

Engineering, Economics & Regulation of the Electric Power Sector

ESD.934, 6.974

Session 12
Module D.3

Generation & wholesale markets Wholesale market design

Prof. Ignacio J. Pérez-Arriaga

Study material

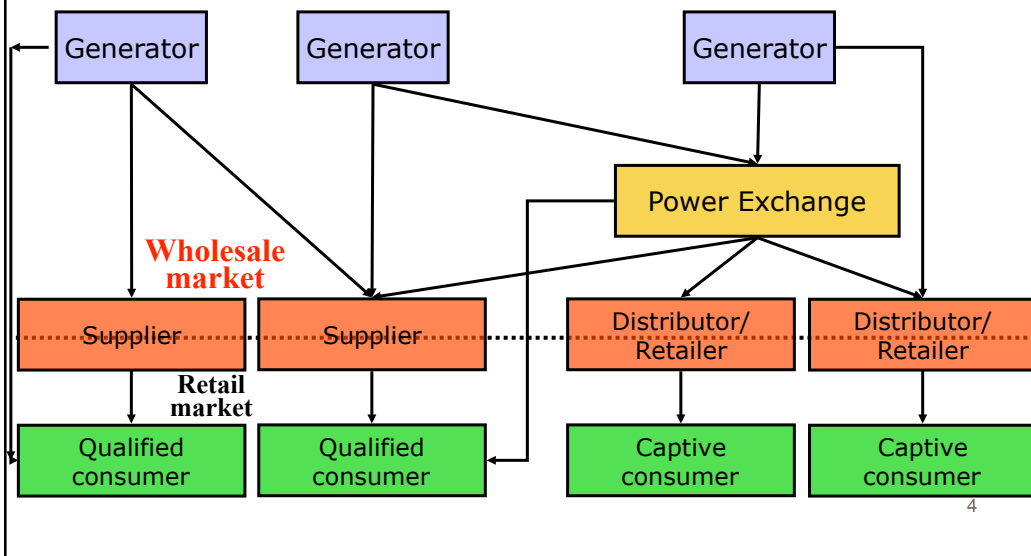
- ❑ Florence School of Regulation (FSR), "Generation wholesale markets"
- ❑ I.J. Pérez-Arriaga, "Grandma's inheritance theorem", October 2005, in the economic journal "5 Días". *<a peculiar version of Coase's theorem>*
- ❑ "Independent System Operators in the USA: History, lessons learned and prospects", Chapter 14 of "Electricity market reform", edited by F.P. Sioshansi, 2006

Readings

- S. Stoft, T. Belden, C. Goldman, S. Pickle, "Primer on electricity futures and other derivatives", Lawrence Berkeley National Laboratory, 1998. <excellent tutorial>
- P.R. Gribik, W.W. Hogan, S.L. Pope, "Market-clearing electricity prices and energy uplift", 2007. <clear statement of the problem and conclusions; the math in the middle is not easy to follow>

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Retail & wholesale markets



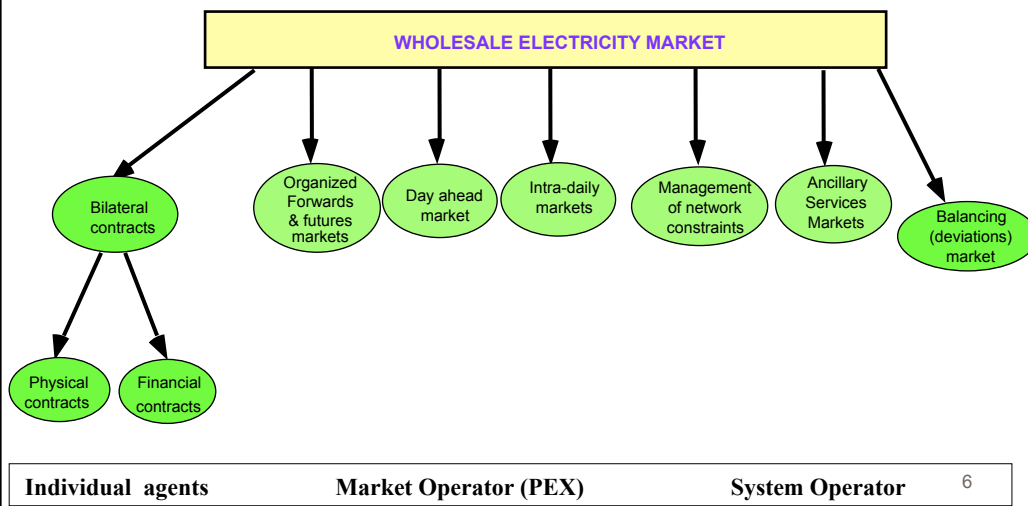
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Typical products and services in a wholesale market

- Different products and services are identified in a liberalised electricity market
 - Scheduled energy (*in long-term contracts, day-ahead, intra-day &/or balancing markets*)
 - Frequency control
 - Primary reserve
 - Secondary reserve
 - Tertiary reserve
 - Reactive power for voltage regulation
 - Black-start capabilities
 - Generation capacity for long term adequacy

Ancillary Services

Sequence & possibilities of transactions



How to design a wholesale market?

And why does it have to be designed?

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Hierarchy of decisions in wholesale market design

→ **Structural & governance** issues

Who are the players?

□ **Organization** issues

What are the possible transactions?

□ **Implementation** issues

What are the rules of the game?

This document uses material from Alberto Pototschnig's presentation on "Electricity wholesale markets" at the Florence School of Regulation Training Course

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Choices in wholesale market design Structure & governance

List of topics:

- ❑ Unbundling of activities
- ❑ Horizontal concentration
- ❑ Vertical integration
- ❑ Risk allocation
- ❑ Governance of market institutions
- ❑ Role of competition authorities
- ❑ A market within a wider market

→ *The players & their environment*

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Issues on structure & governance Vertical integration

- ❑ Complete unbundling of generation/retailing from network activities
- ❑ Avoid consolidation of vertical integration (generation & retail to *captive* consumers) via opaque physical bilateral contracts →
 - ◆ separation of activities
 - ◆ public auctions to allocate the contracts
 - ◆ mandatory purchase from the pool
- ❑ Diagonal integration (gas & electricity)

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Issues on structure & governance

Risk allocation

- Rule: Improve efficiency by allocating to each agent only the risk he may handle
- Case examples
 - ◆ risk of retailers for captive consumers largely depends on the mechanisms of pass-through of the pool price
 - The case of Argentina: no risk for retailer → no incentive to establish hedging contracts
 - The case of California: distributor/retailer was exposed to the full risk of market price volatility
 - Spain, The Netherlands: Use average purchasing cost rather than individual purchase cost

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Issues on structure & governance

Governance of market institutions

- Basic issues
 - ◆ Independence of the market operator or power exchange (public or private) *versus* complete representation of the agents of the market, or maybe a hybrid
 - ◆ Allow flexibility & promote initiative to improve the rules (avoid deadlocks)
 - combine some self-governance with a regulatory backstop

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Market related institutions

Case examples of unbundling

□ Typical EU

- ◆ Market operator is named "Power Exchange" & it can be a public entity or privately owned establishing its own rules
- ◆ Transmission System Operator: SO & transmission ownership, mostly independent
- ◆ Transmission services: Other companies besides the TSO could provide these services, but it is not frequent

□ Typical US (*under RTOs or ISOs*)

- ◆ Independent System Operator (ISO) performs functions of SO & Market Operator
 - Independent & it does not own transmission (nor generation or distribution) assets
- ◆ Diversity of transmission owners

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Issues on structure & governance

The role of competition authorities

- Backstop to self-governance by market institutions; possibility of improving rules
- Make sure that market information is facilitated to all interested parties on a non discriminatory basis
- Expert market surveillance
 - ◆ Market power abuse
 - ◆ investigation of specific complaints

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Issues on structure & governance

Always remember...

“When structure is not conducive to competition, the regulator & pool operator will find themselves unsuccessfully chasing after conduct. The solution is not a better rule, but a change in structure”(*)

(or a gradual introduction of competition, with rules that restrict the freedom of the market agents & prevent market power abuse)

(*) From “Governance & regulation of power pools & system operators”, Barker, J., Tenenbaum, B. & Woolf, F., World Bank, 1997.

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Hierarchy of decisions in wholesale market design

□ Structural & governance issues

Who are the players?

→ □ Organization issues

What are the possible transactions?

□ Implementation issues

What are the rules of the game?

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Choices in wholesale market design Organization

List of topics:

- Elements of the wholesale market
 - ◆ Products & services
 - ◆ Mandatory pools, bilateral contracts & power exchanges
 - ◆ Short-term (spot) markets
 - ◆ Balancing market & provision of ancillary services
- Major issues in organization
 - ◆ Role of demand / firmness of transactions / long-term security of supply / hedging contracts / market power

→ *The allowed transactions*

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Typical products and services in a wholesale market (*again*)

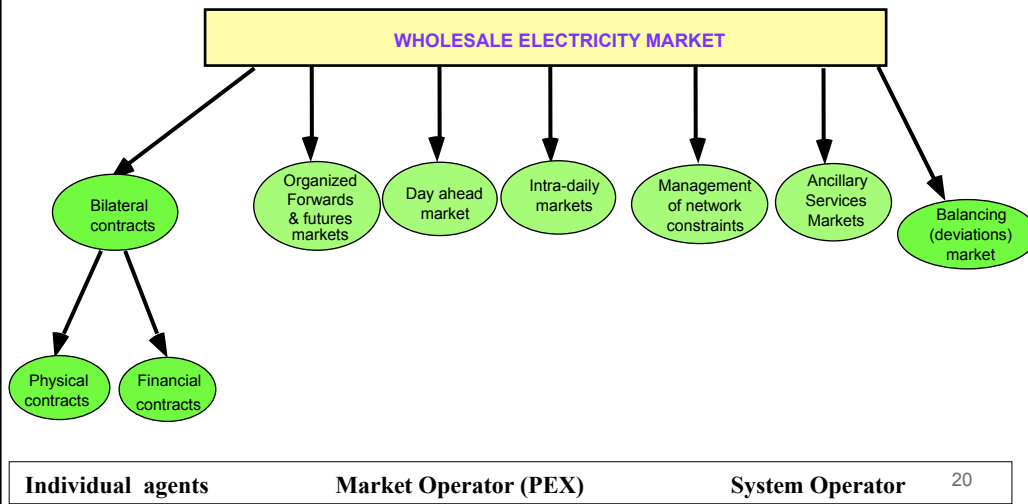
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 - Generation capacity for long term adequacy

Ancillary
Services

Energy trading opportunities

- ❑ Bilateral Over-the-Counter (OTC) contracts with free formats
- ❑ Contracts in organized markets (Power Exchanges, PXs)
 - ◆ Long-term contracts: physical or financial, with different standardized formats
 - ◆ Day-Ahead organized markets (spot markets)
 - ◆ Intraday markets
- ❑ SO-run markets for operating reserves & network constraints
- ❑ SO-run balancing markets

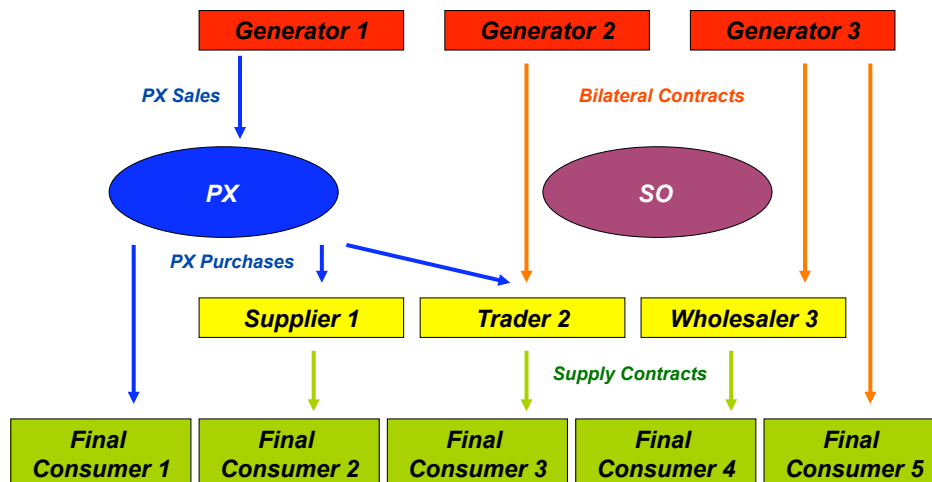
Sequence & possibilities of transactions



A wide diversity of market models

- The “mandatory pool” model
 - ◆ Simple or complex bids
 - ◆ Audited costs or free bids
 - ◆ Optional financial contracts
- The “open trade” model
 - ◆ Bilateral contracts that typically coexist (*not in the UK*) with a PX offering an organized day-ahead spot market & organized long-term contracts of different formats
- All models include the SO providing (*with or w/o ad hoc markets*) operating reserves, network constraint management & some balancing mechanism

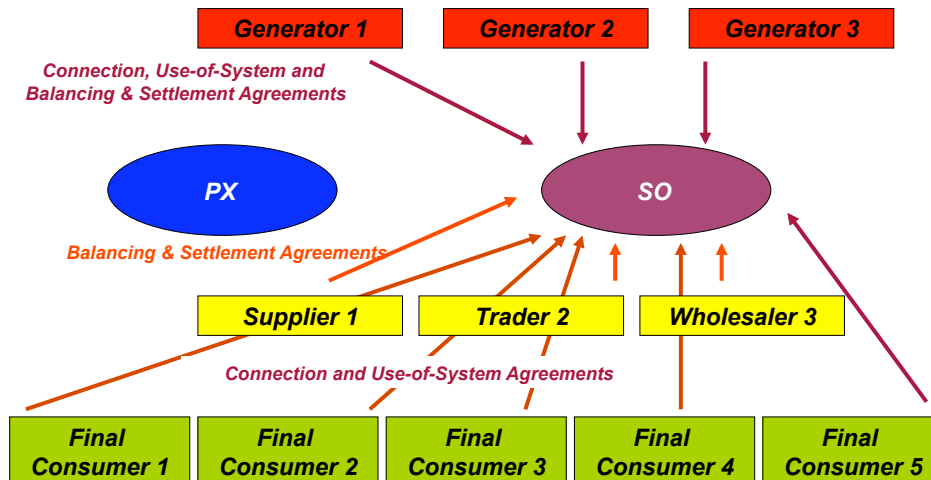
Commercial relationships in a typical market configuration



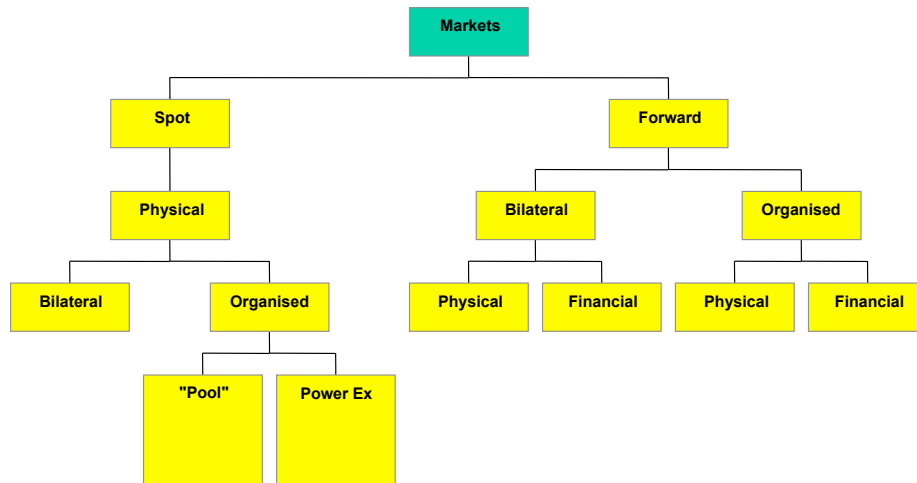
From commercial to physical (as the market gets closer to real time)

- ❑ "Gate Closure" is the deadline for trading electricity to be delivered in a specified period
- ❑ Gate Closure could be from one or more days to one hour or less before delivery time
- ❑ By Gate Closure, balanced (*injections and withdrawals*) positions are declared (*possibly through balance responsible agents*) to the relevant TSO for scheduling (*the PX may itself be a balance responsible agent*)
- ❑ At Gate Closure the TSO takes over the management of electricity flows over the network
- ❑ Deviations of actual injections/withdrawals from positions attract imbalance charges and are settled with the TSO

Physical relationships in a typical market configuration



Possible energy transactions



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Contracts

- **Objective:** Protect market agents against price uncertainty
 - ◆ Make revenue streams more predictable
 - ◆ Facilitate investment decisions
- **Practice:** Dominant form of transaction
 - ◆ Physical vs. financial contracts
 - ◆ Either private (although at least quantities must be declared in physical contracts) or through organized long-term markets
 - ◆ The spot market as an adjustment mechanism to solve differences between contracted amounts & as a reference for other transactions

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The short-term (*spot, typically day-ahead*) **market**

- In most market models there is a short-term (typically day-ahead) market that provides the reference price for the remaining transactions
 - Key issue is the potential for arbitraging between markets
- Why such a diversity of auction formats?
 - Bids: simple, complex, continuous, iterative
 - Dispatch: self-committed, centralized, zoom
 - Network: single node, zonal, nodal
- ➔ Trade-off in market design: simplicity & transparency *versus* efficiency & avoidance of risk

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Intraday markets

- Intraday markets make it possible to adjust (*by adding new transactions, without modifying the previous ones*) the contracted positions in the daily market
 - ◆ In case of occurrence of unexpected events (*generator failure, demand deviation*)
 - ◆ In case of difficulty in following the schedule of the daily program
 - ◆ Arbitrage between markets (*although the regulator may want to reduce it to a minimum*)

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Ancillary services

- ❑ Use market mechanisms whenever possible
 - ◆ Typically mandatory: frequency response (primary reserve)
 - ◆ Markets typically: secondary & tertiary reserves
 - ◆ Possible limited markets: reactive power, system restoration
- Wide diversity of contracting time horizons
- ❑ Secondary & tertiary reserves:
 - ◆ separate prices for capacity & energy use
 - ◆ may provide resources for balancing market

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Balancing market

- ❑ The criticality & volume of this market may be reduced with a zoom of short-term markets
- ❑ The price could be related to the use of secondary & tertiary reserves
- ❑ Most powers markets rely much on it (UK) while others basically avoid it (Spain, *just a penalty applied to deviations*)
- ❑ ISO may adopt emergency measures (*e.g. ad hoc markets*) whenever considered necessary

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Issues in market organization

Demand side bidding

- Demand participation is a basic ingredient of the second generation of power exchanges, but it is still mostly passive
- Incentives & mechanisms are needed so that purchasers
 - ◆ estimate the demand correctly
 - ◆ buy as economically as possible
 - ◆ experience the uncertainty of the pool price and want to hedge against it
 - ◆ have the means of hedging the risk of lack of supply, if they so wish

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Issues in market organization

Firmness of transactions

- A series of markets converging to the real time, each of them with firm transactions, seems to be the currently preferred option
 - ◆ All accepted transactions are firm in quantity & price
 - ◆ Successive markets allow the agents to approximate their buy/sell positions to their current best estimates
 - ◆ Same firmness rule applies in all (long-term, short-term, real time) markets
 - The energy actually bought or sold by an agent in a given period of time is composed of several transactions, each one of them with its quantity & price

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Issues in market organization

Long-term security of supply

The questions

- ◆ Can system short-term marginal prices remunerate the total costs of all plants?
- ◆ Can consumers choose their level of reliability of supply?

The proposed solutions

- ◆ Leave it to the market
- ◆ Regulated capacity payments
- ◆ Capacity markets
- ◆ Price risk-hedging contracts

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Issues in market organization

Information disclosure

- Market information must be accessible to all interested parties without discrimination
- Trade-off between
 - ◆ availability of complete market information
 - example: disclosure on the following day of all accepted & non accepted bids
 - ◆ potential for collusion

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
Issues in market organization

Codes of good practice

- Implicit (most frequent) or explicit (e.g. the Single Electricity Market in Ireland) is a central piece in the regulatory compact
 - ◆ Competition by itself is not a deterrent against anticompetitive behavior in actual markets
 - ◆ A basic understanding of what is permissible (legal) or not is necessary

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Hierarchy of decisions in wholesale market design

- **Structural & governance** issues
Who are the players?
- **Organization** issues
What are the possible transactions?
-  □ **Implementation** issues
What are the rules of the game?

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Implementation

List of topics:

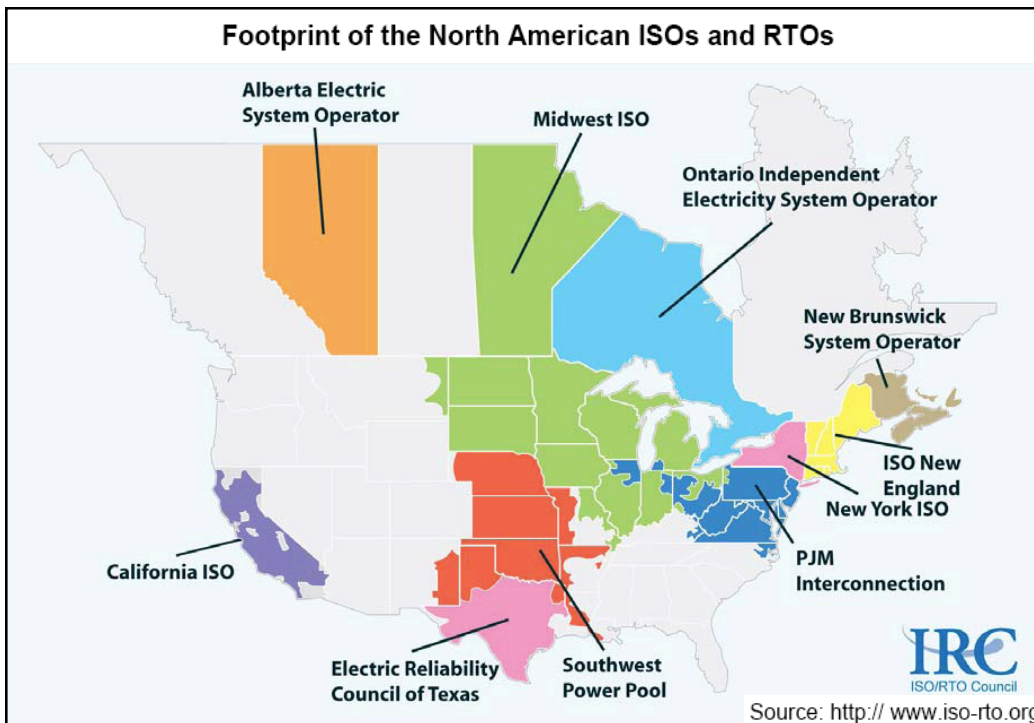
- ❑ Short-term trading: Power exchanges & auction design
- ❑ Longer-term trading: Contract design
- ❑ Ancillary services
- ❑ Management of losses and congestions
- ❑ Integration of wholesale markets

→ *The rules*

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Power exchanges & auction design

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Typical functions of a Power Exchange

- ❑ Reception of bids
- ❑ Elaboration of the merit order
- ❑ Computation of the market price
- ❑ Centralization and processing of measurement data
- ❑ Economic settlement
- ❑ Market supervision (*support to regulator*)
- ❑ Proposal of modification of market rules

Characterization of Power Exchanges

- ❑ Market participation
- ❑ Trading timing
- ❑ Traded products / trading periods
- ❑ Bid and offer format
- ❑ Trading methods / pricing criteria

Market participation

- ❑ Participation can be:
 - Compulsory - in a gross market ("Pool")
 - Voluntary - in a net market for surpluses & deficits
- ❑ All PXs in the EU are voluntary
 - Participation may be compulsory for some types of trading (*e.g. inter-zonal trading in Nordic countries should be effected through Nord Pool*)
 - Some entities may be required to use PXs for part of the energy they trade (*e.g. the Single Buyer in Italy or a prescribed % in OMEL for long-term contracts*)
 - Participation is mandatory in ISOs & RTOs in the US
- ❑ Diversity of roles for demand (load/LSE)

Timing of trading

- ❑ PXs are generally centered around a Day-Ahead Market (DAM), where electricity is traded the day before the day of delivery
- ❑ Longer-Term Markets are generally based on financial products
- ❑ Some PXs also provide Adjustment Markets for modifying commitments deriving from the outcome of the DAM:
 - improving on suboptimal results of the DAM
 - reflecting new information (unplanned outages, ...)
- ❑ Examples of Adjustment Markets:
 - NordPool: Elbas Market
 - Spain: six Intra-day Market sessions, each covering the remaining delivery periods of the day of delivery
 - Italy: Adjustment Market immediately after the DAM (participation limited to generators)
 - Germany: continuous trading

Bid and offer format (1 of 4)

- ❑ **Simple** bids/offers:
 - Bids and offers consist of price-quantity pairs and are submitted independently for each delivery period
 - The market equilibrium for a delivery period is determined independently from the market equilibrium for other delivery periods
- ❑ **Complex** bids and offers:
 - Bids and offers specify constraints covering more than one delivery period
 - The market equilibria for different delivery periods are interrelated

Bid and offer format (2 of 4)

Simple bids/offers

□ Bid:

- one or more quantity-price pairs, each specifying the maximum price at which the participant is willing to buy the corresponding quantity of electricity

□ Offer:

- one or more quantity-price pairs, each specifying the minimum price at which the participant is willing to sell the corresponding quantity of electricity

Bid and offer format (3 of 4)

□ **Complex bids/offers**

- Generators could bid:
 - Technical minima (*minimum output*)
 - Non-divisible blocks
 - Start-up costs
 - Ramp constraint
 - Minimum revenue requirement
- Generators and load/LSE could bid:
 - Block bids/offers: bids/offers for a number of consecutive delivery periods in a standard format

Bid and offer format (4 of 4)

PROS and CONS of Simple and Complex Bids/Offers

□ **Simple** Bids/Offers:

- Simpler and more transparent determination of the market outcome
- Offers only imperfectly reflect generators' costs → generators bear some risk and → market outcome may be suboptimal/technical unfeasible
- Subsequent (adjustment) markets may provide opportunities to modify commitments arising from the outcome of simple-bids/offers DAMs

□ **Complex** bids:

- Offers may reflect actual costs more accurately → reduced risk for generators and → optimal/feasible market outcome easier to achieve
- Computationally more complex and less transparent determination of market outcome
- Computation of the system marginal cost requires some adjustment to reflect the impact of the start-up and no-load prices

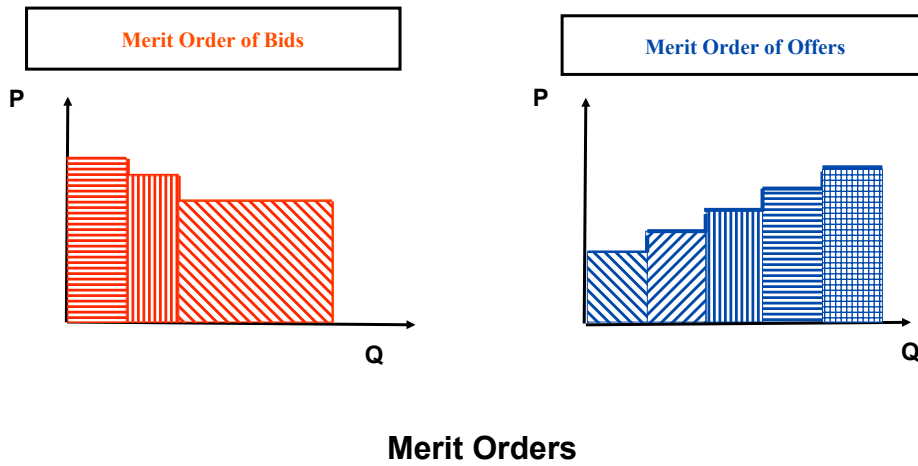
Details

Auction-based trading with simple bids

- Bids and offers for each delivery period are submitted by a specified deadline
- Merit orders are compiled:
 - ◆ Bids are ranked in descending price order
 - ◆ Offers are ranked in ascending price order
- The (equilibrium) market outcome is defined by the equilibrium market price (EP)
- The EP is the price at which the cumulative quantity specified in the merit order of bids is equal to the cumulative quantity specified in the merit order of offers
- Bids specifying a price not lower than the EP are accepted
- Offers specifying a price not higher than the EP are accepted
- Accepted bids and offers are valued at:
 - ◆ the EP (single-price auctions, this is the common procedure)
 - ◆ the price specified in each bid/offer (discriminatory or "pay-as-bid" auctions, rarely used)

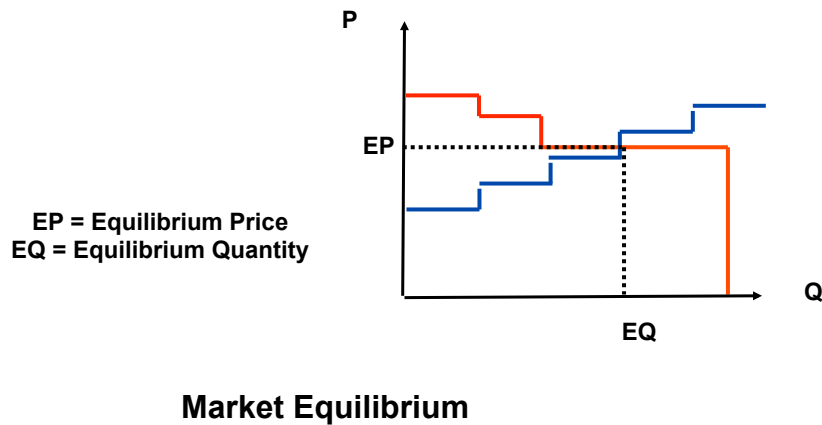
Details

Auction-based trading with simple bids



Details

Auction-based trading with simple bids



Continuous bilateral trading

- ❑ Bids and offers for a specified delivery period are submitted at any time during the trading session
- As soon as it is submitted, each bid/offer is matched, if possible, with offers/bids already submitted for the same delivery period and specifying compatible quantities and prices
- The execution price of a transaction is generally the price specified in the bid/offer submitted earlier
- If no match can be found, bids/offers are held and shown in the “trading book” to be matched with offers/bids submitted later in the same trading session

Comparison

- ❑ **PROs of trading methods/pricing criteria**
- ❑ Auction-based trading
 - Maximises value of transactions → facilitates efficient dispatching
 - Single equilibrium price reference
 - Allows integrated congestion management
- ❑ Continuous bilateral trading
 - Analogous to financial markets trading
 - Participants can “see” the market before trading

US competitive wholesale markets

- Most US wholesale markets have a similar structure
 - ◆ Locational marginal pricing (LMP): Prices vary by location when transmission constraints bind & also because of losses
 - ◆ Multi-settlement system: A day-ahead financial market & a real-time physical system
 - Day-ahead (24 h) is based on complex bids & unit commitment
 - Real time (5 min) is based on an optimal load flow
 - ◆ New England, New York, PJM, MISO, California
 - Texas is planning an LMP market
 - SPP has a locational imbalance market

US wholesale markets Longer-term views

- Transmission networks are planned at ISO level & recently there are coordination efforts at interconnection level
- Some ISOs have set long-term resource adequacy requirements for generation
 - ◆ New England & PJM have an auction-based forward capacity market (4 years in advance)
 - ◆ New York has a demand-curve based monthly capacity market

Contracts

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Formats of contracts

Properties	Trading Method	
	Over-the-Counter	Power Exchange
Anonymity of Trading	No	Yes
Counterparty	Bilateral	Central counterparty
Counterparty Risk	Yes, unless cleared	No
Trading Method	Continuous Trading	Either Continuous or Central Auction

Formats of contracts

- Contracts may be:
 - Customised (bilateral)
 - Respond to the requirements of counterparties
 - Standardised (anonymous)
 - Standard features and clauses
 - Easier to negotiate
 - Easier to trade in a secondary market
- Brokers may facilitate the conclusion of bilateral contracts by matching counterparties with compatible requirements

Delivery can be physical or financial

Physical

Entail physical and cash delivery on expiry

The “hub” (delivery point) is the High Voltage Grid or some node in it

Participants need a right to transport the scheduled volume of power

TSOs must approve the schedules of all participants, to prevent constraints

A mechanism is put in place by the TSOs for settlement and management of the real time imbalances

Financial

Entail only cash delivery on expiry

Differences between an specified index and the contractual price are settled

The buyer pays the contractual price and the seller pays the index

Physical purchased/sold through Spot or physical contract

Exchange (or Pool) prices are normally selected as index

Market liquidity is important to provide a reliable index

Contracts for differences (CfD's)

- The best known example of a risk hedging instrument are the CfD's
- Two way contract:
 - q amount of contracted energy
 - P_m spot price (pool price)
 - P_c contract price (strike price): the expected pool price
 - Option fee OF (risk premium), not needed in a CfD

	consumer	generator
spot market (pool)	$-q.P_m$	$q.P_m$
CfD for q at price P_c	$q.(P_m - P_c)$	$q.(P_c - P_m)$
total	$-q.P_c$	$q.P_c$

<the table shows directly the amount received by each agent.>

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Contracts for differences (CfD's) Deviations & incentives

- Viewpoint #1: Price P_c for contracted amount q_c is guaranteed, but deviations are priced at market price P_m
 - ➔ *Effect of deviations (a generator):*
 - ◆ contracted amount q_c
 - ◆ produced amount q_p
 - ◆ Revenue: $q_c \times P_c + P_m \times (q_p - q_c)$
 - ◆ $q_p - q_c$ subject to pool price risk
- If the CfD is signed by a physical generator who makes its production q_p equal to the contracted amount q_c , then it is totally hedged (*but a pure speculator with no production is fully exposed to the CfD contract risk*)

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Contracts for differences (CfD's) Deviations & incentives

- Viewpoint #2: The implications of the CfD contract $q_c \times (P_c - P_m)$ and the participation in the market (*if this is the case*) with production q_p at a price P_m are examined separately
 - ➔ *Final economic settlement (a generator):*
 - ◆ contracted amount q_c
 - ◆ produced amount q_p
 - ◆ Revenue: $q_c \times (P_c - P_m) + q_p \times P_m$
 - ◆ q_p is totally exposed to pool price risk
- The existence of the CfD contract should not modify the behaviour of the generator in the spot market

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Vesting contracts

- ◆ Established at privatisation or restructuring
 - Usually an obligation imposed by the regulator
- ◆ Make transition easier and less risky
 - Regulated price, which may be different from market conditions
 - Example: Transitory protection of high cost domestic fuel
- ◆ Reduce incentives for pool price manipulation
 - Since price manipulations can only affect the revenues for the non-contracted output
- ◆ Reduced over time to increase room for the market
 - For the market of contracts, since the spot market is not affected

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Bilateral Contracts: the EFET* Example

- ❑ General Agreement (GA) governing Individual Contracts (ICs)
- ❑ GA customisation through the Election Sheet (ES)
- ❑ IC could be:
 - Fixed price
 - Floating price
 - Call Option
 - Put Option
- ❑ ICs confirmed through a Confirmation of Individual Contract (CIC)
- ❑ Cross Border Annex (jurisdiction and taxation issues)

This is the model contract proposed by the European Federation of Energy Traders (EFET), widely used in the EU

Content of EFET General Agreement (1)

- ❑ § 1 Subject of Agreement
 - ◆ GA governs all transactions between the parties
 - ◆ Pre-existing contracts are considered as IC under the GA (*)
- ❑ § 2 Definitions and Construction
 - ◆ ES prevails over GA
 - ◆ CIC prevails over GA and ES
- ❑ § 3 Concluding and Confirming Individual Contracts
 - ◆ ICs can be concluded in any form of communication (incl. orally)
 - ◆ ICs which are not concluded in writing can be confirmed in writing
- ❑ § 4 Primary Obligations for Delivery and Acceptance of Electricity
- ❑ § 5 Primary Obligations for Options

Content of EFET General Agreement (2)

- § 6 Delivery, Measurement, Transmission and Risk
 - ◆ Delivery according to the Schedule specified in the ICs
 - ◆ Seller bears the risk to the Delivery Point; buyer bears the risk from the Delivery Point
- § 7 Non-Performance Due to Force Majeure
- § 8 Remedies for Failure to Deliver and Accept
- § 10 Term and Termination Rights
 - ◆ GA terminates at Expiration Date (if specified) or with 30-day notice
 - ◆ Early termination for Material reasons (non performance, cross-default) and Automatic Termination in case of insolvency of one of the parties
- § 11 Calculation of the Termination Amount
- § 12 Limitation of Liability

Content of EFET General Agreement (3)

- § 13 Invoicing and Payment
- § 14 VAT and Taxes
- § 15 Floating Prices and Fallback Procedure for Market Disruption
- § 16 Guarantees and Credit Support
- § 18 Provision of Financial Statements and Tangible Net Worth
- § 19 Assignment
 - ◆ Assignment of rights and obligations to a third party subject to written agreement of the counterparty
 - ◆ Consent not required in the case of affiliates (*)
- § 20 Confidentiality
- § 21 Representations and Warranties
- § 22 Governing Law and Arbitration
- § 23 Miscellaneous

Organized forward & futures markets Financial (derivatives) trading (1)

- ❑ Prices in wholesale electricity markets vary from trading period to trading period, as a result of demand – supply interaction and transmission capacity
- ❑ Participants are exposed to the risk resulting from the variability of revenues/costs from selling/buying electricity
- ❑ As in financial markets, electricity derivative instruments provide risk hedging

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Organized forward & futures markets Financial (derivatives) trading (2)

- ◆ Non tradable contracts
 - CfDs are difficult to trade
 - Adapted to parties' requirements, non standard
 - Non centrally settled, each party bears default risks
- ◆ Tradable contracts
 - Standard terms, non adapted to parties' requirements
 - Centrally settled, when traded through organized market
 - Favour trading liquidity

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Organized forward & futures markets Financial (derivatives) trading (3)

- Purely financial transactions
 - ◆ do not need to close in a physical shorter-term market
 - ◆ allow the participation of agents without physical assets that are backing the transaction → improve liquidity
- Organized long or medium-term markets will only develop if the underlying market price is reliable
- Types of instruments:
 - ◆ Forwards
 - ◆ Futures
 - ◆ Options

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Organized forward & futures markets Financial (derivatives) trading (4)

- **Forward contracts** commit the buyer to purchase and the seller to deliver a specified quantity of electricity at a specified time in the future, at a pre-determined price (delivery price)
- **Future contracts** are standardised forwards contracts traded in organised and regulated exchanges
- **Option contracts** give the buyer the right, but not the obligation, to purchase ("call options") or to deliver ("put options") a specified quantity of electricity at a specified time in the future, at a pre-determined price (strike price)

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Detail: Call & put options

- Call option
 - ◆ A right to buy at a given price
 - ◆ The option seller compensates the option buyer if pool price is higher than strike
- Put option
 - ◆ A right to sell at a given price
 - ◆ The option seller compensates the option buyer if pool price is lower than strike price
- Similar to one-side contracts for differences
(CfD = buy a call and sell a put)

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Bilateral contracts without a daily spot market

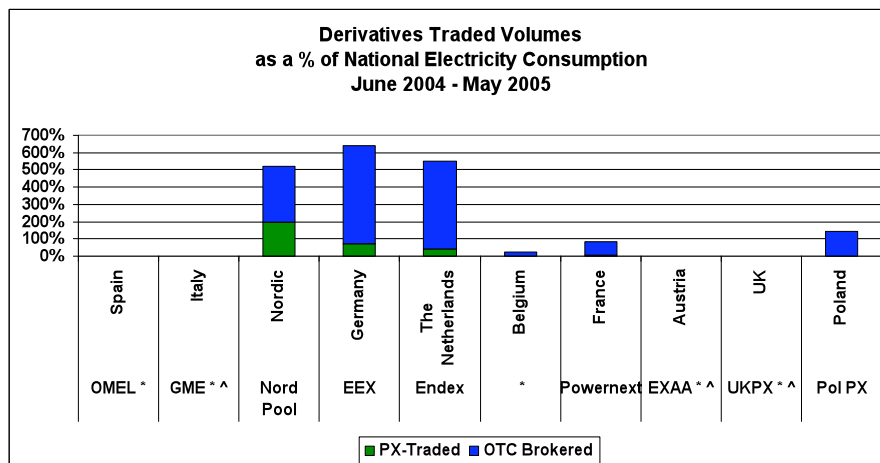
- The NETA (New Electricity Trading Agreement) in England & Wales started in March 2001
 - ◆ bilateral transactions are matched at a mutually agreeable price, both using over-the-counter & organized future markets
 - ◆ any mismatches between the contracted amounts and the actual ones must be solved in a balancing market that opens only 1 hour before real time

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Trading and delivery

- Trading results in long/short positions
 - Long (physical) positions assign the right/ obligation to withdraw power from the grid
 - Short (physical) positions assign the right/ obligation to inject power into the grid
 - Long and short (physical) positions resulting from trading should be balanced (injections = withdrawals) in each delivery period

Traded volumes of electricity derivatives may well exceed physical consumption



* - No PX-trading of derivatives. ^ - Data on OTC Brokered volumes not available

Ancillary services

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Ancillary Services

- ❑ **Primary** (Frequency) Control – maintenance of the balance between generation and demand using turbine speed generators
- ❑ **Secondary** (Load-Frequency) Control – centralised automatic function to regulate the generation in a control area in order to:
 - maintain exchanges with other control areas at the programmed levels
 - return the frequency to its set value in case of a (major) frequency deviation, thus restoring primary control reserve
- ❑ **Tertiary** Control – automatic or manual change of working point of generators (*mainly by re-scheduling*) to restore an adequate secondary control reserve
- ❑ **Black-start** Capability – the ability of a generating unit to start operating and delivering power without assistance from the electric system
- ❑ **Reactive Power** – inject or withdraw reactive power to keep system voltage within prescribed levels at specific nodes

Trading Mechanisms

- ❑ Provision of ancillary services is managed by the System Operator (SO)
- ❑ Ancillary services can be:
 - Provided directly by the SO (e.g. Voltage control through capacitors)
 - Supplied by grid users according to licence conditions (e.g. Primary reserve)
 - Procured by the SO through long-term contracts (e.g. Black start capability)
 - Procured by the SO through dedicated markets (e.g. Secondary reserve)
- ❑ Ancillary services are public goods (they cannot be provided selectively to grid users)

Example

Operating reserves in Spain

- ❑ Mandatory services
 - ◆ Primary reserves
 - ◆ Minimum reactive power support (*no explicit remuneration to transmission facilities*)
- ❑ Market mechanisms for voluntary services
 - ◆ Secondary and tertiary reserves
 - ◆ Contracts for system restoration
 - ◆ Contracts for extra reactive power support

Example

Operating reserves in Spain

Secondary reserves

- ❑ Required bands (MW up & down) are specified for each hour by the System Operator after the daily market closes
- ❑ Generators may bid prices (\$/kW) & bands (kW) to go up & down
- ❑ Selected **bands** are paid the resulting marginal price (\$/kW) & the cost is charged to consumers as an uplift
- ❑ All **energy** used in secondary regulation is paid the price (\$/kWh) of energy of tertiary reserves & the cost is charged to the agents (generators or consumers) who use secondary reserves (deviations between scheduled and real energy, both generators and consumers)

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Example

Operating reserves in Spain

Tertiary reserves

- ❑ After the daily market closes, any capable agent may bid blocks of energy & prices (\$/kWh) to go up & down
- ❑ The System Operator establishes an economic priority list and uses the bids if needed
- ❑ All used bids (& only them) in a given hour are paid the price of the last used bid in that hour (\$/kWh)
- ❑ The cost is charged to the agents (generators or consumers) who use tertiary reserves (deviations between scheduled and real energy, both generators and consumers)

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Network effects

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Typical functions of a system operator

- ❑ Assessment of ancillary services requirements
- ❑ Procurement of ancillary services.
- ❑ Elaboration of the final dispatch
 - ◆ network constraint management
 - ◆ account for physical contracts
- ❑ Operation of the transmission network
- ❑ Transmission expansion planning from the entire system's viewpoint

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Typical transmission functions

- ❑ Network expansion planning (*from the transmission company's viewpoint*)
- ❑ Network construction
- ❑ Maintenance planning (*in coordination with the SO*)
- ❑ Maintenance of transmission facilities
- ❑ Direct operation of transmission facilities

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A very specific case Locally constrained-on generators

- ❑ When generation must be constrained-on because of a network constraint, there is typically very little room for competition (*typically just one company can solve the problem*)
 - ◆ *Preferred:* Regulated remuneration or contracts (*difficult to cover all possibilities*)
 - ◆ *Also:* Pay-as-bid, under regulator's surveillance & subject to competition law

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The general situation Management of losses & congestions

- ❑ Option A: nodal (or zonal) prices
 - automatic solution to losses & constrained-off generators
 - more complex auction algorithm
- ❑ Option B: single node
 - loss & congestion signals are sent separately
 - loss factors modify payments in settlement
 - auction is followed by congestion management
 - ➔ no economic rights for constrained-off generators

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Congestion

- ❑ Congestion occurs when the available transmission capacity is not sufficient to satisfy the demand for transmission services (e.g., from commercial transactions)
- ❑ Therefore, congestion depends:
 - on the demand for transmission services
 - on the available transmission capacity
- ❑ Liberalisation has increased and made more explicit the demand for transmission services
- ❑ Congestion may occur:
 - within a control area
 - between control areas (cross-border)

Approaches to congestion management

Basic approaches:

- ❑ **Ex-post adjustment of market outcome**
 - Redispatching
 - Counter-trading
- ❑ **Ex-ante congestion management**
 - Explicit allocation of (physical) transmission capacity rights (PTRs)
 - Implicit allocation of transmission rights (and energy positions):
 - Implicit Auction
 - Market Splitting
 - Market Coupling (market splitting between different PXs)

Congestion management (1)

- ❑ Ex-post adjustment of market outcome
 - ◆ Redispatching
 - ◆ Counter-trading
- ❑ Ex-ante congestion management
 - ◆ Explicit allocation of (physical) transmission rights (FTR)
 - ◆ Implicit allocation of transmission rights
 - Implicit Auction
 - Market Splitting
 - Market Coupling (market splitting between different PXs)

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Congestion management (2)

Explicit allocation of (physical) transmission rights (PTR)

□ Market-based allocation:

◆ Auctions

- PTR are allocated to the highest bidders in the auction, up to the available transmission capacity
- the price each assignee pays for the allocated PTR depends on the auction design (single price, discriminatory auction, ...)

□ Non market-based allocation:

◆ First-come-first-served

- PTR are assigned according to the chronological order of requests

◆ Pro rata allocation

- PTR are assigned proportionally to the amount requested, up to the available transmission capacity

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Congestion management (3)

Implicit allocation of transmission capacity

□ This happens when available transmission capacity is used to allow:

- ◆ Access to an organised WEM by participants located on the other side of a congested interconnector (implicit auction)
- ◆ Trading between two areas of an organised WEM separated by a congested interconnector (market splitting)

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From National to Regional or EU-wide markets in the EU

- ❑ Historically, the European grid has been developed mainly to serve national markets
- ❑ ... at a time when national markets were typically served by vertically-integrated monopolists
- ❑ ... which had little incentive to integrate markets, except for security and stability purposes
- ❑ Therefore, regional market integration requires:
 - Harmonisation of rules
 - Expansion of cross-border capacity
 - Efficient management of existing capacity

Congestion management in Europe

- ❑ Most cross-border congestion in the EU is managed through explicit auctions (EU Regulation n. 1228/2003 requires market-based solutions), except:
 - NordPool: market Splitting between Norway, Sweden, Finland, Denmark East and Denmark West
 - Trilateral Market Coupling between France, Belgium and the Netherlands
 - Mibel: market splitting between Portugal and Spain
 - Market Splitting in the Irish Single Electricity Market
 - Market Coupling (EMCC) between Germany and Denmark West (AC link) and between Germany and Denmark East (Kontek DC link)

From RIs to a true EU IEM

- ❑ The magnitude of the challenge is worth noticing: coordinated congestion management at EU-wide level
- ❑ 7 Regional Initiatives (RIs) were created to remove barriers to trade & achieve a high level of harmonization just among neighboring countries
 - ◆ with the expectation of integrating the RIs into a single EU IEM later
- ❑ The success has been limited so far & the progress very slow
- ❑ However, major advances have been recently made under the initiative of the Power Exchanges themselves see xxx
- ❑ Progress towards a “seamless” operation among ISOs in the US has been very slow. Recent coordination efforts in transmission planning are encouraging

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Tasks being addressed by the RIs

- ❑ Coordinated transmission capacity calculation & utilization of a common network model
- ❑ Towards a regional single auction platform, with harmonized rules, IT interface & products for medium & long-term allocation
- ❑ Towards a market coupling model for the day-ahead timeframe
- ❑ Towards an intra-day mechanism, possible based on continuous trading
- ❑ Integration of balancing markets
- ❑ Integration of transparency requirements

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