 관리 및 저감활동 추진
온실가스 배출량 관리 및 저감활동 추진	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	폐기물 발생량 관리 및 저감활동 추진
온실가스 배출량 관리 및 저감활동 추진	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	유해화학물질 사용량 관리 및 저감활동 추진
수질오염물질 배출량 관리 및 저감활동 추진	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	폐기물 발생량 관리 및 저감활동 추진
수질오염물질 배출량 관리 및 저감활동 추진	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	유해화학물질 사용량 관리 및 저감활동 추진
폐기물 발생량 관리 및 저감활동 추진	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	유해화학물질 사용량 관리 및 저감활동 추진

<사회·윤리적 책임 지원요인별>

항목	절대 중요	아주 중요	중요	약간 중요	동등	약간 중요	중요	아주 중요	절대 중요	항목
국내외 환경법규 준수	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	환경보고서 발간 및 공개
국내외 환경법규 준수	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	이해관계자 환경 정보요청 대응
환경보고서 발간 및 공개	○ 5	○ 4	○ 3	○ 2	○ 1	○ 2	○ 3	○ 4	○ 5	이해관계자 환경 정보요청 대응

(성취도 조사) 현재 귀하의 병원이 다음 환경정보공개제도 항목 중 환경경영 활동 측면에서 성취(추진)한 정도를 표시하여 주십시오.

항목	환경경영 활동을 잘 추진하고 있다고 생각하십니까?				
	전혀 그렇지 않다	약간 그렇지 않다	보통	약간 그렇다	매우 그렇다
1. 환경경영 비전 및 전략 수립	○ 1	○ 2	○ 3	○ 4	○ 5
2. 환경경영 전담조직 구성 및 업무분장	○ 1	○ 2	○ 3	○ 4	○ 5
3. 녹색구매 지침 보유 및 준수	○ 1	○ 2	○ 3	○ 4	○ 5
4. 용수 사용량 관리 및 절감활동 추진	○ 1	○ 2	○ 3	○ 4	○ 5
5. 에너지 사용량 관리 및 절감활동 추진	○ 1	○ 2	○ 3	○ 4	○ 5
6. 신재생 에너지 투자 및 기술 도입	○ 1	○ 2	○ 3	○ 4	○ 5
7. 온실가스 배출량 관리 및 저감활동 추진	○ 1	○ 2	○ 3	○ 4	○ 5
8. 수질오염물질 배출량 관리 및 저감활동 추진	○ 1	○ 2	○ 3	○ 4	○ 5
9. 폐기물 발생량 관리 및 저감활동 추진	○ 1	○ 2	○ 3	○ 4	○ 5
10. 유해화학물질 사용량 관리 및 절감활동 추진	○ 1	○ 2	○ 3	○ 4	○ 5
11. 국내외 환경법규 준수	○ 1	○ 2	○ 3	○ 4	○ 5
12. 환경보고서 발간 및 공개	○ 1	○ 2	○ 3	○ 4	○ 5
13. 이해관계자 환경정보 요청 대응	○ 1	○ 2	○ 3	○ 4	○ 5

<Appendix 3> Form of Expert Interview for Diffusing Environmental Management in Healthcare Sector

보건의료 분야 환경경영 확산을 위한 전문가 조사

■ 본 조사는 보건의료 분야의 환경경영 도입과 확산에 필요한 사항중 병원에서 추진할 수 있는 실천전략과 지원정책을 개발하는 데 목적을 두고 있습니다.

■ 이번 전문가 조사에 앞서 환경정보공개제도 보건서비스 분야 공개항목을 기준으로 병원에서 추진할 수 있는 환경경영 활동을 13개로 구분하여, 병원의 환경경영을 담당하는 직원들의 인식과 실태를 설문조사 하였으며, 그 결과는 아래와 같습니다.

구 분	환경경영 활동
중요하다고 인지하여 잘 추진되고 있는 분야 (High Important and High Performance)	○ 용수 사용량 관리 및 절감활동 추진 ○ 에너지 사용량 관리 및 절감활동 추진
중요하다고 인지하지만, 추진이 미흡한 분야 (High Important but Low Performance)	○ 환경경영 비전 및 전략 수립 ○ 환경경영 전담조직 구성 및 업무분장 ○ 온실가스 배출량 관리 및 저감활동 추진
중요하다고 인지되진 않지만, 잘 추진되고 있는 분야 (Low Important but High Performance)	○ 수질오염물질 배출량 관리 및 저감 활동 추진 ○ 폐기물 발생량 관리 및 저감활동 추진 ○ 유해화학물질 사용량 관리 및 저감 활동 추진 ○ 국내외 환경법규 준수
중요하다고 인지되진 않지만, 추진이 미흡한 분야 (Low Important and Low Performance)	○ 녹색구매 지침 보유 및 준수 ○ 신재생 에너지 투자 및 기술도입 ○ 환경보고서 발간 및 공개 ○ 이해관계자 환경정보요청 대응

■ 상기 현황조사 외에 보건의료 분야의 환경경영 관련 전문가 의견을 수렴하여 실효성 있는 보건의료 분야의 효과적인 환경경영 확산 정책을 개발하고자 본 조사를 진행하게 되었습니다.

■ 상기 언급한 병원의 13개 환경경영 활동에 대하여 병원에서 환경경영이 확산되기 위하여 귀하께서 필요하다고 생각되는 지원 요인과 정책 방향을 파악하고자 하오니, 귀하의 고견을 알려주시기 부탁드립니다.

■ 바쁘신 중에도 귀한 시간을 내시어 본 조사에 응답해주신 귀하께 진심으로 감사드립니다. 회신은 아래 이메일로 부탁드립니다.

- 연 구 자 :
- 전화번호 :
- 이 메 일 :

보건분야 환경경영 확산을 위한 전문가 의견서

소 속	
직 위	
성 명	

환경경영 활동	전문가 의견
1. 환경경영 비전 및 전략 수립	*왼쪽의 환경경영 활동을 위해 병원에서 환경경영이 확산되기 위하여 필요하다고 생각되는 지원요소 및 정책방향 등에 대해 자유롭게 기술*

환경경영 활동	전문가 의견
2. 환경경영 전담조직 구성 및 업무분장	
3. 녹색구매 지침 보유 및 준수	
4. 용수 사용량 관리 및 절감활동 추진	
5. 에너지 사용량 관리 및 절감활동 추진	
6. 신재생 에너지 투자 및 기술도입	
7. 온실가스 배출량 관리 및 저감활동 추진	
8. 수질오염물질 배출량 관리 및 저감 활동 추진	
9. 폐기물 발생량 관리 및 저감활동 추진	
10. 유해화학물질 사용량 관리 및 저감 활동 추진	
11. 국내외 환경법규 준수	
12. 환경보고서 발간 및 공개	
13. 이해관계자 환경정보요청 대응	
14. 기타 의견	

<Appendix 4> Experts' Opinions for Disseminating Environmental Management in Healthcare Sector

보건분야 환경경영 확산을 위한 전문가 의견서 (Expert A)

환경경영 활동	의 견
1. 환경경영 비전 및 전략 수립	○ GREEN HOSPITAL 정책을 국가 차원 지원 - 연구지원, 자원순환기본법 강화, 인센티브제 도입, 미래 세대를 위한 환경 및 자원 보전에 대한 책임 의식 필요. ○ 병원장 및 임원진의 확고한 의지와 이를 위한 지속적 교육 필요
2. 환경경영 전담조직 구성 및 업무분장	○ 200병상 이상 병원은 그린위원회 설치가 요구되며, 이에 대한 정책적 지원 필요 ○ GGHH의 10가지 Agenda를 시기별로 목표를 정해서 실천
3. 녹색구매 지침 보유 및 준수	○ 녹색구매 실천 병원 인센티브제 도입 ○ 의료장비 소모품 회사의 생산 단계부터 환경친화제품이 만들어 지는 제도화 필요 ○ 또한 생산 단계에서 발생한 불량품은 의료폐기물이 아닌 바, 불량품의 자원 순환 허용 필요. 현재는 불량품이 의료폐기물로 처리되는 실정 개선 필요

환경경영 활동	의 견
4. 용수 사용량 관리 및 절감활동 추진	○ 유치원 때부터 교육이 필요함 ○ 절수 장치 설치, waterless scrub등 선택 버려지는 수액 줄이기
5. 에너지 사용량 관리 및 절감활동 추진	○ 에너지 효율 높은 병원 건물, 태양광 등 에너지 효율 높은 장비 사용. ○ day light 활용, 적절한 조도 선택, 전등 끄기, 적절한 냉·난방
6. 신재생 에너지 투자 및 기술도입	○ 국가적 차원의 지원정책 필요. ○ 단계적 도입 요구됨
7. 온실가스 배출량 관리 및 저감활동 추진	○ 물품을 아껴쓰는 의식과 실천이 요구되며, 지속적 교육 및 관련 인력 필요 ○ 안쓰고 버려지는 의료용품 줄이기, 재활용 가능한 병원 폐기물 분리 수거 ○ 의료폐기물 소각 위주 정책에서 고압멸균 방식의 처리 방식으로의 전환 필요하며, 국가적 지원 필요.
8. 수질오염물질 배출량 관리 및 저감 활동 추진	○ 소독량 적량 사용 훈련 필요. ○ 의약품 적적량 사용, 버려지는 약물 줄이기, 폐수 처리시설 기능 향상 요구됨
9. 폐기물 발생량 관리 및 저감활동 추진	○ 병원 폐기물 분리 수거 의무화 ○ 의료폐기물 분류 현실화 (세분화가 심함) 수액류 비우고 분리수거 ○ 의료폐기물 용기의 합성수지 사용 자제, 정책 지원과 병원 재활용 폐기물 recycling 회사 필요
10. 유해화학물질 사용량 관리 및 저감 활동 추진	○ 소독약 적정량 사용
11. 국내외 환경법규 준수	○ 병원내 실천을 위한 연구 필요. 각 병원의 의료진 및 전문 담당자의 의견 수렴 필요 ○ 실천하는 병원에 인센티브 제공
12. 환경보고서 발간 및 공개	-

환경경영 활동	의 견
13. 이해관계자 환경정보요청 대응	-
14. 기타 의견	○ 전문가 의견, 연구, 과학적 근거에 규제 마련(폐기물 처리방법에 과학적 적용 요구) ○ 모든 의료기관에 그린 위원회 설치, 지원 ○ 의료인 교과에 green hospital 교육 필수 ○ 대국민 참여 홍보 필요(환경이 건강해야 환자 발생도 감소함, 병원 폐기물 중 상당량은 자원임) ○ food bank 운용(진열조차 안된 음식들은 food bank로 갈 수 있도록 유도, 병원 식당뿐 아니라 제과점, 뷔페식당도 참여하도록 적절한 인센티브 필요)

보건분야 환경경영 확산을 위한 전문가 의견서 (Expert B)

전문가(5명) 의견 검토 및 종합적인 의견 제시 (대면)

○ 다른 전문가들과 병원 직원 설문 결과에서 드러났듯이 환경경영을 하기 위해서는 CEO 뿐만 아니라 전 직원들의 흥미와 관심이 매우 중요함

○ 이를 위하여 지속적인 교육, 훈련, 인센티브 제공 등을 통해 자발적으로 참여하는 여건이 조성되고, 이를 지속적으로 할 수 있도록 체계화된 시스템(전담 조직, 비상설 위원회)이 필요함

○ 대형병원은 전담 조직 구성이 가능하나, 300병상 규모의 병원에서는 현실적으로 어렵기 때문에 비상설 위원회가 적합함. 녹색위원회(또는 기획위원회)를 의사를 제외한 직종별 대표 15~16명으로 구성하여, 병원의 1년간 활동 계획, 제안, 실천 및 모니터링하면서 체화함. 매주 4시간 활동을 보장하고, 위원 활동시 2호봉 승급, 매월 15만원의 수당을 제공하였음

○ 특히 병원은 외부에서 보는 것과는 다르게 의사, 간호사 이외에도 여러 직종(조리사, 컴퓨터기사, 청소원, 전기기사, 정원 관리인 등)이 함께 있기 때문에, 이들이 상호 조화되고 인식을 같은 수준으로 끌어올리기 위해서는 교육, 세미나, 독서 등을 통해서 스스로 실천의 중요성을 인식하는 것임. 이를 통해 직원들이 병원의 개선방향을 고민하는 등 CEO 시각을 갖게 될 수 있음

○ 병원에서 환경실천 활동 등 환경경영은 직원이 300명이 넘어서 원장(CEO)이 압력을 주고 강제로 지속적으로 실천을 끌고 갈 수 없기 때문에, 직원들 스스로 깨닫고 자발적으로 실천할 수 있도록 독서 토론회, 봉사활동 등의 기회를 제공하고, 참여 직원들에 대해서는 인센티브를 주고 본인의 활동을 자랑스럽게 생각할 수 있는 여건을 조성해 주는 것이 중요함

○ '믿고 찾아갈 수 있는 병원 만들기'라는 목표 아래 병원의 지역사회와의 out-reach program의 하나로 주변 지역 청소, 매년 자선바자회 개최, 무료 진료, 의료 세미나 개최, 음악회 등을 개최하여 병원이 지역사회의 책임있는 일원으로서 역할을 다하기 위해 노력중. 특히 직원들의 봉사 활동에 대해 Credit를 주고 연말에 우수 직원 및 부서 표창, 호봉 승급 등 인센티브를 통해 봉사가 직원과 부서에서 체질화되도록 노력하고 있음

보건분야 환경경영 확산을 위한 전문가 의견서 (Expert C)

환경경영 활동	의 견
1. 환경경영 비전 및 전략 수립	○ 병원장등 임원진들이 친환경병원에 대한 이해를 높이고 필요성에 대한 동기부여 필요 ○ 임원 대상 친환경병원 포럼을 정기적으로 개최하여 필요성 인식 제고 노력 필요
2. 환경경영 전담조직 구성 및 업무분장	○ 조직구성에 필요한 책임과 권한, 이에 따른 성과목표 및 인센티브가 명확해야 함 ○ 단계적으로 각 병원의 친환경병원 우수사례와 조직을 대외적으로 홍보(언론, 시상, 세미나, 우수병원 탐방 등)시켜 내부 직원들에게 환경경영 조직의 관심을 유도하는 것이 필요 ○ 전담조직 구성시 발대식 등의 행사 지원 - 발대식 및 조직 내용 대외적으로 공개 - 환경부 차원에서 임명장을 수여하여 국내 친환경병원 활동 리더로서의 자부심 고취 ○ 우수 활동자 선발 및 포상 - 친환경정보시스템 내 인터뷰 게시
3. 녹색구매 지침 보유 및 준수	○ 병원만의 차별화되고 공통된 주제의 녹색구매 활동(예, 수은프리 혈압계 퇴출 슬로건 등) ○ 의료소모품의 녹색제품개발 지원 - R&D, 공동연구, 특허출원, 인증지원 등
4. 용수 사용량 관리 및 절감활동 추진	○ 용수절감 우수사례집 제작 및 배포 ○ 용수 절감기기 보급· 확산 시범사업 추진 ○ 용수사용 실시간 모니터링 보급사업 추진 - 한전의 I-SMART 사업처럼 용수 다량 사용 사업장을 대상으로 실시간 모니터링 계량기 보급 지원

환경경영 활동	의 견
5. 에너지 사용량 관리 및 절감활동 추진	○ 에너지절감 우수사례집 제작 및 배포 ○ 에너지 절감기기 보급· 확산 시범사업 추진 ○ Soft BEMS 개발 및 보급·확산 ○ 중소형병원 대상 에너지진단 지원 - 비용 50%지원, 절감액 환원 또는 기부 등
6. 신재생 에너지 투자 및 기술도입	○ 병원은 환자를 포함한 고객들에게 친환경 병원에 대한 이미지 메이킹을 중요하게 고려 ○ 환경부, 신재생 투자기관과 병원협의체간의 신재생에너지 보급 확대와 관련한 MoU를 통해 고객(환자, 내원객 등)에게 친환경병원 이미지 제고` ○ 신재생에너지를 통해 생산된 전기와 전기차 충전소와 연계 시범사업 추진 등
7. 온실가스 배출량 관리 및 저감활동 추진	○ 온실가스 및 미세먼지의 인체유해성을 내원객들에게 전파하고 예방 방법 교육
8. 수질오염물질 배출량 관리 및 저감 활동 추진	○ 용수사용 및 폐수배출 실시간 모니터링 보급사업 추진
9. 폐기물 발생량 관리 및 저감활동 추진	○ 최근 3년간 의료폐기물 적발 병원을 대상 문제점 개선을 위한 컨설팅 및 교육 지원 ○ 의료폐기물 관리감독의 경우 지역과 환경청의 지도심사원에 따라 주관적으로 적용되는 경우 발생 - 구체적인 사례와 함께 세분화된 가이드라인 제작·배포하여 지도점검자의 개별적인 재량적 유권해석 방지
10. 유해화학물질 사용량 관리 및 저감 활동 추진	○ 유해화학물질 관리 가이드라인 제공 ○ 병원내 기피해야 할 유해물질 목록과 대체제에 대한 정보를 공유
11. 국내외 환경법규 준수	-

환경경영 활동	의 견
12. 환경보고서 발간 및 공개	○ 각 개별 병원이 아닌 친환경병원협의체 등 공통의 대외공개용 친환경병원 백서 발간
13. 이해관계자 환경정보요청 대응	○ 친환경병원 담당자들에게 공유할 정보지를 정기적으로 발간과 이를 지원 ○ 친환경병원 정보시스템을 통해 이해관계자들에게 직속적인 정보 제공 ○ 협의체 구성원들간에 BAND 등 SNS를 활성화 하여 온라인 정보공유 활동 전개
14. 기타 의견	○ 미세먼지, 감염 등의 이슈에 따라 병원내 실내공기질 관리가 주요한 이슈로 부각됨 ○ 병원과 적합한 세부적이면서 공통의 주제를 선정하여 캠페인 활동 전개 - 실내공기질 관리, 신재생에너지 + 전기차 충전소 설치 캠페인, 유해물질 Free 캠페인 등

보건분야 환경경영 확산을 위한 전문가 의견서 (Expert D)

환경경영 활동	의 견
1. 환경경영 비전 및 전략 수립	○ 의료기관의 최고경영자와 전 직원이 알 수 있고, 함께 같은 방향으로 노력을 하기 위해서는 환경경영에 대해서 명확한 비전과 전략적 방향성에 대한 공유는 필수적인 요소임 ○ 의료기관의 전략수립에 메인 요소는 아닐 수 있으나 포함될 수 있도록 독려되어야 함
2. 환경경영 전담조직 구성 및 업무분장	○ 병원에서 환경문제에 대하서는 주로 병원의 시설팀에서 담당하고 있기 때문에 전담조직화는 매우 어려운 실정임 ○ 이러한 여건에서 환경경영이라는 개념으로 확대해서 전담조직을 신설하고 업무분장을 하기 위해서는 종합병원급 이상의 의료기관이나 상급 종합병원급의 규모의 행정시스템을 갖추고 있어야 가능할 것임
3. 녹색구매 지침 보유 및 준수	○ 녹색구매 지침을 의료기관들에서 공유하고 따르기 위해서는 정부의 인센티브가 없이는 현실적으로 불가능한 현실임 ○ 이를 위해서는 의료기관의 주무부처인 보건복지부와의 긴밀한 협조가 필요함
4. 용수 사용량 관리 및 절감활동 추진	○ 용수 사용량에 대한 관리와 절감은 의료기관의 노력 여하에 따라서 성과를 쉽게 볼 수 있는 영역으로 판단됨 ○ 용수 조절을 위한 여러 가지 기술들과 장비들을 잘 활용하여 성과측정을 하면 큰 어려움이 없을 것임

환경경영 활동	의 견
5. 에너지 사용량 관리 및 절감활동 추진	○ 병원은 24시간 365일 가동되는 시스템이기 때문에 에너지 사용량이 많음. 따라서 대부분의 병원에서는 에너지 사용량을 관심있게 관리하고 있으며, 절감활동에 대한 성과측정에 관심이 높음 ○ 의료기관에서의 에너지 사용량 관리와 절감활동 추진은 매우 중요한 환경경영활동 중 하나임
6. 신재생 에너지 투자 및 기술도입	○ 의료기관을 신축하거나 개축을 할 경우에는 신재생 에너지에 대한 투자와 관련 기술에 대한 도입을 고려할 필요 ○ 최근 대학병원급에서 신축병원 계획을 가지고 있는 의료기관에 대하여 신재생 에너지 도입 계획이 어떠한지를 확인하면 환경경영에 대한 관심이 어느 정도인지 판단하는데 큰 도움이 되리라 생각됨
7. 온실가스 배출량 관리 및 저감활동 추진	○ 상급종합병원의 경우 온실가스 배출량 관리와 이를 절감하기 위한 활동과 노력을 하고 있는 것으로 알고 있음 ○ 이에 대한 지속적인 관심과 노력이 관계 부처와 해당 의료기관에서의 성과로 이어지도록 지원과 협조가 필수적임
8. 수질오염물질 배출량 관리 및 저감 활동 추진	○ 수질오염물질 배출량 관리는 법적 여건에 맞게 대부분의 의료기관에서 관리를 하고 있음 ○ 이에 대한 절감활동에 대한 관심과 성과향상 측정이 정확하게 이루어질 수 있도록 지속적인 노력이 필요함
9. 폐기물 발생량 관리 및 저감활동 추진	○ 의료폐기물 발생은 병원에서는 불가피하며 법적인 가이드라인이 명확하기 때문에 대부분의 병원에서는 법에 따라 준수하고 있음

환경경영 활동	의 견
	○ 실제 병원에서는 의료폐기물 처리를 위한 비용을 업체로 지불하고 있는 상황이라 가능하면 줄이기 위해서 노력하고 있음
10. 유해화학물질 사용량 관리 및 저감 활동 추진	○ 유해화학물질과 방사능 물질을 포함하여 여러 위험물질이 병원에서 사용되고 있으며, 이에 대한 여러 관계기관들의 감독과 평가가 주기적으로 이루어지고 있음 ○ 절감 노력도 중요하지만 철저한 관리로 유해물질이 환경, 사회, 사람에 영향을 주지 않도록 대응하고 병원환경을 개선하여야 할 것임
11. 국내외 환경법규 준수	○ 법규로 정해진 사항에 대해서는 의료기관들이 잘 따르고 있음
12. 환경보고서 발간 및 공개	○ 의료기관에서 환경보고서를 준비하거나 발간하고 공개하는 것은 쉽지 않음
13. 이해관계자 환경정보요청 대응	○ 아직은 이해관계자가 의료기관에게 요구하는 환경정보요청에 직접적으로 대응하는 것은 수동적이고 방어적 자세를 취하고 있음
14. 기타 의견	○ Healthcare Supply Chain 분야에서의 환경경영에 주안점들을 풀어서 개별적으로 적용하고 확산하였으면 함

보건분야 환경경영 확산을 위한 전문가 의견서 (Expert E)

환경경영 활동	의 견
1. 환경경영 비전 및 전략 수립	○ 친환경병원은 CEO의 지속적 관심과 참여가 될 수 있도록 비전 및 전략을 수립하고 실천할 수 있도록 경영적 관점에서 운영될 수 있어야 함
2. 환경경영 전담조직 구성 및 업무분장	○ 지속가능한 친환경병원을 유지하기 위한 가장 필수 요인으로 전담조직과 예산이 투여 되어야 하며, 경영자가 바뀌어도 지속적으로 친환경 병원이 이루어 질수 있도록 조직과 예산이 있어야 함.
3. 녹색구매 지침 보유 및 준수	○ 장기적으로 친환경 병원에서 직·간접적으로 사회적, 국가적 기여할 수 있는 것으로 모든 구매 제품은 친환경 제품으로 구매하도록 규정
4. 용수 사용량 관리 및 절감활동 추진	○ 전통적인 친환경 활동으로 많은 병원에서 현재 추진, 활동하고 있음.
5. 에너지 사용량 관리 및 절감활동 추진	○ 기후변화의 근본원인으로 지목되는 온실가스 발생을 줄이고 이로 인한 건강, 환경의 피해를 예방하는 보다 많은 활동이 필요함
6. 신재생 에너지 투자 및 기술도입	○ 비용대비 효과의 문제가 지속되지만 근본적인 온실가스 배출량을 줄이는 방법이므로 기술의 진보로 좀 더 나은 온실가스 감축이 된다면 친환경병원에 많은 투자와 설치가 되어야 하고 관련 기술도 적극적으로 도입되어야 함
7. 온실가스 배출량 관리 및 저감활동 추진	○ 기후변화의 원인으로 지목되는 온실가스 발생을 줄이고 이로 인한 건강, 환경의 피해 예방에 많은 활동이 필요함

환경경영 활동	의 견
8. 수질오염물질 배출량 관리 및 저감 활동 추진	○ 전통적인 친환경 활동으로 많은 병원에서 현재 추진, 활동하고 있음
9. 폐기물 발생량 관리 및 저감활동 추진	○ 확대되는 의료 수요로 발생되는 의료폐기물을 포함한 병원에서 발생되는 폐기물 발생량을 저감하는 노력이 지속적으로 실시되어야 함
10. 유해화학물질 사용량 관리 및 저감 활동 추진	○ 면역력이 약한 환자가 있는 공간인 병원에서 장기적으로 계획을 수립하여 유해화학물질 사용량을 줄이고 대체 가능한 것으로 변경하며 연구, 분석을 통해 적합한 물질을 사용토록 지속적 노력이 필요함
11. 국내외 환경법규 준수	○ 전통적인 친환경 활동으로 많은 병원에서 현재 추진, 활동하고 있음
12. 환경보고서 발간 및 공개	○ 환경 관리에 대한 연례보고서를 발간하여 사업의 투명성과 중요도를 높임
13. 이해관계자 환경정보요청 대응	○ 환자, 환자 보호자, 일반 시민 등 이해 관계자의 환경정보 요청에 적극적으로 응해야 함
14. 기타 의견	○ 병원의 자발적인 참여를 유도하는 것이 사업의 성과를 높이는 데 매우 중요하며 이를 위한 지원책 마련이 필요함

보건분야 환경경영 확산을 위한 전문가 의견서 (Expert F)

환경경영 활동	의 견
1. 환경경영 비전 및 전략 수립	○ CEO의 역할이 중요하므로, 병원 임원들의 친환경병원에 대한 이해를 높이고 관심을 제고하는 프로그램 필요 → 병원장 대상 교육과 연계, 의료기관 평가 등에 반영
2. 환경경영 전담조직 구성 및 업무분장	○ 환경경영의 지속적 개선을 위해 가장 중요한 요소의 하나 ○ 별도 환경팀의 운영이 가장 바람직하나, 비상설 위원회 등을 적극 활용하는 추세로서 이러한 경우 정부의 적극적인 홍보 대행 필요
3. 녹색구매 지침 보유 및 준수	○ 병원에 적합한 녹색제품 발굴 필요, 학계, 협의체 등이 R&D 과제 참여 지원 검토 ○ 병원의 구매를 위해서는 보험급여 대상이 되어야 하므로 심평원 등과 사전 협의 중요
4. 용수 사용량 관리 및 절감활동 추진	○ 병원운영진에 대해서는 운영비용 절감효과가 있다는 점을 교육·홍보 필요 ○ 우선 자료의 측정 및 분석이 중요하므로 병동별 데이터 축적이 선행될 필요 ○ 캠페인, 교육 등을 함께 전개할 필요 - 특히 간호사, 간병인에 대한 교육이 중요
5. 에너지 사용량 관리 및 절감활동 추진	○ 병원운영진에 대해서는 운영비용 절감효과가 있다는 점을 교육·홍보 필요 ○ 자료 측정·분석이 중요하며 데이터 축적 필요 ○ 캠페인, 교육 등을 함께 전개할 필요 ○ BEMS 시스템과의 연계 검토 ○ 의료기기의 에너지사용이 많으나 이에 접근이 쉽지 않아 공급업체와 협력 필요

환경경영 활동	의 견
6. 신재생 에너지 투자 및 기술도입	○ 병원에서는 상대적으로 큰 이슈가 없는 분야임 ○ 병원 입장에서는 신재생에너지에 대한 투자는 홍보 목적으로 진행될 확률이 크므로 홍보전략화 지원 필요
7. 온실가스 배출량 관리 및 저감활동 추진	○ 의료기기의 에너지 사용 과다, 서비스업종 등의 이유로 온실가스 저감에 한계가 있음 ○ 온실가스 저감 자체도 중요하나 병원을 통해 환경교육이 이루어질 수 있도록 하는 방안 필요
8. 수질오염물질 배출량 관리 및 저감 활동 추진	○ 병원에서는 상대적으로 큰 이슈가 없는 분야임
9. 폐기물 발생량 관리 및 저감활동 추진	○ 의료폐기물 분리 수거 교육과 홍보자료 제작 필요 ○ 수술실의 Green화 관심유도 필요, 해외에서 주요한 이슈로 다루어지는 분야로 명확한 가이드라인 등 필요
10. 유해화학물질 사용량 관리 및 저감 활동 추진	○ 병원에서 사용되는 유해물질과 대체물질에 대한 정보제공이 중요
11. 국내외 환경법규 준수	○ 의료폐기물 관련 법률 위반이 줄어들 수 있도록 명확한 가이드라인 제시 필요
12. 환경보고서 발간 및 공개	○ 친환경병원 협의체 참여병원 등 선도그룹 중심으로 환경보고서 발간 지원사업 필요 ○ 병원의 홍보 수단으로서의 역할 뿐만 아니라 일반 국민 대상 병원의 환경이슈에 대해 공유하는 수단으로 이용
13. 이해관계자 환경정보요청 대응	-
14. 기타 의견	○ 사업의 실효성 제고를 위해 보건복지부 등과 공동 협업 필요 ○ 친환경병원 참여병원에 대해 자금 지원 등 인센티브 제공 필요

국문초록

한국의 보건의료분야 에코효율성 평가와 개선방안

세종대학교 대학원
기후변화협동과정
기후변화정책전공
김종률

인류는 화석에너지 사용에 따른 경제성장으로 현대의 물질적 풍요를 이루었지만 그 부작용으로 환경오염과 기상이변은 해마다 증가되고 있다. 이러한 기후변화와 환경오염을 효과적으로 대처하기 위해서는 제조업의 환경경영 뿐만 아니라, 공공기관, 학교, 병원, 숙박업 등 공공·사회서비스 분야까지 아우르는 사회 전 분야의 참여와 실천이 중요하다.

보건의료분야는 질병의 치료와 예방 등 의료 서비스를 제공하는 주체로서, 우리 시대가 직면하고 있는 이러한 환경위기를 해결하는데 사회적 책임과 역할이 요구되고 있다. 보건의료분야 중 병원은 환자와 직원이 하루 종일 거주하는 곳으로 많은 에너지와 물을 사용하고, 여러 종류의 유해 의료폐기물을 배출하며, 화학물질, 중금속, 방사성 동위원소 등을 사용하고 있다. 또한 건물에 상주하는 많은 거주인구와 유동 인구가 함께 생활하는 특징이 있으며, 이로 인해 2015년 한국에서 메르스 사태와 같이 각종 병원체 등에 의한 심각한 오염이 외부 사회로 확산될 우려도 크다.

보건의료분야에 환경경영을 효과적으로 확산하기 위하여 그간 한국 정부는 대형병원과 함께 환경경영을 위한 자발적협약의 체결, 에너지·온실가스 목표관리제의 도입, 환경정보공개제도의 운영 등 다양한 정책적 노력을 하고 있다. 이러한 정책적 노력과 비교하여 보건의료분야의 환경경영 현황과 효율성을 평가하는 정부, 산·학·연의 연구는 부족한 실정이다. 이에 본 연구는 보건의료분야의 환경경영 확산을 지원하기 위하여 보건의료분야의 에코효율성을 평가하고, 그 결과를 바탕으로 에코효율성 개선과 정책 지원 방안을 모색하였다.

보건의료분야의 중심이 되는 병원의 에코효율성을 평가하기 위하여 자료포락분석법(DEA) 모형 중 투입기준의 BCC 모형을 이용하였다. 물 사용량, 에너지 사용량, 폐기물 배출량, 유해화학물질 사용량을 투입변수인 환경부하변수로 적용하였으며, 산출변수인 경제적 부가가치 변수로는 매출액, 환자수를 사용하였다. 21개 병원의 2012년에서 2015년 자료를 대상으로 에코효율성을 평가하였다. 2015년도 기준의 에코효율성을 평가한 결과, 평균 0.940으로 분석되었다. 에코효율성이 높아 평가된 점수 '1'인 병원은 전체 병원의 57%인 12개로 나타났고, 평균보다 낮은 병원은 6개로 분석되었다. 에코효율성 평가 점수가 '1'보다 낮아 비효율적으로 평가된 9개 병원의 개선 잠재량을 분석한 결과, 2015년 기준으로 투입요소인 환경부하 변수에 있어 물 사용량 8%p, 에너지 사용량 9%p, 폐기물 발생량 10%p, 유해화학물질 사용량은 24%p의 개선 잠재량을 보였고, 이들 사용량과 발생량을 감소시킬 수 있는 여지가 있는 것으로 분석되었다.

다음으로는 계층분석법(AHP)과 중요도-성취도 분석법(IPA)을 사용하여 보건의료분야의 환경경영 확산 방안을 모색하였다. 병원의 환경경영 관련 담당자를 대상으로 환경경영 확산 요인에 대한 중요도와 성취도의 차이를 설문 조사하였다. 이는 병원의 환경경영을 확산하는데 효과적인 요인을 파악

하기 위한 것이다. 환경정보공개제도의 보건의료분야 공개 항목 20개 중 기업 개요(3개 항목), 정량항목과 중복되는 분야별 '투자 및 기술도입' 항목(4개 항목)을 제외한 13개 공개 항목이 지원 요인으로 사용되었다.

IPA 분석 결과, '유지 영역'(제1사분면)에는 2개, '집중 영역'(제2사분면)에는 3개, '저순위 영역'(제3사분면)에는 4개, '과잉 영역'(제4사분면)에는 4개의 지원 요인이 분석되었다. 보건의료분야의 환경경영 확산을 위해서는 중요도에 비해 성취도가 낮아 제2사분면에 위치한 3개의 요인을 우선적으로 집중 개선하는 것이 필요하다. 2사분면에는 '환경경영 비전 및 전략 수립', '환경경영 전담조직 구성 및 업무분장', '온실가스 배출량 관리 및 저감활동 추진' 3개 항목이 위치하고 있다. 또한, 제3사분면(저순위 영역)에 속하는 '녹색구매 지침 보유 및 준수', '신재생 에너지 투자 및 기술도입', '환경보고서 발간 및 공개', '이해관계자 환경정보요청 대응'도 중요도와 성취도가 낮게 나타나 지속적으로 개선이 필요한 항목으로 나타났다.

또한 정책기관, 컨설팅회사, 대학, 병원에 근무하는 6명의 관련 전문가와 심층 인터뷰를 진행하여, 보건의료분야에 대한 환경경영 지원 정책의 개선 방향을 제시하고자 하였다. 전문가 심층 인터뷰 결과, 보건의료분야의 환경경영 확산을 위해서는 무엇보다 우선적으로 최고경영자와 직원들이 환경경영에 관심을 갖고 환경경영의 필요성에 대한 동기 부여가 제공될 수 있도록 정부차원의 노력이 가장 필요한 것으로 나타났다. 보건의료분야 본연의 목적이 환자의 치료라는 측면에서 환경경영은 경영상의 부수적인 요소로 인식되고 있고 시설관리팀 위주로 관리되고 있다. 이러한 환경경영을 전사적인 차원으로 끌어올리고, 보다 확산시키며 고도화하기 위해서는 최고 경영자의 관심과 강력한 추진, 전담 부서의 구성 또는 비상설 위원회의 구성・운영이 중요한 요인으로 분석되었다.

세부 환경경영 지원요인에 있어, '녹색구매 지침 보유 및 준수' 등 시스템 구축은 어렵지 않으나 이행이 되지 않고 있으므로, 환경부가 보건의료분야의 주무당국인 보건복지부와의 긴밀한 협조를 통하여 인센티브를 개발하고 제공하여 참여를 독려할 필요가 있는 것으로 나타났다. '환경보고서 발간 및 공개'에 있어서는 우선적으로 친환경병원 협의체 참여병원 등 선도 그룹을 대상으로 환경보고서 발간 지원사업이 필요한 것으로 제시되었다. 이 과정에서 환경보고서가 병원의 홍보 수단뿐만 아니라 일반 국민이 보건의료분야의 환경이슈를 공유하는 수단이 될 수 있도록 정부 차원에서 유도하는 것이 중요한 것으로 분석되었다.

의료폐기물의 관리, 물과 에너지 사용량, 온실가스 배출량 등 환경경영 전 분야에 있어서는, 병원 직원뿐만 아니라 병원을 이용하는 환자, 간병인, 다른 이해관계자들이 관심을 갖고 참여를 독려할 수 있는 교육, 훈련, 다양한 캠페인이 필요한 것으로 나타났다. 또한 환경경영을 선도적으로 추진하고 있는 병원의 우수사례를 발굴·공유하여 확산될 수 있는 여건을 마련하는 것이 필요한 것으로 분석되었다.

본 연구는 보건의료분야의 에코효율성을 평가함에 있어 평가가 어려운 절대 목표량 기준 평가를 DEA에 의한 상대적인 비교 평가로 대체하여 에코효율성의 개선 방향과 실천방향을 제시했다는데 의의가 있다. 또한 병원 담당자 설문과 전문가 인터뷰를 통해 DEA 분석의 정성적 한계를 극복하여 한국의 보건의료분야의 환경경영 촉진에 효과적인 실천 방안과 정책지원 방향을 제시하려 노력하였다. 보다 심도있는 정량적인 분석을 위해서는 관련 자료의 지속적 축적과 함께, 장기간에 걸친 실천 노력에 대한 정확한 측정과 비교가 이루어져야 할 것이다.

주요어 : 환경경영, 에코효율성, 자료포락분석법(DEA), 계층분석법(AHP), 중요도-성취도 분석법(IPA)

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'이 짧은 시간 동안', 아직 '도착하지 않은 삶',
그래도 '사람만이 희망입니다.'
이제 다시 '시작'입니다.

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