Electricity Markets and Principle
Market Design Models

(prepared for the European Copper Institute)

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1 Single Buyer

In the restructured electricity markets networks remain regulated while generation is exposed to competition. In the first case the incentives for capital investments are function of the regulation imposed by the regulatory authorities. Differently in the case of generation no explicit price control applies, however the regulators may monitor generation adequacy and establish additional market and tariff based incentives to encourage new investments in the sector.

Under a single buyer model only new capacity development is exposed to competition, while the continued operation of plants with respect to output would be exempt from competition and would rather run under (usually long-term) power purchase agreements. The single buyer is responsible to determine capacity requirements and could also steer the technology decision through appropriate conditions included in the call for tender for new capacity.

In the single buyer model the revenue that a generator is allowed to receive under its contract with the single buyer is normally broken down into two main components, availability payments and energy payments. The energy payments are intended, among other things, to reimburse the generator for the costs associated with running the plant, that is fuel and variable operating and maintenance costs. The availability payments are intended, among other things, to provide the generator with revenue to cover the cost of capital, including a normal rate of return, and the non-variable operating and maintenance costs.
2 Electricity Markets with Wholesale Competition

2.1 Pool versus Bilateral Trading

Over time, different countries have developed a variety of market models with different features. Despite these differences in detail, all markets can be basically grouped into main market models, namely:

- Centralized pools; and
- (Decentralized) Bilateral contracts markets.

As illustrated in the figure below, pool markets represent a centralized concept where all energy is sold and purchased through the pool. This is achieved by the centralized scheduling of all generation units through the pool, whereas all suppliers must purchase their entire demand from the pool. A pool is thus characterized by the uni-directional exchange of energy from producers to the pool, and from the pool to suppliers.

In contrast, in a bilateral contracts market all market participants are basically free to engage into any type of contractual obligations for the delivery of energy, which then provide the basis for the self-scheduling of producers. As a consequence, the bilateral contracts market allows for bi-directional exchanges between any two market participants and principally allows all market participants to act as traders. Hence, whilst a producer can only sell to the pool in the first model, it may both buy and sell energy from/to any other party in the bilateral contracts market.

![Diagram of Centralized Pool and Bilateral Contracts Market](image)

**Figure 1: Basic concept of pool and bilateral contracts markets**

When differentiating between these two basic models as well as the multitude of detailed market designs found in practice, it helps to consider four main design choices:

- Centralized vs. decentralized scheduling;
• Gross vs. net pool;
• Unit- vs. portfolio-based markets;
• One-way vs. two-way bidding; and
• Centralized vs. decentralized dispatch.

As already mentioned, the key different between both models relates to the choice for either centralized or decentralized scheduling. In a pool, the final production schedule of all producers is centrally determined by the market operator, based on the compulsory participation in the pool. That is, the market operator decides both on the (hourly) schedule of each unit and the price to be paid for energy using a central algorithm. In contrast, the bilateral contracts market allows for self-scheduling where each producer may freely decide on the production schedule of each of its generating units.

Pool markets can be further differentiated into gross pools and net pools. In a gross pool, the entire output of each power plant or generating unit is determined by the market operator, i.e. the producer has no direct influence on the production schedule. Conversely, a net pool allows the producer to determine at least an initial production schedule, which then provides the basis for offering any modifications to this base schedule into the centralized market. Therefore a net pool represents a hybrid between a pool and a bilateral contracts market. In practice the concept of gross pools is typically applied to wholesale markets, whereas net pools are more typical for the design of balancing mechanisms.

In practice, most pools are based on unit-based offers, i.e. producers have to submit separate offers for each individual power plant or even individual generating units. The market clearance under pool arrangements typically takes account of several detailed technical characteristics of each unit to ensure the technical feasibility of the resulting schedule. This results in a considerable increase of the mathematical complexity. Bilateral trading, on the other hand, by definition does only consider energy as a commodity, whilst all technical constraints have to be managed by the producer itself. By definition, bilateral contracts markets are therefore based on portfolios. Conversely, most gross pools require unit-based offers, whereas especially net pools may also be based on portfolio offers.
Most power pools rely on the principle of one-way bidding, i.e. where offers are only submitted by producers, whilst the market is subsequently cleared based on a centralized demand forecast. By definition, these markets therefore imply inelastic demand. Two-way bidding, on the other hand, also allows for bids from buyers (suppliers), i.e. the market is cleared on the combined supply and demand curves from generation and demand, respectively sellers and buyers. Due to the necessity to serve all load, two-way bidding is usually implemented in voluntary organized markets, or power exchanges, in bilateral contracts markets.

Irrespective of the basic choice of a pool or bilateral contracts market, a market may be based on either centralized or decentralized dispatch. In the first case, the system operator has direct control about the dispatch of each individual generating unit. In the second case, dispatch may be performed by each producer individually, based on the agreed production schedule, subject to any modifications that the system operator may request in real time (e.g. through the balancing mechanism). The centralized dispatch is more common in pool-type markets (such as PJM in the USA or AEMO in Australia). Self-dispatch is used more in market with bilateral arrangements and balancing mechanism (e.g. Germany, the Netherlands or Great Britain).

### 2.2 Intra-day Trading and Balancing Mechanisms

Most developed markets have a central mechanism (typically operating one day ahead) where the great majority of power has been traded by the time that this market closes. Actual demand in real time will however generally deviate from the day-ahead forecast. To cope with this issue, some pool-type markets (e.g. Australia) are therefore based on a real-time market where the day-ahead clearing is used to determine an indicative production schedule, whilst the final schedule is only decided close to real time.

Other markets have developed arrangements based either on a series of intra-day auctions or continuous trading, which are designed to allow participants to adjust their contractual
positions derived in earlier markets, and hence to ensure each generating unit’s contractual commitments are compatible with the latest forecast of demand and individual generating unit technical characteristics.

For instance in the Spanish market, producers may adjust their scheduled quantities through several 'adjustment markets' between the initial day-ahead market and real-time operations. Conversely, one can observe an increasing trend towards introduction of so-called intra-day trading in European bilateral contracts market, i.e. where market participants are allowed to adjust their (initial) production and exchange schedules until relatively close to real-time.

Except for the case of a true real-time market, it will nevertheless still be necessary for the system operator to have sufficient means for adjusting the final production schedule in real time, i.e. some sort of balancing mechanism. In principle, corresponding mechanisms can basically be found in both pools and bilateral markets, although they are more prominent in the second case. In the first case, balancing is simply performed through a real-time adjustment of production schedules, which is based on the same offers as originally submitted for the day-ahead marker or by using a separate balancing mechanism. Here, primarily producers submit separate bids and offers to increase or decrease the amount of generation (or load), e.g. relative to the agreed schedule of their generating units.

Separate balancing mechanisms have been introduced in virtually all bilateral contracts markets. In practice, such balancing mechanisms often take the form of net pools, such as in Belgium, France, Great Britain or the Netherlands. In these cases, producers must offer their entire available generation capacities for balancing purposes, i.e. either upward or downward, at the latest at the time of final gate closure.

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1 In some cases, balancing has initially been performed based on separate ancillary services contracts.
3 Supplementary Capacity Schemes

In competitive energy markets prices are free to rise and fall in order to clear the market and where customers and generators both see and respond to prices. A pure competitive pricing model does not, however, rule out the need of some kind of a capacity mechanism, brought forth by the risk aversion among market participants. Indeed it is the awareness of such risks that has led to a number of policy makers implementing or considering the implementation of explicit capacity mechanisms to their market arrangements.

A number of alternative solutions are available for addressing the problem of simultaneously trying to ensure security of supply and preserve competitive market dynamics. We group the mechanisms in the following categories: regulated IPP auctions, quantity-based capacity systems and price-based capacity systems.

Under regulated IPP auctions the regulator may be allowed to organise a tender and select the winner who will sign a long-term Power Purchase Agreement (PPA). Traditionally the PPAs are a typical element of the single buyer model. However, the PPAs’ provisions may constitute an obstacle in more competitive models, independent power producers should assume more risks than they have done under the traditional take or pay contracts with a national vertically integrated utility, so as to provide for a level playing field for all investors and market actors.

In a quantity-based system, the system operator estimates the need for capacity in the system and then procures that level of capacity via a market mechanism. The value of capacity in this option thus results from the interaction of buyers and sellers. There are several forms of quantity-based systems including: procurement of strategic reserves, operating reserves system or requirements for installed capacity (ICAP).

In a price-based system generators receive directly payments for capacity which increase the profitability of existing as well as new investments. The payment is either based on a on an assumed value of un-served energy or calculated cost of peak generation capacity. The principal objective of capacity payments is to provide additional assurance that security of supply will be maintained. Rather than setting a target capacity target, this model takes an indirect approach whereby certain payments (capacity payments) are made to generators per MW based on their availability (whether they get dispatched or not), or based on generated energy as an adder to the energy market clearing price. Capacity payments can be roughly divided into two main approaches: under a fixed-fee approach, capacity payments are first determined on a global level and then distributed to individual generators broadly based on their contribution to system reliability. Conversely, capacity payments may also be derived as a function of the actual reserve margin on each day.