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RESTRUCTURED POWER SYSTEMS

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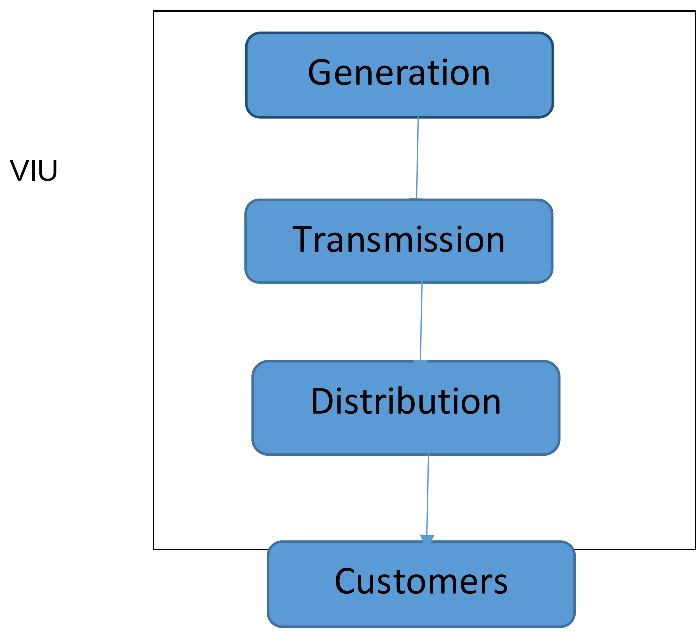
TRADITIONAL POWER INDUSTRY:

- The electric power industry has been operated as a vertically integrated regulated monopoly that owned the generation, transmission and distribution facilities.
- It has also been a local monopoly, in the sense that in any area one company or government agency sold electric power and services to all customers.
- The regulations are generally imposed by the government or the government authority.
- These essentially represent a set of rules or framework that the government has imposed so as to run the system smoothly and with discipline, without undue advantage to any particular entity at the cost of end consumer.
- All practical power systems of earlier days used to be regulated by the government.



CHARACTERISTICS OF TRADITIONAL POWER INDUSTRY:

i) Monopoly franchise : Only the national or local electric utility was permitted to produce, transmit, distribute and sell commercial electric power within its service territory.

ii) Obligation to serve : The utility had to provide electricity for the needs of all consumers in its service area, not just those that were profitable.

iii) Regulatory oversight : The utility's business and operating practices had to confirm to guidelines and rules set down by government regulators.

iv) Regulated rates : The electric utility's rates were either set or regulated in accordance with government regulatory rules and guidelines.

v) Guaranteed rate of return : The government guaranteed that regulated rules would provide the electric utility with a reasonable or fair profit margin above its cost.

vi) Least cost operation : The electric utility was required to operate in a manner that minimized overall revenue requirements.

- However, vertically integrated monopolies could not provide services as efficiently as competitive firms as in airline, telephone and natural and gas industries, the electric power industry plans to improve its efficiency by providing a more reliable energy at least cost to customers through restructuring.
- A competition is guaranteed by establishing a restructured environment in which customers could choose to buy from different suppliers and change suppliers as they wish in order to pay market based rates.

UNBUNDLING GENERATION, TRANSMISSION AND DISTRIBUTION:

- To implement competition, vertically integrated utilities are required to unbundle their retail services into generation, transmission and distribution (Gencos, Transcos and Discos).

- Competition is introduced in the generation activity by allowing other private participants in this segment. In contrast to the vertically integrated case where all the generation is owned by the same utility, there is a scope for private players to sell their generation at competitive prices. The generators owned by the earlier vertically integrated utility will then compete with these private generators.

- Generation utilities will no longer have a monopoly, small businesses will be free to sign contract for buying power from cheaper sources, and utilities will be obligated to deliver or wheel power over existing lines for a fee (non- discriminatory).

- The vertically integrated system is steadily restructuring to a more market based system in which competition will replace the role of regulation in setting the price of electric power.

- The main objective of electric power restructuring is to significantly reduce the cost of power charged to small businesses and consumers.

- The cost of electricity generation will be reduced by driving prices through market forces and more competition; this task will be accomplished by creating an open access environment that will allow consumers to choose a provider (customer choice) for electric energy.

- On April 24,1996 Federal Energy Regulatory Commission(FERC)
  Issued Final rule 888 requiring all public utilities that own, control or operate facilities for transmitting electric energy in interstate commerce to file open access non-discriminatory tariffs.

- This rule caused public utilities to functionally unbundle wholesale generation and transmission services.

- The basic premise of transmission open access is that the transmission owners/providers treat all transmission users on a
  non-discriminatory and comparable basis regarding access to and use of the transmission system and services.

- In addition FERC issued Rule 889, for the development of an electronic communication system called Open Access Same Time Information System (OASIS).

BENEFITS OF DEREGULATION:

The competitive environment offers a good range of benefits for the customers as well as the private entities. It is claimed that some of the significant benefits of power industry deregulation would include:

1. **Electricity price will go down**: It is a common understanding that the competitive prices are lesser than the monopolist prices. It significantly reduces the cost of power charged to small business and customers. The cost of electricity generation will be reduced by driving prices through market forces and more competition.

2. **Choice for customers**: The customer will have choice for its retailer. The retailers will compete not only on the price offered but also on the other facilities provided to the customers. These could include better plans, better reliability, better quality, etc. This will provide greater incentives for short and long term efficiencies than is provided by economic regulation.

3. **Customer-centric service**: The retailers would provide better service than what the monopolist would do.

4. **Innovation**: The regulatory process and lack of competition gave electric utilities no incentive to improve or to take risks on new ideas that might increase the customer value.

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

6. Restructuring in electricity industry will create new business opportunities where new firms selling new products and services will appear, consumers will have alternatives in buying electricity services, and new technologies such as metering and telecommunication devices will develop.

DISADVANTAGES OF DEREGULATION:

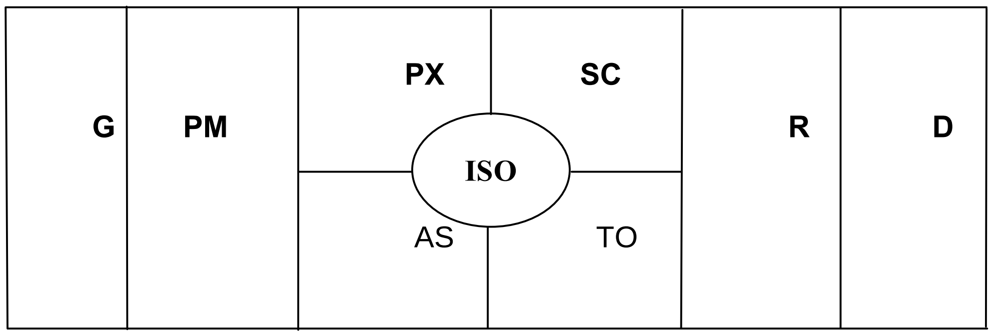
1. Improper implementation or hasty implementation of restructuring may lead to very high whole sale market prices leading to electricity crisis like that happened in California in 2000-2001, which threatened to wreck its economy and caused collateral damage throughout the West.

2. Employee Uncertainty: Restructuring often causes employees to panic and wonder how the changes will affect their job security. When the news gets out that the company is restructuring, some employees may begin looking for new employment.

3.The stress of the restructuring sometimes takes away from the staff's focus on their actual work.

STRUCTURAL COMPONENTS OF RESTRUCTURED SYSTEM:

The structural components representing various segments of the electricity market as Generation Companies (GENCOS), Power Exchange (PX), Scheduling Coordinators (SC), , Independent System Operator (ISO), Ancillary Services (AS), Retail Service Providers (R), and Distribution Companies (DISCOS)



1.Gencos (Generating Company) and Power Marketers

- Gencos and Power Marketers are the primary and secondary generation sectors respectively
- Genco is an owner-operator of one or more generators that runs them and bids the power into the competitive marketplace.
- Open transmission access allows Gencos to access the transmission network without distinction and competition.

Power Marketer: An agent for generation facilities. It markets power on behalf of the generators, may arrange transmission or ancillary services as needed, considered as an intermediary between the buyer and the seller, and expected to reduce prices for customers.

2. Disco(Distribution Company):

- It is the 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 Discos does not sell the power. It only owns and operates the local distribution system, and obtains its revenue by wheeling electric power through its network.

3. Power Exchange (PX)

- Even though short term and long term financial energy transactions could be in bilateral forms in the electricity industry where contracted parties agree individually for certain terms such as price, availability and quality of products, industry restructuring proposals have concluded the necessity of creating a new market place to trade energy and other services in a competitive manner.

- This market place is termed as Power Exchange(PX) or sometimes called spot price pool.

- This market place permits different participants to sell and buy energy and other services in a competitive way based on quantity bids and prices.

- Participants include utilities, power marketers, brokers , load aggregators , retailers, large industrial customers and co generators

- PX is a new independent, non government and non profit entity which accepts schedules for loads and generation resources.

- It provides a competitive market place by running an electronic auction where market participants buy and sell electricity and can do business quickly and easily.

- Through an electronic auction, PX establishes an MCP for each hour of the following day for trades between buyers (demands) and sellers(suppliers).

- In this market place PX does not deal with small consumers.

- PX manages settlement and credit arrangements for scheduling and balancing of loads and generation resources.

- It submits balanced demand and supply schedules for successful bidders to ISO(Independent System Operator) and performs settlement functions with ISO as well as PX participants such as UDCs(Utility Distribution Companies), marketers, aggregators etc

- It also submits ancillary service bids to ISO for maintaining system reliability , adjustment bids(Dec/Inc bids are used to relieve or eliminate congestion on transmission grid)

- PX guarantees an equal and non discriminatory access and competitive opportunities to all participants.

Electric Service Provider(ESP):

- **Broker**: An agent for either entities in negotiating contracts to purchase and /or buy electric energy and other services without owing any transmission or generation facilities , and at the same time does not take ownership of the energy purchased or sold for its agents.
- **Load Aggregator**: Any marketer, broker, public agency,city, country or special district, that combines the loads of multiple end-use-consumers in facilitating the sale and purchase of electric energy, transmission, and other services on behalf of these customers.
  Load aggregator will be municipal or private entities that organise customers in order to obtain more favourable contracts from retailers or marketers. Load aggregators are specialised in bringing buyers together, may arrange for additional services , and negotiate contract terms with retailers and energy service companies for their clients.
- **Retailers**: An Electric Service Provider(ESP) that can be aggregators, brokers and marketers who enters into a direct access transaction with an end-use ï customer. They compete on the basis of price and services to reach and sell only electricity or electricity and other services.
- **Cogenerator:** An entity that owns a generation unit that produces electricity and another form of useful thermal energy such as heat or steam to be used for industrial , commercial, heating or cooling purposes, and cogeneration is the simultaneous production of both usable heat or steam and electricity from a common fuel source.

4. Scheduling Coordinators (SC)

- SCs arrange trading between generators and customers, SC plays an intermediary between ISO, retailers and customers.
- Each SC submits balanced schedules and provides settlement ready data to ISO.
- Each SC maintains a year around, 24 hour scheduling center and provides non emergency operating instructions to generators and retailers.
- Each SC provides the ISO with its customers demand, supply schedule and transmission use and ISO runs the information through a computer program to check for transmission congestion

- If no congestion exists ,ISO will send approval signal to the SC, otherwise the SC will be advised to sell, buy or trade power to resolve the situation.

- In this process, the ISO may provide suggested alternatives to the SC for removing the congestion.

- SC plays a critical role in restructured power systems. In California, SCs are the only market players for generation dispatch and responsible for means that congestion is resolved(through adjustment bids).

- This is different from restructuring proposals in New York, New England and PJM (Pennsylvania ,New Jersey ,Maryland) where ISO resolves congestion.

- Moreover SCs may negotiate bilateral contract with or between its participants, aggregate contracts .between market participants, act as an Electric Service Provider, deliver services and sign direct retail access contracts with consumers.
- SCs may also own, contract for or broker generation, and bundle generation and load.
- In the day-ahead and hour-ahead markets, SCôs schedule at each hour must balance the power injected into the system and the power extracted from the system.
- The ISO is not allowed to adjust individual schedules of SCsô participants (generators or consumers), only SCs have this power, with one exception in the case of extreme emergency (such as severe outages) when the ISO is authorized to change generation or/and load to secure the system.

Difference between SC and PX:

- Even though PX is seen as SC it has a limited role and trading functionalities as compared to other SCs

- An SC would have the ability to negotiate with its own generators and client loads and interact with other SCs. SCs disclose resulting schedules to its own participants and are not obligated to pass on any information to other participants which conclude that SCs could discriminate against some participants.

- This fact is in contrast to the PX which publishes MCP based on non discriminatory auction results and notifies its participants of these results.

- The non-discriminatory is guaranteed in the PX by matching the lowest incremental generation bid with the highest incremental demand bid while the SC can price discriminate by matching the next highest willingness to pay for demand with a slightly lower generation price.

- If SC imposes price discrimination, it could lead to prices which would be higher than a uniform MCP determined by the PX.

- In the day ahead market, SC participants could trade energy for reducing congestion and lowering power costs, while PX traders cannot respond to congestion through bids or trades. This may lead market participants to avoid PX to prevent possible curtailments in the future.

5. Independent System Operator (ISO)

- A competitive generation market and retail direct access necessitated an independent operational control of the grid. However, the independent operation of the grid was not guaranteed without an independent entity , the so called Independent System Operator (ISO).

- An ISO is independent of individual market participants such as transmission owners, generators , distribution companies and end users. The basic purpose of ISO is to ensure a fair and a non-discriminatory access to transmission services and ancillary services to maintain the real-time operation of the system and facilitate its reliability requirements.

Role of ISO:

- The primary objective of the ISO is matching electricity supply with demand as necessary to ensure reliability .

- ISO should control generation to the extent necessary to maintain reliability and optimise transmission efficiency.

  In Order No.888, FERC developed eleven principles as guidelines to the electric industry restructuring to form a properly constituted ISO, through which public utilities could comply with FERCs non-discriminatory transmission tariff requirements :

1. ISO governance should be structured in a fair and non discriminatory manner.

2. An ISO and its employees should have no financial interest in the economic performance of any power market participant. An ISO should adopt and enforce strict conflict of interest standards.

3. An ISO should provide open access to the transmission system and all services under its control at non-pancaked rates pursuant to a single, unbundled,grid -wide tariff that applies to all eligible users in a non-discriminatory manner.

4. An ISO should have the primary responsibility in ensuring short-term reliability of grid operations. Its role in this responsibility should be well defined and comply with applicable standards set by NERC(North American Electricity Reliability Corporation) and regional reliability council.

5. An ISO should have control over the operation of interconnected transmission facilities within its region.

6. An ISO should identify constraints on the system and be able to take operational actions to relieve these constraints within the trading rules established by the governing body. These rules should promote efficient trading.

7. An ISO should have appropriate incentives for efficient management and administration and should procure services needed for such management and administration in an open market.

8. An ISOs transmission and ancillary services pricing policies should promote the efficient use of and investment in generation, transmission and consumption. An ISO or a Regional Transmission Group (RTG) of which the ISO is a member should conduct such studies as may be necessary to identify operational problems or appropriate expansions.

9. An ISO should make transmission system information publicly available on a timely basis via an electronic information network (OASIS) consistent with the commissions requirements.

10. An ISO should develop mechanisms to co-ordinate its activities with neighbouring control areas.

11. An ISO should establish an Alternate Dispute Resolution (ADR) process to resolve disputes in the first instance.

- An ISO is mainly responsible for maintaining system integrity by acquiring resources necessary to remove transmission violations, balance the system in second to second manner and maintain system frequency at an acceptable level to retain stability.

- According to FERC order 888, ISO is authorized to maintain transmission system reliability in real time. As per FERC order 888, each ISO may take one of the following structures:

  1. The first structure is mainly concerned with maintaining the transmission reliability by operating the power market to the extent that the ISO would schedule transfers in a constrained transmission system . An example of this proposal is Midwest ISO.
  2. The second proposal for a ISO includes a PX that is integral to the ISOs operation. In some proposal as those of the UK and PJM interconnection, the PX would function within the same organisation and under the control of the ISO. The ISO is responsible for dispatching all generators and would set the price of energy at each hour on the highest price bid in the market.

- An essential task of the ISO in all restructuring models is the service of mitigating transmission constraints.
- This management process includes billing and accounting procedures for the cost of mitigating constraints and paying those participants who provide mitigation services.
- Also ISO will ensure that proper economic signals are sent to all parties, which in turn, will encourage efficient use and motivate investment in resources capable of alleviating constraints.
- In emergency conditions, system reliability is an absolute responsibility of ISO.
- In these situations, ISO has the authority to commit and dispatch some or all system resources or components. ISO has the ability to call for increase or decrease in generation and to curtail loads to maintain system security.
- To make these services available, ISO contracts with service providers , so that the services are available under the ISOs request.
- When service provider is called by ISO , the provider is paid extra to cover its operating costs. Capacity resources are contracted seasonally by the ISO and providers send their bids to an auction operated by the ISO. The ISO chooses successful providers based on a least-cost bid basis.
- When determining the winners, the ISO takes into account factors such as time and locational constraints and the expected use of resources.
- If the ISO finds that spot market services are less expensive than contracted ones, ISO experiences its authority by acquiring these services from the energy spot market.

6.Transmission Owners/Providers

- The basic premise of transmission open access is that the transmission owners/providers treat all transmission users on a non-discriminatory and comparable basis regarding access to and use of the transmission system and services.

- This requirement could be difficult to ensure if the transmission owners have any financial interests in energy generation or supply.

- A general trend is, therefore to designate an Independent System Operator (tSO) to operate the transmission system and facilitate provision of transmission services.

- Maintenance of the transmission system remains the responsibility of the transmission owners.

7.Ancillary Services

Ancillary services are defined as services which are required to support the transmission of capacity and energy from resources to loads while keeping a reliable operation of the transmission system of a transmission provider in accordance with Good utility practice.

- Ancillary service providers supply the transmission network support services that are needed for reliable operation of the power system.

- In its order 888, FERC has defined six ancillary services that must be provided by or made available through transmission providers.

- They are 1. Scheduling Control and Dispatch services
  2. Reactive supply and voltage control
  3. Regulation and frequency response services
  4. Energy imbalance service
  5. Operating reserve, spinning and supplemental reserve services
  6. Transmission constraint mitigation (congestion management)

- Transmission customers may self-provide these services or buy them through one of the following methods:

(i) Providers of these services advertise their availability via the OASIS or commercial exchanges

(ii) ISO provides these services in real time and charges transmission users.

RESTRUCTURING MODELS:

Three major models are being discussed as alternatives to the current vertically integrated monopoly. The three models are:

1. PoolCo Model
2. Bilateral Contract Model
3. Hybrid Model

PoolCo Model:

- A PoolCo is defined as a centralized market place that clears the market for buyers and sellers where electric power sellers/buyers submit bids and prices into the pool for the amounts of energy that they are willing to sell/buy.
- The main characteristic of this model is the establishment of independently owned wholesale power pools served by interconnected transmission systems.
- This pool becomes a centralized clearing market for trading electricity which would implement competition by forcing distribution utilities to purchase their power from the PoolCo instead of trading with generating companies.
- These companies sell power at a market clearing price (MCP) defined by the PoolCo, instead of a price which is based on generation cost (as is the case in a vertically integrated monopoly).
- The final price for spot market power (spot markets is where market generators are paid for the electricity that they have sold to the pool and market consumers are charged for their electricity consumption.) may exceed MCP to account for charges that the ISO could obligate customers to pay for the associated ancillary services and to cover ISOӳ overhead costs.

- PoolCo does not own any generation or transmission components and centrally dispatches all generating units within the service jurisdiction of the pool.

- In a PoolCo, sellers and buyers submit their bids to inject power into and out of the pool. Sellers compete for the right to inject power into the grid, not for specific customers.

- If a power provider bids too high, it may not be able to sell power. On the other hand, buyers compete for buying power and if their bids are too low, they may not be getting any power.

- In this market, low cost generators would essentially be rewarded. Power pools would implement the economic dispatch and produce a single price for electricity, giving participants a clear signal for consumption and investment decisions.

<u>Bilateral Contracts (Direct Access) Model:</u>

- The Bilateral Contracts model has two main characteristics that would distinguish it from the PoolCo model.

- These two characteristics are: the ISOœs role is more limited; and buyers and sellers could negotiate directly in the marketplace.

- This model permits direct contracts between customers and generators without entering into pooling arrangements.

- In this model, small customersô aggregation is essential to ensure that they would benefit from competition.

- By establishing non-discriminatory access and pricing rules for transmission and distribution systems, direct sales of power over a utilityœs transmission and distribution systems are guaranteed.

- Wholesale suppliers would pay transmission charges to a transmission company to acquire access to the transmission grid and pays similar charges to a distribution company to acquire access to the local distribution grid.

- In this model, a distribution company may function as an aggregator for a large number of retail customers in supplying a long-term capacity.

- Any two contracted parties would agree on contract terms such as price, quantity and locations, and generation providers would inform the ISO on how its hourly generators would be dispatched.

- The ISO would make sure that sufficient resources are available to finalize the transactions and maintain the system reliability.

- To maintain reliability in real time, the suppliers would supply incremental and decremental energy bids to prevent transmission flow congestion.

Hybrid Model:

- The hybrid model combines various features of the previous two models.
- The hybrid model differs from the PoolCo model as utilizing the PX is not obligatory and customers are allowed to sign bilateral contracts and choose suppliers from the pool.

- The California model is an example of the hybrid model.

- This structure has advantages over a mandatory pool as it provides end-users with the maximum flexibility to purchase from either the pool or directly from suppliers.

MARKET CLEARING PRICE (MCP):

- PX accepts supply and demand bids to determine a MCP for each of the 24 periods in the trading day.

Computers aggregate all valid (approved) supply bids and demand bids. Draw the aggregated demand bid curve and aggregated supply offer curve.

- MCPs are determined at the intersection of the two curves and all trades are executed at the MCP, in other words, the MCP is the balance price at the market equilibrium for the aggregated supply and demand graphs.

- Generators are encouraged to bid according to their operating costs because bidding lower would lead to financial losses if MCP is lower than the operating cost and bidding higher could cause units to run less frequently or not run at all.

DAY-AHEAD AND HOUR-AHEAD MARKETS:

- In the day-ahead market and for each hour of the 24-hour scheduling day, sellers bid a schedule of supply at various prices, buyers bid a schedule of demand at various prices, and MCP is determined for each hour.
- Then, sellers specify the resources for the sold power, and buyers specify the delivery points for the purchased power. PX schedules supply and demand with the ISO for delivery.
- Supply and demand are adjusted to account for congestion and ancillary services and then PX finalizes the schedules

The hour-ahead market is similar to day-ahead, except trades are for 1 hour

Once the MCP is determined in the PX, market participants submit additional data to the PX.

The data would include individual schedules by generating unit, take out point for demand, adjustment bids for congestion management and ancillary service bids.

IN-ELASTIC MARKET OR SINGLE SIDE AUCTION MARKET:

An inelastic market or Single side auction market does not provide sufficient signals or incentives to a consumer to adjust its demand in response to the price, i.e., the consumer does not have any motivation to adjust its demand for electrical energy to adapt to market conditions.

Here supply curves show elasticity, i.e., there are different price offers for energy for each of the supply curves, while the demand remains inelastic, i.e. demand for energy is the same, regardless of the price of energy (or the inelastic demand shows no price sensitivity).

ELASTIC MARKET OR DOUBLE SIDE AUCTION MARKET :

Both supply and demand show elasticity, i.e., there are different price offers for energy for each of the supply and demand .

STRANDED COSTS:

- In a vertically integrated monopoly utilities are used to cover their costs of doing business in rates charged to customers.
- Costs include operating costs and invested capital costs, where utilities cover these costs and considerable returns on their capitals through rates imposed on customers.
- But when restructuring is proposed to open market-based competition, and due to the fact that market-based prices are uncertain and sometimes less than vertically integrated rates, financial obligations of vertically integrated utilities may become unrecoverable in a competitive market and the level of revenue earned by a utility may no longer be adequate to cover its costs.
- If market prices are lower than vertically integrated rates, as many expect, utilities could be faced with investments that are unrecoverable in the competitive market.
- Stranded costs is the difference between costs that are expected to be recovered under the rate regulation(previous regulated entity) and those recoverable in a competitive market.

CONTRACTS FOR DIFFERENCES (CFDS):

- Although buyers and sellers in a PoolCo are prevented from making individual contracts for power, participants may hold optional financial instruments called Contracts For Differences(CFD)
- These contracts are long-term price hedging bilateral contracts between generators and distribution utilities or retail customers.
- When used, a power seller is paid a fixed amount over time that is a combination of short-term market price and an adjustment for the difference.
- CFDs are established as a mechanism to stabilize power costs to customers and revenues for generators.

- CFD is the difference between MCP and contract price.
- By holding these contracts, customers gain protection against unexpected spot price increases and generators could obtain a greater revenue stability.

An example of CFDs is as follows:

A buyer (load) and a seller (generator) agree on a contract price of $5/MWh. It fix up a contract for one year.

When PoolCoôs price (MCP) drops to $4/MWh, the buyer pays$4 to the PoolCo and $1 (difference) to the seller.

When MCP increases to $6/MWh the buyer pays $6 to the PoolCo and is paid $1 by the seller.

If price goes up consumer is benefitted and if price goes down seller is benefitted.

TRANSMISSION PRICING:

FERC recognized that transmission grid is the key issue to competition, and issued guidelines to price the transmission. The guidelines are summarized such that the transmission pricing would:

(i) meet traditional revenue requirements of transmission owners
(ii) reflect comparability: i.e. a transmission owner would charge itself on the same basis that it would charge others for the same service
(iii) promote economic efficiency
(iv) promote fairness
(v) be practical
(vi) Even though transmission costs are small as compared to power production expenses and represent a small percent of major investor owned utilitiesô operating expenses, a transmission system is the most important key to competition because it would provide price signals that can create efficiencies in the power generation market.

TRANSMISSION PRICING METHODS:

1. Contract Path Method
2. MW-Mile method

Contract Path Method:

- It has been used between transacted parties to price transmission where power flows are assumed to flow over a predefined path(s).
- Despite its ease, this technique was claimed be a bad implementation of true transmission pricing as power flows would very seldom correspond to predefined paths.
- Physically, electrons could flow in a network over parallel paths owned several utilities that may not be on the contract path.
- Parallel path flows refer to the unscheduled transmission flows that occur on adjoining transmission systems when power is transferred in an interconnected electrical system.
- As a result, transmission owners may not be compensated for the actual use of their facilities.
- Added to parallel flows, the pancaking of transmission rates is another shortcoming of this method.
- Pancaking is when contract path crosses a boundary defining transmission ownership, additional transmission charges would be added to a transaction, which in turn might increase the price of the transaction.
- In-efficient method

MW –Mile method:

- Several ISOs are using a MW-Mile approach to price transmission.
- The MW-Mile rate is basically based on the distance between transacted parties (from the generating source to the load) and flow in each line resulted from the transaction.
- This approach takes into account parallel power flows and eliminates the previous problem that transmission owners were not compensated for using their facilities.
- This approach does not give credit for counter-flows on transmission lines.
- The method is complicated because every change in transmission lines or transmission equipment requires a recalculation of flows and charges in all lines.

CONGESTION PRICING :

The condition where overloads in transmission lines or transformers occur is called congestion.

Congestion could prevent system operators from dispatching additional power from a specific generator.

Congestion could be caused for various reasons, such as transmission line outages, generator outages, changes in energy demand and uncoordinated transactions.

Congestion may result in preventing new contracts, infeasibility in existing and new contracts, additional outages, monopoly of prices in some regions of power systems and damages to system components.

Congestion may be prevented to some extent (preventive actions) by means of reservations, rights and congestion pricing. Also, congestion can be corrected by applying controls (corrective actions) such as phase shifters, tap transformers, reactive power control, re-dispatch of generation and curtailment of loads.

A fast relief of congestion may be possible by removing congested lines to prevent severe damages to the system.

MANAGEMENT OF INTER-ZONAL/INTRAZONAL CONGESTION:

Transmission network plays a major role in the open access restructured power market.

It is perceived that phase-shifters and tap transformers play vital preventive and corrective roles in congestion management.

These control devices help the ISO mitigate congestion without re-dispatching generation away from preferred schedules.

In this market, transmission congestion problems could be handled more easily when an inter-zonal /intra-zonal scheme is implemented.

A congestion problem formulation should take into consideration interactions between intra-zonal and inter-zonal flows and their effects on power system.

Existing approaches to manage congestion are based on Issuing orders by the ISO to various parties to re- schedule their contracts, re-dispatch generators, cancel some of the contracts that will lead to congestion, use various control devices, or shed loads.

Other solutions are based on finding new contracts that re-direct flows on congested lines.

Phase shifters, tap transformers and FACTS devices may play an important role in a restructured environment where line flows can be controlled to relieve congestion and real power losses can be minimized.

FORMULATION OF INTER-ZONAL CONGESTION
SUBPROBLEM:

Objective

1. Modified dc power flow to adjust preferred schedules
2. Minimize the net cost of re-dispatch as determined by incremental/decremental price bids
3. Objective is equivalent to the net power generation cost used in a conventional OPF

Control variables

1.SCôs power generation in all congestion zones. For each generator a set of generation quantities with associated adjustments for incremental/decremental bids are submitted by SCs

2. SCsô curtailable (adjustable) loads. For each load, a set of load quantities with associated adjustments for decremental bids are submitted by SCs. These adjustments are implicit bids for transmission across congested lines

Constraints

1. Limits on control variables
2. Nodal active power flow balance equations
3. Inter-zonal line flow inequality constraints
4. Market separation between SCs

FORMULATION OF INTRA-ZONAL CONGESTION SUBPROBLEM

Objective

1.Modified AC-OPF to adjust preferred schedules

2.Minimize the MW re -dispatch by taking into account the net cost of re-dispatch as determined by the SCô s submitted incremental/decremental price bids.

3.The objective is equivalent to the MW security re-dispatch with incremental/decremental cost-based weighting factors to ensure that less expensive generators are incremented first and more expensive generators are decremented first during the adjustment process. For loads, the most expensive ones will be decremented first.

Control variables

1. SCsô power generation in congested zones. For each generator a set of generation quantities with associated adjustments for incremental/decremental bids are submitted by SCs.

2. SCsô curtailable (adjustable) loads in the congested zone. For each load, a set of load quantities with associated adjustments for decremental bids are submitted by SCs.

3. Reactive power controls including:
- Bus voltages
- Reactive power injection
- Phase shifters
- Tap-transformers

Constraints
1. Limits on control variables
2. Nodal active and reactive power flow balance equations
3. Intra-zonal MVA,M W, and MVAR line flow limits (inequality constraints)
4. Active power flow inequality constraints of inter-zonal lines connected to the congested zone
5.Voltage limits
6. Stability limits
7.Contingency imposed limits

ATC (Available Transfer Capability):

NERC defines ATC as a measure of the transfer capability remaining in the physical transmission network for further commercial activity over and above already committed uses.

ATC is an indication of the expected transfer capability remaining on the transmission network.

It is the available transfer capability that could be scheduled to the designated path under the conditions considered in calculating ATC values.

ATC is a market signal that refers to the capability of a system to transport or deliver energy above that of already subscribed transmission uses. ATC values are used to determine transmission service commitments.

The ATC value is determined based on other parameters, which are
TTC, TRM, and CBM. Mathematically, the ATC value between two
points is give as

ATC = TTC - TRM - (ETC + CBM)

where,

ATC - Available Transfer Capability
TTC - Total Transfer Capability between two points
TRM - Transmission Reliability Margin
ETC - Existing Transmission Commitments including customer services between the same two points
CBM - Capacity Benefit Margin

TTC (Total Transfer Capability):

TTC is the amount of electric power that can be transferred from one area to another over the interconnected transmission network in a reliable manner based on pre-contingency and post-contingency conditions

TTC is constrained by thermal limit, voltage magnitude limit, and stability limit (voltage stability limit, transient angle stability limit, and dynamic angle stability limit).

The thermal limit of a certain transmission network component is the limit that would constrain the amount of transfer that the component can safely handle without being overloaded.

Voltage limits are acceptable operating limits on bus voltage magnitudes across the transmission system.

Stability limits are the required limits that ensure interconnected transmission system would survive when disturbances are imposed on the system.

The constraining condition of the. transmission network would shift among the three limits as the operating conditions change over time.

TTC is determined as:

TTC= Min { Thermal Limit, Voltage Limit,
Stability Limit}

Figure (Refer Text book1) illustrates how TTC is calculated at each time instant as a minimum of the three limits.

TTC is calculated hourly, daily or monthly based on Market requirements

Certain factors should be taken into account in TTC calculations such as the list of contingencies that would represent most severe disturbances, accuracy of load forecast, unit commitment, and maintenance scheduling.

System control devices such as voltage regulators and reactive power control devices would also have a direct impact on TTC values.

As definitions indicate, TTC and ATC would always be defined for a pair of areas, i.e., a power-selling area and a power-buying area.

The definitions also imply that TTC and ATC values are time-dependent as the transmission system conditions would change over time which means that the calculation of TTC, and in turn ATC, would need to be updated continuously to reflect changes in system conditions.

To calculate a point-to-point TTC, i.e., between a source bus and a sink bus, a possible framework for TTC calculation is devised as follows

(1) Starting from the current operating point of the base case, the load on the sink bus would gradually be increased, and the corresponding load flow would be calculated while the source bus acts as swing (reference) bus.

If any of thermal, voltage or stability constraints is reached, the corresponding power transfer from the source to the sink becomes the TTC candidate.

(2) From the prepared contingency list, represent one contingency in the system and the resulting load flow.

Starting from this flow solution (similar to step 1), we would increase the load on the sink bus while the source bus acts as a swing bus until system constraints are reached, and the corresponding power from the source to the sink would become a new TTC candidate.

All of the contingencies in the list should be handled through this step.

(3) The final TTC for the source-sink pair, at the base operation point, is the minimum TTC of all TTC candidates.

Transmission Reliability Margin (TRM) and Capacity Benefit Margin (CBM) are two transmission margins proposed for considering the inherent uncertainty in interconnected power systems.

TRM (Transmission Reliability Margin):

It is defined as the amount of transfer capability necessary to provide a reasonable level of assurance that the interconnected transmission network will be secure.

TRM accounts for the inherent uncertainty in system conditions, its associated effects on ATC calculation, and the need for operating flexibility to ensure reliable system operation as system conditions change.

TRM accounts for the uncertainty in operating conditions such as those in model parameters (e.g., line impedance) or load forecasting errors.

TRM would be time dependent in evaluating ATC, representing a larger uncertainty for longer terms of the ATC evaluation.

Components that should be considered in calculating TRM are:

(1) aggregate load forecasting error, (2) load distribution error, (3) variations in facility loadings for balancing load and generation within a control area, (4)uncertainties in forecasting the system topology, (5) allowances for parallel path (loop flow) impacts, (6) allowances for Simultaneous interactions, (7) variations in generation dispatch due to component outages, and (8) variations in short-term operator response/operating reserves.

The calculated values of these terms may change based on the human experience and means of forecasting the system conditions.

There are several proposed approaches to calculate TRM. One approach is the Monte Carlo statistical approach, which is based on the repeated computation of TTC using variations in the base case data.

Another approach is probabilistic approach based on statistical forecasting error and other systematic reliability concepts

CAPACITY BENEFIT MARGIN (CBM):

Capacity Benefit Margin is defined as that amount of transmission transfer capability reserved by load serving entities to ensure access to generation from interconnected systems to meet generation reliability requirements.

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