DSM Potential Evaluation for Long-term Resource Planning in Korea

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ABSTRACT

DSM programs focusing on peak demand reduction in Korea have been implemented and at present time, try to reduce 4,000 MW amounting to 7% of 54,631 MW peak demand in 2005. The long-term power development plan is going to raise the goal of DSM program peak reduction to 11,000MW, 13% level of peak demand in 2020. Most of the DSM programs were focused on reduce peak demand in summer period using interruptible and voluntary programs. The current peak cutting programs consist of traditional billing incentive program and DLC for large customer. The latter is expected fundamental change in DSM programs during wholesale competition. In addition, this program initiated by government at the first stage will be moving towards DSM bidding in the electricity market during improvement of competition. The Korean government focus on maintain supply adequacy and mitigate price volatility in electricity market. So the DSM programs which obtaining demand-side resource are set as a priority of electricity policy. The key factors in DSM programs are evaluation of peak load potential by program during resource planning period. Most of peak load programs target cover large customer in commercial and industrial sector. At first, this paper suggest to approach analyze on demand resource assessment by end-use and identify achievable load potential by measures before implementation. And we estimate program potential during peak load period for the customer by several end-use like HVAC, lighting, driver, inverter, pump etc. And then we forecast DSM resource by suggesting methodologies by program during horizon years. Finally, we suggest the implementation process and DSM goal setting mechanisms considering program portfolio and cost effectiveness under constraints like supply option, budget etc.

1. INTRODUCTION

The objective of this paper is to assess DSM program potential for power development planning in Korea. This paper focused on demand reduction and energy saving estimation during the planning horizon more than 10 years. Our study relied on an analysis of historic annual data and demand forecast before DSM by government sources including in progress data of planning committee. The first step in the analysis is to develop a forecasting approach of peak reduction and energy saving by programs. Next is to conduct a simulation by alternative scenarios. Finally we suggest DSM performance target for long term resource plan. For these purpose new measurement & evaluation mechanism is being prepared for evaluating programs. It is required that the direction and goal of DSM programs should incorporate sustaining reduction of the peak load for preparing electricity supply/demand imbalance and expanding energy efficiency program for energy conservation and environment issues. Under this background, establishing goal and implementation mechanism of DSM should be preceded and developing effective program and strategy for achieving the above goals become major emerging issues in electricity industry. In particular, since the government wants to maintain adequate DSM resources through DSM investment, it is necessary to develop a new approach and program based on supply/demand balance analysis reflecting demand resource.

2. Peak Load Reduction Target in Resource Plan

2.1. DSM program

The DSM program in Korea has been implemented starting with rebate program in 1974 and seasonal time differentiation rate program in 1977. Since then, in 1990s energy high efficiency technology development was promoted such as electric ballast, compact fluorescent, thermal energy storage system and cooling storage system. In 2001, 3 new programs such as inverter, high efficiency motor, DLC (Direct Load Control) have been implemented.

DSM programs largely consist of load management rebate program, load management special rate program and energy efficiency program. The current programs are shown in Table 1.

Table 1. DSM Programs Status in Korea

DSM Programs			Purpose	Applicable Sector
Existing Program	Tariff System	Summer vacation period coordination rate	Peak Load Shedding	Commercial & Industrial
		Voluntary Energy Conservation Rate	Peak Load Shedding	Commercial & Industrial, Education
		Emergency Load Reduction	Peak Load Shedding	Commercial & Industrial
	Load Management	Cooling Storage System	Peak Load Transfer	Commercial & Education
		High Efficient Vending Machines	Peak Load Shedding	Commercial
		Direct Load Control(DLC)	Peak Load Shedding	Commercial & Industrial
		Remote control Air Conditioner	Peak Load Shedding	Residential & Commercial
	Energy Efficiency	Energy Efficient Lamp	Energy Conservation	Customer Above 6kW Saving
		Energy Efficient Inverter	Energy Conservation	Industrial Customer
		Energy Efficiency Motor	Energy Conservation	Commercial & Industrial
	Others	Gas Cooling System	Load Substitute	Commercial
ew Program	Load Management	Peak Load Management System	Peak Load Shedding	Commercial & Industrial
	Energy Efficiency	Energy Efficiency Pump	Energy Saving	Commercial & Industrial
		Energy Efficiency Transformer	Energy Saving	Large customer

2.2. Performance

After 1990s, due to high growth of peak load, difficulty of power plant financing, emergence of environment and siting issues, the construction of new power plant became difficult. Hence, the performance of peak reduction increased gradually. In 1995, the ratio of peak reduction relative to system peak load was about 3.9% and increased to 7.0% in 2000, 7.7% in 2004, and 8.6% in 2005, respectively. In 2006, the peak reduction of load management was increased to 6,669MW, 10.2%.

Table 2. DSM Performance in Korea

(Unit : MW, %)

	1995	2000	2002	2004	2005	2006
Generating Capacity	34,295	46,078	52,113	57,528	60,818	65,183
Reserve	7.0	12.4	13.9	12.2	11.3	10.5
Demand before DSM	31,085	43,866	49,234	55,519	59,787	65,663
Peak Load After DSM	29,878	41,007	45,773	51,264	54,631	58,994
Peak Reduction By DSM	1,207	2,859	3,461	4,255	5,156	6,669
DSM Performance (%)	3.9	6.5	7.0	7.7	8.6	10.2

※ Generating Capacity and Reserve Margin is based on summer peak load.

The peak reduction volume has been increased annually from 3,461MW in 2002 to 6,669MW in 2006. Among them, the volume of demand management program has been increasing from 2,530MW in 2002 to 4,423MW in 2006, covered 87.1% of total reduction. On the contrary, the portion of energy efficiency program accounts for 12.9% of total DSM programs, which remains relatively at a small scale. In past, the DSM policy has focused on load management because the stabilization of supply/demand imbalance.

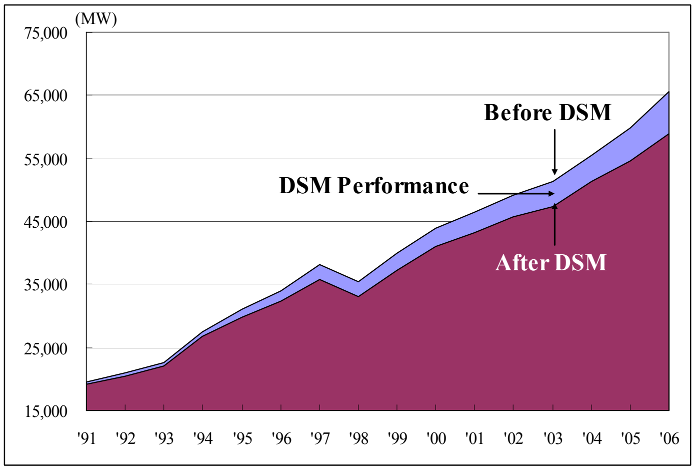

Figure 1. Peak Load and Peak Reduction

Table 3. Peak Reduction by Programs

(Unit : MW,%)

DSM Measures		2002	2003	2004	2005	2006
①Tariff System	SVPC	1,091	1,128	1,191	1,867	1,746
	VCER	*784*	*942*	*955*	*954*	*947*
	Sub Total	1,875	2,070	2,146	2,821	2,693
②Load Management Tool	Cooling Storage	230	268	323	340	385
	EE Vending Machine	1	4	5	5	6
	DLC	*421*	*768*	*1,040*	*1,320*	*1,286*
	Remote Control : Air conditioner	3	15	27	44	59
	Sub Total	655	1,055	1,395	1,709	1,736
③Energy Efficiency	Lamp	94	496	571	653	723
	Inverter	5	12	54	69	114
	Motor	0.8	3	9	8	15
	Sub Total	100	511	634	730	852
④Gas Air Conditioning		991	1,004	1,108	1,215	1,347
Others		831	236	80	-	1,388
Total		3,461	3,872	4,255	5,155	6,669

1) SVPC = Summer Vacation Period Coordination rate program
2) VECR = Voluntary Energy Conservation Rate Program
3) The values in ②, ③, ④ are accumulative total.
4) The actual amount of ‘Emergency Load Reduction’ & ‘DLC’ is not an executed value but a contracted one.

2.3. Target in the Resource Plan

Government reflects the performance of DSM to electricity demand/supply planning made every 2 years. That is, the government overviews performance by programs first and it applies to baseline demand forecast and maximum demand is determined by reflecting the performance of DSM.

Target of DSM varies at every planning and shows a trend that the ratio of DSM relative to system maximum load is continuously increasing. For example, 5th long-term power development plan established in 2000 had 5 new DSM programs and expanded energy efficiency programs, It targeted 7,430MW of peak reduction compared to 6.460MW in 1998.

Table 4. Target of DSM in Korea

Long Term Power Plan	Peak Load (MW) Before DSM	Peak Load (MW) After DSM	DSM Target (MW)	DSM Performance Rate (%)	Target Year
2nd Plan ('91)	-	48,155	1,930	3.4	2006
3rd Plan ('95)	70,852	65,642	5,210	7.4	2010
4th Plan ('98)	76,036	69,572	6,460	8.5	2015
5th Plan ('99)	74,939	67,509	7,430	9.9	2015
1st BPE ('02)	74,784	67,745	7,039	9.4	2015
2nd BPE ('04)	79,266	68,737	10,529	13.2	2017
3rd BPE ('06)	83,424	71,809	11,615	13.9	2020

※ BPE = Basic Plan of Long Term Electricity Supply & Demand

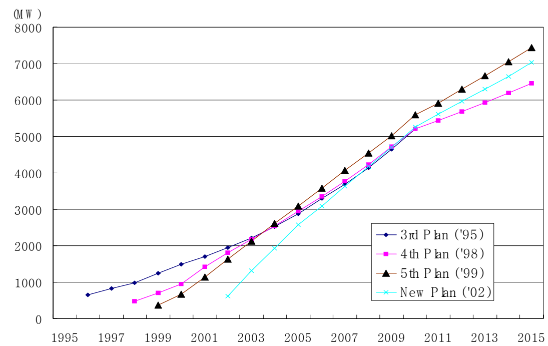

Figure 2. Goal of DSM Activities by Plan

In 2006, the 3rd Basic plan of long-term electricity supply & demand was established. In the target year 2020, the accumulated amount of DSM programs is 11,615MW, which is 13.9% of projected peak load.

3. Program Potential Projection

3.1 Basic Approach

Under the regulated circumstances, the basic direction for DSM target is oriented to long term feasibility considering maximum potential. Especially focusing on peak load reduction assigned in utility as a business performance index. In this study, we first reviewed past performance and trend, and then make trajectory curve using time series factor including extrapolation.

Generally, peak load programs are annually scheduled by utilities or government, considering achievable potential for measures, growth rate of peak demand, and the limitation of budget. In Korea, SVPC(summer vacation period coordination rate program) and VECR(voluntary energy conservation rate program) are implemented as typical peak load programs. Targets of these programs are scheduled respectively.

The first option to find the target or regional potential is an incremental approach. The target of some program in t year is calculated by the previous target in t-1 year and the growth rate of peak demand, as follows.

$$DSM_t = DSM_{t-1} \times \left(1 + \frac{(PL_t - PL_{t-1})}{PL_{t-1}}\right) \quad (1)$$

Where DSM_t , PL_t are the DSM target and the peak demand in t year respectively.

The second option is to use a trend analysis technique, by assuming the future trend would be determined by the past. Target during planning periods is estimated by extrapolation technique based on quadratic polynomial expression with 5 or 6 year recordings. The third option takes into account the market share of measures. The some portion of existing market is substituted to the new measures with policy makers' decision and effort. For example, the market share of high efficiency vending machine increased to 30% in target year or yearly base.

These options could be applied respectively to the program considering the nature of program and the amount of achievable potential.

3.2 Projection Algorithm

This paper suggest to approach analyze on demand resource assessment by end-use and identify achievable load potential by measures before implementation. The peak demand by end-use is calculated by estimated peak pattern and demand energy forecast.

$$Peak\ kW_i = August\ Sales_j \times \frac{August\ Peak\ Use_{i,s}}{Total\ August\ Use_{i,s}} \tag{2}$$

$$August\ Peak\ Use_i = Weekday\ Peak\ Hour\ Fraction_i \times Weekday\ Total\ Energy\ Use_i \tag{3}$$

$$Total\ August\ Use_i = \sum_j Number\ of\ Days_{i,j} \times Daily\ Use_{i,j} \tag{4}$$

$$Calibrated\ Peak\ kW_i = Peak\ kW_j \times \frac{Actual\ Peak\ kW}{\sum_i Peak\ kW_i} \tag{5}$$

And we estimate program potential during peak load period load for the customer by several end-use like HVAC, lighting, motor, inverter, pump etc. And then we forecast DSM resource by suggesting methodologies by program during horizon years. Finally, we suggest the implementation process and DSM goal setting mechanisms considering program portfolio and cost effectiveness under constraints like supply option, budget etc.

For estimate program potential by appliance and technology, we use Bass diffusion model as follows;

$$\frac{f(t)}{1-F(t)} = p + qF(t) \tag{6}$$

Where parameter p is the coefficient of innovation, q is coefficient of imitation, $f(t)$ is the probability of adoption at time t, and $F(t)$ is the accumulated probability of adoption at time t.

Demand $n(t)$ and accumulated demand $N(t)$ are formulated with previous diffusion model and market potential m , as follows.

$$N(t) = m\frac{1-e^{-(p+q)t}}{1+\frac{q}{p}e^{-(p+q)t}} \ \&\ n(t) = m\frac{p(p+q)^2 e^{-(p+q)t}}{(p+qe^{-(p+q)t})^2} \tag{7}$$

Ultimately, we have to determine three unknown parameters, m, p, q . These parameters may solved using a market survey, political decision, analytical solve method with recordings for some years.

4. Simulation

4.1 Load management Program

In this paper, we simulated two load programs – SVPC, VECR - in Korea. The target of SVPC, peak load reduction by adjusting vacation or maintenance schedules, is determined by using load shape data. The annual target is estimated by load shape data of Korea in 2003. Table 5 shows the simulated target for SVPC from 2006 to 2020.

Table 5. Targets for Load Program

(Unit : MW)

Year	SVPC			VECR		
	Ind.	**Biz.**	**Total**	**Ind.**	**Biz.**	**Total**
2006	1,303	52	1,355	893	26	919
2007	1,352	57	1,408	930	29	959
2008	1,445	62	1,461	966	31	998
2009	1,488	671	1,511	1,001	34	1,035
2010	1,531	77	1,560	1,034	38	1,072
2011	1,572	82	1,608	1,067	41	1,107
2012	1,572	87	1,654	1,099	44	1,143
2013	1,611	93	1,699	1,130	47	1,177
2014	1,651	99	1,744	1,161	50	1,211
2015	1,692	104	1,791	1,194	54	1,247
2016	1,731	104	1,836	1,225	57	1,282
2017	1,771	110	1,880	1,256	61	1,316
2018	1,811	114	1,925	1,288	64	1,352
2019	1,852	119	1,971	1,321	68	1,389
2020	1,894	123	2,018	1,354	72	1,426

In the target year 2020, target for SVPC is 2,018MW, 17.4% of total DSM reduction 11,615MW. The target of VECR, average load reduction during summer afternoon peak hours, is estimated by load shape data of Korea in 2003. Results for planning years are shown in Table 6. In 2020, the target amount of VECR is 1,425MW and the industrial sector account for 95% of the target amount.

4.2 Energy Efficiency Program

In this paper, three energy efficiency programs - high efficiency lighting, inverters for improving motor efficiency, and high efficiency motor – are simulated for the scheduled target of those measures during the planning period(2006~2020). The estimated parameters by programs are as shown in table 6. And Figure 3 to Figure 5 is shown the forecast result of each program by measures.

Table 6. Results of parameter for Bass model

High Efficiency Programs			Market Potential	Coefficient of Innovation	Coefficient of Limitation
Lighting	Electronic Ballast (32W)	1-unit set	70,319,369	0.01471	0.12814
		2-unit set	402,089,43	0.0097	0.12059
	Energy efficient compact fluorescents		15,569,843	0.0351	0.05528
Inverter	50Hz		251,239	0.007574	0.27405
	55Hz		13,387,093	0.000149	0.12172
Motor	Medium/Large		520,588	0.00596	0.23248
	Small		2,521,535	0.01429	0.26886

Table 7. DSM Target by programs (2006 – 2020)

Year	Demand Side Management								System Peak Demand	Ratio (%)
	Load Management			Energy Efficiency						
	SVPC	VECR	sum	Lighting	Motor	Inverter	sum	Total		
2006	1,355	919	2,274	80	13	40	133	2,407	58,990	4.1%
2007	1,408	959	2,367	163	29	87	280	2,646	59,680	4.4%
2008	1,461	998	2,459	248	49	145	441	2,901	61,390	4.7%
2009	1,511	1,035	2,546	333	73	214	620	3,166	62,990	5.0%
2010	1,560	1,072	2,632	419	102	296	816	3,448	64,610	5.3%
2011	1,608	1,107	2,715	504	136	393	1,033	3,748	65,940	5.7%
2012	1,654	1,143	2,797	587	177	505	1,269	4,066	67,120	6.1%
2013	1,699	1,177	2,875	669	223	634	1,526	4,401	68,090	6.5%
2014	1,744	1,211	2,956	747	276	779	1,802	4,758	68,830	6.9%
2015	1,791	1,247	3,038	822	334	938	2,094	5,133	69,470	7.4%
2016	1,836	1,282	3,118	893	396	1,109	2,398	5,516	70,050	7.9%
2017	1,880	1,316	3,197	960	461	1,287	2,708	5,904	70,540	8.4%
2018	1,925	1,352	3,277	1,022	525	1,469	3,016	6,293	71,030	8.9%
2019	1,971	1,389	3,360	1,079	588	1,649	3,316	6,676	71,410	9.3%
2020	2,018	1,426	3,444	1,132	647	1,824	3,603	7,047	71,810	9.8%

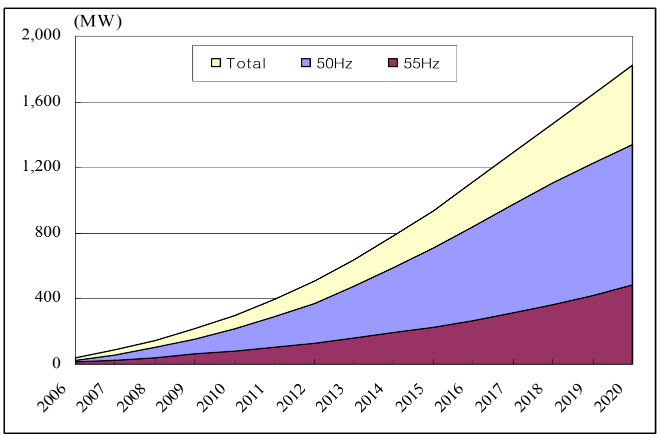

Figure 3. Target for Inverter

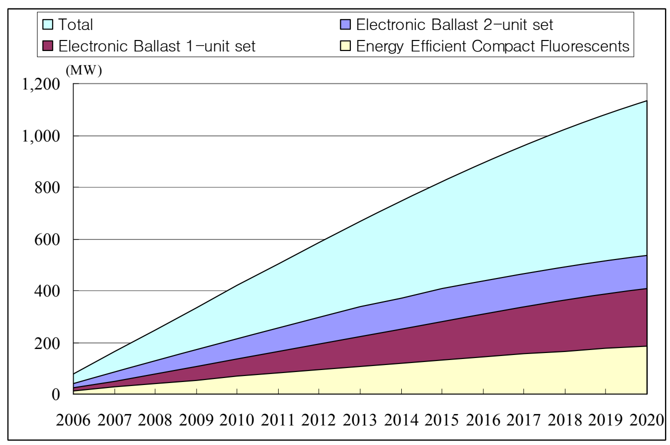

Figure 4. Target for Lighting

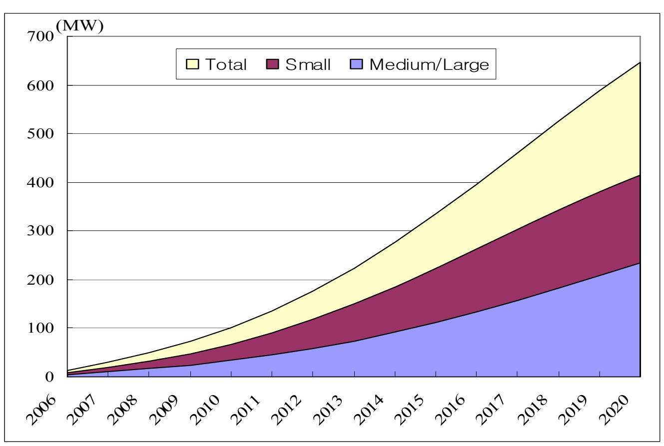

Figure 5. Target for High efficiency Motor

5. Conclusion

In Korea, long-term power development plan is very important as a resource adequacy target and energy balance in the nation. Especially the target after DSM is critical to determine total amount of capacity and technology selection. In this paper we suggest the way to analyze peak reduction and provide the results. The long-term peak reduction target and forecasting approach in the major programs would be measured and testified objectively through this study.

SVPC and VECR are very unique and flexible load programs in terms of their performance even though their peak reduction targets reach 70% of total DSM amount. Besides the specific data of energy efficiency measures is highly variable from application to application and was not available. Therefore the availability of data is the most significant factor for the detailed analysis of the future.

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