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ISSUE PAPER

MARKET OPERATOR
(REGULATORY OVERSIGHT)

Prepared by
KEMA International B.V.

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Market Operator (Regulatory Oversight)

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Preface

Dear Colleagues:

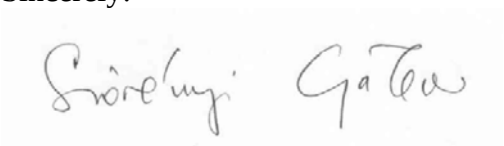
I am honoured to present to you one of the results of our joint work and efforts during 2006 and 2007: an issue paper prepared by KEMA based on a request by the ERRA Licensing/Competition Committee. This paper is submitted to the 8th Annual Conference of ERRA.

The issue paper of *Market Operator (regulatory oversight)* examines and discusses the different segments, different time-horizons of the wholesale market with different terminologies, such as bilateral market-, OTC-, day-ahead-, power exchange, balancing-, ancillary service-, intra-day markets. Additionally, there is an introduction on the role of the different markets and how to support the efficient competition on these markets. The regional aspect of the markets and the role of market operator(s), as well as the method of the regulators regarding oversight of these market operators is introduced. The paper also introduces the different international practice and tendencies.

The ERRA Licensing/Competition Committee suggests to publish this document by the help of the ERRA Online Library by May, 2008.

I would like to thank the continuous technical support received from the National Association of Regulatory Utility Commissioners (NARUC), the U.S. Agency for International Development (USAID) and the Council of European Energy Regulators (CEER). I look forward to our successful work in the next years.

Sincerely:



Dr. Gábor Szorenyi
Chairman, ERRA Licensing/Competition Committee
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Acronyms and Abbreviations

AGC	Automatic Generation Control
APX	Amsterdam Power Exchange (The Netherlands)
BETTA	British Electricity Trading and Transmission Arrangements (UK)
BRP	Balancing Responsible Party
CfD	Contract for Differences
ECSEE	Energy Community for South-Eastern Europe
EEX	European Energy Exchange (Germany)
Elspot	Nord Pool spot market
EXAA	Energy Exchange Austria
FERC	Federal Energy Regulatory Commission (U.S.)
FTR	Financial Transmission Rights
HHI	Hirschman-Herfindahl Index
ISO	Independent System Operator
MMU	Market Monitoring Unit
MO	Market Operator
NETA	New Electricity Trading Arrangements (UK)
NYISO	New York Independent System Operator
OECD	Organizoation for Economic Co-operation and Development
OMEL	Spanish market operator (Compania Operadora del Mercado Espanol de Electricidad)
OTC	Over-the-Counter (bilateral trading)
PJM	ISO of the Pennsylvania-New-Jersey-Maryland market
SO	System Operator
TPA	Third party access
TSO	Transmission System Operator

1. INTRODUCTION

This issue paper has been prepared by KEMA on behalf of ERRA, the Energy Regulatory Regional Association. ERRA is a voluntary, non-profit, international organization, representing 22 energy regulators from Central and Eastern Europe and Central Asia who have primary responsibility for energy regulation in their countries.[1] More specifically, this report has been ordered by the Licensing/Competition Committee, which currently examines the issue of Market Operators (regulatory oversight) under its 2007 work plan.

The overall objective of this paper is to provide the Licensing/Competition Committee with recommendations on the role of the regulator with respect to market operators. To provide the necessary background, the report includes an analysis of the different market models and segments, introduces the different terminologies and explains the role and time horizon of different parts of the wholesale market. Furthermore, we also comment on the issue of regional integration, which plays an increasingly important role in Europe and elsewhere. After introducing the specific role and functions of a market operator, we discuss the role and methods of regulators regarding supervision and development of the energy market. Throughout these discussions, we provide examples from different countries, in order to provide an overview of the different international practices and tendencies. Finally, our report concludes with a summary and a number of recommendations regarding the role of regulators with respect to market operators.

We emphasize that this issue paper concentrates on wholesale electricity markets. In contrast, we do not generally comment on retail supply, although some of the issues are relevant for the retail business as well. Similarly, whilst we do not specifically address other aspects that are relevant e.g. for natural gas we point out that many of the issues discussed in this report apply to gas and electricity markets alike.

The organization of the paper is as follows: Chapter 2 introduces the main actors and products in electricity markets, whilst chapter 3 contains a structured introduction to different market models and segments. In chapter 1, we explain the role of the market operators, before focusing on the role of regulators in chapter 5. Chapter 6 concludes the paper by providing a summary of the main issues and a number of specific recommendations regarding regulatory oversight of market operators. To facilitate understanding of the different concepts and models, the appendices in chapter 7 finally include a glossary with a summary of important terms related to the structure and functioning of electricity markets.

[1] Plus a further 5 associate and partly extra-regional members

2. GENERAL ROLES AND PRODUCTS IN THE ELECTRICITY MARKET

2.1. Actors in the Electricity Market

The understanding and comparison of electricity wholesale markets is complicated by the fact that different countries and jurisdictions apply a number of different, sometimes confusing or even contradictory terms and definitions. For instance, the term 'supplier' is commonly understood in Europe as a party that is selling electricity to end-users of electricity, whilst the same term is often used to describe generators (also known as producers) in Northern America. Consequently, one has to take considerable care when interpreting information from different parts of the world.

To avoid confusion and facilitate understanding, we therefore believe that it is important to apply a clearly-defined and consistent terminology in a report aimed at presenting and analyzing the wide range of international practices. For this purpose, we subsequently introduce a range of definition, which we believe cover the main groups of actors - or functions - that can be commonly identified in wholesale electricity markets. Given that many of the countries represented by ERRA either are members of the European Union (EU) already, or are at least associated with the EU in one way or the other, our definitions are largely based on the applicable provisions of the EU Directives and/or the terminology commonly applied in (continental) Europe. Clearly, our definitions will therefore partially deviate from those applied in e.g. the U.S., Latin America, Australia, New Zealand or Asia. We therefore point out that the reader should carefully consider the definitions and explanations introduced in this chapter 2 throughout the remainder of this report.

As illustrated by Table 1, the range of actors in the wholesale electricity market can be split into two categories. As **market participants**, we understand entities that operate in a competitive environment and that are active in the electricity market to either buy or sell electricity for commercial purposes, i.e. to make profits. Besides **producers**, this group comprises **suppliers**, **traders** and, to some extent, also (large) **consumers**. In contrast, **market facilitators** are entities, which have a monopolistic position and shall provide their services to all market participants in an open and non-discriminatory manner, i.e. to provide the basis for the orderly functioning of the electricity market. Besides the **system operator** (SO), this group primarily includes the **market operator** (MO) and **distributors**.

Table 1: Actors in the Electricity Market

Market participants (competitive functions)	Market facilitators (monopolistic functions)
• Producer • Supplier • Trader • Consumer	• System Operator (SO) • Market Operator (MO) • Distributor

In the following, we briefly describe each of these generic functions in more detail. For the purposes of this paper, these terms shall mean the following:

- **Producers** are the owners/operators of power plants that sell their production in the electricity market. Producers are also known as *generators* or, e.g. in the U.S. as *suppliers*.
- **Suppliers** are market participants that sell or resale electricity to consumers. Suppliers are also often called *retailers*.
- **Traders** are market participants that are both buying and (re-) selling in the electricity market, without necessarily either having their own production facilities or supplying to consumers. Please note that, in many jurisdictions, both producers and suppliers may be active as traders for either physical or financial products.
- **Consumers** mean final customers of electricity that actually consume electricity for their own purposes, such as households (also called residential customers), commercial or industrial consumers. Consumers are also known as *end users* and cover both eligible and captive customers.
- The **system operator**, or **SO**, is a centralized institution, which is responsible for ensuring the safe and reliable operation of the overall power system. The main duties of the SO include operation, or at least coordinating the operation of the transmission system. The SO thus serves primarily technical purposes and may or may not be involved in any directly market-related functions.
- In contrast to the SO, the **market operator**, or **MO**, is a centralized institution, which operates an organized market for the (commercial) exchange of energy or other products on behalf of market participants. Please note that the MO may or not be combined with the SO and that there may exist several market operators (even for the same product!) in the same market.
- **Distributors** are entities whose function is to operate the distribution grid for the physical delivery of electricity to consumers. Distributors do not participate in the market except possibly for the purchase of network losses. Please note that a dis-

tributor may or may not own the distribution network and that most distributors simultaneously serve as supplier for non-eligible customers in their own network.

Please note that these definitions are based on the generic functions of different actors in the electricity market but do not consider the organizational or legal structure of a given entity. In particular, the roles described above are not mutually exclusive, which implies that a given company may simultaneously perform several functions, such as a producer that is also trading electricity (trader), a distribution network that is also operating a supply business, or the possible combination of a system and market operator. Furthermore, we emphasize that our definition of system operators is independent of transmission ownership, i.e. it covers both the model of *Independent System Operators* (ISO) prevailing in the U.S. where the SO does not own but only manages the transmission network as well as the combination of transmission ownership and system operation as commonly being the case in most European countries.[2]

Besides these generic functions, we believe that it is also useful to introduce two other functions that are related to third party access, i.e. the possibility of market participants to use the system or network for the commercial exchange of electricity, as an essential precondition for any energy market. More specifically, these functions include:

- **System user** means any entity that is using a transmission and/or distribution system for the physical exchange of electricity, i.e. by either injecting or taking electricity into or off the grid. In a strict sense, this term therefore covers both producers and consumers, although supplier and traders may be involved in the organization of the corresponding exchanges.
- **Balancing responsible parties (BRP)** are parties that are (1) responsible for planning the production and purchase of electric power such that they correspond to the anticipated consumption and sales of the same party (or other parties the BRP is responsible for), and (2) assume the financial responsible for any resulting imbalances during settlement. Although the concept of balance responsibility is universal to all electricity markets, there exist major differences in the detailed rights and obligations. Also, different countries have developed a wide range of different terms.[3]

Please note that there exist other functions besides those defined in this section.

[2] Whilst the latter is often referred to as TSO, i.e. Transmission and System Operator, in Northern America, we emphasise that the same term generally describes the operator of the transmission system in Europe, in contrast to the Distribution System Operator.

[3] For instance, BRPs are known as balancing unit in the UK, as balancing group in Germany, Austria or Switzerland, as access responsible party in Belgium, as balance administrators in Scandinavia, or as load serving entities (LSE) in the U.S.

2.2. Main Products in the Electricity Market

Electricity is a product with some particular features that must be taken into account when analyzing the functioning of an energy market.

The most important ones are the following:

- Electricity is generated and consumed in a continuous flow;
- Supply must equal demand in real time;
- Unlike other commodities electricity is non storable;
- Electricity consumption varies by time, including during the day; and
- It is not generally possible to identify a direct relation between the injection of electricity (production) at one point of the grid and the simultaneous extraction (consumption) at another point in the grid.

These properties imply that it is not possible to regard electricity as a simply commodity, i.e. energy. Instead, one may distinguish four additional products or services that are required for the orderly functioning of an electricity market:

- Generation capacities / Electric power (MW);
- Transport services;
- Transport capacities; and
- System and ancillary services (including balancing).

Due to the non-storable nature of electricity, it can only be delivered if there are sufficient generation capacities to match the highest possible demand at any time, subject to the need for operational reserves and the non-availability of certain plants. Besides energy (MWh), it is therefore necessary to also consider the need for **sufficient power** (MW) and hence **generation capacities**; this issue is further dealt with in chapter 3.6.

Secondly, we have also comment on the need to ensure non-discriminatory access to transmission and distribution networks, i.e. as a precondition for the physical transport of energy as agreed between different market participants. It is therefore essential that network operators provide **transport services**, which however are beyond the scope of this paper.

In this context, we furthermore note that many networks are characterized by scarce transmission capacities, which limit the transport of electricity from one part of the network to another area. Consequently, it is often necessary to also take account of limited **transport capacities**, which may or may not be considered as a separate product from energy; this issue is further discussed in chapters 3.5 and 3.7.

Finally, we note that the continuous balancing of generation and load in real-time, the management of voltage, the prevention of a system collapse in case of contingencies or the restoration of the system after a partial or total shut-down require a number of additional services, which are commonly referred to as **ancillary services**. The EU defines ancillary services as '*all services necessary for the operation of transmission and/or distribution networks*',[4] whereas FERC has defined ancillary services as '*those services that are necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the Transmission Service Provider's transmission system in accordance with good utility practice.*'[5] Unfortunately, neither of these definitions is sufficiently precise to be applied in practice. Furthermore, we note that there does not exist a single definition that is universally accepted throughout the world, i.e. even in Europe it is impossible to find a single definition that would fit in each country.

For the current report, we therefore apply a definition that was originally developed by CIGRE,[6] according to which:

- '**System Services'** are services supplied by the electricity system to users, in order to maintain system standards; whereas
- **'Ancillary Services'** are services supplied by users to the electricity system, excluding electrical utilization.

In this definition, the term '*system*' is used to refer to the naturally monopolistic parts of system operation, transmission and distribution functions. By referring to system standards, this definition clearly limits the role of ancillary services to those that are required maintain the integrity and stability of the transmission or distribution system as well as power quality. Furthermore, it also the introduces the concept of differentiating between system services, i.e. the services provided by the system, on the one hand, and ancillary services as the services provided by system users to the system, on the other hand.

This separation, as well as the close relation between these two groups of services, is illustrated by Figure 1. On the top, this picture shows four main groups of system services, which network and system operators have to ensure to maintain the system standards. But this depiction also illustrates that, with the exception of system control, each of these three groups of services is roughly 'mirrored' by a corresponding set of ancillary services. This observation highlights that, whilst the provision of system services is a core function of network and sys-

[4] Directive 2004/54/EC

[5] FERC (1996)

[6] CIGRE (1999)

tem operators,[7] most of these services are coordinated e.g. by the SO only but have to be supported by the provision of corresponding services by system users, i.e. mainly producers.

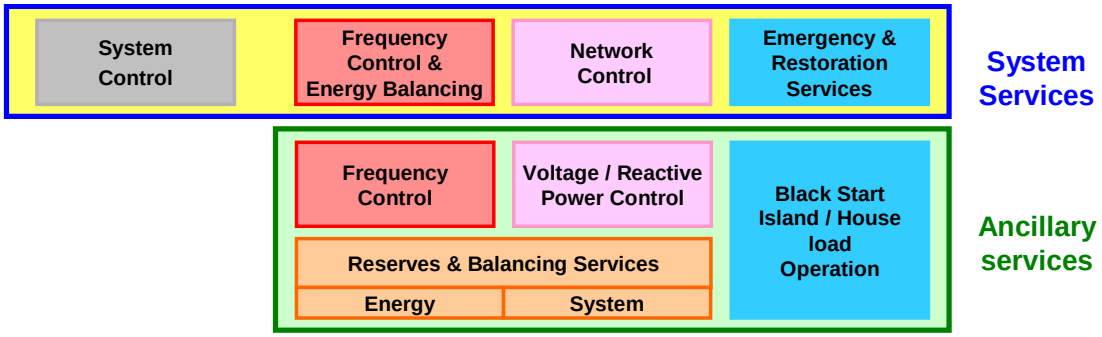


Figure 1: Overview of system, ancillary and balancing services

Besides the differentiation between system and ancillary services, Figure 1 also introduces the concept of **balancing services**, which can be described as a specific set of services within the much broader set of system and ancillary services. Often, balancing services are understood as only those services that serve to maintain or restore the balance between supply and demand in real-time. This is typically achieved by adjusting the production of one or more generation units.[8] In addition, however, the same services may also be used for network control, i.e. as a means of congestion management by modifying the physical flows across the network (compare chapter 3.5). Whilst the former group of actions is also known as *energy balancing*, the latter is also referred to as *system balancing*.

This observation highlights that the classification of system and ancillary services used in this report is based on the function of each (group of) service(s). This is however not necessarily related with the technical characteristics of the underlying technical services. Besides the example already mentioned, it is worth noting that the use of AGC is generally known as *regulation* in e.g. Northern America, New Zealand or Singapore and is used as a means for second-to-second frequency control. In contrast, the same service is known as secondary frequency control (or load frequency control) in UCTE where it serves not only as an instrument of frequency control but also as an important balancing service.

Finally, we point out that we have focused on the typical types of system and ancillary services only. In addition, there exist a number of specific services, which are only applied in some countries but not others, like the example of special protection schemes in Scandina-

[7] Network control and, to some extent, system control are provided by system operators, transmission owners and distributors. In contrast, frequency control and balancing services as well as emergency and restoration services typically are an exclusive responsibility of the SO.

[8] Or the demand of certain, e.g. interruptible customers

via, Great Britain or the former Soviet Union.[9] Similarly, some countries also consider the compensation of network losses as an ancillary service, although this is commonly regarded as an energy-related business in other countries.

Also, we emphasize again that definitions are very different in different countries. For instance, the US combines both system and ancillary services under the term 'ancillary services', whilst the British Grid Code formally excludes any services provided by consumers from the range of ancillary services, which are instead defined as 'other services'. Furthermore, e.g. Norway and PJM do not categorize restoration services as ancillary service, whilst we note that the terms 'secondary response', 'secondary control' and 'secondary reserves' may designate three services that are technically very different even if the wording seems to suggest the opposite.

For the purpose of this report, however, we concentrate on the general classification shown in Figure 1 when discussing the markets for balancing and ancillary services in chapter 1.1.

[9] In the former Soviet Union, these are known as 'anti-emergency automation'.

3. MARKET MODELS AND SEGMENTS

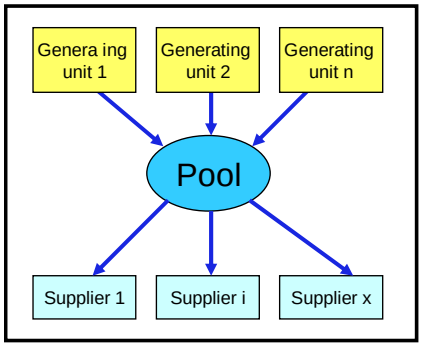
3.1. Market Models for Commodity Energy

3.1.1. Pool versus bilateral trading

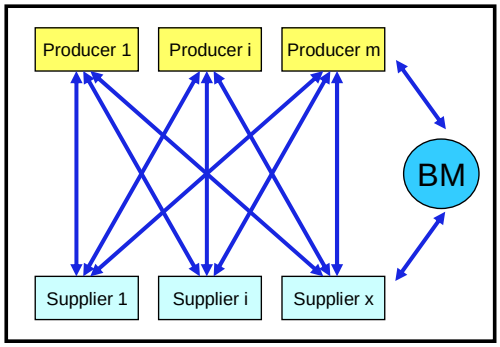
The market for the (physical) trading of energy represents the core part of any wholesale electricity market. Over time, different countries have a developed a variety of market models with different features. Despite these differences in detail, all markets can be basically grouped into main market models, namely:

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

As illustrated by Figure 2, pool markets represent a very 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.



Centralized pool



Bilateral contracts market

Figure 2: 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.

In this context, it is however important to note that pool markets can be further differentiated into **gross pools** and **net pools** (compare Table 3). 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. In some way, a net pool therefore represents some sort of hybrid between a pool and a bilateral contracts market. It is therefore not surprising to see that the concept of gross pools is typically applied to wholesale markets, whereas net pools are more typical for the design of balancing mechanisms (see section 3.1.2).

Table 2: Gross versus net pool (one-way bidding)

	Gross pool	Net pool
Scheduling	Producers submit offers for the entire output of each unit	Producers submit an initial schedule, plus offers for the remaining (unused) capacity of each unit, and bids for self-scheduled capacity
Volume of trading / Settlement	Market is cleared and settled on a gross basis, i.e. for the entire output of each unit	Centralized market is cleared based on total demand (subject to self-scheduled production) as well as submitted bids and offers for decrease / increase of production; Only difference between initial self-schedule and final schedule is settled at market price.

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. To solve the market whilst ensuring the technical feasibility of the resulting schedule, pool markets typically also take account of a number of detailed technical characteristics of each unit, which results in considerably increased 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**.

Table 3: Gross versus net pool (one-way bidding)

	Gross pool	Net pool
Scheduling	Producers submit offers for the entire output of each unit	Producers submit an initial schedule, plus offers for the remaining (unused) capacity of each unit, and bids for self-scheduled capacity
Volume of trading / Settlement	Market is cleared and settled on a gross basis, i.e. for the entire output of each unit	Centralized market is cleared based on total demand (subject to self-scheduled production) as well as submitted bids and offers for decrease / increase of production; Only difference between initial self-schedule and final schedule is settled at market price.

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 have zero demand elasticity. **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 cannot nor-

mally be found in a gross pool, whilst it is normally applied in voluntary organized markets, or power exchanges, in bilateral contracts markets (compare section 3.3.3).

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). Although centralized dispatch is more common in pool-type markets (such as PJM, NEMMCO or Italy), it can only be found in some bilateral markets. Similarly, many countries rely on self-dispatch even if at least the balancing mechanism is based on a net pool (e.g. Belgium, the Netherlands or Great Britain).

3.1.2. 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 like Australia or Singapore 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.

Similarly, other markets have developed arrangements based either on a series of intra-day auctions or continuous trading (see section 3.3.3), 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 pool, 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. This approach was for instance chosen in the original England & Wales pool. At PJM in the U.S., on the other hand, the initial day-ahead market serves as the

basis for a so-called real-time market, which effectively represents a net pool based on specific offers for deviations from the original day-ahead schedule.

In many countries, however, the wholesale market is supplemented by a separate balancing mechanism, which serves only for the purpose of energy and, potentially, system balancing by the system operator. 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. Corresponding mechanisms can be found in both pools and bilateral markets. For instance, both Spain and Italy operate a separate balancing mechanism to supplement the initial day-ahead (and adjustment) market(s) for wholesale trading.

Conversely, separate balancing mechanisms have been introduced in virtually all bilateral contracts markets.[10] 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 (see section 3.2). However, whilst e.g. the system operators of France and Great Britain require unit-based offers, the balancing mechanism of e.g. the Netherlands is at least based on portfolio-based offers, i.e. relating to the entire generation park of a producer. In Austria or Germany finally participation in the balancing mechanism is voluntary, i.e. there is no obligation on producers to offer their generation capacities to the SO.

3.1.3. Diversity of market designs

In the previous sections, we have already commented on the many design choices that can be taken under the two basic market models. Moreover, these choices are not necessarily mutually exclusive, i.e. it is very well possible that the same country may combine several of the options explained above. For example, it is quite common that a bilateral contracts market is supplemented by a power exchange, whilst real-time balancing is managed like a pool. To illustrate the large diversity, Figure 3 presents an overview of different combinations of market designs in different countries. Below, we briefly comment on each of these examples.

[10] In some cases, balancing has initially been performed based on separate ancillary services contracts.

	Singa-pore	England & Wales ('90–'00)	Italy	Spain	PJM (U.S.)	Nether-lands (2005)	Belgium	Sweden
Day-ahead	Energy [a]	Energy	Energy / Energy, Reserves	Energy / Reserves	Energy	Energy (+ PX)	Energy (+ PX)	Energy (+ PX)
Intra-day				Energy			Energy	Energy (+ PX)
Real-time	Energy	Balancing	Balancing	Balancing	Energy / Balancing	Balancing	Balancing	Balancing
Similar examples	*NEMMCO (Australia), New Zealand*					*Germany (< 2006), Romania*	*UK (NETA / BETTA), France*	*Austria, Denmark, Germany*

Gross pool | Net pool | Bilateral | Voluntary | Not allowed

Figure 3: Examples of different market designs

[a] – Preliminary schedule (pre-dispatch forecast)

The **England and Wales (E&W) pool** was a compulsory day-ahead market. Producers had to submit their offers one day ahead for each generating unit, supplemented by various technical parameters. The SO then determined the system marginal price for each half-hour as the most expensive bid accepted, ignoring transmission constraints. A payment for capacity declared available was added to the system marginal price to give the pool purchase price, whilst a further charge for ancillary services was added to give the pool selling price. To cope with changes in plant availability, outages and demand shocks during the day, the SO could either adjust production schedules based on the production schedule and the offers submitted on the day-ahead, or through special contracts for ancillary services.

The **Italian** market combines a mandatory gross pool with elements of a bilateral market. The organized market can be divided into three separate markets: A day-ahead market for energy, an adjustment market to help producers obtain a feasible production schedule, and the ancillary services market for real-time balancing. The day-ahead market is a gross pool based on unit-based offers, but without consideration of technical constraints. These are taken into account through the adjustment market, whilst the ancillary services market takes the form of a net pool, with day-ahead offers.

The **Spanish** electricity wholesale market is organized as a sequence of markets: Following the initial day-ahead market for energy, which is organized as a gross pool, the market operator operates several day-ahead sessions for the procurement of reserves, which take the form of a net pool. During the day, producers can adjust their schedules through a series of so-called 'adjustment markets', whilst the SO uses another net pool for real-time balancing.

The **PJM** combines bilateral trading and self-scheduling with a mandatory centralized market. The centralized market takes the form of a net pool, allowing market participants to self-

schedule their own plants and only offer modifications to this base schedule. For real-time balancing, PJM utilizes a renewed run of the energy market, which is supplemented by separate mechanisms for the procurement of some ancillary services.

The wholesale power market in the **Netherlands** is based on bilateral contracts, supplemented by a voluntary power exchange (APX). Whilst producers can self-schedule their production, they originally had to submit their final nominations on the day-ahead, i.e. they had no choice to formally adjust their balance of exchange with other market participants during the day. For real-time balancing, the Dutch SO operates a separate balancing mechanism with mandatory participation by producers. Offers are submitted on the day-ahead but may be changed until one hour before real-time.

Similar to France and the UK (NETA/BETTA), the **Belgium** electricity market is based on the principle of bilateral contracting. Hence, market participants are themselves responsible to sell their production, contract for their consumption and may engage into any type of bilateral contracts. All (net) exchanges resulting from these contracts have to be nominated to the SO on the day-ahead, as a precondition for successful and reliable system operation. Intra-day nominations for internal exchanges may be submitted to the SO at any time during the intra-day process. Finally, this bilateral market is supplemented by a centralized balancing mechanism which is also operated by the SO and which serves as a tool both to procure (on the day-ahead) and utilize (in real time) the required reserves and balancing services.

The joint Nordic power exchange Nord Pool and bilateral agreements constitute the marketplace for the **Swedish** electricity market. Although the market is based on the concept of bilateral trading, cross-border exchanges are only possible through Nord Pool. Nord Pool also offers an intra-day market (Elbas), which currently covers Finland, Sweden, Eastern Denmark and, since September 2006, also Germany. Real-time balancing is based on a separate balancing mechanism with voluntary participation by producers, which submit portfolio-based offers.

3.2. Market Timeline and the Role of Gate Closure

Trading between market participants takes place across a number of different timescales ranging from forward to ex-post trading. Each of these timescales is typically associated with a different segment of the market. Figure 4 provides a generic market timeline and the predominant trading activity likely to occur in each time period.

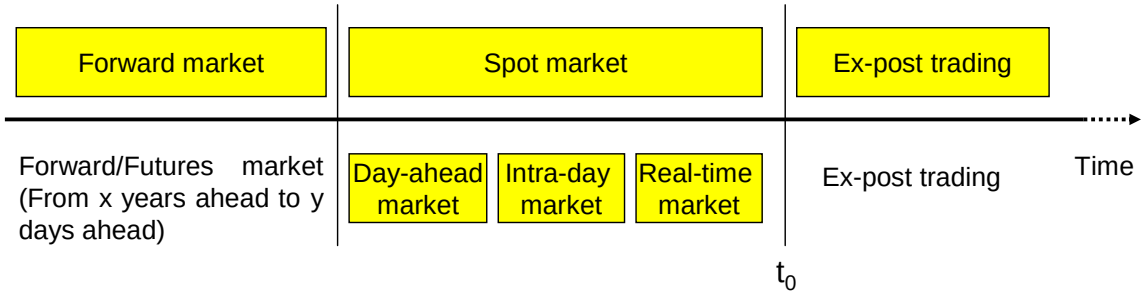


Figure 4: Timeline of market operations

Each of these segments is subsequently explained in more detail

- **Forward market**

  Forward trading is typically used by market participants to hedge themselves against the volatility of daily and hourly market prices. For this reason, suppliers may use the forward market to cover their physical positions as required to satisfy their customer demand or producers for selling their available output. Forward trading may comprise a wide range of different products, ranging from forward contracts for physical delivery, futures contracts which are financially settled against a reference price, or option contracts.

  Forward trading tends to be focused on bilateral contracts, which can be flexibly adjusted to the actual needs of any market participant. In addition, various power exchanges have also introduced futures trading, where standardized products can be traded.

- **Spot market**

  In contrast to the forward market, where delivery will take place at a future date, a spot market is defined as a market where energy is sold and bought for near or immediate delivery. The exact definition varies widely. For instance, in Europe the term spot market is often used to refer to the day-ahead market, as illustrated by the Elspot market of Nord Pool. Conversely, in the U.S. a spot market is understood as a market that only takes place close to real time. In this report, we use the term spot market to cover all trading taking place between the day-ahead and real-time.

  A common feature of spot markets, irrespective of their actual occurrence is time, is that they typically comprise only physical products.

- **Day-ahead market**

  A day-ahead market, as its name implies, operates one day in advance of actual delivery. By this time, participants typically have sufficient information on e.g.

demand forecasts, whilst especially thermal producers already need to decide on their production schedules as they cannot start or stop their plants at short notice. Consequently, the trading in the day-ahead market tends to most liquid when measured in terms of number of transactions.

Besides OTC trading, organized day-ahead markets may either take the form of (voluntary) power exchanges (section 3.3.3) or compulsory pools (section 3.1.1). Whilst the example of Elspot mentioned represents an example of a power exchange, the day-ahead markets of Spain or Italy are examples of day-ahead power pools.

- **Intra-day trading**

  Intra-day trading can be seen as an extension of the day-ahead phase where market participants can adjust their contractual position to manage their overall demand and supply balance, thereby reducing their risks of being out of balance and being obliged to pay imbalance prices. Intra-day trading can be typically found in developed bilateral markets, although intra-day sessions are also used in e.g. the Spanish power pool.

- **Real-time market**

  Real-time markets are used to adjust actual production to load at any time during real-time operations. As already explained in section 3.1.2, there are three basic options: (1) A real-time gross pool as operated e.g. in Australia or Singapore, (2) real-time net pool like the real-time market of PJM or the balancing mechanisms of e.g. France or Great Britain, and (3) a voluntary balancing mechanism like those in Austria or Germany.

- **Ex-post market**

  In several countries, market participants have the possibility to register further trades 'after the fact', i.e. after delivery has actually taken place. Although this is sometimes used also for nominating transactions that have already been agreed at the intra-day stage, the true objective for ex-post trading (also referred to as 'yesterday trading') is to trade out imbalances, e.g. a party being 'long' may trade this imbalance with another party being short' in order to avoid or at least reduce imbalance charges. By definition, such transactions are only useful if they affect the physical position of market participant, i.e. if they take the form of physical trading. This type of trading activity is possible in like Belgium, Germany, Switzerland or the UK.

In the context of market timelines, it is important to introduce the concept of '**gate closure'**. This term was originally developed in the UK and designates that time until which a market participant can modify its physical position, i.e. adjust its planned production and bilateral ex-

changes. As such, gate closure is only relevant for bilateral markets as there is no equivalent in a power pool where producers cannot self-schedule themselves.[11] The need for gate closure in a bilateral market stems from the need to ensure the balance of supply and demand at each location in the power system, which requires the SO to have sufficient knowledge about the planned production at different points in its control area.

As illustrated by Figure 5, the exact time and impact of gate closure varies widely, including for different types of transactions. To start with, most continental European countries, which are interconnected with each other, require external trades, i.e. exchanges with other control areas or countries, to be nominated on the day-ahead. In some cases, like between Austria, Germany and Switzerland or in Scandinavia, these day-ahead nominations can later on be adjusted or supplemented by new nominations until a definitive gate closure , which e.g. be 1 hour before real time. Conversely, for bilateral trading within the same control area (internal exchanges) most system operators have by now moved to a gate closure, which may be one to several hours before real time, even if the same system operators require the submission of initial exchange nominations on the day ahead.[12] For instance in England & Wales or the Netherlands gate closure is 1 hour ahead of real time, whereas France applies a system of several gates at different times during the day. In contrast, market participants in e.g. Belgium or Germany can still trade out their imbalances ex-post, i.e. final Gate Closure is only on the day after delivery.

[11] To some extent, gate closure can however be compared to the deadline for submission of offers.

[12] In the UK or Austria, nominations actually have to be made to the settlement administrator rather than the SO.

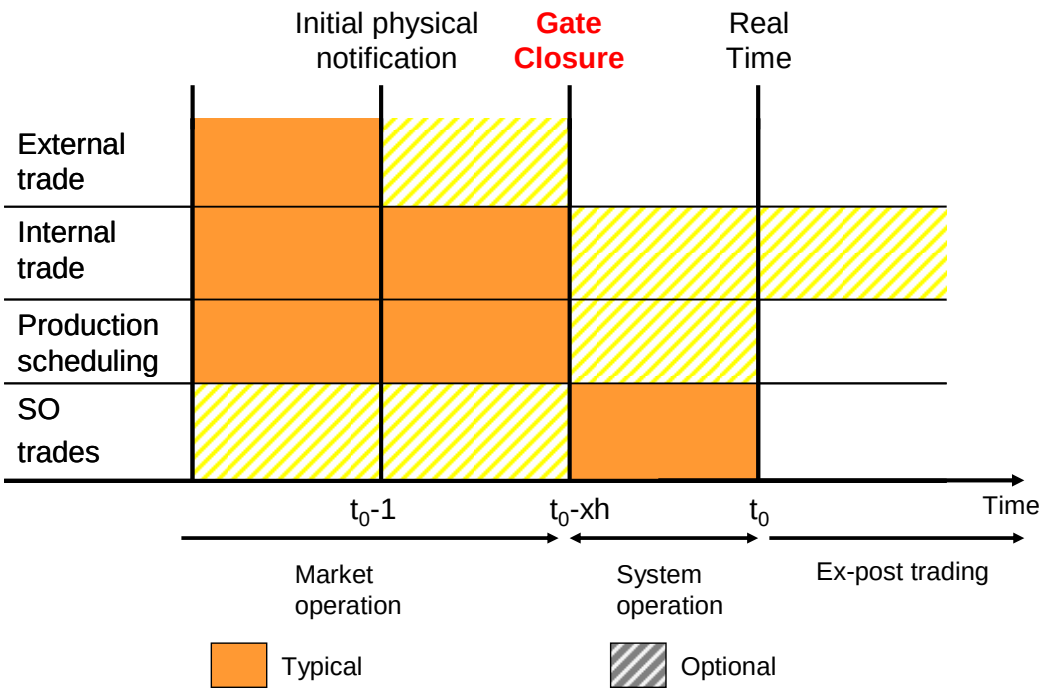


Figure 5: Generic timeline for system operation

As the system gets closer to real time, the SO has to monitor and, if necessary, adjust the output of producers in order to balance the system or manage congestion. For this reason, most system operators impose a firm gate closure for the nomination of production schedules, which effectively means that market operation stops at this time. In many continental European countries, like Austria, Germany or Switzerland, producers are however allowed to adjust the production of individual units until real-time, i.e. their production nominations are for information only and non-binding.

At the latest at the time of gate closure, the operation of the electricity market switches from market to system operation, i.e. the SO is the only party being entitled to instruct the residual balancing of generation as the system real time. In some cases, like in Germany, operation of the balancing mechanism therefore only starts shortly before real time, e.g. 1 hour before delivery. In contrast, other system operators like National Grid in the UK or RTE in France already take balancing actions before gate closure, e.g. where they believe that insufficient capacities may available to cope with the expected system imbalance after gate closure.

3.3. Role of Bilateral and Financial Trading (Energy)

3.3.1. Physical versus financial trading

Electricity trading may take two forms, i.e. physical or financial trading. Physical trading relates to the exchange of firm commitments to deliver or receive a certain amount of energy by means of either producing or consuming the corresponding amount, or by informing the system operator (or settlement administrator) about the corresponding exchange before gate closure. In contrast, financial contracts only provide for some sort of financial compensation to be made between the contracting parties and are not related to the physical delivery of the underlying product. Both physical and financial contracts can be traded either on a bilateral basis or through an organized market.

Under physical contracts, the contracted quantity has to be delivered at an agreed location, time and price. Whilst a financial contract will also include the specification of a quantity, location, time and price, there is no physical delivery included, and thus only a financial transaction. Financial trade requires a reference price against which the financial transactions can be settled; often this price reference is the spot price. Consequently, financial contracts are not suitable for trading close to delivery and are therefore typically used for forward trading. Conversely, spot market and the balancing market are both physical markets, although physical contracts are also used for forward trading.

The interrelation between the physical and the financial markets (both organized and OTC) should be underlined. Generally speaking, a well functioning physical spot market is a precondition for the functioning of a financial market as the latter requires a reliable price reference. On the other hand, a liquid and well organized financial market may also be seen as a precondition for a successful physical market as it provides an important means of hedging against price risks in the (physical) short-term wholesale market.

Especially with regards to financial contracts, it is furthermore necessary to differentiate between different types of corresponding derivatives. Whilst physical trading typically refers to a firm commitment to deliver a certain product, financial products may also take the form of **option contracts**. Options are contracts that give the buyer the right, but not the obligation to buy ('call options') or sell ('put options') the underlying product at an agreed upon price in future ('strike or exercise price').

3.3.2. Role of bilateral trading in a pool market

Irrespective of the choice of the fundamental market model, bilateral trading represents an important instrument for hedging against future price risks. Such contracts create price certainty for the parties and limit their exposure to spot market volatility. Although the pure of concept power pools does not provide for corresponding instruments, international experi-

ence has shown that some sort of bilateral contracts has been implemented in many cases, thereby introducing elements of a bilateral contracts market. Whilst this is obvious in case of a net pool, corresponding approaches can also be found in gross pools.

In practice, there are two main approaches for complementing a pool, namely:

- Contracts for differences (CfD); or
- Nomination of bilateral contract obligations.

In a gross pool model, producers have to purchase their entire output through the pool, whilst suppliers have to purchase their entire demand from the pool. One common method of allowing market participants to hedge against price risks is the use of so-called **contracts for difference**, or **CfDs**. As illustrated by Figure 6, a CfD represents a bilateral financial contract that can be concluded between a producer and a supplier and that does not involve a physical delivery between a buyer and a seller. The term contract for difference stems from the fact that it provides for the contracting parties to compensate each other for the difference between the future pool price and an agreed strike price.

For instance, if the future price was lower than the strike price the supplier would pay the producer the product of the contract quantity and the difference between the contract price and the underlying spot price. Conversely, if the market price was higher than the strike price then the producer would reimburse the supplier for the difference. As a result, a CfD provides for an efficient means of allowing producers to sell their expected output at a fixed price, whilst suppliers may use it to hedge themselves against increasing pool prices. Nevertheless, CfDs do not have any direct impact on actual production schedules in the pool, which are still determined based on daily offers by producers. CfD were originally used in the old England & Wales but can also be found in other markets.

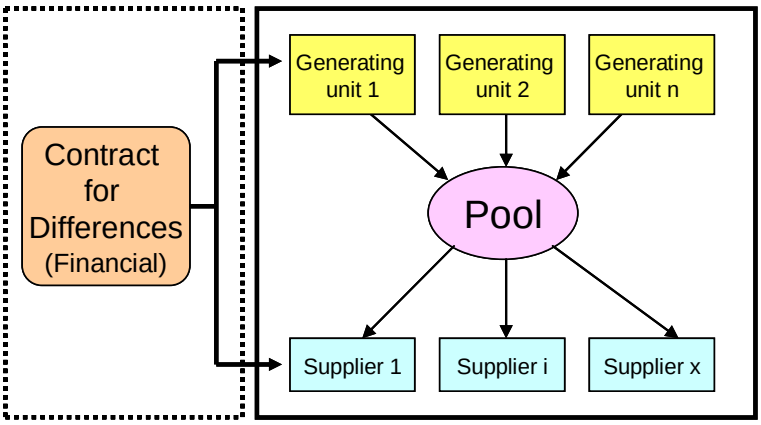


Figure 6: Pool model complemented by CfD

In contrast, other markets have decided to allow for the nomination of bilateral contract obligations even in a (gross) pool. In this case, market participants are entitled are allowed to

explicitly nominate existing physical bilateral contracts when submitting their offers to the pool. As shown in Figure 7, the pool is thus supplemented by physical rather than financial contracts, which implies that this modification does have an impact on the resulting production schedule. Indeed, there are two methods for taking account of corresponding exchanges, i.e. either through a mechanism of priorities or by using a net pool.

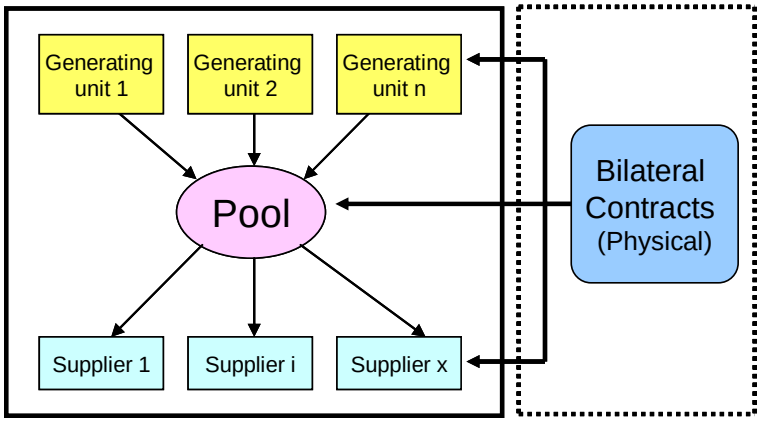


Figure 7: Pool model complemented by bilateral contracts

The first approach is e.g. used in Italy where market participants notify bilateral contracts when submitting their daily bids and offers to the power pool.[13] All bilateral contracts receive a dispatching priority, which is then taken into account during market clearing. Unless a transmission constraint is violated, these priorities ensure that the market system first satisfies the bilateral transactions and only then accepts other production offers. Conversely, bilateral transactions may only be rejected when it is impossible to dispatch the corresponding plants accordingly due to transmission constraints.

At PJM, another approach has been chosen. Here, market participants may self-schedule their power plants and only submit offers for modifications to this based schedule. However, this is only possible for generation and load at the same nodes, or where market participants have sufficient transport rights between different nodes in the system. Subject to these limitations, PJM therefore represents a net rather than a gross pool.

3.3.3. Role and benefits of voluntary organized markets (power exchanges)

In parallel to the introduction of elements of bilateral trading in electricity pools, many European wholesale markets, which are based on the principle of bilateral trading, are supplemented by a voluntary power exchange. As illustrated by Figure 8, a power exchange provides for an organized marketplace where standardized contract can be traded with the exchange as central counterparty. In contrast to a power pool, however, participation in the

[13] In practice, the corresponding information is submitted to the SO and not the MO.

power exchange is voluntary and the market operator is typically a distinct organization that is separate from the SO. Moreover, a power exchange allows all market participants, including producers and suppliers, to both purchase and sell energy on a portfolio basis, i.e. it does not differentiate between different types of market participants.

The main advantages of a power exchange can be summarized as follows:

- Standardization: rules to participate in the power exchange are usually well known and there is no need to negotiate and write contracts.
- Reduction of credit risk: an exchange provides security for traders by acting as the counter party to all trades, eliminating traders' concerns over creditworthiness.
- Concentration of liquidity: made possible by high volume of trade, sufficient number of participants and low transaction costs.
- Commonly accepted price reference: the power exchange provides a reference price, reflecting the market and based on neutral and transparent criteria. This reference is crucial both for the physical wholesale and for financial trade both at the exchange and in the OTC markets.

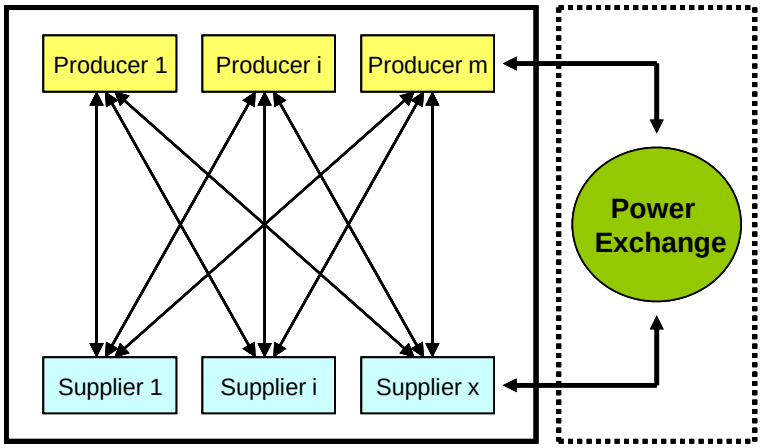


Figure 8: Bilateral market model combined with power exchange

Some well-known examples of power exchanges are Nord Pool in Scandinavia, EEX in Germany (+ Austria and Switzerland), Powernext in France, APX in the Netherlands (and the UK), BelPex in Belgium, EXAA in Austria and, in Central Eastern Europe, OPCOM from Romania and Borzen in Slovenia. It should be noted that power exchanges may offer both physical and financial products for both spot and futures trading.

Example: Nord Pool

The Nordic power exchange Nord Pool is the oldest, most liquid and the only truly regional power exchange in Europe. It offers a range of both physical and financial products and is

also responsible for the allocation of cross-border capacities in Scandinavia by means of market splitting (compare section 3.5). Besides clearing services for bilateral contracts (OTC), Nord Pool operates three different markets:

- A financial derivatives market (Eltermin) with futures and option contracts;
- A spot market for physical contracts (Elspot); and
- An intra-day market for physical trading (Elbas).

European power exchanges use two different types of price finding, i.e.

- Closed auctions; and
- Continuous trading.

Closed auctions are based on closed order books where all offers are collected until a predetermined market closing time. At this time, all valid offers are aggregated into a market demand and supply curve for each hour of the corresponding day and then used to determine a single market price for each trading period. This approach concentrates liquidity at a single point in time and ensures that all energy is traded at the same, i.e. marginal price.

Continuous trading differs from auctions in the following points. Firstly, it is based on an open order book, i.e. market participants have access to the order book and can see at least the marginal offers for the purchase and sale of electricity. Secondly, each incoming bid is immediately checked and matched if possible according to price/time priority. Finally, contract prices are not the same but are specific to each transaction concluded during a given day. Generally, all transactions are settled at the price quoted by one of the parties that are matched at each point in time (pay-as-bid).

Table 4 presents some examples of closed auctions and continuous trading for each market segment. From this table we can conclude that typically the forward and the intra-day markets operate as closed auctions whereas the day-ahead market provides for continuous trading (with the exception of EEX where both systems coexist). It should be also noted that cross-border auctions (see section 3.7) are typically based on closed auctions.

Table 4: Price determination in European power exchanges

	Forward market	Day-ahead market	Intra-day market
Nord Pool (NP), Scandinavia	Continuous	Auction	Continuous
European Energy Exchange (EEX)	Continuous	Auction / Continuous	Continuous
Powernext (PN)	Continuous	Auction	–
Amsterdam Power Exchange (APX)	Continuous	Auction	Continuous

3.4. Markets for Balancing and Ancillary Services

As already explained in chapter 2.2, balancing and ancillary services are essential for the sage and reliable operation of the transmission system and thus provide the basis for the functioning of any electricity market. It is therefore paramount that system and network operators have sufficient access to the required services in a liberalized market. In this section 1.1, we therefore focus on the different mechanisms applied for the procurement of these services. To facilitate the subsequent discussion, it is however helpful to consider that each of these services may require various 'sub-products' as follows:

- Capability means the technical ability to provide a particular service (e.g. a generating unit equipped with AGC);
- Availability means that the corresponding capability is actually available to the system (e.g. producer offers secondary regulation band to SO); and
- Utilization implies that the corresponding capability is actually used by the system (e.g. delivery of secondary regulation).

Throughout the world, SO have developed different mechanisms to procure and utilize balancing and ancillary services. These can be summarized as follows:

- Mandated provision (with/without remuneration);
- Bilateral / multilateral contracting;
- Tendering;
- Real-time market (day-ahead/hour-ahead markets);
- Co-optimization; and
- Self-supply.

In many countries, ancillary services have to be provided on a **mandatory basis**. This approach is typically used for minimum requirements and may apply to all or only certain groups of system users, such as 'large' power plants (e.g. ≥ 100 MW in Germany). Mandatory requirements are common for the capability to provide certain services but are also used e.g. for the provision of primary frequency control in many countries. In some cases, like Spain, Italy, the Netherlands or Slovenia producers are obliged to provide the corresponding services without any remuneration.[14] Conversely, the same service is also compulsory in France or the Great Britain but used to be remunerated on a cost reflective basis. Where applicable, mandatory services are typically remunerated for availability.

The use of **negotiated contracts** provides for a second option. In this case, the overall conditions or at least the compensation for the provision of the corresponding services are subject to bilateral negotiation. Corresponding agreements usually cover longer time scales (≥ 1 year) and are primarily used for services which either are technically complex and/or for which the SO expects no or only a limited degree of competition. The procurement of voltage / reactive power control or black start represents typical examples of ancillary services that are usually procured through direct contracts. Due to the individual nature of corresponding contracts, the structure of remuneration may vary widely.

Tenders represent one option for a market-based procurement mechanism. In this case, the SO or the MO regularly invites offers for certain products and periods and then selects the least-cost combination of offers that satisfy the needs of the system. This approach is usually applied to more standardized products, which can be provided by different market participants and which are not subject to strict locational requirements, such as e.g. frequency control services or reserves. For instance in Germany, primary and secondary frequency control is purchased through a half-annual tendering process. Similarly, many European system operators use tenders to procure (manual) reserves, i.e. to ensure sufficient balancing services in the daily balancing mechanism. Such reserve tenders may half a time horizon of between 1 week and almost 1 year and are usually based on the remuneration of availability, although some contracts also specify specific prices for utilization of the corresponding services.

Balancing mechanisms (compare section 3.1.2) are the main example of a real-time market where the SO or MO invites offers on a daily basis, e.g. on the day ahead or until the time of gate closure. Real-time markets for balancing purposes typically remunerate only the energy (or service) actually delivered but do not provide for any separate payments for availability. In many countries, however, the balancing mechanism is either part of the wholesale energy market (i.e. in a pool-based market) or closely related with other ancillary services. For instance, most European system operators require the reserves contracted under separate tenders in advance to be bid into the daily balancing mechanism.

[14] In the U.S., PJM basically uses the same approach but does not consider it a mandated provision as PJM does not check for actual availability.

In a bilateral contracts market, balancing and ancillary services always have to be procured separately from the energy market. In contrast, it is possible to integrate the offering and selection of these services into the overall wholesale market in mandatory pools in the form of so-called **co-optimization**. Under co-optimization, both reserves/ancillary services and energy are selected through the same optimization algorithm, subject to the condition of minimum total costs. The principle can be explained by the offering of frequency control services in Australia as illustrated in Figure 9. This picture shows the relation between the amount of frequency response that can be made available (vertical axis) and the energy output of the same unit (horizontal axis). By adjusting the production of (active) energy, it is then possible to influence the volume and price of available frequency control services and thus to optimize both products through the same algorithm. Similar approaches are also applied in e.g. New Zealand, Singapore or several of the U.S. markets.

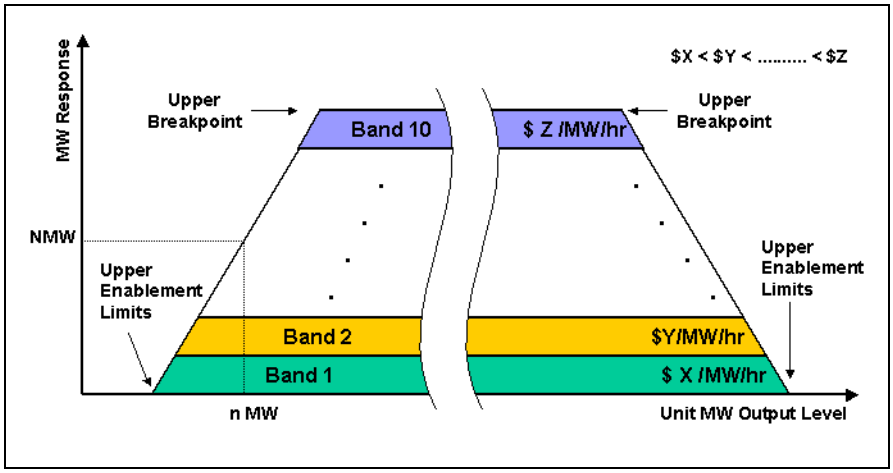


Figure 9: FCAS Trapezium for the frequency control services in Australia (NEMMCO)

Source: NEMMCO (2001)

Finally, it is worth noting that some of the U.S. market designs also allow for market participants to self-supply certain ancillary services, subject to nomination of the corresponding volumes to the SO. For instance at PJM, market participants can meet the obligations for regulation and spinning reserves by self-supplying and self-scheduling the service, including through a bilateral contract with another party. Only if this is not possible, a market participant has to purchase its share of the corresponding services e.g. through the PJM hour-ahead market for regulation. Similarly, regulation and frequency response services and operating reserve service can also be self-supplied in the NYISO market. However, we emphasize that option does not avoid the need for centralized procurement of the remaining needs by the SO.

As already indicated, not all balancing and ancillary services are equally suited to each of the different procurement mechanisms outline above. Amongst others, the choice of the mecha-

nism depends on the complexity of the service in questions, the number of potential providers or bidders and the time horizon and frequency of procurement. Without going into detail, Table 5 presents an overview of the prevailing methods for different types of balancing and ancillary services. This summary clearly shows that market-based methods are primarily used for reserves and balancing services but to a lesser extent for frequency control. Conversely, voltage / reactive power control and restoration services are normally procured under bilateral contracts.

Table 5: Typical methods for balancing and ancillary services

	Frequency control	Reserves & balancing services	Voltage/ reactive power control	Restoration services
Mandatory				
Unpaid	✓	(✓)	✓	✓
Paid	✓	(✓)	✓	✓
Self-supply	(✓)	(✓)	–	–
Bilateral/multilateral contracting	✓	✓	✓	✓
Tendering	✓	✓	(✓)	(✓)
Real-time market / Co-optimization	(✓)	✓	–	–

Low — High: Degree of competition

3.5. Consideration of Limited Network Capacities

3.5.1. Basic approaches to deal with limited network capacities

In many markets, electricity trading is based on the fiction of the so-called ‘copperplate’, i.e. it is assumed that all transactions between any two market participants are feasible. For real-time operation, however, it is also necessary to consider physical constraints in the system. Where the demand for transmission capacity exceeds transmission capacity in the network one has to resolve these constraints either through operational measures or by restricting the free trade of electricity within the market.[16] Congestion management has to find a suitable

[16] The discussion within this section refers to limited network capacities within a single market area. For regional aspects of limited network capacities please refer to section 3.5. In addition it has to be emphasised that from an economic point of view it is not reasonable per se to remove all constraints since the cost caused by constraints and the cost of building additional capacity need to be compared to come to an investment decision.

balance between the conflicting goals of minimizing restrictions for competition in the market, on the one side, and limiting operational costs, on the other side.

Due to the potentially significant impact of limited network capacities, it is important to analyze how different markets deal with capacity constraints. In the following, we discuss a number of different approaches, which differ e.g. by the responsibility for solving transmission constraints, such as through an integrated market for energy and transmission capacity or outside the energy market with interactions of the system operator, of by the representation of network constraints in the market model. Simultaneously, these decisions also influence the allocation of the resulting costs, i.e. whether these or have to be borne by individual market participants. We emphasize, however, that this discussion is limited to the consideration of network capacities 'in the market', whilst we do not comment on technical means of congestion management as a part of system operations.

In general, one may classify different types of congestion management e.g. as follows:[17]

- Nodal pricing;
- Zonal pricing;
- Constrained scheduling;
- Explicit capacity rights; and
- Redispatch.

Nodal pricing was originally developed as a theoretical concept by Schweppe et al. (1988) before later being put into practice worldwide. One of the most well known examples is the PJM market but the same model is also used in e.g. New York, Chile, New Zealand, Australia or the Russian Federation, to mention only some countries. Nodal pricing manages congestion and sets transmission prices through a centralized energy market based on economic dispatch. The basic idea is to organize the market as a pool in which producers (and ideally loads) submit hourly bids for node specific injections and withdrawals of power to the pool operator that has full co-ordination and price setting authority. The pool operator minimizes the total system's gain from trade (demand bids less generation offers) subject to transmission and reliability constraints. The price at each node is then set to the incremental offer or bid price of the most expensive unit generated or consumed at that node. These nodal prices become the e.g. hourly prices charged to loads and paid to producers at the respective nodes.

[17] We note that these approaches may be based on different representations of load flows and/or network capacities. Network capacities can be calculated using an AC- or DC-approach. In practice, most systems and market algorithms however use a DC-model, which has certain advantages in terms of mathematical convergence, although being less realistic than AC-models.

Case Study: Nodal pricing at PJM

At PJM (Pennsylvania – New Jersey – Maryland L.L.C.) nodal pricing is applied to an area covering 13 states and the District of Colombia. Locational marginal cost pricing (LMP) is used for energy transactions through the spot market and financial transmission rights (FTR) to deal with transmission access and price certainty. LMP is defined in the Operating Agreement as the marginal cost of supplying the next increment of electric energy at a specific location on the electric power network taking into account both generation marginal cost and the physical aspects of the transmission system.

LMP = Generation MC + Transmission Congestion Cost + Losses MC

Where MC stands for marginal costs.

LMPs are calculated based upon the actual economic dispatch (i.e. least cost security- constrained dispatch) and the prices of energy offered. If no constraints are experienced on the transmission system during an hour, the LMP is equal to the cost or bid price of the highest increment of energy that is requested to operate by PJM during the hour. Conversely, if constraints are actually experienced on the transmission system during an hour, the congestion cost for a given transaction is the difference in LMP between its source and sink.

Zonal pricing basically follows the same principles as nodal prices but here prices are not calculated for every node of the network but for different network zones. In case of congestion, the market is split into (pre-defined) zones with different prices in order to signal producer the cost of injecting and withdrawal of energy. Probably the most well-known of zonal pricing in wholesale energy markets is market splitting as applied by Nord Pool in Scandinavia. Here, offers from market participants have to be submitted for a total of seven market areas, including Denmark (2), Finland, Norway (3) and Sweden. During market clearing, the trading system checks the resulting flows between different market areas for congestion: If the clearing of the overall market does not create congestion, all market areas form a single zone. However, if the flows create congestion, the area is then 'split' into different zones with respect to congested interconnectors and new market prices are determined for each zone.

Case study Market Splitting:[18]

Market splitting is used to limit transmission at just a few determined borders, primarily borders between countries, and internally in Norway. In order to prepare for this, the market is divided up into geographical areas, known as electricity spot areas. After the spot market has held its auction, the ensuing trade can indicate that the transmission of electricity through a bottleneck will exceed the capacity. The market is then split and separate prices and volumes for the different areas are worked out. The system operators then ensure that the net-

work capacity at the bottleneck is utilized by adjusting the estimated price in the low-price area. The volume of electricity which may be transmitted is included when the price for the high-price area is calculated. Figure 10 indicates how the market price in the low and high-price areas is derived:

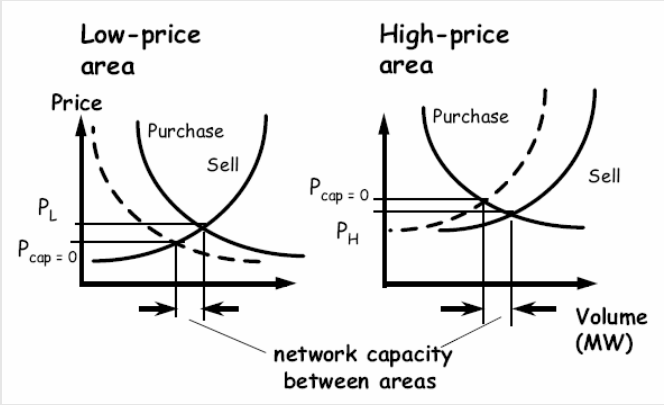


Figure 10: Low and High-price area (market splitting)

Source: Svenska Kraftnät

The following Figure 11 gives an example on the market splitting and the prices in different areas for three different hours on the same day at Nord Pool.

Figure 11: Example: Market Splitting and spot prices at different hours at Nord Pool

Source: Nord Pool

In various markets, trading and market clearing are subject to a **constrained scheduling**. To some extent, this may apply to bilateral markets where market participants are only allowed to engage into certain transactions when they have obtained sufficient capacity rights before. Normally, however, this approach is applied in traditional pools, like the former England and Wales pool or the current Spanish system. Here, the market is initially cleared without any

consideration of network constraints, i.e. Spain is considered a single price zone. Only in a second step, the market results are then checked by the SO for congestion and adjusted as necessary, without however changing the marginal system price determined before. In contrast to the previous two approaches, constrained scheduling therefore internalizes the costs of network constraints but forces certain generating units to be either 'constrained on' or 'constrained off'.

In case of e**xplicit capacity rights**, typically the system operator determines the amount of available transmission capacities in advance and then allocates a corresponding amount of capacity rights to individual market participants through a separate mechanism, such as by means of auctions (compare section 3.7.1). Each market participant, which has obtained a certain amount of capacity rights, is then entitled to nominate transactions up to this level. In other words, transactions across any defined 'flow gate' are only permitted if the market participant has obtained sufficient capacity rights in advance. The application of explicit capacity rights is feasible under different definitions of transmission capacities and for both physical and financial products. For instance in Europe, system operators typically allocate physical transmission rights for cross-border capacities by means of explicit auctions. Today, cross-border capacities are generally defined as program-based capacities (net transfer capacities, or NTC), whilst a transition to a flow-based definition of capacities is currently being considered in several regions (see section 3.7.3). Conversely, in the U.S., most markets have introduced purely financial rights, which are referred to as Financial Transmission Rights (FTR). These FTR entitle the holder of the corresponding rights to receiving the price difference across the given flow gate, whereas the physical allocation and/or utilization of these capacities is realized through nodal pricing.

Especially in bilateral markets, congestion is often solved through **re-dispatch**. Here, market participants are basically free to nominate any transactions and production schedules within a given control area, without consideration of network constraints. Only during intra-day / real-time operation, the SO uses e.g. the balancing mechanism to change the resulting production schedules in order to prevent and/or solve any network constraints. In this sense re-dispatch does not provide price signals to market participants but its costs are typically recovered through network and/or imbalance charges.

3.6. Capacity Mechanisms

Every market system has to address the ability of the power system to provide an adequate level of reliability in production. Competition in generation ideally leads to energy prices equal to system marginal costs (i.e. the variable costs of the last producer dispatched). This implies that the marginal producer is not able to cover its fixed cost. This might create a situation where companies earn too little profit for being able to invest in new (or replace existing) capacity as necessary to meet increasing (or existing) demand. Even worse, this might even

lead to a situation where existing (over-) capacities in production are reduced. The question therefore is how a sufficient reserve margin can be ensured, whilst maintaining, as far as possible, the benefits of competition.

As illustrated by Table 6, various approaches have been developed to deal with the need to ensure sufficient generation capacities. In general, where separate mechanisms are applied, these typically focus on providing incentives for investing in generation capacities, although they may also try to encourage consumers to reduce their demand. Besides these mechanisms, one finally has to mention the option of purely relying on the 'energy-only market'. Indeed, in most European countries the market design does not specifically address the question of generation reliability but simply assumes that a market with bilateral contracts (!) will itself ensure a sufficient level of generation capacities.[19]

Table 6: Capacity Mechanisms – Overview

Method	**Description**
Capacity payments	Independent agent pays for keeping capacity available, ideally reflecting the social value of reliability. Examples: Spain, Argentina (formerly), Columbia, Chile.
Strategic Reserve	An independent agent (usually the SO) maintains a reserve of power generation units, which it dispatches only when the reliability of supply is threatened. The price for electricity should be set high enough not to deter investment. Examples: Finland, Sweden.
Operating reserves pricing	The SO purchases more operating reserve capacities than needed for short-term operations alone. Extra reserves improve the long-term generation adequacy. By contracting them an incentive is provided to generating companies to create more generation capacity. The price paid for the operating reserves influences the investment incentive and would therefore be high enough.
Capacity requirements (ICAP)/Capacity tickets	Load-serving entities (e.g. retail companies) are required to contract for a fixed percentage of reserve capacity. The cost of contracting generation capacity is passed on to customers as part of the electricity price. Examples: PJM, New York Power pool, New England Pool
Reliability contracts	An independent agent purchases call options from producers which cover total generation capacity plus a reserve margin. If the market price of electricity rises above the option strike price, the regulator calls the options and receives the difference between the spot price and the strike price. This difference is passed on to consumers. Not tried in practice.

Capacity subscriptions	Consumers buy the right to a certain volume of capacity during peak conditions and allow their peak consumption to be physically limited to this volume during periods of scarcity. The costs of reserve capacity are internalized: each consumer pays for the level of reliability that he desires. Not tried in practice.

Source: de Vries, Laurens (2004), p. 129.

In the following we concentrate on two types of capacity mechanisms that have been already implemented in practice, namely:

- Price-based capacity systems (capacity payments); and
- Quantity-based systems (capacity markets, capacity requirements ICAPs).

One way of correcting for market failures concerning capacity is for the system operator to pay producers directly for capacity, which increases the profitability of existing as well as new capacity investments. This is the basis for a so-called **price-based system**, where the payments can take two forms: a payment for installed capacity separate from payments for energy, or a **capacity payment** in the form of an addition, or uplift, to the energy payment that depends on the state of the system and the capacity available. The calculations of prices and necessary capacity are done by a central organization and are typically based on an assumed value of un-served energy (VUE, also referred to as Value of Lost Load, or VOLL) or the calculated costs of peak generation capacity. This marks a fundamentally different approach than attempting to allow consumer's willingness to pay for reliability to be revealed via market mechanisms.

Case Study: England and Wales – Pool 1990-2001

The Pool, which operated from 1990 until the end of March 2001, incorporated a capacity payment for plant that was available to run on a day even if it was not ultimately dispatched. This capacity payment was calculated by multiplying the probability that a capacity shortage will occur (LOLP) by the value of this lost load (price at which customers are happy to curtail demand). The value of lost load was set at £2,000/MWh in 1990 but was subsequently tied to a consumer price index so that it reached about £2,850/MWh in 1998.

Although the Pool was open to many criticisms, including the manner in which producers with market power could manipulate the LOLP mechanism, it provided a very successful platform for developing new plant. From 1990 to 2001, 25.9 GW of plant was commissioned and so despite 12 GW of plant being closed and 5 GW of plant being mothballed, total plant available for system use increased since 1990 by 9 GW to 68 GW while demand increased by only 4 GW to 54 GW. As a result, plant margin increased to 26%.

However, this increase in capacity came at a cost. For much of the 1990's the market dominance enjoyed by the two largest fossil producer companies resulted in excessive amounts being paid in capacity payments as the companies were able to manipulate the probability of

a loss of load occurring by withdrawing plant from the merit order. The two companies were also able to take advantage of inherent transmission constraints present in the system to increase overall energy prices.

The response of the regulator was to provide financial incentives for the National Grid Company (System Operator) to better manage the transmission grid, set locational connection charges and absorb a fraction of the congestion costs. In effect, this approach reverted to the use of a monopoly with price cap regulation in order to provide incentives to counteract the effects of inefficient pricing presented to the market participants. Ultimately, the regulator came to the view that the market design itself needed to be changed and so NETA emerged.

In a **capacity market** (**quantity-based system**), the system operator estimates the need for capacity in the system. Contrary to the price-based approach described above, the price to be paid for capacity in a quantity-based system is decided via a market mechanism. The producers are not paid a fixed amount of money. Instead, the value of capacity results from the interaction of buyers and sellers in the capacity market. If there is a surplus of capacity in the system then the value of capacity tickets will be low. A shortage of capacity will, in contrast, result in a higher value. In practice, however, all capacity markets have some sort of price caps that are based on political decisions on how much society is willing to spend. Moreover, since the quantity to be procured is centrally set by the SO, most market designs have suffered from the lack of demand-side elasticity.

The two forms of quantity-based market to choose from are an operating reserves system or an installed capacity (ICAP) system:

- **ICAP-system** – this approach is based built upon the presence of so-called 'capacity tickets'. A ticket symbolizes the responsibility to provide a specific share of the total required capacity in the system. Each customer serving entity in the system is required to procure a specific amount of tickets, based on the company's customer base. They can either get their tickets from their own production capacity or they can buy it from someone with excess capacity. This way, a market for capacity tickets will emerge and as the tickets are traded between market participants, the price for tickets will move upwards or downwards depending on whether there is over- or under-capacity in the system.
- **Operating reserve system** – instead of creating a market for long-term installed capacity, markets could be created for short term operating reserves. In this model, the system operator purchases an estimated optimal amount of capacity reserves for system-operating purposes – capacity that is only to be used for short term balancing and to keep the system functioning. Assuming that prices would be highest during peak periods, this system rewards capacity that is available when it is most likely to be needed. The resulting payments for reserves provide a revenue stream for plants

that can be used in emergency or shortage situations, even if they never actually generate power.

Case Study: ICAP-system of PJM

The starting point for the PJM's capacity obligation is a forecast that the pool operator compiles in November each year of peak demand in the subsequent summer. The sum of this peak demand and a reserve margin (of about 20%) is divided among load serving entities (LSEs) in proportion to their customers' contribution to the forecast peak demand. This allows customers to benefit if their peaks do not coincide with those of the system. The peaks are evaluated in relation to the five hours of highest demand. Each LSE then has to show in advance (i.e. on every day of the subsequent year) that it has sufficient capacity to meet its forecast peak demand plus its share of the reserve margin. The scheme relies on LSE's having capacity a short time (6-7 months) in advance of the peak period. If customers switch their retailer during the period after November, the associated capacity obligation transfers from the old to the new retailer, along with the customer.

PJM organizes monthly and daily markets in capacity, to allow retailers to adjust their holdings and to bring them in line with their obligations.

- Daily market operation. The daily market is a day-ahead market that works as follows: one entity would offer to sell a generation capacity ticket for a particular day & price (Sell Offer), while another entity would offer to buy this daily capacity ticket (Buy Bid). After receiving all the Sell Offers and Buy Bids, the market administrator ranks the Sell Offers from the lowest to the highest and the Buy Bids from the highest to the lowest. The Marginal Capacity Price (MCP) is the price at which the next (or marginal) Sell Offer is < = the next (or marginal) Buy Bid. All market sellers get the MCP. The daily market is useful so that LSEs can update and fine-tune their capacity positions on a daily basis, as retail loads are won and lost, and capacity contracts come on-stream or off-stream. The daily market is conducted based on the position of a participant for the market day estimated on the day the market is run. If a participant has a deficient position, PJM will only accept buy bids up to the deficiency amount. If a participant has an excess position, PJM will only accept sell offers up to the excess amount. PJM strives to clear the market and post market results by 12:00 P.M. on the day the market is run.
- Monthly market operation. The monthly market may cover a period of one month or multiple months. The monthly market is a voluntary market where LSEs can plan ahead to match their capacity obligations with capacity tickets.

Inside the PJM area, total generation capacity exceeds peak demand by about 7%. LSEs therefore have to buy capacity from producers in neighboring control areas to meet the 20%

reserve margin requirement. The PJM rules require evidence of firm transmission capacity up to and into PJM, and define the extent to which capacity imported from other control areas will count towards meeting a capacity obligation. These rules adjust the level of the capacity ticket to allow for the reduction in reliability associated with use of transmission lines under the operational control of a third party, and for the reduction in reliability associated with a lack of short-term operational control over producers outside PJM.

If a PJM member fails to meet its assigned capacity requirements, it must pay a fixed deficiency charge to PJM members who have excess capacity. However, if the LSE incurs the penalty for less than 170 days per year, it works out to be cheaper than building a peaking producer.

3.7. Regional Integration: Energy Markets

In the recent years an increased focus on regional integration of national markets can be observed in Europe. The integration activities touch several phases of the market such as forward trading (explicit auctions), day-ahead and intra-day trading and real-time balancing. In the following, we discuss ways for integrating energy market, whilst we briefly comment on the potential integration of balancing mechanisms in section 3.8 below. Moreover, we restrict our discussion in sections 3.7.1 and 3.7.2 to market-based methods, which are commonly accepted as being economically efficient, non-discriminatory and transparent and are required by current EU regulations. As proven by the examples of e.g. Denmark or Belgium, regional integration may furthermore facilitate or even be a precondition for establishing an organized energy market especially in countries with limited competition. In section 3.7.3 we therefore comment on the preconditions for establishing organized energy and the potential benefits of regional integration in this respect. Finally, we note that regional integration in Europe is supplemented by the planned transition from so-called program-based to flow-based allocation methods. For this reason, we also comment on different definition of capacity rights in section 3.7.4.

3.7.1. Explicit versus implicit auctions

Congestion management is fundamental for regional market integration. Historically, interconnector capacities have not primarily been used to trade electricity but to provide reserve capacity to neighboring markets. Therefore, on most borders, capacities are congested during certain periods of time and need, which requires efficient means of congestion management. Since the application of nodal pricing is not feasible in a bilateral contracts market, European countries had to develop alternatives. Given the importance of the problem, differ-

ent methods have been developed and are applied, most of them being based on the allocation of explicit capacity rights to the market.

Especially in the initial stages of market development, this has included non-market-based methods, such as the first-come-first-served principle, retention or a pro-rata allocation, which have been gradually replaced by auction-based mechanisms over the past few years. Auctions are a well-known type of market mechanism that can be used to allocate scarce resources such as cross-border capacity. Auctions are transparent and efficient as they allocate capacities to those that value it the most. In practice, one can identify two basic models:

- Explicit auctions; and
- Implicit auctions.

In an **explicit auction** of interconnector capacity, the two system operators of the systems between which congestion exists sell available transport capacities to the bidder offering the highest price(s). Variations in auction design are possible with regards to the bidding mechanisms or the time periods, which are auctioned (days, weeks, months, years). Explicit auctions separate energy flows from transmission capacity. Hence, once interconnection capacity has been secured by a market participant, the participant will need another transaction for energy. This can be done on the bilateral market or on a power exchange.[21]

In contrast, **implicit auctions** rely on the combination of capacity allocation with the organized energy market (e.g. power pool or power exchange). Since this method does not separate energy flows from transmission capacity, the process is simpler for market parties. Such system creates revenue for the market operator equal to the size of the interconnector capacity times the price difference. The revenues which the market operator collects should in theory, be the same as the revenues from an explicit auction. The main drawback of this option is that it requires an organized market to function in the downstream side of each congested interconnection. This is currently an important practical limitation in many countries where a liquid and stable organized electricity markets have not yet developed.

Although explicit auctions can still be regarded as the prevailing methods for the time being, implicit auctions are generally regarded as being the most efficient solution and can be expected to become of increasing importance as regional market integration proceeds.

3.7.2. Different types of implicit auctions

As mentioned, implicit auctions are widely seen as the most efficient solution for integration of national markets, at least in the long term. When assigning all or at least a part of cross-border capacities to implicit auctions, the question then becomes, which organizational model to choose? In Europe, power exchanges have developed three basic models, which share a lot of similarities but also bear some important differences.

These three basic models of implicit auctions can be classified as:

- Market splitting (e.g. Nord Pool);
- De-centralized market coupling (e.g. trilateral market coupling between France, Belgium and the Netherlands); and
- Centralized market coupling or open market coupling (OMC) (as proposed by EEX).

In the following, we focus on the organizational and procedural differences between these three approaches. The three concepts are all based on the same basic principles with regards to price determination as they are based on bids on power exchanges. Consequently, one may reasonably expect that all models would render the same results, subject to some possible minor differences due to rounding (especially in an iterative process like de-centralized market coupling) and assuming an equal bidding structure (i.e. step-wise bids or linear interpolation). From a market perspective, all three models can therefore be regarded as equivalent.

Consequently, the relevant differences between these concepts mainly relate to organizational aspects and the clearing process as illustrated by Figure 12. In short, the three main differences effectively relate to the:

- Clearing process;
- Organization of the power exchange(s); and
- Responsibility for cross-border exchanges.

These aspects are discussed in more details for each of the three models below.

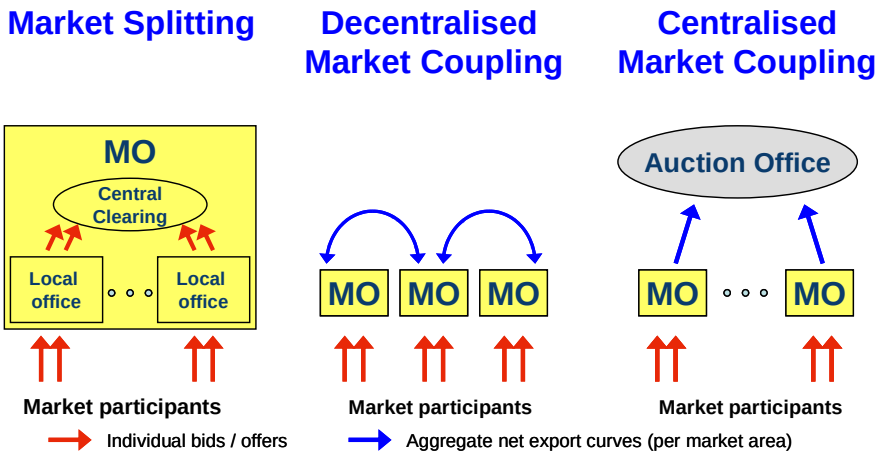


Figure 12: Comparison between market splitting and market coupling

Source: KEMA

Market Splitting

In case of market splitting, which has been successfully applied by Nord Pool in the Nordic market, the regional market is operated by a single power exchange. There is just one single organization, which will be located in one of the countries, although there may possibly exist with local branches in the countries of the regional market. In terms of bidding and clearing, market participants effectively submit their bids directly into one central trading system, even if they formally do so through regional branches. The subsequent clearing process is fully centralized and performed in a single step (i.e. within one system). Furthermore, this central clearing process is based on the individual bids and offers and immediately returns the results for every single market participant. The trading system thus largely resembles those of any market operator to date, with the exception that it must be able to handle different market areas and congestion between these market areas. Finally, the power exchange effectively becomes itself responsible for the transport of electricity between different areas as it is the only party involved on both sides of the border.

Decentralized Market Coupling

In contrast, decentralized market coupling, which represents the basis for the so-called Trilateral Market Coupling (TLC)[22] between France, Belgium and the Netherlands, relies on a fundamentally different approach. In this case, there exist several independent power exchanges, in an extreme case one in each country or the region. Instead of one single organization as under market splitting, de-centralized market coupling is thus based on the coordination between several independent market operators. Again, market participants submit their individual bids and offers to their local market operator, just as in the case of market splitting. However, in this case, each of the national market operators clears its own market, i.e. without consideration of imports and exports (step 1). In a second step, each market operator then produces an export and import curve, i.e. by determining the quantities that this market would be willing to export or import for different prices. After exchanging these export and import curves with their neighbors (step 3), each market operator clears its market again (step 4), but now under consideration of the export and import curves from adjacent markets. This process is then repeated iteratively, until the results converge to a stable solution.[23] When a stable solution has been found, each of the participating power exchanges has simultaneously determined the cleared quantities for every participant. It is only then that these results are communicated to the market.

This illustrates that decentralized market coupling requires a rather complex process, which may involve multiple iterations. This requires extremely reliable communications and trading systems that are capable of handling the entire process, including the establishment and exchange of export curves and the function of the 'regional coordination module'. Both aspects create cost and complexity, but the concept also allows for the continued existence of different trading systems and principles. Finally, it is worth noting that under the current example of TLC the physical exchange between different market areas is realized through bilateral

transactions between the TSOs and a corresponding set of transactions between each TSO and the local market operator. Consequently, the TSOs have to become special members of each power exchange.

Centralized Market Coupling

Centralized market coupling finally is again based on the existence of several independent market operators. This concept was originally proposed by the German power exchange EEX and will provide the basis for the upcoming coupling between EEX (Germany) and Nord Pool (Denmark only) in 2008. Also, this approach is similar to the second model in a sense that each power exchange first collects all individual bids and offers from local market participants, clears the local market and then determines an export and import curve. However, in contrast to the de-centralized model, these export and import curves are not exchanged between different market operators but are submitted to a single auction office. Based on the export and import curves submitted from each area,[24] this centralized institution then clears the entire regional market in one step, i.e. within one single clearing system. This clearing then results in a set of cross-border exchanges and national market prices, which are communicated back to each local market operator. In a final step, each power exchange then introduces the corresponding cross-border exchanges (and prices) into its own market, before performing a final local clearing, in order to determine the results for each market participant.

Compared to the previous concept, centralized market coupling thus requires a set of local trading systems as well as one regional clearing system. However, whilst the local systems have to be able to establish export/import curves (and import the resulting cross-border exchanges), they do not have to handle several market areas. Conversely, the centralized auction office must be able to handle the entire region, but based on a set of aggregate bids and offers only and without requiring interfaces to individual market participants. Furthermore, by performing the regional clearing within one single system, it is much easier to ensure convergence (within a reasonable time frame), and one avoids the risk of communication errors and/or delays, which exist under the decentralized approach. Overall, this model therefore requires an additional clearing system, but unarguably at the benefit of less complexity for each participating system.

Another difference again relates to the procedure for the use of cross-border capacities. In this case, there is an additional party, i.e. the auction office that becomes responsible for the allocation of capacity rights. The question then becomes whether each market operator has to purchase these rights from the auction office, or whether e.g. the auction office would effectively become a participant in each national market, but without submitting its own bids and offers. These considerations are largely related to legal issues.

Case Study: Open Market Coupling EEX and Nord Pool (planned)

Figure 13 shows the competences and duties within the open market coupling of Nord Pool and European Energy Exchange (EEX) that is supposed to start in the fourth quarter 2007. The proposed central auction office EMCC (European Market Coupling Company) is the centre for all information exchanges and communication between the participants. Ideally, there is no direct exchange between the TSOs and power exchanges. This leads to a clear separation of the functions of the power exchanges and the allocation of available capacities (ATC), which is taken over by the EMCC. In addition EMCC is responsible for the distribution of revenues.

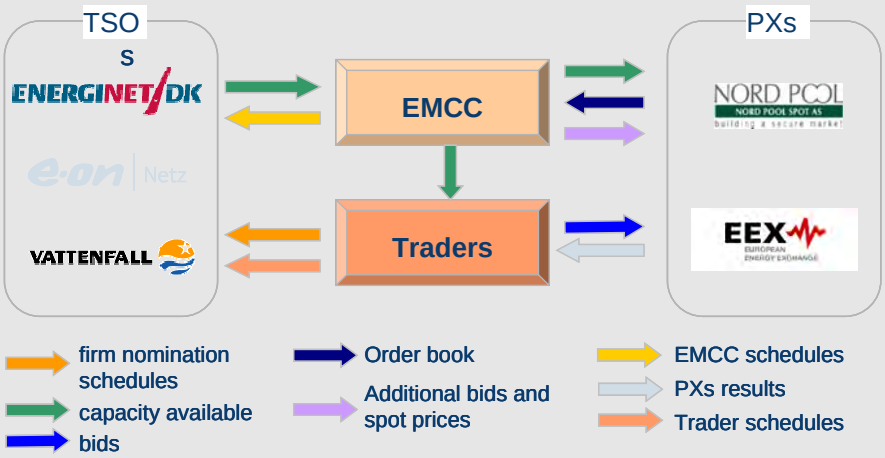


Figure 13: OMC between Nord Pool and EEX (planned)

Source: E.ON et al. (2007)

3.7.3. Regional Integration vs. Establishment of Separate Organized Markets

When introducing the two basic models for wholesale electricity markets in section 3.1 we have explained that a centralized pool is by definition based on a single market operator with compulsory participation in the pool. However, we have also pointed out that bilateral contract markets are often supplemented by voluntary organized markets. Indeed, to date power exchanges have been set up in all markets that are based on bilateral contracts in Western Europe as well as in several Central and Eastern European countries. At the same time, only a few of these power exchanges can be regarded as truly successful, whilst most of them – in Western and Eastern Europe alike – suffer from low trading volumes and lack of liquidity. Although the range of less successful power exchanges includes the UK market, we note that such problems can especially be observed in smaller countries, markets with a high degree of concentration or the continued existence of regulated end-user tariffs.

Since these features are characteristic for many countries being members of ERRA it seems useful to consider the following questions:

- Are there any potentially negative effects of creating a Market Operator especially in countries with limited scope for competition?
- What are the preconditions for the successful establishment of an organized market?
- How may regional integration help to establish functioning markets in countries with limited scope for competition?

As explained in section 3.3.3 properly working organized markets offer a number of significant benefits, like concentration of liquidity, the provision of a commonly accepted reference price or a reduction of credit risk. On first sight, the establishment of an organized market could therefore be seen as an important objective in the design and implementation of a bilateral contracts market. There are however several important aspects to consider: First, these benefits depend on the proper functioning of the corresponding markets, including a sufficient level of liquidity. The mere existence of an organized market does therefore not necessarily facilitate progress towards effective liberalization and competition.

Secondly, although existing power exchanges in Europe largely share the same basic mechanism they nevertheless inhibit a number of important differences in detail. As proven by prior and current experience from in Western Europe, market coupling may therefore require a number of important changes to the design of the organized market, i.e. its rules, systems and contracts. In many cases, it may therefore be easier to extend the exchange model from one country to another, rather than trying to harmonizing the design of two existing power exchanges. In this respect, the 'premature' establishment of market operator may therefore complicate the road towards future regional integration.

Thirdly, one has to bear in mind that the establishment and operation of an organized market comes at certain costs, i.e. namely for the organization and IT systems of the market operator. Although the corresponding costs, which may easily reach several million Euros annually, may appear as small in relation to the overall market volume (i.e. national consumption), they are nevertheless significant especially in smaller countries. When put into relation into potential trading volumes they may result in excessive trading fees for exchange participants or, alternatively, require separate mechanisms to compensate for the remaining loss. Indeed, trading participants regularly complain about current trading fees at several Western European exchange, stating that it may be considerably cheaper to trade through brokers, which obviously represents a substantial risk for the success of an organized market. In summary, one should therefore carefully analyze whether the costs of establishing an organized market are justified in relation to the potential benefits, which are strongly related to the expected success of the corresponding market.

These considerations are closely related to the second question raised above, i.e. the preconditions for the successful establishment of an organized market. Such preconditions relate to overall market design and rules, on the one hand, and the underlying market struc-

ture, on the other hand. To start with, a power exchange will only be successful if at least the wholesale market has been opened to a certain degree and if market participants have effective and non-discriminatory access to the network, including imbalance charges that are also tolerable to new entrants and smaller market participants. At the same, we note that e.g. the development of EEX or Powernext has shown that an organized market may be relatively successful even in an environment, which still has many shortcomings in this respect.

The second group of preconditions basically implies that a functioning market requires a sufficient number of market participants, which can compete with each other at different price levels. This fundamental precondition is obviously unlikely to be met in countries with a dominant or even monopolistic player, or if producers have very different production costs. Further obstacles in this respect include e.g. the existence of a single-buyer scheme, large-scale power-purchase agreements (PPA), regulated wholesale prices or feed-in tariffs and other subsidy schemes, which may effectively exclude significant parts of the industry from the market. Arguably, these aspects therefore are arguably even more important. Unfortunately, we believe that many of these obstacles are currently present in many of the countries being represented by ERRA, including both smaller and larger markets. It therefore appears that it may not easily be possible – if at all – to establish national market operators in many of these countries.

This highlights the importance of the last question mentioned above, i.e. to which extent regional integration may help to provide the necessary preconditions in this respect. For this purpose, it is instructive to consider e.g. the case of the Belgian electricity market, which is of limited size and is strongly dominated by one single player with almost 90% of total production capacity. As a result, there was a common agreement that it would not be possible to establish an isolated national market. It was only in November 2006, i.e. several years later than in neighboring countries, that the current power exchange BelPex was successfully created. This development was however only made possible by the simultaneous introduction of market coupling with France and the Netherlands. This did not only allow Belgium to largely rely on the existing organization and systems of APX (in particular with regards to clearing and settlement), which resulted in considerable cost savings. Even more importantly, by reserving a certain proportion of cross-border capacities for allocation by implicit auctions it has been possible to 'import competition'. As a result, the Belgium formed e.g. part of a larger combined market with France and/or the Netherlands for some 98% of time in January 2007 (see Figure 14), which has removed the dominant position of the incumbent company for almost all the time.

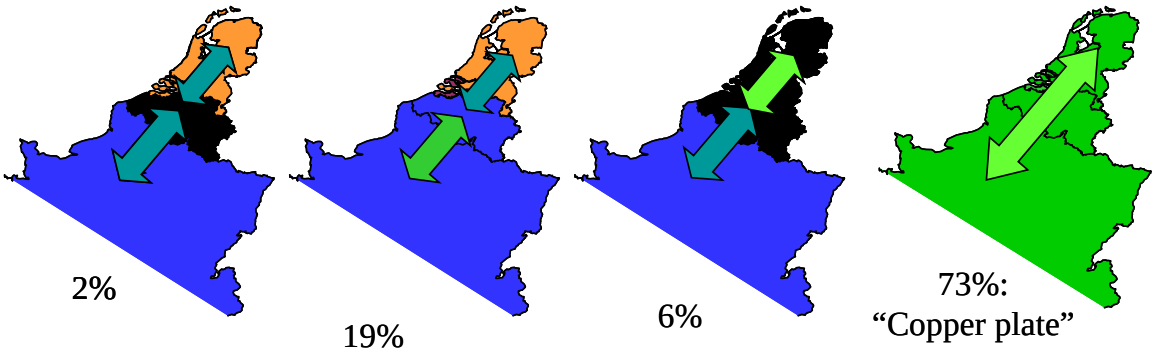


Figure 14: Price convergence in the TLC-area (January 2007)

Source: APX

This development, which partially resembles former experiences from the integration of Western and Eastern Denmark into Nord Pool, clearly shows how regional integration may enable the establishment of organized markets even in countries, which lack the necessary preconditions on their own. In turn, this suggests that a possible strategy for those ERRA members facing the problems mentioned above could be to refrain from the creation of a separate national market operator but to focus instead on joining one of the emerging regional markets. At first, this would most likely be feasible for those countries at the perimeter of one of the existing or currently emerging markets, such as Nord Pool (Baltic States), the Central-West Initiative (+ Austria?) or, possibly, one of the current initiatives in South-Eastern Europe, whereas it does obviously represent a medium-term option for other countries only. Finally, we note that this strategy is basically independent of the choice for one of the models described in section 3.7.2, i.e. it might still be possible to either establish a separate national exchange or to join a regional market operator.

3.7.4. Definition of capacity rights: NTC vs. PTDF

Today, transmission capacities in Europe are commonly specified in form of so-called transfer capacities. The transfer capacity is defined as a (commercial) exchange program that can be realized between two different control areas. In this context, an exchange program represents a transaction / exchange of power between two different parties that can be notified by the corresponding parties to the TSOs during the scheduling process. In essence, an exchange program therefore represents a transaction or 'commercial program' between two system users or regions. Conversely, it is important to note that the transfer capacity is not generally equivalent to the physical flows across a given border, but merely indicates the amount of commercial transactions that can be executed across the corresponding border.

The detailed specifications regarding the definition and determination of transfer capacities have been defined by the association of European Transmission System Operators (ETSO). Overall, ETSO has specified a total of four different parameters, which jointly describe the

maximum permitted use of an electrical border between two or more control area. These different determinants, which are also illustrated in Figure 15, can be summarized as follows:

- The **Total Transfer Capacity (TTC)** defines the maximum exchange program between two control areas that is compatible with operational security standards applicable at each system if future network conditions, generation and load patterns were perfectly known in advance.
- To take account of the necessary security margins that are required to cope with uncertainties,[25] the TTC is reduced by the so-called **Transmission Reliability Margin (TRM)**, which specifies the amount of TTC that cannot be used for commercial purposes but has to be reserved for operational purposes.
- After subtracting the TRM from the TTC, one receives the **Net Transfer Capacity (NTC)**, which is defined as the maximum exchange program that can be safely executed between two control areas under consideration of uncertainty.
- When furthermore taking into account any capacity rights or exchange programs that have already been awarded / notified before,[26] the **Available Transfer Capacity (ATC)** finally represents the remaining transfer capacity that can still be allocated to the market and be used for commercial transactions.

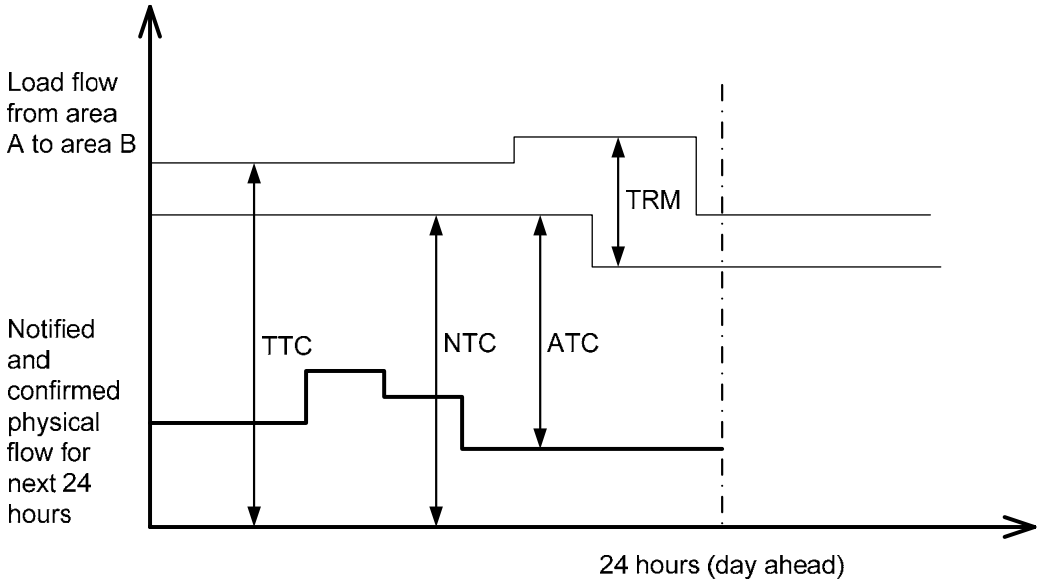


Figure 15: Main determinants of transfer capacities (example of 24 hours)

Source: ETSO

Program-based transfer capacities have however two main disadvantages. First, transfer capacities do not generally allow making use of all possible combinations of exchange pro-

grams that might be possible in theory. And secondly, the determination of these capacities is strongly influenced by several subjective assumptions to be taken by different TSOs. As a consequence, there is an increasing trend towards the application of so-called flow-based mechanisms and border capacities.

In contrast to transfer capacities, border capacities and flow-based mechanisms are based on physical flows. This is achieved by not considering all exchange programs directly, but by first converting each commercial transaction into a set of physical flows, based on the use of so-called **Power Transfer Distribution Factors (PTDF)**. A PTDF represents the share (percentage) of energy that flows via a given cross-border interconnection for a given exchange program between two control areas. These PTDFs are calculated by the TSOs based on a DC load-flow analysis. The results of this analysis represent an approximation of physical flows in a (AC) transmission network.

The background and meaning of PTDFs can be explained by the very simply electrical network shown in Figure 16. This simple meshed network consists of three nodes and three connections in between, all of them with the same electrical impedance.

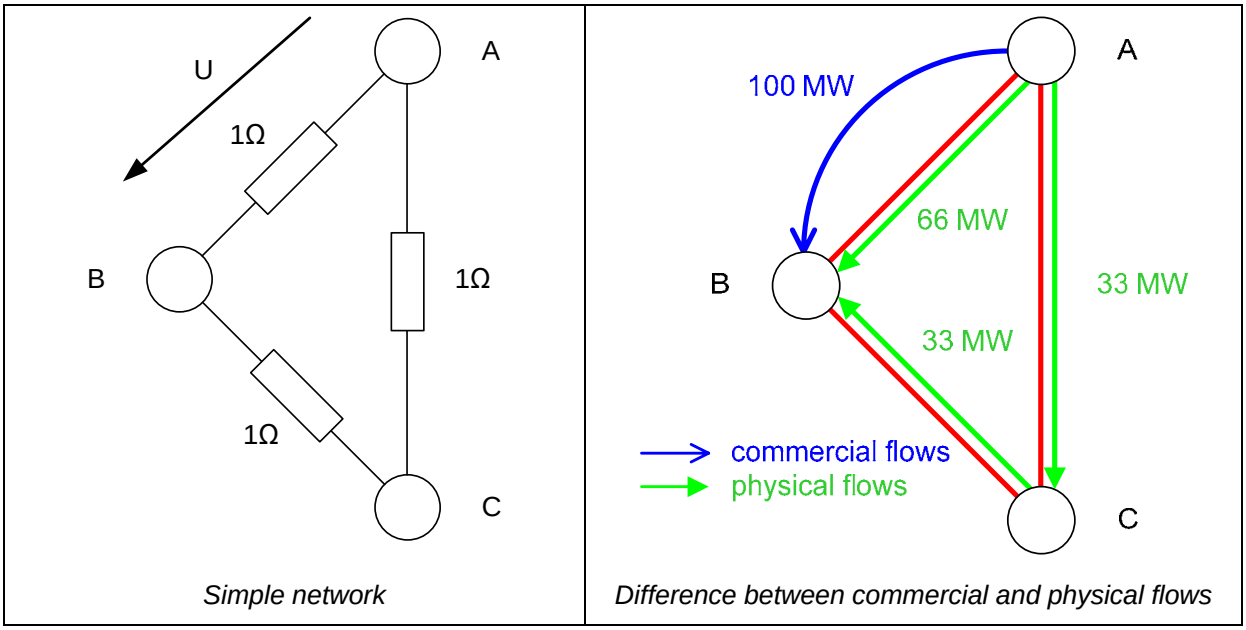


Figure 16: Concept of PTDFs in a three-node network

Under these circumstances, only 66% of a desired flow between nodes A and B will actually flow across the corresponding link A→B, whilst the remaining 33% will flow from A to B via C. This allows determining an equivalent set of Power Transfer Distribution Factors (PTDF) for this example as shown in Figure 16.

These numbers can now also be applied to e.g. a commercial transaction of 100 MW from area A to area B. As shown in Figure 16, this transaction would only use a capacity of 66

MW on the cross-border interconnection between A and B, but an additional 33 MW on the two links between areas A→C and C→B. This simple example therefore illustrates how a given commercial transaction (or exchange program) can be converted into a set of physical flows between different areas by means of PTDFs.

These considerations also indicate that it is insufficient to only consider the available capacity between the two areas directly involved in a given transaction, like areas A and B in this example. If for example the capacity of the cross-border connection between A and C was limited to 25 MW, a transfer of 100 MW from A to B would not be possible. Besides information on the PTDFs, flow-based approaches therefore also require information on the so-called **Border Capacity (BC)**. Similar to the use of transfer capacities, the BC can be defined as the maximum physical exchange that can be safely executed across a given electrical border without endangering the security of the power system.

Border capacities are determined through the same general process as applied for NTCs. Moreover, it is again possible to differentiate a number of different indicators, similar to the use of TTC, NTC and ATC. As also shown in Figure 17, these indicators primarily include:

- **Notified Transmission Flow (NTF)** is the physical flow over the tie-lines between the considered areas observed in the base case model prior to any generation shift between the areas. It results from the set of Base Case Exchanges (BCE).
- **Additional physical flow ΔFmax** is the physical flow over the tie lines between two areas, induced by the maximum permissible generation shift ΔEmax.
- **Total transfer Flow (TTF)** or **Border Capacity (BC)** is the net physical flow across the border associated with an exchange program of magnitude TTC, provided that no other exchanges have been modified from the base case (except the one between the two areas between which the TTC is calculated).

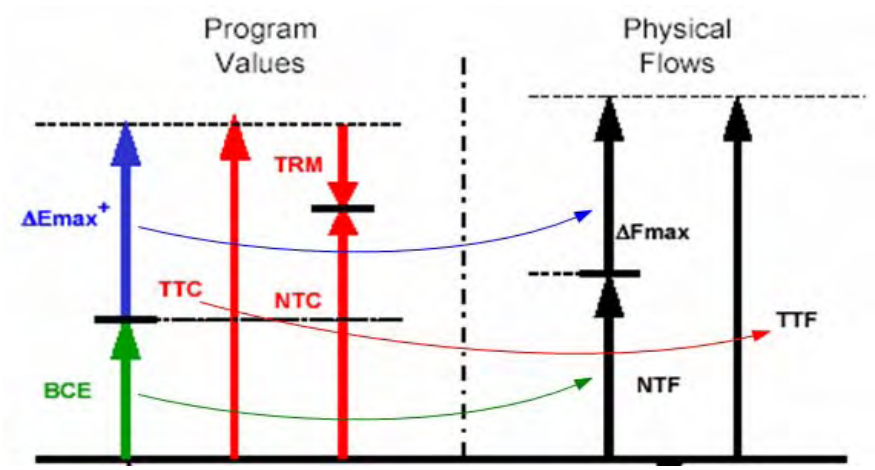


Figure 17: Comparison between TTC and TTF

Source: ETSO

Despite these similarities, it is important to note that BCs cannot be directly compared with NTC values. Namely, whilst BCs represent physical limitations for cross-border flows, NTCs represent available commercial capacities. Whilst transfer capacities relate to commercial transactions or exchange programs, flow-based border capacities are always connected with actual physical flows that could also be metered in practice. In combination with Figure 17, this observation allows drawing an interesting (even if somewhat simplified) conclusion: Namely, the border capacities used in a flow-based mechanism are roughly equivalent with the border limits shown in Figure 17. In other words, there is a direct relation between the determination of transfer and border capacities. However, using border capacities has two main advantages:

- The size of border capacities primarily depends on the technical parameters (impedance, maximum limits) of different network elements, which are known and can be assumed to be largely constant. In contrast to transfer capacities, however, the choice of the base case only has a minor influence on the resulting capacities.
- Since border capacities are not directly related to any commercial transactions, flow-based approaches principally allow using the entire solution space defined by the different border limits (compare Figure 17).

As a result, flow-based mechanisms are less dependent on subjective decisions and allow for a much better use of technically available cross-border capacities. Although it is true that the existing models of market splitting and decentralized market coupling are based on the use of NTCs, whilst the concept of OMC has been presented as a flow-based mechanism, each of these mechanisms could use NTCs just as well as BCs.[27]

3.8. Regional Integration: Balancing Services

Besides the integration of national wholesale markets, the establishment of a truly regional market would also benefit from the integration of national balancing markets. At least some form of cross-border coordination in terms of system balancing is a necessary precondition for the introduction of implicit auctions. Furthermore, the integration of national balancing markets offers clear benefits due to access to additional reserve capacities and the chances of an improved utilization of existing balancing services, especially in a region with different generation structures. In this context, it is worth noting the corresponding initiative by SETSO on the establishment of a regional balancing mechanism as e.g. presented during the last Athens Forum in October 2006. This project falls short of a full integration of national balancing mechanism and has been explicitly limited to the exchange of available balancing energy (not reserve capacities) during real-time operation. Nevertheless, it provides an important step forward in terms of a more coordinated use of available balancing services, thereby

promoting both security of supply and efficiency. Furthermore, it may also serve as a starting point for a true integration of national balancing mechanisms in a second step.

In contrast to the integration of wholesale market, there has been relatively little progress on the integration of balancing mechanisms so far. To date, the common Nordic balancing mechanism represents the only functioning example of a truly multinational market. In addition, the German balancing mechanism by now covers four independent control areas, each being operated by a separate SO. Finally, the UK system operator National Grid routinely uses balancing offers from France, whilst the French balancing mechanism benefits from the participation of Swiss and German producers. Generally speaking, however, integration at all other European borders has so far been largely limited to the mutual provision of emergency reserves. Nevertheless, several initiatives have been started or are being studied.

In general, one can identify two different concepts as also illustrated by Figure 18:

- Actor-TSO; and the
- TSO-TSO model.

The main difference between the Actor-TSO and the TSO-TSO model is whether reserves provider of one market area offer their services directly to the SO in another area (Actor-TSO model) or exclusively to the local SO (i.e. in Figure 18: their own area), whilst the exchange of balancing services is handled between the system operators of the corresponding control areas (TSO-TSO model).

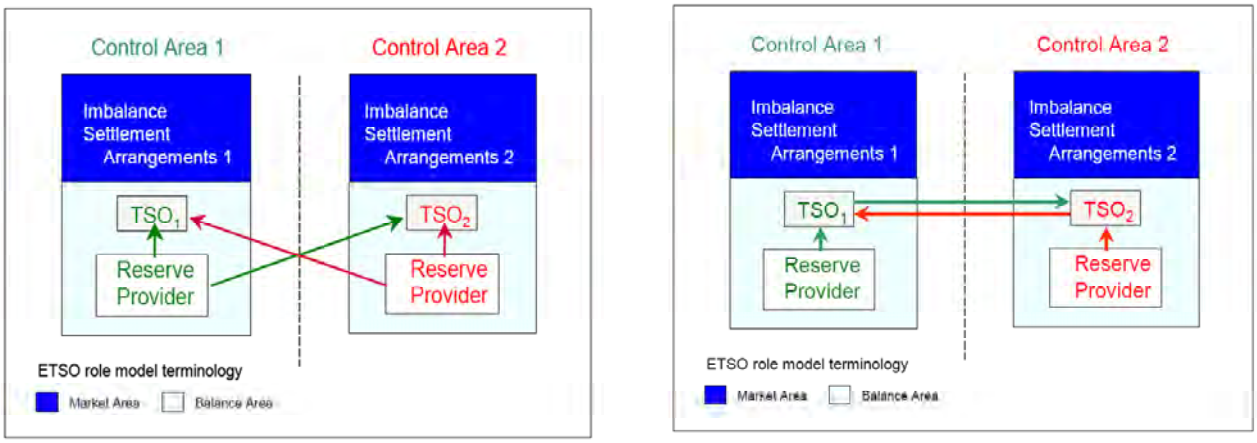


Figure 18: Basic concept of the Actor-TSO (left) and TSO-TSO model (right)

Source: ETSO (2005)

Under the Actor-TSO model, each (foreign) balance provider is offering his services to the TSO on an individual basis. As a result, the balance provider is himself responsible for being able to make the corresponding services available to the TSO. In some cases, this may involve the reservation of sufficient cross-border capacities, although this is not generally the

case. Most importantly, however, the Actor-TSO model will typically require the external bidder to make all necessary nominations in its own control area whenever the 'requesting TSO' has activated an offer. Depending on the conditions of the 'connecting TSO' (i.e. the TSO where the external bidder is located), this includes:

- The (counter-) nomination of the resulting cross-border exchange, i.e. to match the corresponding nomination by the requesting TSO, and
- The modification to the bidder's own production schedule (where applicable).[28]

Conversely, under the TSO-TSO model, all balance providers exclusively offer their corresponding services to the 'local' TSO, i.e. the TSO of the control area, in which the corresponding plants are located. Any exchange of balancing services is therefore directly agreed upon, and realized, between the two TSOs concerned.[29] In practice, there exist examples of both models:

Case study: Actor-TSO and TSO-TSO Model in practice

The current import by France of balancing services from Germany and Switzerland is based on the Actor-TSO model, whilst the exchange of balancing services across the UK-France interconnector is effectively based on the TSO-TSO model.[30] For imports of balancing services into France, RTE usually deals with limited cross-border capacities itself, at least at the borders to Germany and Switzerland. Conversely, the tendering conditions of the German TSOs clearly state that any potential bidder from another control area must guarantee delivery, including sufficient access rights to cross-border capacities.

4. THE ROLE OF THE MARKET OPERATOR

4.1. General Role and Functions of a Market Operator

In chapters 2 and 3, we have frequently referred to the notion of a 'market operator'. Moreover, we have generally defined a market operator in section 2.1 as a centralized institution being responsible for operation of an organized market for the (commercial) exchange of energy or other products on behalf of market participants. This definition highlights three important aspects that are characteristic for the notion of a market operator as being understood in this report:

- A market operator represents a single institution being responsible for operation of a given market on behalf of all existing or potential market participants;
- The corresponding market is organized in a sense that it follows a set of explicit rules and conditions for standardized products, which the MO and all market participants have to comply with; and
- The market facilitates the commercial exchange of a certain product between different market participants, resulting in a set of commercial transactions, obliging the sellers to 'deliver' the corresponding 'products' to the buyers subject to the market rules mentioned above.

It should be noted that this definition conceptually extends far beyond the trading of commodity energy within a pool or power exchange. For instance, one may reasonably argue that the allocation of cross-border capacities (see section 3.7.1), the procurement of reserves and balancing services through a market-based mechanism (see section 1.1) or operation of a market-based capacity mechanism (section 3.6) also represent organized markets. In a wider sense, system operators therefore often have to at least partially assume MO functions, even though there may be other market operators as well, as discussed in more detail in section 4.2 below.[36] Conversely, we note that a broker does not represent a market operator as brokered contracts typically allows for negotiated and hence tailored solutions, in contrast to a standardized product definition in an organized market.

Regardless of which market model is adopted, market operators have to perform the following general functions in order to facilitate the functioning of the market:

- **Registration of market participants**

  The market operator has to register all market participants that are eligible and wish to participate in the market. Depending on the market and the range of products, this

may include producers, suppliers or traders. In order to participate in the market, potential participants to submit an application and typically sign an agreement, which specifies all rules and procedures, which the market participant must adhere to.

- **Receiving bids/offers from market participants**

  One of the main functions of the MO is to organize the trading of electricity. This implies that sellers and buyers submit to the MO their bids and offers for the market they want to trade within the specified time-frame. The timeframe and procedures of how to bid/offer are normally in the market rules and are also published on the respective website of the power exchange.

- **Market Clearing**

  Once bids and offers have been submitted by market participants, the market operator clears the market, i.e. it matches offers to sell with bids to buy. Depending on the choice between continuous trading or closed auctions (see section 3.3.3), this may either be a permanent process, whilst the market is open for trading, or a single activity taking place after the deadline for submission of bids and offers. As a result of market clearing, the MO will establish firm transactions for the 'delivery' of the corresponding products, which may either be between the MO and individual participants or, in case of a brokered market, between different market participants.

  After market clearing, the market operator will notify market participants about the accepted quantities and prices, publish certain information subject to the market rules (such as market prices and volumes) and, where applicable, also forward certain information to the system operator.

- **Delivery, Settlement and Invoicing**

  Once the market has been cleared and the final transactions been established, the final duty of the market operator is to ensure settlement and invoicing and, in a physical market, also delivery of the corresponding services. In a market for commodity energy, physical delivery is typically ensured by notifying the corresponding contractual volumes to e.g. the system operator, which then establishes an obligation on the contractual parties (including the MO) to nominate a corresponding exchange during the scheduling process. Settlement and invoicing, on the other hand, covers the determination and realization of payments to be made to and by the MO. Please note that these tasks are often delegated to separate settlement administrators.

4.2. Relation between Market and System Operation

As already mentioned in the previous section, it is sometimes questionable whether a certain activity should be regarded as a function of the market or the system operator. Whilst this differentiation can be considered as fairly straightforward in terms of the 'energy only' commodity market, the issue becomes more complex when taking account of market-based mechanisms for balancing and ancillary services, capacity tickets or the allocation of cross-border capacities. Although the latter type of mechanisms is typically characterized by only a single buyer or seller on one side of the market, i.e. the system operator, it may nevertheless be interpreted a market operation.

Before discussing the different allocation of these functions to system and market operator, it seems useful to first define the generic functions of a market operator, on the one hand, and a system operator, on the other hand. For this purpose, Table 8 compares the key functions of a market operator (as defined in section 4.1) with those of a system operator. It is clearly visible that the MO facilitates the commercial exchange of certain products between different market participants, whilst the SO primarily serves technical purposes. Consequently, the basic functions of a system operator are basically the same in any market, whereas those of a market operator are strongly influenced by the actual market design of a given market.

Table 7: Generic functions of market and system operation

Market Operator	System Operator
• Operate and/or facilitate the market • Registration of market participants • Receiving bids/offers from market participants • Market clearing • Settlement and invoicing	• Operate the system,[(a)] ensure reliability and security • Real-time dispatch to balance supply and demand • Managing ancillary services to maintain system reliability • Manage congestion

[(a)] – Or at least coordinate the operation of the system (in case of an ISO)

In practice, the responsibilities for market operation may be distributed to one or more institutions. In this context, it is interesting to note that European markets typically show a different structure than e.g. those in Northern America. As illustrated by Table 8, market operation and system operation are usually integrated and are the responsibility of an Independent System Operator (ISO) in the U.S. In contrast, at least the energy (commodity) market is usually considered a separate activity in Europe, which is performed by a distinct market operator, whereas the procurement of ancillary and balancing services or the allocation of transport capacities are mostly – but not always - performed by the system operator.

Table 8: Separation between MO and SO functions in different markets

"Market"	PJM (U.S.)	Spain	Scandinavia	Belgium	Great Britain	Romania
Energy	SO/MO	MO	MO	MO	MO	MO
Ancillary services	SO/MO	MO (D-1) SO (real-time)	SO	SO	SO	SO
Balancing			SO	SO	SA / SO	SO
Transport capacities	SO/MO	MO	MO	AO (forward) MO (spot	SO	SO
Similar examples	*NYISO, NEMMCO*	*Italy*	*-*	*France, Netherlands*	*Austria*	*Germany*

Note: MO – Market Operator; SO – System Operator; AO – Auction office (SO-owned); SA – Settlement Administrator

As explained in chapter 3.1, most wholesale electricity markets in the U.S. are based on a centralized pool with amongst others a real-time market based on nodal pricing. On first sight, one might therefore conclude that the integration of market and system operation is a typical feature of pool-type markets, or at least for a real-time market with nodal pricing. As the examples of Spain and Italy in Table 8 show this is however not necessarily the case since both countries rely on a pool operated by a market operator, whilst real-time operations are performed by an independent system operator. Furthermore, we note that these functions are also split in e.g. New Zealand or Singapore, although both markets are based on real-time markets with nodal pricing as well. We therefore conclude that operation of the energy (commodity) market is a market operator function, which does not necessarily have to be integrated with system operation and should thus be regarded as a distinct function.

The different market structure nevertheless plays an important role. For instance, we have explained before that many European markets are based on bilateral contracts but are supplemented by a voluntary power exchange. These power exchanges are typically operated by independent commercial entities, which are profit-oriented enterprises. As a result, the operator of a voluntary power exchange has a vital commercial interest in the success and acceptance of an organized market place and must adjust its products and conditions to the desires of market participants. Conversely, system operation ultimately represents a regulated activity, which is provided from a monopoly position and which shall ensure a given service at the lowest possible costs.

In contrast to the energy market, at least the utilization of ancillary and balancing services is a core function of the system operator. As Table 8 illustrates, it is nevertheless possible to provide for a partial involvement of independent market operators, e.g. when performing an advance tendering of reserves or for collection of bids/offers and settlement. Finally, we note that European markets also show approaches for distributing the responsibility for allocation

of transport capacities, even though this can be considered as a core function of system operators as well. Indeed, the recently signed Memorandum of Understanding (2007) for the establishment of regional market between France, Belgium, the Netherlands, Luxemburg and Germany clearly states that:

- *'Allocation of capacity is a regulated activity, and TSOs must have appropriate control in this respect;*
- *Power Exchanges products, services and prices fixing are an exchange responsibility, and PXs must have appropriate control in this respect'.*

Although these statements must be seen in the light of the specific situation of the Central Western European regional initiative on market coupling and the different legal and regulatory constraints in the participating countries, we nevertheless believe that the key message also applies for the idea to confine SO and MO activities.

4.3. Market Governance

As stated in section 4.1, organized markets must be based on a clearly defined and non-discriminatory set of explicit rules and conditions. From a regulatory perspective, it is furthermore necessary to generally ensure a fair and transparent access to and functioning of the market. It thus follows that electricity markets require a minimum level of market rules and regulatory oversight. Whilst some of these functions have to be performed by regulators (see section 5.1 below), others may or even should be delegated to the market operator. In practice, it is however important to note that market operators also represent separate organizations. Especially when being organized as profit-oriented enterprise, these may have to follow their own objectives, which may not necessarily have to be the same as the overall market. It therefore seems useful to clearly differentiate between corporate and market governance as illustrated by Table 9.

Table 9: Corporate vs. market governance

Corporate Governance	Market Governance
• Management of a single company as commercial enterprise • Rules and procedures for making decisions on corporate affairs • Setting, obtaining and monitoring company objectives • Protecting interests of owners / shareholders	• Supervise the development and operation of a market • Decisions on (further) development of the market • Monitor and ensure proper functioning of market • Protect interest of stakeholders (i.e. market participants and consumers)

Corporate governance is related to the management of a single company as a commercial enterprise. In this regard, it represents a structure for a single commercial entity, spelling out

the rules and procedures for making decisions on corporate affairs. Amongst others, corporate governance thus provides the structure through which the company objectives are set, as well as the means of attaining and monitoring the performance of those objectives. In essence, corporate governance stems from the need to protect the rights of the company's owners (i.e. the shareholders).

In contrast, **market governance** has a much wider scope as it concerns the development and operation of a market (or industry). In essence, it thus has provide a reasonable framework for ensuring a proper protection of the interest of different stakeholders in the wholesale market, including e.g. market participants (like traders), the market operator, possibly the system operator and, last but not least, consumers. In this regard, market governance provides a structure for decisions on the future development of the market place and for monitoring and ensuring that the objectives are actually met with a particular focus on the (commercial) interests of the users. In a wider sense, market governance includes all measures aimed at providing for a fair and non-discriminatory market place, including governmental and/or regulatory rules and interventions. This includes e.g. the definition and adjustment of rules and regulations, market monitoring and dispute resolution.

In this context, it should be noted that the scope and structure for market governance strongly depends on the underlying market structure. For instance in a mandatory market, market governance has to serve public interests, such as providing a transparent, non-discriminatory and efficient market. Simultaneously, it will often be possible to impose necessary amendments. Conversely, in a voluntary market, such as those operated by a power exchange, the focus will naturally be on complying with the demands of market participants. More importantly, however, it is important to note that the market operator (and the regulator) may not have any direct rights to influence the further development of the market, other than those stipulated in the underlying market rules. These aspects have to be taken into consideration when deciding on an appropriate structure for market governance (see Table 10).

Table 10: Approaches of market governance

Regulatory supervision	Self-governance	Advisory body
• Market rules prescribed ***/*** approved by regulator • Commonly applied in markets related to system operation • Possible influence of financial regulator on power exchanges	• Rules established and agreed by market members • Consultation and approval • Common for voluntary markets and in Anglo-Saxon countries	• Collaborative approach to provide forum for wider group of stakeholders • No decision-making power

The most direct way of market governance obviously is **regulatory supervision**, even though the degree of the regulator's involvement may vary e.g. with the maturity and the level of liberalization and competition in the respective markets. As a general rule, however,

one will typically find this approach in markets related to system operation or other regulated activities, i.e. where the primary activities are already subject to regulation. The degree of regulation may range from ex-post oversight over monitoring and approval of market rules to the actual development of the relevant rules and conditions by the regulator. This aspect will be further discussed in section 5.1 below. It should however be noted that this process may not only involve the energy regulator. Besides the role of the competition authority, this is particularly relevant for financial trading and operation of power exchange, where the financial regulator often has a direct role.

The concept of **self-governance** can in general terms be defined as the autonomous organization of (parts of) the electricity and gas market without any direct intervention of a regulatory institution. This has been e.g. the case for the organization of third party access to the network infrastructure in the German electricity and gas market until the enactment of the new Energy law in July 2005. Similarly, the market rules of most European power exchanges are at least partially based on self-governance as they are decided by specific body of market representatives. For instance the *Balancing & Settlement Code* in Great Britain provides for a certain structure for dealing with proposed amendments in a structured manner. In Germany, a so-called *Exchange Council* is responsible for the approval of market rules and for the appointment, supervision and dismissal of the directors of the exchange (in agreement with the responsible governmental body, i.e. the State of Saxony). Although these responsibilities are ultimately defined in the German Exchange Act, the execution of these powers is left to the exchange council whose members are elected from the range of market participants (with a minimum representation of different types of market participants).

The Dutch power exchange APX represents a hybrid form of these two approaches. In principle, APX is free to organize its market place within the boundaries of the Dutch Electricity Act and related secondary legislation, the Dutch Civil Code and other applicable laws. According to the APX market regulations, trade on the day-ahead-market is supervised by APX itself according to the rules laid down in its regulations. All participants are bound to the regulations through a participation agreement concluded with APX. In order to manage any disputes and complaints the APX has established an independent *Appeals Committee,* which all participants can appeal to. In addition, APX may take disciplinary measures stipulated by the regulations for the day-ahead market, such as suspending a participant for a maximum of six months if this participant has not breached a condition of the participation agreement. Any complaints against such decisions by APX can be lodged with an independent Appeals Committee, which has its own proceedings for dealing with complaints and is independent from the management or supervisory board of the APX.

Besides regulatory oversight and self-regulation, **advisory bodies** may also play an important role in market governance. Corresponding bodies are often set up on a supplementary basis and represent a collaborative approach, which provides a forum for wider group of stakeholders. Whilst corresponding bodies are often set up as committees with representa-

tion of different types of stakeholders, they differ from the examples mentioned above insofar as they may not necessarily have decision-making powers, i.e. their role may be limited to a purely advisory function. This structure is common in many Anglo-Saxon markets, both for the governance of organized markets and for the supervision and development of commercial and technical market rules (e.g. Grid Codes or Network Codes etc.). Similarly, the Spanish wholesale market operator OMEL performs its functions under the monitoring and control of a *Market Agents' Committee*. The Market Agents' Committee is a body on which all main stakeholders involved are represented. The mandate of this institution is the monitoring and supervision of the economic management of the system. More specifically, the Market Agents' Committee shall amongst others monitor the functioning of the market, help to identify any problems, and make proposals for improving the market rules.

4.4. Market Monitoring

Effective market monitoring is a crucial precondition for the successful functioning of any electricity market. It involves a number of different activities, which can be briefly summarized as follows:

- Continuous analysis to identify potential problems requiring further study (including design flaws and undesirable behavior);
- Investigation of any problems identified by own screening, or in response to complaints from others;
- Taking corrective actions (where applicable), initiating and recommending rules changes and other improvements;
- Regular reporting on the results of analysis and investigations; and
- Collecting and publishing other relevant market information.

Thee functions are also reflected by the generic block diagram of relevant processes in Figure 19. The first level of market monitoring is the collection of qualitative and quantitative information on the functioning of the market. This information can be used for the calculation of specific indicators or, more generally, continuous market analysis, which may help to identify specific issues, such as design flaws or undesirable behavior by individual market participants. Where corresponding problems have been identified, or been reported by other parties, a detailed investigation of these issues represents the next step. This in turn may require a series of other steps, such as escalating the issue to other authorities like the competition authority or taking corrective actions. The latter exceed beyond market monitoring and may involve initiating or at least recommending rule changes or taking actions against a party having been found guilty of rule breaches. Finally, market monitoring also involves

other regular activities, namely the preparation of confidential reports for internal purposes and the publication of other data and reports to the public.

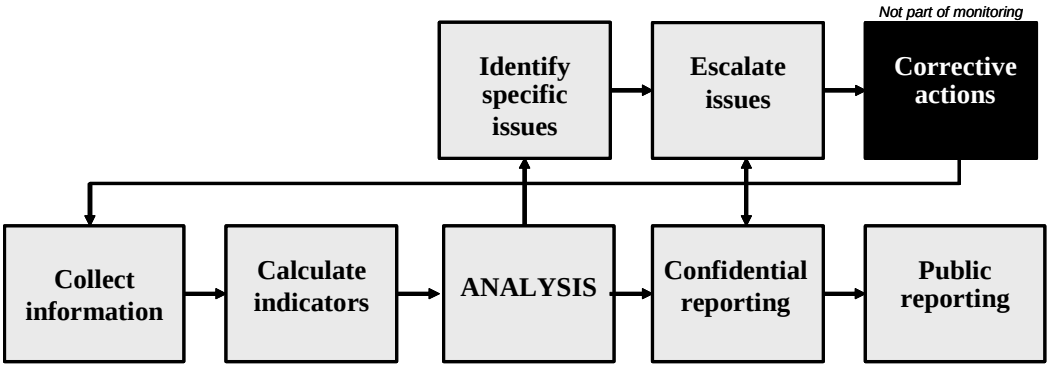


Figure 19: Generic structure of market monitoring

4.5. Role of the Market Operator for Market Monitoring and Development

In the following section, we have briefly summarized the scope of market monitoring. For the execution of monitoring activities, it is however also important how these tasks are handled from the organizational point of view. For the purpose of this report, this question is particularly relevant with regards to the distribution of responsibilities between the market operator, on the one hand, and the regulator, on the other hand. In the following, we first focus on the responsibilities and activities of the market operator, whereas we deal with the involvement of regulators in section 5.2 below.

To start with, it is worth noting that successful monitoring crucially depends on adequate information, such as individual offers, market prices and volumes etc. In practice, this often results in two main problems being related to:

- Availability of information; and
- Access to information.

First of all, it is paramount that information is at all available such that it can be used for monitoring purposes. Although this statement appears trivial, we emphasize that information on individual transactions is not typically available to any central institution in a bilateral contracts market. As also illustrated by Figure 20, market monitoring therefore is inherently more difficult in bilateral than in mandatory markets. However, even where this information is physically available, the corresponding institutions must also be entitled to use it for monitoring purposes, which may not be permitted without a specific legal mandate. Indeed, many European market operators and regulators face the problem that they are not legally entitled to access and use the information, which they would need for effective monitoring.

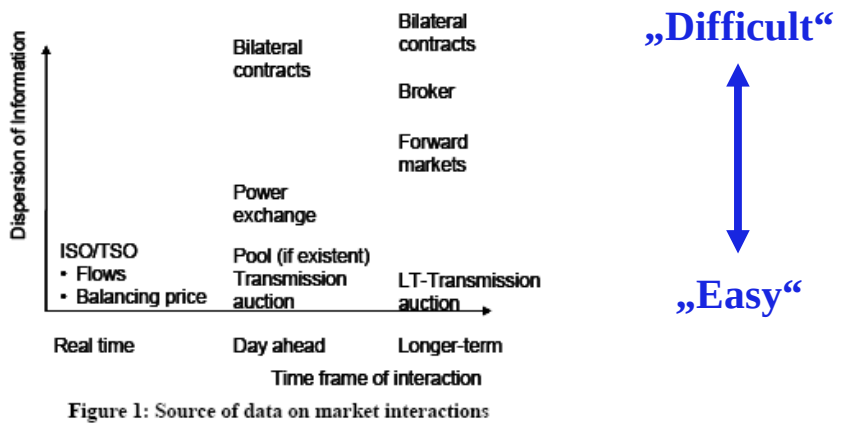


Figure 20: Critical role of access to information for market monitoring

Source: Twomey et al. (2005)

On first sight, it appears that the market operator may be best suited for monitoring the market since it generally has the best access to information and is permanently involved in operation of the market. At the same time, though, this constant involvement also represents a certain risk, amongst others due to the need for neutrality, which may be undermined if the market operator has to take the role of an active 'referee' that analyzes and ultimately judges the behavior of individual market participants. Furthermore, there may be concerns about potential conflicts of interest, especially where the market outcome is strongly influenced by the behavior of the market operator, which will often be the case in market operated by the system operator. Last but not least, we note that a market operator will not generally be in a position to force market participants to disclose information, which they do not want to reveal, which represents a fundamental limitation for effective monitoring. Whilst market operators therefore obviously have a crucial role to play, these considerations already indicate that market monitoring also requires at least a certain degree of regulatory involvement.

With regards to the organizational structure for market monitoring, one may generally identify three different approaches:

- Separate but integral department within overall organization;
- (Semi-independent) Market Monitoring Units; and
- Additional support by fully independent advisory bodies, such as a Market Advisor or a Market Surveillance Committee.

In the first case, market monitoring is performed as integral task within the organization of the market operator. Whilst this option is most straightforward in terms of organization, it appears as problematic with regards to neutrality and for preserving the confidentiality of sensitive in-

formation. For this purpose, many market operators especially in the U.S. have established so-called Market Monitoring Units, which operate at an arm's length to the rest of the organization and are not directly supervised by the management of the MO. However, even in these cases, there may remain doubts about conflicts of interest and these units may not have sufficient time for an in-depth investigation of specific issues. For this reason, a third option is to set up independent advisory bodies, which may provide additional support where necessary and which may also provide a wider forum for a discussion of important aspects.

These different approaches are also reflected by practices in different countries. For instance in **the Netherlands**, the market operator *APX* is responsible for the collection and publication of market results and indices for transparency purposes. In addition, APX publishes different descriptive reports (weekly, monthly) on an aggregate level, monitors the compliance of individual participants[40] and is entitled to carry out any investigation. Similarly, the **Nordic** power exchange *Nord Pool* has a market surveillance department that analyzes the spot and forwards market on a quarterly basis in terms of:

- Reporting of non-exchange trades (financial);
- Disclosure of insider information (physical and financial);
- Insider trading (physical and financial);
- Market manipulation (physical and financial);
- Publication of short quarterly reports on what has been investigated.

In a very similar way, the **Romanian** Market Operator *OPCOM* has a market surveillance department which monitors the day-ahead and bilateral markets and reports on these to the Romanian Regulator ANRE. For instance, OPCOM regularly determines the market shares of each participant (buying/selling, offered/traded), concentration ratios or the Hirschman-Herfindahl Index (HHI), and also monitors market prices as well as offered and traded volumes. The **French** power exchange *Powernext* finally has established its own market surveillance department, which is not only responsible for market surveillance but which is also entitled to take corrective actions where deemed necessary.

Most of these approaches resemble the first option described above and are not subject to any strictly formalized rules. In comparison, the U.S. electricity markets generally have a much longer tradition of market monitoring, which is also reflected by a very pronounced and formalized market monitoring. Today, all of the ISOs in the U.S. have established separate Market Monitoring Units (MMU). The objectives, scope and activities of these MMUs are defined in a so-called Market Monitoring Plan, which has to be approved by the Federal regulator FERC. For illustration, the monitoring activities of PJM aim at supervising the operation of both the pool and the bilateral market, detecting flaws in the operational rules of the PJM

market, and last but not least at ensuring compliance with the pool rules. To this end, they basically comprise the supervision of the following:

- Operational issues in the pool and the bilateral market e.g. system and price loads, PJM congestion, PJM volumes, offers and dispatch, available capacity, concentration ratios, price-cost margin;
- Compliance with pool rules and PJM market rules;
- Potential exercise of market power; and
- Market monitoring requests by market participants.

In section 4.2 above, we have commented on the distribution of activities between the MO and the SO. This issue is also reflected in the responsibility for market monitoring, which may or may not be split between these two organizations (where applicable). For instance in Romania, the monitoring department of OPCOM also covers the balancing market in close collaboration with the TSO (in his role as operator of the balancing market). Conversely, the market operators in most Western European countries limit themselves strictly to operation of their own markets, whilst there are not yet any formalized means for monitoring of the balancing mechanisms in most of these countries.

5. ROLE OF THE REGULATOR IN MARKET SUPERVISION AND DEVELOPMENT

In the previous chapter, we have already discussed the scope and objectives of market monitoring and supervision. In section 4.4 we have explained that market monitoring comprises a number of different activities, ranging from the collection and analysis of market data or regular reporting to the investigation and potentially also escalation of any problems identified. We have also argued that effective market supervision furthermore requires corrective measures to be taken, exceeding the regular activities used under market monitoring. Although the previous chapter has focused on the role and responsibilities of the market operator, we have repeatedly pointed out the need for the regulator's involvement.

To supplement our previous analysis, the current chapter therefore focuses on the role of the regulator. More specifically, section 5.1 first deals with market supervision in a broader sense, including the design and development of the market framework, before we focus on the area of market monitoring in section 5.2. Finally, we discuss a number of potential measures that can be taken to support competition in section 5.3.

5.1. Role of the Regulator in Market Supervision

Whilst market and system operators are responsible for facilitating the market, regulators also have an essential role to play. Not being involved in the day-to-day operations they are able to act as a neutral 'referee', which does not have any vested interests in any particular part of the market. Due to their involvement in the regulation of network activities, energy regulators furthermore have an in-depth understanding of the entire industry and market framework, which represents a fundamental difference in comparison to e.g. competition authorities or courts.

In general, one can identify two basic roles of the regulator in the supervision of electricity wholesale markets, namely:

- Supervision of the market and the market operator; and
- Development and/or approval of market rules.

The first function largely corresponds to the task of market monitoring as already explained in section 4.4. As further discussed in section 5.2, one important aspect is however that the regulator's role involves supervision of the market operator. This is important since the market operator will naturally have his own objectives, which are not necessarily equivalent to those of the entire market, especially in case of profit-oriented enterprises, as typically being

the case in Western Europe. In addition, we note that this task may also involve specific actions against individual market participants, which are taken based on the results of market monitoring. As explained above, effective market monitoring has to be supplemented by corrective actions in order to ensure that any breaches of the market's rules are not without consequences. Even though e.g. any cases anti-competitive behavior may need to be escalated to competition authorities, whereas other disputes may have to be settled in court, there will typically remain a wide range of specific issues, which are easier and better dealt with by the regulator. Most importantly, this relates to detailed provisions of the market rules or any other decisions, which may have a strong impact on other parts of the overall market.

As a result of market monitoring and related investigations, the regulator will often become or be made aware of any deficiencies in the current design of the market and its current rules. The second major responsibility in the context of market supervision, which cannot be executed by any other regulatory authority, therefore concerns the development and/or approval of market rules. Market rules define the commercial business aspects of the functioning of an electricity market and are essential for providing a fair, efficient and non-discriminatory market place. Although we have explained in section 1.1 above that many markets leave the development of the corresponding rules to the main stakeholders, experience has shown that the regulator may have to interfere at least in those cases where these stakeholders cannot come to an agreement, or where these decisions may be unduly influenced by certain (groups of) market participants.

In principle, the regulator's involvement may range from being the designer of the market and the market rules to being limited to the review and/or approval of the rules agreed by the market. In the first case, it is effectively the regulator who has full control about the design of market and who can largely decide himself about any potential adjustments. This approach can be found e.g. in Romania but bears a significant risk of the regulator taking unilateral decisions without sufficient consultation with the market. In most countries, preference is therefore given to a different approach where commercial and technical rules are developed e.g. under the supervision of the market and/or system operator, whilst the regulator plays a role for the approval of any new and/or amended rules.

The latter approach has the advantage of removing the regulator from many detailed discussions and allowing it to focus on those issues, which are decisive for the functioning of the market. For instance, the market operator will normally have a much better view of the practical implications of any proposed rules, e.g. on its own organization or the trading and settlement systems, or data flows and communication requirements. Conversely, the regulator's role should be primarily to ensure that the rules developed by the Market Operator and/or the market comply with the principles of efficiency, transparency and non-discrimination. For example, the regulator must try to assess whether the rules will offer everyone equal opportunities to participate, or whether it might put certain participants at a disadvantage, and whether the market arrangements will facilitate new entry, and their implications for wholesale and

retail pricing etc. Finally, one can reasonably believe that this approach will be sufficient to ensure an adequate influence of the regulator. Indeed, it would be hardly useful for both the market facilitators (MO and SO) and other market participants to spend huge efforts on market rules, which are unlikely to be approved by the regulator in the end.

Irrespective of the choice for one of these alternatives, it is important to ensure sufficient involvement of all relevant stakeholders in the entire process. Hence all sides should work closely together, e.g. the stakeholders on the market side developing an idea or concept, which is then presented to the regulator for discussion and approval for taking the next steps. Where the regulator is not convinced that a particular proposal is in the best interests of customers or market participants, greater analysis may be required from market or system operator to demonstrate the case. In order to ensure that all interests are considered and also to increase transparency of the process, the regulator should also check that all relevant parties have involved in the process.

In practice, the actual scope of the duties and possibilities of a regulator in this respect also depends on the overall market, legal and regulatory. For instance in a mandatory market where the rules for the wholesale trading are integrated with system planning and operation, the regulator will typically have a much stronger role due to its direct powers on the activities of the system operator. Conversely in case of a voluntary market, like most European power exchanges, the regulator will often not have any direct powers as the market operator may easily claim that it might otherwise stop its activities. These aspects are therefore also related to the legal and organizational structure of the market operator and the corresponding schemes for market and corporate governance.

In this respect, the experiences from the **Netherlands** provide some interesting insights. The original version of the Electricity Act did not contain any provisions with regards to the establishment and operations of the Dutch Power Exchange APX or the monitoring of the wholesale market. From a purely legal point of view, there was thus no direct legal basis for DTe to supervise the activities of APX and wholesale trading. The regulator nevertheless required some producers participating at APX to provide information about the functioning of the spot market. Although participants claimed that DTe was not entitled to supervise the way in which producers organize their activities, a court decided otherwise and confirmed that the Electricity Act provides DTe with general powers as regards the promotion of electricity trade. Following recent amendments to the Dutch Electricity Act, the situation has now been clarified. DTe may now officially require all relevant information from the power exchange, however still under special conditions: the regulator has to make specific requests and does not have free access to confidential data of the exchange on a regular basis.

This example also highlights another factor, which may have a strong influence on the extent to which the regulator may supervise the development of the wholesale market. At least in countries based on the French tradition of written law, the regulator will often only be entitled to exercise certain powers if these have been explicitly stated in primary legislation. This le-

gal mandate may e.g. authorize the regulator to either develop the market rules or only review and decide on those that are put forward for approval, or may be restricted to pure market monitoring. Furthermore, the situation may be different for physical and financial trading or for those market mechanisms related to system operation. For instance in **Romania**, the regulator ANRE has been given the right to develop and approve all the market rules for the entire wholesale market, whilst the **Dutch** regulator DTe may approve the rules for all activities related to network access and system operation (including the balancing mechanism) but does only have monitoring rights for the power exchange.

Similarly in **Germany**, the Bundesnetzagentur has limited rights to request or even impose changes of rules related to SO-related activities but has no direct influence on the power exchange. In **France**, the regulator CRE is (together with the Competition Council) responsible for the supervision of the correct application of the unbundling principles, cross-subsidization, discrimination or restriction on completion. Moreover, CRE reclusively monitors the organization of the balancing market. The supervision of the power exchange is however under the scope of both French Financial and Electricity Acts, i.e. it is jointly exercise by CRE and the financial regulator (Autorité des Marchés Financiers). Furthermore, whilst CRE may ask Powernext for any information related to the organized electricity markets, it has no regulatory power on the bilateral market.

In principle, it may furthermore be helpful to also consider supranational legislation, such as the EU's rules on the Internal Market in general and the electricity and gas markets in particular, or the Treaty for the Energy Community of South-Eastern Europe (ECSEE). Unfortunately, these sources primarily includes more general stipulations, such as assigning regulatory authorities with the responsibility to supervise network access or to ensure non-discrimination, effective competition and the efficient functioning of the market, without however granting any explicit powers in this respect to the regulator. Detailed provisions, on the other side, are largely limited to SO-related activities. For instance Regulation (EC) 1228/2003 on Cross Border Exchange of Electricity and the related Guidelines on Congestion Management explicitly contain corresponding provisions regarding the management and allocation of interconnection capacity but is not applicable to congestion management within individual countries.

5.2. Market Monitoring

As mentioned above, market monitoring represents a key function of an effective regulator. This obviously requires sufficient resources as further discussed at the end of this section. In addition, we have already pointed out in section 4.5 that access to (confidential) information is a crucial precondition in this respect. In most cases, this will however require a clear legal mandate. Since legislation in many countries lacks sufficient precision in this respect, it will thus often depend on the regulator's own interpretation whether it can exercise its corre-

sponding duties in an effective manner.[43] Although supranational legislation and agreements represents another potential source of corresponding powers, we have already noted above that they typically lack sufficient details. Nevertheless, we emphasize that the proposed contents of the 3rd legislative package for the EU's energy markets contain a significant number of explicit provisions especially with regards to market monitoring and transparency.

The range of corresponding legal mandates and current practices varies widely. For instance in **Austria**, the Electricity Act explicitly requires the regulator E-Control to monitor and supervise the development and competition in both the wholesale and the balancing market, including support to the competition authority with regards to analyzing the behavior of individual market participants. In addition, market participants, system and network operators and the settlement administrator are required to provide a wide range of specific information to the regulator. Based on this information, E-Control regularly reports on the development of the Austrian electricity and gas markets, including the degree of competition.

In **the Netherlands**, electricity wholesale monitoring is characterized by a well-developed approach, which arguably represents one of the most advanced in Europe. As mentioned above, the Dutch regulator DTe has successfully tried to obtain access to otherwise confidential information from the power exchange and individual market participants. Besides the right to request specific data from APX, DTe collects data from producers twice a year covering e.g. the capacity and technology of power plants (MW), actual output per hour and, last but not least, marginal costs. In addition, DTe relies on publicly available data and several indicators, which have been calculated in close collaboration with APX. These indicators cover three aspects, namely liquidity, transparency and competition:

- Since there are neither a standard definition for the term '*liquidity* of a market' nor standard methods for measuring it, DTe uses a combination of indicators to estimate the level of liquidity, such as the number of traders active on the marketplace, price volatility, trading volumes (including the involved in price formation on the power exchange), price spreads on the OTC market, or the sensitivity of the market price to individual transactions.
- In terms of *transparency*, DTe review the situation in the Netherlands within a European context, in order to assess the availability of information and to determine the need for improvement.
- With regards to *competition*, DTe finally uses e.g. the Hirschman-Herfindahl Index (static, based on installed capacity, and dynamic, based on actual generation), the Lerner Index for electricity prices on the wholesale market and in some cases also the spark spread. In addition, DTe uses questionnaires, which are directly sent to market participants and conducts surveys addressed to market participants and brokers.

Romania represents another example of a relatively developed market monitoring approach. Besides the activities of the market operator (see section 4.5), the regulator ANRE also features a market monitoring department, with its role being clearly defined in the *Methodology of Wholesale Electricity Market Monitoring*. This methodology entitles ANRE to monitor not only the organized wholesale and balancing market, but also the bilateral contracts market and mutual influences between different segments of the wholesale electricity market. This is done on a monthly and annual basis by means of a thoroughly defined set of indicators which can be found in the above mentioned methodology. Furthermore, the monitoring departments of the market operator and the system operator are required to fully cooperate with the regulator and disclose a wide range of information, partially on a regular basis and partially on request. Based on this information and its own activities, the regulator draws up a monthly market monitoring report for internal purposes, including a synthesis of the information provided by MO and the TSO and information on special events in the monitored markets as well as reasons for significant price movements.

These examples also show how some of the regulators interact with the corresponding market operator(s) in their countries. In this context, we note that the activities of the regulator largely overlap with those of the MO, except of course for the supervision of the MO itself. As least the day-to-day monitoring may therefore be left to the market operator or another independent monitoring body (compare section 4.5). However, we emphasize that access to information if crucial for effective monitoring. Consequently, the regulator should in any case be entitled to request all relevant data where necessary. Furthermore, we note that market monitoring and analysis also serves for a better understanding of the actual functioning of the market. Hence the regulator should be involved in at least a certain amount of regular monitoring activities.

5.3. Measures to Support Competition

Distortions in competition on energy markets may lead to disadvantages for competitors on the wholesale and retail stage and welfare losses for consumers due to higher prices. Before promoting measures to support competition it is necessary to analyze and identify the reasons for the dysfunctions on the energy market. The structure of the market (e.g. number and structure of competing producers on the wholesale level, unbundling of MO/SO and generation) as well as the market design (e.g. priority rules) could influence the market outcome and the effectiveness of competition. We therefore briefly evaluate different potential measures that may help to develop and/or improve the functioning of energy markets.

As illustrated by Table 11, we focus on two different areas: First, we consider different measures, which are related to behavioral aspects, such as the market design and market governance itself, market monitoring or the imposition of price caps. Secondly, we also discuss a number of structural elements since especially the structure of the generation market may

provide barriers to a fully competitive wholesale market. An effective means of improving competition may therefore be to increase the number of market participants on the producers' side, including divestiture or the introduction of so-called virtual power plants.

Table 11: Potential measures to support competition

Behavioral	Structural
• Market monitoring • Increase transparency • Improve market design and governance • Price caps and other explicit constraints	• Ownership separation / unbundling • Divestiture • Virtual Power Plants (VPP) • Market Integration

Behavioral measures may include e.g. one of the following:

- **Market monitoring**

  As pointed out in section 4.4, effective market monitoring is important to constrain anti-competitive behavior and to detect and deficiencies of the existing market design. It is therefore paramount to continuously monitor and analyze the functioning of the market. Market monitoring may be performed by the market operator(s), the regulator and/or other monitoring bodies and should include qualitative, quantitative as well as informal measures. Whereas qualitative monitoring may e.g. use structured surveys and questionnaires and serves primarily to check compliance, quantitative monitoring may also serve to detect anti-competitive behavior by checking against pre-defined numerical thresholds (e.g. market share / concentration, price levels etc.). Informal monitoring finally relies on discussions stakeholders and market participants. Where any these analyses have identified certain problems, or where such cases have been reported by other parties, they need to be investigated and appropriate measures be taken where necessary.

- **Market design and market governance**

  Proper market design is fundamental for allowing competition in the energy market. Market monitoring has therefore be supplemented by actions in response to any problems identified, including the commitment to initiate, impose and/or approve market rules or organizational changes as deemed beneficial to the market. Such actions should be performed both on an 'as-needed' basis and be based on regular analysis of the market development.

  Besides market design, market governance also helps to provide an environment for fair and non-discriminatory market place. This can be facilitated by organizational measures, which provide for a structured and transparent approach for dealing with the supervision of the market and rules changes, and allowing market participants

and other stakeholders to participate in this process through sufficient disclosure of relevant information and consultations.

- **Increase transparency**

  Many markets suffer from information advantages, which typically are to the disadvantage of new entrants and smaller market participants. One option to improve the conditions for competition is therefore to remove the advantages of large / dominant players by promoting equal access to information. This can be easily achieved by publishing and/or instructing the publication of relevant market data, in line with several corresponding initiatives within EU. Besides reducing the discriminatory nature of information asymmetries, transparency also enables „self-regulation' through additional 'market monitoring' by market participants and other stakeholders.

- **Price caps and other explicit constraints**

  Ideally, regulators should refrain from any direct interventions and allow the free market to work. In practice, it is however often possible that the market does not always work, e.g. due to a lack of competition under some specific circumstances. Where it is not possible to provide the basis for sufficient competition, a second-best choice may therefore sometimes be to explicitly limit the flexibility of all or some market participants. This may e.g. involve the imposition of a general price cap or the establishment of special contracts with individual parties, with the latter being a common instrument to deal with local and/or structural network constraints. Care should however be taken when applying such measures since price-caps may distort pricing signals. In extreme cases, this may result in an effectively „regulated market' or other adverse effects, which may undermine efficiency and competition.

The second group of structural measures largely focuses on the abolition of market power, which can e.g. be achieved through a reduction in market concentration. Since access to production capacities is key to the development of a functioning wholesale market, many of the options described below aim at increasing competition between producers through various forms of vertical and horizontal separation. Since such measures will typically require more far-reaching interventions, they cannot almost be implemented by the energy regulator alone and may hence have to be seen in a wider context.

Amongst others, one may consider one of the following approaches:

- **Ownership separation / unbundling**

  Where system, network or market operators are vertically integrated with e.g. producers or suppliers this might influence the independence of these market facilitators. Besides operational decisions, corresponding conflicts of interest may also arise when designing the market rules or when defining the principles for selecting and remunerating balancing services. It is therefore in the interest of the overall market to

ensure neutrality of such market facilitators, which is best achieved by ownership separation. It should however be taken into account that ownership separation has strong legal and commercial implications, which may require a limitation to effective legal, organizational, information and management unbundling.

- **Divestiture**

  Economic theory identifies high concentration in the ownership of generation as a key factor creating the potential to exercise market power. For instance, a classical strategy for exploiting market power is for a firm to raise market prices by withholding capacity from the market, raising the market price and thereby increasing profits over competitive-market levels. Two types of withholding can be defined: 'physical withholding' can be done through declaring a power plant unavailable, while 'economic withholding' consists of bidding some capacity at extremely high prices that in practice removes it from the dispatch. In practice, the two strategies have similar effects.

  Where such problems exist, one possible measure may be reducing the market share of individual market participants by forced sales of assets. It is clear that a corresponding measure has important implications and would require strong political commitment and backing to be feasible. Moreover, especially in case of smaller countries, it may be easier to either reduce the effective market share through regional integration (see below) or by making parts of the corresponding production capacities available to other market participants as virtual power plants.

Case study: Divestiture in England and Wales

Initially, in 1990 three producers controlled over 90% of the market in England and Wales. This percentage was brought down to 49% in 2000 due to divestitures and market entry. In addition, input costs for producers dropped extremely. The effect on the energy prices with a real decline of 2.1% per year in this period was however not as high as expected.

- **Virtual Power Plants (VPP)**

  While strict ownership separation and divestiture are sensitive issues in most countries, a pragmatic approach may consist of auctioning parts of the capacity of major producers for a certain time period to give other parties access to these capacities. In other words, generating companies with market power may have to transfer market control of a portion of their production assets rather than divesting of assets through direct sales. This approach is commonly known as 'Virtual Power Plants' (VPP) where as VPP stands for the right to nominate the output of a 'virtual plant' typically on the day ahead at a pre-defined price. Strictly speaking, a VPP therefore represents a special type of auction contracts since the buyers of VPP capacities do not get any tangible rights on existing physical assets. Nevertheless, the introduction of

VPPs mimics divestiture by transferring authority on operational decisions and flexibility to other market participants

In a strict sense, virtual power plants are neither structural remedies since they do not involve actual divestiture nor truly behavioral remedies since they do not define any behavior to be followed by the 'dominant player'. Yet, as virtual power plants require the dominant player to produce electricity at the request of the buyers of VPP capacities, the incumbent has effectively lost control of a share of its capacity, thereby resembling any other the other structural measures. Compared with divestitures, VPP have the following advantages: (1) VPPs do not require any transfer of assets, (2) VPPs are rather easy to implement and flexible, (3) VPP improve market liquidity and facilitate market entry, and (4) VPP mitigate market power.

Case study: VPPs in Western Europe

Virtual power plants were first introduced in Europe as a remedy in a merger case following an undertaking given to the European Commission in connection with EDF's acquisition of an interest in German utility Energie Baden-Württemberg HG (EnBW). VPP were secondly introduced in Belgium following approval by the Belgian Competition Council of various transactions leading to the appointment of a subsidiary of Electrabel, as the default supplier for the customers of several intermunicipal distribution companies. Finally in the Netherlands, the acquisition of Reliant Energy Europe by Nuon raised horizontal and vertical concerns with respects to its impact on the electricity market which led to a decision of the Dutch competition authorities to require Nuon to auction part of its production capacity through virtual power plants. In these three cases the objective of this remedy is to reduce parties´ market power and restore conditions for effective competition which would be distorted as a result of the acquisition creating or strengthening a dominant position. By contrast with these cases, the Dutch regulator DTe discussed VPP as a tool to stimulate competition and liquidity in the Dutch wholesale market.

- **Market Integration**

  The previous measures all focus on limiting power share by reducing the amount of capacity being available to a dominant player. An equally suitable alternative could however be to enlarge the relevant market, thereby reducing the relative market share of individual players. Regional integration as discussed in section 3.7 therefore offers an important means of increasing the scope for competition without any complicated and easily contestable interventions into existing ownership structures. At the same time, regional integration also enable efficiency gains e.g. through better utilization of complementary production / consumption structures.

6. SUMMARY AND RECOMMENDATIONS

This report analyses different models and components of wholesale electricity markets, the resulting market design and the functions of different market institutions and stakeholders. In this context, one has to consider that the simple term 'electricity market' represents a complex set of different markets for different products across different time scales. Consequently, one has to apply special care when comparing examples from different markets as they may not always be comparable. The key decision for the design of any electricity market is however the fundamental choice for one of the two basic models of an energy (commodity) market, namely between a mandatory pool with centralized scheduling, on the one hand, and a bilateral contracts market with decentralized self-scheduling of generators, on the other side. Apart from this fundamental decision, however, the detailed market design of any country is based on a large number of design decisions and is also influenced e.g. by market size, generation structure, technical standards, degree of interconnection etc. Consequently, there is no uniform strategy for the design and implementation of competitive electricity markets.

Similarly, it is not possible to provide for a universal definition of the role and functions of market operators. While in the U.S. the term 'market operator' is generally understood as a synonym of the system operator, i.e. the entity being responsible for the coordination of system and market operation, the same term is typically used in Europe to describe a purely commercial entity, which is an entirely separate organization from the system operator and only deals with the commercial operation of the (wholesale) market, i.e. typically a 'power exchange'. However, even in Europe, there is no common agreement as to whether the operation of e.g. a balancing mechanism or the market-based procurement of ancillary services by the system operator shall be defined as 'market operations', or whether this represents a normal function of the system operator. Whilst it is therefore possible to define some core functions of a market operator, i.e. in particular the collection of bids and offer and the clearing of an organized market, the detailed scope of different market operators depends on the underlying market design, organizational choices and the products offered.

In contrast, the need for effective market monitoring is universal for all types of electricity markets and across all market segments. Again, the detailed implementation has however to be tailored to e.g. the fundamental choice between a mandatory or voluntary market (see above), but also to the legal and regulatory basis, the legal mandate of the institutions involved and, last but not least, access to and dispersion of relevant information. In any case, market monitoring requires a structured and consistent approach to be successful and crucially depends on access to sufficient information. In terms of organization, it is furthermore necessary to decide on the distribution of the corresponding functions between one or more

institutions. Ideally, market monitoring may best be structured at 3 levels, although this structure may have to be tailored especially to the size of smaller countries:

- Day-to-day monitoring by each of the 'market operator' concerned (i.e. MO, SO), being responsible for on-going collection publication and analysis of relevant data;
- Supplementary analysis by an independent monitoring body, which should operate at an arm's length from the market operator(s), be somewhat removed from daily operations, in order to enable in-depth analysis and investigations, and focus on the behavior of market participants and the market operator; and
- Constant supervision and involvement by regulator, focusing on the market design and non-compliant behavior.

Although a considerable part of market governance and market monitoring can be left to the market, regulators have an essential role to play. They two primary duties involve (1) a constant or at least regular involvement in market monitoring, in order to ensure full understanding of the market's development, and (2) commitment to act on any problems identified, including amendments to the existing market design and rules. In accordance with the three-level structure mentioned before, the daily analysis and reporting may however be best left to system and market operators or, preferably, an independent monitoring body, which would allow the regulator to focus on forward-looking analysis and any actions required. In this respect, it may however be necessary to agree concurrent powers e.g. with other competent authorities, such as the competition authority for cases of assume anti-competitive behavior.

Finally, we emphasize that market monitoring should best follow a number of guiding principles, which should also be communicated to the market to increase the transparency, credibility and predictability of the entire process. In particular, we believe that market monitoring should aim at complying with the following principles:

Guiding principles of market monitoring

- **Transparency**

  Market monitoring should promote the public availability of data in order to help market participants protect themselves and allow other parties to analyze market performance on their own.

- **Forward-looking approach**

  Market monitoring should be based on a careful analysis, trying to anticipate the impact of current developments and any proposed changes to the market rules.

- **Consistency and predictability**

  To ensure consistency and to increase the predictability and credibility of the process, consistent measures of market performance should be prepared and applied that are comparable over time and (where applicable) across markets.

- **Commitment**

  Regulators should clearly show their willingness and ability to quickly intervene and fix any problems discovered through market monitoring since their commitment to corresponding actions is a crucial precondition for the credibility and effectiveness of the entire process.

- **Independence**

  Regulators should ensure that the market monitoring process is given full independence from all stakeholders involved, including the market and system operators as well as wider politics. Whilst day-to-day data collection or routine analysis and reporting may e.g. be delegated to market operators, it is paramount that in-depth analysis and detailed investigations are performed by truly independent organizations.

- **Clear legislative mandate**

  Effective market monitoring requires access to a.o. confidential information as well as the ability to take appropriate actions where requires. This requires a clear mandate to ensure that the objectives of the market monitoring process can be met and that all analysis is based on solid footing.

7. APPENDICES

7.1. Glossary

Active energy / Active power	Electricity that can be transformed into energy of another sort (for example, mechanical energy); active energy is measures in Watthours (Wh), whereas electric power is measured in Watts (W).
Adequacy	Structural ability of the system to supply the aggregate power and energy demand required by the market at any moment.
Ancillary services	Services supplied by users to the electricity system.
Automatic Generation Control (AGC)	AGC is a centralized control system used to remotely control the output of generating units, enabling the generating unit to automatically respond to external signals in real time to control the power output within a prescribed area.
Balancing market	A balancing mechanism that is based on market principles, i.e. bids and offers from the supplier of balancing services.
Balancing mechanism	A mechanism used by the SO to perform energy and potentially system balancing close to real time.
Balancing Responsible Party (BRP)	BRP are those entities responsible for balancing energy schedules, normally for the day-ahead and to keeping the real time balance close to the schedule. Normally there is a penalty (an imbalance charge) for deviations from that schedule balance. BRP is also referred to as balancing unit, balancing group and load serving entity.
Balancing services	Balancing services comprise those ancillary services used to ensure balance between supply and demand in real time by manually activated power reserves.
Bilateral contracts	Contracts for the exchange of electricity (energy) that are directly concluded between two market participants. Bilateral contracts may take the form of either physical or financial contracts.
Bilateral market	Market which is not regulated by an organized market authority but allows for direct transactions between individual market participants.

Black start	Black start is the ability of a generation unit to start up without any external supply and then to energize a part of the network, thereby enabling the gradual connection of load and the start of other generating units after a system shutdown.
Block bidding	Offer to sell or buy the same quantity of energy for a period of consecutive hours.
Capacity payment	A payment for making generation capacity available to the system.
Captive customer	A consumer that does not have, or has not exercised its right to choose another supplier of electricity and is therefore supplied by the franchise supplier in a given (distribution) network.
Centralized market coupling	A model of market coupling where regional clearing is centrally performed by a regional auction office, whilst the national markets are still being cleared by independent power exchanges.
Closed auction	A closed auction is a trading system in which participants can submit and change their offers until the closure of the call phase. All the submitted offers are collected in a closed order book, i.e. participants know only their own offers. Following the end of the call phase, the market is cleared based on all valid offers submitted until this time.
Congestion	Congestion occurs when a transmission line (or lines) reaches its maximum carrying capacity. When this occurs, the regions on either side of the constraint are considered 'islands' in price terms. One 'island' cannot supply any more electricity to the other, meaning demand has to be met by local generation plant.
Constraint	See Congestion
Consumers	Consumers mean final customers of electricity, which consume electricity for their own use. Consumers are also known as end users.
Contingency	The unexpected failure or outage of a system component, such as a generator, transmission line, circuit breaker, or switch.
Continuous trading	The continuous trading is a process where open bids are displayed on the market and potential buyers and sellers can select offers. The contract price is not the same for all transactions as it is related only to the two bids matched at a given time.
Contract for differ-	A trade contract in which the purchaser pays the seller the differ-

ences (CfD)	ence between the contract price and some market price, usually the spot price. In Scandinavia, CfD refers instead to the difference between two area prices in the spot (day-ahead) market.
Corporate governance	Corporate governance is generally seen as a management structure for a single commercial entity (i.e. enterprise), spelling out the rules and procedures for making decisions on corporate affairs.
Counter-flow	A flow of power in the opposite direction to the predominant flow.
De-centralized market coupling	A model of market coupling where regional clearing is achieved through an iterative process between the power exchanges of the participating national markets.
Derivative	A derivative is a financial instrument (contract) between two parties with opposite views on the market, who are willing to exchange certain risks. Many derivative instruments are used in electricity trading, but the most common ones applied to energy risk management strategies are future, forward and option contracts.
Dispatch	To operate and control a power system, especially with respect to determining the outputs of the system's generators. Also the set of generators that are providing power at any point in time and their output levels.
Distributors	Distributors are entities whose function is to operate distribution and grid for the supply of electric power to final consumers. Distributors do not participate in the market except possibly for the purchase of network losses.
Eligible customer	A consumer that is free to choose and/or change its supplier of electricity. In some jurisdictions, this may require the consumer to first become a (self-) supplier of electricity.
Emergency services	All system and ancillary services aimed at preventing a partial or total shutdown of the system (e.g. black-out) in case of major contingencies.
End users	See consumers.
Explicit auction	An auction for explicit capacity rights, which have to be purchased by market participants as a precondition for being permitted to nominate a corresponding energy transaction.
Financial trading	Type of trading in which contracts provide for some sort of finan-

	cial compensation to be made between the contracting parties but which do not provide for the physical delivery of the underlying product.
Forward contract	A contract relating to the future delivery of the underlying product.
Forward markets	The market segment in which electricity is traded for future periods. Typical delivery times can range from several days to some years in the future.
Franchise supplier	A supplier that has the right or duty to supply all consumers in a given network (i.e. its franchise area), which have not selected, or are not allowed to choose an independent supplier.
Frequency control	Maintaining the frequency within the given margins by continuous modulation of active power.
Futures contract	An exchange-traded, standardized contract for the delivery of a specific quantity of the underlying product at a specified time (or over a specific period) in the future.
Gaming	An attempt by a market participant to profit by exploiting imperfections in the market rules.
Gate closure	Gate closure is the time up to which a market participant can modify its physical and commercial position.
Generators	See producers.
Gross pool	A pool market where production schedules are fully determined by the market operator.
Hedge	A financial instrument that insures the purchaser against uncertainties in the spot price.
Hirschman-Herfindahl Index (HHI)	Index of market concentration that sums the square of the market shares of individual participants and gives then a first approximation for the distribution of the respective shares throughout the market. The HHI is typically interpreted as follows: – HHI < 1000: not concentrated, – 1001 <HHI < 1800: moderately concentrated, – HHI >1801 highly concentrated market.
House load operation	House load operation is the ability of a generator to operate isolated from the system and using its output to power its own auxil-

	iaries until the unit is resynchronized to the system
Imbalance	The differences between production, consumption and exchanges of a market participant, where production and consumption are typically determined from meter values but exchanges with other market participants are accounted for as nominated.
Imbalance charge	The price to be paid or received for an imbalance.
Implicit auction	A market-based mechanism where transport capacities are allocated in parallel with the establishment of transactions for commodity energy.
Independent System Operator (ISO)	A System Operator that does not own the transmission grid the operation of which it is responsible for. The management and control of an ISO is typically structured to be completely independent of the generation and transmission owners, such as to help ensure fair access to the transmission system.
Island operation	Island operation is the ability of a generator to operate isolated from the system and using its output to power not only its own auxiliaries (see house load operation), but also an isolated segment of system load until the unit is resynchronized to the system.
Load-Serving Entity	A term being commonly used in Northern America to describe a party that acts as a supplier and as BRP for a group of customers.
Marginal Bid	The highest accepted offer (to sell) or the lowest accepted bid (to purchase) in an organized market.
Market	A place or institution in which buyers and sellers of a good or asset meet, including all types of organized markets, such as power exchanges, power pools, balancing markets and OTC markets.
Market coupling	A method for integration of several market areas for commodity energy by means of implicit auctions.
Market design	The overall institutional arrangement of an electricity market.
Market governance	Supervision of the development and operation of a market (or industry) which serves a number of different, typically competing stakeholders including all measures aimed at providing for a fair and non-discriminatory market place such as governmental and/or regulatory rules and interventions. On the one hand these activities include the definition and adjustment of rules and regu-

	lations and on the other the monitoring whether market participant abide by the latter and as well as the set up of dispute resolution procedures in case of breach.
Market monitoring (narrow sense)	Monitoring of competition in the market.
Market monitoring (wider sense)	Monitoring of the liberalization process (including monitoring of compliance in the EU/Energy Community Treaty context as well as in terms of market structure, wholesale market, tariff reforms, market integration…etc.).
Market Monitoring Unit	All ISOs in the US feature a Market Monitoring Unit which monitors and reports on issues relating to the operation of the wholesale electricity market.
Market Operator (MO)	MO is a centralized institution, which operates an organized market on behalf of market participants.
Market power	Ability of a firm to profitably raise the price of a product.
Market rules	Market rules define the commercial business aspects of the functioning of an electricity market and include the general principles governing the trading and settlement arrangements.
Market splitting	A model of market coupling where the regional market is operated by a single power exchange, which splits the entire region into several market areas in case of congestion.
Market-clearing price	The price that all sellers receive and that all buyers pay in an organized market with a single market price determined in a closed auction.
Merit order	The order with which, instant by instant, generating plants are called into operation to satisfy the demand for electricity.
Net pool	A pool market based on offers for incremental changes to an initial schedule decided by producers.
Network access	See third-party access.
Network Service	Network operators provide services that are necessary to ensure reliable power transport
New electricity trading arrangements (NETA)	The trading arrangements put place in 2001 in England and Wales.

Nodal pricing	Integrated energy and transport price calculated for every node of the network. Price differences between nodes occur due to constraints and losses.
Non-spinning reserves	Non-spinning reserves must be started which may take anywhere from ten minutes to an hour.
Notice to deliver	Notice to deliver is the minimum notice needed by a balancing market participant to deliver the power of its balancing offer.
One-sided pool	Pool model in which there is no participation on the buyer's side.
Open market coupling	A specific model of centralized market coupling, which foresees the parallel application of explicit and implicit auctions for day-ahead transport rights through the same mechanism
Option contracts	An option contract includes a right (not obligation) to buy or sell a specified quantity of an asset at a certain future time for a certain price. To enter an option contract, the buyer pays a premium to the seller of options, while in futures and forwards, the buyer does not have to pay any charges. A call option gives the holder the right to purchase the underlying asset at some future date, and a put option gives the holder the right to sell the underlying asset at some future date.
Over-the-counter (OTC)	Term used to refer to electricity trading contracts which are negotiated directly between the parties concerned.
Pay-as-bid	Pricing rule in which market participants pay the prices that they quote.
Physical trading	Type of trading in which contracts provide for the physical delivery of the underlying product.
Pool	A compulsory market with centralized scheduling
Pool purchase price	The price at which energy is purchased by the market operator in a pool.
Pool selling price	The price at which energy is sold by the market operator in a pool.
Power exchange	An organized marketplace where market participants can buy or sell electricity under either physical or financial contracts.
Power pool	See pool
Power Transfer Dis-	A term from DC load flow calculations defining the influence on a

tribution Factor (PTDF)	given line or interconnector from changing the electric power transfer from one area in the network to another. For flow-based allocation methods, ETSO defines Power Transfer Distribution Factors as the physical flow on a given interconnection that would be provoked by a requested commercial exchange between two control areas.
Producers	Producers are the owners/operators of power plants that sell their production in the electricity market. Producers are also known as generators.
Reactive energy (power)	In an alternating current electricity system, reactive energy is the energy exchanged continuously between the different electromagnetic fields associated with the functioning of the electricity system and all the equipment connected to it. Reactive energy is measure in Volt Amperes reactive (VAr). Unlike active energy (power), it cannot be transformed into energy of another type.
Real-time market	The continual market for energy to follow the load and to maintain reliability of the transmission system.
Restoration services	Restoration services are services related to the capacity to return to a normal operation after total or partial system breakdown.
Retailers	See suppliers.
Security	Ability of the system to withstand major or sudden disturbances, such as the loss of production units, grid elements, due to outages or natural catastrophes, but also accidents or even attacks (threat response capability).
Security-constraint dispatch	A dispatch of a control area that minimizes generation cost taking into account the security limits on transmission.
Self-governance	The autonomous organization of (parts of) the electricity and gas market that go without any intervention of a regulatory institution.
Self-scheduling	Unit commitment and scheduling decided and controlled by the unit's owner rather than the SO or MO.
Self-supply	Supply of various ancillary services by a supplier or demander rather then the SO or MO.
Settlement	The process of accounting for electricity that generators produce and customers consume.
Settlement adminis-	Settlement administrator means an organization that has been

trator	assigned for the settlement of certain systems in a given country.
Spinning reserves	Spinning reserves, generators that are running and synchronized with the AC grid, and producing at less that full output, can begin supplying more power almost instantly after a contingency occurs.
Spot market	A market for goods, securities, or currencies for immediate delivery or in some case a short time is allowed for delivery. In Europe, the spot market for wholesale electricity refers to the day-ahead market. In the US the spot market is the real time market. In this presentation the spot market includes all transactions day-ahead for delivery the following day. These transactions can be realized through a marketplace and/or bilaterally.
Suppliers	Suppliers are market participants that sell or resale electricity to end users. Suppliers are often called retailers.
System control	All activities of a system or network operator for coordinating the operation of the system in real time, including at least the coordination of operational planning across different time horizons (i.e. from year ahead to real time), scheduling and real-time dispatch.
System coordination	See system control
System marginal price	This is the half hourly price derived from the offer price of the most expensive flexible generating unit scheduled in each half hour in the unconstrained schedule.
System operation	See system services.
System Operator (SO)	SO is a centralized institution, which is responsible for ensuring the safe and reliable operation of the overall power system. The duties of the SO include operation, or at least coordinating the operation of the transmission system. In the USA the SO is an independent entity (ISO) but the SO can be an integrated transmission system operator (TSO) as it happens in most European countries. In contrast to the TSO the ISO does not own, but manage the transmission network.
System services	Services that are provided by system operators to ensure compliance with system standards.
System users	System users mean any entity supplying to a transmission or distribution system.
Third party access	According to European directive 96/92/EC on the internal energy

	market, access gives producers and eligible customers, that is, third parties who do not own the transmission system, the possibility of injecting and/or withdrawing electricity to or from a transmission and distribution network. Also known as network access.
Traders	Traders are legal entities buying and selling in the electricity market and they can enter in physical and/or financial trade.
Transmission System Operator (TSO)	See System Operator.
Two-sided pool	Pool model in which there is participation of both demand and supply sides.
Uniform pricing	Pricing method in which all quantities of the underlying product (e.g. energy) are bought and sold at the same price, i.e. typically the marginal price.
Unit commitment	The starting of a generator. Starting is expensive, so once a generator has been started, it is said to be committed. The unit commitment problem is the problem of finding the most economical times to commit and de-commit all the individual generators in a control area.
Voltage control	Voltage control comprises all measures to control the voltage profile on the system by means of 'reactive power' management.
Zonal pricing	Integrated energy and transport price calculated for zones of the network. Price differences between zones occur due to constraints and losses.

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