

Lee, Suil

**Research Report**

## Improvement of Power Generation Facility Investment Systems for Achieving Resource Adequacy in Electric Power Industry

KDI Policy Forum, No. 260

**Provided in Cooperation with:**

Korea Development Institute (KDI), Sejong

*Suggested Citation:* Lee, Suil (2015) : Improvement of Power Generation Facility Investment Systems for Achieving Resource Adequacy in Electric Power Industry, KDI Policy Forum, No. 260, Korea Development Institute (KDI), Sejong, <https://doi.org/10.22740/kdi.forum.e.2015.260>

This Version is available at:

<https://hdl.handle.net/10419/200904>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

KDI Policy Forum Vol. 260 (eng.), January 29, 2015

**Questions about Article** Suil Lee (82-44-550-4127)

**Subscriptions** Publication Officer(82-44-550-4346)

# Improvement of Power Generation Facility Investment Systems for Achieving Resource Adequacy in Electric Power Industry

Suil Lee Fellow, KDI

- Investment in power generation facilities in Korea is planned and implemented in accordance with the Basic Plan on Electricity Demand and Supply, which involves the following problems:
  - Problem 1: An underestimation of long-term electricity demand due to optimistic projections on electricity price results in insufficient investment in power generation facilities.
  - Problem 2: Uncoordinated investment plans in power generation facilities and transmission networks can exacerbate regional disproportion of power facility distribution and can cause inefficiency and instability in transmission networks.
  - Problem 3: Leaving the assessment of uncertainty factors up to the small group who lead the planning may distort future power generation mix.
  - Problem 4: A considerable number of the planned investment projects remain unexecuted due to the absence of effective means to enforce or induce implementation of investment plans
  
- This paper attempts to propose deregulation of power generation market entry and introduction of a capacity obligation scheme as measures to deal with Problems 3 and 4.

\* This is the translated version of *KDI Policy Forum* released on April 14, 2014.

\*\* This article is based on "Korean Systems for Achieving Resource Adequacy in Electric Power Industry" by Suil Lee, a research monograph published by the Korea Development Institute in 2013.

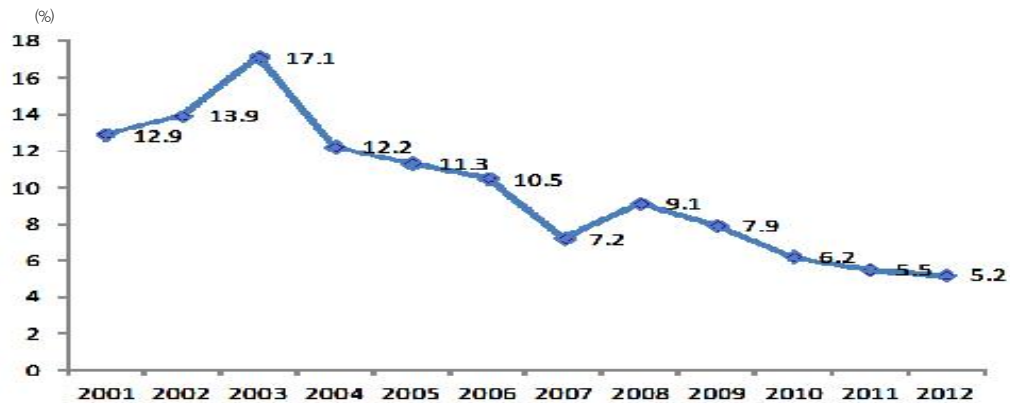
- The efforts to handle Problems 1 and 2 is not addressed in this paper, as there were efforts to resolve these concerns in the Sixth Basic Plan on Electricity Demand and Supply in 2012.
- Uncertainty factors affecting the economic feasibility and environmental performance of power generation facilities vary by energy source. In the case of coal- and LNG-fired power generation, the possibility for distortion within the power generation mix can be minimized by lowering the barriers to market entry. This can be achieved by offering more autonomy to power producers in assessing future uncertainty factors.
- Uncertainties over investment in power generation facilities can be minimized via a contract between power producers and suppliers, arranged through the introduction of a capacity obligation scheme. In such a scheme, obligation is imposed upon the power supplier (KEPCO in Korea) to secure power capacity that can ensure a stable supply to meet future demand for electricity.

## 1. Introduction

- In the electric power industry, resource adequacy is attained when sufficient resource to meet the electricity demand at a socially optimal level is secured at as minimal cost as possible.
  - Resources in the electric power industry are divided into supply-side and demand-side components. The supply-side resources include power generation and transmission facilities, while the demand-side resources include demand response and energy efficiency.
  - On the supply side, resource adequacy broadly refers to not only the stable construction of power generation and transmission facilities but also adequate energy mix for the purpose of minimizing power generation cost, efficient operation of generation facilities as well as efficient distribution of generation facilities and transmission networks.
- Recent events, such as the nationwide blackout on September 15, 2011, have shown that resource adequacy has not yet been achieved in the Korean electric power industry.
  - Peak load increased by 5.3 percent per annum from 2001 to 2012<sup>1</sup> while power

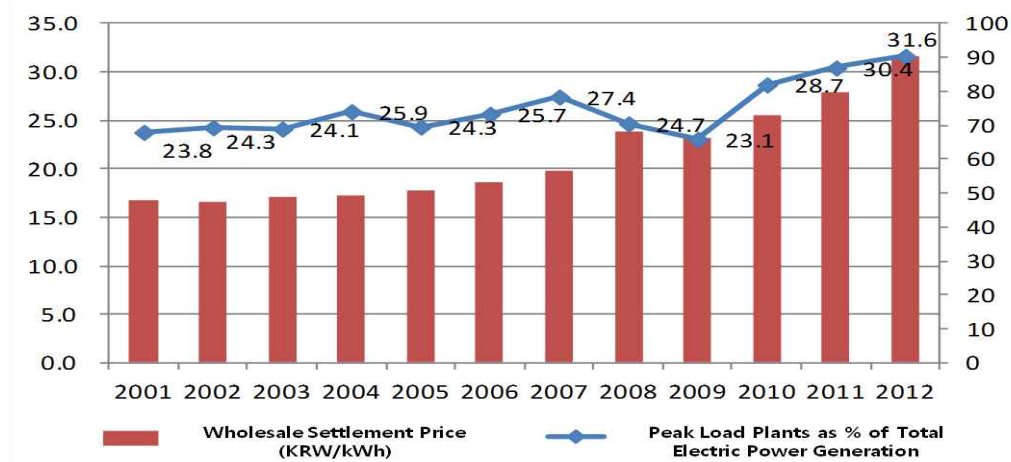
generation capacity grew 4.7 percent per annum over the same period, resulting in the power supply reserve ratio to drop recently to the 5 percent level (see Figure 1).<sup>2</sup>

[Figure 1] Trends in Power Supply Reserve Ratio



Notes: Power supply reserve ratio=(supply capacity-peak load)/peak load×100.  
Source: Electric Power Statistics Information System(EPSIS, epsis.kpx.or.kr).

[Figure 2] Peak Load Plant Shares of Total Electric Power Generation and KEPCO's Unit Settlement Price



Sources: 1) Electric Power Statistics Information System(EPSIS, epsis.kpx.or.kr);  
2) KEPCO's Monthly Report on Major Electric Power Statistics(March 2013).

<sup>1</sup> Real GDP grew 4.2% per annum over the period.

<sup>2</sup> Power supply reserve ratio in Korea is set based on an assumed installed reserve ratio of 22% (15% minimum reserve requirement plus 7% for consideration of demand uncertainty).

- The wholesale settlement price for electricity surged due to an increase in peak load plant shares of power generation, the fuel price hikes in the 2000s, and the development of generation facilities focused on peak load power generation such as LNG (see Figure 2).
- This paper attempts to outline the current state and problems of Korean system, with a focus on power generation facility investment. It also seeks to propose two measures to achieve resource adequacy in the electric power industry.

## 2. Current State and Problems of Systems Related to Power Generation Facility Investment

- Investment in power generation facilities in Korea is organized in accordance with the Basic Plan on Electricity Demand and Supply, and power producers recoup the costs of their investment in generation facilities through electricity market.
- Drawn-up biannually, the Basic Plan on Electricity Demand and Supply (hereinafter the Basic Plan) projects electricity demand for the next 15 years and establishes the construction plans for power generation facilities that reflect the optimal capacity and power generation mix.
  - Once the basic plan about future generation facility investment which is derived through an optimal computational model based on the long-term electricity demand projection reflecting demand-side management target is set, power generation facility plan is established, selectively reflecting the evaluated power producers' construction intent.
  - The evaluation criteria for power producers' construction intent consist of cost indicators (such as interconnection, transmission, construction, and fuel costs) and implementation indicators (such as residents' acceptance, project environment, power system conditions and a degree of construction delay of previous project).
- The electricity market is divided into energy and ancillary service markets. Power producers receive the energy payment in the energy market in return for power production, and the ancillary service payment in the ancillary service

market.

- In addition to the above arrangement, power producers are also offered capacity payment is also given to the power producers with the object of recovering the investment costs.
  - This arrangement reflects the reality that recovering 100 percent of investment costs in the energy market is essentially impossible in Korea, where energy payment is determined using a cost-based pool (CBP) model<sup>3</sup> which is based on variable costs.
  - Capacity payment is offered to an individual power producer after being determined according to the following formula: capacity price coefficient by season, time and region x base capacity price x power generation capacity available for supply.
  
- As seen in the First through Fifth Basic Plans, underestimation of long-term electricity demand led to underinvestment in power generation facilities (Problem 1). The fact that power generation facility planning preceding the transmission network planning resulted in regional disproportion of power generation facility distribution and caused instability in transmission networks (Problem 2).<sup>4</sup>
  - Electricity demand was steadily underestimated due to an optimistic assumption of future electricity price, as well as flawed estimation model which doubly deducted demand-side management amount.
  - Leaving behind the previous practice of accommodating power producers' construction intent to the greatest extent possible, power producers' construction intent is now selectively reflected after evaluation in accordance with electricity demand prospects since the Third Basic Plan in 2006. Consequently, underestimation of electricity demand directly leads to

<sup>3</sup> Costs of power generation are divided into variable costs, which change depending on power generation volume, and fixed costs. Costs of investment in power generation facilities are classified as fixed costs based on the assumption that the investment will be paid back in an equal amount over the useful life of power generators.

<sup>4</sup> Recently, there has been an increasing level of awareness regarding problems in the electricity market, such as the underestimation of long-term electricity demand and the power generation facility planning preceding the transmission network planning. While drafting the Sixth Basic Plan in 2012, power producers' construction intent was taken into account on the precondition of transmission network building, which was part of the effort to address these problems.

underinvestment in power generation facilities.

- The planning of power generation facilities was conducted without sufficient consideration of the conditions for interconnection to transmission networks. As a result, construction of power generation facilities was centered on four regions of Korea where it was relatively easy to secure land sites, with investment in transmission lines connecting generation facilities to power system lagging behind. This practice has been the source of inefficiency and instability in transmission networks.
  
- As the assessment of future uncertainty factors is carried out by a small group and as arbitrary intervention of the government is easy, inefficiency in the power generation mix is likely to occur (Problem 3).
  - Considering that power generation facilities have a lifespan of several decades, a rational assessment of future uncertainty factors is critical for achieving a socially optimal power generation mix.
  - Future uncertainty factors that may influence the power generation mix include power generation efficiency, lifespan, fuel costs, carbon dioxide emission costs, and the cost of investment depending on energy sources.
  
- The planned investment projects often remained unexecuted, with a number of projects being delayed for more than six months or even canceled due to the absence of effective means to enforce or induce the implementation of investment plans (Problem 4).
  - Under the First through Fifth Basic Plans, 35.6 GW worth of power generation facilities were scheduled for construction during 2002-2013, but 14.9 GW (41.8 percent) of the capacity construction was delayed for more than six months or even canceled.
  - The issue of uncommitted investment is particularly conspicuous among private power producers, with 76.9 percent of the planned projects by a number of power generators, or 83.2 percent by capacity, being delayed for more than six months or being canceled.<sup>5</sup>

<sup>5</sup> Uncommitted investment is particularly conspicuous among private power producers because they tend to reflect potential investment plan in the Basic Plan first before deciding on whether or not to go ahead with the plan, depending on uncertainties unfold. In practice, these uncommitted investments are rarely penalized.

- There are no effective means to enforce implementation of investment plans under the current Basic Plan and approval systems.
  - According to the Electricity Business Act, project permission grant is revoked only if no implementation begins within a 10-year preparation period, a term so large that there is little push for timely implementation of investment plans. Given that the preparation period can also be extended, it becomes increasingly clear that the regulation has no force in practice.

〈Table 1〉 Unexecuted Investment in Power Generation Facilities, Initially Scheduled for Completion in 2002~13

	Private Power Producers				Power Generation Subsidiaries			
	No. of Power Generators	Generation Capacity (MW)	Weighting (%)		No. of Power Generators	Generation Capacity (MW)	Weighting (%)	
			By Number	By Capacity			By Number	By Capacity
Initial Plan	26	12,567			38	23,003		
Completed	6	2,110	23.1%	16.8%	32	18,603	84.2%	80.9%
Delayed	5	2,807	19.2%	22.3%	5	4,200	13.2%	18.3%
Canceled	15	7,650	57.7%	60.9%	1	200	2.6%	0.9%
Delay/Canceled	20	10,457	76.9%	83.2%	6	4,400	15.8%	19.2%

〈Table 2〉 Power Generation Facility Investment Process and Problems

Process	<ul style="list-style-type: none"> <li>• Forecast long-term electricity demand</li> </ul>	<ul style="list-style-type: none"> <li>• Calculate the necessary power generation capacity</li> <li>• Decide the construction location</li> <li>• Calculate the power generation mix</li> </ul>	<ul style="list-style-type: none"> <li>• Achieve the necessary power generation capacity</li> </ul>
Problems	<ul style="list-style-type: none"> <li>• Underinvestment due to systemic underestimation of electricity demand (Problem 1)</li> </ul>	<ul style="list-style-type: none"> <li>• Regional disproportion of power generation facilities and inefficient/unstable transmission networks (Problem 2)</li> <li>• Likelihood that the power generation mix will be distorted (Problem 3)</li> </ul>	<ul style="list-style-type: none"> <li>• Underinvestment due to the absence of means to enforce or induce implementation of investment plans (Problem 4)</li> </ul>
Related Systems	<ul style="list-style-type: none"> <li>• The Basic Plan on Electricity Demand and Supply</li> </ul>	<ul style="list-style-type: none"> <li>• The Basic Plan on Electricity Demand and Supply</li> </ul>	<ul style="list-style-type: none"> <li>• The Basic Plan on Electricity Demand and Supply</li> <li>• Approval system (Electricity Business Act)</li> <li>• Capacity payment scheme</li> </ul>



- Effective systems to induce implementation of investment plans are also not present.
  - A capacity payment scheme in Korea is designed to function as an incentive to invest in power generation facilities, but fundamentally it is difficult to determine a price level that is appropriate to induce investment in the required capacity.
  - Reference capacity price is used as a base for determining the capacity payment price, but it has not been updated since its introduction in 2001.<sup>6</sup> As such, the capacity payment scheme does not serve its proper function, which is to induce investment in power generation facilities.

### 3. Measures to Improve Power Generation Facility Investment Systems for Achieving Optimal Power Generation Mix in Electric Power Industry

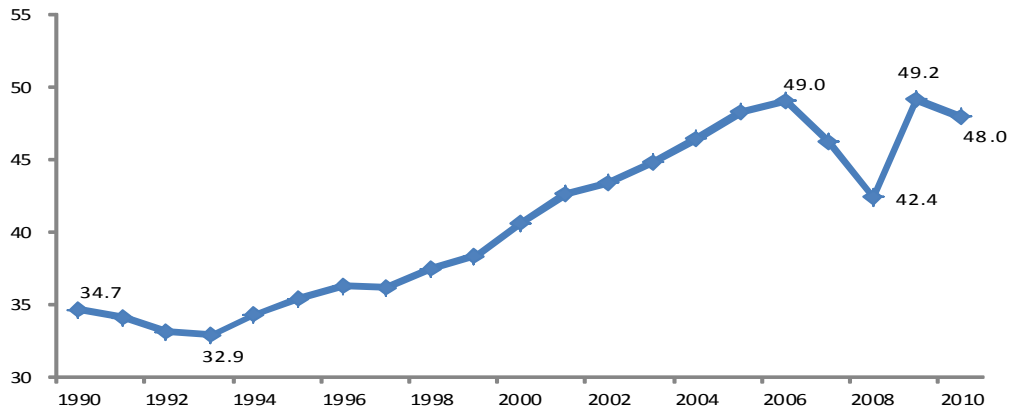
- This paper attempts to propose measures to overhaul the current system, focusing on the likelihood of the power generation mix being distorted(Problem 3) and the absence of effective means to enforce or induce implementation of investment plans(Problem 4).
  - As some efforts were put forth to resolve the Problems 1 and 2 when drifting the Sixth Basic Plan, this paper attempts to suggest a general direction to counter the remaining problems.
  - Any practical measures to address the errors in long-term electricity demand projection (Problem 1) would require an improvement of existing policy on electricity pricing and demand management, disclosure of information used in demand forecast, and stronger external monitoring.
  - Regional disproportion of power generation facility distribution and inefficient and unstable transmission networks (Problem 2) could be addressed by a system that better coordinates investment in power generation facilities with the transmission networks.

<sup>6</sup> Despite significant changes in the components of capacity payment price, such as construction costs, fixed operating and maintenance costs, useful life, and discount rates, the reference capacity price has not been updated since its introduction in 2001.

## A. Deregulation on Power Generation Market Entry

- The nation's power generation mix and the manner in which it is achieved are two variables that both have significant influence on energy security and climate change response in Korea.
  - In Korea, energy imports represented 12.1 percent of GDP in 2010. Power generation fuel's share of the nation's total energy consumption approached 50 percent in the late 2000s (see Figure 3).
  - Korea has been the world's seventh largest carbon dioxide-emitting nation since 2010, and the nation's per capita carbon dioxide emissions growth (1990~2011) is the third largest in the world. The percentage of greenhouse gas emissions produced by the transformation sector reached 38.0 percent in 2010 after increasing steadily since 1990 (see Figure 4).
  
- Future uncertainty factors affecting economic feasibility and environmental performance vary according to the energy source.
  - In terms of economic feasibility and environmental performance, most of the uncertainty factors related to merits and demerits of nuclear power generation and renewable energy are directly affected by the contents and the progress method of the government policy.
    - Adequate reflection of overall policy expenditure on nuclear power plants, accident risk costs, decommissioning costs, waste treatment costs, commercialization potential/time of carbon capture and storage (CCS) technology all have a significant impact on the perceived superiority of nuclear power generation in terms of economic feasibility and environmental performance.
    - With regards to renewable energy sources, the government-led policy effort to accelerate distribution would be inevitable over a considerable period of time.
  - In contrast, the relative superiority of coal- and LNG-fired power generation is influenced mostly by market factors which the government cannot fully control.
    - These market factors include the volatility of international oil prices, shale

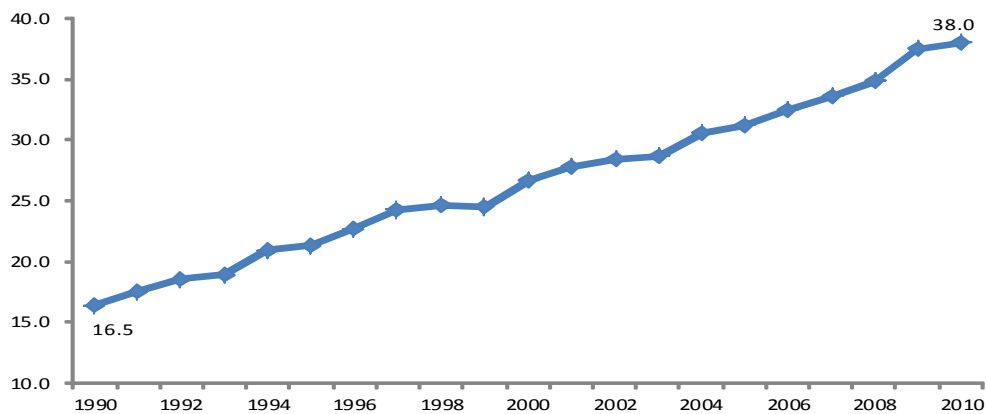
[Figure 3] Trends in Fuel Consumption for Power Generation/Total Energy Consumption



Note: Converted into tons of oil equivalent(toe)

Source: KESIS

[Figure 4] Shares of Greenhouse Gas Emissions in Transformation Sector



Source: KESIS

gas outlook, commercialization potential/time of CCS technology, and certified emission reduction (CER) price forecast.

- The current practice of determining shares of coal- and LNG-fired power generation based on the assessment of uncertain market factors by a small group of those who lead the planning and/or based on the government's policy position may cause significant inefficiency in the future.

- Therefore, in order to efficiently respond to future uncertainty factors, differentiation between policy resources, such as nuclear power generation renewable energy, and market resources, such as coal- and LNG-fired power generation is necessary. In addition, the barriers to entry need to be lowered with regards to the market resources.<sup>7</sup>
  - Once a future installed reserve ratio is set based on electricity demand projection and reliability standards, the share of policy resources should be reflected in the Basic Plan in accordance with the government's policy.
  - In terms of investment in market resources, a mechanism must be in place where power producers can push for investment in market resources based on their own assessment of future uncertainties, and implement the plans.
  - At the same time, the government needs to focus its efforts on minimizing uncertainty factors that power producers may face.
  
- As a complementary measure to cushion the effects of deregulation, this paper proposes a transition to a grading scheme for evaluating power producers' construction intent. Under the grading scheme, grades will be given to each project reflecting the progress made towards completion and overall project conditions. By making the relevant information available to the public, the market will be able to have access to the projected supply/demand conditions.

## B. Adoption of Capacity Obligation Scheme

- Underestimation of long-term electricity demand, prolonged delay of planned investment in power generation facilities, and repeated project cancellation are all major causes of the recent shortage of power generation capacity. The absence of any effective means to enforce or induce implementation of investment plans creates a major obstacle for the implementation of the planned power facility projects.
  
- As an alternative measure, the ability to secure implementation of the planned project will be enhanced in two ways: by strengthening regulatory elements of the existing Basic Plan or the approval systems, or by utilizing a contract between power producers

<sup>7</sup> In terms of energy security, a balanced fuel choice is needed to maximize the positive effects of lowered entry barriers in market resources segment.

and suppliers.

- Regulatory elements of the Basic Plan can be strengthened either by revoking approval or by levying penalty on project delays. We may introduce a deposit scheme. In such a scheme, the deposit would be forfeited in the event of project delays.
- Regulatory elements of the approval systems can be strengthened by tightening requirements, such as written consent of municipal governments and councils, and by allowing the Electricity Regulatory Commission to revoke approval or levy penalty after a formal review. The review process would be initiated in the event of a one-year or more delay in each major step after breaking down the preparation period into several major process phases.
- A contract between power producers and suppliers can be used to enforce implementation of the planned projects by replacing the existing capacity payment scheme with a capacity obligation scheme.
  - A capacity payment scheme is neither a binding instrument to enforce implementation of investment plans in power generation facilities, nor is it a practical inducement to investment because of the difficulty in determining the appropriate level of capacity payment.
  - A capacity obligation scheme obliges a power supplier (KEPCO in Korea) to secure the power capacity (defined as  $D(1+r)$ ) that can ensure a stable supply of power to meet future end-user demand for electricity ( $D$ ) and the minimum electricity reserve requirement ( $r$ ) set by the administrative authorities.
  - A power supplier can secure the required capacity by building its own power generation facility, entering in a bilateral contract with a power producer, and/or participating in a centralized capacity market.<sup>8</sup>
  - Upon transition to the capacity obligation scheme, a power producer will be paid in return for power generation capacity offered under a bilateral contract with a power supplier or via the capacity market transactions, which replaces the existing capacity payment.

□ Given that strengthening of regulatory elements of both the Basic Plan and the

<sup>8</sup> It would be reasonable for a power exchange to serve as an operator of a centralized capacity market.

approval systems may result in considerable problems (as follows), it would be more reasonable to introduce a capacity obligation scheme, which could minimize the uncertainty regarding investment in power generation facilities.

- Regulatory tightening may cause distortion of process planning, excessive administrative costs, and abuse of discretionary power by allowing exceptions and vulnerability to lobbying. The idea of regulatory tightening is inconsistent with the long-term policy goal of liberalizing the electricity market.
  - A power producer may have an incentive to make an artificially long process planning if there is risk of approval revocation or penalty for project delays.
  - Determining whether delays have occurred in any of the major process, either via document evaluation or on-site inspection by regulatory authorities, would incur huge administrative costs.
- Under the capacity obligation scheme, on the other hand, power supplier's required capacity is procured via contract with power producer. Therefore, the capacity obligation scheme is not exposed to the problems involved in strengthening regulatory elements of the Basic Plan and the approval systems, and is also inherently immune to the problem of uncommitted investment by power producers.
  - The centralized capacity market will work to reduce trading costs via product standardization and to restrain the exercise of market power by power producers.<sup>9</sup> Given the merits, it will be more efficient if system operators can procure power generation capacity in an auction in the centralized capacity market, even under the monopolistic power supply conditions.

<sup>9</sup> To restrain the exercise of market power by power producers in the capacity market, it will be reasonable to set the capacity market as a forward market, thereby inducing power producers' participation and to set the length of the forward period at four or five years considering time required in building a coal-fired power plant.