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A Economic Feasibility Analysis of Energy Saving Technology Application to Underground Subway Station

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Abstract

In Korea, new total energy-saving solution has planned to build test-bed in underground subway station. Breaking energy is one of the most energy saving method in railway, but it has not be fully used up for economical purpose. This paper demonstrates on energy saving technology application including breaking energy and heating energy to underground subway station. It also offer solution of optimization of power energy flow. Moreover, economic feasibility analysis performed for undergound test bed constuction.

Keywords: *total energy-saving solution, underground subway station, breaking energy, economic feasibility analysis, test bed constuction, EMS(energy management system), ESS(energy storage system),* TLS(Thermal lining system).

1. Introduction

Nowadays, electric power consumption of the underground stations are increasing every year in South Korea. Moreover, electric cost increase exponentially based on the policy of utility company.

Electricity use in Seoul Metropolitan Rapid Transit is 490,171 MWh in 2011, but 627,851 MWh in 2013. It is increased to about 16.7 %. From 384 million [US$] in 2011 to 6.9 million [US$] in 2013, electric power prices is increased to 47.1 percent. The electric power cost per unit is increasing every year and peck power also become higher than before. Many trials for reducing energy consumption such as regenerative energy etc. is attempted, but it is limited to cut peak energy and reduce power consumption. Regenerative energy technology takes advantage of the vehicle from the side of the vehicle. Driving scheduling technology, power facility ventilation, lighting control system and renewable energy sources have been introduced and applied to railway systems separately. For example, less ventilation operation time, the more discomfort for passenger. Even though it is reducing power consumption, air quality is degraded. To use above individual trial is less effective. Because of key point of peak energy control, total solution for energy saving is required in order to get better result.

Here, three parts for energy saving can be discussed. First is energy generation, such as renewable energy,

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regenerative energy, and thermal lining system. This part is including energy conversion, energy saving, interconnection of the grids. Second is the optimization of energy use such as energy management system, ventilation. The last is the real application to test-bed for underground subway station. This paper is focused on economic feasibility analysis for total solution of energy saving. Next section shows that composing facilities such as ESS, EMS and TLS(Thermal lining system).

2. Energy saving technology

The energy flow in underground subway station is shown in Figure 1, which is composed of regenerative power system, ventilation, thermal lining with energy storage system.

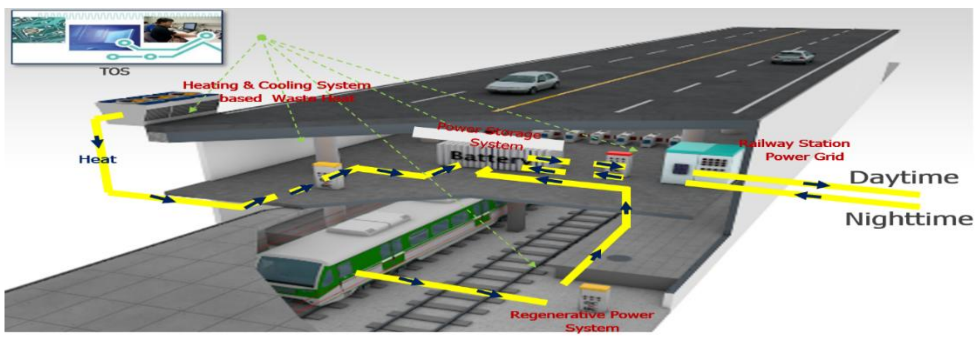

Figure 1. The energy flow in underground subway station

Energy management system called TOS is expected to be reduce 5~10 percent of peak power of railway substation. Maximum peak rush hour is 08 to 10 o'clock in the morning. When breaking energy is generated, the regenerative power is draining to nearby trains or to energy storage. The purpose of regenerative energy storage rises for 10 seconds is cut peak power about 15 minutes. Table 1 show the main facilities for energy saving.

Table 1. Main facilities of energy saving

	Specification	comment
Energy Storage System	500kWh	Li-ion, size, life
Power conversion	200kW	Output 380V, 90% and over efficiency
Thermal lining system		time reduction of ventilation
Ventilation Motor	317.4kW	High efficiency Blow, Inverter control

Regenerative energy is outstanding for energy saving. Average regenerative energy per day is calculated equation (1).

$$\text{ARE} = \text{ESS} * \frac{OT}{3600} * \frac{RFW*NWY+RFE*NEY}{365} \quad (1)$$

Where ARE : Average regenerative energy per day

ESS : quantity of ESS OT : generating time of breaking energy

RFW : regenerative frequency on weekday NWY : Number of weekday per year
RFE : regenerative frequency on weekday NEY : Number of weekend per year

For Thermal lining system, average energy saving is shown in equation (2). Ventilation fan for subway platform is just 4 hours per day in summer, 2 hours per day in spring and fall respectively.

$$\text{ARE} = \text{Fan} * \text{No.}* \, gain * (date\ Number) \tag{2}$$

Where Fan : energy quantity of ventilation, No. :Number of ventilation fan

Economic feasibility is focused on recovery year based on investment. Payback rule on applying to a break-even point is usually applied for 12 years as energy payback on investment. Suppose that economic feasibility is satisfied when recovery year is less than six years. Recovery year is indicated as followings

$$\text{Recovery year} = \frac{Investment}{Annual\ cash\ Flow*(Annual\ profit+depriciation\ cost)} \tag{3}$$

3. Case Study

Input of 1500V switchgear panel of substation is shown in figure 2. To interconnect ESS facility, existing panel of 1500V switchgear hooks up ESS incoming panel. Standard of cable is shown in table 2. For example, secondary rate current for rectifier is 333kV. The cable 6/10kV HFCO 150mm^2 1C X 1 can be applied.

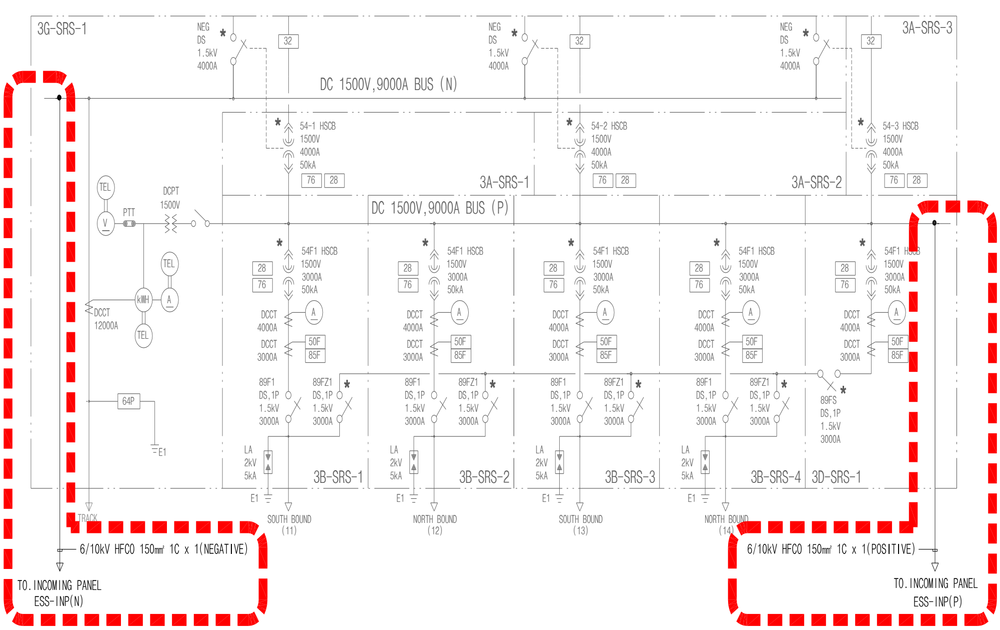

Figure 1. INPUT(DC 1500V SWITCHGEAR PANEL) in underground subway station

Table 2. cable parameters

FROM	TO	Standard
Solar cell module	DC-DC converter	0.6/1kV HF-CO 00 ㎟ 1C x 0
DC-DC converter	ESS	0.6/1kV HF-CO 00 ㎟ 1C x 0
ESS	PCS	0.6/1kV HF-CO 00 ㎟ 1C x 0
PCS	ATS-2	0.6/1kV HF-CO 00 ㎟ 1C x 0

As shown in table 3, regenerative energy is most important part than other facilities. Also, when the use of ESS is more effective for cut peak energy. Recovery year of each facilities is shown in table 4.

Table 3. Energy saving of A station in Korea

Facilities	Saving [kWh/day]	Saving ratio (%)	comment
Energy Storage System	(40)		Peak energy saving 5%
Regenerative Energy	840	18.1	Regenerative energy 70% Use
Thermal lining system	176	3.8	4hours/day
Ventilation Blower	158	3.4	SynRM (inverter control)
Energy Management System	232	5.0	5% energy saving
Total	1,406	30.4	

Table 4. Saving energy economic efficiency analysis

Facilities	Investment cost	Amount of savings	Recovery year
Regenerative Energy	100,000	37,497/year	2.3 years
Thermal lining system	131,007	1,430/year	10.6 years
Ventilation Blower	48,130	7,059/year	4.3 years
Energy Management System	273,000	12,956/year	7.6 years
Total	552,137	58,942/year	

From table 4, regenerative energy systems are the most effective. High-efficiency system with ventilation blower is also good choice for economic reason. For energy manage system, energy peak power and amount of electricity energy recovery is considered. Restoration of the economic and efficient energy is required to be readjust investment cost. However, TLS system is less effective and extends to require the heating and cooling system.

4. Conclusion

This paper deals with economic feasibility study in energy saving of underground subway station. From the analysis of energy saving, breaking energy and ventilation is the most important part of energy savings. The reason is the most productive for breaking energy and the largest electric load for ventilation. Even though TLS and EMS is fully satisfied with economic sense, the combination of regenerative energy and ventilation are add up energy efficiency.

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