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A STUDY ON THE ECONOMIC EVALUATION AND THE ANALYSIS OF MCFC POWER GENERATION UNDER RPS SYSTEM

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ABSTRACT

Korean government has the goal to raise the power generation rate by New&Renewable energy to the amount of 11% within 2030. To achieve this target, the policy to promote New&Renewable energy industry and power production will be changed from Feed-in-tariff(FIT) to Renewable Portfolio Standard(RPS) in 2012. In the FIT system, each type of New&Renewable energy power generation has been alloted each amount of power production and power providers have been guaranteed fixed earnings directly from the gorverment agency(Korea Power Exchage, KPX) for fifteen or twenty years. So the business conditions of New&Renewable energy power production have been stabilized, but on the other side the financial problem of government has appeared in sight along with the expansion of New&Renewable energy power generation. So Korean government decided to introduce RPS system to promote the competition between New&Renewable energy industries and to solve the financial problem by putting the price decision function of RECs(Renewable Energy Certificates) to the market.

In this study, we analyzed the factors to influnce the costs and benefits of power generation fuelcell(MCFC) in the view of New&Renewable energy power providers under the RPS system compared with current FIT system. We focused on the below factors :

- Earning from SMP
- Earning from REC
- Earning from recovered Heat Sale
- Fuelcell system price
- Natural gas price
- Maintenance cost, etc

As POSCO POWER is unique provider of MCFC in Korea, we used the information about the costs of facilities and maintenance from this company. For the price of natural gas is determined by the international oil market, we used statistical price and the prospect report about increasing rate of oil and gas price from the EIA(Energy Information Administration). Korean government anticipates the price of REC would be determined by the specific REC market, but there is some possibility of failing to construct REC market because the number of obliged large-scale power providers is small. So, we considered the penalty of other countries as well as the anticipated REC price. Lastly we investigated the prospect of SMP considering newly planned nuclear power generation plants. In conclusion, we analyzed each component above and suggested the guideline about optimal investment(e.g. in the shape of REC vs IRR).

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1.1. Power Generation Fuelcell

The fuelcell is a high efficient and environment-friendly generation system which produces electric and thermal energy through an electrochemical reaction with hydrogen and oxygen, discharges a small amount of CO_2, hardly discharges NOx and SOx, and generates very low noise. If the hydrogen produced by fuel reforming reacts with air, DC power is produced, converted into AC power through an inverter, and provided through a power network. In general, a fuelcell from tens of kW to hundreds of MW is referred to as a power generation fuelcell, a phosphoric acid fuelcell (PAFC) and molten carbonate fuelcell (MCFC) are commercialized, and a solid oxide fuelcell (SOFC) is being developed.

Classification	PAFC [1st generation]	MCFC [2nd generation]	SOFC [3rd generation]
Development /Commercialization	1988/1992	1996/2001	(N/A)
Efficiency (Complexation)	37%	47% (60%)	60% (70%)
Electrolyte	Phosphoric Acid (Liquid)	Molten Carbonate (Liquid)	Solid Oxide (Ceramic)
Operating Temperature	200℃	650℃	800℃
Main Company	UTC(US)	FCE(US), Ansaldo(Italy) MIU(Germany) POSCO POWER(Korea)	GE(US), Siemens(Germany)

Table 1.1 Types of Fuelcell for power generation

1.2. RPS

Korean Government plans to change a support system for New&Renewable energy generation based on "New Energy and Renewable Energy Development, Use, Spread Promotion Law" from current Feed-in Tariff (FIT) to Renewable Portfolio Standard (RPS) from 2012. [1,2]

FIT is a system by which the government sets an annual support limit for each New&Renewable energy and buys produced power at a predetermined price for 15 or 20 years. Through this system, the government gives a New&Renewable energy generation company (hereinafter referred to as a generation company) the difference between system marginal price (SMP) and standard price. RPS introduced to replace FIT is a system by which a predetermined compulsory amount of power, which will be obliged to an electric companies equipped with generation facilities of predetermined capacity or more, is obligated to be provided as New&Renewable energy, and a Renewable Energy Certificate (REC) is issued or bought as an obligation fulfillment means in

order to fulfill obligations. The generation companies will obtain profits through power sale on the SMP and selling of REC to the obligated companies. These are compared in FIG. 1.1 below.

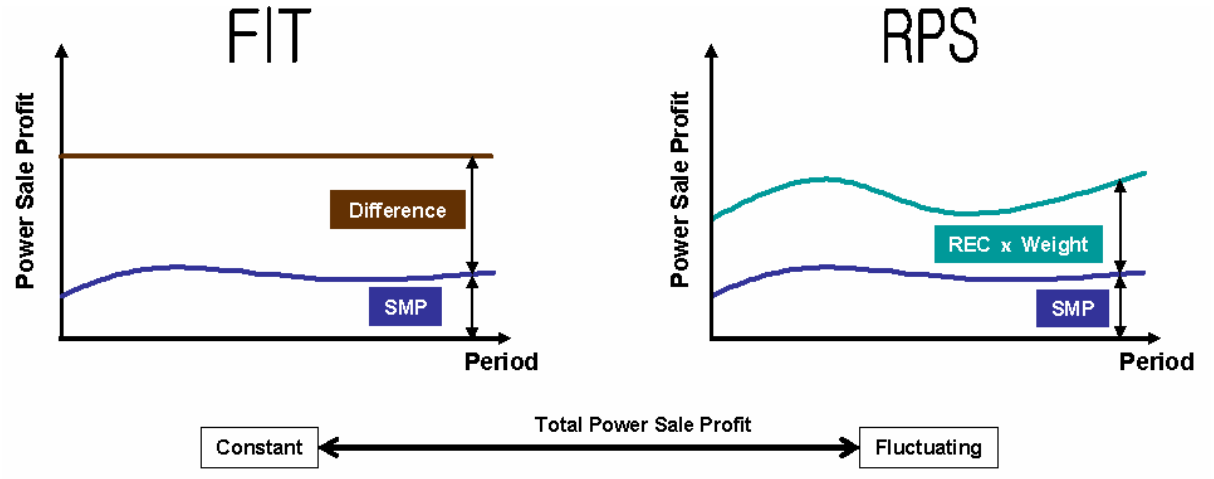

Fig.1.1 FIT vs. RPS

It is expected that the introduction of RPS will considerably affect fuelcell industry. The first reason is that a high discount rate will be applied due to a fluctuation expansion of a power sale price when deciding an investment. In FIT, a power sale unit price is fixed to a standard price. But in RPS, it will be determined as [SMP+Weight×REC], and SMP and REC prices fluctuate by individual market mechanism. These fluctuations become investment risk factors.

The second reason is that RPS will be the competition system between New&Renewable energy sources while FIT is that within each New&Renewable energy source. Therefore, it is important to secure comparative advantages compared with other New&Renewable energy sources. Differently from FIT in which a support capacity is set per power sources, in RPS, a compulsory supply amount will be assigned to obligators, and the generation companies can determine the type of power sources. Therefore, the generation companies compare each New&Renewable energy source to select specific power, and the most important determination criteria will be an economic feasibility.

2. Expenditure and Profit Factor Analysis

Profit and expenditure factors affecting the economic feasibility of the fuelcell power generation business are shown in Table 2.1. below.

Items	Contents
Profit Factor	● SMP (System Marginal Price) ● REC (Renewable Energy Certificate) ● Heat Sale Price
Expenditure Factor	● Fuelcell System Price ● Natural Gas Price ● Maintenance Cost ● Others (Water, Personnel, Insurance etc.)

Table 2.1. Profit and Expenditure factors of generation fuelcell business

2.1. Profit Factors

In the fuelcell power generation business, profits are obtained through electric power and heat sales, and a ratio of heat sale profit is very lower than that of electric power sale profit in Korea. The power sale profit is determined as [SMP+Weight×REC]. An applied annual operation rate of MCFC system is 85%, which is officially guaranteed by a selling company, POSCO POWER.

2.1.1. SMP (System Marginal Price)

SMP refers to a electric power market price (KRW/kWh) for a power amount applied per dealing time and is determined as the highest price of effective electric power generation prices of all electric power generators to which outputs are allocated per time slot. In this study, we used the annual SMP price projections of Korea Electrotechnology Research Institute from 2012 to 2022, and after 2022 we applied 3.15% that is an average value of above period.

2.1.2. REC (Renewable Energy Certificate)

In RPS, the obligator will have to supply a predetermined part of electric power generation of them as New&Renewable energy and submit REC corresponding to this to the government to finish fulfillment of its obligations. REC is issued per 1kWh. If a submitted amount of REC is smaller than allocated amount of REC, the obligator will be assigned penalty as much as shortage. If the New&Renewable energy generation cost is cheaper than the penalty, there is a high possibility of the obligated company choosing the penalty. Therefore, an upper limit of the REC price at which the New&Renewable energy generation company can sell REC to the obligator may be regarded as the penalty price. This research applied the REC price of 35, 40, 45, and 50 KRW/kWh based on the expected penalty.

Also, since there are differences among techno-economic feasibilities of New&Renewable energy sources, weights as shown in Table 2.1 will be set to promote balanced developments of each New&Renewable energy source and prevent RPS system from leaning toward specific power sources.

Fuelcell is assigned a top-grade weight of 2.0. In other words, if 1kWh is produced using a fuelcell, REC corresponding to 2 kWh is assigned.

Weight	Target Energy
0.25	IGCC, Byproduct Gas
0.5	Waste, Reclaimed land gas
1.0	Water, Offshore Wind(onshore), Bio, RDF burning, Waste Gasification, Tidal(with seawall)
1.5	Wood biomass burning, Wind(offshore, connecting under 5km)
2.0	Wind(offshore, connecting over 5km), Tidal(without seawall), Fuelcell

Table 2.2. Weight factors of each New&Renewable energy under RPS system(except for solar energy)

2.1.3. Heat Sale Price

When it is assumed that all of recovered heat can be sold, an annual profit is expected to be about 500 million KRW. The heat sale profit of 500 million KRW is applied as a fixed value each year.

2.2. Expenditure Factor

2.2.1. Fuelcell System Price

Power generation fuelcells operated in Korea are mainly MCFC type and are supplied by POSCO POWER. PAFC type has not briskly but partially been distributed due to a slightly high system price in comparison with power efficiency. MCFC system price of POSCO POWER is on the level of 5,700,000 KRW in 2010 and has constantly fallen. In this study, we adjusted this system price for searching the appropriate price which the economic feasibility can be secured. The number of years of facility contents was assumed to be 20 years.

2.2.2. Natural Gas Price

In Korea, KOGAS supplies natural gas to city gas companies in each district, and they appropriately marginate and sell it. Since the natural gas rates for fuelcell are not currently set, cogeneration rates were applied in this study. We applied three increasing proportions of natural gas to 2010 cogeneration domestic unit price of Seoul City Gas 630 KRW/m3 in order to expect gas rates per each year. They are respectively the increase rate 6.27% for the past 10 years, the LNG price increase rate estimate 4% of EIA[4], and the international oil price increase rate estimate 1.7%[5].

2.2.3. Maintenance Cost

Since the efficiency of a fuelcell system decreases with time, a stack is to be replaced in 3-year to 5-year intervals. Maintenance cost including replacement cost of stack, and general check and service repair are decided on a contract stage. This research assumed the maintenance cost to be 900 million KRW.

2.2.4. Others

Water expenses were decided to be 15 million KRW, personnel expenses were decided to be 4 million KRW, and insurance rates and other overhead expenses were also included.

2.3. Analysis Method

IRR was calculated based on profits and expenses for each year. IRR refers to a discount rate at which Net Present Value (NPV) is 0, i.e., a discount rate at which a present value of cash inflow and a present value of cash outflow become the same. If IRR is higher than capital costs, an investment plan can be adopted. In an opposite case, the investment plan can be dismissed. A whole analysis method of economic feasibility is as shown in FIG. 2.2 below.

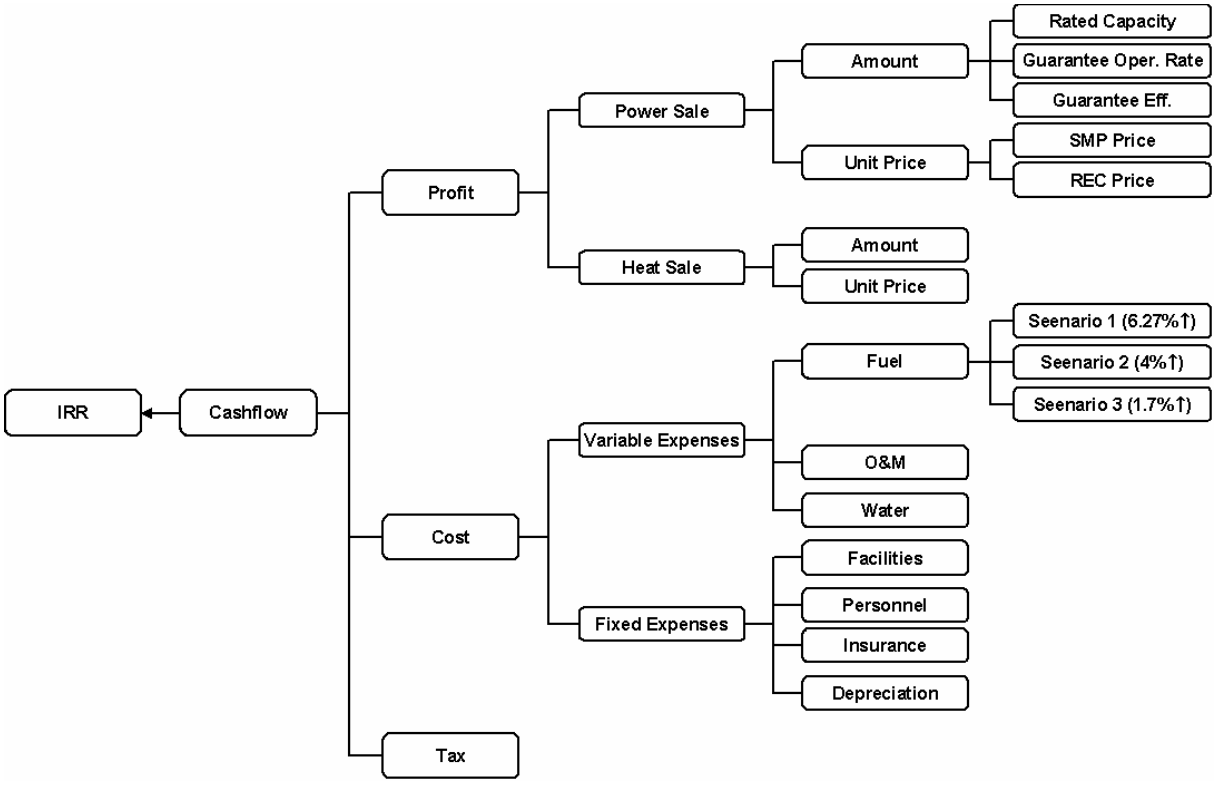

Fig.2.2. Analysis Method of Economic Evaluation

3. Analysis Results

In this study, the economic feasibility was regarded as being secured by a generation company when IRR is 7% or more in consideration of opportunity cost and the risk of fuelcell power generation business. This criteria may be differently applied to other companies.

3.1. Case 1: System Price 5,700,000 KRW/kW

IRR [%]		REC Price [KRW/kWh]				Notes
		35	40	45	50	
Natural Gas Price Increase Rate [%]	6.3	(N/A)	(N/A)	(N/A)	(N/A)	Cogeneration Rates
	4.0	(N/A)	(N/A)	(N/A)	(N/A)	EIA, LNG
	1.7	(N/A)	(N/A)	1.6	3.4	EIA, Oil

Table 3.1. IRR calculation results at 5,700,000 KRW/kW installation charge

Table 3.1 shows IRR values to the REC price and natural gas price increase rate when the system price is 5,700,000 KRW/kW. Even in the most advantageous conditions, i.e., even when REC is 50 KRW/kWh, and the natural gas price increase rate is 1.7%, IRR of about 3.4% was obtained, which has no investment attractions.

3.2. Case 2: System Price 3,500,000 KRW/kW

The economic feasibility of fuelcell power generation can be secured through a reduction in a system price caused by technology development and mass production in a situation in which it is difficult to control an electric power price and a gas price. As a result of calculating IRR by adjusting the system price based on this point of time, IRR is set to be 3,500,000 KRW/kW and the calculation results are as shown in Table 3.2 below

IRR [%]		REC Price [KRW/kWh]				Notes
		35	40	45	50	
Natural Gas Price Increase Rate [%]	6.3	(N/A)	(N/A)	(N/A)	(N/A)	Cogeneration Rates
	4.0	(N/A)	0.6	1.1	1.4	EIA, LNG
	1.7	1.0	3.9	6.5	8.9	EIA, Oil

Table 3.2. IRR calculation results at 3,500,000 KRW/kW installation charge

In the most advantageous conditions, i.e., when REC is 50 KRW/kWh, and the natural gas price increase rate is 1.7%, IRR of about 8.9% was obtained, which has investment attractions.

IRR graph of Case 1 and 2 is as shown in FIG. 3.1 below.

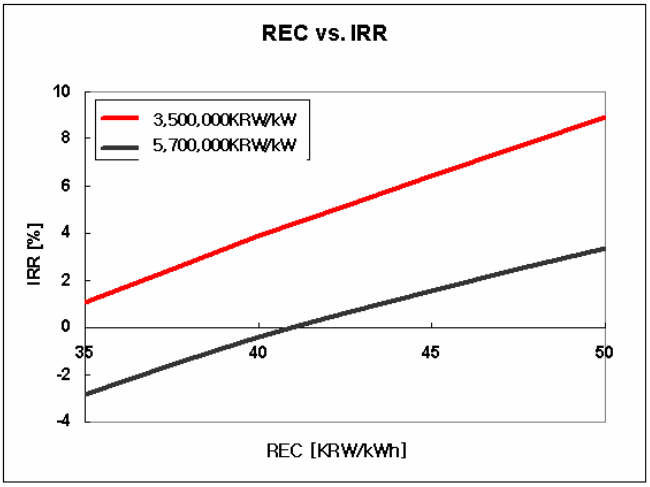

Fig.3.1. REC vs. IRR

4. Conclusion

4.1. FIT vs. RPS

It is expected that fuelcell generation business will earn low profits under RPS in comparison with FIT. FIT support profit in 2011 is 250.13 KRW/kWh [3], and RPS expected electric power sale profit in 2012 is 217.8 KRW/kWh based on REC 50 KRW, i.e., decreases to about 13%. The gas price is applied equally to FIT and RPS business companies. Therefore, if the system price is not greatly changed, there is a high possibility that the profits of the fuelcell power generation business will worsen under RPS in comparison with FIT.

In addition, differently from FIT in which predetermined power sale profits can be secured for 15 to 20 years, profits under RPS are affected by SMP and REC prices operated with each mechanism. This becomes a risk factor and requires a risk premium.

4.2. Competitiveness with Other New&Renewable Energy Sources

4.2.1. CAPEX and OPEX

Renewable energies come from costless natural energy and thus we can consider only CAPEX. However, OPEX occupies high portion of new energy power generation including fuelcell because of used energy. Price level and fluctuation of such used energy become risk factors of new energy power business and require a risk premium for compensating for the risk factors. Therefore, the price level and fluctuation operate as barriers to enter the fuelcell power generation business.

4.2.2. Techno-Economic Securement Speed

Differently from FIT in which competitions occur within New&Renewable energy sources, competitions occur between New&Renewable energy sources in RPS. New&Renewable energy sources that rapidly secure techno-economic feasibility are highly likely to be gradually advantageous. In order to secure an economic comparative advantage with respect to other New&Renewable energy sources, fuelcell should achieve system price reduction and maintenance cost reduction through relatively rapid technology development and market expansion.

4.3. Conclusion

IRR necessary for an investment intention decision was calculated through profit and expenditure factors that are considered to push ahead with fuelcell generation business. According to the calculation result, an absolute profit of the fuelcell generation business falls, and risks related to SMP and REC prices are added under RPS in comparison with FIT. Therefore, it is determined that the fuelcell power generation business will likely contract. In order to overcome this, manufacturers and government have to make efforts to lower system prices and to set up the market, respectively. In addition, a method of removing risks through a long-term contract among a New&Renewable energy generation company, an RPS obligated company and a city gas company is required to be found.

5. References

1. Ministry of Knowledge and Economy Notice No.2010-490(2010.12.29) Fifth Power Supply and Demand Basic Plan (2010~2024)

2. (RPS Notification Enactment Public Hearing) Renewable Energy Supply Obligation System Detailed Enforcement Plan Review, KERI, 2010.

3. Ministry of Commerce, Industry and Energy Notice No.2006-89 (2006.8.30) Renewable Energy Use Standard Price Guideline of Generated Power

4. Annual Energy Outlook 2010, Table 13, Main Reference Case Tables (2007- 2035), EIA

5. Annual Energy Outlook 2010, Table 12, Main Reference Case Tables (2007- 2035), EIA

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