

Chapter 1 Introduction to Restructuring of Power System

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Power System Structure

- Power system is known as "**vertically integrated utility**".
- In this type of structure, one utility handles all the functions of
 - ❖ **Generation**
 - ❖ **Transmission**
 - ❖ **Distribution**
- The operation and coordination of such a system is somewhat simple, since all functions are controllable by a system operator.
- The operational objectives were to provide quality power to a consumer, while ensuring reliability and overall economy.

Power System Structure



- The price of power is “**regulated**” based on actual costs.
- An alternative is to treat power as a **tradable commodity**.
- The functions of **generation** and in many cases, **distribution**, are open to private participation.
- While the “**technical objectives**” are similar to those in a vertically integrated utility, the price is not regulated, but depends on market forces and competition between the participants.
- In a generation deficit scenario, price may still need to be regulated.

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Power System Structure

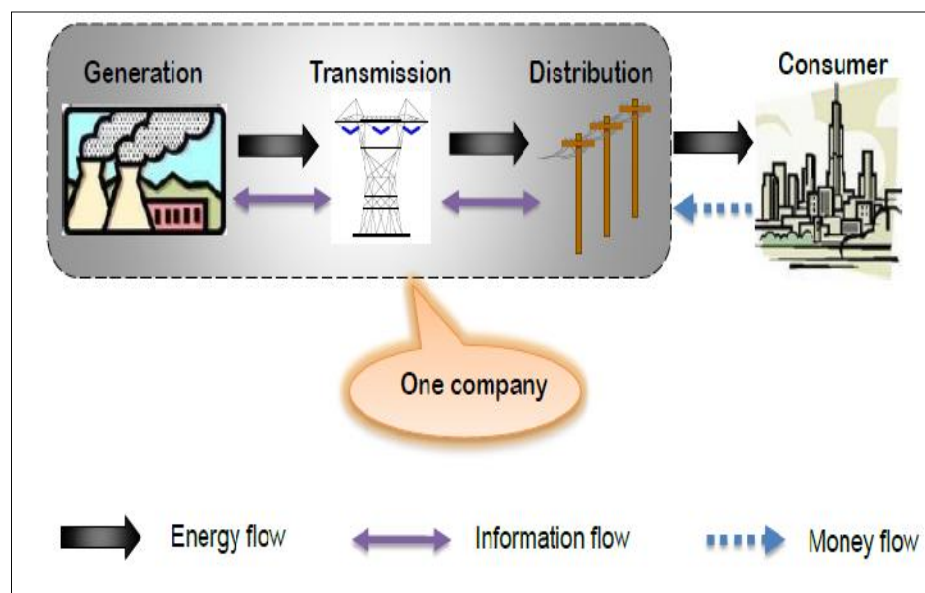


- The cost of use of transmission lines would also be regulated.
- Therefore a “**regulator**” would still be required.
- However, a regulator would be an independent body.
- An **independent system operator (ISO)** would perform the coordination functions required to operate the system reliably and ensure that voltage and frequency are within limits.
- The real and reactive power resources, required to maintain voltage, frequency and reliability, may be “**purchased**” and charged to all the players in a fair manner.

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Structure of a Traditional Vertically Integrated Electric Industry



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Structure of a Traditional Vertically Integrated Electric Industry

- Such utilities served as the only electricity provider in a region and were obliged to provide electricity to everyone in the region.
- 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.
- In this system, 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.

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Structure of a Traditional Vertically Integrated Electric Industry



➤ The **state electricity boards (SEB)** in India were examples of a vertically integrated utility; they are now being restructured.

Characteristics of Vertically Integrated Electric Industry:

❖ Monopoly Franchise

➤ Only the local electric utility can produce, move or sell commercial electric power within its service territory.

❖ Obligation to serve

➤ The utility must provide service to all electric consumers in its service territory, not just those that would be profitable.

❖ Regulatory Oversight

➤ The utility's business and operating practices must confirm to guidelines and rules set down by government regulators.

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Structure of a Traditional Vertically Integrated Electric Industry



Characteristics Vertically Integrated Electric Industry:

❖ Least Cost Operation

➤ The utility must be operated in a manner that minimizes its revenue needs.

❖ Regulated Rates

➤ The utilities are set in accordance with government's regulatory rules and guidelines.

❖ Assumed Rate of Return

➤ The utility is assured a fair return on its investment, if it confirms to the regulatory guidelines and practice.

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Advantages of Traditional Electric Utility:



- This offered a **risk free way to finance** the creation of electric industry.
- The utility could focus on building up the systems without having to worry about the competitors.
- To prevent exploitation of consumers due to monopoly, the government brought in regulation.
- This legitimized (**decriminalized**) the electric utility business.
- It gave electric utilities recognition and support from the government, which was necessary to solve problems like '**Right of Way**'.

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Conditions Leading to Changes in Traditional Power System Structures



- There are many reasons that are leading to restructuring of power systems.
- One force was the change in generation economies of scale that occurred throughout the 1980's.
- Very large generators produced power at less than half the cost per kilowatt of small generator units.
- The bigger the generator, the more economical the power it produced.
- For the reasons stated below, the shift in economy of scale was observed:
 - ❖ **Technological innovation improved the efficiency of small units for gas turbines, combined cycle, hydro and fuel cells.**

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Conditions leading to changes in traditional power system structures



- ❖ 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.
- ❖ Computerized control systems have been developed that often reduce the number of on-sight personnel to zero.
- ❖ Data communications and off-site monitoring systems can control the units from remote operations centers.
- It became possible for the industrial and commercial users of electricity to build and operate their own plants.

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The Reasons for Restructuring (Deregulation)



1. The need for regulation changed.

- First, the original need for regulation, which was to provide risk free finance to build the infrastructure, did not exist anymore.
- Second, most of the major electrical infrastructure was paid for, decades ago.
- The revenue gained by the electric utilities was invested to renew their system.
- The electricity could now be thought of as an essential commodity, which can be bought and sold in the marketplace in a competitive manner.

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The reasons for restructuring (Deregulation)



2. Ideological Reason : Privatization

➤ The 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.

3. Cost is expected to drop

➤ Competition is expected to bring innovation, efficiency, and lower costs.

4. Customer focus will be improved

➤ 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.

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The Reasons for Restructuring (Deregulation)



5. Encouragement for innovation

➤ The regulatory process and the lack of competition gave electric utilities no incentive to improve on past performance.

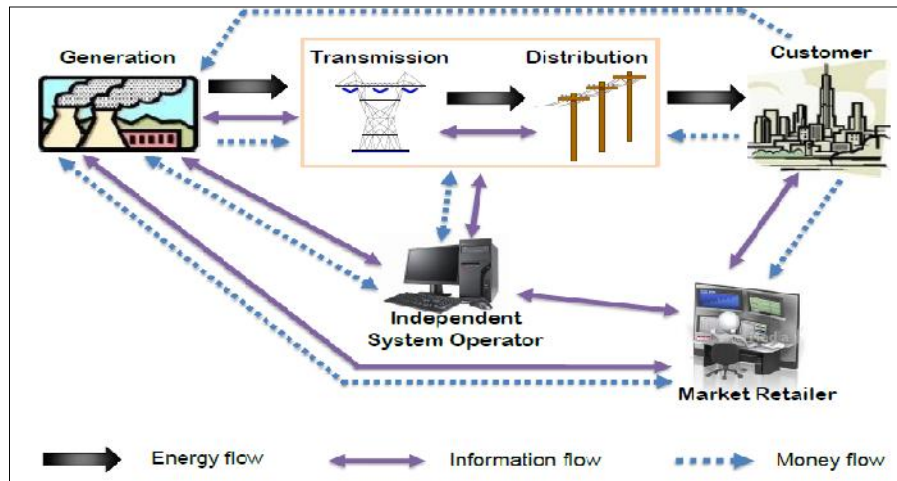
➤ Under deregulated environment, the electric utility will try to innovate something for the betterment of service and in turn save its costs and maximize the profit.

6. Other Reasons

- ❖ Global economic crisis
- ❖ Political and ideological changes
- ❖ Lack of public resources for the further development
- ❖ More demanding environment issues
- ❖ Pressure of financial institutes

Structure of a Deregulated Industry

➤ The figure below shows the structure of a deregulated utility with links of information and money flows.



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Structure of a Deregulated Industry

➤ Different power sellers will deliver their product to their customers (via retailers) over a common set of T & D wires.

➤ These operations are supervised by an **independent system operator (ISO)**.

➤ The generators, T & D utility and retailers communicate with the **ISO**.

➤ Mostly, customers communicate with a 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.

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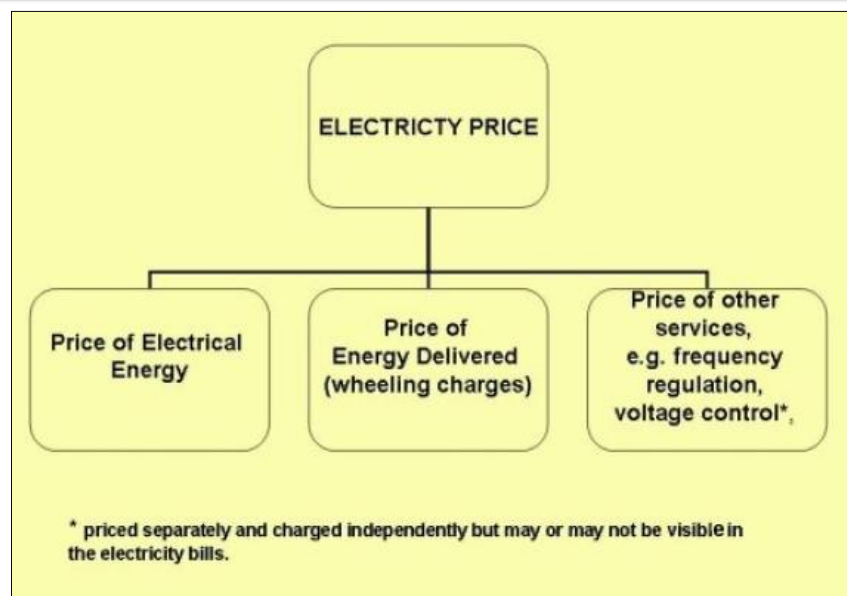
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Structure of a Deregulated Industry

- **ISO** is the one responsible for keeping track of various transactions taking place between various entities.
- A customer can also enter into a bi-lateral contract with a generator directly for supply of the required energy.
- In the vertically integrated 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:

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Structure of a Deregulated Industry



Understanding the Restructuring Process



- The process of deregulation has taken different formats in different parts of the world.
- Also, the reasons for power sector to adopt the reforms vary from country to country.
 - ❖ For the developed countries, introduction of competition to achieve social welfare was probably the most important reason.
 - ❖ The developing countries mainly banked on the capacity addition through entry of private players.
- There is neither one reason for driving deregulation of power industry nor a single objective of the same.

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Understanding the Restructuring Process



- The restructuring process starts with the unbundling of the original vertically integrated utility.
- For example, the unbundling of power industry involves separating **transmission** activity from the **generation** activity.
- Further, **distribution** can be separated from **transmission**.
- Three mutually exclusive functions are created and there are separate entities or companies that control these functions.
- Then, the competition can be introduced in the generation activity by allowing other private participants in this segment.
- There is a scope for private players to sell their generation at competitive prices.

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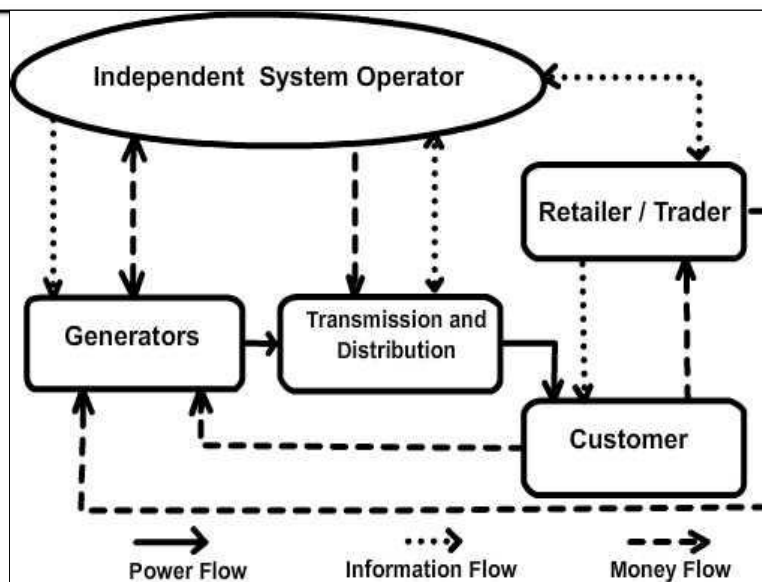
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Understanding the Restructuring Process

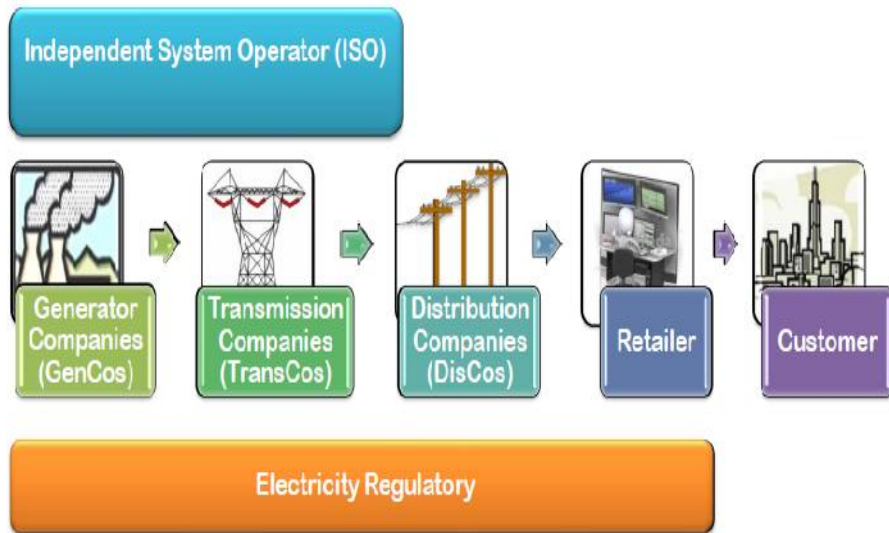
- The generators owned by the earlier vertically integrated utility will then compete with these private generators.
- The transmission sector being a natural monopoly is most **unlikely to have** competing players in the sector.
- This is because for natural monopolies like transmission companies, the business becomes profitable only when output is large enough.
- Following figure shows the representative structure of deregulated power system.
- In contrast to the vertically integrated utility, there are many alternative paths along which the money flows.
- There can be many more versions of deregulated structure.

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Understanding the Restructuring Process



Different Entities in Deregulated Environment:



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Different Entities in Deregulated Environment :

❖ GENCO (Generating Company) (GSECL)

- **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.

❖ TRANSCO (Transmission Company) (GETCO)

- **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.

Different Entities in Deregulated Environment :



❖ TRANSCO (Transmission Company) (GETCO)

- The **TRANSCO** owns and maintains the transmission lines under monopoly franchise, but does not necessarily operate them.
- That is done by Independent System Operator (**ISO**).
- The **TRANSCO** is paid for the use of its lines.

❖ 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.

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Different Entities in Deregulated Environment :



❖ DISCO (Distribution Company)

- In many other cases, however, the **DISCO** does not sell power.
- It only owns and operates the local distribution system, and obtains its revenues by 'renting' space on it.

❖ 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.
- Either way, a **RESCO** buys power from **GENCO** and sells it directly to the consumers.

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Different Entities in Deregulated Environment :



❖ ISO (Independent System Operator)

- 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.

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Different Entities in Deregulated Environment :



❖ ISO: Major Responsibilities

- **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 & 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.

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Different Entities in Deregulated Environment :



❖ Customers

- A customer is an entity consuming electricity.
- In deregulated markets, a 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.

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The Level of Competition :



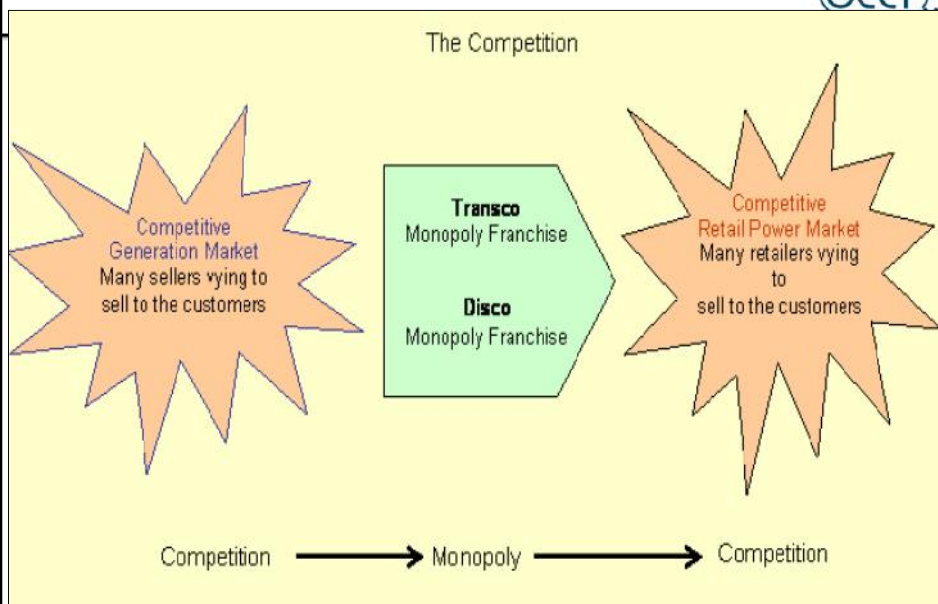
- In a deregulated environment, two levels of competition exist or are encouraged.
- **GENCOS** produce and sell bulk quantities of electric power.
- Power is typically sold in bulk quantities to other companies or very large industrial customers, through some deregulated power market mechanism.
- The **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.

The Level of Competition :

- These companies arrange for transport the power to each community.
- Here they do business, so that they have power to divide up and sell to individuals locally.
- Thus, a restructured or 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 **retails** levels.
- The important thing to note is that the power delivery i.e. **transmission** and **distribution** remain the monopoly franchise.

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The Level of Competition :



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 buyers' locations, but it must be kept under proper control on a real time basis.

➤ Both require **objectivity** and **equality** of operation towards all competitors.

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The Market Place Mechanisms



➤ Under deregulation, some system must be put in place where competitive sellers of electricity can offer their product (**power**) and transact sales.

➤ There are three basic ways in which it can be done:

a) PoolCo

b) Bilateral Trading

c) Power Exchange (PX)

a) **PoolCo**

➤ There is only one buyer in this system.

➤ It is a governmental or quasi-governmental agency that

❖ buys power for everyone,

❖ taking bids from all sellers & buying enough power,

❖ taking the lowest cost bidders,

❖ running the power system (**combined buyer-system operator**)

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b) Bilateral Trading

➤ 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, 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/ kWhr**”, whereas, the seller would enter his demand as, “I have **400 MW** and would like to sell it at **Rs.4/ kWhr**”.

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c) Power Exchange (PX)

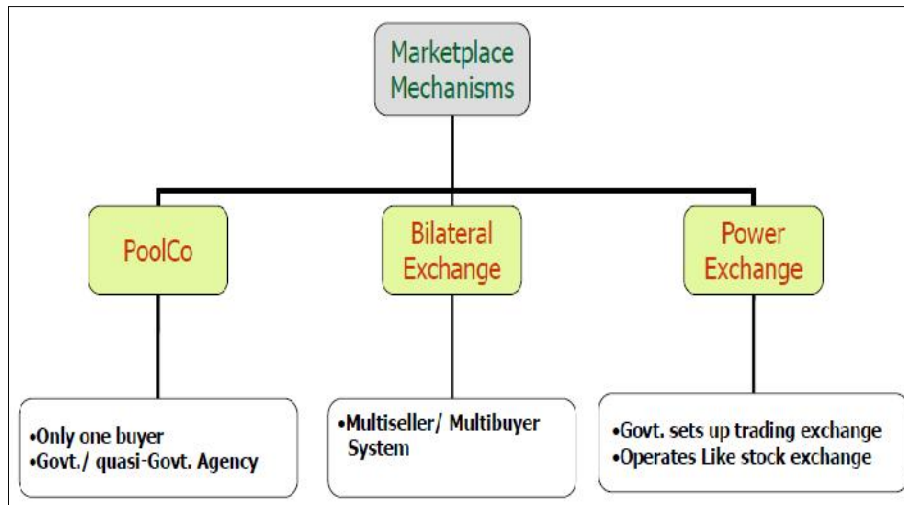
➤ When they transact business with the power exchange, buyers and sellers are really talking to the ‘**marketplace**’ and not the individual buyers and sellers.

➤ 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.



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Comparison between different Mechanisms

System	No. of buyers	Buyers know sellers?	All buyers pay same price?
PoolCo	One	Yes	Yes
Bilateral Exchange	Many	Yes	No
Power Exchange	Many	No	Yes

Sector-wise Major Changes Required



- An electricity has some distinguishing characteristics of its own, which demand satisfaction of technical constraints before accomplishing the commercial trades.
- Two important features of electricity as a commodity are:
 - ❖ need for real time balance
 - ❖ inability to wheel the commodity through desired path (in bulk)
- Hence, a set of principles laid down by standard micro-economic theory cannot be mapped directly to the electricity commodity markets.
- Tackling network congestion is one of the challenging issues of the de-regulated era.

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Sector-wise Major Changes Required



- **Transmission network** provides the path through which transactions are made in a power market.
- But each transmission network has its own physical and **operating limits**.
- The power injection and withdrawal configuration should be such that no limit gets violated.
- So, any arbitrary set of transactions can't be organized on the power network to avoid condition like blackout.
- When some components in a power network appear to be overloaded due to a trading arrangement, that particular arrangement is said to create **congestion** on the network.

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Sector-wise Major Changes Required



- The purpose of congestion management is to make necessary corrections in order to relieve congestion.
- Provision of **ancillary services** is another tough task carried out by the system operator under the deregulated framework.
- **Ancillary services** are defined as all those activities on the grid that are necessary to support the transmission of power with **reliable operation and safety**.
- The system operator (**SO**) acquires a central coordination role to ensure the reliability and security.
- It manages system operations like scheduling and operating the transmission related services.

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Reference: Restructured Power System by A. R. Abhyankar, S. A. Khaparde, www.nptel.iitm.ac.in/courses/108101005/

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