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A Proposal to Reform the Korean CBP Market

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by

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1. Introduction

In April 2001, Korea took a first step to transforming its electricity industry from the vertically integrated SOE monopoly into a competitive one by separating the generation stage from the rest of the system and establishing a wholesale market that allocates resources based upon the cost data of generators and the estimated demand. The DJ administration also announced a plan for further restructuring that included the plan to replace the cost based competition by price competition among generators within 2 to 3 years. At the time, the CBP (cost based pool) market, the wholesale market in which electricity is traded based on an indirect competition using cost data of generators, was expected to last only 2 to 3 years.

Subsequent unfolding of events in the electricity industry, however, made it inevitable for Korea to use the CBP market for a much longer time. The two administrations that succeeded DJ administration postponed further restructuring and have not replaced CBP market with a market in which a direct price competition by generators determines resource allocation or a PBP market. As a consequence, the CBP market has been in operation in the last 9 years. There is no plan to replace it with a PBP market. Thus, it will continue to be in operation at least in the next couple of years and possible longer. Thus, it is crucial that the market rules lead to efficient allocation of resources in the CBP market.

However, a glance at the CBP market reveals the possibility that there exist serious problems. One phenomenon that one can immediately notice is that while the market rules require that all the electricity must be traded in the spot market through KPX (Korea Power Exchange), generating companies sell their electricity at different prices based on the generators used in generation and the ownership structure of generating companies. Nuclear generators and coal-fired generators receive lower prices that are lower than the price that combined cycle generators owned by generating companies that are not owned by KEPCO. Combined cycle generators owned by the generating companies that are subsidiaries of KEPCO also receive a lower price for the electricity they produce than the peak load generators owned by other generating companies.

Another visible phenomenon in the electricity market is large losses KEPCO has been suffering in recent years. KEPCO is the monopolist in the transmission, distribution, and marketing stages of the industry and is subject to rate regulation. As a franchise monopoly in a public utility industry, KEPCO is supposed to earn revenues that cover its operating costs and proper return on its rate base. Thus, why is has been suffering large losses in recent years becomes an important question that has implication on efficiency of the electricity industry and stability of the public utilities regulation.

A closer look at the CBP rules, various prices applying to different generators, revenues of KEPCO and various generators reveal that the CBP market in Korea has a number of characteristics that are at odds with the market principles. This paper attempts to identify the major problems that plague the electricity industry of Korea today and analyze effects of the key aspects of the CBP market rules in use. We found out that the CBP market was unstable from the start and probably was in need of a sophisticated set of measures that could compliment a cost based pricing mechanism. We also found out that the successive measures the Korean government implemented in response to the problems that plagued the wholesale market in the last 9 years were all stop-gap measures that could not and did not solve the problems.

The paper is organized as follows: Section 2 summarizes the CBP market and compares it with PBP market. Section 3 summarizes the evolution of the industry since 2001, focusing on various changes the government made to the CBP rules and their effects. In section 4, we analyze the problems in the current system. Section 5 contains policy recommendations and conclusion.

2. Comparison of CBP and PBP

Let us briefly summarize well established results about the wholesale markets for electricity[1]. In virtually all countries, electricity industry had been run as a government monopoly until privatization and competition started in some countries in 1980s and 1990s. In some regions of U.S., electricity industry has been maintained as a regulated monopoly. Monopoly here means vertically integrated monopoly encompassing generation, transmission, distribution, and retail.

In a vertically integrated government or SOE monopoly, the government centrally solves the social utility maximization problem, given estimated demand functions, estimated cost functions associated with generation for various generators, and estimated cost functions of constructing generators of various types and sizes. Optimization problem consists roughly of two smaller optimization problems. In the very short run, the government solves the minimization of the generation cost subject to the constraint that the electricity

[1] Joscow and Tirole (2004) offers a comprehensive and rigorous comparison between outcomes in a regulated monopoly and in competitive electricity markets. It also discusses many technical constraints that exist in the electricity market that market designers need to take into account.

produced meets the demand in each time period. The next problem is to choose generator mix and the capacity of each generator that minimizes the cost of construction and operating costs, given estimated demand functions and the solution to the first problem.

The solution to the first optimization problem leads to optimal generation decisions given existing generators. The solution to the second problem leads to optimal generator mix and optimal capacity. Pricing decisions will be made to allow the generators to receive fair return on their investment in addition to covering operating costs.

While these solutions look fine in theory, they are hard to obtain in practice due to various problems arising from information asymmetry and incentives. Starting with U.K., a number of countries changed the structure of their electricity industry by replacing monopoly in the generation stage with a competitive market. They also allowed competition in the retail stage. In most of these countries, a wholesale market has been established to allow generating companies in the upstream and retailers in the downstream bid prices to determine the resource allocation.

There are two types of market that are based on price competition that have been used. One is the wholesale market consisting of energy market only. The other is the wholesale market consisting of the market for energy and the market for capacity. In the former, generators earn revenues from the sale of electricity alone. The spot price of electricity is allowed to go up to a high level in this market, thereby allowing the peak load generators that have high marginal costs to recover the investment cost[2]. In some countries, the government imposes a cap on the spot price of electricity for various reasons. In these countries, some generators cannot recover their construction cost from the sale of electricity alone. Thus, the government operates a separate market in which pure capacity is traded. Price for capacity is determined by market forces.

In countries or regions that operate two markets, energy market works reasonably well to lead to efficient allocation of resources in the short run, provided that strategic behavior of generating companies aimed at reducing competition can be checked effectively. Capacity market proved to be much more difficult to operate efficiently. It is fair to say that many countries are still trying various market rules in to make their capacity market efficient and that forward contracts are widely used and are believed to have increased efficiency in the capacity market.

CBP market, on the other hand, does not allow competition by price bidding. The wholesale market consists of generating companies only. Demand side is represented by a

[2] Those generators run only when demand peaks. Thus, in order for them to recover the construction cost, spot price of electricity needs to be allowed to go up to high levels.

vertical demand curve[3]. Instead, the government uses the following mechanism to allocate resources. In energy market, the government receives cost data from generators and forces the generators to bid a price based on its reported marginal cost. This forced bidding leads to a hypothetical supply curve. Equilibrium in the energy market is attained at the point of intersection between this hypothetical supply curve and the vertical demand curve. The government must also determine the capacity price.

Usually, there is a single capacity price per unit of capacity that applies to all generators because at any given time, capacity has the same value regardless of the types of generators that provide it. Thus, the revenue of a generator consists of the revenue from the energy payment and the revenue from the capacity payment. A potential investor in generating facilities compares the expected revenue from the energy payment and capacity payment with the expected cost of building and operating a generator. Conversely, an investor who owns and operates an obsolete, inefficient generator compares the expected revenue from the energy payment and capacity payment with the expected profits he can earn by retiring the generator and using the existing assets for alternative purposes. Thus, capacity price is a crucial incentive mechanism in the market for investment in capacity.

It is beyond the scope of this paper to survey the literature on PBP and CBP markets. We will be content with summarizing a fundamental result about the CBP market. It is well known that (1)if the government forces each generator to bid at a price that equals its marginal cost of generation, resulting equilibrium will ensure the efficiency in the energy market, provided that the cost data are accurate, and (2)if the government chooses the capacity price appropriately so that it reflects the opportunity cost of capital associated with investment in the peak load generator and if the generator mix of the society is approximately optimal, then the capacity price and the energy price will lead to efficient investment in generators in both capacity and type.

The equilibrium price for energy in each time period when each generator is forced to bid at the price that equals its marginal cost of generation is called the system marginal price or simply SMP. Thus, by forcing all generators to bid at their marginal costs and by allowing them to receive SMP that prevails in each time period, the government can make sure the efficiency of generation. In markets that have a generator mix that is close to an optimal mix, a capacity price that is based on the true opportunity cost of capital invested in a new gas turbine generator is expected to induce efficient investment in generating capacity[4].

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3 In very short run, demand curve for electricity from the final consumers is virtually vertical for various reasons.

4 A more complete treatment of the capacity price is probably required in order to analyze

The reason is that a gas turbine generator usually requires the lowest per unit capacity cost to build among the new generators that can be built while entails highest marginal cost of generation. The a new gas turbine generator will earn an operating profit that is close to zero from the energy market but will be able to break even from the capacity payment that just compensates for its cost of capital. It can also be shown that by giving all the other generators will also receive revenues from the energy market and capacity payment that are barely sufficient to break even when they receive this capacity price[5].

The CBP mechanism described above will be inferior to a well functioning PBP mechanism in that cost data are estimates and differ from true costs and that generators have lower incentive to minimize costs compared to the PBP market. In particular, the PBP mechanism will give investors a stronger incentive to minimize the cost of building generators and to choose the types of generators that are more profitable. Also, it is not easy for the government to calculate the true cost of capital associated with a new generator that the needs to be built, given a forecasted demand.

CBP is also riddled with problems associated with estimating and verifying cost functions of various generators, fuel prices, and market price of capital invested in generating facilities. However, it should also be clear that within the CBP context, the optimal SMP and the CP described above is an optimal mechanism. Other mechanisms in the CBP context can be compared to this optimal mechanism.

3. Evolution of the wholesale market and market rules

In this section, we summarize the evolution of the CBP market in Korea. The focus is given to the pricing mechanisms the government has been using since the establishment of the market. The government has not used the optimal SMP and CP mechanism described in

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the problems that exist in the capacity price mechanisms Korea has been using. But, a full survey of the literature on the capacity price is beyond the scope of this paper. Crampton and Stoft (2005) and Joscow (2008) provide comprehensive analyses of the need for having a separate market for capacity.

5 We will not explain this in detail here and will be content to make the following observation. Base load generators will earn significant amounts of operating profits from the energy market as their marginal costs will be substantially lower than SMP during some time periods. However, they receive capacity payments that are substantially short of their fixed costs including capital costs of investment as base load generators are more expensive to build than gas turbine generators per unit of capacity. In equilibrium with free entry, each type of generators will receive approximately normal profits in the ex ante sense.

the preceding section. Instead, it has used a variety of pricing mechanisms that are inconsistent with a market in which competition determines resource allocation.

Before April 2001, KEPCO was the near monopolist in the generation stage and was the monopolist in transmission, distribution, and marketing stages. In generation stage, KEPCO owned most of the generators at the time including all of the nuclear and coal-fired generators. The generators owned by other firms consisted mostly of a handful of peak load generators owned and operated by private IPPs according to a PPA agreement with KEPCO, co-generators owned mostly by KDHC (Korea District Heating Corporation), and hydro power plants owned by K-Water. The share of the generators owned by KEPCO's subsidiaries was higher than 90% in terms of both capacities and revenues.

In April, 2001, the government forced KEPCO to establish 6 generating companies as 100% owned subsidiaries and give all of the generators it had previously owned to the 6 generating companies. The government also established a wholesale market in which the 6 companies and other generating companies were to compete. The government wanted to operate a price based wholesale market in which competition between a multiple number of retailers as purchasers and a multiple number of generating companies in which price and generation decisions are made by price bidding from both directions. But on learning that introducing competition in the retail stage could take a considerably long time, the government decided to use a cost based market during the first 2 ~ 3 years of transient period. Thus, the CBP market was created.

The government of Korea did not adopt the optimal SMP and CP mechanism described earlier when it established the CBP market. Instead, it used two different prices for energy and two different prices for capacity depending on the whether a generator is a base load generator. For peak load generators, consisting of all generators other than nuclear and coal-fired, SMP was used as the energy price. For them, results of the estimation of the fixed operating cost and cost of construction of a hypothetical gas turbine generator were used as a CP. In particular, estimation of the capital cost associated with a hypothetical gas turbine generator was conducted in the following way.

Since Korea did not have a gas turbine generator, the government picked a combined cycle generator that was built most recently, which turned out to be a generator built in Ulsan in 1998, and estimated the cost of building a gas turbine generator in 2000 from the accounting cost of building the combined cycle generator. Let us denote this by K. This generator had the expected life span of 30 years. The government also estimated the market rate of return on investments in comparable projects using a financial model, which turned out to be $r = 8\%$. Then, the government calculated the annualized capital cost of the project using 8% discount rate and used the outcome as the standard capacity price for peak load generators after normalizing it by adjusting it by the capacity and the number of hours of operation in each year.

In short, the capacity price for peak load generators was determined by solving the following equation for *k*, where K is the estimated cost of building a hypothetical gas turbine generator in 2000, and *r* = 0.08 was the estimated cost of capital invested in comparable projects.

$$\mathrm{K} = \mathrm{k}\left\{\frac{1}{(1+r)} + \frac{1}{(1+r)^2} + \cdots + \frac{1}{(1+r)^{29}}\right\} \text{ ...... (1)}$$

Let us assume for a while that the solution to the above equation indeed reflects the true cost of capital invested in a gas turbine generator. Then, the fundamental result about the optimality of the CBP mechanism, explained above, suggests that if this value is applied to all generators as their capacity price and SMP is applied to all generators as their energy price, an efficient outcome will result.

However, the government used different mechanisms for nuclear and coal-fired generators. Instead of applying SMP, the government imposed a cap of 18.95 Won/kwh on the energy price that was called a BLMP standing for base load marginal price. Since peak load generators determined SMP more than 80% of the time, this means that the energy price base load generators receive became much lower than SMP. The government also calculated a separate capacity for base load generators using an equation similar to Eq. (1) above with K replaced by the cost of building a new coal-fired generator. Since per unit construction cost of coal-fired generators is much higher than that of a gas turbine generator, the resulting capacity price for base load generators was higher.

The [Table 1] below summarizes two energy prices and two capacity prices that were used when the CBP market in Korea started operation.

[Table 1] Prices for energy and capacity in 2001

	Peak load	Base load
Energy price	SMP	7.17 won/kwh
Capacity price	SMP Cap 18.98 won/kw	21.49 won/kw

The standard CP that was obtained by solving Eq. (1) has the property of fully compensating for the cost of investment in a gas turbine generator made in 2000 if the proper rate of return on such an investment was expected to be 8% on average in the next 30 years. In this sense, a gas turbine generator built in 2000 would be fully compensated for the investment cost. The reason is as follows.

Suppose that a gas turbine generator has the highest marginal cost among all generators that have a chance of selling electricity as is usually believed. Then, even if a gas turbine generator sells no electricity in its life time, it would earn normal profits on its investment because the fixed cost including cost of construction is fully compensated by the capacity price. The generator will also earn zero profit from the sale of energy even if it generates and sells electricity because its marginal cost is the same as SMP.

In November, 2003, the government changed the capacity price for base load generators based on the change in the discount rate from 8% to 7 %. As a result, the capacity price for base load generators dropped from 21.49 won/kw to 20.49 won/kwh.

In October 2004, the government began to apply a new capacity price for nuclear generators that is lower than the capacity price it had been receiving. The government set the capacity price at 20.03 won/kw for nuclear generators while maintaining the same capacity price for coal-fired generators. In May 2006, the government lowered the capacity prices of both nuclear and coal-fired generators 17.65 won and 13.22 won. Then in October 2004, the government raised the capacity price for coal-fired to 16.89 won.

In May 2008, the caps were abolished. Instead, the government began applying different prices for energy based on the ownership of a generator and the type of a generator. Specifically, the government began to use the following formula to determine the price for energy of a generator owned by generating companies that are KEPCO's subsidiaries. Measurement is won/kwh: Energy price = fuel cost + (SMP – fuel cost) x correction factor. The energy payment can be obtained by multiplying the energy price obtained this way by the volume of electricity produced.

Since then the government periodically changed the prices of energy sold by the generators owned by generating companies owned by KEPCO by changing the numbers for the correction factors during May 2008 and December 2010. The following table shows how unstable the energy prices have been. The table clearly shows that the CBP market rules are not consistent with a market in which competition determines the price and outputs.

[Table 2] Correction Factors used since August 2008

Generator Type / Time of Change	Nuclear	Coal-fired	LNG-fired	Anthracite
August 2008	0.2184	0.0894	0.0894	0.75
August 2009	0.3052	0.1865	0.327	0.75
August 2010	0.1913	0.1315	0.32	0.5

4. Fundamental problems in the electricity market in Korea

The pricing mechanisms that have been used in the CBP market in Korea are peculiar and fundamentally different from the mechanisms used in other markets and raise a number of questions. The first question to ask is why the Korean government did not adopt the optimal SMP and CP and turned to extraordinary mechanisms that are so erratic and complex that it is difficult to analyze their properties.

The prevailing theory is that the government adopted the pricing mechanism summarized in [Table 1] instead of adopting the optimal SMP and CP for all generators as it opened the CBP market in order to avoid overpayment to generating companies by KEPCO. It was clear in 2001 that applying the optimal SMP and CP would lead to a sharp increase in the amount of money KEPCO paid to generating companies[6].

The reason for this outcome is a wide gap that existed between the optimal generator mix and the actual generator mix that existed in Korea in 2001. In 2001, Korea had a generator mix in which the proportion of nuclear and coal-fired generators was much lower than their proportion in an optimal mix of generators considering the costs of construction, fuel, and fixed operating costs. When a country switches from a ROR regulation to a CBP and adopts the optimal SMP and CP under such a generator mix, it allows base load generators to receive energy prices that are substantially higher than the break-even levels when CP payments are taken into account too[7]. Under an optimal generator mix in 2001 was widely believed to require the proportion of base load generators be higher than 80%[8]. In reality, the proportion was 64% in 2001.

The combination of energy prices and capacity prices the government applied to nuclear and coal-fired generators in 2001 led to a decrease in the payments that KEPCO needed to make to base load generators. But it is still not clear why the government chose this particular method to reduce the payments to generators among a million methods that would lead to the same or similar outcome. More importantly, it was not clear in what

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[6] According to an estimate, KEPCO's payment to generators was to increase by more than 20% as a result of switching from a ROR type compensation to generators to the optimal SMP and CP mechanism.

[7] The opposite is also true. If a country switches from a ROR type regulation to a CBP market that adopts the optimal SMP and CP when there are more base load generators than an optimal mix of generators dictates, revenues of the generators will generally decline.

[8] Kim and Kim (2010) used a simple simulation model to estimate the optimal generator mix in 2010. They estimated that in optimal generator mix, the proportion of nuclear, coal-fired, and LNG generators will be 63.5%, 20.5%, and 16.9% respectively. Thus, the proportion of base load generating capacities under an optimal generator mix was estimated to be 84%. While their model made a number of simplifying assumptions, their simulation result seems to be roughly correct.

sense an increase in the payment that KEPCO had to make to generators as Korea switched from a ROR type regulation to a CBP market is a problem. It was not clear what was the most appropriate way to resolve the problem if it is a problem[9].

Let us focus on the properties of the current mechanism. The current mechanism has the following problems.

First, it reduces the incentives of the generating companies affiliated with KEPCO to lower costs of generation because they are allowed to keep only a part of their cost saving while their competitors are allowed to keep all of the result of cost saving. Over time, this distortion in incentives will lead not only internal inefficiency of those generating companies affected by the correction factors, but will lead to higher SMPs compared to the situation when there is no correction factors.

Second, the generating companies affected by the correction factors will have a lower incentive to invest in new generators because the energy price that applies to them is substantially lower than the price their competitors receive. Over time, the generating companies that are affiliated with KEPCO are expected to build fewer generators and smaller capacities, including based load generators that are in great need in Korea. Inefficiency in generator is expected to persist as a result, leading to increased cost of generation. Korea could also suffer from a shortage of capacities too, which will cause outages and loss of social efficiency due to unserved energy.

Third, it is simply too absurd that a government to assign different prices for the same commodity based on the production method or ownership structure of the producer. Such manipulations of the prices by the government are not compatible with a market in which competition determines resource allocation. It will be the government, not the firms and competition between them, which will determine the outcome in such a market. The market will stop functioning very soon. It may have stopped functioning properly in Korea already.

Fourth, it is not equitable that the government assigns different prices to different producers because the act will affect the profitability of firms profoundly.

Fifth, the mechanism for energy pricing has the above four serious problems even if the CP is properly set. It turns out that the CP currently in use has fundamental flaws. Current CP was based on the annualized capital cost of investment in a hypothetical gas turbine

[9] It is not clear whether the government realized the relationship between the generator mix and the financial outcome of applying the optimal SMP and CP in the CBP market. Had it understood the link clearly, it would probably have induced construction of more base load generators. The proportion of base load generators actually decreased in the last 9 years from 64% to 56%.

generator and the price of capital invested in comparable projects in 2000[10]. As explained in the preceding section, the cost of construction of a gas turbine generator was estimated using the accounting data on the cost of building a combined cycle generator built in Ulsan because there was no gas turbine generator in Korea[11].

It is common knowledge in the industry that per unit construction cost of a gas turbine generator is lower than per unit construction cost of a combined cycle generator consisting of the gas turbine generator and an additional facility that recycles the heat. On the other hand, per kwh fuel cost of a gas turbine generator is higher than that of a combined cycle generator. However, the estimated construction cost per kw of the hypothetical gas turbine generator that became the basis for the CP in 2001 was 387,000 won while per kw construction cost of the combined cycle generator built in Ulsan was 316,000 won. Obviously, the estimation was fundamentally flawed, and the true cost of construction of the hypothetical gas turbine generator was below 316,000 won. As a consequence, CP used in 2001 was larger than an appropriately determined CP.

There are other flaws too. The method used to calculate the capital cost of investment in gas turbine generators in 2001 was based on the construction cost of a gas turbine generator in 2000 and the price of capital invested in comparable projects in 2001, which was estimated to be 8%. Cost of constructing gas turbine generators and price of capital for a project in the financial market change over time, reflecting changes in various factors that affect the generation industry and financial market. Naturally, the cost of capital part of the standard CP calculated from an equation like Eq. (1) will result in different values in different years. Thus, the government should have calculated the standard CP for each year after 2001. However, the government has not changed the capital cost part of the standard CP since 2001. This means that CPs used in each after 2001 did not reflect the appropriate cost of capital if the CP used in 2001 for peak load generators reflected the appropriate cost of capital if the CP used in 2001 for peak load generators.

The above argument strongly suggests that the CPs used in the last 9 years probably did not reflect the true opportunity cost of capital associated with investment in generators in Korea even if the definition of the cost of capital invested in generating capacities imbedded in the use of the Eq. (1) in 2001 was appropriate. It turns out that the definition of the capital cost used in 2001 in calculating CP does not capture the idea of cost of capital associated with investment in a generating capacity.

In the Korean CBP market today, a generator receives the CP for the capacity available for

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[10] Recall the derivation of the CP currently in use given in page 7.

[11] There still does not exist a gas turbine generator in Korea. It appears that the government has not allowed the construction of a gas turbine generator.

generation in each time period. Thus, CP is a spot price for capacity. In this interpretation of CP, every generator should receive the same CP in each time period regardless of the generator type. The CP should reflect the true value and opportunity cost of adding or subtracting a unit of generating capacity in each time period. For instance, if demand for electricity suddenly dropped for some reason, such as closing down of many factories due to severe recession, the value of an additional unit of capacity will be close to zero. The CP should be close to zero in such a situation.

If the society needs installment of additional generating capacities due to increased demand while the cost of building a generator went up sharply for some reason, a higher CP will be needed to attract investments in new generators. This higher CP should apply to all generators that were built in the past too as the capacities they provide have the same value. If a big earthquake occurs that destroyed substantial portion of generating capacities, the value of additional capacity will be quite large, and CP should be maintained high until sufficient new capacities are built.

The definition of CP used in Korea is based upon the full recovery of investment in a gas turbine generator in an annualized way. For instance, a gas turbine generator built in 2001 was guaranteed to recover the construction cost fully with an interest according to 8% interest rate over the 30 years by receiving 4.14 won per kw in each hour during which it is available for generation. The capital cost part of CP for this generator is fixed for every hour for 30 years.

The above definition of CP is clearly a price of a long term contract according to which the generator promises to provide capacity during its entire life span. The solution to Eq. (1) will vary as K and r change across years, leading to different CPs for generators built in different years. It is clear that CP obtained this way does not reflect the value and the opportunity cost of capacity in each time period. This CP is not a spot price for capacity.

It appears that the government has been using a wrong CP as the spot price of capacity in the last 9 years. Naturally, current CP does not have the desirable property of inducing optimal supply of capacity in each time period even when it is used along with SMP without the correction factors.

5. Conclusion: A Proposal for reform of the CBP market in Korea

<u>Overpayment problem</u>

As discussed above, a switch from a conventional ROR regulation to the optimal CBP rules led to a sharp increase in the amount of money KEPCO needed to pay to generators in 2001 due to suboptimal generator mix in Korea at the time. It was estimated that the switch led to an increase in the payment roughly by 3 trillion won in 2001. This implies that the amount of money consumers needed to pay to generators increased by that amount.

After 9 years, this gap between the amounts of money consumers would pay to generators under a ROR regulation arrangement and the amounts they need to pay under the CBP rules if SMP and CP apply to all generators ballooned to around 20 trillion won. This increase is due to distortion in generator mix which worsened during the 9 years.

Persistence of the shortage of base load generators suggests that there is severe entry barrier into the generation market. Environmental regulation, political resistance to building power plants by local residents, and tight control by the Ministry of Knowledge Economy over investment in new generators are seen to be ultimately responsible for the persistence of base load generators[12].

Under such a situation, control of profits to base load generators that is due to the distortion in generator mix is needed until the generator mix approaches an optimal mix. This adjustment of profits should be conducted in ways that minimize the loss of efficiency in generation and investment in capacities. In particular, manipulating prices of energy and capacity based on fuel types and ownership structure of a generator are likely to distort incentives of generators and investors resulting in serious losses of efficiency. The adjustment needs to be done in ways that do not involve manipulation of prices for energy and capacities.

We propose the use of payments from the base load generators that are expected to earn windfall gains due to the distortion in generator mix that do not depend on the price of energy and capacity. There are many ways. One possibility is to force a generator to pay the difference between the profit it is expected to earn if the generator mix were optimal and the expected profit in each year. An amount can be estimated before the start of the year and can be imposed on generators. This will not affect the incentives of generators in generation or the incentives of the generating companies and potential investors facing investment in generating capacities. Such payments can be interpreted as an optimal franchise fee for the right to operate a generator that has the prospect of earning excessive profits.

The above is just one of many methods one can think of in designing a scheme that allows consumers to protect themselves from a windfall loss due to distortion in generator mix while at the same time allowing generators and investors to increase the efficiency in generation and investment in generators. Designing such a scheme is a

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[12] There may be similar entry barriers to combined cycle generators, although the barriers are lower compared to the case of base load generators. In this case, the mechanism we propose to deal with the overpayment problem in section 5 may need to include some combined cycle generators that are significantly more efficient than marginal generators that operate in Korea.

complex project that is beyond the scope of this paper. We will be content to point out that there are ways to deal with the overpayment problem arising from a wrong generator mix in Korea that do not involve manipulation of prices that can lead to more efficient outcomes while resolving the overpayment problem.

Capacity price

Since the CP in the CBP market is the spot price paid to generators for the capacities they supply to the retailer, and ultimately to consumers, current formula of calculating the CP is incorrect. One way to calculate the spot price for capacity is the following. Suppose that the cost of building a gas turbine generator this year, that has the expected life span of *n* years, is K, that the estimated cost of capital invested in comparable projects in the financial market is *r*, and that the construction cost of the same generator is expected to rise by an average rate of *s*.

Then, the capacity price this year can be obtained by solving the following equation for x.

$$\mathrm{K} = \mathrm{x}\left\{\frac{\{(1+s)}{(1+r)} + \frac{(1+s)^2}{(1+r)^2} + \cdots + \frac{(1+s)^{\mathrm{n}-1}}{(1+r)^{\mathrm{n}-1}}\right\} \text{ ...... (2)}$$

The solution for x in Eq. (2) is the amount of money that is just enough to induce the investor to invest in a gas turbine generator if it is common knowledge that r is the appropriate return on comparable investment and s is the expected increase in the cost of construction of the generator. The investor, and everyone else too, expects that the CP will increase to this year's CP times (1 + *s*).

Next year, the cost of building the same generator is realized and equal to K'. K' will in general be different from K(1 + *s*). Next year's CP will be determined by the following equation.

$$\mathrm{K}' = \mathrm{x}'\left\{\frac{\{(1+s')}{(1+r')} + \frac{(1+s')^2}{(1+r')^2} + \cdots + \frac{(1+s')^{\mathrm{n}-1}}{(1+r')^{\mathrm{n}-1}}\right\} \text{ ...... (3)}$$

In Eq. (3), *s'*, is expected rate of increase in the construction cost assessed next year, *r'* is the estimated average cost of capital assesses next year, and x' is the CP next year. The CP in each future year will be determined similarly. The CP obtained in the way described above is a spot price for capacity that changes over time, reflecting the market conditions each year.

The shortcomings of the above method is that it requires the government to forecast the construction cost of generators and estimated the appropriate cost of capital invested in comparable projects, and use them to determine the price for capacity and apply it to all generators. There will be controversy over the accuracy and reliability of forecast. The government may not want to take the risk of forecasting *s* and *r* and use the results to determine CP because it involves too high a political risk.

If the government refuses to adopt the spot price CP, the only alternative that is feasible seems to continue to use the current formula. Then, the government should calculate a CP for each year for the generators built in that year, which solves an equation like Eq. (1) that reflect relevant construction cost and cost of capital in that year, and apply it to the generators built in that year only. 29 years later, there will be 29 CPs, each of which applies to the generators built in each year.

The best way to avoid this confusing situation is to replace the current CBP with a PBP as soon as possible. In fact, most of the problems that exist in the wholesale market in Korea today can be traced to the nature of the system that allows the government to make decisions on resource allocation instead of the firms in the generation market. Replacing the current CBP market with a PBP market requires at least a couple of years in preparation. Reform measures we propose in this paper can be implemented in the CBP market until it is replaced by a PBP market.

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