

Economic Feasibility Analysis of PV Installation for a CES Apartment Complex

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Abstract— This paper analyses the economic feasibility of PV installation for a CES apartment complex in Seoul, Korea. PV installation cost is estimated based on the real PV installation for a building in the complex. PV power generation amount of the complex is estimated based on the real PV power generation data from ETRI, Korea. Real power consumption data for the CES from year 2015~2016 is used for the simulation of power cost saving. The simulation results show that the power purchase rate can be reduced as 34.2% by adopting PV power generation.

Keywords— Microgrid, CES, Smartgrid, photovoltaic, economic feasibility

I. INTRODUCTION

Renewable energy, especially photovoltaic power, is getting attention as a kind of inexhaustible and clean energy. Many countries, communities and individuals are already using photovoltaic system for more economic and eco-friendly energy consumption. This paper analyses the economic feasibility of PV installation for a Korean community energy system (CES) provider planning to adopt photovoltaic power system for more economic power generation and consumption for about 3,000 CES households in Seoul, Korea.

II. POWER CONSUMPTION OF CES COMPLEX

A. Introduction of CES

CES is a kind of service which provides self-generating power to the power users in the area of CES complex without going through the grid market utilizing power generating units under the certain capacity specified by the Electricity Enterprises Act in Korea [1]. CES A, the targeted CES provider in this paper generates heat and power using CHP (combined heat and power) and provides them to about 3,000 households in the CES apartment complex.

CHP power generators and boilers are operated using gas and the generated heat is used for hot water and heating. The power generated by CHP is provided to the CES households, and the shortage is purchased from KEPCO (Korea Electric Power Corporation) or KPX (Korea Power Exchange). Figure 1 shows the energy provision architecture when CES A constructs PV systems for power generation in addition to the CHP power generators.

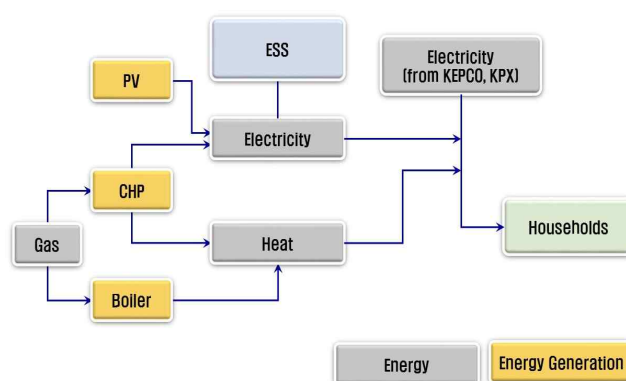


Figure 1. Energy purchase and provision of CES A with PV and ESS

B. Power Consumption of CES Complex

We got the power generation and purchase data for a year ('15. November ~ '16. October) from CES A. Monthly amount of power purchase and CHP power generation is shown in Figure 2.

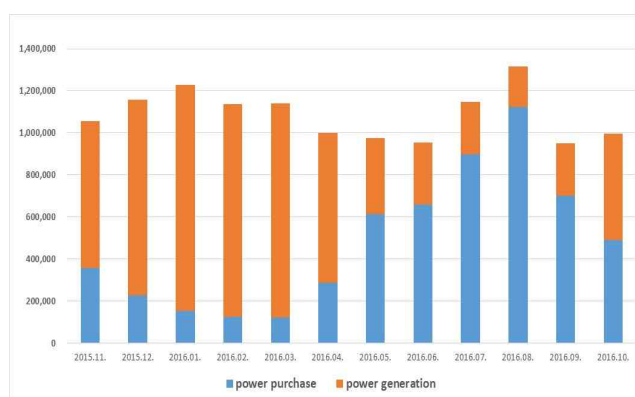


Figure 2. Monthly amount of power purchase and CHP power generation

The total power demand is the highest in January and August, since great amount of power is consumed for air-conditioning and heating in summer and winter. Unlike the total power demand, the portion of power purchase is the highest in summer and the lowest in winter, since CHP power generator is operated following the heat demand.

Power consumption patterns in the CES households are analysed by month and times in this clause, and the Figure 3

shows the real power consumption from '15.11 to '16.10. The power data is gathered every two hours, and the average of power consumption data for the middle of each month (from the 12th to 18th days) is used for power consumption patterns.

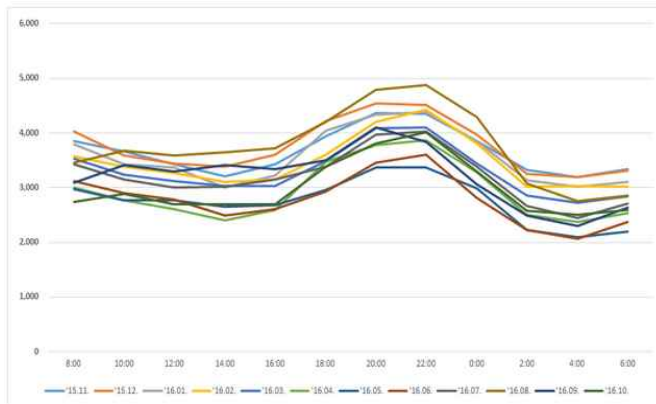


Figure 3. Power consumption pattern

Power consumption is the highest around the PM 10, and the lowest around AM 4, which is similar with the PV purchase rate system described in the following chapter.

III. ECONOMIC FEASIBILITY OF PV INSTALLATION

A. PV Installation Cost

There are several cost unit for PV system installation including PV panel purchase, power and communications line installation, inverter purchase, and so on. Table 1 summarized PV installation cost for about 3,000 households in the CES apartment complex.

TABLE 1. PV CONSTRUCTION COST

Item		Value	Note
PV capacity(kW)		50	for a complex
PV Construction cost (thousand won)	PV panel	35,000	for 50kW
	Power line	10,000	
	Communications line		
	Metering device	2,000	
	Inverter	20,000	
	Total cost	67,000	
PV construction area(m²)		16,060	3,000 houses
PV capacity per panel(W)		315	-
PV capacity(estimated, kW)		600	3,000 houses
PV construction cost(estimated, thousand won)		804,000	3,000 houses
PV construction cost per year(estimated, thousand won)		58,200	3,000 houses / year
PV operation cost(estimated, thousand won)		100	3,000 houses / year

As of the end of 2016, PV system is installed with the power generation capacity 50kW for a single building in the

CES complex. Total PV installation cost for the whole CES complex is estimated from the cost data of the single building.

When PV system is installed for the whole CES households, it is estimated that PV panels of about 600kW capacity can be constructed. The estimation is from the assumptions that:

- PV panels with 20kW are constructed in a single building in the CES with 530m²-area rooftop
- PV power generation capacity is proportional to the number of PV panels constructed on rooftops of the buildings
- Total area of rooftops for the CES households is 16,060m² (see Figure 4.)



Figure 4. CES Microgrid households in Seoul, Korea

Total PV system installation cost is converted into an annual cost considering that:

- PV panels, power and communications lines and metering devices can be used for 20 years
- Inverters can be used for 8 years

Power generation of PV panels are generally deteriorated by one percent per year, and they are recommended to be exchanged into new ones when the performance is degraded more than 20 percent.

B. PV Power Generation Data

We only can get real PV power generation data for the Seoul CES households from the early 2017 since PV installation is finished in the end of 2016. Therefore, we estimated the amount of PV power generation based on the real power generation and capacity data from PV systems in ETRI, Korea.

A little portion of PV data is omitted, and the omitted data is estimated using other existing data. When d is the day when some PV data is omitted, PV_{d-n+1} , the amount of PV power generation at time t in the day d , is estimated as:

$$PV_{d \cdot (n+1)} = PV_{(d-1) \cdot (n+1)} \times \sum_{t=1}^n PV_{d \cdot t} \div \sum_{t=1}^n PV_{(d-1) \cdot t}$$

with the assumption that PV generation data exists in the day d and $d-1$ from time 1 to n .

Although estimated PV power generation data is used instead of real PV data when analysing economic feasibility of PV installation in this paper, it is expected that PV data estimation does not have great effect on the accuracy of the result of economic feasibility analysis.

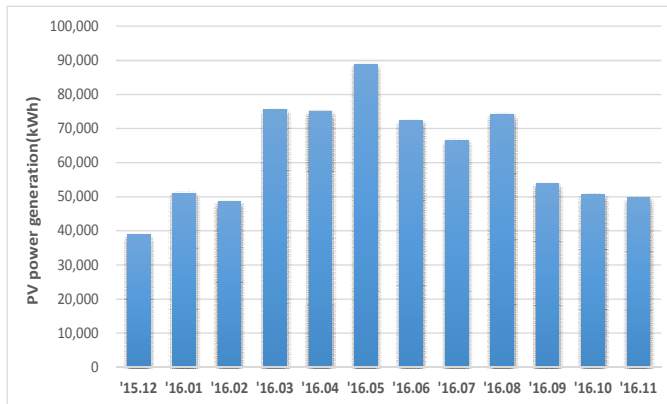


Figure 5. PV power generation(by month)

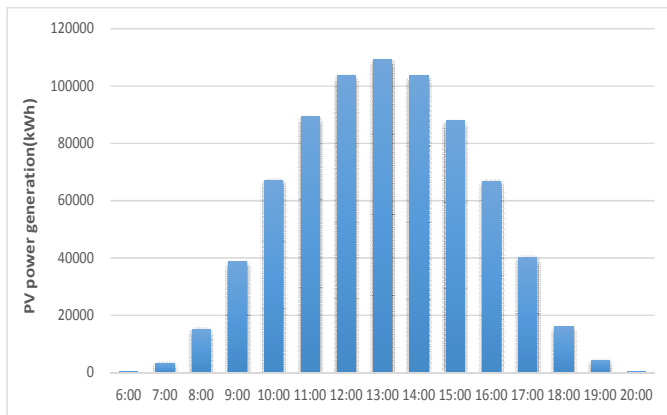


Figure 6. PV power generation(by time)

C. Economic Feasibility of PV System Installation

Korean CES providers follow a TOU (Time of Use) power rate system composed of base rate calculated based on maximum electric power for the previous 1 year and usage rate calculated based on the amount of electric power purchased. The basis rate for the usage rate varies according to the time zone and seasons.

Among KEPCO power rate systems, *CES A* follows *General Supplement Electricity Rate (High-Pressure A)* shown in Table 2[2].

For example, when the maximum electric power purchased during the previous 1 year is 2,308.8kW, the basic rate for the power usage in this month is calculated to be about 12,260 thousand won.

Figure 7 shows the cost of electric power purchased for the *CES A* from '15.11~'16.10.

TABLE 2. GENERAL SUPPLEMENT ELECTRICITY RATE(HIGH-PRESSURE A)

Base rate (won/ kW)	Energy charge(won/kWh)			
	Time zone	Summer (month 6~8)	Spring, Autumn (month 3~5, 9~10)	Winter (month 11~2)
5,310	Light load	74.2	74.2	74.2
	Heavy load	106.9	79.6	90.9
	Maximum load	155.5	93.6	110.4

(A) Energy Charge

Time slot	Summer	Spring/autumn	Winter
	June ~ August	March ~ May, Sep. ~ Oct.	Nov.~ Feb.
Light load	23:00~09:00	23:00~09:00	23:00~09:00
Heavy load	09:00~10:00	09:00~10:00	09:00~10:00
	12:00~13:00	12:00~13:00	12:00~17:00
	17:00~23:00	17:00~23:00	20:00~22:00
Maximum load	10:00~12:00	10:00~12:00	10:00~12:00
	13:00~17:00	13:00~17:00	17:00~20:00 22:00~23:00

(B) Season and Time slot

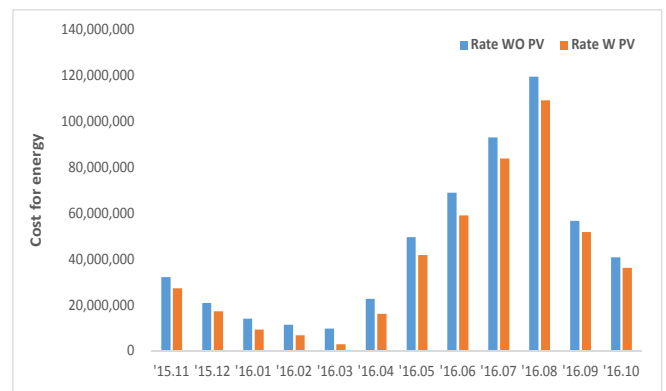


Figure 7. Cost for power purchase

The total power purchase cost for one year without PV system is about 540 million won and the cost with PV power generation is about 462 million won. The difference is about 78 million won. Considering that annual PV installation cost is about 58 million won, *CES A* can get 34.2% benefit from the PV power generation.

IV. CONCLUSIONS

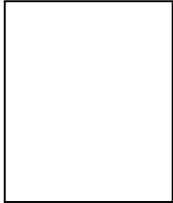
The result of economic feasibility analysis for PV system installation for about 3,000 CES households shows that the investment can get about 34.2% profit every year. However, the real revenue can be different since we used the estimated PV power generation data based on real data.

ACKNOWLEDGMENT

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REFERENCES

- [1] Electricity Enterprises Act, Korea
- [2] KPX(Korea Power Exchange), <http://www.kpx.or.kr/>



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