Introduction to Deregulation in Power Industry

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1. Introduction

During the nineties decade, many electric utilities and power network companies world-wide have been forced to change their way of operation and business, from vertically integrated mechanisms to open market systems. This can be specifically observed in countries like UK, Sweden, Finland, Norway, US and some countries of South America. The reasons for change have been many and have differed over regions and countries.

For developing countries, the main issues have been a high demand growth coupled with inefficient system management and irrational tariff policies. This has affected the availability of financial resources to support investments in improving generation and transmission capacities. In such circumstances, many utilities were forced to restructure their power sectors under pressure from international funding agencies.

In developed countries, on the other hand, the driving force has been to provide electricity at lower prices and offer them a greater choice in purchasing economic energy.

The goal of changing the way of operation, i.e. re-regulation, or deregulation, as we say, is to enhance competition and bring consumers new choices and economic benefits.

Under Deregulation, the former vertically integrated utility, which performed all the functions involved in power, i.e. generation, transmission, distribution and retail sales, is dis-aggregated into separate companies devoted to each function. The electricity bill for the end consumer now involves at least two components: one from the distribution and transmission network-operator responsible for the network and services, and the other from the company that generates the electrical energy.

All this seems to be very straightforward at first glance, but there are several complexities involved in restructuring and many issues have been raised.

In the discussions to follow, the issues involved in the restructuring process will be considered.

2. Brief Concepts of Regulation and Deregulation

- **Regulation:** Regulation means that the Government has set down laws and rules that put limits on and define how a particular industry or company can operate.
Nearly all industries in all nations are regulated to some extent. Very competitive businesses such as auto manufacturing, airlines and banking are all heavily regulated with myriad government requirements defining what they must, can, and cannot do, and what and to whom and when they must report their activities.

Regulation of electric utilities is not the only way government can control the electric power industry within its jurisdiction. The other way is to own and operate the power company directly, as a government utility.

- **Deregulation:** *Deregulation in power industry is a restructuring of the rules and economic incentives that government set up to control and drive the electric power industry.*

As the terms suggest, they represent fundamentally opposite ideas. But neither concept is necessarily good or bad. Both regulation and deregulation make sense, and one or other is preferable under certain conditions.

3. **Why Was Electric Utility Industry Regulated?**

3.1 **Original need for regulation**

During early days of the electric power industry, both government and business favored utility regulation. The reasons are manifold:

1. Regulation offered a risk free way to finance the creation of electric industry. Establishment of electric industry required large capital for infrastructure building. At the dawn of the electrical era, government leaders were resistant to invest large amounts of public capital in untried technology. Early electric businessmen like Westinghouse, Edison, Brush, etc. knew that their technology was sound. So, it was agreed from both the sides that, the businessmen would risk their money, not the government, towards capital investment. In turn, the government guaranteed them a fair return on their investment through regulated rates. Government also assured businessmen the local monopoly and a stable market. Thus, regulation provided both sides with risk minimization they needed.

2. Regulation legitimized the electric utility business. Government franchises and regulation clearly implied to a possibly skeptical public that civic leaders thought electricity was a good thing.

3. It gave electric utilities recognition and support from the government, which was necessary to solve problems like ‘Right of Way’.

4. It established a local monopoly. The utility leaders could focus on building up their systems without having to worry about the competitors undercutting the prices to gain market share etc.

3.2 **Characteristics of regulated electric industry**

1. *Monopoly franchise:* Only the local electric utility can produce, move, or sell commercial electric power within its service territory.

2. *Obligation to serve:* The utility must provide service to all electric consumers in its service territory, not just those that would be profitable.
3. **Regulatory oversight**: The utility’s business and operating practices must confirm to guidelines and rules set down by government regulators.

4. **Least-cost operation**: The utility must operate in a manner that minimizes its overall revenue requirements.

5. **Regulated rates**: The utility’s rates are set in accordance with government regulatory rules and guidelines.

6. **Assumed rate of return**: The utility is assured a fair return on its investment, if it confirms to the regulatory guidelines and practices.

### 3.3 Structure of regulated industry

The electric power industry has over the years been dominated by large utilities that had an overall authority over all activities in generation, transmission and distribution of power within its domain of operation. Such utilities have often been referred to as vertically integrated utilities. Such utilities served as the only electricity provider in the region and were obliged to provide electricity to everyone in the region.

A typical structure of a vertically integrated electric utility is shown in figure (1).

![Diagram of energy flow](image)

**Figure 1**

In figure (1), the money flow is unidirectional, i.e. from the consumer to the electric company. Similarly, the information flow exists only between the generators and the transmission systems.

The utilities being vertically integrated, it was often difficult to segregate the costs involved in generation, transmission or distribution. So, the utilities often charged their customers an average tariff rate depending on their aggregated cost during a period.
4. **Conditions that Led to Deregulation**

4.1 **Basic motivation: Change in power industry scenario**

There are many reasons that led to deregulation of power system. One force that led to the deregulation of electric power was the change in generation economies of scale that occurred throughout the 1980’s.

Traditionally, electric utility systems evolved with the central station concept because of significant economy of scale in power generation. Very large generators produced power at less than half the cost per kilowatt of small generator units, and the bigger the generator, the more economical the power it produced.

For the reasons stated below, the shift in economy of scale was observed:

1. Technological innovation improved the efficiency of small units for gas turbines, combined cycle, hydro and fuel cells over that of large ones.

2. Improvements in materials, including new high temperature metals, special lubricants, ceramics, and carbon fiber, permit vastly stronger and less expensive small machinery to be built.

3. Computerized control systems have been developed that often reduce the number of on-site personnel to zero.

4. Data communications and off-site monitoring systems can control the units from remote operations centers, where one central operator can monitor a dozen units at various sites, as if present at each.

Thus in many instances, it was possible to build new power plants that could provide energy at a lower price than what customers were paying for that coming from the existing old, giant power plants. It became possible for the industrial and commercial users of electricity to build and operate their own plants to produce power cheaper than that of utility and also sell the excess power to small customers.

4.2 **The reasons for deregulation**

The reasons for initiating the idea of deregulation in power industry are many. Following are the main reasons:

1. **The need for regulation changed.**

More fundamental than any other reasons for change was the fact that the basic needs for regulation of electric industry had died away before the end of 20th century. First, the original need for regulation, which was to provide risk free finance to build the infrastructure, did not exist anymore. Second, the omnipresent electric system created, was paid for, decades ago. The revenues gained by the electric utilities was invested to renew their system and the level of risk in doing so was less as compared to that existed in the initial era.

Being a proved technology, the risk involved in investing money in such a technology was nullified. The electricity could be thought of an essential commodity, which can be bought and sold in the marketplace in a competitive manner, just like other commodities.
2. Privatization
   Usually the motive was the government’s firm conviction that private industry could do a better job of running the power industry. This belief, of course came from better privatization experiences of the other industries.
   Deregulation does not necessarily have to be a part of privatization efforts. The deregulation to free up the rules nearly always accompanies privatization.

3. Cost is expected to drop
   Competition brings innovation, efficiency, and lower costs. The rate of cost decline is different in different areas. The reasons for this are manifold. The overall experience all over the world is that the electricity prices have declined.

4. Customer focus will improve
   Although monopoly franchise utilities have an obligation to serve all customers, that does not promote the pro-active attention to customer needs. A monopoly franchise utility listens to its customers when they explain their needs, and then responds. A competitive electric service company anticipates customer's needs and responds in advance. The technological advances that will be applied under deregulation, address customer service. More important gain of competition in the electricity market is the customer value rather than lowering the cost.

5. Encourages innovation
   The regulatory process and the lack of competition gave electric utilities no incentive to improve on yesterday’s performance or to take risks on new ideas that might increase customer value. If a new idea succeeded in cutting costs, the utility still made only its regulated rate of return on investment; if it didn’t work, the utility would usually have to ‘eat’ a good deal of the failed attempt, as imprudent expenses. Furthermore, why would a regulated utility want to use new ideas to lower its costs under a regulated rate of return framework?
   Under deregulated environment, the electric utility will always try to innovate something for the betterment of service and in turn save its costs and maximize the profit. By means of this, the utility will try to ensure that it will maintain its customer base in spite of competition.

   Some other forces supporting the main reasons for motivating the deregulation can also be enlisted as follows:
   1. Overstaffing in the regulated electric industry.
   2. Global economic crisis
   3. Political and ideological changes
   4. Managerial inefficiency in the regulated company
   5. Lack of public resources for the further development
   6. More demanding environment issues
   7. Pressure of financial institutes

   It is unfair to blame the electric utilities for their unwillingness to take risks, and their lack of technological progress and lower customer focus under regulation. They were simply responding to the system of rules set down by
government. The problem was with the regulatory system, itself. It had provided growth and stability when that was needed. But, too much stability means stagnation and that was the ultimate result in the electric utility industry.

Thus, what needed to be fixed was the regulatory framework, and, hence deregulation.

5. **Overview of A Deregulated Industry**

5.1 **Disaggregation of traditionally vertically integrated utility**

One of the principal characteristics of a competitive structure is the identification and separation of the various tasks which are normally carried out within the traditional organization so that these tasks can be open to competition whenever practical and profitable. This process is called *unbundling*. An unbundled structure contrasts with the so-called vertically integrated utility of today where all tasks are coordinated jointly under one umbrella with one common goal, that is, to minimize the total costs of operating the utility.

One of the first steps in the restructuring process of the power industry has been the separation of the transmission activities from the electricity generation activities.

The subsequent step was to introduce competition in generation activities, either through the creation of power pools, provision for direct bilateral transactions or bidding in the spot markets.

On the other hand, the transmission system having significant economics of scale consequently had a tendency to become a monopoly. Thus it was felt necessary to introduce regulation in transmission so as to prevent it from overcharging for its services. The transmission system thus became a neutral, natural monopoly subject to regulation by public authorities. And to overcome the monopolistic characteristic, the trend has been to establish new legal and regulatory frameworks offering third parties open access to the transmission network.

An important point to note is that the restructuring process was however not uniform in all countries. While in many instances, it started with the breaking up of a large vertically integrated utility, in certain other instances restructuring was characterized by the opening up of small municipal monopolies to competition.

In brief, Electric utilities are expected to split apart into unbundled companies, with each utility re-aligning itself into several other companies that respectively focus on each part of the new industry, i.e., power delivery and retailing. This is known as Disaggregation.

Under deregulation, the vertically integrated utility, one giant company that generates, transmits, distributes and sells electricity in coordinated manner will become thing of the past. To function in an open access system, such utilities will have to rearrange their operational organization to match the unbundled functions they must perform. Each part of the company will need to work in its new form. Generation will have to compete in the competitive power generation market place. T & D will have to operate as an open provider of delivery services. Competition will be present in retailing.
Generally, the governments advocating deregulation want competition in energy production, and they want to see significant levels of customer choice in the retail market for electricity. At the same time, it recognizes that it is best to have only one transmission and one distribution system in any one area. Therefore, the purpose of deregulation is to restructure the electric industry so that power production and retail sales are competitive, while delivery is still a regulated, monopoly franchise business.

5.2 **Structure of deregulated industry**

Figure (2) shows the typical structure of a deregulated electricity system with links of information and money flow between various players.

![Diagram of electricity system](image)

**Figure 2**

The configuration shown in the figure is not a universal one. There exist variations across countries and systems.

A system operator is appointed for the whole system and it is entrusted with the responsibility of keeping the system in balance, i.e. to ensure that the production and imports continuously match consumption and exports. Naturally, it was required to be an independent authority without involvement in the market competition nor could it own generation facilities for business. This system operator is known as Independent System Operator (ISO).

Referring to figure (2), there is no change as compared to figure (1) so long as energy flow is concerned. Customer does its transactions through a retailer or transacts directly with a generating company, depending on the type of a model.

Different power sellers will deliver their product to their customers (via retailers), over a common set of T & D wires, operated by the independent system operator (ISO). The generators, T & D utility and retailers communicate ISO. Mostly, customer communicates with the retailer,
demanding energy. The retailer contacts the generating company and purchases the power from it and makes it transferred to its customer’s place via regulated T & D lines. The ISO is the one responsible for keeping track of various transactions taking place between various entities.

In the regulated environment, the electricity bill consisted of a single amount to be paid towards the generation, transmission and all other costs. But, in the restructured environment, the electricity price gets segregated into the following:

1. Price of electrical energy
2. Price of energy delivery (wheeling charges)
3. Price of other services such as frequency regulation and voltage control, which are priced separately and charged independently but may or may not be visible in the electricity bills.

5.3 Different entities in deregulated environment

The introduction of deregulation has brought several new entities in the electricity market place, while on the other hand redefining the scope of activities of many of the existing players. Variations exist across market structures over how each entity is particularly defined and over what role it plays in the system. However, on a broad level, the following entities can be identified as shown in the figure (3).

![Different Entities in Deregulated Environment](image)

**Figure 3**

1. **Genco** (Generating Company): Genco is an owner-operator of one or more generators that runs them and bids the power into the competitive marketplace. Genco sells energy at its sites in the same manner that a coal mining company might sell coal in bulk at its mine.
2. **Transco** (Transmission Company): Transco moves power in bulk quantities from where it is produced to where it is delivered. The Transco owns and maintains the transmission facilities, and may perform many of the management and engineering functions required to ensure the system can continue to do its job. In most deregulated industry structures, the Transco owns and maintains the transmission lines under monopoly franchise, but does not operate them. That is done by Independent System Operator (ISO). The Transco is paid for the use of its lines.

3. **Disco** (Distribution Company): It is the monopoly franchise owner-operator of the local power delivery system, which delivers power to individual businesses and homeowners. In some places, the local distribution function is combined with retail function, i.e. to buy wholesale electricity either through the spot market or through direct contracts with gencos and supply electricity to the end use customers. In many other cases, however, the disco does not sell the power. It only owns and operates the local distribution system, and obtains its revenues by ‘renting’ space on it, or by billing for delivery of electric power.

4. **Resco** (Retail Energy Service Company): It is the retailer of electric power. Many of these will be the retail departments of the former vertically integrated utilities. Others will be companies new to the electric industry that believe they are good at selling services. Either way, a resco buys power from gencos and sells it directly to the consumers.

5. **Independent System Operator** (ISO): The ISO is an entity entrusted with the responsibility of ensuring the reliability and security of the entire system. It is an independent authority and does not participate in the electricity market trades. It usually does not own generating resources, except for some reserve capacity in certain cases. In order to maintain the system security and reliability, the ISO procures various services such as supply of emergency reserves, or reactive power from other entities in the system.

6. **Customers**: A customer is entity, consuming electricity. In deregulated markets, the customer has several options for buying electricity. It may choose to buy electricity from the spot market by bidding for purchase, or may buy directly from a genco or even from the local distribution company.

5.4 **The competition**

In a deregulated environment, two levels of competition exist, rather, encouraged. At what can be termed as wholesale level, gencos produce and sell bulk quantities of electric power. Power is typically sold in bulk quantities to other companies or very large industrial customers, through some deregulated power market mechanism. The gencos bid their power at the marketplace so as to maximize their profits.
Locally, retail delivery is accomplished by retailers, who compete for the business of the consumers in the area by offering low price, good service and additional service features. These are the companies buying power at the wholesale level and arranging for transport to each community where they do business, so that they have power to divide up and sell to individuals locally.

Thus, a restructured, completely competitive electric industry is a sandwich of competition above and below a power delivery system. This structure can be conveniently divided into wholesale and retail levels. The important thing to note is that the power delivery i.e. transmission and distribution remains the monopoly franchise. This is shown in figure (4).

![The Competition Diagram](image)

**The Competition**

**Figure 4**

6. **The Wholesale Power Marketplace**

In order for a deregulated power industry to work well, apart from the entities discussed earlier, two additional entities or functions must be created:

**Power Market**: There must be some way for power producers to sell their power, and for buyers to buy the power.

**System Operation**: The transmission system can move power from sellers’ site to the buyer’s locations, but it must be kept under proper control on a real time basis.

Both of these functions must be accomplished in one form or another in every deregulated electric power industry. Both require objectivity and equality of operation towards all competitors. None of the competitive companies involved (Gencos, Rescos) can possibly serve either of these roles. System operation can be accomplished by Transcos and Discos, under some types of deregulated structure, but the power market is a concept that was completely unfamiliar to the power industry prior to deregulation. For this reason, deregulation usually requires that one or more new entities be created in one form or another.

6.1 **The marketplace mechanisms**

Under deregulation, some system must be put in place where competitive sellers of electricity can offer their product (i.e. power) and transact sales.
There are three basic ways in which it can be done: Poolco, Bilateral Trading and Power Exchange. Often these are combined in different ways to form a composite mechanism.

A. Poolco
There is only one buyer in this system. The Poolco is a governmental or quasi-governmental agency that buys for everyone, taking bids from all sellers and buying enough power to meet the total need, taking the lowest cost bidders. The Poolco operator also has responsibility for running the power system, and is thus a combined buyer-system operator.

B. Bilateral Exchange
In this type of multi-seller/ multi-buyer system, individual buyers and sellers make a deal to exchange a power at prices and under the conditions they agree to, privately.

C. Power Exchange (PX)
The Government sets up, or causes the power industry to establish, a trading exchange for electric power, which operates much like a stock exchange. The buyers and sellers enter their needs into the power exchange. For example, a buyer would say, “I need up to 200 MW at 1600 hours IST. I would pay Rs. 3.5/ kWh”, whereas, the seller would enter his demand as, “I have 400 MW and would like to sell it at Rs. 4/ kWh”.

When they transact business with the power exchange, buyers and sellers are really talking to the ‘marketplace’ and not the individual buyers and sellers. As in stock exchange, the power exchange constantly updates and posts a market clearing price (MCP), which is the current price at which the transactions are being done.

Note that when buyers and sellers communicate to the power exchange, they don’t know whom they are dealing with.

These three market mechanisms are not mutually exclusive. Multiple combinations of all three could be made to work. It is common for two of these three mechanisms to be present simultaneously. For example, transactions through Bilateral Exchange are permitted in California, but Western Power Exchange (WEPEX) was created to permit buyers and sellers to do business with the marketplace on a real time, next hour or day-ahead basis (Power Exchange).

The details of implementation of these three mechanisms can vary a great deal, too, from one political jurisdiction to another. For example, some jurisdictions force the parties to any bilateral power sale agreement to disclose publicly the quantity, the place, the time and the price of their deals. Others don’t. This disclosure requirement affects the strategies buyers and sellers adopt in the marketplace.

Likewise, the time period of power sales trade through the PX varies from one deregulated system to another. Many power exchanges permit trading of power for only day ahead and an hour ahead trading. Anyone wanting longer term purchases must find an entity with which to make ‘bilateral deal’. Other power exchanges permit buyers and sellers to make deals of power for longer periods, even months or years.
But regardless, every competitive power industry establishes a ‘power marketplace’ with some form of one or more of the three structures discussed.

6.2 Energy auction and competitive bidding

In a competitive electricity market, the sellers and buyers submit bids for energy buy and sell. The bids are generally in the form of price and quantity quotations and specify how much the seller or buyer is willing to buy or sell and at what price. After the bids are available to the market operator, it settles the market based on some criteria. Once the market is cleared, all selling participants receive a uniform price for their power delivered, i.e., the market price from the buying participants.

In case of an auction, where all winning bidders are offered the same price without discrimination, and regardless of their individual bid, is known as non-discriminated or second price auction. This is usually, the price of the highest priced bid that is cleared in the market. The non-discriminated auction provides incentives to bidders to bid their true costs and avoid guessing the bids of others.

On the other hand, in a discriminated auction or first price auction, all bidders are not offered the same price after the market is settled. The bidders get the price that they had actually bid for, in the first place. A disadvantage of this system is that, it can give rise to gaming opportunities for the participants thereby providing ample scope for over-bidding and pushing up the market clearing price.

Once the buyer and seller bid the amount of energy and the price, the power exchange forms an aggregate supply bid curve for suppliers and aggregate demand bid curve for consumers. The curves are plotted on the coordinates of, supply and demand energy and price as shown in the figure (5). The point of intersection of the two curves determines the market-clearing price (MCP). At this point, the supply satisfies the demand.

![Diagram of market clearing price](image)

**Figure 5**

The MCP is the price of electric energy that is paid by consumers at all the places. The sellers are also paid the price equal to the MCP. Consider the power exchange auction. MCP is the highest sell bid or lowest buy bid accepted in the auction. Thus, a seller is certain he will be paid no less than its
cost of production if he bids its marginal cost, and may be paid more. If a
seller bids less than his marginal cost, he would lose money because his bid
may set the MCP. If he bids more than his marginal cost, he may bid more
than other sellers and fail to be selected in the auction. If the seller’s bid sets
the MCP then he would recover his running cost and if the MCP is higher than
his marginal cost, then he would earn profit or contribution to fixed cost.
Buyer itself makes similar considerations.

7. **Market Models**

There are mainly two models of deregulation presently preferred in the
various countries all over the world. The Poolco model adopted primarily in
UK, and the ISO model adopted in Nordic pool and California in US. The
various countries like Australia, New Zealand and European Union are
employing one of the two models with minor changes to meet their specialized
demands.

7.1 **Pool model**

The UK model is monopsony, i.e., there is only a single buyer for all the
energy generated by gencos. The buyer here is a Poolco, which also operates
the system. So, UK Poolco is responsible for inviting bids for energy and
deciding the energy price for a particular period in the future markets like day-
ahead market. It is also responsible for real time operation of the system;
hence it also buys ancillary services.

The way, UK market works is quite similar to centralized unit commitment
and economic dispatch. The difference is that in traditional unit commitment
and economic dispatch the actual cost of the energy generations are considered
but in deregulated environment, the gencos place price curves of each of its
generators and the actual cost is hidden from general knowledge. Poolco being
the system operator and auctioneer as well, takes care of network congestion
at the auction level itself in a manner similar to the economic dispatch.
Participation in the auction conducted by Poolco is a must for all gencos. As
Poolco is the only buyer, there are no bids from buyer’s side; the auction is
single sided auction.

7.2 **Open access model**

The models used in Nordic Pool and California are examples of this
model. The energy auction and future markets are conducted by an
independent entity called Power Exchange (PX) and the system is operated by
another independent body called Independent System Operator (ISO), who
assures equal opportunities to all sellers and buyers through open access to
grid. The buyers and sellers have an option of entering in bilateral transactions
or be participants in the energy auction conducted by the PX. The auction
conducted by PX is double sided auction as sellers as well as buyers place the
bids. The sellers and buyers are allowed to place a portfolio bid, i.e. a
combined bid for many generators.

Figure 6 shows how a PX operates.
Figure 6

The initial outcome of PX auction is an Uncongested Market Clearing Price (UMCP), and Uncongested Market Clearing Quantity (UMCQ). Each seller is also notified about tentative quantity it has sold. The sellers and buyers then provide Initial Preferred Schedule (IPS), specifying the actual location at which they would deliver or extract from the grid. The ISO then performs the load flow and security studies and approve the auction. If it finds a possibility of congestion, the UMCP is changed to a different value on either side of a congested line, this being the actual price of energy paid on each side.

In this manner, the PX is concerned only with economic side of auction and ISO the technical side of the market.

7.3 Comparison between two market structures

<table>
<thead>
<tr>
<th>Open Access</th>
<th>Pool</th>
</tr>
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<tbody>
<tr>
<td>Bulk of the energy transactions are carried out as bilateral trades while there may also exist a day ahead spot market.</td>
<td>All energy transactions are carried out through the pool, which may be organized through a day ahead trading mechanism.</td>
</tr>
<tr>
<td>The ISO is responsible for market administration, generation scheduling or dispatch functions.</td>
<td>The Poolco Operator is responsible for the market settlements, unit commitment and determination of pool price.</td>
</tr>
<tr>
<td>Participation in the market by gencos is not mandatory</td>
<td>Participation by gencos is mandatory</td>
</tr>
<tr>
<td>The ISO is responsible for system security and control, procuring necessary ancillary services.</td>
<td>The Poolco operator is responsible for system security and control, procuring necessary ancillary services.</td>
</tr>
<tr>
<td>Example: Nordic Markets</td>
<td>Example: UK Market</td>
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8. **Major Responsibilities of ISO**

The independent system operator (ISO) is the central entity to have emerged in all deregulated markets with the responsibility of ensuring system security and reliability, fair and equitable transmission tariffs and providing for other system services. With differing market structures evolving in various countries, it has been noticed that based on the responsibilities assigned to them and their functional differences, ISOs could be placed in two categories.

The first and the most common one is the pool structure in which the ISO is responsible for both market settlement including scheduling and dispatch, and transmission system management including transmission pricing, and security aspects. Here, ISO is also known as Poolco Operator.

The other structure is that of open access, one dominated by bilateral contracts. In this system, bulk of the energy transactions are directly organized between the generator and the customer, and the ISO has no role in generation scheduling or dispatch and is only responsible for system operation. The role of ISO is minimal and limited to maintenance of system security and reliability functions.

In any market structure, the ISO has following basic functions laid out for it:

- **System security:** Operator must assure that the power system continues to operate in a stable, economical manner.
- **Power Delivery:** The operator should provide the power transportation services requested of it by buyers and sellers.
- **Transmission pricing:** System operator must determine and post the prices for transmission usage, offer to reserve or sell usage, track, bill and settle with users, and pass on revenues to transmission owners.
- **Service quality assurance:** The system operator must assure the quality of service it provides.
- **Promotion of Economic efficiency and equity:** The overall operations of system operator should obey economic efficiency and also it should have fairness and equity in it’s dealing and should not benefit only some players in the system.

The system operator faces many daunting challenges in performing them. But it has many resources, including a large staff of experienced power system operators and engineers, a fully computerized control centre, and a massive remote data collection system to monitor, analyze, and control the power system.

9. **Issues Involved in Deregulation of Power Industry**

9.1 **Network congestion**

9.1.1 **Problem definition**

When the producers and consumers of the electric energy desire to produce and consume in amounts that would cause the transmission system to operate at or beyond one or more transfer limit, the system is said to be congested.
Congestion is a consequence of network constraints characterizing a finite network capacity that precludes the simultaneous delivery of power from an associated set of power transactions.

Line outages or higher load demands are the causes of congestion in the transmission network.

9.1.2 Effects of network congestion

When a generator bids other than its incremental costs, in an effort to exploit imperfections in the market to increase profits, its behavior is called strategic bidding. If the generator can successfully increase its profit by strategic bidding or by any means other than lowering its costs, it is said to have market power. The obvious example of market power is a non-regulated monopoly with a zero elasticity demand, where the generator can ask whatever the price it wants for electric energy. Market power results in market inefficiency.

There are many possible causes of market power. One of the main reasons is congestion. Consider a simple example of two-zone system connected by an interface as shown in the figure (7).

![Diagram](image)

**Figure 7**

Let each zone have a 100MW constant load. Zone A has 200 MW generator with an incremental cost of Rs.100/MWh. Zone B has a 200 MW generator with an incremental cost of Rs.200/MWh. Assume both generators bid their incremental cost.

If there is no transfer limit between zones, all 200 MW of load will be brought from generator A at Rs.100/MWh as shown in figure (7a). If there is a 50 MW transfer limit, then 150 MW will be brought from A at Rs.100/MWh and the remaining 50 MW must be brought from generator B at Rs.200/MWh, as shown in figure (7b). The total cost of 200 MW in un-congested market is Rs.20000/h and that in the congested market is Rs.25000/h. Congestion has
created a market inefficiency of 25% of the optimal cost, even without strategic behavior of the generator. Congestion has also created unlimited market power for generator at B.

9.1.3 Ways to tackle congestion

In different types of market, the method of tackling the transmission congestion differs. There are three different ways mainly adopted to tackle the network congestion:
1. Price Area Congestion Management
2. Available Transfer Capability (ATC) based Congestion Management

The first method is used in Nordic pool; the second one in US and the third one is employed in UK.

1. Price Area Congestion Management

In Nordic pool, which consists of Norway, Sweden, Denmark and Finland, when congestion is predicted, the system operator declares that the system is split into price areas at predicted congestion bottlenecks. Spot market bidders must submit separate bids for each price area in which they have generation or load. If no congestion occurs during market settlement, the market will settle at one price, which will be same as if no price area existed. If congestion does occur, price areas are separately settled at prices that satisfy transmission constraints. Areas with excess generation have lower prices, and areas with excess load have higher prices.

2. Available Transfer Capability (ATC) based Congestion Management

This is particularly used in US system. The US Federal Energy Regulatory Commission (FERC) established a system where each ISO would be responsible for monitoring its own regional transmission system and calculating the available transfer capability (ATC) for potentially congested transmission paths entering, leaving and inside its network. ATC is a measure of how much additional electric power can be transferred from starting point to end point of a path. The ATC values for next hour and for each hour in the future are placed on a web site known as Open Access Same-time Information System (OASIS), operated by ISO. Anyone wishing to do transaction would access OASIS web pages and use ATC information available there to determine if system could accommodate the transaction.

3. Optimal Power Flow (OPF) Based Congestion Management

Optimization is performed to minimize generator-operating cost with set of constraints that represent a model of the transmission system within which the generators operate.

The generators send a cost function and those wishing to purchase load send a bid function to the ISO. The ISO has a complete transmission model and can then do an OPF calculation. OPF solution gives prices/Mw at each node of the system. In some countries zonal pricing method is followed in which the system is divided into various zones on geographical basis. The zone prices determined by the OPF are used in the following manner:
1. Generators are paid the zone price of energy
2. The loads must pay the zone price for energy.

If there is no congestion, there is one zone price throughout the system, and the generators are paid the same price for their energy as the loads pay. When there is congestion, zone prices differ, each generator is paid its zone’s price, and each load pays its zone’s price for energy.

Thus, the OPF, through the pricing in the zones, performs the function of controlling the transmission flows (that is, maintaining transmission system security).

9.2 Optimal bidding

For a genco to survive in competitive environment, it has to operate very efficiently. But only efficient operation sometimes may not suffice because in the energy auction it has to sell its products at competitive prices to get the maximum profit out of it. Several factors affect the profitability of a genco like its own bids, bids placed by its competitor, total energy demands among others, etc.

While a genco has no control over the bids of its competitors and the energy demand, it can make its own strategy to place such a bid that provides it highest profit at lowest risk. By risk it is meant that the amount of regret involved. A bid is called highly risky if it can yield large profit but its probability of being selected is low, so more often than not it will not be selected leading to regret. A low risk bid is such bid, which may have lower profit earning capability but high probability of being selected, so there is no regret.

The methods by which the optimal bidding problem is solved are as follows:
1. Game theory
2. Dynamic Programming
3. A genetic algorithm based method
4. Optimization based bidding strategies.
5. Markov Decision Process

9.3 Transmission Pricing

Transmission Open Access (TOA) is gaining attention in countries that desire to introduce competition into traditional cost-of-service regulated utilities without giving up their existing regulatory structures. Issues and concerns associated with TOA could be categorized into economic and operational ones. TOA formats are usually resulted from attempts to combine these two inherently different regulatory approaches: traditional cost-of-service regulation and fully competitive market.

As part of a TOA and competitive electricity market, 'wheeling' of electrical energy is one of the more prevalent of such unbundled services. Wheeling can be defined as 'the use of utility’s transmission facilities to transmit power for any buyers and sellers'. In the wheeling transaction at least three parties are normally involved: a seller, a buyer and one or more wheeling utilities, which transmit the power from the seller to the buyer. Pricing the transmission service is intended to meet a common set of objectives: economic efficiency, revenue sufficiency and efficient regulation. Wheeling rates are the prices which are charged for the use of the transmission network(s) and are
payments made by the seller and/or buyer to compensate the wheeling utility(ies) for the costs incurred. There are two critical elements, which determine the wheeling rates. The first one is that prices are determined in relation to real time situation and the second one is that prices are determined through market-based competition. The costs of transmission transactions have four major components:

- Operating cost: Production (fuels) costs due to generation re-dispatch and rescheduling resulting from the transmission transaction.
- Opportunity cost: Benefits of all transactions that the utility forgoes due to operating constraints that are caused by the transmission transaction.
- Reinforcement cost: Capital cost of new transmission facilities needed to accommodate the transmission transaction.
- Existing system cost: The allocation cost of existing transmission facilities used by the transmission transaction.

There are several transmission pricing methods that are listed below. One of the important issues to examine in any pricing method is not only how it distributes the cost, but also the degree of difficulty the system operator will have in determining the cost to the required level of detail.

1. Flat fee
   Flat fee prices are the simplest possible approach to distribution of cost over a large number of customers. Everyone pays the same amount. If the cost is one lakh rupees and if there are thousand users, then everyone is charged a hundred rupees.

2. Postage Stamp Method
   Postage stamp transmission tariffs set a price on use of the grid that depends only on the amount of power moved, the duration of use. In this case, the approximation is to ignore distance in allocating cost among users, which is effectively how postage is priced.

3. Pro forma transmission tariffs
   In this method, each user must pay a capacity fee, based on the installed cost of the transmission system as a whole, allocated on a per kW basis, as well as other fees for use associated with the variable operating costs incurred at the time of their use.

4. MW-mile Method
   This is the pricing that simply sets a wholesale wheeling price proportional to both amount and distance. A fixed price throughout the network can be used, e.g., Rs.1 per MW-mile/hour, anywhere, anytime, or different rates can be charged for different routes or times.

5. Contract path method
   Contract path pricing calls for the price of transmission from point A to point B to be based on the cost of a single identified path. The parties moving 500 MW from Koyna to Bhubaneshwar might choose a particular route
between the two cities as ‘contract path’. Even though they know the actual power flow will split itself among many parallel paths, they compute the price to be paid on the basis of this one line. ("This segment of route has 500 MW capacity, and you are moving 500 MW, so we will charge you for the whole cost of the line. This other segment in the route has 1000 MW capacity, so we’ll charge you 50% of its costs") The price usually includes a capacity charge to cover the capital cost of the equipment, and energy charges based on losses and other operating costs.

6. Rated System Path

This method bases the cost on a computed set of parallel paths for a particular path. Here, a rated system path from Koyna to Bhubaneshwar would be identified by load flow and other engineering studies of the grid.

9.4 Ancillary Service Management

Ancillary services are defined as all those activities on the interconnected grid that are necessary to support the transmission of power while maintaining reliable operation and ensuring the required degree of quality and safety.

In deregulated power systems, transmission networks are available for third party access to allow power wheeling, and spot markets for electricity have been developed in many countries. In such an environment, the ancillary services are no longer treated as an integral part of the electric supply. They are unbundled and priced separately and system operators have to purchase ancillary services from ancillary service providers.

The North American Reliability Council (NERC) together with Electric Power Research Institute (EPRI) has identified 12 ancillary services. They are:

1. **Regulation**: The use of generation or load to maintain minute-to-minute generation/ load balance within control area.

2. **Load Following**: This service also refers to instant-to-instant balance between generation and load.

3. **Energy Imbalance**: The use of generation to meet the hour-to-hour and daily variations in load.

4. **Operating Reserve- Spinning**: The provision of unloaded generating capacity that is synchronized to the grid and can immediately respond to correct for generation/ load imbalances, caused by generation and/ or transmission outages and that is fully available within several minutes.

5. **Operating Reserve- Supplemental**: The provision of generating capacity and curtail able load to correct for generation/ load imbalances, caused by generation and/ or transmission outages, and that is fully available within several minutes. However, unlike spinning reserves, supplemental reserve is not required to respond immediately.

6. **Backup Supply**

7. **System Control**: The control area operator functions that schedule generation and transactions and control generation in real time to maintain generation/ load balance.

8. **Dynamic Scheduling**

9. **Reactive Power and Voltage Control from Generator Sources**: The injection or absorption of reactive power from generators or capacitors to maintain system voltages within required ranges.
10. **Real power transmission losses**

11. **Network Stability Services from Generation sources**: maintenance and use of special equipment (PSS and Dynamic braking resistances) to maintain a secure transmission system.

12. **System Black-Start Capability**: The ability of a generating unit to proceed from a shutdown condition to an operating condition without assistance from the grid and then to energize the grid to help other units start after a blackout occurs.

### 9.5 Risk Analysis and Hedging:

Deregulated electricity markets are known for high volatility relative to that observed in markets of more traditional commodities. This presents uncertainties to the participants in the market that they did not have to face during regulated era. The participants in the market must find ways to deal with these uncertainties when contracts are evaluated. There are many risk factors corresponding to these uncertainties that can affect the efficiency of different entities of the system.

#### 9.5.1 Some Sources of Risk in Electricity Markets:

1. **Supply shortage**: A supply shortage due to generation outages can cause electricity prices to shoot up drastically.
2. **Defaults**: The default of the participant to complete the transaction can raise the issue of creditworthiness and this also may load to price hike.
3. **Transmission Constraints**: A constrained situation could reduce the ability of transmission providers to transfer power, which in turn could force market participants to request more power from the hourly spot market, and contribute to price spikes.
4. **Lack of Experience**: Market participant’s lack of experience with hedging tools could be another source of risks in electricity markets.
5. **Price Information**: Inadequacy in realistic and timely price information is another source of risk in electricity markets, especially at times when markets have major events such as outages of large generation units, defaults and other factors that could cause price spikes.

### 10. **Deregulation and Current Scenario Around the World**

#### 10.1 Milestones of Deregulation:

- 1982 Chile
- 1990 UK
- 1992 Argentina, Sweden & Norway
- 1993 Bolivia & Colombia
- 1994 Australia
- 1996 New Zeeland
- 1997 Panama, El Salvador, Guatemala, Nicaragua, Costa Rica and Honduras
- 1998 California, USA and several others.
10.2 **Latin America**

From 1980 onwards, a major transformation took place throughout the electric power industry in South America. The first to begin was Chile, which made modest reorganization efforts in 1980, and privatized *Nacional de Electricidad S.A.* in 1988, purchased by *Endesa* (Spain). *Endesa* along with other utilities purchased stakes in the Chilean electric industry. Over time, government owned power gave way to five generating companies competing in the main grid.

In Argentina, the government separated generation, transmission and distribution in 1991. The two state owned companies were split into almost 40 competing private generator companies, many with only a single power plant. This fragmentation was designed to assure that no one generator had anything approaching dominant position in the marketplace. Transmission assets were sold to private Transcos, and 18 electric distribution companies were created.

**Main features:**
- Disaggregation of generation, transmission and distribution into separate business sectors.
- Creation of intense competition in power production through fragmentation of national generating resources into many companies, none of which dominates the market.
- All generating companies bid into ‘Poolco’ like structure, essentially centrally dispatched by an independent Poolco operator.
- There are almost no barriers to the construction of thermal, wind and solar plants. Licenses and government cooperation are required for construction of hydroelectric plants.
- Licensed, open access operation of power delivery assets, usually having local monopoly franchises limited to power movement, not sales.
- Local distribution concessionaires are assigned an obligation of supplying electricity to consumers with long-term franchises.

**Results:**
- Increasing investment in new facilities, especially new generating plants
- Substantial increase in thermal plant availability
- Reduction in specific power consumption of thermal plants and consequent decreases in both spot and contract market prices
- Service quality improvements, reduction in non-served energy and decrease of system failure probability
- Reduction in total service losses
- Considerable consumption growth (40% increase in last five years)
- Transmission investments in the period have been moderate, because of the strict economic criteria required for their implementation by interested party.
- Reduction in non-supplied energy because better transport service quality
- Reduction of prices since beginning of the process around 50 %
- Average monthly electricity prices in wholesale market dropped from $60/MWhr to $30/MWhr

10.3 The UK

The most widely quoted example of deregulation is the United Kingdom. The process of privatization in the UK began in February 1988, and in some ways the UK led the world in electric industry deregulation. Great Britain was privatized in three stages, with England and Wales first, followed by Scotland, then Northern Ireland.

Main Features:

- Central Electricity Board was split into four entities, which consisted of two private generating companies, National Power and Power Gen, a government owned generator, Nuclear Electric, and the National Grid Company (NGC), which is the independent transmission system operator.
- 12 local electricity boards privatized as Regional electric Company (REC), each having monopoly franchise on local power distribution
- National Grid became National Grid Company (NGC), initially owned by 12 RECs. But now a public traded corporation.
- Scottish non-nuclear companies, Electricity de France (EdF) and IPPs became the member of pool.
- Non-franchise customers (earlier > 1 MW, later > 100 KW and now free) have option of choosing their supplier from any RECs, National Power or PowerGen.
- Pool maintained by NGC
- REC submit grid forecast to Pool co operator
- Generator bids are entered into NGC’s GOAL program
- The GOAL program derives half hourly marginal costs
- The “System Marginal Price” (SMP) is the price quoted by the most expensive generator which is accepted for dispatch during each half-hourly time slot when transmission constraints are ignored – simple unconstrained dispatch

New Electricity Trading Arrangements (NETA):

In July 1998 the Director General of Electricity Supply (DGES) published a proposals document describing new market based trading arrangements for electricity (NETA). In October 1998 the Government accepted these proposals.

The proposals envisaged market-based trading arrangements more like those in commodity markets elsewhere. Forwards and futures markets would operate up to several years ahead, evolving in response to demand. A voluntary Short-term Bilateral Market would operate from at least 24 hours to about 4 hours before real time, allowing participants to fine tune their positions. When the Short-term Bilateral Market closes, a voluntary Balancing Market would open with the National Grid Company, in its role as System Operator, accepting bids for increments or decrements of generation or demand to enable it to balance the system. There would be a settlement
process to reflect differences between contract positions and metered volumes of output and to recover other costs to be borne by market participants.

A Balancing and Settlement Code would contain a set of rules covering the balancing market, the imbalance price and the settlement system.

Results:
- Staffing at generation plants fell by 60%, while productivity increased almost 75%
- Improved operating efficiency.
- Prices have fallen for majority of customers with increased reliability

10.4 The Nordic Pool (Norway, Sweden)

The Swedish electricity sector was never completely centralized or nationalized. Till 1991, the sector was dominated by Vattenfall, which in addition to owning about 50% of the total generation also managed the 400 kV and 220 kV transmission lines and some large networks at lower voltage levels, down to the customers. There were about a dozen other large generating companies and 270 distribution companies, which operated the networks at lower voltage levels and often owned their own generation.

The Norwegian electricity sector was dominated by small/ medium sized municipality owned power companies, each vertically integrated, i.e., they generated power and transmitted that to their own dedicated customers. Most of the transactions were on a bilateral basis, between the utility and bulk consumers.

Main features of Norwegian deregulated market:
- Deregulation was created in by the Energy Act of June 1990 and market operation started in May 1992
- Restructuring removed the transmission ownership from Statkraft, a national utility, and the creation of a new national owned company Statnett to be transmission owner, market operator and ISO.
- Nord pool is not a mandatory pool. Generators and consumers voluntarily decide whether or not they wish to sell or purchase electricity through this market. As a consequence, the majority of electricity is still traded via bilateral contracts between generators and consumers, with the pool serving primarily as a wholesale market for marginal electric supply.
- There is a future market where weekly financial futures contracts ranging from a week ahead to 3 years ahead are traded.
- Norwegian Water Resources and Energy Administration (NVE) is responsible for monitoring grid operation in Norway and for setting the tariffs for the local distributions companies throughout Norway.

Main features of Swedish deregulated market:
- Passed deregulation legislation in October 1995 and joined existing Norwegian market structure in January 1996 inspired by the Norwegian initiative.
• Transmission operation was removed from national utility Vattenfall that continues to operate generation, and Svenksa Kraftnat, the national grid owner and ISO, was formed.
• Nord Pool, a market operator was formed, owned equally by Statnett & Kraftnat, to look over spot and future market for the both countries.
• Some large retail distributors also generate all or a large fraction of the electricity they distribute.
• Sydkraft and Stockholm Energi, the two largest distribution companies, are the next largest generators after Vattenfall.

Results:
• Prices have declined about 2% for residential & 7% for commercial consumers
• Service reliability has remained at or near traditionally high levels
• Management of hydro energy has resulted in no shortages or apparent waste of water resources.

10.5 Canada
January 1, 1996 was a turning point for Alberta’s electric industry since it meant vertically integrated utilities became a thing of the past. Since then, restructuring is moving cautiously, trying to retain the benefits of the existing low cost generators for customers while making the transition to fully competitive market.

Main features:
• New power pool, through which all energy in the province will be traded. The hourly pool price will be the same for buyers and sellers.
• Competitive bidding for future generation. Utilities will continue to own and operate their existing power plants. However, as these are retired, IPP will be brought on to replace them and meet load growth. This will lead to the generation sector becoming fully competitive.
• A province-wide transmission grid, which will be administered by the Grid Company of Alberta Inc. (Gridco). It is owned by the four utilities that own transmission facilities in the province and will contract with those individual owners to supply transmission services.
• An advisory group, the Electric Transmission Council, will represent the interests of consumers and transmission users.

10.6 California (US)
In the United States, the Federal Energy regulatory Commission (FERC) deregulated the wholesale generation and bulk transmission parts of the electric power industry with its order 888, in April 1996. The wholesale generation market throughout the United States will be competitive, with low barriers to entry and dominance by no one. The transmission grid will be open to access by all qualified parties.
Individual states are free to pursue different approaches to how they implement and operate the electric industry in their state, within the FERC guidelines. Naturally, the fifty states are pursuing deregulation in different directions.

Electricity costs in California were claimed to be about 50% higher than the national average. So, this state has been most aggressive in pursuing restructuring. On March 31, 1998 California became the first state to offer all customers a choice of electric service providers

Main features:

- A ‘power exchange’ (PX) - a spot market, runs much like a stock market for power, into which both buyers and sellers bid.
- Unlike some systems, this PX allows only short term (real time, hour and day-ahead) trading.
- Bilateral trading of power over short or long periods is not only allowed, but also encouraged.
- Operation of transmission system in an open access manner.
- Open customer access at the retail level.
- Postage-stamp pricing implemented on a zonal basis.
- Congestion management through adjustment of zonal prices.
- Nuclear power do not bid and contracted ahead of time as must run. Schedule and price are calculated and disclosed.
- Renewable must be bought as and when available.
- The ISO will maintain interconnected system operation, monitoring and controlling the system to assure it stays in a secure and stable state all the time.
- The ISO should provide equitable access for all potential users to reserve the system transmission capability they want.
- The ISO should satisfy the power shipment needs of all the participants.
- The ISO provides settlement, billing the users and passing revenues on to the transmission owners.

Some of the important websites/links related to the topic are as follows:

http://www.ferc.fed.us
http://www.nordpool.no
http://www.statnett.no
http://www.ofgem.gov.uk
http://www.caiso.com
http://www.nationalgrid.com
http://www.bmreports.com/bwx_home.htm
http://www.elexon.co.uk/
http://www.fingrid.fi
http://www.svk.se
http://www.ucei.berkeley.edu/ucei/datamine/datamine.htm
11. **Indian Scenario of Deregulation**

In India, the power sector was mainly under the government ownership (>95% distribution & ~98% generation) under various states and central government utilities, till 1991. The remarkable growth of physical infrastructure was facilitated by four main policies: 1) centralized supply and grid expansion 2) large support from government budgets 3) development of sector based on indigenous resources 4) cross subsidy.

In mid 1990s, Orissa began a process of fundamental restructuring of the state power sector. Under the World Bank (WB) loan, the state decided to adopt, what is known as WB-Orissa model of reform. This consisted of a three pronged strategy of: 1) Unbundling the integrated utility in three separate sectors of generation, transmission and distribution, 2) Privatization of generation and distribution companies and, 3) Establishment of independent regulatory commissions to regulate these utilities. Soon afterwards, several other states such as Andhra Pradesh, Haryana, Uttar Pradesh and Rajasthan also embarked on similar reforms and also availed loans from multilateral development banks such as WB and Asian Development bank, etc. Meanwhile, some moderate steps were taken towards reforms until the Electricity Bill 2003 was approved by Parliament in May 2003. This unified central legislation passed after 10 drafts. The Bill now replaces pervious three acts on electricity of 1910, 1948 and 1998 (with their amendments).

**11.1 The Electricity Act 2003:**

The conceptual framework underlying this new legislation is that the electricity sector must be opened for competition. The Act moves towards creating a market based regime in the power sector. The Act also seeks to consolidate, update and rationalize laws related to generation, transmission, distribution, trading and use of power. It focuses on:

- Creating competition in the industry
- Protecting consumer interest
- Ensuring supply of electricity to all areas
- Rationalizing tariff
- Lowering the cross-subsidization levels

Some of the major provisions of the Electricity Act are:

- Elimination of licensing for setting up a generating station, subject to compliance with technical standards. This excludes Hydro-Electric power station
- Removal of captive power plants from the ambit of licensing and other permissions
- Provision for issuing more than one license for transmission and distribution in the same geographical area.
- Provision of ‘Open Access’ with respect to transmission
- Introduction of a spot market for bulk electricity
- Unbundling of the SEBs on the basis of functions (generation, Transmission and Distribution)
- Compulsory metering of all consumers in order to improve accountability
State Governments will have the freedom to decide the sequence and phases of restructuring, and also retain the integrated structure of the SEB for a limited period.

References: