ESTABLISHMENT OF ESS BY CUSTOMER TYPE FOR OPTIMAL EFFECT AND ANALYSIS OF EFFICIENCY IMPROVEMENT OF POWER SYSTEM OPERATION THROUGH INSTALLATION OF ESS

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ABSTRACT

Energy policy is shifting from supply to demand management, and the need for ESS is increasing due to the energy conversion policy centered on renewable and clean energy. As a result, ESS special fare plans have been introduced to encourage customers to voluntarily install ESS.
In this paper, based on the results of ESS operation of each type of load of 127MWh battery installed by Kepco Energy Solution in 2017, we analyzed the effect of customer's business improvement and proper installation plan due to ESS special fare plan. In addition, we analyzed the effect of ESS installation on the customer load to improve the operation efficiency of power transmission and distribution system.

INTRODUCTION

Korea relies on imports for 97% of its energy consumption and has a manufacturing-centered economic structure.
In addition, according to various social issues such as increasing nuclear safety requirements and opposing the expansion of transmission networks, existing supply-oriented energy policies have reached their limits, and now government is shifting paradigms to demand management-oriented policies.
To this end, demand management is shifting from post management to supply shortage to proactive demand management to reduce the burden of supplying resources, and government is aggressively pursuing market transformation through policies that encourage voluntary demand management.
Besides, Korean government has established an energy transition policy to transform the power supply system of nuclear power plants and coal-based power generation to the center of renewable and clean energy. They are trying to convert 70% of coal power generation and nuclear power to renewable energy.
As a result, renewable energy supply will increase to 20% by 2030, more than seven times the current level.
As the energy paradigm shifts and the energy conversion policy increases the uncertainty of the power system, the need for ESS, especially in distributed power systems, is increasing.
Therefore, the government has created an ESS special fare plan, and it is encouraging voluntary participation by increasing the ESS installation profit of the customer.
In 2017, 'Kepco Energy Solution', an energy-efficient company, has launched a total of 127 MWh ESS installations for microgrid(or power distribution connected) applications in the public, general industrial(heavy industries, electronics, plastics, film, manufacturing, etc.) and general building sectors.
In this paper, based on this business experience, we analyze the effect of electricity cost reduction according to customer 's power consumption patterns, and propose a method of using optimal ESS suitable for domestic conditions.

< ESS special fare plan in Korea>
In order to induce voluntary ESS installation of the customer, the Korean government establish a new ESS special fare plan.
ESS special fare plan ①Discounts base rate based on average discharge amount during weekday maximum load time through ESS(the basic rate is limited) ②50% discount on the charge electricity fee during the light load period, ③Differential discount rate depending on ratio of ESS installation capacity to contracted power of customer.
In addition, the ESS special fare plan maximizes the customer's energy savings by ④Reducing the base rate due to peak load reduction, ⑤Reducing the electricity rate cost due to price difference of electricity unit rate by time zone, which are the common effects of ESS installation.

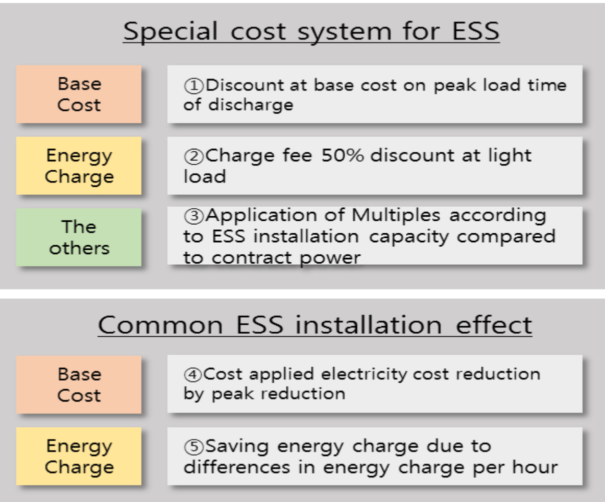

Figure1. Customer's benefit by installing ESS

In the case of base rate discounts based on ESS special fare plan,
"Monthly base rate reduction amount (kW) = [(discharge amount of weekday maximum load time period - charge amount of weekday maximum load time period) / (number of weekdays × 3 hours)]".
By the year 2020, three times discounts the above formula is recognized to promote ESS business.
In addition, plan apply a 50% discount on the charge period during the light load period and apply a weight of 0.8 ~ 1.2 times according to the installed capacity of ESS per customer contract capacity. (From January 2021, only the basic rate reduction amount of the above formula is recognized) [1]

OPERATION PLAN BY POWER CONSUMPTION PATTERN

IN CASE OF THE POWER CONSUMPTION PATTERN IS UNIFORM

If the consumer has the same level of power consumption pattern in the middle load time and the peak load time (typical industry: 24-hour manufacturing industry), it is hard to expect to ④reduce the applied electricity rate, which is a common ESS application effect.
Consumers with this pattern can reduce energy costs due to ESS special fare plan : ①Saving base rate based on average discharge amount during weekday maximum load time ②Saving the charge fee during the light load period, ⑤Saving the cost due to price difference of electricity unit rate by time zone.

'L' COMPANY CASE (Electronic Manufacturer) [2]
As a result of L company's business effect analysis with 13MWh ESS installed,
when the target peak is set and operated, the average daily cost of 1.2 million won / day can be saved,
when operating in the maximum load time zone discharge mode, it was shown to save 2.8 million won / day.
The total project cost was 6 billion won, and the investment payback period was 6 years.
Consumers with uniform consumption patterns showed that the reduction effect from the special fare plan is larger than the common reduction effect, and the business effect is 2.4 times different depending on the driving method even though the same special fare plan is applied.

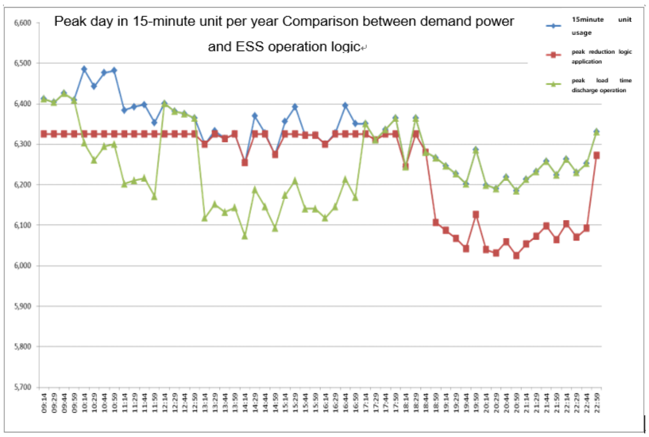

Figure2. L's Daily operation pattern according to ESS installation

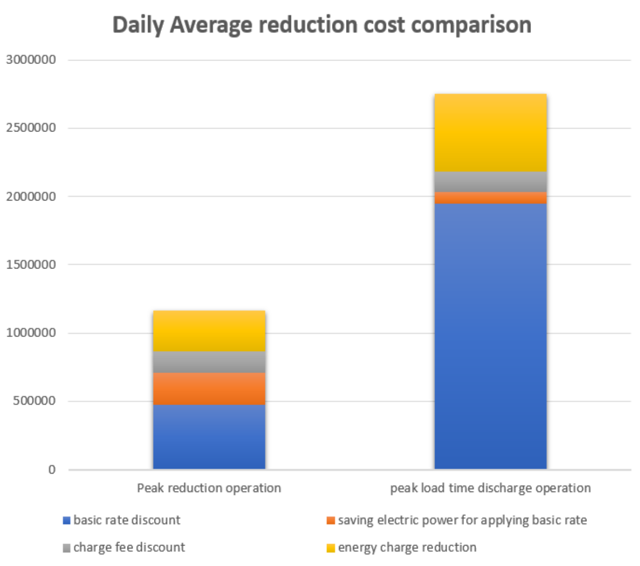

Figure3. Compared with the reduction items by operation pattern of 'L' (won/day)

IN CASE OF REMARKABLE PEAK LOAD PATTERNS

When the customer shows a pattern of power consumption in which the price applied power appears at the peak load time (representative industries: heavy industry, business buildings, etc.), the business effect is very good because it is applied not only to common ESS installation effect but also discounts based on ESS special fare plan.
The discharge mode and the peak reduction at the peak load time have the same effect.

'H' COMPANY CASE (Heavy Industry) [4]
As a result of H company's business effect analysis with 50MWh ESS installed,
the average daily savings can be reduced by 21.0 million won / year, and the investment payback period for the total project cost of 22.0 billion won was 3.7 years.

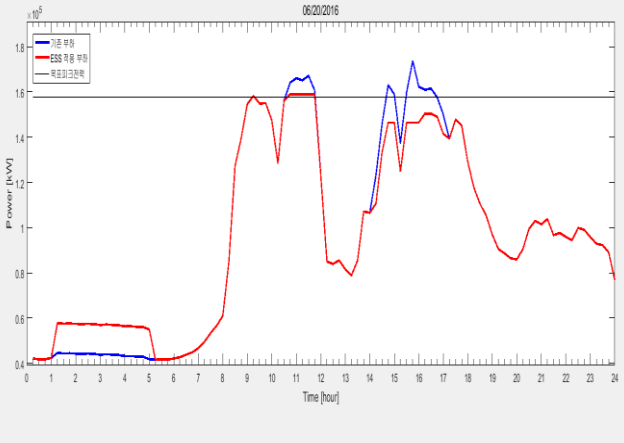

Figure4. H's Daily operation pattern according to ESS installation

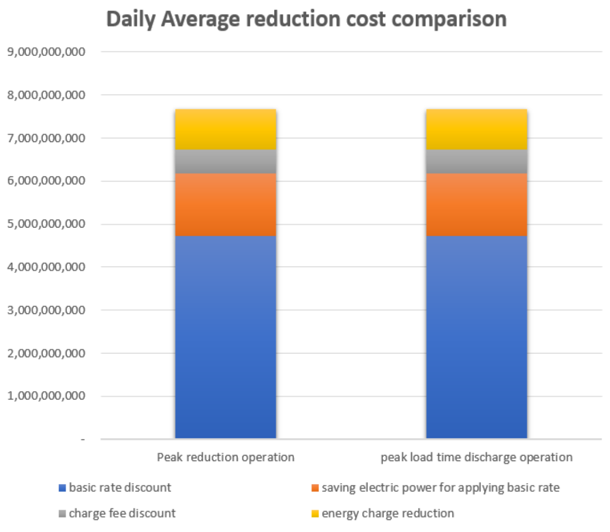

Figure5. Compared with the reduction items by operation pattern of 'H' (won/day)

As a result of analyzing ESS operation pattern by customer type, it was found that the rate of saving items varies according to the operation pattern due to the power system load. We also found that users with remarkable peak loads are more likely to benefit from the ESS business.

However, as the above two cases have limitations in analyzing the business effect according to the business expense, We analyzed the operation method according to the load characteristic through the average value of 13 customers installing 127MWh.

ESS OPERATION PLAN ACCORDING TO ESS SPECIAL FARE PLAN

In the case of the above two examples, it is not suitable to analyze the effect due to the special fare plan because the difference between the minimum and maximum value of the construction unit cost is 1.3 times due to the difference in scale.

We present the optimal ESS installation method based on the average value of actual business progress since the fluctuation is very large according to the supply timing of the battery, which accounts for 76.5% of the total construction cost.

The table below shows the business effects of the 100MWh ESS installation project.

The proportion of the savings due to the special fare system was analyzed as 71.8% ~ 83.8% depending on the type of customer load.

ESS Saving Effect Item	Average Amount (won/kWh*)	Rate (%)
ⓐCommon Effect(=ⓑ+ⓒ)	19,391	16.2
ⓑBase Rate Savings		0.0
ⓒElectricity Rate Savings	19,391	16.2
ⓓSpecial Plan Effect(=ⓔ+ⓕ)	100,641	83.8
ⓔ Base Rate Savings	92,137	76.8
ⓕ Electricity Rate Savings	8,504	7.1
ⓖTotal(=ⓐ+ⓓ)	120,032	100.0

* Average savings rate per installed battery capacity

Table1. Weight by items of reduced loads with uniform power consumption patterns

ESS Saving Effect Item	Average Amount (won/kWh*)	Rate (%)
ⓐCommon Effect(=ⓑ+ⓒ)	40.146	28.2
ⓑBase Rate Savings	20,730	14.6
ⓒElectricity Rate Savings	19,416	13.6
ⓓSpecial Plan Effect(=ⓔ+ⓕ)	102,160	71.8
ⓔ Base Rate Savings	93,647	65.8
ⓕ Electricity Rate Savings	8,513	6.0
ⓖTotal(=ⓐ+ⓓ)	142,306	100.0

* Average savings rate per installed battery capacity

Table2. Weight by items of reduced loads with remarkable peak load patterns

Item	PCS (won/kW)	Battery (won/kWh)	Electric Work (won/kWh)	Total Cost (won/kWh)
Min. Unit Price	107,696	272,547	41,580	361,636
Max. Unit Price	194,141	331,700	74,670	452,543
Average Unit Price	134,083	309,405	54,872	404,387

Table3. Average unit price by item

If the power consumption pattern is uniform, it is impossible to recover the investment cost due to the investment recovery period of 20.9 years in the absence of the ESS special fare plan, and the payback period of the investment cost can be shortened to 3.4 years due to the ESS special fare plan.
However, since the base rate is discounted at the limit of the amount of electricity applied to the fare, it is not necessary to install the battery capacity beyond the amount of electricity applied to the fare. On the other hand, it is necessary to design the C-rate as small as possible for the minimum construction cost.
Considering the Korean electricity tariff system, it is economical to design a business with a maximum load time of 6 hours/day, a PCS capacity is battery capacity divided by 6 hours, and a C-rate of less than 0.2.

If the peak load is smooth, the investment payback period in the absence of the ESS special fare plan is 10.1 years but the ESS special fare plan can shorten the investment payback period to 2.8 years.
In this case, the target peak should be first determined based on amount of electricity applied to the fare, the capacity of the PCS should be designed by the difference amount, and the battery capacity should be designed to replace the usage amount exceeding the target peak. Also, the C-rate is designed to be 0.5 level.
If the battery capacity remains above the target peak, the user will be able to obtain additional base rate discounts due to the special fare plan by discharging the remaining battery to the maximum load time zone.

CONCLUSION

Energy policy is shifting from supply to demand management, and the need for ESS is increasing due to the energy conversion policy centered on renewable and clean energy. As a result, ESS special fare plans have been introduced to encourage customers to voluntarily install ESS.
In this paper, we analyzed the ESS installation effect by customer load pattern of the 2017 ESS installation project carried out by Kepco Energy Solutions.
Due to the discount rate offered by the special fare system, the amount that can be saved for each type of customer load is as large as 10%, so ESS business can secure business feasibility and economy. Also, by designing the C-rate at 0.2 ~ 0.5 level for each customer type, the economical efficiency can be maximized.
In addition, it is confirmed that ESS can be used as a means to improve efficiency and economical efficiency in power system operators side by avoiding power transmission and distribution construction cost.
However, the problem is that customers are not able to secure business feasibility without the special fare plan because the cost to build ESS is high.
It is necessary to carry out a comprehensive review according to the ESS installation considering the simple saving cost, effect on the social ripple effect and system marginal price due to the system operation in the future.

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