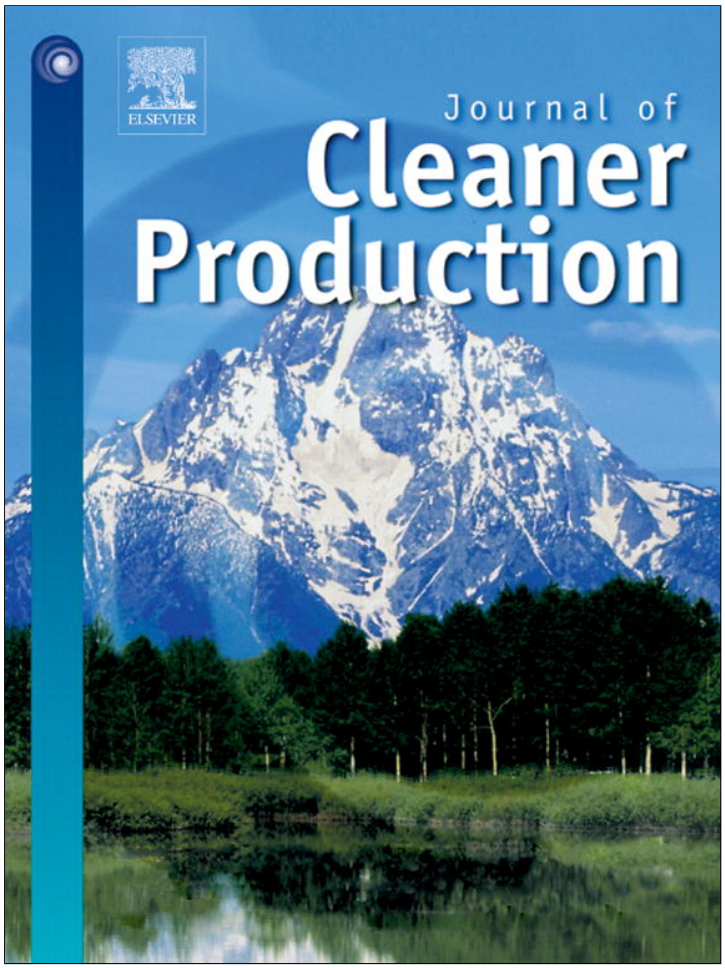

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A survey study of energy saving activities of industrial companies in the Republic of Korea

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ABSTRACT

This study measures industrial energy saving activities (ESAs) in the Republic of Korea and identifies their determinant factors by a questionnaire survey to the energy-intensive companies. More than 90% of the samples have practiced the institutional and managerial ESAs, requiring relatively lower costs and efforts. Although the companies have felt strong pressures from the governmental regulations and recognized the importance of industrial associations, the externally coercive, normative and mimetic factors still indicate no significant influence on their ESAs at present. As internal factors, the willingness for energy saving, support from top management and internal training specific for energy saving determine a company's practice level of ESAs. Economic incentives, like financial subsidies, are useful for encouraging the company's involvement in ESAs. Korean government shall also provide more technical support to the companies, particularly the small and medium-sized ones, for enhancing their capacities in promptly reacting to the newly initiated mandatory regulations on industrial energy efficiency.

1. Introduction

The Republic of Korea (Referred as Korea hereinafter) has developed its economy by heavily relying on energy consumptions (Kim et al., 2011). The rapid economic growth along with sharp increases in energy consumptions has led the country to be the tenth largest energy consumer in the world since 2005. The national total CO_2 emissions have been substantially increasing since 1990. According to a report of the Organization for Economic Co-operation and Development (OECD), the most CO_2 emissions-related industries contribute to around 30% of the Gross Domestic Product (GDP) of Korea. In spite of a temporary slowdown of CO_2 emissions during 1997–1998, the upward trend remains far more significant than the other OECD countries (OECD, 2008).

The national energy efficiency strategy of Korea has been outlined in its 'Energy Use Rationalization Act', enacted in 1979 soon after the global oil crisis in late 1970s. As so far, four master plans for rational utilization of energy were consecutively launched since 1993. Accordingly, a series of policies have been introduced and implemented, including the support of diffusion of energy efficient facilities and equipments, energy audit, voluntary agreement between the government and industry and the ESCO (Energy Service Company) projects. In the 4th master plan for 2008–2012, the Voluntary Agreement (VA) for energy efficiency improvement is emphasized for the companies using more than 20,000 TOEs (Ton of oil equivalents) of energy per year. This policy will be gradually expanded to the companies with annual energy consumption of 5000–20,000 TOEs. The 'National Energy Plan (2008–2030)', as the country's long-term strategy for energy security, specifies three energy policy goals: to improve the overall energy intensity in a unit of TOE/1,000USD to 0.185 by 2030 from 0.341 of 2007; to reduce the share of fossil fuels in total energy mix from 83% to 61%; and, to increase the share of renewable energies up to 11% from 2.4% during the same period.

Korea announced the new national vision of "Low carbon GreenGrowth" in 2008 and pledged in 2009 to reduce 30% of its greenhouse gases (GHGs) emissions from the business as usual (BAU) scenario by 2020 compared with 2005 levels. The national overall reduction target was further decomposed into specific targets of twenty five types of businesses in seven sectors, including industry, energy conversion, transportation, building, agriculture, waste and other public sector in July 2011. As a key measure for realizing the decomposed targets, the 'Target Management Scheme' (TMS) was recently initiated to limit the energy consumptions and GHGs emissions of major entities and business sites of each sector. The targets of TMS include entities emitting more than 125,000 t-CO_2 or using more than 500 TJ of energy annually, and business sites with more than 25,000 t-CO_2

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emissions or 100 TJ of energy use per year. As of the end of 2011, a total of 471 entities were designated as the TMS targets, whose GHGs emissions accounted for 61.3% of national total of 2007 (620 Million t-CO_2). Their energy consumptions shared 42.4% of national total of 2008 (10,087 thousand TJ). Among which, 372 entities are from the industrial and power sectors, with GHGs emissions and energy consumption accounting for 96.3% and 97% of all the TMS targets, respectively. The number of small and medium-sized enterprises (SMEs) under the TMS is 120, with a share of 32.1% of the entities from industrial and power sectors. The TMS targets from these two sectors will become 560 and the share of SMEs will increase to 40% by 2014 (MKE, 2010). These entities are managed by the monitoring, reporting and verification (MRV) system of Ministry of Knowledge Economy (MKE).

Korea government has been discussing market-based instruments (MBIs) for enhancing the industrial energy saving and GHGs mitigation, particularly carbon tax and emission trading scheme (ETS). In 2008, Korea Institute of Public Finance (KIPF) firstly suggested a carbon tax proposal with tax rates of 34–96 KRW/l for fossil fuels (Kim et al., 2008). The total expected tax revenues would be 8.5–9.1 trillion KRW (Korean Won) (7.38–7.91 billion USD) per year if based on 2007 emissions of Korea, about 1% of the country's GDP. KIPF further suggests the implementation of this policy from 2012 to replace the extant transportation tax to be ended in 2012 (Kim and Kim, 2010). The latest proposal of a GHG ETS, which will start from 1 January 2015, has been approved by the parliament after reflecting the comments of industries. The GHG ETS in Korea would cover the entities with certain amounts of energy use or GHG emissions and the policy targets will be adjusted considering international trend. Ninety five percent allowances may be allocated for free in the initial period. The emissions exceeding the allowances are subject to a penalty below three times of average market price. How to avoid the policy overlap between the TMS, ETS and carbon tax is a remaining question for further discussions.

Under such an emerging policy progress, Korean companies would have more motivations to integrate their energy saving into daily business operations. However, the company's green strategies were found still at an early stage since they were seldom required to do so in the past (Kim, 2009). The gap between the rapid policy progress and the company's laggard responses to energy and climate issues in Korea bears research concerns (Lee et al., 2010). With aims to close the existing research gap, this study seeks to identify major factors determining a company's energy saving practices in Korea by a survey mainly targeting SMEs from energy-intensive industries. Two topics are therefore discussed in this paper: a) the current status of energy saving activities (ESAs) of Korean companies; and, b) determinant factors, external and internal, predicting the level of a company's involvement in ESAs.

2. Literature review

Energy efficiency improvement is crucial, especially for the energy-intensive industries, due to its usefulness in cost reduction and GHGs mitigation. However, wide studies have indicated that the cost-effective energy saving measures could not be undertaken as expected (Rohdin et al., 2007). Barriers hindering the adoption of energy-efficiency practices have been largely discussed. Hirst and Brown (1990) once classified the barriers into structural and behavioral ones. Structural barriers include distortions in fuel prices, uncertainty about future fuel prices, limited access to capital, government fiscal policies, regulatories, codes and standards, and supply infrastructure limitations. Behavioral barriers include attitudes toward energy efficiency, perceived risk of energy-efficiency investments, information gaps, and misplaced incentives. Weber (1997) categorized the obstacles to efficient energy use into institutional, market, organizational and behavioral barriers.

Empirical studies have figured out specific barriers and drivers for energy saving practices in developed economies. Cagno and Trianni (2010) conducted a survey to 104 SMEs in northern Italy, and identified the access to capital and the lack of information on energy efficiency solutions as the most relevant barriers. Prindle (2010) distributed a questionnaire survey to nearly 100 companies of the U.S. and found that these firms' energy efficiency strategies are driven by the commitment to reduce CO_2 emissions and the desire to reduce operating cost. The common barriers for these U.S. companies include lack of funding; lack of personnel with the appropriate skills and insufficient technical information. A questionnaire survey to Swedish foundry industry confirmed that limited access of capital is the largest barrier to energy efficiency. Barriers within the private foundries are more related to information problems. The most important driver was long term energy strategies of these companies (Thollander et al., 2007). Kounetas et al. (2011) revealed that the information barrier is the major obstacle restricting companies from adopting energy efficiency technologies (EETs) in Europe. This study shared the experience for Greek manufacturing companies to adopt EETs by overcoming the information barrier. Thollander et al. (2007) confirmed the low priority of energy efficiency issues as a major barrier for SMEs of Sweden in energy efficiency measures in over the past 15 years. De Groot et al. (2001) analyzed the determinants of energy saving of Dutch firms by using a data set of 135 samples. They concluded that the cost saving potential is the most important driver behind investment decisions for energy saving. More attractive opportunities and uncertainty of possible declines in the price of new technologies are impediments for not investing in energy saving. In Asia, Liu (2012) carried out in-depth interviews to companies from the most fossil fuel-intensive industries in Fujian province, China. Although the companies are relatively well informed the knowledge and value of carbon management and have a strong willingness to act, there is no indication for them to take practical actions. He summarized the barriers as being structural, regulatory, contextual and cultural. Nagesha and Balachandra (2006) identified relevant barriers to energy efficiency in the small scale industry (SSI) clusters in India. The financial and economic barrier (FEB) and behavioral and personal barrier (BPB) have emerged as the two major impediments.

Empirical analyses at the company's level are rather scarce in Korea. As two exemptions, Lee et al. (2010) reviewed the green innovation status of 447 manufacturing companies of ten energy-intensive industries and confirmed the importance of regulations in pushing the company's green innovations. A company's green innovations are determined by the company's capacity and the perceived regulation pressures. Supportive policies and strategies are recommended to satisfy the needs of companies. Hong (2010) conducted a survey to 500 SMEs in Korea, with 33.8% of them being energy-intensive. More than half of respondents have recognized the regulative initiatives for GHG reductions. Lack of awareness and sufficient preparation is identified as major barriers for them to make efforts in GHG reductions.

3. Methodology

3.1. Analytical framework of this study

The analytical framework of this study is similar with our previous analysis of energy saving practices of Chinese companies, as depicted in Fig. 1 (Liu et al., 2012).

This model admits the importance of externally coercive, normative and mimetic pressures, recognized by the institutional

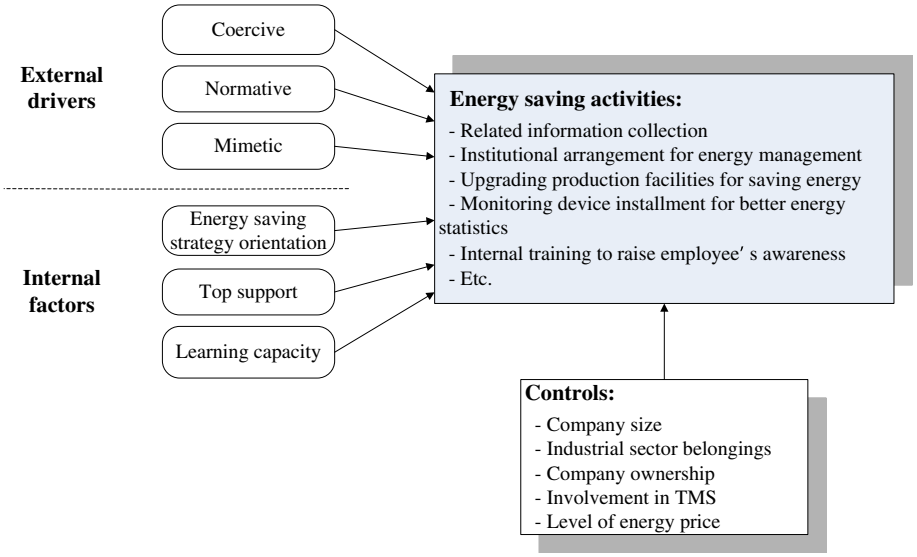

Fig. 1. The overall analytical framework of this study.

sociology, for enhancing company's environmental management (DiMaggio and Powell, 1983). The companies may take heterogeneous energy management practices due to their individual interpretation of the objective external pressures. Therefore, our model adds three internal factors, a company's energy saving strategy orientation, top support and learning capacity, to jointly explain a company's ESAs. Previous studies showed that large companies are more likely to be supervised by the environmental authorities (Hettige et al., 1996). The companies from energy-intensive industries are more sensitive to energy prices due to the higher reliance on energy use. Meanwhile, they have longer experience with energy efficiency programs (Prindle, 2010). Aiming to analyze the differences in ESAs of the companies with various characteristics, the company's size, ownership, sector belongings, involvement status of TMS and the level of energy price are selected as control variables in this analysis.

3.2. Econometric approach

3.2.1. Valuation of the variables

3.2.1.1. Dependent variable. The overall level of ESAs of a company, abbreviated as *TESA*, is the dependent variable in this analysis. Usually, the comprehensiveness of a company's energy saving efforts can be presented by a series of energy saving goals, management procedures as well as the practical activities for improving energy efficiency. It is difficult to quantify a company's energy saving practice level since it does not necessarily equal to the sum of energy saving plans and practices. An operational way is to list a series of ESAs, which may reflect a company's energy saving involvement. The number of ESAs under implementation can be defined as the proxy indicating a company's *TESA*. Table 1 lists fifteen representative items of ESAs for Korean companies in our survey.

Since the relative importance of each activity for a company is difficult for being scored, the fifteen activities are assumed to equally contribute to a company's *TESA*. A value of '1' is given to an activity if the company has adopted it. Otherwise, a score of '0' is assigned. Each ESA will obtain a score of '1' or '0'. The sum of the scores of all the fifteen ESAs is used to indicate a company's *TESA* in this study. A higher score implies a higher level of energy saving practices.

3.2.1.2. Independent variables. The independent variables include coercive, normative and mimetic pressures as external factors, and energy saving strategy orientation, top management support and learning capacity as internal factors. The proxies of these variables are listed in panel A of Table 2. The descriptions of independent variables were directly used as the survey items in the questionnaire. The governments enhance the company's energy saving by announcing mandatory energy efficiency requirements. The coercive pressure from abroad may also influence a company's ESAs. In this study, the strength of governmental requirements on energy saving and the level of product export are defined as domestic and international coercive drivers, respectively. The influence of related industrial associations is used to represent the normative pressure. Companies are likely to mimic the practices of leading companies and major business competitors in the same sector. The overall energy management level of the sector is used to indicate mimetic pressure for the companies. A company's willingness to improve energy efficiency is defined as the proxy of the company's orientation of energy saving strategy. The top managers may largely decide the operations of SMEs. Top manager's support is selected as another internal factor influencing ESAs of SMEs targeted by this survey. The energy efficiency of a company is dynamic and closely related to the abilities of the company's employees (Hart, 1995). The education level of employees and the frequency of internal training specific for energy saving are adopted as proxies of learning capacity.

A five-level point method was applied for the valuation of independent variables. The companies were requested to present a value to measure the level or strength degree of each factor with '1' = very low; '2' = relatively low; '3' = moderate; '4' = relatively high; and, '5' = very high. There are two exceptions in the survey. One is the export ratio of the product, which used a five-level classification with '5' representing more than half of the products being exported; '4' meaning a 30–50% export ratio; '3' meaning a 20–30% export ratio; '2' being a 10–20% export ratio, and '1' being an export ratio of less than 10%. The other exception is average education of employees, with '5' representing more than 70% of employees holding a college and above diploma, '4' being a ratio of 50–70%, '3' being a ratio of 30–50%, '2' meaning a ratio of 10–30%, and '1' meaning a ratio of under 10%.

3.2.1.3. Control variables. As indicated in panel B of Table 2, a company's size, sector belongings, ownership, involvement status of TMS, and level of energy price are defined as controls and individually represented by SIZE, SECTOR, OWNERSHIP, TMS and PRICE. For the valuation, the company's size is divided into

Table 1
Description of energy saving activities and the valuation.

Item	Description	Valuation	
		0	1
ESA1	Collect information on energy saving and carbon mitigation policies		
ESA2	Establish internal energy management institution with full-time energy management staffs		
ESA3	Establish internal management regulations on energy saving and carbon mitigation		
ESA4	Conduct energy auditing for understanding internal energy use situation and to identify energy-saving potentials		
ESA5	Adjust the structure of energy consumption by using cleaner energy		
ESA6	Considering to invest in upgrading the production facilities for energy-saving		
ESA7	Having invested in new production facilities to reduce energy use and carbon emissions		
ESA8	Strengthen daily maintenance of production equipments to reduce energy use		
ESA9	Install monitoring devices for major energy-consuming equipments for better statistics of internal energy use		
ESA10	Promote eco-design and develop energy efficient products		
ESA11	Optimize the transportation of raw materials and products to reduce energy use of logistics		
ESA12	Arrange internal training of employees to raise their energy -saving awareness		
ESA13	Organize the employees to practice daily energy-saving activities in office (such as lighting, air-conditioner, etc.)		
ESA14	Participate in energy-saving training and pilot projects arranged by national or local governments		
ESA15	Apply for energy-saving subsidies at national or local level		

three categories, small, medium and large. The sector belongings are categorized into four types: petro-chemical, pulp & paper, power and the others. Firm's ownership is grouped into two types, domestically private and the others. The respondents are sorted into TMS target or not. Regarding the variable of PRICE, the companies were requested to give a value to measure the level of current energy price, with '1' = very low; '2' = relatively low; '3' = moderate; '4' = relatively high; and, '5' = very high.

3.2.2. Empirical model for the analysis

According to the explanations above, the regression capturing the functional relationships between the *TESA* and the classified variables can be constructed and expressed by following equation, where ε represents the error term and β_0 is the constant.

$$\begin{aligned}\text{TESA} = {} & \beta_0 + \beta_1\text{REGULATION} + \beta_2\text{EXPORT} + \beta_3\text{ASSOCIATION} \\ & + \beta_4\text{COMPETITOR} + \beta_5\text{WILLINGNESS} \\ & + \beta_6\text{TOPSUPPORT} + \beta_7\text{EDUCATION} + \beta_8\text{TRAINING} \\ & + \beta_9\text{SIZE} + \beta_{10}\text{SECTOR} + \beta_{11}\text{OWNERSHIP} + \beta_{12}\text{TMS} \\ & + \beta_{13}\text{PRICE} + \varepsilon\end{aligned}$$

4. Outline of the questionnaire survey and the samples

The data of this study was collected by a questionnaire survey with the principal objective to monitor the company's ESAs and identify the pre-classified determinants. The questionnaire format consists of four major components: general information of the company including the size, ownership, sector belongings, involvement status of TMS, etc.; activities of the companies in energy saving and GHG mitigation; the degrees of external pressures and internal factors of the company; and, some additional questions for clarifying related issues like the financial subsidies received by the companies, barriers of and optional policy measures for practicing ESAs. During a period of about three weeks from 28 January to 17 February 2011, the questionnaire was sent to a total of 362 business sites of 244 companies via faxes and emails. Among which, the responses from 66 business sites were confirmed to be valid and used for this analysis. The distribution of the usable samples is summarized in Table 3.

The samples from power, petro-chemical and paper sectors account for more than 60% of the total. Fifty four respondents are the targets of TMS. A majority of samples (86.4%) is small and medium-sized companies and the large ones share 13.6%.

5. Results and discussions

Stata 10 was used for the statistical analysis in this study and the results are described and discussed as follows.

5.1. Energy consumption status of the samples

During the survey, the companies were requested to show the range of their annual energy consumption amounts. The result indicates that 97% of the respondents consumed more than 2000 TOEs of energy in 2010. The samples using more than 100,000 TOEs in 2010 account for 41% of the total. According to Kim (2009), only the top 2.2% of SMEs in Korea consumed more than 2000 TOEs and 85% of the remaining SMEs even used less than 200 TOEs in 2009. This implies that the respondents of this survey may represent the heavy energy-consuming SMEs in Korea.

5.2. Statistics of company's ESAs

The reliability of construct of the fifteen ESA items was tested by the calculation of Cronbach's alpha. The scale coefficient of 0.78 confirmed the reliability of company's answers on their ESAs according to the criteria that the alpha should be larger than 0.7 (Nunally and Bernstein, 1994).

Fig. 2 provides a statistical summary of ESAs adopted by the surveyed companies. The similar as our previous study in China (Liu et al., 2012), the surveyed Korean companies prefer to practice the ESAs by institutional and managerial measures probably because these activities usually require lower costs and less resources compared with the ESAs by technological and engineering methods. Specifically, ESA13 (Organize the employees to practice daily energy-saving activities in office, such as lighting, air-conditioning, etc) and ESA1 (Collect information on energy saving

Table 2
Description and valuation of determinant factors and control variables.

Variable		Description and abbreviation of the proxy	Valuation
			0 1 2 3 4 5
Panel A: independent variables			
External pressures	Coercive	Strength of governmental requirements of energy saving (REGULATION)	
		Export rate of the product (EXPORT)	
	Normative	Influence of association of industrial sector (ASSOCIATION)	
	Mimetic	Energy management level of competitors (COMPETITOR)	
Internal factors	Strategy orientation	Willingness to improve energy efficiency (WILLINGNESS)	
	Top support	Top manager's support to energy saving activities (TOPSUPPROT)	
	Learning capacity	Average education level of employees (EDUCATION)	
		Frequency of internal training on energy saving (TRAINING)	
Panel B: control variables			
Characteristics of the firm	Firm's size (SIZE)		
	Industrial sector belongings (SECTOR)		
	Firm's ownership (OWNERSHIP)		
	Involvement in the TMS (TMS)		
	Level of current energy price (PRICE)		

and carbon mitigation policies) are the most adopted ESA items, with the ratio of 'YES' answer being 95.5% and 93.9%, respectively. More than half of the surveyed companies participated in ESA6 (Considering investment in upgrading the production facilities for energy-saving, with a share of 78.8%), ESA7 (Having invested in new production facilities to reduce energy use and carbon emissions, 62%) and ESA8 (Strengthen daily maintenance for the reduction of energy use of the production equipments, 66.7%). Other three ESAs with participation ratios slightly more than 50% are ESA2 (Establish internal energy management institution with full-time energy management staffs), ESA9 (Install monitoring devices for major energy-saving activities) and ESA12 (Arrange internal training of employees to raise their energy-saving awareness). The moderate participation of ESA12 is consistent with statistics of the independent variable of TRAINING as shown in the following Section 5.3, where the companies admit a relatively low frequency of internal training on energy saving.

On the other hand, the item with the lowest ratio of 'YES' answer is ESA10 (Promote eco-design and develop energy efficient products). ESA3 (Establish internal management regulations on energy saving and carbon mitigation), ESA5 (Adjust the structure of energy consumption by using cleaner energy), ESA11 (Optimize the transportation of raw materials and products to reduce energy use of logistics) and ESA14 (Participate in energy-saving training and pilot projects arranged by national or local governments) achieved participation ratios of less than 30%. This implies that the involvement of ESAs of the sampled SMEs is at an early stage. The company's energy saving practices can not be merged into their business cycles, such as research and development of the products and strategic cooperation with external business partners. The low participation ratio of ESA14 may be partly attributed to the lack of training opportunities provided by the governments for SMEs. Korea Energy Management Corporation (KEMCO) under MKE arranges 'Energy Educational and Training Programmes' for the people responsible for energy management in the companies using more than 2000 TOEs of energy annually. Nevertheless, SMEs complain that energy saving related training and information dissemination are largely inadequate (Hong, 2010; KID, 2008). Dias et al. (2004) clarified that education is one of the best ways to change the human behaviors for rational use of energy. The governments shall make continuous efforts in providing technical support to enhance the awareness of SMEs and assist them in appropriately practicing ESAs.

Fig. 3 further shows the distribution of company's *TESA*. The average *TESA* is 7.5, indicating a moderate level of the surveyed companies in adopting ESAs in overall. Only 3.3% of the respondents practiced all the fifteen activities. There is one company even carrying out none of the pre-listed ESA. Half of the samples practiced 4 to 7 items of ESAs and 30% of the companies implemented 8 to 11 items of ESAs.

Table 3
Distribution of the valid respondents.

Classification criteria		Number of respondents	Percentage (%)
Sector	Steel	6	9.1
	Power	11	16.7
	Petro-chemical	21	31.8
	Pulp and paper	10	15.2
	Cement	6	9.1
	Nonferrous metal processing	5	7.6
	Machinery	4	6.1
	Oil refining	3	4.5
	In total	66	100.0
Involvement status of TMS	Yes	54	81.8
	No	12	18.2
	In total	66	100.0
Size	Large	9	13.6
	Medium	49	77.3
	Small	8	9.1
	In total	66	100.0

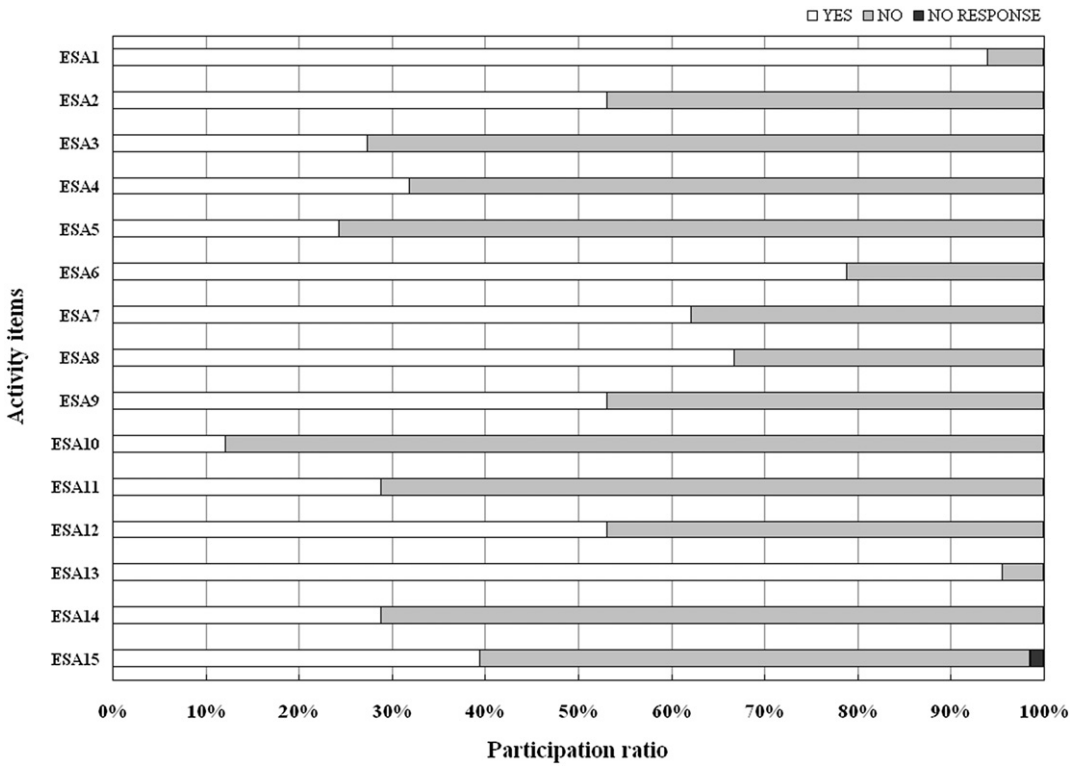

Fig. 2. Distribution of company's energy saving activities ($N = 66$).

5.3. Statistics of the independent and control variables

Table 4 summarizes the statistics of independent variables and the quantitative control. The skewness and kurtosis values were listed to show the shape of the distribution of scores achieved by these variables. The variable's skewness ranges between −1.51 and 0.01, with the absolute values less than 3, and their kurtosis ranges from 1.47 to 4.58, with the absolute values less than 10. This confirms that the skewness and kurtosis of the adopted variables is not significant (Kline, 1998).

The external factor of 'ASSOCIATION' achieved a high score, indicating the significance of industrial associations in influencing the companies in the same sector in Korea. The requirements of energy efficiency from the governments are strongly felt by the companies, with the average score of 'REGULATION' being 3.80. This reveals positive role of discussions and implementation of various energy saving policies recently for enhancing the company's perception of coercive pressure from the governments. The sampled companies somewhat evaluated the energy management level of their competitors, with the variable of 'COMPETITOR' being presented a mean of 3.67. 'EXPORT' achieved a moderate mean, implying that the products of the samples are mainly supplied for domestic market. The respondents with products exported only account for 22.7% of the total.

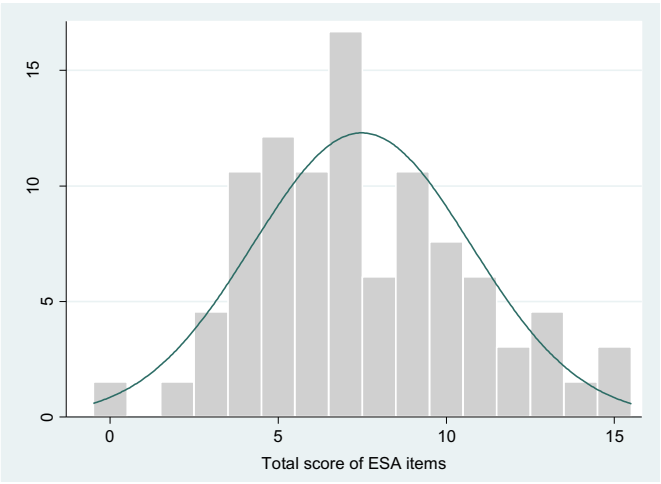

Fig. 3. Distribution of overall scores of energy saving activities ($N = 66$).

For the internal factors, the respondents expressed high willingness for energy saving, with 'WILLINGNESS' achieved a mean of 4.31. The top managers support energy management of the companies, with 'TOPSUPPORT' having another high mean of 4.15. This is encouraging since companies would be more likely to adopt an environmental innovation strategy if their managers gave priorities for environment issues (Fergusson and Langford, 2006). The low score given to the variable of 'TRAINING' means that internal training for energy saving has been arranged occasionally in the surveyed companies. The education level of employees is moderate, with the average score of 'EDUCATION' being 3.30.

The companies really felt high pressure of current energy prices and the quantitative control of 'PRICE' obtained a mean of 4.05. Regarding the other controls indicating a company's characteristics, as described in Section 4, most samples are SMEs although 81.6% of them is affiliated to large companies. Large companies, with more than 1000 employees, only share 13.6% of the total. By ownership, 63.6% is domestically private corporations. The remaining 36.4% is state-owned, joint-ventures and fully foreign-funded. The ratios of respondents from petro-chemical, power, paper and pulp and the others are 31.8%, 16.7%, 15.2% and 36.4% individually.

5.4. Correlation matrix and bi-variable results

Pair-wise correlation was calculated to preliminarily explore the relationships between *TESA*, independent variables and the

Table 4
Statistical summary of independent variables and the quantitative control.

Variable		Obs.	Mean	Std. Dev.	Min.	Max	Skewness coefficient	Kurtosis coefficient
Independent	REGULATION	66	3.80	0.79	1	5	−0.78	4.44
	EXPORT	64	2.92	1.58	1	5	0.03	1.47
	ASSOCIATION	66	4.13	1.16	1	5	−1.51	4.58
	COMPETITOR	66	3.67	0.84	2	5	−0.23	2.49
	WILLINGNESS	66	4.31	0.66	3	5	−0.44	2.26
	TOPSUPPORT	66	4.15	0.82	2	5	−0.45	2.06
	EDUCATION	66	3.30	1.15	1	5	0.31	1.68
	TRAINING	66	2.65	0.94	1	4	−0.28	2.24
Control	PRICE	66	4.05	0.59	3	5	0.01	2.87

quantitative control. The result is listed in Table 5. There is no indication for an unacceptable level of multicollinearity problem between these variables as the highest correlation coefficient is 0.502. Harmful levels of multi-collinearity are expected not to happen until the correlation coefficient reached ±0.8 or ±0.9 (Farrar and Glauber, 1967). The correlation matrix indicates that 'WILLINGNESS' (Willingness to improve energy efficiency) is significantly and positively associated with *TESA* at $P < 0.01$. The other variables showing significant relationships with *TESA*, with significance level at $P < 0.01$, are 'COMPETITOR', 'TRAINING' and 'TOPSUPPORT'.

5.5. Factor analysis of ESA items

An exploratory factor analysis was conducted on the fifteen ESAs to find if there are different dimensions of these items. The Kaiser-Meyer-Olkin (KMO) test was carried out to assess the appropriateness of the factor analysis. The rotated component matrix of the analysis and KMO values are listed in Table 6. The KMO values are generally greater than 0.5 indicating a satisfactory factor analysis to proceed. Four principal component factors are extracted. The first factor accounts for 57.4% of the variance in total and the other three accounts for about 17%, 13% and 11% individually. ESA2 to ESA4 and ESA6 to ESA13 are highly associated with factor 1. ESA 14 and ESA15 are highly associated with factor 3. ESA1 and ESA5 are related to factor 2 and factor 4, respectively. According to the result of factor analysis, four sets of constructs of ESA may be defined. The ESA items highly associated with factor 1 are internally independent ESA of the companies. ESA14 and ESA15, associated with factor 3, are the ESA in cooperation with the governments. We thus classified the ESA into four categories and defined them in Table 7. Besides the overall level of ESA, *TESA*, the variables, representing the involvement of sub-categories of ESAs, are also used as dependent variables for the multivariate regressions to observe their respective relationships with the predicting factors.

5.6. Multivariate analysis with TESA and sub-categories of ESAs as dependent variables

As the dependent variables, *TESA* and sub-categories of ESAs are in an ordinal measurement, the ordered logistic regressions were performed. The analysis results of *TESA* and ESA_{IN} are listed in Tables 8 and 9, respectively. The results for ESA_{Ex}, ESA_{INF} and ESA_{SA} are not listed since their significant relationships with the identified factors could not be found. The robustness of the results was tested by repeating the regression with certain variables omitted. Three models were adopted. Model 1 is the case of excluding all the control variables. Model 2 is the case of adding the quantitative control, 'PRICE'. Model 3 is the case of including all the variables discussed earlier. There are no obvious changes between the results of the three regressions, confirming the robustness of results. The total observations of econometric analysis are 64 due to data missing of two respondents.

The results in Tables 8 and 9 indicate that the identified determinant factors influence a company's *TESA* and ESA_{IN} in a similar manner, and are therefore discussed together as follows. The same as our previous survey of Chinese SMEs (Liu et al., 2012), there is no significant relationship between *TESA* (ESA_{IN}) and coercive pressures, including 'REGULATION' (The pressure of governmental requirements of energy saving) and 'EXPORT' (The level of product export). This implies that the strongly regulative pressure perceived by the surveyed Korean companies, as shown in Table 4, still does not start to function as the determinant for their practical ESAs. So far, the regulations specific for industrial energy efficiency and GHG reductions in Korea focused on the large companies rather than SMEs targeted by this survey (Hong, 2010). Although the newly initiated TMS targets some SMEs with large energy consumptions and GHG emissions, certain time is necessary for the companies to respond to the implementation of this regulation. The companies under TMS were determined in 2010 but the specific reduction targets and measures were declared until the late middle

Table 5
Correlation matrix and bi-variable results.

	TESA	REG.	EXP.	ASS.	COM.	WIL.	TOP.	EDU.	TRA.	PRI.
TESA	1.000									
REGULATION	0.212[c]	1.000								
EXPORT	0.258[b]	0.012	1.000							
ASSOCIATION	0.166	0.097	−0.003	1.000						
COMPETITOR	0.351[a]	0.225[c]	0.238[c]	0.063	1.000					
WILLINGNESS	0.502[a]	0.122	0.069	0.043	0.413[a]	1.000				
TOPSUPPORT	0.345[a]	0.212[c]	−0.041	0.218[c]	0.359[a]	0.277[b]	1.000			
EDUCATION	0.150	0.186	−0.006	0.199	0.058	0.236[c]	−0.033	1.000		
TRAINING	0.406[a]	0.197	0.102	0.200	0.317[a]	0.332[a]	0.427[a]	−0.066	1.000	
PRICE	0.060	0.019	−0.100	−0.032	0.184	0.159	−0.046	−0.035	−0.165	1.000

[a] Significant at 1% level.
[b] Significant at 5% level.
[c] Significant at 10% level.

Table 6
Rotated component matrix of factor analysis and KMO values.

Energy saving activities	Components				KMO value
	1	2	3	4	
ESA1	0.243	0.404	0.127	−0.107	0.532
ESA2	0.537	0.125	−0.065	−0.143	0.678
ESA3	0.618	−0.039	0.165	−0.146	0.750
ESA4	0.625	−0.116	−0.239	−0.045	0.763
ESA5	0.299	−0.163	−0.133	0.449	0.508
ESA6	0.434	0.306	−0.093	0.144	0.597
ESA7	0.573	0.202	0.144	0.188	0.680
ESA8	0.544	0.16	−0.198	−0.13	0.751
ESA9	0.549	−0.013	0.106	−0.206	0.740
ESA10	0.465	−0.433	0.193	0.085	0.726
ESA11	0.53	−0.306	−0.024	0.027	0.741
ESA12	0.496	−0.182	−0.211	−0.046	0.725
ESA13	0.34	0.256	−0.188	0.114	0.610
ESA14	0.226	−0.077	0.389	−0.223	0.620
ESA15	0.243	0.148	0.421	0.337	0.440

Table 7
Definition and valuation of the sub-category of ESA items.

Abbreviation	Description of the sub-category	Valuation
ESA_{IN}	Firm's internally independent energy saving activities	Sum of scores of ESA2 to ESA4 and ESA6 to ESA13
ESA_{Ex}	Energy saving activities in cooperation with governments	Sum of scores of ESA14 and ESA15
ESA_{INF}	Information collection for energy saving	Score of ESA1
ESA_{SA}	Company's efforts to adjust energy consumption structure	Score of ESA5

of 2011. This survey was conducted in early 2011 and the surveyed companies might not know how to prepare for this new regulation at the survey time. In spite of the effectiveness of regulations in enhancing a company's energy performance confirmed in some other literature (e.g., Jones, 2010; Pellegrini-Masini and Leishman, 2011), the surveyed SMEs in Korea are still not sufficiently influenced by regulative pressures at present.

As the proxy of normative pressure, the variable of 'ASSOCIATION' shows no significant influence on a company's energy saving practices. SMEs are usually lack of funds and expertise for investment and technological innovation. It is apparently necessary for them to rely on the available networks, including industrial association of the same sector, for seeking external support and cooperation opportunities (Hong, 2004). Therefore, the industrial association has strong impact on business operations of SMEs (Palm and Thollander, 2010). Our survey confirms the importance of industrial associations for the companies in Korea, as listed in Table 4. However, the industrial associations still do not play a significant role influencing the SMEs to improve their energy efficiencies. The industrial associations shall be a bridge between the government and individual companies since they well known the company's opportunities and actual needs while the government usually does not (Chappin et al., 2008). In the near future, the Korean industrial associations are expected to play more active role in supporting company's energy saving as the sector representative. In contrast with the result of previous study in China, we can not confirm the significant relationship between the externally mimetic pressure, with 'COMPETITOR' as the proxy, and a company's energy saving practice level (Liu et al., 2012).

Regarding the internal factors, 'WILLINGNESS' shows significant and positive relationship with *TESA*. This reveals that Korean company's ESA involvement level would be partly attributed to its own strategy orientation under current situation of laggard government regulations and weak normative pressure from industrial associations. The positive and significant impact of 'TOPSUPPORT' confirms the needs of support from top managers in a company's energy saving practices, particularly for the SMEs in this survey. While 'EDUCATION', as a variable representing learning capacity, has no significant relationship with *TESA* (ESA_{IN}), 'TRAINING', as another proxy, indicates significant and positive influence on a company's energy saving practices. Zografakis et al. (2008) confirmed that education can transform human behavior toward the rational use of energy and increase energy literacy. In this survey, the average educational level of the company's employees is not significant probably because their energy saving skill is mainly improved by internal trainings (Liu et al., 2012).

In terms of the controls, the company's size is significantly associated with *TESA* (ESA_{IN}). The large and medium-sized companies have better energy saving practices in comparison with small ones. This finding follows the resource-base perspective and is consistent with empirical studies documenting that company size has significant effect on the proactiveness, with larger organizations being more likely to adopt proactive environmental practices (e.g., Sharma, 2000). None of the other company's

Table 8
Ordered logistic regression result with *TESA* as dependent variable ($N = 64$).

	Model 1			Model 2			Model 3		
	Coef.	Std. Err.	*P*	Coef.	Std. Err.	*P*	Coef.	Std. Err.	*P*
REGULATION	0.233	0.293	0.427	0.214	0.295	0.468	0.141	0.303	0.643
EXPORT	0.345	0.157	0.028	0.353	0.158	0.026	0.113	0.224	0.614
ASSOCIATION	0.130	0.195	0.504	0.133	0.197	0.501	0.156	0.210	0.457
COMPETITOR	−0.122	0.348	0.725	−0.135	0.349	0.698	−0.118	0.380	0.756
WILLINGNESS	1.301	0.429	0.002	1.245	0.446	0.005	1.182	0.489	0.016
TOPSUPPORT	0.485	0.334	0.147	0.506	0.337	0.134	0.703	0.373	0.060
EDUCATION	0.147	0.215	0.493	0.161	0.215	0.456	0.306	0.252	0.225
TRAINING	0.451	0.298	0.130	0.476	0.302	0.114	0.575	0.323	0.075
PRICE				0.188	0.408	0.644	0.385	0.450	0.392
SIZE_Large							2.157	1.189	0.070
SIZE_Medium							1.552	0.833	0.063
SECTOR-Paper							−0.167	1.130	0.883
SECTOR-Chemical							1.014	1.052	0.335
SECTOR-Others							0.642	1.123	0.567
TMS							−0.063	0.708	0.930
OWNERSHIP-Domestic private							0.417	0.612	0.496
LR chi	31.51	31.72	37.13						
Pseudo R^2	0.099	0.100	0.117						

Table 9
Ordered logistic regression result with ESA_{IN} as dependent variable ($N = 64$).

	Model 1			Model 2			Model 3		
	Coef.	Std. Err.	*P*	Coef.	Std. Err.	*P*	Coef.	Std. Err.	*P*
REGULATION	0.113	0.284	0.690	0.105	0.284	0.712	−0.031	0.296	0.916
EXPORT	0.278	0.156	0.074	0.289	0.157	0.065	0.039	0.223	0.863
ASSOCIATION	0.083	0.196	0.670	0.089	0.198	0.655	0.099	0.211	0.641
COMPETITOR	−0.094	0.337	0.780	−0.125	0.340	0.713	−0.211	0.379	0.578
WILLINGNESS	1.264	0.432	0.003	1.207	0.439	0.006	1.163	0.479	0.015
TOPSUPPORT	0.634	0.339	0.061	0.666	0.342	0.051	0.939	0.392	0.017
EDUCATION	0.164	0.212	0.441	0.182	0.212	0.390	0.314	0.254	0.217
TRAINING	0.450	0.293	0.124	0.489	0299	0.101	0.628	0.326	0.054
PRICE				0.264	0.395	0.504	0.627	0.453	0.166
SIZE_Large							2.560	1.205	0.034
SIZE_Medium							2.140	0.873	0.014
SECTOR-Paper							−1.318	1.159	0.255
SECTOR-Chemical							0.505	1.054	0.632
SECTOR-Others							0.152	1.141	0.894
TMS							−0.020	0.704	0.977
OWNERSHIP-Domestic private							0.464	0.626	0.459
LR chi	30.7	31.15	40.05						
Pseudo R^2	0.103	0.105	0.135						

characteristics, including sector belongings, ownership and the involvement status of TMS, are significantly associated with *TESA* (ESA_{IN}). Different from the result of Prindle (2010) and Liu et al. (2012), confirming the energy price to be influential for company's energy efficiency, 'PRICE' indicate no significant relationship with energy saving practices of Korean companies in this survey.

5.7. Statistics of the supplementary survey questions

5.7.1. Status of energy saving subsidies received by the companies

MKE provides subsidies and tax credits to support the company's energy efficiency investment. The total budget in 2011 was 600 billion KRW (KEMCO, 2011). According to the result in Fig.2, approximate 40% of the respondents have the experience of applying for energy-saving subsidies from the governments. During the survey, the companies were requested to answer two additional questions for further understanding whether they know about this incentive policy and to what extent they have successfully obtained the subsidies from the governments in the past. The status of subsidies obtained from the governments is shown in Fig. 4.

More than half of the respondents (56.1%) knew about the subsidy policy encouraging the company's energy saving. Probably due to the limit volume of the subsidy budget, nearly half of the surveyed companies never received energy saving grants in the past. The ratio of the samples, which once received the subsidies from central government, is 39.4%. The ratios of the companies obtaining the subsidies from local governments are much lower. This confirms quite limited financial sources from the governments for industrial energy saving in Korea even economic incentives are the most preferable for the companies as described in the following Section 5.7.3.

5.7.2. Major barriers for company's energy saving

To measure the factors hindering a company's practice of ESAs, the surveyed companies were asked to rank seven listed barriers using a scale from one to five, with '1' representing not important at all and '5' being very important. Table 10 summarizes the statistics of the responses.

The respondents present moderate evaluations to all the barriers. The barriers of 'lack of economic incentive from the governments' and 'low energy efficiency of out-of-date production facilities' achieved the highest mean of 3.62 and 3.61. 'Lack of funds for upgrading production facilities' achieved a relatively high score (Averaged at 3.47). The sampled companies viewed their production facilities being low efficient. To encourage company's investment in the advanced energy efficiency technologies, the financial incentives may be essential. Since certain difficulty exists for SMEs to get commercial funding, they turn to expect financial support from the governments for energy efficiency improvement as a kind of efforts for public good. The others with high scores include 'lack of energy management specialists' (Averaged at 3.48), implying that the lack of capacities restrict the energy saving efforts of the surveyed SMEs.

5.7.3. Effective measures enhancing company's energy saving

In this survey, we asked the companies to rate the effectiveness of optional measures for them to practice ESA better. The valuation score is from one to five, with '5' being very effective and '1' meaning not effective at all. The statistical result is shown in Table 11.

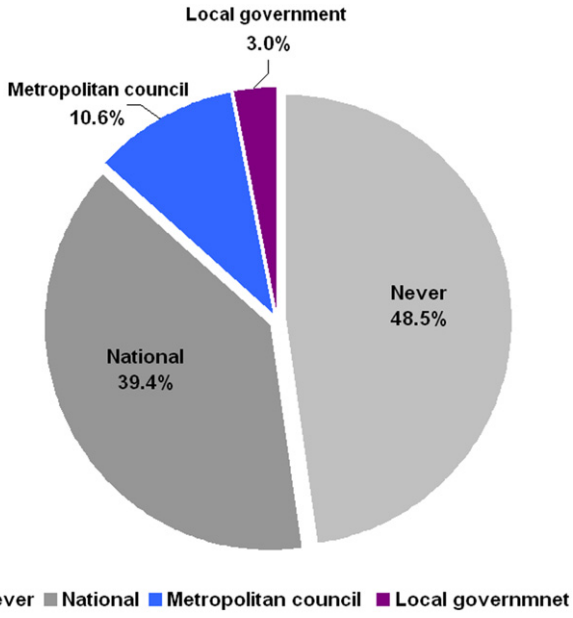

Fig. 4. Status of energy saving subsidies received by the companies ($N = 66$).

Table 10
Statistics of barriers for company's ESAs ($N = 66$).

Barriers	Obs.	Mean	Std. Dev.	Min.	Max.
Unclear of internal energy use status and saving potentials	66	3.06	1.11	1	5
Lack of awareness of employees on energy saving	66	3.21	1.02	1	5
Low energy efficiency due to out-of-date production facilities	66	3.61	1.04	1	5
Lack of funds for upgrading production facilities	66	3.47	1.13	1	5
Lack of information related to energy saving	66	2.97	0.86	1	5
Lack of energy management specialists	66	3.48	1.03	1	5
Lack of economic incentive from the governments	66	3.62	0.91	2	5

Comparatively, 'providing subsidies for energy saving' was ranked as the most effective method, with a mean of 4.29. Providing technical assistance satisfies the actual needs of SMEs in capacity building for energy saving and achieved relatively higher evaluations of effectiveness. For example, 'support to set up firm's internal energy management system' and 'providing information support for energy saving' obtained another two high means of 3.98 and 3.92, respectively. In overall, the companies view the listed measures useful and gave all of them relatively high scores.

6. Conclusions

This study seeks to figure out the current status of energy saving practices of SMEs with high energy intensities in Korea and identify the determinant factors. The surveyed SMEs have become aware of the importance of energy efficiency and expressed strong willingness for energy saving. In practice, they prefer to perform the managerial activities. The technological ESAs with higher costs and difficulties achieved lower participation ratios (KID, 2008). The newly launched TMS, as the major mandatory regulation for large energy-consuming companies, and emerging discussions of carbon tax and GHG ETS have generated pressures for the companies. However, under a situation of laggard regulations and weak function of industrial associations, the company's energy saving practices are mainly attributed to their internal motivations at present.

Providing technical support is useful for enhancing the capabilities for energy saving and appreciated by the surveyed companies. Probably due to the difficulty for commercial financing, the respondents highly expect subsidies from the government. With the regulations providing pressures for the laggard companies, energy saving subsidies may function as a strategy encouraging the efforts of good performers (Lee et al., 2010). Due to the limited budget available and the momentary role of subsidy policy, it is necessary to consider the other economic instruments, which may appropriately define the externalities of energy use and carbon emissions. Korean government also needs to expand the scope of mandatory regulations to gradually cover the large amount of companies with less energy consumptions for enhancing their energy saving practices by regulative tools.

This study has several shortcomings. The survey relies on the company's self-reporting for data collection. Although the respondents may represent Korean energy-intensive SMEs, quite limited number of samples may lead to some bias for the generalization of analysis results. The survey time was too close to the starting time of TMS. The effectiveness of this mandatory policy in enhancing energy saving practices of companies could not be observed in this survey. Keeping a track on the behavioral changes of companies on energy saving in response to the progress of related policies would be useful for understanding the appropriate and effective policy direction.

Table 11
Statistics of effective measures for company's energy saving.

Possible measures	Obs.	Mean	Std. Dev.	Min.	Max.
Promote the establishment and enforcement of regulations	66	3.94	0.76	2	5
Providing subsidies for energy saving	66	4.29	0.82	2	5
Providing credit for energy saving efforts	66	3.86	0.91	2	5
Providing advantage for financing (Soft loan, etc)	66	3.82	1.01	2	5
Support to set up firm's internal energy management system	66	3.98	0.92	1	5
Proving technical support like energy audit	66	3.74	0.97	1	5
Providing information support for energy saving	66	3.92	0.88	1	5
Strengthening training for energy saving	66	3.86	1.08	1	5
Cooperate with business partner for energy saving	66	3.62	1.02	1	5

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