Current Status and Implications of Energy Efficiency Programs in Korea

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ABSTRACT

The energy supplier in Korea, Korea Electric Power Company (KEPCO), is currently implementing an energy efficiency program offering a subsidy to energy consumers who purchase high efficiency equipment. KEPCO provides a subsidy to install high efficiency equipment; certified lighting, transformers, and Variable Speed Drives (VSD). Thus, to evaluate the planning and results of the program, economic analyses from various perspectives are required. The California Standard Practice Test (CSPT) has been widely used in Korea to analyze the economic performance of energy efficiency programs because of the advantages it provides for analyzing cost and benefit by stakeholders (program administrator, participant, rate-payer, and total resource). This study presents the results of evaluation of energy efficiency programs in Korea by applying the CSPT. As a result of economic evaluation, most programs have cost-effectiveness except energy welfare program.

1. Introduction

The increasing energy consumption, corresponding environmental problems, and restricted economic activities associated with high oil price are now the foremost global issues. Thus, countries around the world no longer only focus on industrial growth and economic development. They have instead focused on preparing, formulating, and implementing diverse policies and measures to respond to the new environmental changes. Likewise, Korea is implementing diverse policies to address with climate change and reduce energy use. Among these measures is the program for improving energy efficiency to provide energy to users at a reasonable cost. However, in pursuing the energy efficiency program, it is difficult to determine the scale of investment and appropriate levels of subsidies to encourage the market to adopt high efficiency equipment. To address this challenge, it is imperative to determine the cost-effectiveness of investments in efficiency improvement.

In case of the US, the California Standard Practice Test methodology has been established to evaluate the economic feasibility and quantitative aspects of the demand side management programs from various perspectives. This evaluation test has been adopted in the US and numerous countries around the world (CEC & CPUC 2001). One of the greatest strengths of CSPT is in examining cost-effectiveness by stakeholder. Thus, since the early 2000s, Korea has been actively using CSPT to conduct cost-effectiveness analyses for demand side management. This test is mainly applied in the electric power sector, and research is underway to apply this method in the gas sector. To spread high efficiency equipment widely, Korea is implementing subsidy programs for the new installation or replacement of specific equipment. Thus, in this study, a cost-effectiveness analysis of energy efficiency subsidy programs implemented in 2010 was conducted based on CSPT.

This paper is outlined as follows. Chapter 2 presents the current energy efficiency subsidy programs in Korea. Chapter 3 discusses the cost-effectiveness analysis and procedure of energy efficiency programs using CSPT. Chapter 4 suggests the implications and future directions of the energy efficiency program and policy.

2. Energy Efficiency Subsidy Programs of Korea

2.1 Overview

The energy efficiency subsidy program has been implemented as a part of the investment program of energy suppliers for demand side management by the Rational Energy Utilization Act. Figure 1 exemplifies the energy efficiency program being implemented by the electric power supplier, KEPCO (MKE 2011).

First, the Ministry of Knowledge Economy (MKE) has the responsibility to formulate the overall energy efficiency policies and functions as the regulator. The Electric Power Public Tasks Evaluation and Planning Center is responsible for operating the public electric infrastructure fund of the power industry. The Project Director of DSM, as an expert of DSM, is responsible for planning and evaluating the energy efficiency programs. Next, Korea Energy Management Corporation (KEMCO) has the responsibility to supervise, evaluate plans and results of energy efficiency programs. Finally, consumers apply for subsidies with KEPCO if they have installed the high-efficiency equipment or requested the old ones to be replaced. KEPCO checks their applications and pays subsidies to the consumers.

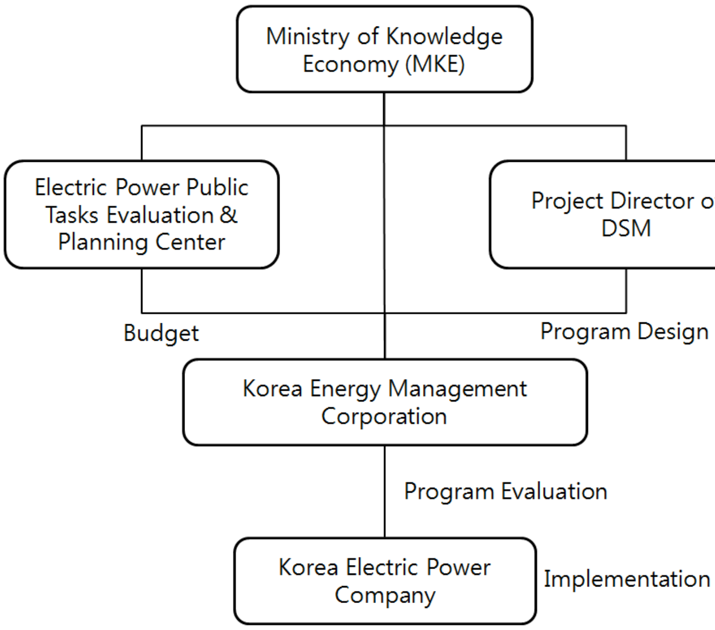

Figure 1. Implementation System of Korea's Energy Efficiency Program

The energy efficiency subsidy program, started in 1993 to support high-efficiency lighting equipment, is now being implemented across a wide range of areas encompassing high-efficiency lighting, VSDs, transformers, and other energy welfare programs. Table 1 shows the energy saving results of the energy efficiency subsidy programs implemented for recent three years, from 2008 to 2010. The table shows the annual amount of energy savings of the program implementer, KEPCO, as reported to the government (KEPCO 2009, 2010, and 2011).

Table 1. Energy Reduction Results by Energy Efficiency Program, 2008–2010 (Unit: GWh)

Program	**2008**	**2009**	**2010**
Lighting	142.9	57.6	163.1
VSD	365.7	111.2	130.2
Transformer	10.5	5.1	31.0
Energy Welfare	34.4	30.4	14.1
Total	553.5	204.3	338.4

Savings of the above table were estimated by the number of subsidized units which was reported by KEPCO by annual basis and they are not total lifetime savings. Local offices of KEPCO are responsible for inspection of subsidized units in their jurisdiction and reporting the number of high efficiency equipments to the head office of KEPCO. Because Korea does not take into account free-riding and spill-over effect, all savings data are gross.

2.2 High Efficiency Equipment Subsidy Program

The subsidy program for high-efficiency lighting equipment began targeting electronic ballast for high-efficiency certified fluorescent light and bulb type fluorescent light in 1993. The program of introducing high-efficiency lighting primarily aims to reduce electric energy consumption. The equipment that received government support include 32W electronic ballast, compact fluorescent lamp, high efficiency metal halide lamp and ballast, and light-emitting diode (LED). In addition, the energy welfare program targeting low-income family and social welfare facilities, where the replacement of existing low efficiency lighting device into energy efficiency lighting device is conducted free of charge, has been promoted since 2004. The current subsidy levels are shown in the tables in the Appendix.

The program for the high efficiency VSD provides a subsidy to install VSD on power equipment with loads between 3.7kW and 220kW that do not have any VSD. The level of subsidy depends on the reduction in energy consumption.

The program for high efficiency transformers provides subsidy for the purchase of certified high-efficiency three-phase transformers with primary rated voltage of less than 22 kW. It has a 100-kVA to 3,000-kVA capacity with a reduced electric power per transformer of about 0.8 kW to 10.6 kW. The subsidy from 267-3,533 EUR per unit is paid according to the capacity of the transformer (see Table A-5).

3. Economic Evaluation of Energy Efficiency Programs

3.1 Overview

The general economic evaluation indices, which are used in analyzing the feasibility and cost-effectiveness of a business or project, include net present value (NPV) for the duration of the project, benefit-cost ratio (B/C ratio), payback period, and internal rate of return (IRR). The CSPT, developed by the US CPUC and CEC in the 1980s, is widely used in Korea and other countries around the world (CEC and CEC 2001) to analyse the cost effectiveness of demand side management programs such as the energy efficiency programs, The CSPT is based on four tests: program administrator cost test (PACT), participant cost test (PCT), ratepayer impact measure (RIM), and total resource cost test (TRC). The following Table 2 presents the key question answered and summary approach for each test (EPA 2008).

Table 2. Cost-Effective test of CSPT

Program	Key Question Answered	Summary Approach
PACT	Will utility bills increase?	Comparison of program administrator costs to supply-side resource costs
PCT	Will the participants benefit from the measure?	Comparison of costs and benefits of the customer installing the measure
RIM	Will utility rates increase?	Comparison of administrator costs and utility bill reductions to supply-side resource costs
TRC	Will the total costs of energy in the utility service territory decrease?	Comparison of program administrator and customer costs to utility resource savings

Relevant cost and benefit indices vary according to each stakeholder's perspective. The economic indices consist of:

- Avoided costs: avoided power infrastructure construction, i.e. power plant, transmission and distribution network construction, costs by peak demand reduction; and avoided energy costs by reduced fuel consumption in power generation.
- Program costs: equipment installation costs incurred when consumers replace or newly install the energy efficiency equipment.
- Administrative costs of program implementers.
- Subsidies paid to customers.
- Bill reductions achieved by the energy saving of program participants.

Table 3 shows the benefits and costs from each stakeholder's perspective based on the CSPT.

Table 3. Benefit (+) / Cost (-) Indices for Each Test

Index	PACT	PCT	RIM	TRC
Avoided Cost	+		+	+
Installation Cost		-		-
Administrative Cost	-		-	-
Subsidy	-	+	-	
Bill reductions		+	-	

The economic evaluation of the investment in the energy efficiency program first needs the definition of equipment's lifetime and discount rate in order to convert the total cost and benefit which are outcomes over its lifetime into present values. Therefore, this paper applied 6.5% discount rate which depends on KEPCO's financial status. It was provided by KEPCO for economic evaluation of the DSM. Table 4 represents expectancy lifetime which was determined by experimental result for each energy efficiency measure (KEPCO 2011).

Table 4. Expected Lifetime by Measure

Measure	Expected Lifetime(yr.)
32W Electronic Ballast	7
CFL	3
High Eff. MH Lamp	4
VSD	15
High Eff. Transformer	15

Figure 2 presents the economic evaluation procedure and input indices with regard to the energy efficiency program implemented in this study.

First, based on the amount of dissemination in the relevant year, the energy efficiency equipment installation costs and the incentives (subsidies) are calculated. Then the annual energy and peak savings are calculated, while considering the operating hours and the coincident factor for peak hours. All savings are deemed savings (ex ante and ex post). Next, the annual avoided costs and the energy sales revenue reduction (bill reduction of the customer) of the electric power company are calculated. These costs or benefits are generated during the lifetime of the equipment, and these are converted into present value by applying the equipment's lifetime and discount rate. The administrative costs including the labor costs and marketing and outreach costs of the program implementer were reported by KEPCO and added. Finally, the benefit/cost ratio for each test is calculated.

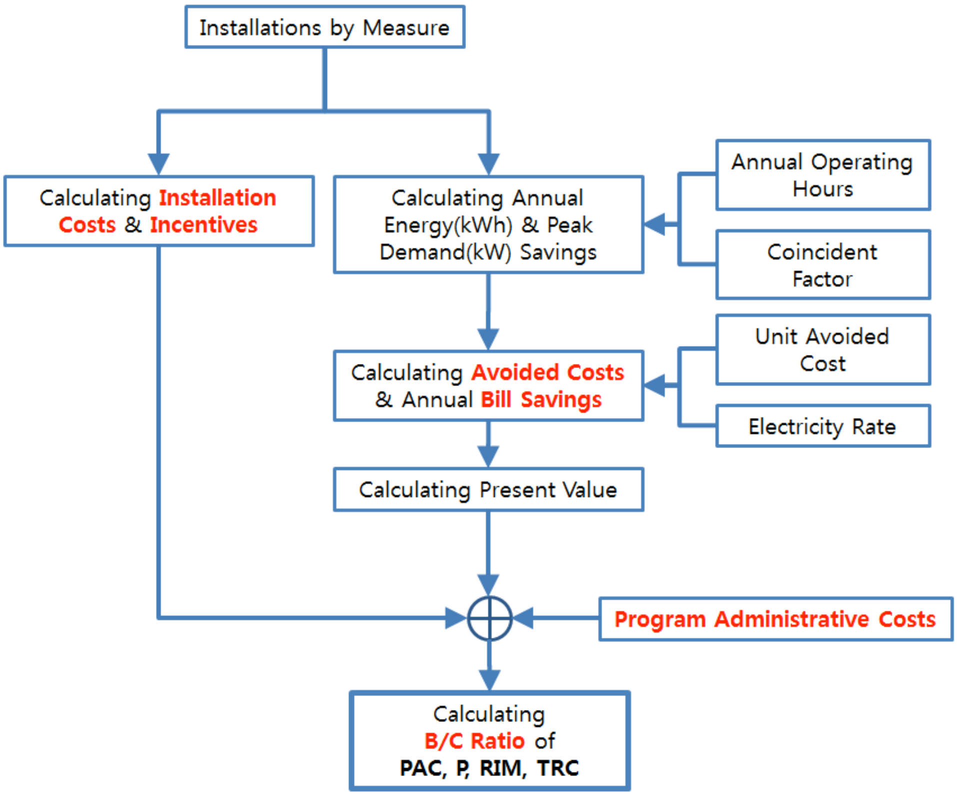

Figure 2. The Flow Chart on Economic Evaluation

3.2 Results of Economic Evaluation by the Program

Table 5 shows the results of the calculation of each item of the energy efficiency subsidy program for its economic evaluation. These values were used as the basic data in the calculation of the B/C ratio from the each perspective of the CSPT.

Table 5. Calculation Results of Evaluation Factor by Program

Program		Energy Savings (MWh)	Peak Savings (MW)	Avoided Costs (kEUR)	Installation Costs (kEUR)	Incentives (kEUR)	Administrative Costs (kEUR)	Bill Reductions (kEUR)
Lighting	Electrical ballast	89,493.6	17.7	57,739	6,119	1,486	493	38,846
	LED	73,641.3	21.2	54,309	18,637	6,035	279	28,069
VSD		130,178.5	19.8	136,781	14,099	689	337	71,208
Transformer		30,995.5	3.5	20,802	5,280	974	332	19,287
Energy welfare		14,051	2.6	7,819	-	8,619	517	5,665
Total		338,360.0	64.8	277,451	44,134	17,803	1,957	163,075

Based on the aforementioned economic evaluation methodology of energy efficiency programs, the economic evaluation results of Korean energy efficiency programs for year 2010 are outlined as follows.

In the case of the lighting programs, electronic ballasts have a high B/C ratio from the PACT. On the other hand, in the case of LED, the focus of a recently introduced program, although its energy reduction ratio and subsidy level are high, its cost effectiveness is somewhat low due to its equipment cost, which is higher than that of electronic ballasts. The B/C ratio of PACT for VSD program turned out to be the most cost effective among the programs. Although transformer has the longest operating hours among high efficiency equipments, the B/C ratios are lower than VSD program due to its high equipment cost. In case of the energy welfare program, the B/C ratios were below 1 except PCT because their total installation costs are paid by the program administrator.

Table 6. Evaluation Results by Program (B/C Ratio)

Program		PACT	PCT	RIM	TRC
Lighting	Electrical ballast	29.17	6.59	1.41	8.73
	LED	8.60	1.83	1.58	2.87
VSD		133.31	5.10	1.89	9.48
Transformer		15.93	3.84	1.01	3.71
Energy welfare		0.86	∞	0.53	0.86
Total		14.04	4.10	1.52	6.02
Total (except welfare)		25.38	3.77	1.60	5.92

4. Conclusion and Implications

In Korea, policy decision makers regard the TRC as the most important index of policy priority. This is because TRC is an index of economic value from the national perspective. The B/C ratio of TRC for energy efficiency subsidy program in year 2010 was 6.02.

The energy efficiency programs are assessed for their effectiveness by analyzing the stakeholders' B/C ratio, evaluating whether to continue and expand the programs, and considering the portfolio of the entire programs. The B/C ratio analysis revealed that the programs' cost effectiveness was very good, suggesting that the programs offer benefits to all stakeholders.

However, for a more accurate cost-effectiveness analysis, the M&V should first be required. Korea, which has shown scant interest in M&V in the past, has recently strived to implement various energy policies by considering these agenda. Notably, the public's requests are being raised to assess and verify the energy efficiency programs. The fund, raised partly from the electric fees, should be rationally invested. Against such a backdrop, the verification system of energy suppliers' achievements has been implemented since 2011. Under these systems, energy suppliers will monitor and assess achievements through surveys and measurement, verified by third-party institutions.

Of course, from the total energy saving, as calculated through the M&V, the net energy savings needs to be calculated while considering the free-rider effect and the spill-over effect. Although Korea does not consider this factor, it will introduce after establishing the M&V schemes.

In conclusion, to prioritize energy efficiency programs and assess their necessity, more reliable and accurate evaluation should be ensured. To that end, the establishment of evaluation, measurement, and verification scheme is essential. Thus, the formulation of energy efficiency and policy direction can be better evaluated. In formulating energy resources plans, an accurate comparative evaluation of other supply side resources and priorities of investing resources will be determined.

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Appendix

This appendix provides the unit savings and the subsidy level of each energy saving measure. In the case of high efficiency electronic ballasts, unlike with other equipment, differentiated subsidies are provided according to the new installation and replacement of the equipment. Also, Korea use a deemed savings calculation without the onsite M&V.

Table A-1. Subsidy of High-Efficiency Electric Ballast

Type & Capacity		Unit Savings (W/Unit)	Subsidy (EUR/Unit)	
			New	Replacement
FPL T-5	32W Single	18	0.93	1.40
	32W Double	36	1.40	2.07
MH	150W	50	6.13	
	200W	70	6.67	
	350W	90	7.20	

Table A-2. Subsidy of High-Efficiency LED Light

Type/Capacity		Unit Savings (W/Unit)	Subsidy (EUR/Unit)
Internal converter	-5W	25	7.40
	5W–10W	50	9.00
	10W-	90	11.47
External converter	-5W	25	4.33
	5W-	50	5.00
Encased or fixed type	-14W	9	22.00
	-27W	18	45.33
	-33W	3	45.33
	33W-	9	60.00

Table A-3. Subsidy of High-Efficiency LED Exit Sign

Type/Capacity		Unit Savings (W/Unit)	Subsidy (EUR/Unit)
Single face	Small	3	6.67
	Medium	3	8.00
	Large	2	10.00
Double face	Small	6	8.67
	Medium	6	10.40
	Large	4	13.00

Table A-4. Subsidy of High-Efficiency VSD

Capacity (kW)	Unit Savings (kW/Unit)	Subsidy (EUR/Unit)	Capacity	Unit Savings (kW/Unit)	Subsidy (EUR/Unit)
3.7	1.3	71	45	15.3	765
5.5	1.9	106	55	18.7	935
7.5	2.6	145	75	25.5	1,275
11	3.7	212	90	30.6	1,326
15	5.1	289	110	37.4	1,621
18.5	6.3	357	132	44.9	1,945
22	7.5	424	160	54.4	2,357
30	10.2	510	200	68.0	2,947
37	12.6	629	220	74.8	3,241

Table A-5. Subsidy of High-Efficiency Transformer

Capacity (kVA)	100	150	200	300	400	500	600
Subsidy (EUR/Unit)	267	400	467	633	833	1,033	1,267
Capacity (kVA)	750	1,000	1,250	1,500	2,000	2,500	3,000
Subsidy (EUR/Unit)	1,267	1,700	2,567	2,567	2,700	3,433	3,533