« Can competitive reforms solve the long run investment problem (incentive and coordination) in electricity market? »

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I. Introduction

Starting from the 90s, we have witnessed massive restructuring reforms worldwide that are undertaken in the electricity industries.

These restructuring reforms emphasize functional unbundling of a vertically integrated system: generation, transmission, distribution and retail services in order to introduce competition in two sectors: generation and retail services, while the operation of transmission and distribution wires remains a monopoly. The most fundamental characteristic of the restructuring process is that market mechanisms have replaced the highly regulated procedures that were used in the decision-making processes under the traditional regulation [14].

Policymakers' initial expectation by introducing competition is that competitive forces will work better than regulation at providing incentives to suppliers to increase efficiency, reduce costs, and provide more and better services [13]. However, such reform can not only pursue and implement the policymakers' initial goal, but also have various other effects, among which includes investment behaviour.

We often assume that competitive market mechanism can be beneficial when an investor seeks to effectively invest in the short run. However, in the long run, efficient investments in the electricity market are doubtlessly influenced by the market mechanism and some other factors such as future electricity demand, forward market prices, variations of regulatory policies, as well as the financial status [10].

Then, the most important question is whether these competitive reforms can effectively solve the long-term investment problem.

The objective of this article is to, firstly, relate the organizational forms to competitive reforms implemented; and second, identify investment problems due to organizational forms in the electricity market.

I find that after restructuring of the market, there exists two main long-term investment problems: incentive problem and coordination problem. I will separately analyze each problem under various organizational forms and the influence of the competitive reform policy on each aspect.

Investments in the electricity industry can be divided into three types according to their function: generation, transmission and distribution. In this article, I will only analyse investments in generation and in transmission which could be largely influenced by the macroeconomic policy. Investments in distribution is normally organised at the local level, and thus less influenced by macroeconomic policy, will be omitted here.

The organization of this article is as follows: the second section will introduce the organizational forms in electricity industry. By concentrating my research on generation investment and transmission investment, I will discuss investment incentive problem under various organizational forms in the third section and investment coordination problem in the fourth section. The fifth section concludes and derives implications for my future research.

II. Organizational forms in electricity industry

According to the intensity of governmental interference and the degree of competition introduced, I distinguish five main organizational forms in electricity industry:

Table 1: Organizational forms in electricity industry

	Attributes	**Example in Generation**	**Example in Transmission**
Public sector	Vertically integrated and public ownership	Organisational form before 1990 in Europe and Asia	
regulated vertically integrated enterprise	Vertically integrated, private and regulated	Mainly used in USA and also in Germany before 1990	
regulated integrated monopoly with access regulation	Integrated with another upstream or downstream function, regulated	when the incumbent generating company integrated with transmission owner coexists with independent power producers	when a TSO coexists with TOs or some MTI owners
unbundled regulated enterprise	Disintegrated, regulated		TOs
unbundled unregulated enterprise	Unregulated, competitive	IPPs	MTI

1. *Public sector (public vertically integrated enterprise)*: Before 1990, almost every electricity industry consisted in a large integrated owner of generation, transmission, and distribution either state-owned (the majority case) or under regulated private ownership (particularly in the USA, but also in Germany). In the case of public ownership, investment decisions are directly made or influenced by public authorities. Accordingly, public-ownership was considered as a regulatory form.
2. *Private regulated vertically integrated enterprise*: traditionally, it was the main organizational form in USA. The industry was regulated as a whole by regulators. Investment depends here mainly on the chosen regulation instrument (rate-of-return, cost plus, *franchising*) and the appropriateness of the regulatory institutions.

3. *Regulated and integrated monopoly with access regulation*: a prominent example for this case is in electricity generation when the incumbent generating company integrated with transmission owner coexists with independent power producers. Another similar example in electricity transmission is when a TSO coexists with TOs or some MTI owners.
4. *Vertical disintegration* was used in the UK and in the USA (especially in California) to organise transmission (TOs) in electricity markets.
5. *Private unregulated enterprises*: technological developments could change the natural monopoly characteristic of electricity industry and remove the necessity to regulate. With the process of restructuring, the industry is privatized and deregulated. The most important cases are introduction of competition in electricity generation sector and the implementation of merchant transmission investment in Australia.

Table 2: Examples of generation and transmission organizational forms

<table>
<tr><th></th><th colspan="3">American model</th><th>European model</th><th colspan="2">Australian model</th><th colspan="3">UK model</th></tr>
<tr><td>SO</td><td colspan="3">Regulated ISO = RTO</td><td rowspan="2">Regulated TSO (in each country)</td><td colspan="2">Regulated</td><td colspan="3">NGC</td></tr>
<tr><td>TO</td><td rowspan="2">Integrated TO (with generation)</td><td>Disintegrated TO</td><td>(MTI)</td><td>TSOs</td><td>MTI</td><td>(disintegrated TSO in E&W)</td><td>Integrated TO[1] (with generation)</td><td>Integrated TO[2] (with generation)</td></tr>
<tr><td>GEN</td><td colspan="2">competition</td><td>Monopoly/ competition</td><td colspan="2">Competition</td><td colspan="3">competition</td></tr>
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III. Investment incentive problems under various organizational forms

After having discussed the evolution of the organizational form in electricity industry, in this section, I concentrate to develop one investment problem – incentive problem under every organizational form, firstly in generation sector and secondly in transmission sector.

3.1 Generation incentive problem:

If the question of investment incentives in generation sector merits to be discussed, it is simply because that there are some unique characteristics exhibited in electricity generation that are absent in the production of more conventional goods. We will start the discussion in this subsection by introducing the characteristics of electricity generation that could raise some issues or problems in firms' investments behaviour.

3.1.1 Generation characteristics

[1] Scottish transmission owner & Scottish power
[2] Scottish and southern energy (S&S)

Generation is the primary function of electricity industry. Investment in generation accounts for about 35 percent to 50 percent of the final cost of delivered electricity.
In this function, several characteristics influence investment.

- *Competition in generation*: Traditionally, generation was considered having economics of scale characteristic and was bundled with transmission and other functions in a vertically integrated enterprise. A new technology, combined cycle gas turbines (CCGTs) made that economies of scale in electricity generation were not an inevitable part of, and opened the door to competition in generation. Therefore, the main objective of restructuring reforms at the end of the last century was to unbundle the vertically integrated industry and introduce competition in generation. In reality, the problems of investment incentives are not caused by competitive forces introduced into the sector. Indeed, such forces seek to better guide firms' investment decisions. The problems stem from the fact that in competitive electricity markets, demand is not sufficiently elastic with respect to prices, that is, there are not sufficient consumers' responses.
- *Asset specificity*: two important asset specificities are found in the electricity generation. These are "site specificity" [3] and "temporal specificity" [4] [8].The transaction costs are high[5] because of the complexity involved in coordinating the generation and the transmission. In fact, it was considered to be impossible to separate these two functions due to technical issues. In the absence of regulatory protection of generators' rights to access to clients through networks owned by third parties, vertical integration becomes one of the commonplace institutions of the electricity market [8].
- *''Public good''[6] characteristic of reliability and capacity adequacy*. The reliability of electricity and operational availability are examples of complementary products that are provided besides the main commodity (kilowatt hours). They have public-good like features that could result in free-riding and thus underinvestment.
- *Mixed technologies*: In fact, production costs can be disaggregated into fixed (sunk) costs and variable costs. One can assume that there exist competitiveness and substitutability between these two types of costs (in electricity production). Variable cost varies widely from place to place and from one technology to another. The proportion of fixed and variable costs differs according to the underlying production technology used. Consequently, when one opts for a certain type of technology to generate electricity, one has to take into consideration not only the sunk costs involved in the generator/equipment, the geographical location of the station, and the long run returns, but also the amount of variable costs involved latter in the coming future, as well as the possibility to access to necessary primary resources. In this article, to simplicity's sake, the consideration of variable costs is integrated in the problem of generation investment.

3.1.2 the primary responsibilities of electricity generation

[3] Because electricity is only transported along specially equipped lines and through a continuous link between the producer and the consumer, production of electricity is subject to site specificity [8].
[4] Temporal specificity is brought about through the impossibility of storing electricity energy and the danger of the electric flow being broken in the event of an imbalance between production and consumption [8].
[5] In absence of any system operator authority
[6] It is not the case according to Shmuel S. Oren in his paper "ensuring generation adequacy in competitive electricity market". He considers security as a public good but adequacy as a private good.

As an essential infrastructure to the economy, there are many responsibilities that the electricity industry has to bear, even if one tends to consider **reliability** as the primary one.

Reliability of electricity generation has been one of the overriding concerns guiding the restructuring of the electric power industry. The slogan "keeping the light on" has been the principal motivation for many technical and economic constraints imposed on market designs. NERC (National Electric Reliability Council in USA) defines reliability as:" the degree to which the performance of the elements of the technical system results in power being delivered to consumers within accepted standard and in the amount desired". In fact, the concept of reliability as defined by NERC encompasses two attributes of the electricity system: security and adequacy [11].

- *Security* describes the ability of the system to withstand disturbances (contingencies). It is provided by means of protection devices and operation standards and procedures that include security constrained dispatch and the requirement for so called *ancillary services* such as: voltage support, regulation (AGC) capacity, spinning reserves etc.
- *Adequacy* represents the ability of the system to meet the aggregate power and energy requirement of all consumers at all times. Precisely, adequacy represents the systems ability to meet demand, on a longer time scale basis, considering the inherent fluctuation and uncertainty in demand and supply, the non-storability of power and the long lead time for capacity expansion. The electricity market failure in California and a series of blackout[7] have brought this subject to the forefront.

3.1.3 Different market organizational forms and Generation reliability

In the above subsections, we have discussed the major characteristics involved in electricity generation and the responsibility of the industry to provide a certain level of reliability in its generation. In this section, we will focus on the impact of various organizational forms on the industry's incentives to invest adequately with respect to reliability. Indeed, because of the unique characteristics of electricity generation, how the industry is organized will provide different incentives to invest.

A. Generation reliability in the vertically integrated industry

As we have discussed above, the generation sector was organized in a vertically integrated industry initially, which holds a monopoly granted by government in return for which it has a legal obligation as a public utility to serve all customers in an area. It (or several utilities) is responsible for the operation of a control area, within which it must maintain reliability and dispatch generation economically. The form of regulation was effectively cost-of-service regulation.

In this case, decisions on the amounts, locations, types, and timing of investments in new generation have been made by the vertically integrated utilities with approval from state public utility commissions. It was the responsibility of utility companies to assure that enough generation capacity was available and usually there was a centralized generation planning. The traditional approach to this was to build

[7] In the summer of 2003, a spectacular series of electricity blackouts shook the world of utilities, both in the US (August 4) and in Europe (London, August 28, Italy, September 28, Sweden and Denmark, September 29).

planning reserves based on the forecasted load, loss of load probability (LOLP) calculation and estimates of the value of lost load (VOLL), and allocate the costs of the extra capacity implicitly among consumers.

The advantage of this organisational form in generation investment is the vertical and horizontal coordination advantage that the company can take a centralised decision in space and time to carry on a unified investment plan to ensure generation reliability. Under this type of organization, underinvestment is less preoccupying, since the vertically integrated firm is vested with the mission to meet all consumers' demand. As such, there will be sufficient incentives for the firm to undertake any necessary investments. Obviously, imperfect regulation related to market power is also a serious problem that we cannot overcome in this organizational form.

B. generation reliability in the competitive electricity market environment

Restructuring of electricity industry starts from the premise that while transmission and distribution networks are natural monopolies requiring regulation, generation and retailing are potentially competitive activities.

Over the past several years, several important changes in the role of competing generators have begun to occur. Probably the most important changes are associated with the growing importance of wholesale power markets, in particular, the development of a competitive independent generating sector made up of power supply entities that sell power to distribution utilities for resale without being subjected to traditional price and entry regulations. I distinguish two types of them:

- ❖ Generation company integrated with TO: generating companies owned by a transmission owner. These generating companies often compete with the other generating companies to access to their own transmission lines which are dispatched by an ISO.
- ❖ Independent power producer (IPP): independent generating companies who sell output under contracts, often life-of-plant contracts. They do not serve a designated service territory.

In these cases, decisions on whether to build new generators and to retire, maintain, or repower existing units are made by these competitive generating companies. Generally there is no central planning for new generation capacity additions and no guarantee is made any more for recovery of generation investment and return. On the other hand, generating companies do not have any obligation for ensuring sufficient supply of electricity in nowadays and in the future. Each generating company makes its own independent assessments of the profitability of new generation projects. In making generation investment decision, the locations, capacities and timing of new power plants are basically at the generation companies' own discretion although an indicative generation planning may be provided by the regulator to guide the investment and planning, as is the case in several Latin American countries such as Chile, Peru, Bolivia and Argentina [10].

Thus, in the competitive electricity market environment, the key issue on generation reliability is whether (1) competitive generation markets for capacity and energy will be sufficient to maintain socially desirable levels of reliability, or (2) government regulators and system operators will need to impose mandatory minimum-reserve obligations on load serving entities (LSEs) to ensure that customers are not involuntarily interrupted from their electricity supplies.

Several market designs are proposed to maintain generation reliability:

a) energy-only market

Energy-only electricity markets have been adopted in the original Californian design, in Nordpool and the Australian Victoria pool. Generators in such markets bid only energy prices and, in the absence of constraints, all bids below the market-clearing price in each hour get dispatched and paid the market-clearing price. The primary income source for recovery of capacity cost is the difference between the market clearing price and the generators' marginal costs. When ancillary services are procured by the system operator, as in California and ERCOT, generators can earn additional revenue by selling ancillary services, such as regulation and spinning reserve capacity, through short term ancillary service markets or long term contracts [11]. However, not all generators with available capacities can receive these payments and only those generators with winning bids in the ancillary service markets are eligible. In designing these markets, the generation adequacy problem was ignored either because at the time when restructuring was proposed there was a significant over-capacity in the system or because they believed the market could solve this problem by itself [10].

Economic theory shows that a long-term equilibrium of energy only market itself is enough to provide adequate investment signals and that the rational response of the generators to the prices in the spot market is to install facilities until the socially optimal level of investment is reached [14].

Although ideally the market itself should be enough to provide adequate investment incentives, there are several factors as follows that prevent this result from being achieved, and some actual markets such as the California market have already experienced problems related with a lack of generation capacity.

Firstly, the price often cannot be high enough to induce investment[8] *because of the frequent use of price cap.* There are two reasons for the frequent use of price caps:

- *Insufficient price elasticity of demand response:* in practice, the revealed price elasticity is quite low. An important reason is that due to the high costs of real-time meters equipment and their operation, few customers are exposed to real-time prices (Littlechild, 2003). When the consumers are isolated from spot prices either by regulated tariffs or by average tarification procedures, they feel neither the volatile prices nor the need for hedging against high prices. Because of the

[8] In theory, the price in any competitive market, for any product, is set by the highest cost supplier actually selling product when there is plenty of supply, and by the marginal (lowest value) demand actually served when the supply is constrained. [1]

If the spot price in the market reflects the marginal cost of the last generator selected (which it will when supplies are available, that is, most of the time) how do generators ever get paid for their investment costs? There are two answers: ①Generators with lower running costs will make a profit from the market prices set at the highest bid – and this is a contribution to the investment costs. ②But how can the last generator cover his investment? The prices need to rise at the peak times to provide enough to cover the investment of the last generator on the system – and in fact it can be shown that all the generators need this amount to recover their investment. It is the prospect of these returns that induces generators to invest. In a word, prices must be high enough to induce entry. [1]

lack of demand elasticity, energy-only markets can provide incentives for investment, but only at unacceptable prices [13]. This is because they can only do this by subjecting consumers to price volatility, supply shortages, and a level of risk to reliability that customers and policymakers would find unacceptable. As a practical matter, policymakers have imposed or proposed prices caps or bid limits in competitive markets. A price cap needs to be instituted in the short-term market to protect consumers in real-time against excessive prices.

- Another reason that policymakers are reluctant to accept a very high price is that they cannot distinguish whether the high price is caused by scarcity rent or by market power from an *oligopolistic behaviour* of the incumbent utilities, which may under-invest in order to raise the market prices, when the barriers to entry are sufficient to block the contestability effect of potential new entrants. In fact, many price spikes are believed to be the result of market power exercised by generation companies [10].

Thus, if in an energy-only market, the only revenue source for recovery of capacity costs is the difference between the market clearing price and generators' marginal costs, and we want to rely on this price to reflect short-term supply and demand status will create market signals for a proper capacity expansion, then the use of price cap will impede the price to go up and then induce the investors' investment incentive.

Secondly, uncertainty and investors' risk aversion are the other factors which reduce investors' incentive to invest

Karsten Neuhoff and Laurens De Vries (2003) show that in the absence of a sufficient volume of long-term contracts[9] or a similar mechanism, spot markets will provide insufficient incentives for investment in generation capacity when investors or final consumers are risk adverse [15]. They identify several types of uncertainty such as the high peak load price uncertainty, the regulatory uncertainty and involution of future supply and demand uncertainty, all of which induce risk-averse investors to reduce the equilibrium volume of generation capacity relative to risk-neutral investors.

- *The high peak load uncertainty*: Generally the duration of a peak load period is very short since it is usually the result of exceptional weather conditions or some important events. Prices must be very high in peak load periods so as to justify investments to meet the peak demand. Basically, it is very difficult to attract peak capacity investment by the price of electricity in an energy-only market since the expected revenue is very unstable and the investment cost may not be recovered. The high peak load price uncertainty in electricity markets may also prompt regulators to intervene during periods of high prices, which limits the expected revenues and therefore reduces the incentive to invest in generation capacity.
- *Uncertainty about evolution of future supply and demand*: Because the construction of generation plants is characterized by a long lead-time and their economic life is also long, incomplete information about the future evolution of demand and supply increases investment risk. In addition, if an incumbent vertically integrated firm and IPPs coexist, there is an information asymmetry

[9] Obstacles to long-term contracts: generally, generators do not sell their electricity directly to final consumers but to retail companies which act as intermediaries. In this situation, generation companies would only sign a limited volume of long-term contracts with retail companies in an environment with strong retail competition. The risk to generators stems from the fact that retail companies may lose their customers to new retail companies at times when their long-term contracts exceed the short-term price [15].

between generation investment planned by the vertically integrated firm and the new entrants concerning the expansion and upgrading of the network infrastructure. This would also reduce investors' incentive to invest.

If we cannot completely rely on energy-only market to maintain socially desirable levels of reliability, then what should government or regulator do to ensure generation adequacy?

There are three workable methods to deal with these problems – demand bidding, a capacity payment, or a system of capacity obligations with capacity markets [1] [14].

b) Demand bidding (consumers' responses)

The most orthodox solution to this problem would be the demand bidding.
With demand bidding in electricity markets, the customers or their representatives (the distribution companies or retailers, or large customers who participate in the process directly) bid for what they want to take and participate in setting the price. Under such circumstances, consumers can react to variations in price, and therefore reflect their willingness to pay. An increase in price will marginally discourage a fraction of consumers from consumption. Such a reaction has two consequences: firstly, the price will not continue to increase and the market clearing price can be reached; and secondly, consumers who do not choose to continue their electricity consumption would have the risk of service interruption. The amount of rents that results will compensate the invested capacity and serves to attract necessary supplementary investments[10]. At the same time, if one assumes that the consumers are risk adverse and rational, then in an ideal market, consumers seeking a better reliability would try to sign long-term contracts to protect themselves against high prices and service interruptions. This should also encourage the entrance of more generation, since the contracts would bring the income stability that the generators are looking for.

However, actual markets do not perform so efficiently. As I have discussed above, in most cases, the consumers are isolated from spot prices either by regulated tariffs or by average tarification procedures, they feel neither the volatile prices nor the need for hedging against high prices and they see no advantage in long-term contracting[11]. The lack of demand-side response creates a malfunctioning of the long-term market that cannot be solved in the short run, and causes a lack of generation investment that paves the way for potential future shortages.

c) Capacity payments

Ensuring generation adequacy through capacity payments has been implemented in the UK (before the new trading arrangements (NETA)), Spain and several Latin American countries such as Argentina, Colombia. The idea is by adopting an explicit remuneration for the installed capacity as an economic signal intended to augment the volume of installed and available generation. Generators in such system are given a per MW payment based on their availability (whether they get dispatched or not) or based on generated energy as an adder to the energy market clearing price.

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[10] The same reason as in reference 8

[11] It should be noted that the basic consumers' response that is needed is not demanding less energy from the market when prices are high – that is the typical goal of demand-side management programmes – but signing efficient hedging contracts to express their risk aversion and their need for a higher reliability level.

The concept of capacity payment is rooted in the theory of peak load pricing whose application in the context of electric power was pioneered by Boiteux[12]. According to this theory generation of electricity requires two factors of production, capacity and energy where the amount of energy that can be produced in any given time period is constrained by the available capacity. Consider a simple case of two consumption periods: peak and off-peak with two perspectives deterministic demand function and assume that the same fixed capacity is available in both periods. According to the basic theory, energy is priced at marginal cost in both periods and a capacity payment that would recover the fixed capacity cost is imposed on the peak-period energy users. The optimal capacity will be such that the incremental cost of a capacity unit equals the shadow price on the capacity constraint that is active during the peak. That shadow price reflects the incremental value of unserved load as measured by willingness to pay net of marginal energy cost.

Another system – capacity adders - was also used in the early competitive trading arrangements in Argentina and the U.K. Pool. This was due to the concern that the generators would not bid prices high enough to cover the cost of capacity. In the case of Argentina, the generators were only permitted to bid their marginal costs; in the United Kingdom, the worry was that with bids being made more than a day ahead, there would be no way for the generators to know that this was the day to bid higher. In the form adopted in the United Kingdom, the National Grid Company calculates, on a day-ahead basis, the expected loss-of-load probability (LOLP) for each 30-minuite period. The market price was set as the highest bid unless there was some probability of shortage, in which case the value of lost load (VOLL) came into play. There, the LOLP is multiplied by the VOLL to develop a capacity charge, which is added to the system marginal price. It means that the price was the weighted average of the highest bid and the VOLL, weighted by the probability that there would be a shortage: (highest bid) x (1-LOLP) + VOLL x LOLP. This formula also acted as a price cap of VOLL if the system was actually short of power.

In theory, capacity payments would attract new investment, resulting in lower (and more stable) market prices, with this price reduction being compensated by the capacity payment itself.

However, there are still some problems:

- The regulated nature of the procedure has created strong disagreements regarding both the total volume of money to be paid to the generators and the allocation of it among the different facilities, especially when there are thermal and hydro units involved. Besides, it is unclear whether the method can effectively enhance the reliability of the system, and dissatisfied consumers argue that they are paying a capacity charge in exchange for nothing [14].
- Another problem is also the reason why this approach has received little attention in the United States. It is because the capacity charge is too easy to manipulate for companies that own large amounts of generation. They can declare units unavailable in the day-ahead market and then make them available in real time to collect the high-capacity charge caused by the unavailability declarations. This is

[12] Boiteux, Marcel P. “La tarification des demandes en pointe: Application de la théorie de la vente au coût marginal », 1949, Revue générale de l’électricité

found in England & Wales electricity market in which gaming for capacity payment was serious [10].

d) Capacity obligations (capacity market)

Ensuring generation reliability by imposing an installed capacity obligation on load serving entities (LSEs) has been implemented in the eastern pools in the US including PJM, NYPP and New England. Specially, the LSEs are required to have or to contract with generators for a prescribed[13] level of reserve capacity above their peak load within a certain time frame. Capacity markets, which are established to facilitate trading, allow trading of capacity obligations among the LSEs who have already accompanied installed capacity (ICAP) obligations. The basic motivation for the ICAP requirements is similar to the argument in favour of capacity payments. The capacity markets prompted by the obligation provide generators with the opportunity to collect extra revenue for their unutilized reserve generation capacity and provide incentives for the building of reserves beyond the reserves that meet the short term needs for ancillary services [11].

In theory, capacity markets will help to ensure an economically efficient and socially optimal level of capacity by taking into account the full value of that capacity to all users of the system thus providing the financial incentive necessary to induce the level of investment needed to meet the established reliability criterion [13]. Moreover, experience to date from operating competitive wholesale electricity markets suggests that without a capacity obligation, incentives for investment are, in fact, not adequate to achieve the objectives of electric industry restructuring. Inclusion of a capacity obligation as the standard of electricity market design is necessary to ensure both the efficient operation of competitive electricity markets and the protection of customers with respect to price and reliability.

Although in practice, capacity markets are workable[14], there are problems:

- One of the fundamental problems with capacity markets is that there is disconnect from the energy market. The fundamental relationship between capacity and energy prices in a long run equilibrium is such that the expected social cost of unserved energy as reflected by the energy-only markets prices should equal the marginal cost of incremental capacity. However, the separate capacity markets created for trading reserve capacity requirement set through engineering based methods may produce prices that are not in equilibrium with the energy market prices.
- There are policing and other problems with the sellers of capacity, because it is difficult to produce incentive-compatible capacity market rules. Generators who are being counted as reserve may sell the same capacity in another market if external prices are attractive, meaning it is not available in the first market when a generator outage or other problem arises.
- The reliance of capacity payments and capacity obligations on engineering based calculation has been criticized repeatedly on the grounds that the VOLL used in these calculations is administratively set and has no market base.

3.1.4 Conclusion for this section:

[13] the regulatory authorities determine the amount of firm capacity that each one of LSEs has to buy, as well as the maximum amount that each generator is allowed to sell

[14] There are workable capacity markets in various parts of the USA.

From the above discuss, in the present energy-only market, given the lack of consumers' responses and the political realities, prices lack the ability to adjust adequately to induce investment when capacity tightens. We often end up with insufficient generation adequacy and serious shortage in the market.

Therefore, three workable solutions are proposed to solve this problem. Demand bidding, capacity payments and capacity market.

In the long tem, demand bidding is certainly the best solution, but during the transition to a fully competitive market, capacity payments that are related to the need for capacity in each hour can do the job quite well [1]. An explicit capacity obligation could also do the job by signalling capacity shortages (and surpluses) and inducing investment when appropriate. However, given the serious gaming problems caused by capacity payments and capacity market, in the long term, the relevant public authorities should take steps to encourage and provide necessary equipment for consumers to actively react to price variations in electricity and a reasonable use of long-term contracts[15].

Another interesting question concerns the role of regulation: should the government or regulator play an active role for ensuring the system adequacy? This is highly debate of issue. The approaches employed in several Latin American countries such as Bolivia, Chile and Peru may be of value for reference, especially for developing countries in Asia on the procedure of restructuring their power industries. In these Latin American countries, a better balance is maintained between competition and regulation. The regulators transferred the responsibility of expansion of generation capacity additions to the private sector in a market environment, but the government still keeps an indicative role to strategically direct the generation capacity expansion. It is believed that private investment decision may not coincide with what is socially optimal. Hence, the government would have to provide adequate signals [10].

A regulatory framework is proposed in [14], in which reliability contracts based on financial call options are auctioned, and both the price and allocation among different plants are determined through competitive mechanism. In this way, the incomes of generating companies can be stabilized and this in fact provides a clear incentive for new generation investment.

3.2 Transmission incentive problems

Similarly, we firstly discuss some transmission characteristics that could influence the investment.

3.2.1 Transmission characteristics

Transmission is an important function in the electric industry. It accounts for about 5 percent to 15 percent of the final cost of electricity [1].

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[15] The volatility in prices presents its own risks for both generators and customers, and there will be a natural interest in long-term mechanisms to mitigate or share this risk. The choice in a market is for long-term contracts. Long-term contracts focus on the problem of price volatility and provide a price hedge not by managing the flow of power but by managing the flow of money.

In this function, several characteristics influence investment.

- o *Economies of scale and lumpiness*: transmission investments are characterised by significant economies of scale and "lumpiness", that is, the average cost of a new link declines as its capacity increase, other things equal. Transmission investment is profitable only if the discounted value of earnings from sales of new transmission capacity exceeds investment plus operation costs. Because of the lumpiness, investment will only be profitable if the network constraint partly persists after investment. If congestion is fully eliminated, no congestion rent can be extracted from the network users to cover investment costs [18]. Lumpiness thus results in an *underincentive* to reinforce the system for the same reason that an incumbent grid owner rewarded by congestion rents has suboptimal incentives to remove these congestion rents [2].
- o *Network Externalities*: the physical laws of power flows and network conditions (e.g. congestion) cause externalities in the transport of electricity that may change due to the generation /consumption pattern within the grid. Due to the laws of physics, the flow of electricity cannot be totally controlled since it follows the path of least resistance. Because of that, it is misleading to price the use of the network with the aid of a contract path principle based on the fiction of one definite path between the point of injection and the delivery point. Concerning investment, this may lead to *free-rider problems* when investment decisions of one network owner induce positive externalities in other networks.
- o *State–contingent problems*: normally, we consider one line's capacity is well-defined and non-stochastic. In practice, the actual capacity depends on exogenous environmental parameters[16]; furthermore, system operators (SO) have substantial discretion on defining and implementing security constraints, affecting the actual power flows on the link in real time [2].

3.2.2 Contributions of transmission investments

As demand grows and new generating capacity is added to replace older less efficient capacity or to meet growing demand efficiently in the long term, investments in transmission capacity are likely to be necessary to minimize the overall costs of wholesale electricity supplies, to maintain reliability, to mitigate locational market power, and to improve the performance of competitive wholesale and retail markets [2].

In this section, I try to respond to some concrete questions related to the main contributions of transmission investments. What is a "justified" investment? What are the societal goals that a transmission investment framework should seek to achieve? What are the respective roles of economic goals, reliability goals and other potential public policy goals?

A "justified" investment

- ❖ Societal goals: It can achieve unified decisions, global optimal and maximal social utilities (solve the following problems: transmission as a public good and serving to benefit out-of-area users).

[16] For example, the physical capacity of transmission lines depends on temperature and other exogenous contingencies [2].

❖ Economical goal: “invest in network assets only while the additional network investment cost is still smaller that the additional saving in system operation costs” [19]. That is:
Savings in system operation costs (congestion cost + loss of supply)
> Investment costs
❖ Reliability goals: transmission expansion can increase network reliability and enhance national security. The reliability goal is considered to be the crucial goal of transmission expansion and transmission investment is often simply justified by reliability considerations.
❖ Public policy goals: one example of European public policy goal is the interconnection in European single electricity market. European countries need a better interconnected transmission grid to enhance reliability and to improve efficiency because political boundaries make no sense for a natural electricity market form either from an electrical or market point of view.

To discuss the transmission investment problems, I consider two types of transmission investments that can increase the capacity of the network and reduce congestion [2].

- *Network deepening investments*: these are investments that involve physical upgrades of the facilities on the incumbent’s existing network. These are specific investments (as described by Williamson 1983) that we assume can be undertaken most efficiently by the incumbent network owner. Similar to network deepening investments are network maintenance decisions. Like network deepening, maintenance is most efficiently performed by the owner of the link or grid.
- *Independent network expansion investments*: these are investments that involve the construction of separate new links that are not physically intertwined with the incumbent network except at the point at either end where they are interconnected. These investments can (in principle) be made either by incumbent transmission owners, by stakeholders (generators, load-serving entities), or by a third-party merchant investor.

In our subsequent discussion, we will focus specifically on incentives of independent network expansion investments in transmission. We assume that network deepening investments can be undertaken most efficiently by the incumbent network owner under any organizational form.

3.2.3 Transmission investment organizational forms and their incentive problems

In this section, I firstly characterize the most important organizational forms in transmission; secondly, I try to answer the following questions in every organizational form: what entities are expected to organize or to develop the new facilities? What are the corresponding investment incentive problems?

To answer the question of what entities are expected to organize or develop the new facilities, we should first recognize that in reality different entities take these responsibilities under different organizational forms. Here I distinguish three entities who are concerned with these responsibilities: systems operators, transmission owners and public authorities. In most cases, the system operators' responsibility is to operate the system, coordinate generation and transmission and also study the needs or opportunities for transmission expansion.

Following the classification of organizational forms in section II, I combine the first two organizational forms and there are four main transmission organizational forms: (i) public or private vertically integrated enterprise; (ii) transmission system operator (TSO), in which transmission owner (TO) is integrated with SO; (iii) TO + ISO. With some strong assumptions, a (iv) merchant transmission investment approach exists, in which investments in transmission are assured through a market-based mechanism.

- **Vertically integrated model (public or private)**

The public vertically integrated model is also called centralised decision model and is still largely used today. Its characteristics have been discussed in the second section. The crucial investment problem in this case is the verification of appropriateness of decision-making.

With the process of privatization, the industry was privatized and private vertically integrated utilities appeared. In this case, investment decisions are the responsibilities of the system operator/transmission owner or the regulator, who come up with some transparent and stable rules to identify, evaluate, build and charge new facilities that are required.

The obvious advantage of this model is that decisions are centrally taken and there are no vertical or horizontal coordination problems. The difficulty is to identify and prove which investment is cost-effective and allocate costs to market participants.

- **Regulated TSOs (public or private)**

The regulated TSO is the transmission organizational form in most European countries and some other countries such as Australia. In European countries, there is one TSO per country. In Australia, there are several TSOs. TSO is a for-profit company, whose profit is adjustable by a regulator based on the cost and performance of the transmission system under its control and ownership. Here, SO and TO are integrated because that network characteristics imply that it is not efficient to separate SO and TO. Another name for this sort of company is Transco, and the example is the National Grid Company (NGC) in E&W.

The obvious advantage of this organisational form is the vertical coordination advantage between SO and TO: system operation, network maintenance, and network investment are vertically integrated and can be managed in a coordinated manner by the TSO. The company can benefit from sufficient information about transmission expansion need studied and provided by the system operator and carry out efficient transmission plan in space and time.

However, when there is congestion, the notorious market power problem will appear. Market power may be significant at particular locations where competition is limited by import constraints into the area. Locational market power leads to inefficiencies in terms of dead-weight losses resulting from deviations of prices from marginal costs, from inefficient entry and other rent-seeking behaviour, and from alternative imperfect market power regulatory mechanisms such as price cap [2].

- **ISO + TO (integrated with generation or not)**

This model is characterized by the separation of system operations from transmission ownership, investment and maintenance. The Independent System Operator (ISO) does not own or maintain transmission assets, but is responsible for scheduling and dispatching generation and load in coordination with operating reliability criteria and market rules, managing and enforcing procedures and rules for allocating scarce transmission capacity and interconnection arrangements, administering tariffs governing transmission service prices, and working with TOs and other stakeholders on the coordination of maintenance schedules and planning for new transmission investments to support changes in the demand for and supply of generation services. This is the model that has been or is being adopted in large portions of the US, Argentina, Norway and other countries.

There are several rationales for creating a separate independent system operator rather than a TSO. An ISO is created to sit on top of the vertically integrated utilities to provide an independent network manager and tariff administrator to govern relationships between market participants and transmission owners. It can treat fairly all market participants and distribute the network capacity unbiasedly. This is especially important when merchant investment is expected to play an important role in the system. The ISO can also manage a larger physical network with multiple transmission owners more efficiently than would be the case if each TSO operated its own control area.

The difficulty in this case is that vertical separation of SO from TO is likely to make coordination between system operations, network maintenance and outage restoration harder, and investment could be more costly than if the TO/SO functions were combined.

- **Merchant transmission investment (MTI)**

MTI was initially conceived as unregulated transmission investment projects that would be developed on an entrepreneurial basis in response to congestion (differences in locational prices). In return for investment in additional transmission capacity, merchant investors are awarded by transmission rights created by the new transmission investment. The value of this transmission right, the FTR[17] (financial transmission right), provides the financial incentive for incumbent suppliers or new entrants to invest in new transmission capacity.

The hope is to rely upon competition and free entry to exploit profitable transmission investment opportunities and to solve the problems associated with imperfect regulation against a “natural monopoly”.

[17] See Salle Hunt and Joskow and Tirole (2000) for more explications for FTR, it is also called transmission congestion contract (TCC). In return for investment in additional transmission capacity, FTRs allow merchant investors to collect congestion revenues equal to the difference in nodal energy prices associated with the incremental point-to-point transmission capacity that their investment would have created.

Unfortunately, the feasibility of the merchant transmission model depends on a number of strong assumption and conditions[18]. Under these stringent assumptions, Joskow and Tirole (2003) explained that the merchant investment model has remarkable attributes which could solve the natural monopoly problem.

However, these assumptions and conditions are likely to be inconsistent with the actual attributes of transmission investments and the operation of wholesale markets[19] in practice [2].

The mains factors that undermine the performance of merchant transmission investment model and the investors' incentive are the followings:

- Economies of scale and cost-recovery: there can be massive economies of scale. The transmission charges relying on the price differentials (congestion rent) will not entirely recover fixed costs with optimal capacity size[20]. If investors cannot expect to recover at least their investment costs effectively, they will not have incentive to invest. There are several transmission pricing methods available from research in pricing mechanisms, such as second-best pricing and user-specific two-part pricing[21]。But their feasibility and efficiency haven't been verified.
- Free-riding problem: if the investment in transmission could reduce congestion, all connected participants could be affected. In this case, it's difficult to define the benefit of a particular participant who benefits from them; similarly it is difficult to charge the corresponding fee to each beneficiary. Roughly speaking, the more meshed the network is, the more difficult it gets to identify users in an economically useful way [5].
- State-contingent problems: as we discussed above, SOs have substantial discretion on defining and implementing security constraints, affecting the actual power flows on the link in real time. With an ISO, there are fewer problems because ISO is independent from any TO and it treats market participants justly. But in the case of TSO, SO has the same financial interest with TSO, merchant investors will have biased treatments.
- Provision of public-benefit good (i.e.: interconnection). When there is not enough profit to compensate costs of interconnection that benefit out-of-area users or increase social optimum[22], it is difficult to persuade each network owner to invest. Thus, there is no guarantee for interconnections between networks under different network owners, and there is a presumption of underinvestment [5].

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[18] These assumptions are: transmission investments are characterized by no increasing returns to scale, there are no sunk cost or asset specificity issues, there is free entry into the development of new transmission capacity, nodal energy prices fully reflect consumers' willingness to pay for energy and reliability, all network externalities are internalised in nodal prices, transmission network constraints and associated point-to-point capacity are non-stochastic, there is no market power, markets are always cleared by prices, there is a full set of futures markets, and the system operator has no discretion to affect the effective transmission capacity and nodal prices over time [2].

[19] There are a number of reasons why these assumptions are unlikely to be the case. Market power may distort nodal prices; regulatory interventions like price caps may distort prices; the absence of a complete representation of consumers demand in the wholesale market may distort prices; discretionary behaviour by system operators may distort prices under "extreme" conditions when the network is constrained.

[20] More detail see [5]

[21] More detail see [5]

[22] Interconnection enables more generators to compete in a large aggregate market to serve the combined load.

3.2.4 Conclusion for this section:

We conclude that completely relying on a market driven framework to organize investment in electricity transmission networks is likely to lead to inefficient decisions and undermine the performance of a competitive market. We need centralised decisions and reasonable regulation to organize investment while taking advantage of market mechanism as much as possible.

A significant research challenge is to design regulatory mechanisms for system operators and incumbent transmission owners and a better framework for defining transmission property rights that will stimulate efficient investments by regulated incumbent transmission owners and by merchant entrants responding to market opportunities when they are the most efficient suppliers [2].

IV. Investment coordination problems under various organizational forms

4.1 Vertical coordination problem:

In a vertically integrated enterprise, decisions on investments in generation and transmission and associated locational decisions were typically made by the same firm based on a given load forecast and a generation expansion plan. The advantage is that it internalizes the operating and investment interrelationships between generation and transmission inside public or private organizations where the potential public goods and externality problems …, can be solved with internal operating hierarchies rather than market [20].

Accordingly, in the restructured industry after deregulation, generation and transmission expansion decisions are made separately by decentralised companies; each generation or transmission company makes its own independent investment projects. Thus, new challenges arise in this case in ensuring co-ordination between the different new entities (generators and transmission owners) to guarantee electricity supply.

Interdependencies between transmission and generation which make it difficult to make investment decisions of them separately manifest as follows:

- *There are competitiveness and substitutability between the decisions of generation investments and those of transmission investments*

For example, there are two possible solutions for an area which does not have sufficient electricity to increase the supply: either to construct a power station near the load, or to connect the load to some faraway power station through transmission expansion. Obviously, the investment in power station in the first case and the investment in transmission lines in the second case are substitutable.

- *Location of generation influences network congestion and vice versa*

Interestingly, additional investments to expand generating capacity may be inefficient if the increased power flows from the new generator increase network congestion costs, constrain the operation of low-cost generating plants at particular locations, or

reduce reliability. Congestion is the result of having more than enough local generation, but at a cost higher than the cost of remote generation that could be accessed with a larger transmission line [3].
The optimal amount of transmission investments to eliminate congestion should minimize the total cost of producing and delivering electricity. In addition, the locations chosen by new generators, and retirement decisions by existing generators at particular locations, will depend, in part, on forecasts of network congestion that may affect prices for generation service at different locations over many years into the future.

- *Network investment influences investments profitability of generation and vice versa*

Decisions regarding investments in new generation (including location) and transmission facilities are inherently interdependent. A new generator requires at least some supporting investment to connect it to the network. Indeed, most new investments in generation of any significant size must be accompanied by expansions of the transmission network [2].
Similarly, transmission investors often do not completely know generation expansion planning. Indeed beyond the 5- or 10- year horizon, generation scenarios are largely unknown. Investments in transmission are long-lived sunk investments and their value depends on changing and uncertain supply and demand conditions over many future years. Compounding the matter is that generation expansion decisions may be affected by decisions on transmission expansion and vice versa [4].

- *The risk of hold-up:*

As I described above, due to asset specificity characteristic of electricity generation and the technical complexity involved in coordinating the generation and the transmission, it was considered to be impossible to separate these two functions.
Vertical integration reduces uncertainty along the vertical value-added chain. Forced unbundling may then lead to a hold-up problem[23]: investment rents are threatened by the potentially opportunistic behaviour of buyers that will seek to renegotiate contract terms once the investment is sunk.
Williamson (1985) insisted on the importance of long-term contracts[24] to deal with the hold-up problem. Glachant and Finon (1998) explain that in the absence of regulatory protection of generators' rights to gain access to clients through networks owned by third parties, vertical integration is one of the commonplace institutions of the electricity market [8].

Therefore, in restructured electricity industry where generation and transmission investment decisions are made independently, some governance framework must be found to facilitate efficient coordination of generation and transmission investments and to account for the short run and long run social costs of congestion, changes in reliability and market power[joskow and Tirole, 2003]. In fact, whether the competition-oriented unbundling approach will be welfare enhancing depends on the comparison of the deadweight-losses from non-competitive price setting on the one hand, and the potentially higher productive efficiency of vertically integrated structures on the other (Williamson-Harberger conflict").

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[23] Relationship-specific investments always create a hold-up problem
[24] They are the transmission right here. To manage the risk of congestion charge volatility, a transmission user may also buy a transmission right.

4.2 Horizontal Coordination problem:

4.2.1 G-G coordination

The horizontal coordination advantage of vertical integration exhibits in generation to ensure generation reliability.

In a competitive electricity market environment, when the investment decisions are made by decentralised generators, generators do not have any obligation for ensuring sufficient supply of electricity or for coordinating with other generators. In fact, to make generation investment decisions, besides the consideration network' evolution, generators should also consider the decisions about geographic location, technology, primary energy of other generating companies. If generators do not have sufficient horizontal coordination, the generation expansion decisions would be non social optimal or the new generation capacity is not efficient. The possible solution is that the relevant public authorities should take steps to provide necessary information about generation capacity expansion planning and direct the generation capacity expansion.

4.2.2 T-T coordination

In the forms of vertically integration or horizontally integrated TSOs, there is also obvious horizontal coordination advantage. The company can take a centralised decision in space and time to carry on a unified transmission investment plan which is supposed socially optimal.

In a competitive electricity market environment, where the merchant transmission investment is applied, two coordination problems which cannot be solved by market appear.

1) The power systems are dynamic. Load grows; generators are built and retired. Because of market volatility, a line worth building may not necessary be built. It may be better to wait a while and build a larger and more economical project [3].
2) Provision of public-benefit good (i.e.: interconnection). When it is difficult to persuade each network owner to pass through those costs that benefit out-of-area users or increase social optimum, there is no guarantee for interconnections between networks under different network owners, and there is a presumption of underinvestment [5]. As a result, if some further investment in interconnectors is socially profitable, this investment should be organized by public coordination [16].

4.3 Conclusion for this section:

Vertical and horizontal coordination problems are created when the electricity industry is being restructured. The main goal in introducing competition into the sector is to enhance efficiency. However, in our opinion, competition provides incentives for efficient production, but in electricity the coordination of operations also contributes to efficiency. As such, to a certain extent, while we have benefited from competition, we are now confronted with problems due to inadequate coordination.

Table 3: Generation or transmission investment problems caused by sectors' characteristics under various organizational forms and impacts of regulatory or non-regulatory solutions

	Sector's Characteristics	Corresponding problems could appear	Market Organizational forms which has similar problems	Regulatory or non-regulatory solutions	impacts of regulatory forms
Transmission	Economies of scale	Market power (deadweight losses)	TSO/vertically integrated entity	Rate-of-return	Over-investment
		Investment recovery (under-investment)	MTI/TO	FTRs	
	Network externalities	Free-riding (under-investment)	MTI/TO	FTRs	challenge
	State–contingent problems	Uncertainty about transmission capacity (insufficient incentive to invest)	MTI/TO	ISO/RTO	
				New regulatory mechanisms for system regulator	
Generation	Competition in generation	problem of acceptability (In the case without demand response: price volatility)	Unbundling utility (Energy-only market)	Price cap	under-investment
				Capacity payment or capacity market	Could ensure sufficient capacity adequacy (Serious gaming problems)
	Asset specificity (in the absence of system operator authority)	High Transaction cost Hold-up problem (insufficient capacity adequacy)	IPPs	FTRs or Vertically integrated enterprise	
	"public good" characteristic of reliability and capacity adequacy	Free-riding (insufficient supply of public good)	Unbundling utility (Energy-only market)	Capacity payment or capacity market	Could ensure sufficient capacity adequacy (Serious gaming problems)
				Public coordination governance	

Table 4: incentive and coordination problems in electricity investment under various organizational forms

Organizational forms	Generation & Transmission		
	examples	**Incentive issues**	**Coordination issues**
Public sector	Before 1990, in most European and Asian countries	**Advantage**: centralised Investment decisions, no incentive problem. **Problems:** difficult to verify the appropriateness of decision-making and allocate costs to market participants.	**Advantages**: it internalizes the vertical and horizontal operation and decision on investment inside enterprise where the potential public goods and externality problems can be solved with internal operating hierarchies rather than market potentially higher productive efficiency (Joskow, 2003)
Private vertically integrated enterprise	Before 1990, in USA and Germany	**Advantage**: sufficient incentive about profitable investment. **Problems**: market power problem which leads to inefficiencies in terms of dead-weight losses or in terms of imperfect regulation.	

	Generation			Transmission		
	Examples	**Incentive issues**	**Coordination issues**	**Examples**	**Incentive issues**	**Coordination issues**
regulated integrated monopoly with access regulation	Generating companies integrated with TO (when it coexists with independent power producers)	Insufficient generation adequacy caused by electricity market's realities and imperfect regulation such as price cap	More efficient vertical coordination between TO and generating companies	Regulated TSOs are either public (in most European countries nowadays) or private (E&W) (when it coexists with TOs or MTI owners)	Over-investment caused by imperfect regulation	Vertical coordination advantage between SO and TO can induce more efficiency
unbundled regulated enterprise				ISO + TOs in large portions of the USA, Argentina and Norway	**Advantage**: relying upon competition and free entry to exploit profitable transmission investment opportunities and to solve the market power problems. **Problems**: o insufficient investment o Undermine the performance of a competitive market.	**Problems**: o Insufficient horizontal coordination to provide public good and solve externality problems o Non social optimum of decision-making o Lower productive efficiency (lack of coordination between SO and TO)
unbundled unregulated enterprise	IPP		**Problems**: o Non social optimum (lack of horizontal coordination) o Inefficiency of investment decisions (lack of coordination between G and T) o Risk of hold-up	MTI (Australia)		

V. Conclusions and Implications for MY future research

Both incentive and coordination problems in investment appear after the restructuring of electricity industry. In this article, the impact on electricity investment of various organizational forms is developed and compared.

My conclusion is that it is insufficient to offer electricity investment either in generation or in transmission only by market competition mechanisms. Insufficient investment incentive and insufficient horizontal coordination exist both in MTI and in competitive generation market; accordingly, insufficient vertical coordination exists in the whole unbundling industry. All these will lead to under-investment. This could lead to congestion in transmission and insufficient system reliability and capacity adequacy in generation.

Interestingly, the conclusion derived by Joskow and Schmalensee (1983) using the framework of new institutional economy is similar. From the comparison of several hypothetical models, they conclude that the adoption of the disintegrated competing model with decentralized agents, complete separation of the network and spot market, poses the worst difficulties with respect to the decision to invest.

An issue that merits our attention is that, according to table 4, a specific investment pattern (e.g. in the sense that public or regulated forms generate overinvestment and private deregulated forms generate underinvestment) is not directly caused by an organizational form. It is the exact specification of the regulatory systems that matters. For example, the standard instrument to regulate private utilities was cost-plus regulation, including its US version: rate-of-regulation. It was widely criticized back in the 1980s, due to overinvestment (Averch and Johnson; 1962). In contrast, price cap regulation (incentive-based regulation) was considered as the reaction to the inefficiency caused by rate-of-return regulation. The Littlechild Report (1983) argued that price cap regulation lacks investment incentives.

In fact, investment is not an objective in itself. Comparing different organizational forms and regulatory systems, welfare effects of over- and underinvestment have to be weighted and traded-off against short-term incentive effects, regulatory complexity and other objectives. Policy should thus put less emphasis on investment strategies than on defining and implementing regulatory approaches and the appropriate institutional framework.

Moreover, a wide variety of regulatory approaches exist for electricity industries in different countries. As a result, regulatory theory is confronted with national-specific factors such as investment environments (over- or under-investment); ownership patterns and institutional arrangements. Therefore, more emphasis needs to be placed on the institutional aspects of regulation and to find out the regulation approaches chose by different institution to deal with various electricity investment problems.

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