Miracle

Micro-Request-Based Aggregation, Forecasting and Scheduling of Energy Demand, Supply and Distribution

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1 Summary

The energy sector is in transition. Firstly, the deregulation process forces companies to restructure their value chain in order to increase their market efficiency. Secondly, in order to reduce carbon emissions, the use of renewable energy sources is enforced by national and international regulations. Thirdly, smart metering is being widely adopted. The main goal of the project is to develop an Information Communication Technology (ICT) system that fits the future deregulated energy sector and enables the integration of a higher rate of distributed and renewable energy sources into the electricity grid. We will explore an approach for demand (and supply) side management in which electricity consumers and producers issue flex-offers indicating flexibilities in time and amount of the electricity. These flex-offers will be processed by our system in order to balance electricity supply and demand in near real-time.

In this deliverable, we describe the goals of our envisaged Energy data management system (EDMS) and the observations and assumptions we made and we will build upon. A major prerequisite to design the EDMS in a way that it will be applicable to the future deregulated energy sector is to understand the current situation of the energy sector in different European countries and foresee its future structure. We therefore describe the current national electricity markets for some European countries in detail and compare the national roles to the roles defined in the European Network of Transmission System Operators for Electricity (ETSO) harmonized model. Based on that we describe the EDMS and the processes in which it is used. We then analyze the use cases on two hierarchical levels of the energy system, on balance group level and in market balance areas in terms of roles involved and processes executed on these levels. Finally, we describe functional, non-functional, and market-system-based requirements for the EDMS and describe its conceptual architecture.

With the description of the role and process model, the use cases and the conceptual architecture of the EDMS, we provide the base for all technical work packages. This deliverable is an extended version of the deliverable D1.1 State of the art report and initial draft of the role model. Final adjustments to the role and process model and the detailed architecture will be added in the next deliverable D1.3 Conceptual draft of the flex-offer management architecture and its design.

2 Goals and Assumptions

The main goal of the Miracle project is to design and develop an Energy data management system (EDMS) that allows to efficiently manage higher amounts of renewable energy and balance support and demand using flexibilities in supply and demand which have been specified by small and medium prosumers (*pro*ducers and con*sumers* or both) such as households or Small and medium enterprises (SMEs). With the use of the EDMS we will achieve the following goals:

1. A higher rate of renewable energy in the production of electricity can be achieved in the European electricity system.
2. Prosumers are actively involved in the electricity management.
3. The use of the specified flexibilities by an actor within the electricity system will improve balancing of the supply and demand within its area of responsibility.
4. The stability of the electricity grid and electricity system will be maintained.
5. The affordability of electricity will be maintained as well.

Our work is motivated by the following observations and assumptions.

1. The electricity production of some renewable energy sources especially the ones using wind and sun energy is highly unpredictable.
2. Some demand and supply of electricity is flexible. The most important feature of this flexibility is time variability which allows to schedule real production or consumption for any time within a time interval We assume that prosumers will offer some of these flexibilities to a balance responsible party in form of flex-offers.
3. The amounts of distributed renewable energy sources (RES) are increasing. The European 20-20-20 goals require that the share of the consumption of renewable energies to be 20% of total EU consumption by 2020. In Germany for example, the share of RES of the total final energy consumption has increased from 3.2% in 1998 to 10.1% in 2009 [FME10].
4. An increased amount of RES in the energy mix can lead to a more expensive system, a less reliable system or even both. This is caused by the property of intermittent RES being not or at least less equipped to ‘follow’ demand.
5. There is a trend of ‘electrification’; e.g. the transition of using electricity for heating with heat pumps instead of gas fired heating installations as well as a transition to electricity in the mobility sector with electric road transport.

3 Role model analysis and selection

3.1 A view on different energy markets

The vision and initiative to start treating energy as a marketable product and thus bring into the electricity supply systems the concept of market has generated a process of transformation of electricity generation and supply systems around the world. The process was accompanied by a steady stream of publications, papers and policy-stating documents by various stakeholders and independent researchers ever since. A fair representation of this process can be inferred from the list in Table 1.

Year	Subject	Document/ stakeholder 's level	Document title or description	Ref.
2009	model for structuring of the energy market	European - ebIX	UMM 2 Business Requirements View for structuring of the European energy market	[EBIX09]
2009	European roles model	European - ENTSO-E, (+EFET, ebIX)	The Harmonized Electricity Market Role Model version 2009-01	[ENTS09]
2009	European roles model – Implementation guide	European - ENTSO-E, (+EFET, ebIX)	Collection of documents collectively called Implementation guide (for the Harmonized Electricity market Role model)	[ENTS09a]
2009	Market model	Alliance of TSO's (interest group)	The European Electricity Grid Initiative (EEGI): a joint TSO-DSO contribution to the European Industrial Initiative (EII) on Electricity Networks, Public version, The Contribution of Network Operators to the European Industrial Initiative on Electricity Grids, September 18th 2009	[EEGI09]
2009	Baltic Market model	Inter-national, EC DG TREN	Market Design, Present Regulatory and Legal Framework, Existing Barriers in the Baltic Member States of Estonia, Latvia and Lithuania – Roadmap towards an integrated power market between the Baltic Member States and the Nordic Countries, CESI Report, 8.5.2009 (report on contract for DG E & T)	[CESI09]
2009	Austrian current market model and players	National, APCS – imbalance settlement responsible	Rules and regulations, Balance group model, Market actors, Balancing energy market, Clearing (http://en.apcs.at/rules_regulations/new_version/	[APCS]

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2008	European roles model	European - ETSO	The Harmonized Electricity Market Role Model, Version: 2008-01, 1.7.2008	[ETSO08]
2007	Danish Role model	TSO - national	The Danish role model, Energinet.dk, January 2007, Rev. 1, Regulation F: EDI communication, Appendix report 3	[Ener07]
2006	Inter-national market model	Nordic Energy regulators (interest group)	THE INTEGRATED NORDIC END-USER ELECTRICITY MARKET – Feasibility and identified obstacles, Report 2/2006, Nordic Energy Regulators (NordREG)	[Nord06]
2006	Market model	Electric industry in Europe (interest group)	The Role of Retail Competition in Developing the European Electricity Market, TF Linking Wholesale & Retail Market, Union of the Electricity Industry–EURELECTRIC, EURELECTRIC's Position Paper, November 2006	[EURE06]
2004	CEE Electricity market models	national independen t	A comparison of electricity market models of CEE new member states, by Péter Kaderják, Regional Centre for Energy Policy Research at the Corvinus, University of Budapest. (Czech Republic, Hungary, Poland, Slovak Republic and Slovenia)	[Kade04]
2000	Eurostat information requirement s	national	Electricity Market Restructuring and Statistical Data Collection Note by Prof. P. Capros, May 5, 2000	[Capr00]
1998	Spanish Market model	national	Liberalization of the Spanish Electricity Sector: An Advanced Model, 1998, Elsevier Science Inc., 1040-6190/98/$19.00 PII S1040-6190(98)00047-5, June 1998	[Urza98]

Table 1: Documents on Electricity market and roles and process models

In this process, due to various local initial conditions and regulatory policies in different countries around the world, several types of emergent electricity market concepts were attempted. However, out of these there soon emerged two main types of market organization, (i) Power Pools or centralized markets and (ii) Bilateral Contracts Model or decentralized markets. Most electricity markets can be classified as of being of type (i), (ii) or its variants. Both types are present also on European territory and are of relevance as the technology framework for Miracle technology of flex-offer based trading. For this reason, we shall represent their basic traits as described in a Cigre paper in 2005 [Cigr05]. For veracity purposes, the relevant passages are taken as summary from the paper.

3.1.1 Energy Pools

In an energy pool, all producers offer price-quantity pairs for the supply of electricity. This forms an aggregated supply curve. On the demand side, the market operator may forecast demand and dispatch generating units against this. This is called a *one-sided pool*. In more sophisticated pools (*two-sided pools*), the market operator may dispatch on the basis of a demand curve created from price-quantity bids made by the buyers on the market, such as distribution companies and eligible consumers (Figure 1).

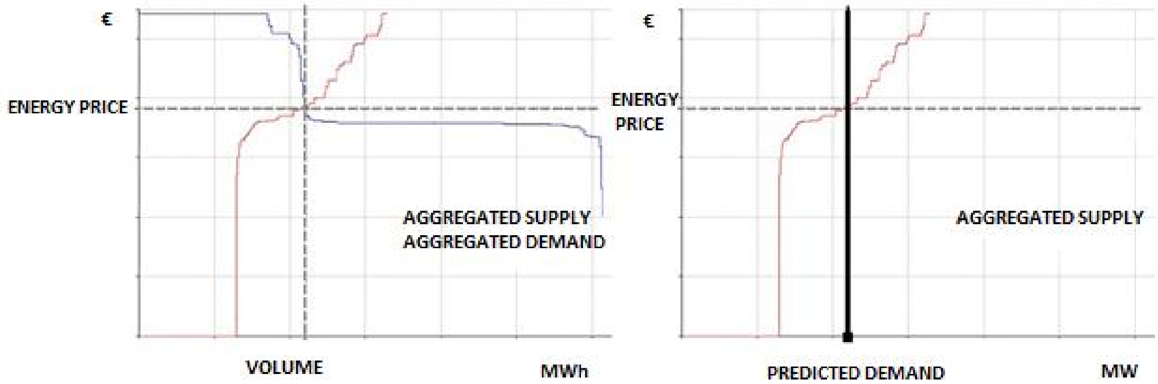

Figure 1: Price discovery - either at the intersection of demand and supply, two-sided pool (left side) or supply and predicted demand, one-sided pool (right side)[BCGP]

A pool can operate a day-ahead market or a close to real-time market (e.g. five minutes-ahead). There can also be a combination of several markets (day-ahead, intra-day and five minutes-ahead). Where a five-minutes-ahead market is operated, other sessions can still be run on the basis of non-firm offers and bids. Such sessions are used to create a forecast of the market prices as an indication for the market participants. Such price seeking sessions are based on non-firm offers and bids and are important to allow for non-dispatched demand side response in case of high market prices.

3.1.2 Bilateral Contracts Model

The alternative to the energy pool model is a market mechanism based on physical *bilateral contracts*. This means that sellers and buyers freely enter into bilateral contracts for energy supply. These types of transactions are referred to as Over the Counter (OTC). In parallel to the bilateral contracts, a voluntary energy exchange could be set up or could develop in the future on the initiative of the market participants. Such energy exchange could offer day-ahead and intra-day trade.

This energy exchange will have no metered production or consumption and will therefore never have imbalances.

The model with bilateral contracts and a voluntary energy exchange has been implemented in several European countries, with exchanges in the Netherlands (Amsterdam Power eXchange), France (Powernext), the Scandinavian countries (NordPool), Germany (EEX), Poland (PolPX) and Austria (EXAA). One can even have several competing exchanges in one country, as was the case in Germany (EEX and LPX) and England (UKPX , APX, PowerEX and IPE).

3.1.3 Comparison

The two models (pools and bilateral contracts) are equivalent in a world without transaction costs. In a world with transaction costs however, the bilateral contracts model may result in a sub-optimal outcome, where price and quantity do not reflect real-time demand and supply. In a pool, prices and quantities should reflect actual demand and supply, more so depending on how far ahead of real time the trade occurs. Though prices

in a pool may be more volatile than in a bilateral contracts market, there are hedging instruments available. Conversely, a simple contracts market is more straightforward and less expensive to set up than an energy pool.
Both market models, pools and bilateral contracts, can coexist on the same market. A pool could have bilateral contracts alongside of it and in a bilateral contacts mechanism a voluntary energy exchange could be considered. Generally speaking, the selection of the type of the market model is connected to the type of dispatch: central dispatch of all generating units is usually related to mandatory pools. Self-dispatch regime, in which producers decide on the dispatch of their own generating units, usually applies to bilateral contracts models.

3.2 National role models

As already mentioned, different electricity market models have been formulated in different European countries: Additionally, they are currently in various stages of implementation. In the next section, a representative selection of these markets is briefly discussed. The sample is based on the national mix of Miracle partners.

3.2.1 Greece

3.2.1.1 Description of physical grid

The Greek mainland has a well-developed electricity transmission system (see Figure 2) which is interconnected with the transmission systems of the neighboring countries in the north and through a DC 400 kV direct-current submarine cable with the Italian transmission system. An interconnection at the border with Turkey is currently under construction. Greece operates under the UCTE system. However, the electrical stability of the Greek electricity system is vulnerable because of the high concentration of generation units in the northwest part of the country and the high distance from the south where most of the load is concentrated. In addition, the synchronous and the high capacity interconnections with other countries are also located at the northern borders. Transporting electricity to the main demand (which is situated in the South and principally in the Attica peninsula) involves losses and leads to high needs for reactive power and instability of voltage. Due to this high geographical imbalance between generation and demand, it is necessary to transfer large quantities of capacity along the North–South axis, through four long-distance High Voltage (HV) lines, which operate in parallel. The interconnected transmission system consists of the High Voltage (HV) lines of 149–400 kV, including the interconnections with neighboring countries, and of the 66 kV submarine connections to some of the islands. It has currently a length of approximately 11,300 km. The (interconnected) distribution network consists of the Medium (MV) and Low Voltage (LV) lines of 15kV, 20kV and 400V. It has approximately 7 million metering points and a length of 207,300 km, covering the whole population. Part of the distribution network is also the autonomous networks of the approximately 2,000 non-interconnected islands of the Aegean Sea. The exclusive owner of both the transmission system and the distribution network is Public Power Corporation (P.P.C.). Within the framework of the unbundling requirements, however, the operation of the transmission system was granted in 2000 to a separate company, namely the Hellenic Transmission System Operator S.A. (HTSO S.A.), which since July 1st, 2007 is also responsible for the operation of the distribution network. The HTSO does not own the grid assets.

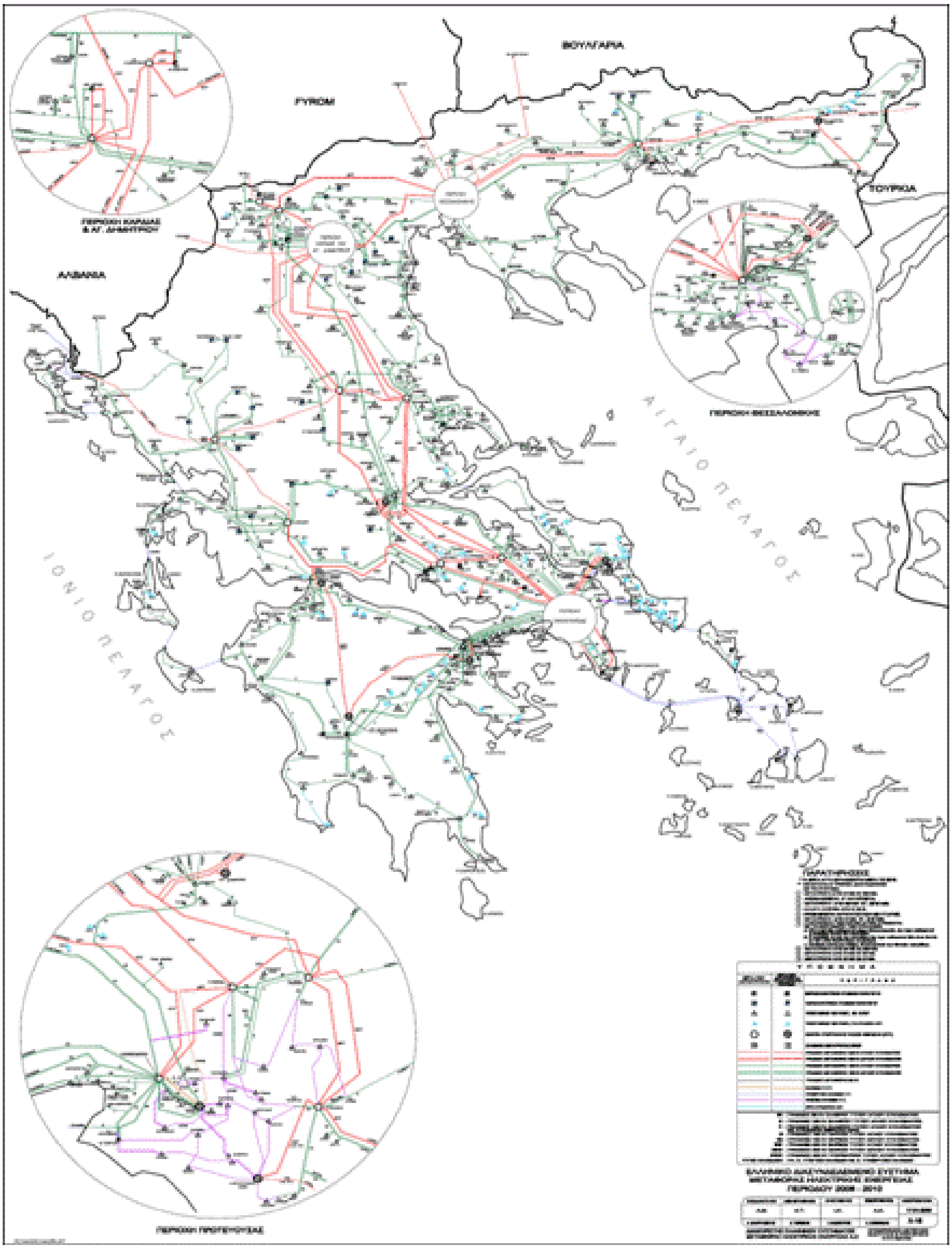

Figure 2: Greek Electricity Transmission System

3.2.1.2 Historical development

For almost 50 years, the electricity sector in Greece has been organized according to the monopolistic model: a vertically integrated, 100% state owned company, namely the Public Power Corporation (P.P.C.), was granted exclusive rights for all electricity activities as regards the construction, functioning and exploitation of hydroelectric and thermal power plants, as well as of the transmission and distribution networks. At the same time, the Law prohibited any private business initiative or action in the electricity sector. The

liberalization of the Greek electricity sector started in 1999, with the enactment of Law 2773/1999, which divided the electricity sector into two sub-sectors: the networks which have remained monopolistic and regulated, whereas free market rules have been applied for electricity generation and supply to eligible customers with the institution of a Regulatory Authority of Energy (RAE) to supervise the whole market. The law imposed, as a condition for any activity in the electricity sector, the issuance of a relative license, issued upon decision by the Minister of Development after a simple opinion of RAE. Also, during the first years of market restructuring, several electricity system codes such as the System Operation Code (2001), the Power Exchanges Code (2001), the Authorizations Regulation (2000) and the Supply Code (2001) were adopted.
In 2003, a Mandatory Pool System was introduced where all suppliers acquired the obligation to purchase energy from the Pool and all generators can now operate only if selected by the market operator according to their economic bids to the Pool. Furthermore, in 2007 it granted the right to the consumers to choose their supplier, after all consumers, even household customers, became eligible with the exception of the customers situated on the non-interconnected islands. Finally, in April 2010 a new Law regarding RES licensing procedure is designed to be issued in order that the whole procedure becomes direct and simplified, releasing the licensing of small RES units from bureaucracy procedures regarding permissions from urban-planning authorities, archaeology authorities and forest – inspection authorities.

3.2.1.3 Market Players in Greek Electricity Market – Resemblance to Role Model

The roles existed and distributed among the different parties and entities in Greek Electricity Market can be identified in the following.

3.2.1.3.1 Consumers

Consumers of electricity can be specified in eligible customers and non–eligible customers. Eligible customers are considered gradually:

- From 2001 to 2005 all High Voltage and Medium Voltage consumers,
- From 2005 to 2007 all consumers except residential consumers and
- From 2007 all consumers even households.

Currently with the existing law framework eligible customers are those who are located on the mainland and all interconnected islands. The eligible customers in contradiction to non-eligible can choose their own electricity supplier in the electricity retail market and also can participate in the Market Pool System declaring their loads if having the licence to do so. In that case, the customers are self–supplied customers and can act as Balance Responsible Party representing their own production in the Market Operation. Eligible customers are the large hydro-electric plants which declare as load the Pumping Units used for pumping the water to the appropriate height. The non–eligible customers are the ones located on the non-interconnected islands where their electricity supply is assigned to P.P.C. automatically. In reality, all residential consumers, households, small industries which are connected to low and medium voltage are having their electricity supplied by P.P.C and act as non–eligible customers. Despite the law issuing towards the total liberalization of the market, the ownership of the DSO network by P.P.C, the strong market barrier posed by its monopolistic activity all those years and the strong regulated tariffs to low and medium voltage consumers render P.P.C. as the dominant party on supplying electricity in Greece obtaining almost 98% of market (95% on wholesale market and a virtual 100% on retail).

3.2.1.3.2 Producers

The producer role in the Greek Electricity Market is performed by parties or entities licensed from the former Ministry of Development (now Ministry of Environment, Energy and Climate Change) after the recommendation of RAE to inject their producing capacity into the transition or distribution network. Producers can be distinguished into traditional producers producing electricity through thermal stations units or through big scale (bigger than 10MW) hydro plants (mostly owned by P.P.C.) and RES producers (P.P.C. and independent, RES energy companies or individuals). All thermal stations units and large scale hydro plants owned either by P.P.C. or private companies are obliged to be declared for their generation offer declarations into the day–ahead schedule (DAS) at the Wholesale Market along with Declaration of Units' Techno-Economical Data and Non–Availability Declaration. Independent individuals acting as RES producers and small CHP producers (smaller than 35 MWe) declare their nominal capacity to the Market Operator and Regulator (RAE) through the licensing procedure and after the issuing of it their whole electricity production is absorbed by the Market in priority to all other (traditional) producers. Furthermore, RES producers and small CHP producers do not need to submit any power injection declarations to the DAS System as this obligation is being carried out by the Market Operator itself.

3.2.1.3.3 Suppliers (Traders), Balance Responsible Parties

The process of trading into the Greek Electricity Market is being implemented only by the licensed authorized Suppliers. The Licenses for Authorization for Supplying Energy are issued following similar procedure to the Producers' Licenses. Suppliers of Electricity can be parties or entities which are contracted to consumers (Eligible and Non–Eligible) and have the obligation to fulfill their electricity needs. They have the right to participate in the wholesale market declaring the loads offers derived from their customers' needs, declaring generation offers representing traditional producers into the wholesale market or declaring imports (or exports) satisfying loads in Greece (or abroad) acting as Traders in the broad European Electricity Market.
To be authorized to supply, a supplier must:

- Own adequate capacity in the EU
- Own, or contract on a firm basis, additional capacity to meet reserve requirements
- Arrange, on a long-term basis, the necessary interconnector capacity and transmission capacity within Greece

Suppliers also must provide Power Availability Certificates (PAC) of appropriate size that corresponds to a long term guarantee of system load demand supply. In the most usual case, suppliers in Greece have their own generation by having their own production units. The suppliers' activity in Greece makes them perform the role of Balance Responsible Parties responsible for their Balance Groups, comprised by consumers and traditional producers. In reality P.P.C. is the biggest supplier in Greek Electricity and the major Balance Responsible Party responsible for the generation absorption of the Generation Units (95% of total generation capacity, except RES) under its ownership and at the same time for the load coverage of the consumers contracted to it (98% of total market). P.P.C. - also operating as a Distribution Operator (DSO) at Medium and Low Voltage - is virtually the sole supplier to non–eligible customers and of the consumers of non–interconnected islands. Despite the provision of the Law 3426/2005, where since July 1st 2007 all customers, including households, became eligible, there is practical no customer that has changed supplier so far. This is mainly due to the regulated tariffs that P.P.C. is obliged to apply, these tariffs are often below cost, making new entry into the supply business almost impossible.

3.2.1.3.4 Market Operator, Transmission System Operator (TSO), Distribution System Operator (DSO)

Before 1999, P.P.C. was the sole operator of the transmission and distribution network in Greece and the market opening of the electricity market was still unrealistic so no market operator role was existed. According to the initial provisions of Law 2773/1999, legal unbundling was introduced only for the operation of the transmission system. The related responsibilities were assigned to Hellenic Transmission System Operator S.A. (HTSO), or DESMIE, a majority state-owned company, with 49% of its shares belonging to P.P.C.. The full unbundling of P.P.C. activities is yet to be implemented. Currently the HTSO operates the transmission network where P.P.C. still holds the operation of distribution network covering all non–eligible customers and most of eligible customers under the medium/low voltage. With the liberalization of the electricity market, after the enactment of Law 3175/2003, a new System Operation and Power Exchanges Code, providing for the organization of a competitive day-ahead wholesale market, was adopted in 2005. The HTSO is granted the duties of the market operator along with those of System Operator, Imbalance Settlement Responsible. Within that framework, the HTSO:

- Collects (a) the demand declarations that are submitted by the load representatives and exporters, and (b) the generation offers that are submitted by the generators and the importers.
- Computes the system marginal price (SMP) for each hour of the next day by sorting in ascending order the economic bids.
- Determines the operation schedule for the next day applying least cost unit commitment based on economic offers and system constraints.
- Controls the operation of power plants and the use of interconnections acting as Control Area Operator.
- Settles financial transactions, and manages imbalances acting as Imbalance Settlement Responsible.
- Plans for and carries out the provision of ancillary services, such as voltage control, reactive power and power reserves.

3.2.1.3.5 Market regulator

The Regulatory Authority for Energy (RAE) was established under the provisions of Law 2773/1999 as an independent administrative authority, and started to operate in summer 2000. More specifically, RAE duties and responsibilities may be summarized to: (i) advisory duties, (ii) decision making powers, (iii) dispute settlement procedures, including arbitration in cases of disputes between consumers and market participants or between market participants and the companies having duties with regard to the networks, (iv) monitoring and reporting duties regarding the performance of energy enterprises, (v) monitoring duties regarding security of supply.

3.2.1.4 Market organization

The Greek Electricity Market structure with the involvement of the above mentioned entities and parties performing the roles identified in the market are illustrated in Figure 3. Continuous lines show the electricity flow from the generation to the consumption of eligible and non-eligible customers through the HTSO transmission network and P.P.C.'s Distribution. It clearly illustrates the necessity of P.P.C. distribution network for the supply of electricity coming for independent suppliers owning their generation units or contracted with traditional generation units. It can also be shown that the non–eligible customers are available for electricity contracts for other suppliers than P.P.C.

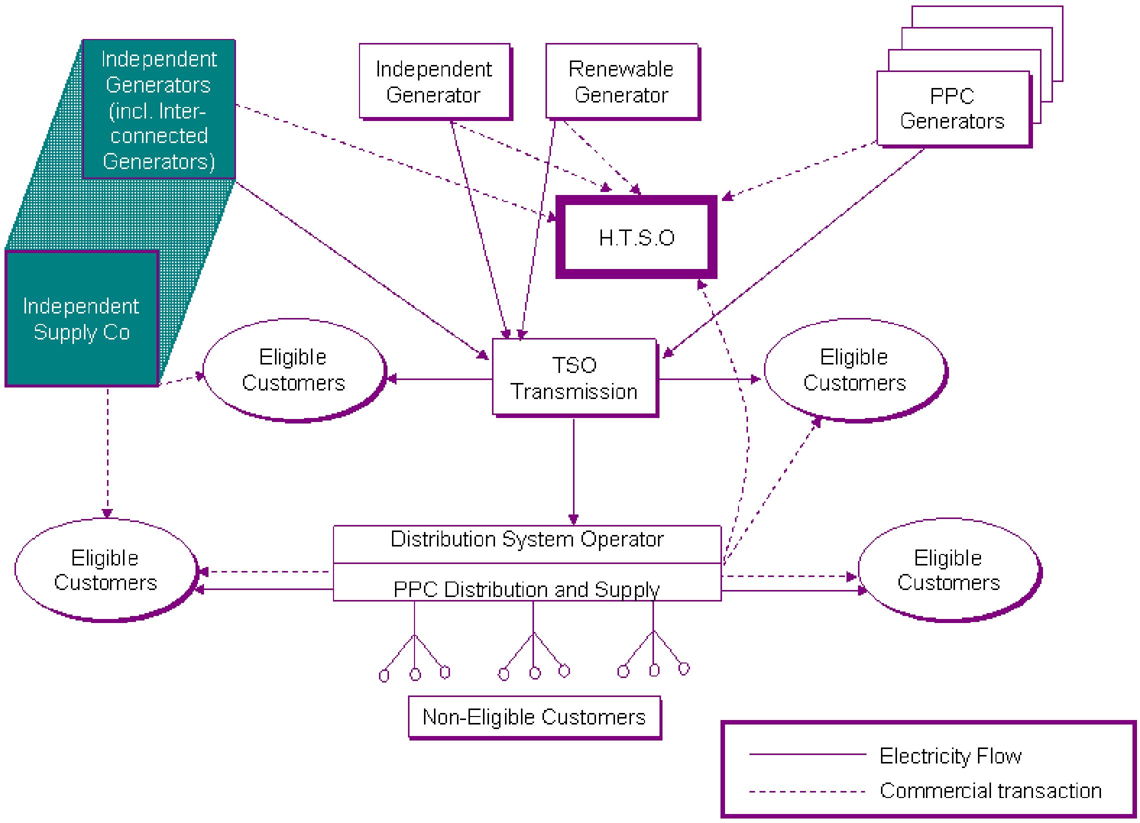

Figure 3 : Greek Electricity Market Structure

After the enactment of Law 3175/2003, a new System Operation and Power Exchanges Code, providing for the organization of a competitive day-ahead wholesale market, was adopted in 2005. According to the Law, a Mandatory Pool System was introduced for power generation and wholesale supply, covering the entire market for the interconnected system. All suppliers acquired the obligation to purchase energy from the Pool and all generators can now operate only if selected by the market operator according to their economic bids to the pool. The pool was designed to operate on an hourly and daily basis. The applicable model is the one of the mandatory pool system which can be illustrated as shown in Figure 4.

As it can be seen on the Figure 4 in the schematic illustration of the processes in Greek Electricity Market, all the basic processes occur on three Days referring to Dispatch Day, which are day ahead (D-1), dispatch day (D) and on the day after (D+1). On the day ahead (D-1) the processes of consumption and production forecasting through the load and generation declaration offers from the responsible parties to the market and the initial scheduling of units, resulting to the first calculation of SMP.

On the dispatch day, the real load consumed and generation produced is being scheduled by adjusting the one of Day Ahead resulting to the final SMP. After the Day after (D+1), the imbalance settlement between measured and scheduled production and consumption is initiated. All imbalance settlement procedures including the funds and payments transfer are concluded several days after dispatch day (D).

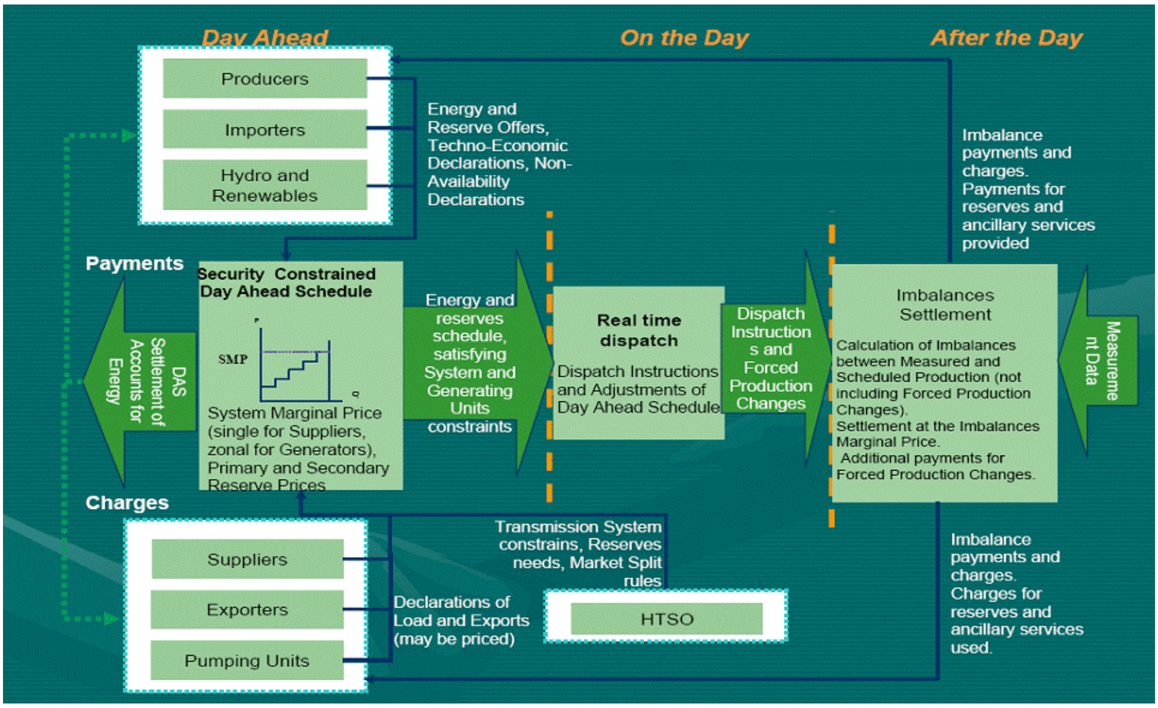

Figure 4: Model of Day-Ahead Wholesale Market

3.2.1.4.1 Electricity Trading Processes on the Wholesale Market

The processes occurring among the identified roles in Greek Electricity Market can be categorized in six basic steps:

3.2.1.4.1.1 Day-ahead forecasting

On the day-ahead forecasting participate the parties and entities which are authorized to declare load and generation offers on the day ahead scheduling. These entities are Balance Responsible parties of the Balance Group of clients they represent and for the Greek Market can be:

- *Producers*, holders of production licenses units, registered in the Record of Distributed Units
- *Suppliers*, holders of supply license
- *Self–supplied* customers, selecting customers which choose to be supplied energy from the electricity trading system for their own

Load declarations are submitted by the BRP of each group trading for load in the market. The content of Load Declarations can be:

- Non–priced declarations (offers) for every consumption in Greek territory which include the load quantity for every dispatch time period (one hour) of the dispatch day.
- Priced offers for exports and pumping which include pairs of load quantity and respective price for every dispatch time period of the dispatch day.

Loads can be declared for 48 hours until the end of the Day Ahead 12:00pm and there is a possibility of re–declare for five times for each participant and is declaration is mandatory in relation to the mandatory representation of clients from the BRPs on the market.

Regarding generation offer declarations, those are submitted by each producer or importer. The content of generation offer declarations for the day ahead can be:

- Pairs of generation offer quantity and respective price for each block of generation offer which are categorized to: i) priced block of generation offer for every registered production unit, ii) priced block of generation offer for imports, with the number of maximum blocks of generation offers to be defined to 10 and prices for each block of generation offer are monotonous increasing.
- Non–priced quantities of generation offers for RES and mandatory Hydro Units.

Generation offers can be declared for 48 hours until the end of the day ahead 12:00pm with possibility of re-declare also for 5 times for each producer. Generation offer declarations are submitted mandatory and separately for each production unit. The producer is obliged to submit offer for the total of nominal power of each production unit which agrees to the data of the record of production and distributed units. Producers along with the generation offer declaration must also submit declaration of techno-economical data for each of the units and unit non–availability declaration as well.
After the declarations of load and generation offers the HTSO as market operator continues with the load forecasting on the day ahead level taking into consideration all load declaration data, and then the forecast schedules for the generations units production. These schedules are “unconstrained” or “constrained”. The unconstrained schedule does not take into consideration the transmission constraints of this system where the “constrained” does. Both schedules also ignore the long terms contracts of generators. The result of market operation is the hourly system price, published by HTSO officially at its website. This initial calculation of SMP’s is a forecast of the final SMP which will apply after the real dispatch of the Units, where the real quantities of generation will be injected to the system and real consumption load will be demanded. The day–ahead forecasting process concludes with the HTSO publishing the forecasted initial SMP’s for each hour of the dispatch day and sends the schedules to the participants. The full timeline of the day ahead processes is illustrated in Figure 5.

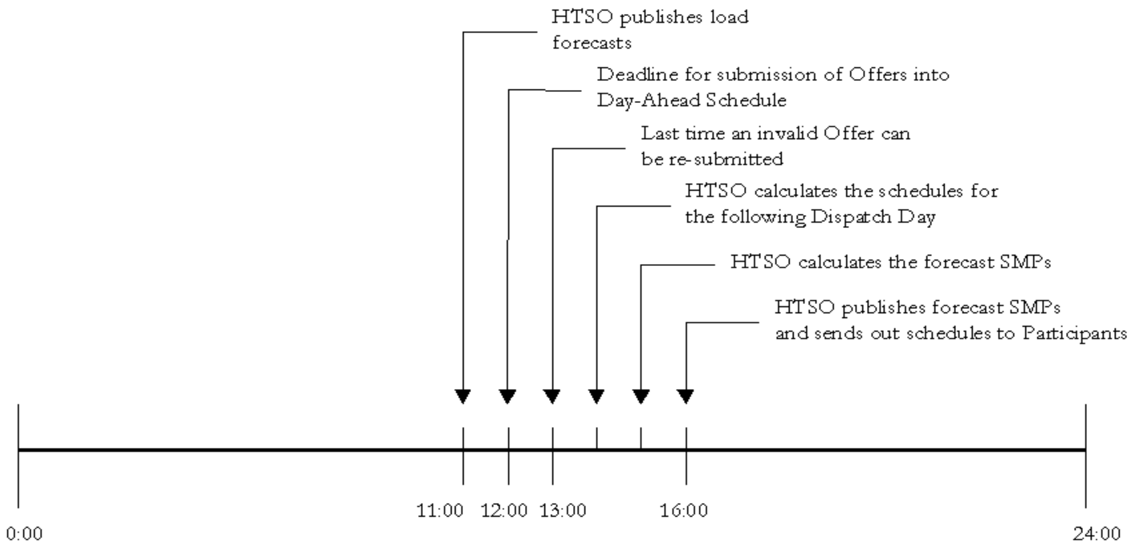

Figure 5: Timeline of Day-Ahead Processes

The HTSO may instruct available Units in Greece to start-up and synchronize at some point during or before the dispatch day to ensure adequate generation capacity is available for the real time dispatch of the system. Generators are obliged to follow these instructions. In real time, system load, generation availability and other constraints may change from those forecast on the day-ahead. Although these changes are normally not significant, they must be accounted for so that the transmission system is operated reliably. Accordingly, a separate dispatch in each dispatch hour determines the actual energy quantities dispatched from units in Greece to meet actual demand on the system. The dispatch is determined according to the merit order established day-ahead from the prices in the offers. The units have to obey their dispatch instructions in real time so as to keep the transmission system stable. Scheduled generators are not able to resubmit the quantity component of their offers between the time the offer was submitted and the dispatch hour unless they have a “legitimate” reason to do so. A legitimate reason is a prior approval by the HTSO, or an unexpected (forced) outage that renders some or all of the capacity of the unit unusable or hazardous to use for reasons of safety or protection of physical equipment. The HTSO may only issue prior approvals for reasons relating to unpredictable external factors such as wind strength in the case of wind-powered units. Offer revisions that are not demonstrably legitimate may result in penalties being assessed. Under no circumstances may the price parameters of an offer change between the time of submission into the day-ahead forecast and the actual dispatch hour.

3.2.1.4.1.2 Metering and calculation of Systems Marginal Price (SMP)

In the day ahead an initial calculation of the SMP is occurred as a forecast to the final calculation of the SMP taking place after the dispatch day where the real quantities of energy have been consumed and produced. The System Marginal Price (SMP) in each dispatch hour reflects the marginal cost of meeting actual demand on the system given actual generation availability in that hour. The SMP is calculated ex-post, i.e., after the dispatch has been completed, and after Meter Quantity data has been determined. They are calculated on the Calculation Day (D+4), the day four days after the dispatch day. SMPs are calculated independently for each dispatch hour of the dispatch. SMPs are calculated based on the same principles as are used to determine the day-ahead forecast SMPs, except that the calculation includes updated information on actual unit availability and actual load so SMPs are used also in the settlement process and also called as Imbalance Marginal Price. In the event of suspension of the System’s Trading Arrangements, SMPs are set to an Administered Price.

3.2.1.4.1.3 Metering

All electricity delivered to or taken from the transmission system must be metered for HTSO settlement purposes. All energy produced by distribution-embedded units and all energy consumed by those eligible customers connected to the distribution system who are not supplied by P.P.C. distribution must also be metered for HTSO settlement purposes. Each BRP is required to account to the HTSO for all the energy used by customers for whom it has responsibility. The registered information for a BRP must identify the meters of eligible customers whose load must be evaluated in order to calculate the total load of the BRP. In the case of P.P.C. distribution, the registered information also specifies the meters at each connection point between the transmission system and the distribution system, and identifies the meters of distribution-embedded units and eligible customers not supplied by P.P.C. distribution connected to the distribution system below each transmission connection point.

BRPs are obliged to notify the HTSO whenever they acquire a new eligible customer or lose an existing one, or when their responsibility or allocation for the metered volume of an existing eligible customer otherwise changes, so that the HTSO can update the registered information for BRPs accordingly. The HTSO is responsible for maintaining the registered information and maintaining a central register of each eligible customer, identifying the corresponding meter, the corresponding BRP that have responsibility for its metered load, and the allocation rules, if any, to apply. The HTSO ensures that for settlement purposes, participants take responsibility for 100% of all data metered. In the calculation of the meter quantity attributable to each BRP responsible for supplying its clients and generator at each node, the HTSO uses the registered information to determine:

- which meter-readings to aggregate for each purchaser at each node; and
- which unit meter-readings to aggregate for each generator at each node.

The HTSO is also responsible for verifying and correcting metered data, collected from participants' meters, in order to establish meter quantity information. Such verification and correction shall be carried out in accordance with the validation, editing and estimation procedures published on the HTSO web-site. At the request of HTSO, participants shall assist HTSO in correcting or replacing defective meter data and in detecting and correcting the underlying causes of for such defects.

3.2.1.4.1.4 Calculation of Settlements

Imbalance is the Energy Deviation which shall be defined separately per Energy Offer and Load Declaration and separately per dispatch period, and it shall be the difference in MWh between the energy quantity scheduled for injection to the system or absorption by it in accordance with the DAS schedule and the energy quantity injected to or absorbed by the system in real time operation as is measured for the same dispatch period and corresponded to the participant and the Energy Offer and Load Declaration in question.
There are two types of Energy Deviations:

- Uninstructed Generation Deviation in MWh of a unit for a dispatch period shall be the difference between the quantity energy established by dispatch instructions to be injected to the system for the same dispatch period and the energy quantity measured for the same dispatch period at the Unit Meter;
- Instructed Generation Deviation in MWh of a unit for a dispatch period shall be the difference between the quantity energy declared in the energy offer for the unit to the extent that this is included in the DAS schedule for the same dispatch period and the energy quantity established by the dispatch instructions for injection to the system for the same dispatch period.
- Imbalances Settlement apart from those related to Generation Deviations can also be identified in the settlement of transactions for Ancillary Services and the Uplift Accounts.

The procedure followed for the calculation of Settlements is that at the end of each dispatch day, the HTSO activates the Imbalances Settlement Procedure which shall be completed within four (4) calendar days (Imbalances Clearing Period). Clearing Day (or Calculation Day) shall be the last day of the Imbalances Clearing Period. Generation Deviations will be settled at a single price (€/MWh), (Imbalance Marginal Price).
The HTSO's timeline at the Clearing Day can be described as:

- Determination of final SMPs (imbalance marginal price) and meter quantity information
- Calculation of each participant's daily purchases and sales of energy through the market and records them in the participant's account;
- Accumulation of any Ancillary Services costs, HTSO administrative costs, the net cost of energy exchanges with adjacent control areas, the net cost of payments in respect of energy generated, Constrained-On Payments and Constrained-Off Payments, net

revenues from transmission losses, and participant non-compliance net revenues, as they are incurred, in the Uplift account; and

- Accumulation of the cost of payments made to the P.P.C.'s Transmission Business Unit as they are incurred and in accordance with the terms of the Transmission Control Agreement, in the transmission account.

The HTSO is not involved in the settlement of any existing or future contracts between Participants, nor the settlement of retail tariffs. Nor does the HTSO collect charges from Participants in respect of penalties. On the Billing Day in respect of a month, HTSO informs the RAE of the amount of any penalties assessed on a Generator for each day in the month.

3.2.1.4.1.5 Billing and funds transfer

On the Billing Day in respect of each calendar month (the day fifteen days after the last Dispatch Day of each calendar month) the HTSO clears, on an accrual basis, the Uplift costs accumulated for the month. It does this by making transfers to the participants' accounts so that the Uplift account has a zero balance on the HTSO's books as of the beginning of each new settlement month. Uplift costs are allocated to BRPs on the basis of their pro-rated energy consumption for the month. Funds due must be transferred on or before the day fifteen days after the billing day (or on such day as the HTSO specifies when it publishes its calendar of payments prior to the beginning of each year).

3.2.1.4.2 Bilateral Contracts

Apart from the day–ahead pool market mandatory to participants in the system, an important feature of the Greek Electricity Market is that it also has gross settlement in respect of contracts and net settlement in respect of ownership. This means: i) all electricity generated or consumed is sold by generators, bought by purchasers, and settled by the HTSO, ii) the HTSO does not take into account independent contractual arrangements between Participants with regard to its settlement of transactions in the Market, iii) the HTSO does, however, consolidate invoices and remittances of participants owned by the same parent entity. Suppliers, which are both purchasers and generators are therefore invoiced or paid for their net financial imbalance. (Each supplier is treated as a separate generator and purchaser in the market – in this way it is possible for the HTSO to conduct a least cost dispatch of the full available capacity of suppliers and not just the capacity net of their final customer load.) The purpose of this is to illustrate how a supplier, being both purchaser and generator, can use the market serve its load and match imbalances between its generation and consumption. It also illustrates how participants can enter into bilateral energy contracts with one another within the framework of the Market to buy and sell imbalance energy at predetermined prices, rather than at SMPs, if they so wish. SMPs fluctuate according to market conditions. Participants, if they desire, can make bilateral contracts between one another to "lock-in" the price at which imbalance energy is bought and sold, so as to remove the financial uncertainty of paying or being paid the SMP. The form of contract that participants can enter into for this purpose is a Contract for Differences (CFD). A CFD is a financial contract between the parties to the bilateral transaction and is independent from the HTSO. A CFD has a strike price and a MW quantity. In its most simple form it specifies that:

- when the SMP is higher than the strike price, the generator pays the purchaser the SMP minus the strike price, multiplied by the CFD MW quantity, for that hour; and

- when the SMP is lower than the strike price, the purchaser pays the generator the strike price minus the SMP, multiplied by the CFD MW quantity, for that hour.

The financial effect of a CFD, therefore, is that both the generator and the purchaser receive a guaranteed net price – the strike price – at which they respectively sell and buy the CFD MW quantity of imbalance energy. The existence of a CFD does not change the way the Generator offers its capacity to the HTSO, or the way in which the HTSO operates the system. Furthermore, the settlement of CFD payments is made independently of the HTSO, between the participants concerned. Consequently, since executing bilateral transactions in the form of CFDs does not require any special action from the HTSO in addition to its regular responsibilities as system operator and market operator, there are no special rules regarding these contracts in the market. The HTSO does not need to be aware of their existence.

3.2.1.5 Balancing the production/consumption

The balancing of production/consumption in the Greek electrical system due to the mandatory pool market for all the participants occurs on the system operator level as this is the level that P.P.C. and all other potential suppliers of electricity acting as BRPs submit their load declarations to the pool and thus HTSO having the responsibility to balance the whole Greek Area. Balancing the production/consumption apart for covering the electricity deviations derived at the dispatch day, ensures the system's reliable system operation. For that reason HTSO sets requirements for the so-called "ancillary services" including:

- Frequency control: fast response to fluctuations in frequency achieved either through governor action and/or by use of Automatic Generation Control.
- Reserves: several types of reserve are usually required to maintain system security. The definition of these services varies according to the required time frame for response and duration of response. The types of reserves used will in part depend on the generation mix and security standards.
- Voltage control: can be provided by either dynamic sources or static sources.
- Black start: arrangements to restore the transmission system following an outage.

Reserves are separate commodities that can be traded in the day-ahead market, thus establishing reserve markets. The primary reserve requirement is set at 80 MW, while the secondary reserve requirement varies between 150-300 MW for secondary reserve up, and between 50-150 MW for secondary reserve down. Tertiary reserve requirement is set for the moment at about 5% of the system load. Currently, there are separate primary and secondary reserve markets; tertiary reserve is not remunerated, but the relative requirement enters the DAS program as a constraint.

3.2.1.6 Tariff system

The structure of P.P.C. tariffs has remained unaltered since the beginning of the monopoly period, i.e. for almost 40 years. Only the numerical values of total tariff levels per sector are changed every year as a result of government's regulations. These tariffs are applied in a uniform manner for all customers independently of their geographic location in Greece. The tariffs vary per connection voltage level and sector to which the consumer belongs (for example industry, residential, etc.). Recently RAE launched a procedure for the revision and rationalization of P.P.C. tariffs. This procedure is ongoing. Furthermore, P.P.C. recently elaborated and presented an unbundled tariff structure, separating the regulated from the competitive charges. Low tariffs are exceptionally applied for agriculture, P.P.C. employees and families with more than three children. The High Voltage (HV) and the Medium Voltage (MV) tariffs are based on separate charges for power and for energy. The tariffs apply a generally higher price on the power component (MW) than on the energy component (MWh). The related supply contracts apply ‘take-or-pay’ obligation clauses regarding the power component, based on mentioning in the contracts per customer the volume of power on which take-or-pay obligations apply. The Low Voltage (LV) tariffs are based only on an energy component and include a fixed payment term. The residential tariffs vary stepwise and follow an upwards increasing slope; the first step is almost half the fourth and the subsequent steps. Commercial and small industry electricity prices are significantly higher than average electricity cost, whereas the high voltage prices as well as the residential and agriculture tariffs are below average cost. Therefore, cross-subsidizations between different consumer categories exist in Greece. Also cross-subsidizations apply to the benefit of consumers located in non-interconnected islands.

3.2.2 Slovenia

3.2.2.1 Description of the physical grid

3.2.2.1.1 Transmission network

Slovenian transmission network is synchronized with the continental European system UCTE. Figure 6 represents a map of the transmission network of Slovenia.

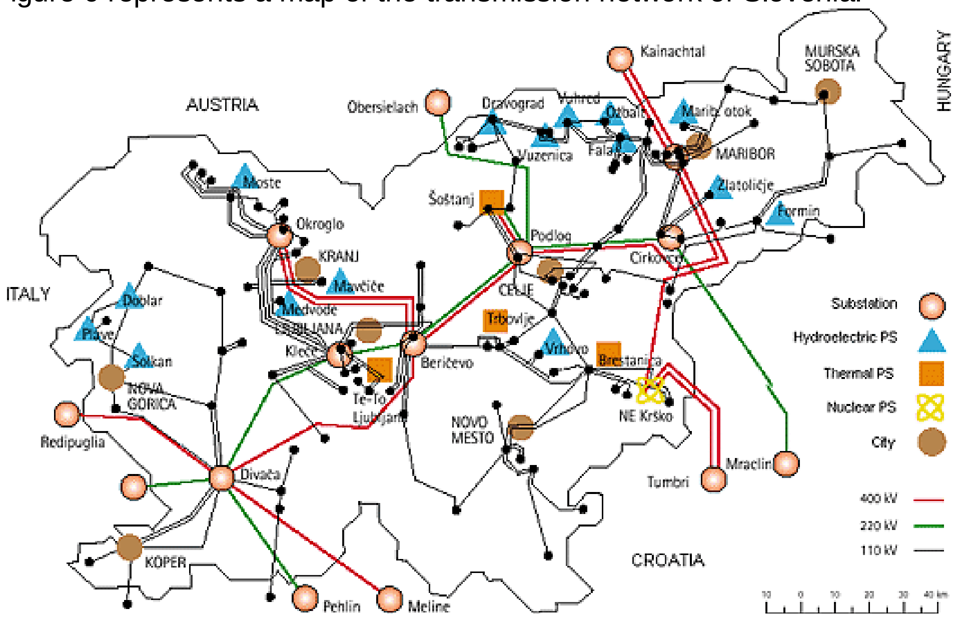

Figure 6: Map of transmission network

Slovenian high voltage transmission network works on three voltage levels 400 kV, 220 kV and 110kV. Slovenia has 21 distribution stations with 27 transformers. The combined system length of all transmission lines is 2.572 km and the aggregate power of all transformers is 4,768 MVA. Table 2 represents a length of the power lines and number of the transformers that are in use for each voltage level.

Type of power line	Length	Number of transformers
110 kV	1,736 km	8
220 kV	328 km	10
400 kV	508 km	9

Table 2: Basic information about the transmission network

Slovenian transmission network is also used for an import, export and transition of the electrical energy with the neighbouring countries. The Table 3 represents a list of power lines that connects the Slovenian transmission system with the neighbouring countries.

Country	Type of grid
Austria	2x400 kV and 220 kV grid
Italy	400 kV and 220 kV grid
Croatia	2x400 kV, 2x220 kV, 3x110 kV grid

Table 3: Connections with neighbouring countries

With Hungary there is no high voltage connection, but a 400 kV power grid is planned on the relation Cirkovce - Pince. Slovenia and all neighbouring countries except Hungary are members of European UCTE union.
The transmission systems in Slovenia is owned, developed, and operated by the public company Elektro-Slovenija, d.o.o. (ELES). ELES has exclusive right to perform public service as the transmission network system operator in Slovenia. The founder and the sole owner of the company is Republic of Slovenia.

3.2.2.1.2 Distribution network

The distribution network in Slovenia is working on several voltage levels 110 kV, 35 kV, 20 kV, 10 kV, and less than 1 kV. It includes 90 transmission transformers stations, 55 km of high, medium and low voltage wires and 12,650 transformer stations on distribution network. Table 4 represents some basic information about Slovenian distribution network.

Type of power line	Length	Number of transformers
110 kV	806 km	81 (Transformation from 110 kV to lower voltage levels)
10, 20, 35 kV	16,740 km	16,198 (Combined low level voltage transformers)
<1 kV	44,979 km	

Table 4: Basic information about distribution network

Republic of Slovenia gave a license for the electricity distribution system operator to the public company Electricity Distribution System Operator, d.o.o. (abbreviated name: SODO, d.o.o.). SODO has signed lease contracts on the electricity infrastructure and provision of services for electricity distribution system operator with five distribution companies Elektro Celje d.d., Elektro Primorska d.d., Elektro Gorenjska d.d., Elektro Ljubljana d.d., Elektro Maribor d.d. and some other closed distribution systems in Slovenia.
SODO and its contractual companies provide the supply of electricity to more than 900,000 users of the distribution network in Slovenia.

3.2.2.1.3 Electricity generation

The structure of the electricity generation has not significantly changed in the past ten years. The power producers that are using nuclear and fossil fuel still represents the largest electricity producer with around 70% of generation. Table 5 represents the production of the electrical energy for the year 2009 in Slovenia.

Production	Energy [GWh]
Renewable energy	4,717
Fossil fuel energy	5,945
Nuclear energy	5,739
Gross production	16,401

Table 5: Types of the electrical energy production

Figure 7 represents distribution of electrical energy production by different type of producer. Approximately 30 % of all the produced energy in Slovenia is coming from the renewable sources.

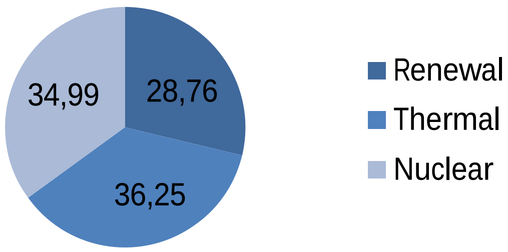

Figure 7: Net energy production for Slovenia in 2009

The majority of the energy produced from renewable sources comes from the hydro power plants (see Table 6). Compared to the year 2008 there was 100% and 300% increase in use of biogas and solar energy for production of electricity.

Production	Share [%]
Hydro power plants	96
Wood and wooden residues	2
Bio gas, solar and other	2

Table 6: Renewable energy production

The export and import of the electrical energy for the year 2009 in Slovenia is presented in the Table 7.

	Energy [GWh]
Export	6,156
Import	9,222
Balance	-3,066

Table 7: Export and Import of electrical energy

Slovenian electrical energy system has to import electrical energy to satisfy all the consumption needs.

3.2.2.2 Historical development

Important milestones regarding the opening up of the electricity market:

- December 1996: Adoption of European directive 96/92/EC concerning common rules for the internal market in electricity.
- October 1999: Implementation of European directive 96/92/EC. This Directive established common rules for the generation, transmission and distribution of

electricity. Directive has made significant contributions towards the creation of an internal market for electricity. Experience in implementing this directive shows the benefits that may result from the internal market in electricity, in terms of efficiency gains, price reductions, higher standards of service and increased competitiveness. Directive established the rules relating to the organization and functioning of the electricity sector, access to the market, the criteria and procedures regarding to the calls for offers.

- June 2000: The Slovenian regulator of the markets for electricity and natural gas (the Energy Agency of the Republic of Slovenia) is established. Energy Agency goal is to provide the objectivity and equality of all the participants in the energy markets, and to help establish necessary conditions for an effective operation of these markets.
- April 2001: The opening of the market for consumers with a connected load of over 41 kW. By opening the market for these types of consumers, consumers can chose their supplier according to the free market rules.
- January 2003: Slovenia was opened to foreign countries and become a member of the single European cross-border trading mechanism.
- June 2003: Adoption of Directive 2003/54/EC concerning common rules for the internal market in electricity.
- May 2004: Amendment of the Slovenian energy act (the implementation of Directive 2003/54/EC). This directive established common rules for the generation, transmission, distribution and supply of electricity.
- July 2004: The opening of the market for all non-household customers.
- July 2007: The opening of the market for all customers. This was the final step in providing access to the free market for all customers.

3.2.2.3 The electricity market in Slovenia

Organized electricity market is a central place where the supply and demand for electricity are faced. Electricity market in Slovenia is organized and operated by public company Borzen. Borzen was founded on 28th March 2001 for the implementation of the public utility service relating to the organization of the electricity market and many other important activities in the Slovenian energy field connected with stimulating the use of renewable sources and the efficient use of energy. Borzen, which was previously owned by Elektro Slovenija, passed into the direct ownership of the Government of Slovenia in December 2007. Figure 8 represents the structure of the market organizer Borzen.
The Market organizer Borzen runs the following major tasks

- market operator,
- power exchange and the
- financial settlement.

3.2.2.4 Market operator

As the market operator Borzen is responsible for notification of bilateral contracts, managing of balance scheme, managing of operational schedule and imbalance settlements with balancing market.

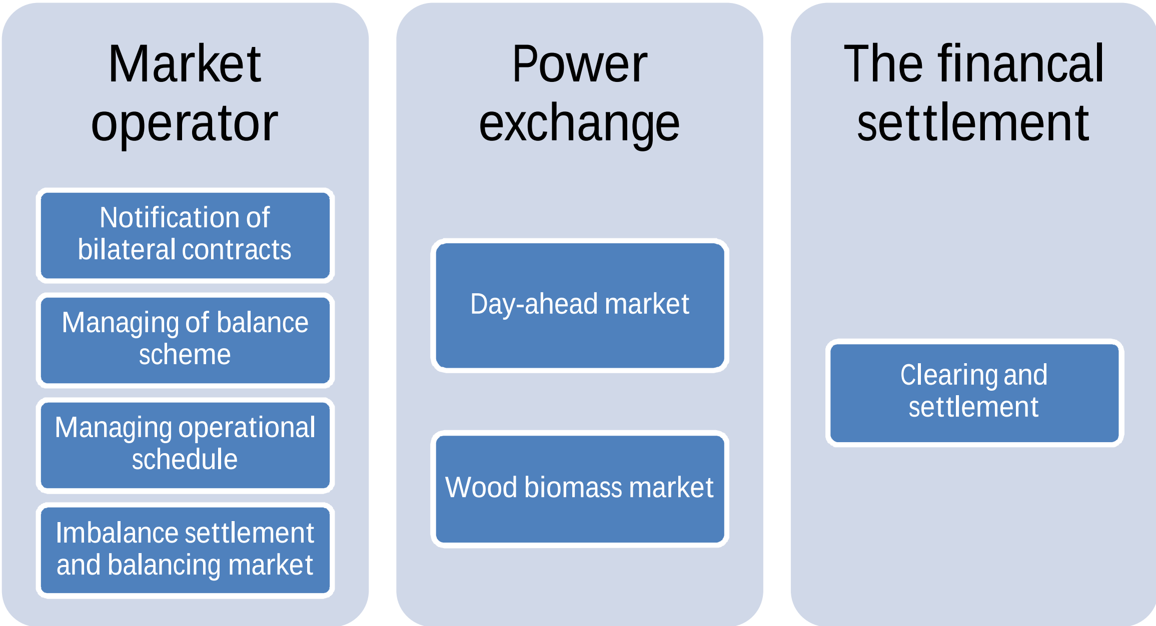

Figure 8: Structure of the market organizer Borzen

3.2.2.4.1 Notification of bilateral contracts

The following contracts represent the basic types of legal relationships on the organized market:

- **Balance scheme membership agreements**
  The organized market is hierarchically arranged into a balance scheme where the relationships among the balance scheme members and the management of their balance of inflow and outflow are uniformly defined with balance scheme membership agreements.
  Balancing agreement is a legal transaction or other relation which legal and natural persons utilize to manage the supply of balancing energy and financial settlement of imbalance settlement with the market operator, by which the legal or natural person is included to the balance scheme as the balance responsible party and acquires a membership status in the balance scheme.
- **Open contracts**
  Open contracts are legal transactions and other relations defining balancing affiliation of the delivery points. Open contracts include supply agreements or virtual open contracts.
  - **Supply agreements**
    A supply agreement is an open contract concluded between a supplier and an owner/holder of a delivery point, acting as consumer or producer, the subject of which shall be the supply or the receipt of electricity at the delivery points, defined in the contract which constitutes a balancing affiliation to the supplier.
  - **Virtual open contracts**
    Virtual open contracts are legal transactions or other relations which occur if:
    - Delivery point is a part of the network, managed by the system operator and that this delivery point does not have balancing affiliation to other balance scheme member.
    - Delivery point delimits either two networks managed by two different system operators, or two distribution areas, managed by the same distribution system operator.

        - Consumers have ability of self-supply.

- **Closed contracts**
  The closed contracts are legal transactions or other relations among the balance scheme members of the organized electricity market where the amount of supplied electricity in a relevant time period is fixed for each accounting interval. The closed contracts with the use of the cross-border transmission capacities also fall within the category of the closed contracts and are considered as the closed contracts for the supply of electricity across the Slovenian borders and to which the rights of cross-border transmission apply as well. The closed contracts include real closed contracts and virtual closed contracts.
    - Real Closed contracts
        - A contract concluded between two balance scheme members for the supply of electricity within Slovenian borders.
        - A contract for the supply of electricity with the use of cross-border transmission capacities concluded between a Balance Scheme Member and a neighboring market participant.
    - Virtual closed contracts
        - A cross-border electricity transmission of a balance scheme member who is, at the same time, also the participant of the neighboring market, with the use of cross-border transmission capacities.
        - The occurrence of effects of the exclusion of the balance scheme member in the record of closed contracts.

3.2.2.4.2 Managing the balancing scheme

3.2.2.4.3 Balance scheme

Organized electricity market is hierarchically arranged into a Balance Scheme. Any legal or physical person that wishes to operate on electricity market actively must become a member of the Balance Scheme. Membership and structure of the balance scheme are defined with the balancing agreements, concluded with the power market operator (Borzen), and with compensation agreements, concluded with the balance scheme members. Power market operator, which represents the peak of the balance scheme, provides balancing energy delivery to the balance groups through balancing agreements.

3.2.2.4.3.1 Balance groups

Balance group is balance scheme member. Its peak is represented by a balance responsible party which is followed by any number of hierarchically inferior balance group members. Balance groups can act on the market as traders which buy or sell electricity according to the volumes known in advance (closed contracts), or as suppliers of electricity which beside electricity trading also deal with electricity supply to the consumers or with electricity purchase from the producers (open contracts). Transmission system operator (ELES), distribution system operator (SODO), and energy exchange are also balance scheme members. Besides that, the centre for support has also established one Eco group with special status in the balance scheme in accordance with the regulations in force.
Any demand for energy or the energy transfer request must belong to one group.

3.2.2.4.3.2 Balance sub-groups

In general balance group can be assembled with several different types of sub group members for the purpose of balancing production and consumption of electricity. Balance

sub group can form balance sub-sub groups. Each entity connected to the grid has the right to select which balance group or which balance sub-group it will belong to.
Balance sub-groups are represented by the balance subgroup responsible party, who is responsible for:

- The conclusion of a compensation agreement with the balance responsible party or the balance subgroup responsible party on the upper level.
- The exchange of data with the balance responsible party or balance subgroup responsible party on the upper level.
- The reporting of concluded closed contracts to the balance responsible party or balance subgroup responsible party on the upper level.
- The reporting of operational forecasts for the delivery points that belong directly to him or to the balance scheme members in his balance subgroup to the balance responsible party or balance subgroup responsible party.
- The reporting of concluded supply agreements, namely the notifications on their own supply to the competent system operators.

Balance sub-groups act on the market same as balance groups. Balance sub-group can act as traders which buy or sell electricity according to the volumes known in advance (closed contracts), or as suppliers of electricity which beside electricity trading also deal with electricity supply to the consumers or with electricity purchase from the producers (open contracts).

Any operator of a distribution network may represent a special balance group or subgroup, in which power is purchasing to cover losses on the distribution network. The balance group also includes qualifying producers who are not liable for the payment discrepancies.

3.2.2.4.3.3 Types of balance groups

- **Traders, market agents and market brokers**
  These types of groups are not connected on physical network. This groups and sub groups are trading with electrical energy on global market to which Slovenian market belongs. They operate in closed contracts with other balance groups and insure balance between production and consumption.
- **Suppliers**
  Suppliers are forming balancing groups from producers and consumers and traders in order to balance production and consumption of electricity. Supplier has contracted open contracts with producers and consumers. These types of groups must include enough producers with enough power to supply all their consumers. All unbalances in energy consumption are penalized. These groups are typically assembled with several sub- groups of different types for insuring a balance of energy.
  - *Producers*
    Two type of producers are present in Slovenian electrical energy system ones that are connected on transmission network and others that are connected on the distribution network.
  - *Consumers*
    Two type of consumers are present in Slovenian electrical energy system ones that are connected on transmission network and others that are connected on the distribution network.
- **Commercial public service providers**
  In Slovenia there are three balance groups that provide public services.

- *Transmission system operator*
  TSO forms special balance group that insures safe/stable transport of electricity, measurements on transmission network, balancing the transport network endpoints (online measurements), control the energy reservations (primary, secondary, tertiary), controls/executes auctions on the capacities of international transport, buying technical losses and participate in imbalance process. TSO physically implements the balancing of the electric power system.
- *Distribution system operator*
  The tasks of the system operator of the distribution system are supporting the distribution grid, buying technical losses, providing services (measurements). The distribution system operator is a separate balance group for providing the financial transactions for the self-operation. The distribution system operator unifies five geographical dislocated distribution companies and provides common functionalities. Each distribution company forms its own balance subgroup to buy technical losses.
- *Eco group*
  An Eco group is designed for the settlement of differences between announced and realized production and sale of electricity, gathered from participants of the support scheme which are entitled to guaranteed purchasing.

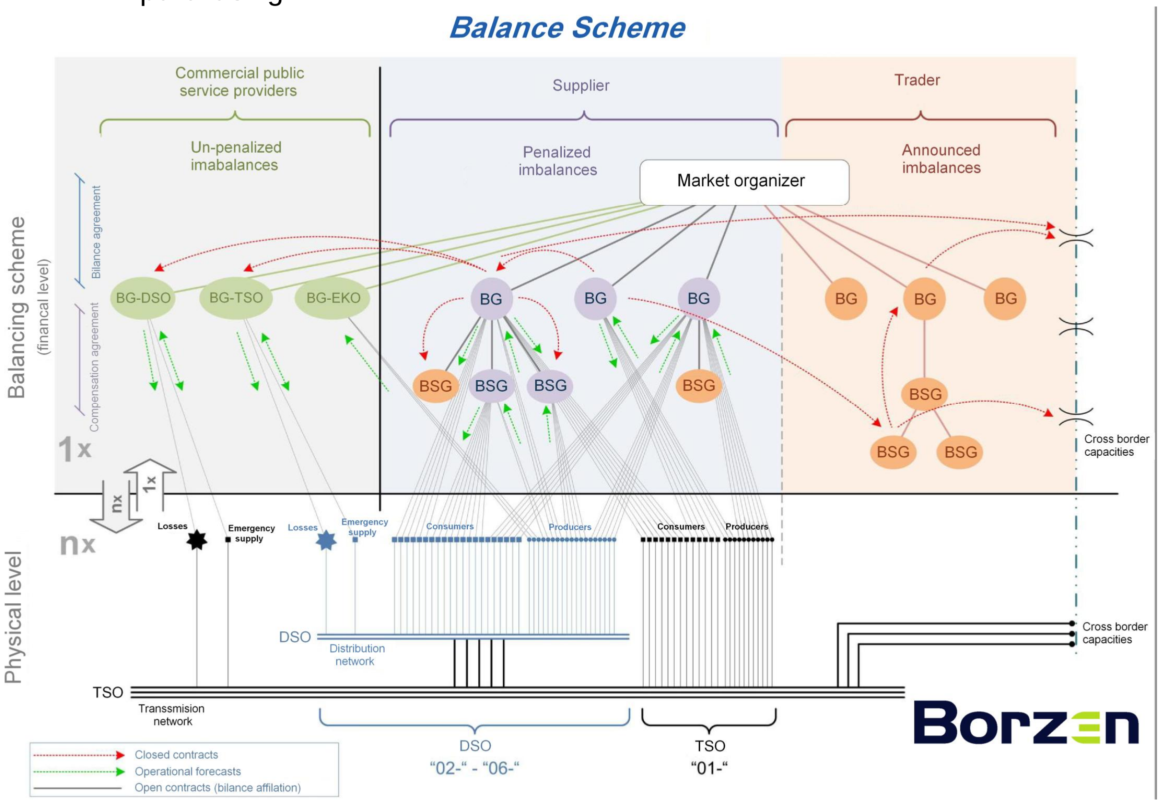

Figure 9: Structure of balance scheme

3.2.2.4.4 Managing operating schedule

On the basis of recorded closed contracts and operational forecasts (operational forecast is a forecast of the production and consumption of electricity of each balance scheme member for an individual delivery point for which an open contract was contracted.), the market operator draws up an indicative operating schedule of the transmission and distribution network and sends it to the system operators. The indicative operating schedule comprises of:

- The operating schedule of the Transmission Network
- The operating schedule of the Distribution Network Areas
- The operating schedule of exchanges with other countries
- The market plans of the Balance Scheme Members
- The Register of Closed Contracts with the use of cross-border transmission capacities

The market operator draws up and sends an indicative operating schedule to the transmission system operator not later than thirty (30) minutes after the deadline for the report of closed contracts and operational forecasts. The final operating schedule is an indicative operating schedule which has been supplemented by the transmission system operator with the solutions of possible technical restrictions and system services. If the transmission system operator fails to provide the solutions of possible technical restrictions and system services, the indicative operating schedule shall be deemed as the final operating schedule. The final operating schedule shall form the basis for the operation of the energy system for the following day. The transmission system operator submits the final operating schedule to the market operator.

3.2.2.4.5 Imbalances settlement and market balancing

The imbalance settlement is a settlement of balance groups within which the amount of imbalances is determined and calculated by comparing the whole realization of the balance groups and their market plan. Besides the amount of imbalances, settlement also includes the financial values of imbalances. Within the framework of the imbalance settlement, according to the balance scheme position, and basing on the received data, the market operator performs the calculation of:

- The calculation of the market balance
- The calculation of balance sheets of balance groups
- The calculation of whole balance group realization
- The calculation of imbalances
- The calculation of forecasted imbalances

The imbalance settlement is carried out once per accounting period and separately for each accounting interval. The length of accounting period is one month.

3.2.2.4.5.1 Managing imbalances

A market plan represents the basis for an imbalance settlement. On the basis of registered closed contracts, the market operator prepares a market plan for an individual balance scheme member for each accounting interval which represents a position plan of each balance scheme member on the organized market and is an outcome of all closed contracts concluded by a balance scheme member and hierarchically inferior balance scheme members. Balance scheme members who have no appurtenant delivery posts (the traders) have to have a market plan which equals 0 MWh in all accounting intervals. If the market plan of a balance group which has no appurtenant delivery posts does not equal 0 MWh in all accounting intervals after the deadline for the report of closed contracts, it shall be considered that the balance responsible party has reported the forecasted imbalances.

3.2.2.4.5.2 Market balance

The market balance is a joint balance of inflows and outflows of all balance groups for each accounting interval. The market balance is calculated by the market operator according to the balance scheme status. The balance of a balance group is the balance of inflows and outflows of a balance group for each accounting interval and contains the imbalances which are calculated from the difference between the complete realization and the market plan of a balance group.

3.2.2.4.5.3 Balance of the balance group

The realized production of a balance scheme member in an individual accounting interval equals the sum of realized production values of all delivery points which belong to a balance scheme member:

$$W_{production} = \sum_{j=1}^{m} W_j$$

Where $W_{production}$ is the realized production of a balance scheme member; W_j is the realized production of a delivery point j, and m is a number of delivery points of a balance scheme member.

The calculation of the production of non-measured producers in an individual accounting interval with an analytical procedure is carried out using data on total measured monthly production of non-measured producers and the type of a monthly diagram for the production of all measured producers whose production is measured in intervals which are shorter or equal to the accounting interval. The type of a monthly diagram for the production of non-measured producers equals the type of total monthly diagram for the production of all measured producers. The whole monthly production of a non-measured producer, distributed by accounting intervals into a type of the monthly diagram, must comply with the measured monthly production.

The realized consumption of a balance scheme member in an individual accounting interval equals the sum of realized consumption values of all delivery points which belong to a balance scheme member:

$$W_{consumption} = \sum_{j=1}^{n} W_j$$

Where $W_{consumption}$ is the realized consumption of a balance scheme member, W_j is the realized consumption of a delivery point j, and n is a number of consumption delivery points of a balance scheme member.

The calculation of the consumption of non-measured consumers

For the delivery points without registration meters or the registration interval of which is longer than the accounting interval (non-measured consumers or non-measured producers), the realized consumption or production in an individual accounting interval shall be determined with an analytical procedure. Differences that occur between actual (or invoiced) quantities and quantities from the analytical procedure are yearly recalculated within the annual recalculation.

According to the appurtenant delivery points in an individual accounting interval, the consumption and production balance equals the difference between the whole realized consumption and the whole realized production of the delivery points which belong to a balance scheme member according to the balance scheme status:

$$W_{balance} = W_{consumption} - W_{production}$$

Where $W_{balance}$ is the consumption and production balance of the appurtenant delivery points according to a balance scheme member, $W_{consumption.}$ is the realized consumption in an accounting interval according to a balance scheme member, and $W_{production}$ is the realized production in an accounting interval according to a balance scheme member.

3.2.2.4.5.4 The calculation of network losses

The distribution system operator estimates the electricity losses which occur during the operation of individual distribution network areas for the purpose of balance settlement on the basis of the past accounting data. The distribution system operator calculates the ratio of losses for each distribution network area on the basis of data on actual losses on the annual level in the past. The quotient of losses is equal in all accounting periods of one calendar year and is calculated for the whole calendar year. The distribution system operator submits the quotients to the market operator not later than thirty days after the end of the accounting year. The estimated losses in the distribution network area are calculated in each accounting interval with multiplying the quotient of losses by the total accepted energy of the distribution network area in the same interval. Annually, the actual losses of electricity which occur during the operation of individual distribution system network areas are calculated from the difference between the total received and delivered electricity. Actual losses of the distribution system are considered in the annual recalculation of the imbalance settlement.

The total accepted electricity is the electricity which is taken over from an individual distribution network area on the contact points with a transmission system, on the contact points with foreign networks, on the production delivery points, on the delivery points which divide two distribution network areas, or within the non-regulated supply.

The total delivered electricity is the electricity which is delivered from an individual distribution network area on the contact points with a transmission system, on the contact points with a foreign network, on the delivery points, on the delivery points which divide two distribution network areas, or within the non-regulated supply.

Actual electricity losses which occur during the operation of the transmission system are calculated in each accounting interval from the difference between the accepted and the delivered electricity which has been received or delivered by the transmission system on contact points with a distribution network, on delivery points which separate the transmission network from networks of neighbouring transmission system operators, on production delivery points, and on consumption delivery points.

3.2.2.4.5.5 The complete realization of a balance group

The complete realization of a balance group is the sum of consumption and production balance of appurtenant delivery points, and the consumption and production balance on the delivery points which belong to hierarchically inferior balance scheme members in an individual accounting interval according to the balance scheme status:

$$W_{realisation} = W_{balance} + \sum_{l=1}^{r} W_{balance.comp.agr}^{(l)}$$

where $W_{balance}$ is the consumption and production balance of the appurtenant delivery points in an individual accounting interval, $W_{realization}$ is the realization of a balance group in an individual accounting interval, $W_{balance.\ comp.\ agr.}$ is the compensation and production balance which belong to any hierarchically inferior balance scheme member in an individual accounting interval, and r is the number of all compensation agreements concluded with hierarchically inferior balance scheme members.

3.2.2.4.5.6 The calculation of imbalances

For each **balance group** with appurtenant delivery points, the market operator determines forecasted imbalances of the complete realization (of electricity consumption and production) from the market plan in the accounting interval by calculating:

$$W_{imbalances} = W_{realisation} - W_{market\ plan}$$

Where $W_{imbalances}$ is the imbalance of consumption and production of a balance group from the market plan in an individual accounting interval, $W_{realization}$ is the complete realization of a balance group in an individual accounting interval, and $W_{market\ plan}$ is the market plan of a balance group in an individual accounting interval.

The positive imbalances mean that the complete realization is higher than the market plan (higher consumption or lower production than planned). The negative imbalances mean that the complete realization is lower than the market plan (lower consumption or higher production than planned).

The **transmission system operator's imbalances** are comprised of imbalances on the borders of the distribution network with networks of foreign transmission system operators and the imbalances from the market plan. The imbalances on the borders are calculated from the difference between the announced power flows on the borders, which are calculated by the market operator from the recorded closed contracts with the use of cross-border transmission capacities, and the accounting data of measured power flows on the borders. The transmission system operator's imbalances from the market plan are calculated from the difference between its realization (the sum of the realization of losses in the transmission system and the emergency supply) and the market plan. The distribution system operator's imbalances are calculated from the difference between its realization (the sum of the realization of losses in the distribution system and the essential supply) and the market plan.

The **forecasted imbalances** are the differences between the total operational forecast and the market plan of a balance group. The forecasted imbalances are determined for balance groups with no appurtenant delivery points (traders). If the balance group with no appurtenant delivery points does not have a market plan in all accounting intervals that is equal to zero, the market plan that is not equal to zero is deemed as the forecasted imbalances. In each accounting interval, the forecasted imbalances are calculated in the following manner:

$$W_{forec.\ imbalances} = -W_{market\ plan}$$

where $W_{forec.imbalances}$ are the forecasted imbalances of a balance group in an individual accounting interval and $W_{market\ plan}$ is the market plan of a balance group in an individual accounting interval.

3.2.2.4.5.7 The balancing costs of the transmission system operator

For the purposes of the imbalance settlement, the transmission system operator submits to the market operator the costs, prices, and number of transactions regarding the electricity system balancing in the republic of Slovenia for each accounting interval separately not later than the fifteenth (15_{th}) working day of each month following the accounting period, namely separated by:

- Transactions on the balancing market
- Transactions with the balance scheme members according to closed contracts
- Transactions with the neighboring transmission system operators
- The secondary regulation by installations

- Transactions according to the closed contracts with the use of cross-border transmission capacities
- The tertiary regulation by installations
- The load restrictions and changes in the base power

Among balancing costs settled by the market operator within the imbalance settlement, the costs covered from other financial sources, like the network charges, are not included. The transmission system operator has to submit to the market operator the specific data regarding all actions within the electricity system balancing in the republic of Slovenia from which all balancing costs arise. The data must show at least technical characteristics of the action, the service operator, the price, the quantity, and the service costs. The market operator calculates the basic imbalance prices on the basis of the transmission system operator's costs incurred within the balancing. The costs are settled by the market operator within the imbalance settlement for each accounting period separately. The basic imbalance prices are different for positive and negative imbalances.

3.2.2.5 Power exchange

Power exchange is occurring on two different types of markets

- scheduling and
- day-ahead market.

The market objects that are traded on these markets are called products and represents packets of energy. Different types of products are used for trading on scheduling and day-ahead market.

3.2.2.5.1 Scheduling market

Scheduling market is a type of market on which only long-term products are traded. Long-term products are contracts that represent amount and quality of the electricity on the specific day in future with prices that are settled in present. These products are used as wholesale supply. Trading on the scheduling market can be organized (stocked) or bilateral (agreement between two parties).
In Slovenia the scheduling market is provided on bilateral level. For this market it is very important that it is centralized, manageable and insures liquidity and not-discriminative access to all eligible customers. All these conditions are supervised by competed institution like UVK (Slovenian bureau for preventing of corruption).

3.2.2.5.2 Day-ahead market

The day-ahead market is used for balancing the daily needs of the energy. Day-ahead market is managed by company BSP South Pool d.o.o which belongs to company Borzen. Products that are purchased here are representing the difference between the short-term forecast for the production or consumption of the electricity and the long-term contracts from the scheduling market.
The company may participate on trading market if it has a valid balance contract with market organizer. The electricity exchange happens when the offer of and the demand for standardized electricity products (for the following day or for the period of time until and including the next working day) meet.
Trading is organized as continuous (spot) and auction trading.

- Continues trading

  During continuous trading, prices are determined by matching orders at the best possible buy and sell price limits indicated in the order book. Orders entered in continuous trading are recorded in open order book. In the event that prices of buy orders are identical to prices of sell orders or higher, orders of the same product are matched in the order in which they were entered into the trading system (price-time priority), respecting restrictions in the individual orders. The continuous session comprises of two consecutive periods with the following characteristics:

  - Trading phase: during trading phase, the entering, withdrawing, modifying, and deactivating of orders in the trading system is enabled. Orders that can be executed with one another are matched, which leads to the conclusion of transactions.
  - Inactive phase: at the beginning of this phase all orders entered in trading phase become inactive. Market participants are not allowed to enter orders, they can only check and download their concluded transactions.
- Auction trading

  Auction trading is carried out through the trading system. Auction trading comprises of five consecutive session phases with the following characteristics:

  - Call phase: orders can be entered, modified or deleted from the trading system during the call phase. This is the only session phase of the auction in which exchange traders can submit orders. Orders for an individual trading session can be entered into the trading system no more than 14 days prior to the execution of the auction.
  - Freeze phase: call phase is followed by the freeze session phase during which the market supervision can examine the orders and check compliance of individual exchange participants with the trade limits and, in case the trade limit has been exceeded, remove any orders of that exchange participant it deems appropriate and test excitability of the auction and, in case the auction is not executable, remove any orders it deems appropriate. If orders have been removed, market supervision informs the affected exchange participant by suitable means.
  - Price determination phase: freeze phase is followed by the price determination phase in which market supervision executes the auction. A market clearing price is calculated and transactions are concluded.
  - Post-trading phase: when the price determination phase is finished, the auction is in the post-trading phase. In this session phase, the auction participants have the possibility of checking the results of the auction and, if necessary, file an objection to auction results due to mistrade. In such a case it is possible that the auction is rolled back. Auction participants can download their results.
  - Inactive phase: in this session phase the auction is concluded. Auction participants can access the auction results and download their final transactions.

Products that are used for trading in auction trading type of market are hourly and block products.

- Hourly products represent 1MWh of energy for one hour. There are 24 hourly products each represent hour in day (product named “00-01” represent energy from 0:00 am to 1:00 am).
- Block products:
    - Base (00:00 am – 12:00 pm),
    - Peak (06:00 am – 10:00 pm),
    - Off-peak (00:00 am – 06:00 am, 10:00 pm – 12:00 pm),
    - Off-peak1 (00:00 am – 06:00 am),
    - Off-peak2 (10:00 pm – 12:00 pm),

- Euro-peak (08:00 am – 8:00 pm),
- Euro-off-peak (00:00 am -08:00 am,08:00 pm -12:00 pm)
- Euro-off-peak1 (00:00 am – 08:00 am), and
- Euro-off-peak2 (08:00 pm– 12:00 pm)

3.2.2.6 The financial settlement of imbalance settlement

3.2.2.6.1 Clearing agent

The market operator acts as the clearing agent within the financial settlement of the imbalance settlement and provides the implementation of the financial settlement in accordance with rules and the settlement agreement. The market operator carries out the settlement of financial claims and liabilities of financial settlement participants and implements the settlement of liabilities and claims through a settlement account.

3.2.2.6.2 Bank accounts of market organizer

At the settlement bank, the market operator has a settlement account, a deposit account, and an account for keeping imbalance settlement surpluses.

The financial settlement of imbalance settlement is carried out through a settlement account. Net debtors are obliged to cover their liabilities onto the **settlement account** on the basis of the received invoice for the supplied energy of positive imbalances. The market operator settles its liability to net creditors for consumed energy of negative imbalances by transferring financial funds to their business accounts.

Financial guarantees in the form of cash deposits, submitted by financial settlement participants, shall be administered on a **deposit account**. The market operator opens a deposit sub-account within the main deposit account for each financial settlement participant who submits a financial guarantee in the form of a cash deposit. On the basis of an irrevocable authorisation issued by a financial settlement participant for using funds on the deposit sub-account for financial settlements arising from imbalance settlement, these funds may only be disposed of by the market operator as the administrator of the deposit account. The funds on the deposit account are completely separated from the market operator's funds.

The market operator administers a special **account for keeping surpluses of the imbalance settlement** for the purposes of the risk management for non-fulfilment of the financial settlement or for delayed payments of liabilities of financial settlement participants in the imbalance settlement. The surpluses of the imbalance settlement are transferred from the settlement account to a special account for keeping the imbalance settlement surpluses. The market operator prepares a written report on the status of the funds on the account for keeping imbalance settlement surpluses not later than by the end of April in the current year for the previous year.

3.2.2.6.3 Financial settlement

On the settlement day, the financial settlement of imbalance settlement is carried out on the basis of calculated amounts of the final imbalance settlement for the supplied electricity of positive or for consumed electricity of negative imbalances in a selected accounting period. Financial settlement participants become net debtors when their net balance of the final imbalance settlement is positive; and net creditors when their net balance of the final imbalance settlement is negative. On the basis of the final imbalance settlement of an accounting period, the market operator issues invoices for the supplied energy of positive imbalances or invoices for consumed energy of negative imbalances in a selected accounting period to the financial settlement participants. Annex to the invoice is a final imbalance settlement for the supplied energy of positive imbalances or

consumed energy of negative imbalances in a selected period for an individual balance group. On the basis of the received invoice for the supplied energy of positive imbalances in an individual accounting period, net debtors are obliged to cover their liabilities onto the settlement account within the deadline set out in the invoice for the supplied energy. The payments must be carried out in cash. The market operator pays the net creditors of the financial settlement the credit balance to their business account within the deadline set out in the invoice for the consumed energy of negative imbalances.
The settlement day is the seventh (7th) working day from the day of issuing the invoice for the supplied energy of positive imbalances and for consumed energy of negative imbalances. Costs or revenues which occurred with purchasing or selling of electricity for the purposes of the imbalance settlements of the electricity system in the republic of Slovenia are settled between the transmission system operator and market operator. The financial settlement of the electricity system balancing is carried out after the conclusion of the imbalance settlement in a selected accounting period.
The surpluses of revenues over expenditures arising from the imbalance settlement are transferred to the account for keeping the imbalance settlement surpluses.

3.2.2.7 Tariff system

The electricity supply differentiates three tariff periods: lower daily tariff (MT), higher daily tariff (VT), and uniform tariff (ET). The smaller and bigger daily tariff are read by the in-built two-tariff counter, while the uniform tariff is read by the one-tariff counter. Household consumers in the basic package 1 cannot choose between two-tariff and one-tariff measuring, since this basic package includes only one-tariff measuring of electric power. Household consumers in the basic packages 2 and 3 have a stationed counter which enables one-tariff and two-tariff measuring of electric power. The arrangement of daily tariff times is as follows:

- VT – higher daily tariff, read by the two-tariff counter each working day from 6 am to 10 pm.
- MT – lower tariff is a tariff read by the two-tariff counter each working day from 10 pm to 6 am of the following day, each Saturday, Sunday, and on each public holiday from 0 am to 12 pm.
- ET – is a uniform tariff read by the one-tariff counter each day 0 am to 12 pm.

3.2.3 Denmark

3.2.3.1 Description of physical grid

The Danish physical electricity system is divided into two electrically unsynchronized Western and Eastern parts [Energinet.dk, Villa07]. Each is distinct electricity transmission and distribution facility that operates at the 132 kV - 400 kV and 0.4 – 50/60 kV voltage level, respectively.

3.2.3.2 Transmission systems

The Western Denmark electricity system is synchronized with the continental European system UCTE. Its topology is characterized by parallel lines at the 150 kV level and a combination of ring and radial connections at the 400 kV level (see [Ener07]). The system consists of interconnections to Germany, Sweden, and Norway. The interconnection to Germany consists of one 400kV, two 220kV, and one 150 kV AC connections with a total transmission capacity of 1500 MW. The interconnection to Sweden is the DC type and consists of two 250 kV connections with a total transmission capacity of 740MW. The interconnection to Norway consist of two 250kV and one 350kV DC connections with a total transmission capacity of 1040MW.

The electricity system in Eastern Denmark is synchronized with Nordel. It is composed of a radial grid at the 400kV level and a ring-connected grid at the 132kV level. The interconnection to Sweden is a link to the Nordic grid, and it consists of two 400 kV and two 132 kV AC cable connections with a total capacity of 1900MW. The interconnection to Germany, Kontek, is a 400kV DC connection with a transmission capacity of 600MW. A HVDC cable is now being established to connect the Eastern and Western Danish electricity systems. The cable is expected to be put into operation in 2010. Some of the Danish islands are not directly connected to these two power systems, but to other countries. An example is the Bornholm Island that is connected to Sweden at 60kV.
The transmission systems in Eastern and Western Denmark are owned, developed, and operated by Energinet.dk. This state-owned entity is the only Danish transmission system operator (also an operator of the natural gas system), and it is in charge of maintaining the market and the security of supply. Energinet.dk owns the 400kV installations and the international connections, as well as the 132kV grid in Northern Zealand (Eastern Denmark). However, the 150/132kV installations are owned by regional transmission companies that make them accessible to Energinet.dk.

3.2.3.3 Distribution systems

The distribution network (60 kV or lower voltage levels) is owned and operated by more than 100 companies. A characteristic feature of the Danish electricity system is that, unlike in other countries, 40% of the total Danish generating capacity is connected to the distribution network [Dsup08]. This "distributed generation" mostly consists of decentralized (local) combined heat and power plants and wind turbines.

3.2.3.4 Electricity generation

The total installed power capacity in both Eastern and Western Denmark is approx. 13 GW. The power capacities and the amounts of generated energy from different generation units in 2008 are presented in [Dsup08].

Generation unit	**Capacity in MW**	**Production in GWh**
Central power stations	7,217	20,549
Small local plants	1,829	4,943
Wind turbines	3,166	6,928
Others	596	2,317
Production total		**34,736**

Table 8: Electricity generation and generating capacities in Denmark

In 2008, 20% of the electricity generation in Denmark was produced from wind turbines, and 59% from the central generation plants. A large number of the plants in Denmark (including the central generation plants) are co-generating, i.e., they generate and supply both electricity and heat. In terms of fuel, the central generation plants use coal (76%), natural gas (13.4%), biomass (6.3%), and oil (4.3%).

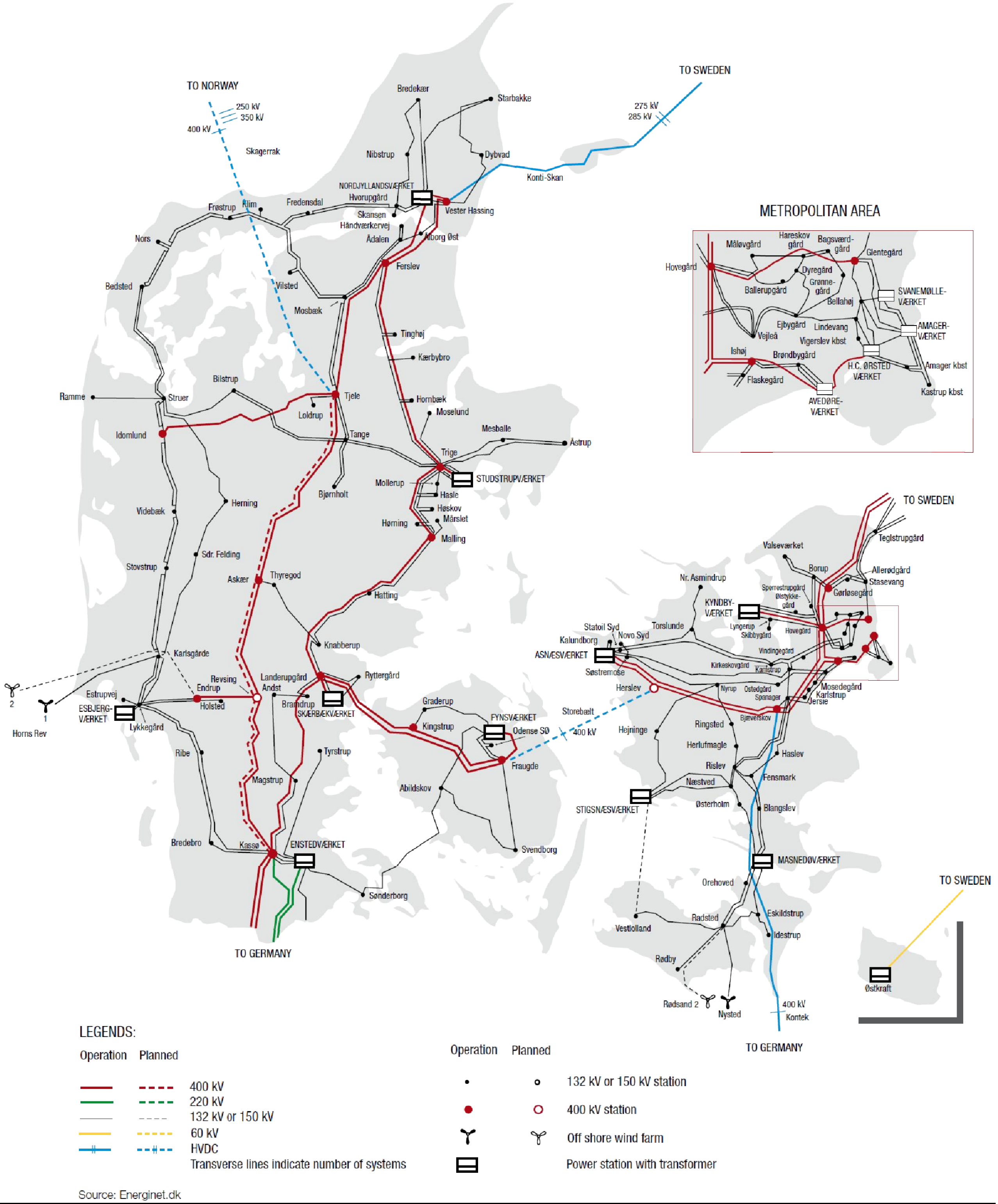

Figure 10: High Voltage Network in Denmark [Dsup08]

3.2.3.5 Historical development

The key historical facts about the Danish electricity market are the following.

- In December 1997, with the Kyoto Protocol, Denmark committed itself to lower the CO_2 emissions with 21% by 2008-2012 from the 1990 levels.
- In 1999, the EU directive on the full liberalization of the electricity markets was adopted. This led to the unbundling of the transmission grid from the electricity generation in Denmark.
- In 1999-2000, Western Denmark (1999) and Eastern Denmark (2000) join the Nord Pool's Elspot and financial market areas.
- In January 2003, the full liberalization of the electricity market spurred the entire Danish electricity sector to cooperate on the laying down of rules and preparing performance requirements for the systems that manage the mutual relations between electricity traders, grid companies, system operators, and for handling the settlement between the market players.
- In 2004-2007, Eastern Denmark (August 2004) and Western Denmark (March 2007) joined the ELBAS market.

3.2.3.6 The electricity market in Denmark

3.2.3.6.1 Overview

Since January 2003, the Danish electricity market is a free market [Ener07] in which all electricity consumers are entitled to buy electricity from a supplier of their choice. The market was established in order to create competition.

3.2.3.6.2 Market players

Several types of stakeholders are involved in the Danish electricity market. Specifically, central and local power plants sell electricity in the free market. Wind power producers, smaller local CHP plants, and industrial co-generating plants sell their electricity and also receive politically predetermined prices or subsidiaries for their generation. The distribution network/regional transmission network companies, in addition to their primary task of ensuring the security of supply, perform a number of customer-related services. Electricity trading companies in Denmark sell electricity to end-consumers based on the Danish Energy Regulatory Authority (DERA) regulated prices, and they are subject to mutual competition. The security of supply in the overall electricity system is ensured by Energinet.dk, which is also responsible for the drawing up of market rules that ensure a well-functioning electricity market.
There were 3.2 million electricity consumers (number of metering points), more than 36 trading companies with granted supply obligations, 12 regional transmission companies, and almost 90 distribution companies in Denmark by the end of 2009 [ReCh09].

3.2.3.6.3 Market organization

The Danish electricity market is an integral part of the free Nordic electricity market [Energinet.dk, Nordpool.com], where exchange services are offered through Nord Pool ASA and Nord Pool Spot AS. Nord Pool Spot AS operates the physical electricity market and organizes the trade of electricity at Elspot (day-ahead) and Elbas (intra-day) market places. Nord Pool ASA, among other services, provides a marketplace where the exchange members can trade derivative contracts in the financial market. Figure 11 visualizes the concept of power exchange at Nord Pool. Here, financial (Nord Pool ASA), Elspot, and Elbas markets are handled by Nord Pool, and trades are executed prior to the physical delivery of electricity. The balancing of supply and demand is accomplished by national TSOs.

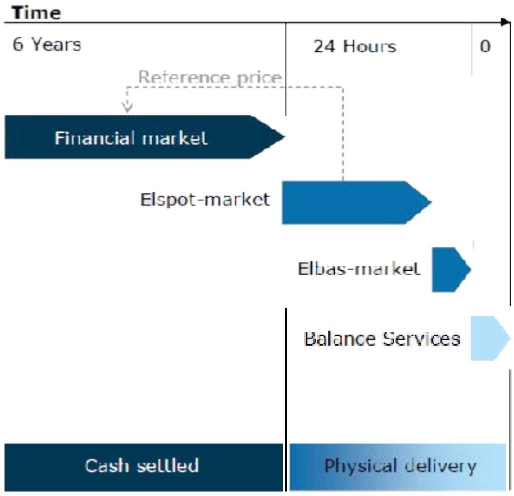

Figure 11: Nord Pool power exchange concept

3.2.3.6.3.1 The Elspot market

On Elspot, hourly power contracts are traded daily for physical delivery during the next day's 24-hour period. Trade is based on the auction principle. The day-ahead prices are calculated based on the balance between electricity purchase and sale bids that are received from all market participants until the gate closure at 12:00 am (noon). Three different bidding types are used: hourly bids, block bids, and flexible hourly bids that cover some or all of the 24 hours of the next day. All participants who meet the requirements set by Nord Pool Spot and have a balancing agreement with the respective transmission system operator (or through a third party) are given access to the Elspot market.

Due to the limited capacity of the connectors (bottlenecks) between/within the Nordic countries, the Nordic area is divided into a number of bidding areas. Denmark is treated as two different bidding areas: Eastern Denmark and Western Denmark. Two commercial participants separated by a bottleneck in the grid cannot trade physical energy (kWh) with each other. When a participant issues a bid, it must specify the bidding area the bid is issued from. Elspot then calculates a price for each bidding area for each hour of the following day.

The Elspot market also carries out day-ahead congestion management in the Nordic area. So-called market splitting and market coupling are used for congestion management through implicit capacity auctions. Here, Elspot (with other electricity exchanges in some cases) uses the available capacity for directing power to high price regions and extracting power from low price regions. Thereby, the prices in high price regions are reduced, whereas the prices in low price regions are raised. Currently, the market coupling is performed on the two interconnectors between Germany and Denmark and also on the Baltic cable between Sweden and Germany.

3.2.3.6.3.2 The Elbas market

Elbas is a continuous cross border intra-day market where one-hour contracts are traded until one hour prior to delivery. Participants are allowed to trade on Elbas two hours after Elspot is closed. Thus, they can obtain balance by making adjustments to trades done in the day-ahead market.

Elbas covers the Nordic countries and Germany. All trades done on Elbas are implicitly utilizing the available cross border capacity, which is updated after each executed trade. The participants of Elbas are power producers, consumers, and traders. They are obligated to report the trades done on Elbas to their local TSOs. Elbas provides the opportunity to sell power bought in the day-ahead market with a profit in the intraday market.

At 08:00 am CET and 02:00 pm CET, the hour-contracts for the next day are opened for trade in Germany and the Nordic area (Finland, Sweden, Western Denmark, Eastern Denmark, Norway, and Estonia [from April 2010]), respectively. Because the capacities available for Elbas trading are published approximately at 02:00 pm CET, Germany is treated as a separate bidding area between 08:00 am CET and approximately 02:00 pm CET.

3.2.3.6.3.3 The Nord Pool ASA financial market

Nord Pool ASA is a marketplace where the exchange members trade contracts of power derivatives (financial contracts with a value linked to the expected future price) and emission derivatives (EUA emission allowances, and CER carbon credits) in the financial market.

The power derivatives are base and peak load futures and forwards, options, and contracts for difference. These derivatives are owned by Nord Pool ASA and they are used to guarantee prices and manage risk when a participant trades power. Nord Pool ASA offers contracts with a trading horizon of up to six years, which cover daily, weekly, monthly, quarterly, and annual contracts. The spot prices of the Elspot, EEX Phelix (Germany), and APX (Netherlands) markets are used as an underlying reference price for Nord Pool ASA contracts. There are more than 400 market participants from over 20 countries, and they include producers, retail companies, industrial companies, hedge funds, and professional traders. There is no physical electricity delivery of these financial market contracts.

The power and emission markets are open every day. For both markets, a participant's orders are binding until the end of the trading day, or until the member has changed or cancelled them and received a confirmation receipt. Once the market closes, written trade confirmations are made available for all participants. At a random time within the last 10 minutes of the trading day, closing prices for power and emission contracts, used for settlement and margin calculations, are determined. The randomization is used to prevent potential closing price manipulation. For contracts outside the buy and sell spread, or bid and offer price, or contracts that have not been traded, the closing price is defined as the average of the bid and offer, as specified by the rulebook for the financial power and emission market. Nord Pool ASA distributes closing prices to the market as soon as possible after the market closes.

Cash settlement is made throughout the trading and/or the delivery period, starting at the due date of each contact (depending on whether the product is a future or forward). The clearinghouse Nord Pool Clearing guarantees financial settlement.

3.2.3.6.4 Balancing the production/consumption

The Nordic electricity market is divided into two balance areas [DesBa08], with Western Denmark being in the UCTE system and Eastern Denmark being in the *synchronous* part of Nordel. In Western Denmark, Energinet.dk is responsible for maintaining the balance between consumption and production in relation to the UCTE system. In the synchronous part of Nordel, Statnett and Svenska Kraftnät have a joint responsibility to maintain the balance between consumption and production using regulating resources from a joint

Nordic list. However, regulating resources from Denmark are co-ordinated via Energinet.dk.

The operational requirements for the Nordic power system includes an obligation to maintain sufficient operational reserves in the synchronous part of Nordel and to distribute the reserves between the subsystems (Denmark West has special conditions in relation to the UCTE system). Therefore, to ensure that sufficient reserve capacity is available, Energinet.dk makes reserve capacity agreements, according to which Energinet.dk pays participants a fixed amount for being available.

The operational reserves consist chiefly of frequency controlled reserves and fast reserves. Temporary peak load arrangements are used to balance regulation in special circumstances only. The frequency controlled reserves, specifically the *frequency controlled normal operation reserve* and the *frequency controlled disturbance reserve*, are activated automatically by frequency deviations. The fast reserves, specifically the *regulating bids* and *fast disturbance reserves*, are activated manually within 15 minutes, and they are based on trades in the regulating power market (RPM).

In RPM, balance responsible parties are allowed to trade by submitting regulating bids for upward or downward regulation to the local system operator. A bid may cover an entire day of operation, and it states the offered quantity (MWh) and price (DKK/MWh). The entered prices and volumes can be adjusted (by the bidder) until up to 45 minutes prior to the upcoming delivery hour. The system operators submit the regulating power bids to a 'coordinator' (Statnett) that compiles a joint list of all regulating power bids in the Nordic countries, sorted by price. If regulation of the frequency in the joint Nordic system is needed, the most advantageous regulating power bids on the joint list are activated, taking grid congestions into account. Not later than at 12:00 on the day after the day of operation, Energinet.dk sends the player a statement of the used regulated volume and the price involved.

All East Denmark regulating power bids are activated and settled by Energinet.dk. If a balance responsible party concludes a monthly reserve capacity agreement with Energinet.dk, it is committed to submitting bids to the regulating power market for each hour of the relevant month.

3.2.3.7 End-user business relations

3.2.3.7.1 Changing of the supplier

The Danish electricity retail customers are divided into two types [Dsup08, ReCh09]: template customers (primarily households and small business) and customers with hourly metering (electricity consumption is registered and settled per hour – mainly customers with an annual consumption of more than 100 MWh). All the customers have access to private contracts for energy supply on the retail market and may switch supplier free of charge. "Passive" template customers, i.e., customers who do not actively choose a supplier, are automatically supplied by the retailer company with the granted supply obligation for the consumers' geographical region ("default supplier"). However, medium and large customers with hourly metering must actively choose their supplier (no "default supply").

There is a 30 day notice period before a supplier switch takes effect [Ener07]. It also has to be done on the 1st day of the month. Customers have almost 90 suppliers to choose from. The process of supplier switching is web-based and it involves the following steps:

- The customer inquires about a possible switch to the new supplier.
- A contract is made and signed between the customer and the new supplier.
- The new supplier announces the switch to the distribution system operator (DSO).
- If the DSO approves the switch then it also notifies the old supplier.

- The DSO informs the customer about the approved switch.

3.2.3.7.2 Retail prices and tariff system

In accordance to Danish legislation, the regulation of energy prices for retailers with a supply obligation must reflect the wholesale market price levels [ReCh09]. Therefore, Danish Energy Regulatory Authority, DERA, sets a mark-up or gross margin for the competitive market by comparing non-regulated prices with Nord Pool Spot prices and taking profiling into consideration. This margin constitutes the cap of mark-ups of the “obligation to supply prices” of individual supply companies. If mark-ups exceed the cap, prices must be lowered accordingly. Every quarter, DERA calculates the tariff cap for all “obligation to supply” companies and publishes it on the website. Each supply company sets its own tarification and has to submit it to DERA each quarter. These are then published on the DERA website.
Retailers with a supply obligation offer several alternatives for their supply obligation products. Elpristavlen.dk shows all the alternatives. There are generally two categories of products. First, there are products with a variable price, where the consumer electricity price follows the developments in the wholesale market. Second, there are fixed-price products where the consumer electricity price is fixed for an agreed period (up to a maximum of six months). The suppliers of electricity also offer various other electricity products, e.g., “green products” pool electricity, and spot electricity.

3.2.3.8 Future actions on the market development

The Danish energy system is facing a paradigm shift [SysPl09]. Due to the recently adopted Climate and Energy Package in the EU, Denmark has to increase its share of renewable energy significantly, reduce greenhouse gas emissions, and carry out significant energy efficiency improvements. The Danish energy system has to be re-aligned and re-thought to allow large amounts of renewable energy to be efficiently integrated and used in the places where it is most valuable.
The most significant future development in the Danish electricity network includes increased integration of wind power into the power system, the intelligent application of electricity-based solutions in the heat and transport sectors, as well as significantly greater utilization of the potential for producing biogas.

3.2.4 Germany

3.2.4.1 Description of physical grid

The German electricity grid has four voltage levels, which are operated by alternating current and connected by transformers with each other.
The extra high voltage level works with 220kV and 380kV and had in 2008 a length of 35.7 thousand kilometers. It is connected to other European networks, but is used primarily for national distribution of electricity and to supply very large industrial companies. The high voltage level operates with 110kV and has a length about 76.3 thousand kilometers. It supplies larger businesses parks, industrial plants and railways.
The medium voltage level works with 20/10kV, has a length of about 507.2 thousand kilometers and supplies regional distribution networks as well as small and medium industrial companies. The low voltage grid supplies finally, with the known voltage of 230/400V, end users such as households, small commercial enterprises and agricultural enterprises.
The entire German power grid thus has a length of 1.78 million kilometers and requires about 566.200 transformers to supply the different voltage levels.

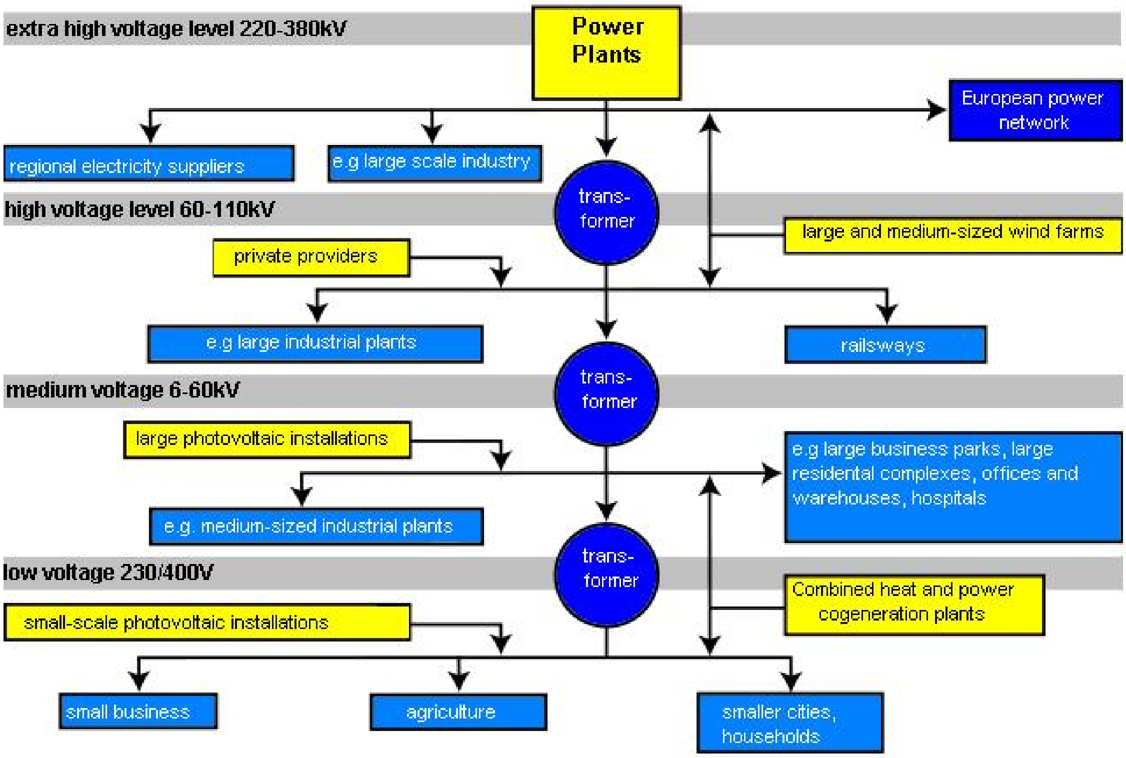

Figure 12 : Structure of the German electricity market [Frie]

In the regions of high voltage networks the grids of the different transmission system operators are connected with each other to a national integrated network.
Currently there are four transmission system operators in Germany (see Figure 13):

- Amprion GmbH,
- EnBW Transportnetze AG,
- TenneT TSO GmbH, and
- 50 Hertz Transmission.

In addition to these four operators, there are a variety of mostly local operators. In Germany, these are about 900 distribution system operators that operate on a regional level and provide the electricity to end customers. The grid operators do not receive their charge from the sale of electricity, but for the provision of networks. For that they receive from the power plant operator a network usage fee.
However, the interconnected system does not end at the German border. International tie-lines between Germany and neighbored countries link the national subsystems to form a synchronous European extra-high-voltage system (see Figure 14).
Today's extra-high-voltage system is strongly meshed. Electricity flows in the system based on the laws of physics described by Kirchhoff's or Ohm's Law. The current circuit arrangement in the system, also referred to as topology (lines switched on or off, transformer tap positions etc.), the local power output to subordinate distribution grids, delivery to large industrial customers as well as the current deployment of power plants determine how much electricity flows across individual lines. The transmission grid operator therefore only has limited control over physical load flows by changing the power plant deployment and by rearranging circuits in the system. This is why it is extremely important to monitor the flow of electricity as well as the loads on all the equipment in order to identify overloads and bottlenecks in the network soon enough and to be able to

take corrective action. The systems of each energy utility were designed in such a way that demand in any utility's own control area can be met from its own power plant capacity without any bottlenecks arising in the system.

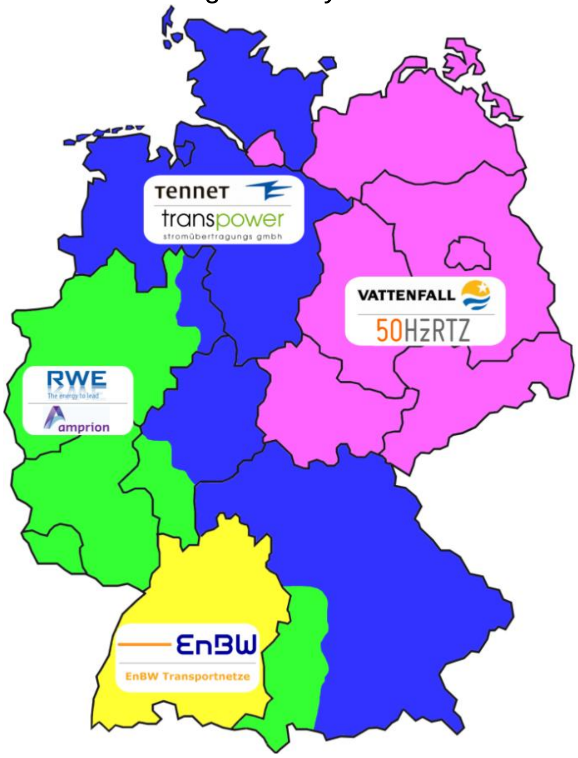

Figure 13: Four control areas of the German TSOs [WPa]

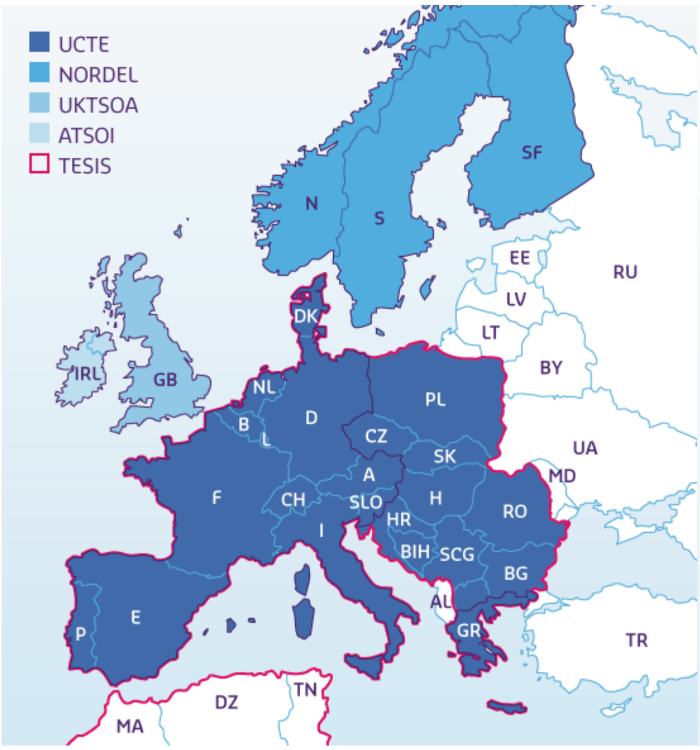

Figure 14: European integrated network [Ampr]

A major goal of interconnected operation in the electricity industry consists in exchanging electrical energy between the interconnected partners while maintaining security and availability. If more energy flows across national or international interconnection lines into a control zone than flows out of it, this difference constitutes the import of electrical energy. Conversely, if more energy flows out of the control zone than into it, electrical energy is exported.

Each control zone is lined up to the program value by means of load frequency control in order to be able to specifically influence and control export/import even in a highly meshed system. In its interaction with the primary-controlled power plants, load frequency control also maintains the network frequency (typically 50 Hz).

3.2.4.2 Historic development

The liberalization of the German electricity market, starting in 1998, ended more than 100 years of local monopoly supply. Germany implemented the EU Electricity Market Directive of 1996 into a new energy law, the Energiewirtschaftsgesetz (EnWG), on 19 April 1998. This was its first fundamental change since 1935. The EnWG combined the negotiated third party access model with an optional single buyer approach for small municipalities in order to protect their local interests (e.g. using profits from sales of electricity to fund public transport). With these legal changes, Germany, in contrast to most of its neighbors, opened its market fully to competition at once, ending an era of regional monopolies protected by demarcation agreements. Suddenly every consumer was able to choose from a wide range of different suppliers.

The results were remarkable. Wholesale market and heavy industry prices fell sharply by as much as 60% and approached marginal production costs during 1999. Average industry tariffs were reduced by 27% from the beginning of the liberalization to the end of 1999. As a result of the fall in profitability, all eight of the major vertically integrated generating companies, and many smaller ones, were involved in merger negotiations by the beginning of 2000.

Germany rejected the idea of an independent system operator and left questions, for example the detailed regulation of grid access and transmission pricing, to be negotiated by different associations in the electricity industry itself and the German heavy industry. The results of these talks were the so-called association agreement or Verbändevereinbarung (VV) in May 1998, and the grid code by the grid operators' organization. However, practical problems still remained, mainly because of insufficient regulation of transmission. High transmission prices, several cases of transmission access being refused and the vertically integrated structure of the German ESI with 8 large companies owning the grid and most of the generation capacity provoked criticism, leading to a revision of the first VV. The VV2 came into effect on 1 January 2000 and was designed to overcome major problems, abolishing distance-based tariffs apart from a transmission fee between two newly established zones (North-South) and facilitating access for small customers.

Just like the other member states of the European Union, Germany was obligated by the EU legislation to establish an independent electricity regulator, and also to introduce an ex-ante regulation of the electricity tariffs, where they are either set or approved by the regulator, before they are applied to the customers. The German choice to respond to this EU requirement, as well as to promote cost efficiency and thus lower total energy costs, was to introduce a new regulatory model for the electricity market called incentive based regulation. In 2005 the new federal regulator was established, the Bundesnetzagentur, which is involved in the responsibility of regulating multiple public services: electricity, gas, telecom, railways and postal services.

3.2.4.3 Market players

3.2.4.3.1 Transmission system operator

Transmission system operators are natural or corporate persons or juridical dependent organizational units of a power supply company. They are responsible for the operation, the maintenance and if necessary for the extension of the transmission grid in a definite area and if needed also for the connecting line to other grid operators. There are several TSO's in Germany, all in the process of adapting to the new regulations. For convenience, in describing TSO's functions in this Section, the example of EnBW Transportnetze AG is used only as an indicative example.

3.2.4.3.1.1 Network Access

EnBW Transportnetze AG (TNG) calculated the prices for the use of the transmission network of TNG in accordance with the requirements of the "Ordinance on Incentive Regulation of Electricity Networks (ARegV) which came into force on 29th October, 2007. The revenue cap for the year 2010 in accordance with ARegV is the basis for the calculation of the prices for the use of the transmission network and the prices for measuring and the allocation of the meter data.

3.2.4.3.1.2 Price Components

The price components comprise network use, reserve network capacities, monthly demand charge and other services.
Network use. The price for the network use includes:

- The network infrastructure, i.e. provision and maintenance of lines, circuit breakers, transformers and further operational components of the transmission network.
- System services, i.e. services required for transmission and distribution of electricity and for determining the functional efficiency and safety of the electricity supply. This includes: primary control power and output, provision of secondary control power and minutes reserve power as well as operational management of the transmission network.
- Coverage of electric losses, i.e. provision of electrical energy for compensation of losses occurring during transport of electricity in the transmission network.

Reserve network capacity. Customers with in-plant generation can order reserve network capacity for the failure of their in-plant generation systems. Details are governed by the network utilization agreement.
Monthly demand charge. EnBW Transportnetze AG offers a monthly demand charge system for customers with temporarily high power consumption versus significantly lower or even no power consumption at all during the remaining time. The established price system consisting of demand charge and kilowatt-hour rate is applied irrespective of the network customer's hours of consumption.
To use the monthly demand charge system the customer has to chose this system before the beginning of the accounting period and give EnBW Transportnetze AG written notice on that.
Other services. In addition to the above-mentioned prices, the following services are charged separately:

- Operation of a measuring point: The operation of measuring points includes the installation, the operation and the maintenance of measuring devices.
- Measurement: The measurement costs depend on the technical design of the tapping point, the measurement and metering devices and the extent of data provided.

- The prices for billing include the services for commercial processing of the meter data as well as expenses for the provision of due charges for system usage and billing.
- Additional charges in accordance with KWK-G (Act on Retention, Modernization and Extension of Cogeneration): according to KWK-G dated 19th March, 2002 surcharges for ultimate consumers are raised with the network charges.

3.2.4.3.1.3 Code of practice for calculation of network charges

The following data of a network customer are required to calculate the charges for network utilization:

- Tapping level (in kV),
- Annual output E in kWh of received energy,
- Maximum annual power P in kW (highest quarter hour power average per accounting year);
- For network customers with own generation, reported reserve network capacity PR in kW.

We calculate the charges for the reserve network capacity based on an annual demand charge (EUR/kW and year). This is dependent on the duration of the annual reserve utilization (hrs p.a.) and the tapping level.

3.2.4.3.1.4 Metering

The liberalization of metering implemented with § 21b EnWG requires a consistent requirements profile for the metering performed by the operator of the measurement point. Here we provide information about the principles of metering and measurement in the networks of EnBW Transportnetze AG.
In the principles of metering and measurement, EnBW Transportnetze AG defines the EnBW standard for metering in the electricity networks. The principles are classified according to voltage level, output and annual volume of kilowatt-hours.

3.2.4.3.1.5 Balancing Groups of EnBW Control Zone

EnBW Transportnetze AG manages energy volume accounts as balancing groups for acting traders in the EnBW control zone. The documentation of energy deliveries (load) and energy procurements (coverage) of the balancing group managers (Balance responsible person) is accomplished by means of the following accounting transactions: load time series, feed time series and schedules. These accounting transactions conform to the provisions of the balancing group agreement. As the responsible transmission system operator, EnBW Transportnetze AG always compensates the total balance (i.e. the difference between load and coverage for every quarter-hour of all balancing groups).
The principles of schedule processing and daily trading are in accordance with § 5 German Regulation on Access to Electricity Networks
Since January 1st, 2007, EnBW Transportnetze AG has given all market participants the opportunity to register intraday scheduled trading with 45 minutes lead-time for every quarter-hour within Germany.
For this purpose, the German transmission system operators have developed a concept intended to facilitate the coordination of a large number of simultaneous short-term schedule changes in a highly automated manner in accordance with the time specifications set forth in the Regulation on Access to Electricity Networks.
The procedure and the prices for the settlement of balance groups is as follows.
EnBW Transportnetze AG offers the balancing group managers in the EnBW control zone to perform the balancing group settlement up to and including 31st December,

2001, thus beyond August 2000, based on the procedure of a simplified balancing group settlement.
On explicit request, we offer the individual balancing group managers to apply the balancing group settlement procedure described in VVII, i.e. with output prices as well as only weekly balancing possibility.
Since 1st January, 2002, balancing group settlement has been performed in accordance with the procedures published in the prices and provisions for the utilization of the networks of EnBW Regional AG and EnBW Transportnetze AG.
EnBW Transportnetze AG procures (positive) secondary balancing power with a maximum output of +870 MW and/or provides (negative) secondary balancing power with a maximum output of -390 MW. This is accomplished in graduated output bandwidths and different tariff zones (HT/NT) in a range from €65 per MWh to €90 per MWh for positive balancing output and from €0 per MWh to €16 per MWh for negative balancing output.
EnBW Transportnetze AG assures that the energy from the contractually available minimum reserve to support secondary balancing will be procured and further calculated at prices of maximum €100 per MWh until 31st July, 2002.
Within the scope of the above-mentioned contractually available secondary balancing and minimum reserve, EnBW Transportnetze AG guarantees that the balancing energy prices of the balancing group managers, in monthly average broken according to supply and delivery direction in the EnBW control zone, are not more expensive for positive balancing power and not cheaper for negative balancing power than the respective most favorable price of the transmission system operators RWE Net and E.ON Netz.
The procurement of balancing power in extreme situations, e.g. in case of deliberate misuse by the balancing group managers in times of highly volatile exchange quotations, beyond the reserved volume secured by us will be calculated at the then prevailing current market prices.

3.2.4.3.1.6 Network Operation

The transmission network serves as the platform for market partners in the liberalized power market
Within the scope of schedule management, balancing group managers will have to submit reliable cumulative schedules for generation and consumption in a balancing group as well as obligatory schedules for control zone exchanging and control zone internal trading schedules during the previous day. Schedules are to be communicated to the respective transmission system operators concerned on workdays not later than 02:00 pm for the subsequent day.
As an operator of a transmission network, EnBW Transportnetze AG assumes responsibility for the operation, maintenance and needs-based expansion of a safe, reliable, efficient and ecologically compatible energy supply network as far as this is commercially reasonable.
EnBW Transportnetze AG is also responsible for permanently securing the efficiency of its network in line with the demand for transmission of power, and thus contributes to security of supply by means of appropriate transmission capacity and reliability.
In order to meet these requirements, EnBW Transportnetze AG in particular complies with German and European standards as well as accepted rules of technology. In principle, the transmission system of EnBW Transportnetze AG is planned and operated in accordance with the (n-1)-principle. A network is (n-1)-secure if it is still able to perform its network function for a forecasted maximum transmission and supply assignment under acceptance of tolerable functional restrictions in case of non-availability of an operating resource.

3.2.4.3.1.7 Renewable Energy Act: Basics and Description

The Renewable Energy Act (EEG) dated 21st July, 2004 became legally effective on 1st August, 2004. For power input from specific renewable energies, the EEG stipulates acceptance by the network operators and the payment of a legally determined minimum compensation for a legally defined term. In addition, it provides for comparative distribution of different regional EEG input respectively burden of electricity supply companies (EVU) servicing the end consumer.
The transmission system operators (TSO) who are responsible for the German control zones are entrusted by the EEG with the accomplishment of nationwide “compensation of load” for power quantities from such sources and their financial impact.
In the course of this compensation of burdens, the distribution network operators (VNB) pass on the power amounts received in their networks from plant operators to the transmission system operators and in return receive the legally determined minimum compensation paid to the plant operators minus avoided network use charges.
The transmission system operators again shift their costs for EEG power to the electricity supply companies servicing end consumers within the scope of nationwide compensation of charges. The nationwide average EEG price for end consumers is calculated based on the EEG power volume and the compensation paid.
Monthly installment payments have to be effected for the power amounts and payments to be expected.
Within the scope of an annual settlement, differences between the installments rolled over and the annual deliveries are determined by means of meter readings and subsequently balanced. The procedures for the implementation of these laws are organized according to civil law and are conducted by the network operators under coordination by the Association of Network Operators (Verband der Netzbetreiber e.V.(VDN) in Berlin. VDN has published instructions for the implementation in a so-called “Description of EEG procedures”.
The legal conformity of execution is confirmed by certifications from accountants respectively auditors on the part of all partners cooperating in this process. As a responsible network operator, EnBW Transportnetze AG implements the provisions of the EEG in the respective network area.

3.2.4.3.2 Distribution system operator

Distribution system operators are natural or corporate persons or juridical dependent organizational units of a power supply company who observe the task of the distribution of electricity and are responsible for the operation, the maintenance and if necessary for the extension of the distribution grid and if need be also for the connecting line to other grid operators. Following § 21b EnWG the grid operator is responsible for the metering point running and the measuring as far as no other convention is resolved. Following § 4 passage 4 MessZV the grid operator is under obligation to manage the meter points in his grid area, to submit the rehashed account relevant measured data to the grid operator and also to archiving the transmitted dates in the course of the grid access needed period. The grid operator conclude the responsible contracts with the metering point operators and measuring service providers which are active in his grid area. If a third metering point operator falls out, the grid operator is obligated to take the services metering operation and measurement at the affected measuring point immediately. In this case the measuring instruments which do not belong to the standard portfolio of the grid operator might have to be taken over.
The grid operator has no incentives to secure his investments in intelligent meters on a long term basis because the connection user makes alone the decision who carries out the metering point service and the measurement with him. This might be one of the

reasons that currently investments in smart metering systems, on the part of the grid operator, stay assessable. Beside the insecurity of the investments, the standards for data formats are being absent until now.
It is of the above-named facts to reckon that from the 1/1/2010 on the part of the grid operator only measuring devices were built which fulfils the legal frame work.

3.2.4.3.3 Metering point operator

The metering point operator is responsible for the installation, the operation and servicing of measuring devices. If no other arrangements are met, the grid operator takes over this part. The measuring point operator is according to the law responsible to the opening of the metrology for the installation of intelligent counters under the changed conditions § 21b EnWG. Herein stated in paragraphs 3a and 3b:

- (3a) As far as this is technically doable and economically reasonable the metering point operator have from the 1 January 2010 by the installation of measuring devices in buildings, which are newly connected to the energy supply grid or which undergo a major renovation in the meaning of the leading line 2002/91/EG of the European Parliament and the council of 16 December 2002 over the energy efficiency of buildings (ABV. EG 2003 No.L1 p.65), for the given situation built in measurement devices which reflect the respective connection user the in fact energy consumption and the in fact use time.
- (3b) As far as this is technically doable and economically reasonable, have the metering point operator from the 1 January 2010 for existing metering devices offer each time metering devices, which reflect the respective connection user the in fact energy consumption and the in fact use time. The connection user is entitled to reject the offer, and agree to replace the existing installation of a measuring device.

There is no clarification what is under the in fact use time and the in fact energy consumption meant. According to the Physical-Technical- Federal Institute is already fulfilling a Ferraris dual tariff meter statuary requirements, so that the metering operator maybe mustn't take a modification to fulfill the standards of the EnWG.
Also open is when a new facility is a stock plant, id est. from when the connection user, whom maybe a smart metering device built in against his will, can engage another measuring point operator who remove that measuring device again.
Therefore it is reckon from 1/1/2010 that for the ultimate consumer a confusing ragbag of measuring devices is available which all interpret the faulty legal conditions differently.

3.2.4.3.4 Metering service providers

The metering service company is responsible for the measurement, so for the reading of the metering devices as well as the passing on the data to the entitled people. However, substitute value formation, plausibility and validation of the metered values remain an assignment of the grid operator.
If no other arrangements are made, the grid operator is also the measuring service provider.

3.2.4.3.5 Supplier

The supplier is responsible for the supply of the end customer with energy. He supplies his customer by means of finished supply contracts (with or without grid use) and regulates the use of the grid with the distribution grid operator to whose grid his customer is connected. For this purpose he concludes with the grid operator a supplier framework contract in which inter alia the details for the measuring data provision are regulated. Following § 40 EnWG the suppliers are obliged to cash up the energy consumption after

their choice monthly or in other periods, which may not significantly exceed twelve months. By request of the end customer the supplier is obliged to agree on a monthly, quarterly or semi-annual billing. However the data provision of the account relevant data takes place after the measure access regulation through the net operator.
The suppliers play a central role in the future scenarios with a volatile production from regenerative energies and an influenceable consumption of the consumer.
To be able to perceive their role, the suppliers need in future possibilities for the transmission of tariff information to the customer and his counting features and in reverse direction for the accounting data which results from these tariffs.
Today the tariffs for private and small commercial consumers are mainly formed according to standardized load profiles. The meter reading takes place yearly. In tariffs with several tariff steps, as many counter mechanisms are led accordingly. The change between the different tariff steps happens time-controlled or by use of ripple control. Price changes occur only in longer distances, also mostly in a yearly turn.
Variable tariffs dependent on the current energy offer should be offered to the customer in the future by the application of smart meters. On this the supplier needs from the smart meter suitable load curves and all relevant counting data for the accounting and billing of variable tariffs. To be able to offer the customer time-variable tariffs and to deduct them rightly, the supplier must be able to transfer his tariff information in due time to the customer. To secure a timely transference of these data, a bidirectional communication must be available accordingly. Variable tariffs are investigated in the MEREGIO research project.
It means even so a significant challenge to the energy trading to calculate time variable tariffs, as well as for the accounting such tariffs needful counter dates to conceive and to deduct. A comprehensive changeover of the today's procedures of the price formation and of the energy amount balance will become necessary to this. Only so the economic advantages of an energy consumption shifting can affect more favorable tariffs also equal to in the equilibration of the supplier and cause thus the price advantages for dealer and customer initially.
The ICT systems must be adapted to the significant more complicated accounting and the processing of a multiple of the today's date volume rising amount of processed dates.
Changed account modalities might also cause a need for adaption of the legal basic conditions of the accounting, e.g. in the Measures and Weights Act.

3.2.4.3.6 Load consumer

Load consumers are customers who purchase energy for own consumption. The customer concludes a supply contract with the supplier. The end customer decides alone in his role as power customer which metering point operator and measuring service provider is active for him. Market surveys have shown that the end customer rather has a temporary interest in detailed consumption data and wishes a short runtime for the services of the metering point operation and the measurement.

3.2.4.3.7 Energy service provider

Due to the possibilities offered by smart meters, it is expected that a new quality of energy consulting for the end customers might develop regarding energy efficiency and energy saving. Because the metering instrument will be able to monitor the load curve also in a high resolution, exact conclusions on single behaviors can be analyzed promptly.

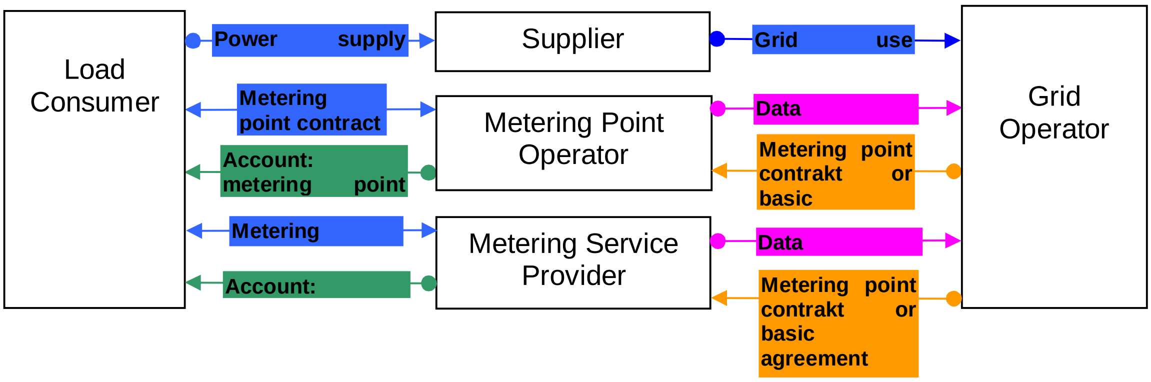

Figure 15: Market roles in Germany

3.2.4.4 Market organization

3.2.4.4.1 European Energy Exchange

The European Energy Exchange AG (EEX) [EEX] was founded in 2002 as a result of the merger of the two German power exchanges Leipzig and Frankfurt. Since then EEX has established itself as a leading trading market in European energy trading. Moreover, EEX has evolved into a corporate group which is open for European and international partnerships. EEX relies on an open business model which generates increased flexibility, market coverage and volumes through systematic spin-offs and partnerships. This model is reflected in the corporate structure of EEX.

In the field of power trading EEX cooperates with the French Powernext SA. EEX holds 50% of the shares in the joint venture EPEX Spot SE based in Paris which operates short-term trading in power – the so-called Spot Market – for Germany, France, Austria and Switzerland. German and French power derivatives trading is concentrated within EEX Power Derivatives GmbH, a majority-owned EEX subsidiary with headquarters in Leipzig. Clearing and settlement for all spot and derivatives transactions on power are provided by EEX, which has already been settling the natural gas transactions traded on Powernext since November 2008.

EEX is an exchange under the German Exchange Act and a regulated market within the meaning of MiFID. EEX has the following executive bodies: the Exchange Council, the Management Board of the Exchange and the Market Surveillance and the Sanctions Committee.

In Germany, an exchange is established as a public institution with a partial legal capacity upon granting of the corresponding exchange license by the exchange supervisory authority. The Exchange Supervisory Authority which is in charge of EEX is the Saxon Ministry for Economic Affairs and Labor (SMWA) in Dresden.

EEX is characterized by liquidity, transparency and fairness in pricing and this creates the confidence which the trading participants place in EEX. Safeguarding this is the central task of EEX and of its executive bodies.

For this reason, EEX has established a set of Exchange Rules, which is based on the German Exchange Act and binding both for itself and for all trading participants. This set of rules and regulations comprises the Exchange Rules, the Trading Conditions, the Contract Specifications, the Admission Rules as well as the Code of Conduct.

The Exchange Rules establish the essential provisions regarding the organization of the exchange, the tasks of its bodies and the preconditions for access to trading in the form of a statute. The Trading Conditions establish provisions regarding the trading process, while the Contract Specifications, which constitute a part of the Trading Conditions, establish precisely what is traded on the exchange. The preconditions for admission as a trader, especially the requirements with regard to the proof of personal responsibility and vocational qualification through a trader examination, are contained in the EEX Admission Rules. Now, EEX also has the Code of Conduct in addition; it contains the conduct to be observed by the trading participants and, in particular, serves the purpose of ensuring proper trading.

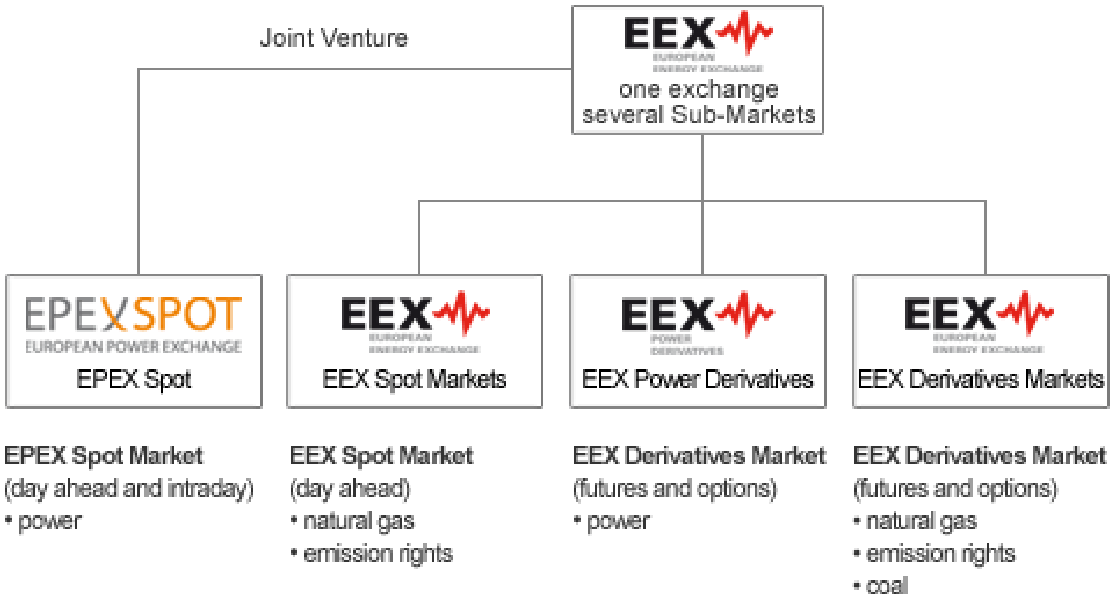

Figure 16: Sub-Markets of the European Energy Exchange (Source: www.epexspot.com)

3.2.4.4.2 EPEX Spot Market

EPEX operates a Spot Market for electricity to optimize portfolios on short term. For that EPEX offers two options which are described in the following sections.

3.2.4.4.2.1 Auction Trading

With this tool it is possible to trade electricity for optimizing for the following day for Germany and Austria. The trading participants use the day-ahead market in order to optimize short-term purchase and sale of electricity. The commandments of the hourly auction make it possible to simultaneously buy and sell different quantities at different prices in each auction. The exported quantity depends on the determined auction price.
The daily auction takes place at 12:00 am, 7 days a week, year-round, including statutory holidays. After the auction results, members have 30 minutes to raise objections against errors falling within EPEX Spot SE responsibility.
Deliveries are made within one of the following TSOs zones:

- Amprion GmbH
- TenneT TSO GmbH
- 50Hertz Transmission GmbH
- EnBW Transportnetze
- Austrian Power Grid

All these places of delivery form one market zone. In case of congestion between TSOs zones, prices can be determined by separate auctions for each market area. In case of changes in the composition of the market areas, EPEX Spot SE informs Exchange Members before auction price calculation in order to allow them to modify their bids accordingly.

3.2.4.4.2.2 Intra-day trading of electricity

This means electricity contracts with delivery on the same or next day. Market participants usually buy because of increasing needs of additional electricity. In this way, it is possible to consider even short-term deviations from consumption forecasts and avoid schedule deviations.
The intra-day trading takes place every day of the year, around the clock.
Electricity traded for a delivery on the same or on the following day on single hours or on block of hours. Each hour or block of hours can be traded until 75 minutes before delivery begins. Starting at 3pm on the current day, all hours of the following day can be traded.
Deliveries are made within one of the following zones:

- Amprion GmbH
- TenneT TSO GmbH
- 50Hertz Transmission GmbH
- EnBW Transportnetze

3.2.4.5 Balancing the production/consumption

3.2.4.5.1 Market for control reserve in Germany

The German transmission system operators (TSOs) have the task of keeping equilibrium between electricity generation and consumption in their control areas at all times. For the performance of this task the TSO needs different types of control reserve as described in the UCTE (Union for the Coordination of Transmission of Electricity, now part of ENTSO-E) Operation Handbook Policy 1 (primary control reserve, secondary control reserve as well as minute reserve which is the equivalent of tertiary control reserve), which differ according to the principle of activation and their activation speed. Close co-operation between the TSOs contributes to keeping the total requirements for control reserve as low as possible.
Since 2001 the German TSOs have been procuring their required primary control reserve, secondary control reserve as well as minute reserve on an open, transparent and non-discriminatory market for control reserve according to the guidelines of the Bundeskartellamt.
The procurement is carried out as a tender auction on the German Control Reserve Market with participation of numerous bidders (both generation sets and (controllable) loads).
By pooling technical units (generation sets and (controllable) loads) in order to reach the minimum lot sizes (which differ across the three types of control reserve) it is also possible for small bidders to take part in the tender. Approximately 90% of all generation sets within the control block Germany are able to provide control reserve and have been prequalified by (at least) one of the TSOs. Starting in 2004, providers from the Austrian control areas of TIWAG and VKW have also been able to participate in the German market for minute reserve.
Until 30 November 2007, each TSO individually procured primary and secondary control reserve via half-yearly auctions. Prior to the start of joint procurement of minute reserve on 01 December 2006, each TSO individually procured minute reserve via daily tenders.

In order to process these daily tenders, IT-based procurement platforms had been developed along with suitably defined, market-based control reserve products able to support the stable operation of the grid.
With the entry into force of the Energy Act (abbreviated as "EnWG" in German) on 13 July 2005 as well as the associated Electricity Grid Access Regulation ("StromNZV") and Electricity Grid Tariff Regulation ("StromNEV") on 29 July 2005 the legal framework for procurement and use of control reserve changed significantly.
Since 01 December 2006 the TSOs' required minute reserve has been procured via a joint daily tender processed via the present internet platform. A common tender for the procurement of primary and secondary control reserve was introduced on 01 December 2007 and is also processed via www.regelleistung.net.
A certain amount of control reserve may need to be provided from within the TSO's control area (i.e., by technical units physically connected to the grid within the TSO's control area) as required by § 6 (2) Electricity Grid Access Regulation (StromNZV), the objective being to ensure continuous availability of the control reserve even in case of disturbances ("islanding" of the corresponding TSO's grid).

3.2.4.5.2 General information on control reserve - imbalance pricing and settlement

The imbalance pricing system applied to balance responsible parties' imbalances has the following characteristics:

- Imbalance prices are computed for each balancing interval (equivalent to the scheduling interval of ¼ hour)
- The imbalance price for each balancing interval is determined by adding up the TSO's net energy expenditure (payable to or receivable from those providers of secondary control reserve and minute reserve that have been activated during the quarter-hour) and dividing this by the aggregate imbalance during the balancing interval
- The imbalance price is symmetric (a balance responsible party with a positive imbalance - i.e., which has fed more energy into the grid than scheduled - receives the same price as that paid by balance responsible parties with a negative imbalance and conversely). Note that because of negative energy prices a balance responsible party with a positive imbalance may have to pay
- Imbalance prices are published on TSOs' websites and are freely accessible to all market participants, thus ensuring transparency
- Capacity fees for secondary control reserve and minute reserve as well as the total cost of primary control reserve (for which no separate energy price is payable) are not passed on to balance responsible parties but are instead factored into grid use tariffs

3.2.4.5.3 General information on control reserve - technical aspects

A permanent equilibrium between electricity generation and demand is an important precondition for the stable operation of the grid. Ensuring that their customers are supplied with power in a reliable fashion is at the heart of TSOs' responsibilities. For the purpose of maintaining the above-mentioned balance between supply and demand, TSOs procure control reserve (also known as balancing power).
A need for control reserve arises as soon as the current in-feed differs from current off-take. Such imbalances are caused, inter alia, by load fluctuations (on the demand side) and power plant failures (on the supply side). An excess of generation over load leads to an increase in the system frequency whereas an excess of load over generation causes the system frequency to fall.

The objective of activating control reserve is, on the one hand, to maintain the system frequency within a narrow range around its target frequency of 50 Hz and, on the other hand, to eliminate deviations in exchanges between control areas from their scheduled values. To attain these objectives requires that three different types of control reserve be deployed in a coordinated fashion.

Based on the rules set out in the UCTE (Union for the Coordination of Transmission of Electricity, now part of ENTSO-E) Operation Handbook Policy 1 the German TSOs procure the following types of control reserve:

Primary control reserve

- Provided jointly and simultaneously by all TSOs in the UCTE synchronous area for the benefit of the entire system with each TSO's contribution a function of the corresponding control area's electricity generation
- Automatic and complete activation of primary control reserve within 30 seconds if required
- Primary control reserve has to be supplied for up to 15 minutes per incident

Secondary control reserve

- Deployed both to return frequency towards its target value as well as to bring exchanges with adjacent control areas back to their scheduled values
- Automatic activation by the TSO concerned (i.e., the TSO responsible for the control area in which the incident has occurred)
- Complete activation within five minutes (at most)

Minute reserve (tertiary control reserve)

- Activation by telephone by the TSO
- Complete activation within fifteen minutes of the telephone call
- Minimum activation time of fifteen minutes (and up to several hours if required)

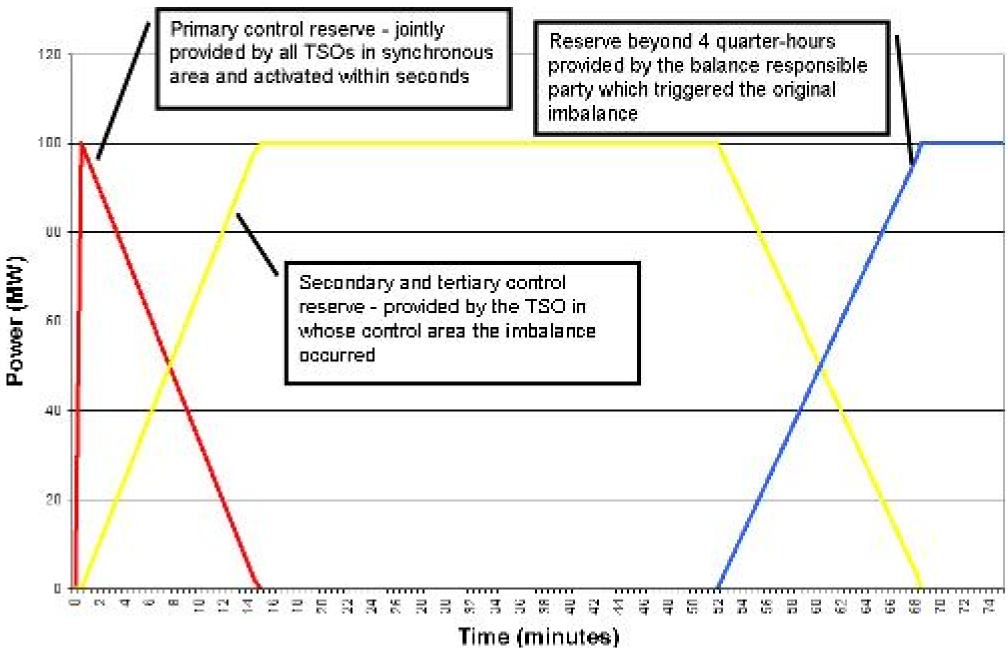

Figure 17: Types of control reserves (Source: www.regelleistung.net)

3.2.4.5.4 Prequalification procedure for the provision and activation of control reserve

The transmission system operator (TSO) requires control reserve in order to be able to continuously balance generation and load.
Prospective providers of the different types of control reserve have to complete a prequalification procedure to demonstrate their ability to meet the TSOs' requirements in this respect. In addition to technical competence, prospective providers also have to demonstrate that they will be able to perform satisfactorily under operational conditions and that their financial situation does not give cause for concern.
The Reserve Connecting TSO (i.e., that German TSO in whose control area the technical units (generation sets and (controllable) loads) providing the control reserve are physically connected to the grid (independently of the voltage level) is responsible for the prequalification procedure regardless of the type of control reserve. Upon successful completion of the prequalification procedure the Reserve Connecting TSO issues a certificate that is accepted as proof of successful prequalification by the other German TSOs.
In the case of secondary control reserve, prequalification also involves the connection of the technical units providing secondary control reserve to the Reserve Connecting TSO's load-frequency controller as well as verification of the correct functioning of this connection. If a bidder wishes to market technical units in several control areas, connections with all the relevant load-frequency controllers have to be established and the correct functioning has to be demonstrated via a separate test procedure. However, the prequalification procedure with the Reserve Connecting TSO has to be successfully completed first.
Following the successful completion of the prequalification procedure, TSO and prospective provider sign a framework agreement on the basis of which the prospective provider can participate in tenders. For each of the three types of control reserve, a separate agreement needs to be signed. In the case of primary control reserve and minute reserve, only the framework agreement with the Reserve Connecting TSO is required. In the case of secondary control reserve, the prospective bidder has to sign an additional framework agreement with each TSO whom it wishes to supply.
The prequalification procedure may be started at any time. Once all the required certificates and other documents have been submitted, a minimum of two months will normally be needed to complete the process. More time may be needed in the case of secondary control reserve if connecting the technical units to the TSO's load-frequency controller turns out to be particularly complicated.
Changes in the prospective provider's circumstances (equipment etc) that are relevant with respect to the prequalification requirements need to be signaled to the TSO immediately and may require renewal of the prequalification.
The prequalification requirements are contained (in German) in the TransmissionCode 2007 ("Netz- und Systemregeln der deutschen Übertragungsnetzbetreiber") issued by the TSOs. Chapter 5 ("Systemdienstleistungen" - ancillary services) contains general requirements whereas the detailed requirements for each of the three types of control reserve are described in Annex D.

3.2.4.6 End user business relations

As described in section 3.2.4.3 Market Players; the end customer today has a supply contract and a grid use contract. Since the liberalization of the metering he is also able to choose an metering point operator and a metering service provider. Normally all market roles are carried out by the supplier.

In the future a new market role might occur, the demand side manager. It bundles the requests of a number of customers to satisfy their needs and to trade control energy using the flexibility of a high number of participants.

3.2.4.7 Future actions on the market development

3.2.4.7.1 Smart grid

Concerning renewable energy there is a lot of political framework conditions: first of all the resolution of the European Union. The European parliament demands a share of 20% of renewable energy until 2020 at the total energy consumption (electricity, mobility, heating, cooling). In addition to that there is a political cooperation contract in Germany. According to this cooperation contract there is consensus that the Renewable Energies Law and its goals (30% renewable energy until 2020) is to be continued. This increase of renewable energy leads to a higher flexibility on the generation side. This has to be equalized by also a higher flexibility on the consumption side.

3.2.4.7.2 Use of renewable energies

The amount of wind energy which is the main resource of renewable energy in Germany is continuously increasing. Since November 2009 there are 60MW offshore wind energy plants working in the test field “Alpha Ventus” in the North Sea. At the Federal Office for Sea Navigation and Hydrographic there are already more than 1.500 other plant locations in 22 wind parks sanctioned. In the next decade large grow rates of offshore wind turbines are expected. The Federal Government of Germany aims to grow up the installed capacity of offshore wind energy plants up to 25 GW till 2030. Due to better wind conditions the use of wind energy is primarily concentrated in northern and eastern Germany. The expected expansion of offshore wind energy will increase the inequality of regional distribution.
With the expansion of renewable energies, especially the wind energy, the proportion of electricity from fluctuating production will increase. For the grid integration of this fluctuating energy there are new challenges coming up which have to be resolved:

- it occurs more and more generation situations with excess energy (strong wind/weak load situations)
- the large (and often short-term) fluctuations of renewable power generation must be compensated by balancing energy from conventional power plants for grid stabilization

The rising share of fluctuating renewable energy sources requires the flexibility of the German energy system. An important condition to improve the flexibility of the power generation system can be provided by the extension of the European UCTE (Union of the Co-ordination of Transmission of Electricity) grid. The power flow over country’s frontiers will increase significantly in the future. It is easily to point out that in strong wind situations in Germany also in the neighbored countries a high wind energy input is expected. This reduces the possibility to export excess wind energy. In addition to the grid expansion as well as optimization and flexibility measures the storage expansion is an important measure for reducing the current temporary excess energy.
The strong (an often short-term) fluctuations of renewable power generation cannot alone be balanced by grid expansion or distribution within the European UCTE grid, or only by storing of the excess energy. For the compensation of these fluctuations it also requires flexible production plants to provide the higher demand of control- and balancing energy. Pumped hydro storage plants will be able to make these services available and thus they

contribute to an efficient and safe power supply, also concerning the future needs by a higher share of fluctuating renewable energy.

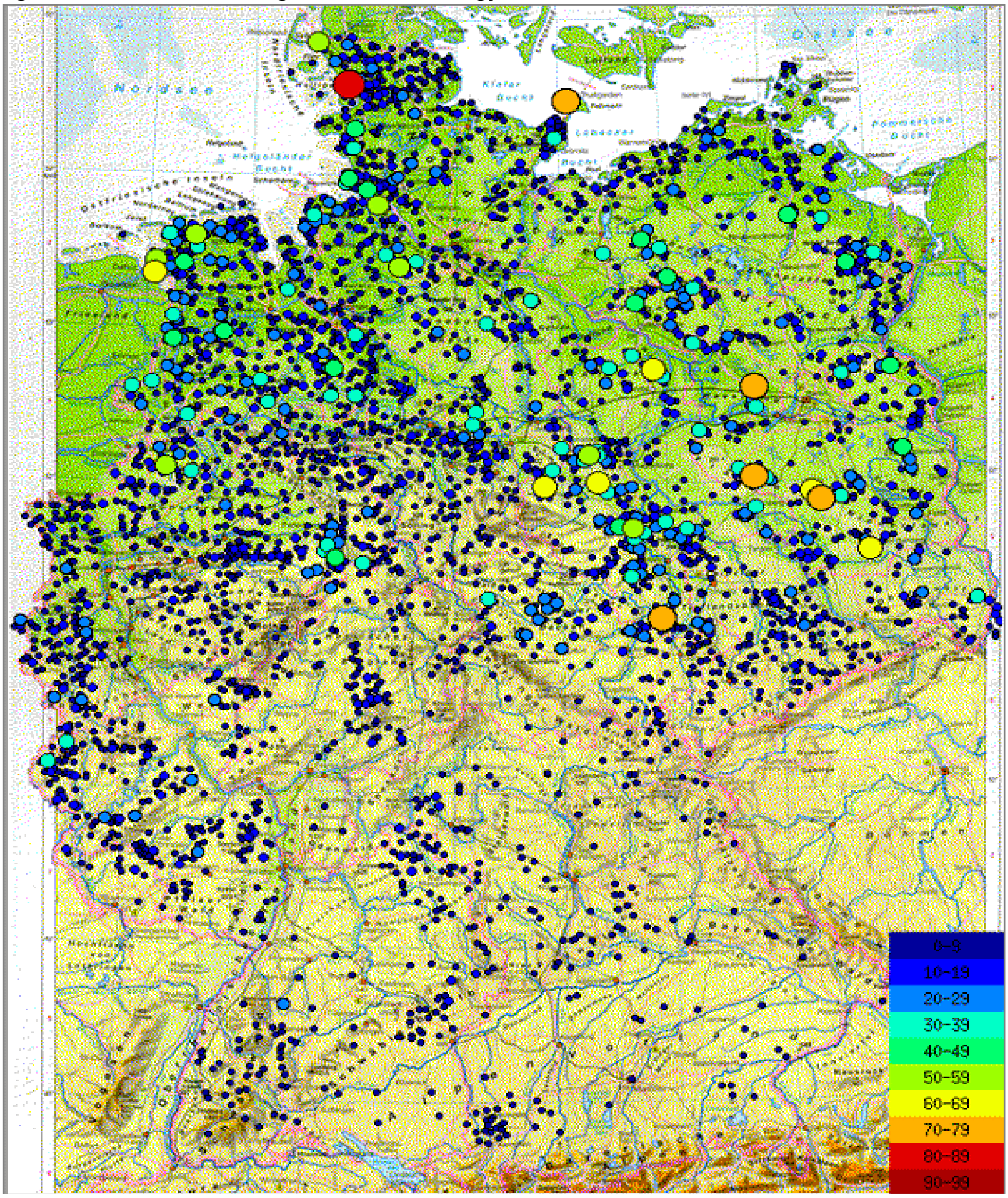

Figure 18: Allocation of installed wind turbines (Source: ISET, IWES)

3.2.4.8 Current evolution of national roles model

For the improvement of the purchase of balancing energy, since 1st May 2010 a nation-wide grid control cooperation has been implemented in Germany. This innovative control concept has caused great international interest – extension planned.

The EnBW Transportnetze AG has expanded together with the other German transmission grid operators the grid control cooperation, according to the Federal Network Agency, successfully onto whole Germany till the 1st May. Situations as in the past, in which excess energy in a regulation zone and a power deficit in another regulation zone corrected independently from each other, are avoided completely by this in Europe unique innovative control concept.

The grid control cooperation includes the dimension and the basic procurement as well as the input and the deduction of balancing energy. Annual cost savings are supposed to be achieved at about 200 million EUR, after the evaluation of the Federal Network Agency, by the extension of the grid control cooperation on whole Germany. These cost savings can be increased by the planned international extension of the grid control cooperation. The cost savings finally will prove advantageous to all electricity customers. With the grid control cooperation the German transmission system operators continue their already in 2005 started cooperation regarding provision and usage of balancing energy consequently.

Furthermore it was established within the scope of an expert report of the Federal Network Agency that the grid control cooperation offers advantages concerning the system security. In the grid control cooperation, the German TSOs have harmonized their information technology systems so that an opposed operating reserve demand between the control areas is noticed in real time and the necessary balancing energy is minimized directly. Due to the fact that in the grid control cooperation the available operating reserve is used together, it can be also reduced to a minimum in Germany. Moreover an economic optimization leads to the fact that all control areas across Germany always use the most advantageous balancing energy offer. The grid control cooperation also reduces the information technology outlay for the supplier of operating reserve. Only one information technology connection is needful to offer operating reserve in whole Germany. Thus, a single market for balancing energy in Germany is being created. For the accounting responsible persons this market becomes visible by an all over Germany uniform balancing energy price.

After the German-wide implementation, the four German TSOs aim an international extension of the grid control cooperation as quickly as possible. On this, big interest exists internationally – concrete conversations with different foreign TSOs are already running. Because the grid control cooperation is built modular and can be easily adapted to the respective circumstances, an enlargement far above existing transborder grid bottlenecks is possible without affecting the international electricity trading. Germany can make with this innovation an essential contribution to the optimization of the European energy supply system and in addition to it also a contribution to a better integration of renewable energies in Germany.

3.2.5 The Netherlands

In accordance to the European directive 96/92/EG, the Dutch electricity sector is liberalized; i.e. a clear distinction is made between the responsibilities for supply and transport of electricity. This liberalization occurred in 2004 and enables customers to choose their energy supplier irrespective of their geographical location and new producers and suppliers to enter the Dutch electricity market ([EiN10]).

Figure 19 provides a simplified view of the unbundled electricity sector in The Netherlands. The remainder of this section will be structured according to the elements within this figure. After discussing the various areas of the electricity sector a domain and role model of the sector is provided.

3.2.5.1 Transmission and distribution

A total of around 250.000 kilometers of electricity network connect the Dutch producers and consumers. The national transmission network, operating at 220 and 380 kV, and transmission networks of 50, 110 and 150 kV are operated by the Dutch transmission system operator (TSO) TenneT. The layout of this network is shown in Figure 20.
7 cross-border connections to Norway, Germany and Belgium are in place and 4 more are being developed including interconnection to United Kingdom and Denmark. See section 3.2.5.7 for more information about the trading of capacity on these interconnections. Market coupling based on these interconnections is discussed in section 3.2.5.5.1.

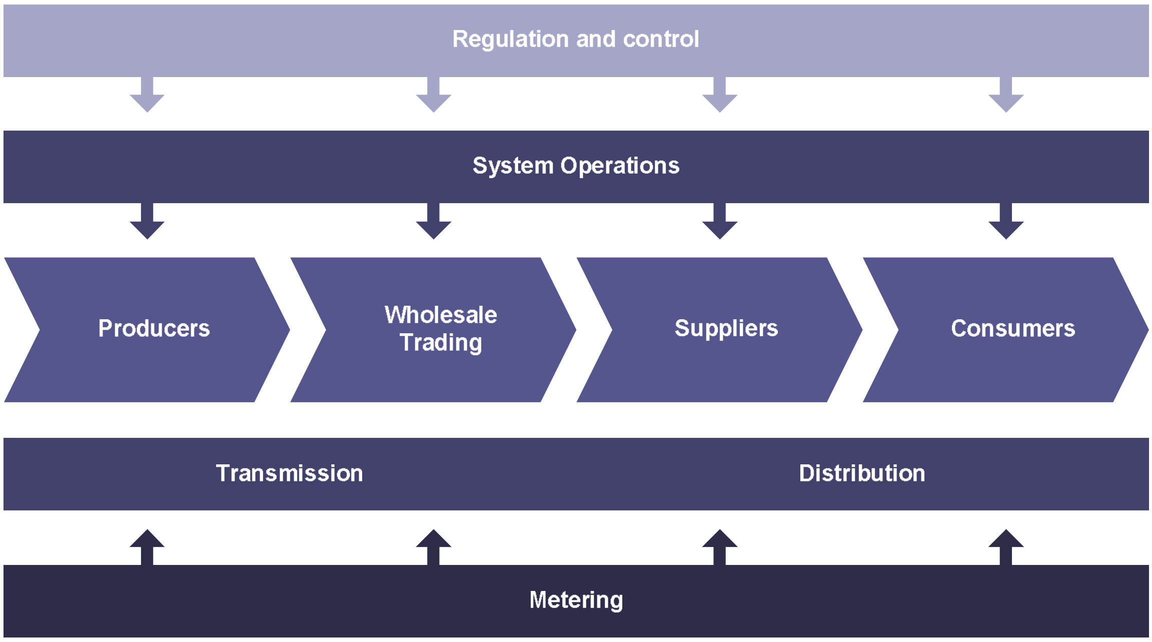

Figure 19: Simplified view of unbundled electricity sector

The network consists of multiple high voltage levels; 110 kV (black), 150 kV (blue), 220kV (green) and 380 kV (red). The layout of the transmission networks shows two rings; a 220 kV ring in the north east and a 380 kV ring for the rest of the country. The ring structures are essential for the high availability of the network as they allow the reversal of the direction of the electricity flows in case of outages.
The regional medium- and low-voltage electricity networks, operating at voltages ranging from 25 kV down to 230V for domestic use, are operated by eight regional network operators ([EiN10]). Figure 21 provides a geographical overview of the Dutch distribution grid operators.
The regions correspond with the following operators: 1) Cogas Intra en Beheer, 2) Delta Netwerkbedrijf, 3) Endinet, 4) Enexis, 6) Liander, 7) RENDO Netbeheer, 8) Stedin, 9) Westland Infra Netbeheer (number 5 is missing since this grid operator, ‘Intergas’, only operates gas networks). All of the organizations mentioned also operate distribution grids for gas. However in a given area one organization may be the electricity grid operator while another operates the gas distribution grid. Alignment of these areas is discussed so that electricity and gas are operated by the same organization.

Figure 20: High voltage network in the Netherlands

Figure 21: Dutch distribution grid operators

3.2.5.2 Production and supply

In 2009 a total of 32 organizations are licensed to supply consumers of electricity within The Netherlands. 7 organizations are operating large generation units. Apart from these large (mostly thermal) power plants, a large number of electricity is produced by decentralized units, which is mostly cogeneration ([EiN10]). The suppliers are the commercial and administrative contact points for consumers. A number of organizations in the role of supplier are also producers. These producers and suppliers coordinate with the Dutch system operator in order to main the stability of the energy system as discussed in 3.2.5.3.

3.2.5.3 System operations

The TSO is also responsible for maintaining the balance of the Dutch electricity system. For this purpose, generators, traders, suppliers and large consumers need to coordinate their activities with the TSO. Parties with these responsibilities are named 'programma verantwoordelijken' in The Netherlands; balance responsible parties (BRP) in terms of [ETSO09]. In the Netherlands a distinction is made between balance responsible parties with responsibilities for parties connected to the grid and parties whose activities are restricted to trading only ([SCE09], [BLE10], and [OPS05]).

Schedules are provided by BRP's to the TSO on a daily basis for production, consumption, transactions, imports, exports and transits. The BRPs responsible for installations of 60 MW[1] or more are obligated to also report their ability to control their installations up- or downward[2].
The TSO checks for internal and external consistency of these schedules and technical limitations. The BRPs are able to update schedules, respecting consistency constraints. Schedule updates can start every hour and need to be communicated one hour in advance of said hour.
To maintain balance in the energy system and to alleviate congestion, control, reserve and emergency power is offered to the TSO (see [SCE09] and [TO04]). The market for this is described further in section 3.2.5.5.5.
Each day the TSO informs the BRP's of their deviations from their approved schedules (imbalances), the price of imbalance per interval[3] and the total price. The TSO, together with the regional network operators, performs a monthly profile-based reconciliation with the BRP's with connections smaller than 3x80A.

3.2.5.4 Metering processes

In The Netherlands the market for metering services is liberalized; parties connected to the grid are able to select their metering responsible party ([MCE10]). It must be noted that at the time of writing the parties licensed by the TSO to provide metering services is mainly limited to metering divisions (legally separated entities) of network operators.

3.2.5.5 Wholesale trading and markets

3.2.5.5.1 Spot market

APX-ENDEX provides a fully electronic exchange for spot trading in the Netherlands ([APN10]. Three types of markets are operated: day-ahead, strips and intraday. In total 27% of the Dutch electricity usage was traded on the spot market in 2009 ([EiN10]). All trade is cleared and settled by the market operator. The trade results are communicated to the transmission system operator.

3.2.5.5.2 Day-ahead market

Hourly contracts as well as blocks (consecutive trading intervals within a single bid which need to be traded all or none) are traded on this market. Trading takes place, as the name indicates, on day in advance. Prices are calculated per hour ([APN10]).
The Dutch day-ahead market was coupled in 2006 with those in Belgium and France: the trilateral market coupling (TLC, [Ma07]). The TLC was supported by the market operators (APX-ENDEX, BelPEX, PowerNEXT) and the three TSO's (TenneT, Elia and RTE). Since November 9th 2010 the Central Western European Market Coupling (CWE, [CWE10]) was launched expanding the TLC with Germany and Luxembourg is planned. Furthermore the CWE region is also coupled with the Nordic region (Denmark, Sweden, Finland, Norway and Estonia) through interim tight volume coupling (coupling based on placing price-independent bids by a 3rd party) and expansion of CWE through NorNed is planned.

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[1] Both installations which can consume and produce more than 60 MW.
[2] The ability to provide or consume more or less power than their scheduled power produced or consumed.
[3] The intervals in a schedule sent from a BRP to the TSO (PTE, programmatijdseenheid). The length of these intervals in The Netherlands is 15 min.

3.2.5.5.3 Strips market

On this market strips: base from 00:00 to 24:00, peak from 08:00 to 20:00, and off peak from 00:00 to 08:00 and 20:00 to 24:00. These strips can be traded for individual days as well as weekends, which can be traded until 2 days or 1 weekend ahead respectively ([APN10]).

3.2.5.5.4 Intra-day market

In order to close positions on the day of operation, the intra-day market provides BRP's the possibility to trade products of 15 min., 1 hour or 2 hours up to 2 hours in advance.

3.2.5.5.5 Futures market

Apart from a spot market a futures market is operated by APX-ENDEX. On this market base and peak load can be traded for periods of months, quarters or years.

3.2.5.5.6 Bilateral

Bilateral trade is trade directly between two parties. A clearing house can be used to support this trading.

3.2.5.6 Control and reserve power

On this single buyer market control and reserve power[4] is offered by BRP's to the Dutch transmission system operator (TenneT, which is the only buyer). The control and reserve power is used in order to maintain system balance and alleviate congestion in the network. Control power is directly controllable by the TSO. Full power is to be provided available within 15 min. for control and reserve power, for emergency power this period is 30 min. ([TO04]).

3.2.5.7 Cross-border transport

The capacity for transport on cross-border connections is auctioned by the TSO to BRP's in several rounds: bi-annually, monthly and daily for respectively transport capacity which is auctioned for a full year, a month and a day (spot trading). In these auctions, the cross-border transport capacity is auctioned distinguishing between grouped cross-border transport capacities. It must be noted that for some interconnections, e.g. with Norway, only daily auctioning is performed. Apart from these explicit auctions, for spot trading also implicit auctions of cross-border transport capacity is performed; i.e. the cross-border capacity is directly related to auctioning of energy ([NCE10], see also section 3.2.5.5.2).

3.2.5.8 Congestion

In some cases congestion (might) occur in the network. Within an area from which the congestion arises, parties connected to the grid or their BRP's offer to reduce or increase their production or consumption to the (local) network operator, with which the network operator can prevent actual congestion. The TSO uses control/reserve power (outside of the congestion area) to compensate for the reduced or increased consumption or production ([NCE10]).

3.2.6 Austria

The energy market in Austria is well documented. The Energie-Control GmbH which is the Austrian regulatory authority for electricity and gas economy has published material which is the base for this section.

[4] Both the ability to increase and decrease power consumed or produced can be offered.

3.2.6.1 Description of physical grid

The electricity market in Austria is shown in Figure 22. The grid is divided into three balance areas and 35 balance groups. The balance area marked in blue is managed by Verbund AG (http://www.verbund.at/). The turquoise balance area is managed by TIWAG-Netz AG (http://www.tiwag-netz.at/). The violet balance area is managed by VKW-Netz AG (http://www.vkw-netz.at/) which belongs to the VorarlbergerKraftwerke AG (http://www.vkw.at/). In Austria, there are two clearing centers, approx. 150 suppliers, 155 distribution system operators, approx. 4 million end consumers (i.e. measuring points). The yearly demand is about 63 TWh. The installed power is 16.800 MW; the peak demand is 9.200 MW [Kape2005].

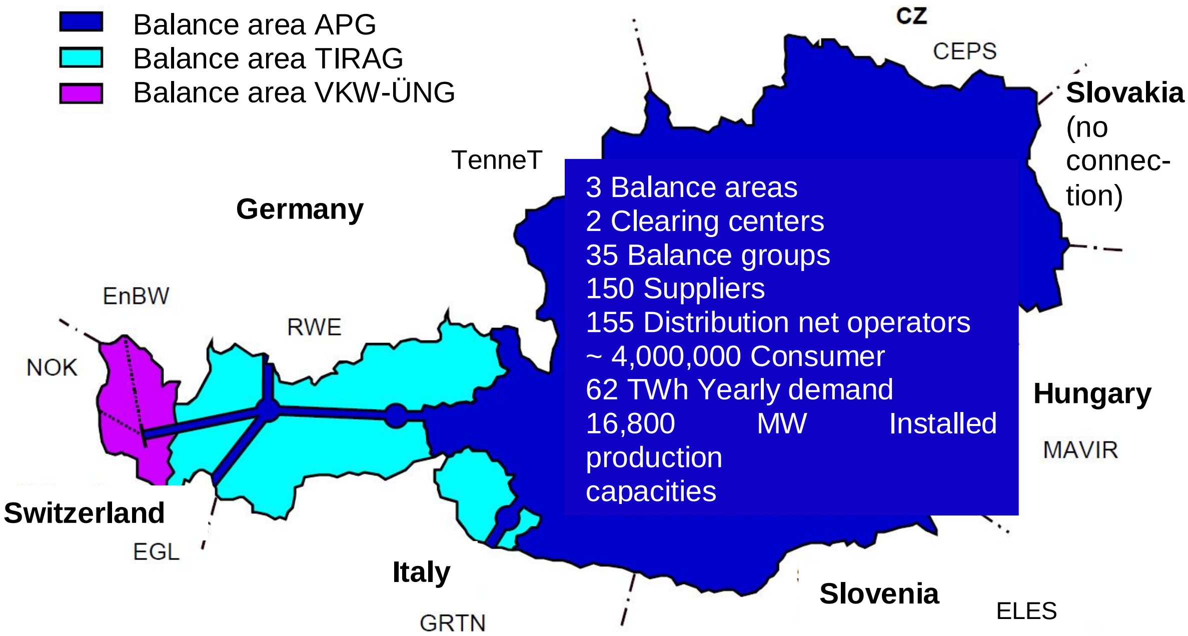

Figure 22: Electricity market in Austria

The physical grid is visualized in Figure 23. The 380 kV grid is shown in red. The dotted lines are cables that are planned or under construction. The green lines are 220-kV cables and the blue ones 110-kV cables. The triangles visualize transformation substations, the rectangles are grid control stations.

The Austrian grid has 380 kV connections to Germany, Switzerland, Slovenia, Hungary and Czech Republic. It has 220-KV connections to Italy, Slovenia, Hungary, Czech Republic, and Germany. There is a 110-kV connection to Germany.

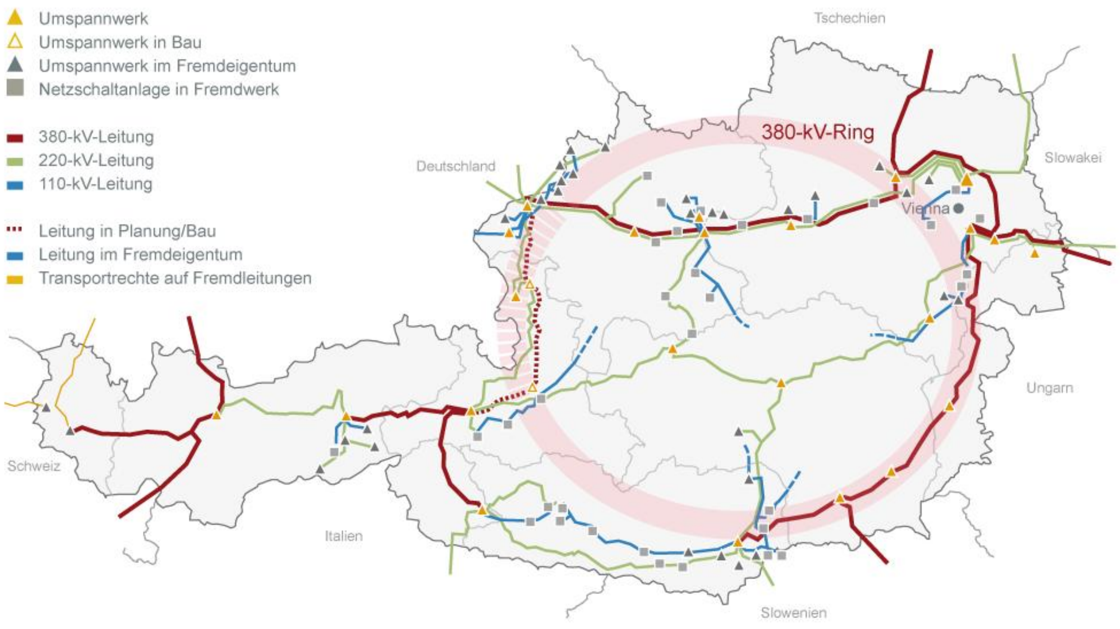

Figure 23: Physical grid [WP]

3.2.6.2 Historical development

The deregulation of the Austrian electricity market is specified in the law called "Das ÖsterreichischeElektrizitätswirtschaft- und -organizationsgesetz (ElWOG)". The law has been enacted in 1999. The law has been changed in 2000. The changed law has opened the electricity market for all customers in 2001.

3.2.6.3 Market players

The market players in Austria are the following [Econ1]:

- An **Imbalance Settlement Party** (Bilanzgruppenkoordinator, BKO) is a legal entity which operates a clearing center (Verrechnungsstelle) for the organization and the billing of the balance energy provisioning within a balance area based on a governmental license.
- A **Balance group responsible** (Bilanzgruppenverantwortlicher, BGV) represents a balance group to other market participants and the *Imbalance settlement party*.
- **Balance group participants** are *suppliers* and *customers* which belong to a balance group. Within a balance group production and delivery of electricity are balanced.
- A **Supplier** (Lieferant) is a legal entity which provides electricity to other entities.
- A **Customer** (Kunde) is an *end consumer*, *electricity broker* or *electricity company* which buys electricity.
- An **End consumer** (Endverbraucher) is a consumer of electricity which buys electricity for its own usage.
- An **Electricity broker** (Stromhändler) is an entity which sells electricity in order to make profit.
- A **Wholesaler** (Großhändler) is an *electricity broker* which has no transmission or distribution function within or beyond the grid in which he acts.

- A **Distribution system operator** (Verteilnetzbetreiber) operates a part of the middle- and low-voltage distribution grid.
- A **Transmission system operator** (Übertragungsnetzbetreiber) operates a part of the high-voltage transmission grid.
- An **Electricity company** (Elektrizitätsunternehmen) is a natural person or a legal entity that performs one of the functions production, transmission distribution, delivery or purchase of electrical energy in order to make profit.
- A **Net operator** (Netzbetreiber) operates a transmission or distribution grid with a rated frequency of 50 Hz.
- A **Producer** (Erzeuger) is a natural person or a legal entity which produces electricity.
- A **System operator** (Regelzonenführer, RZF) is responsible for the power-frequency control in a control area.
- A **Grid user** (Netzbenutzer) is a natural person or legal entity that feeds in or takes electricity from the grid.
- Energy exchange (Strombörse)
-

The relations among some of them are described in [Econ2,Kape2005] and visualized in Figure 24.

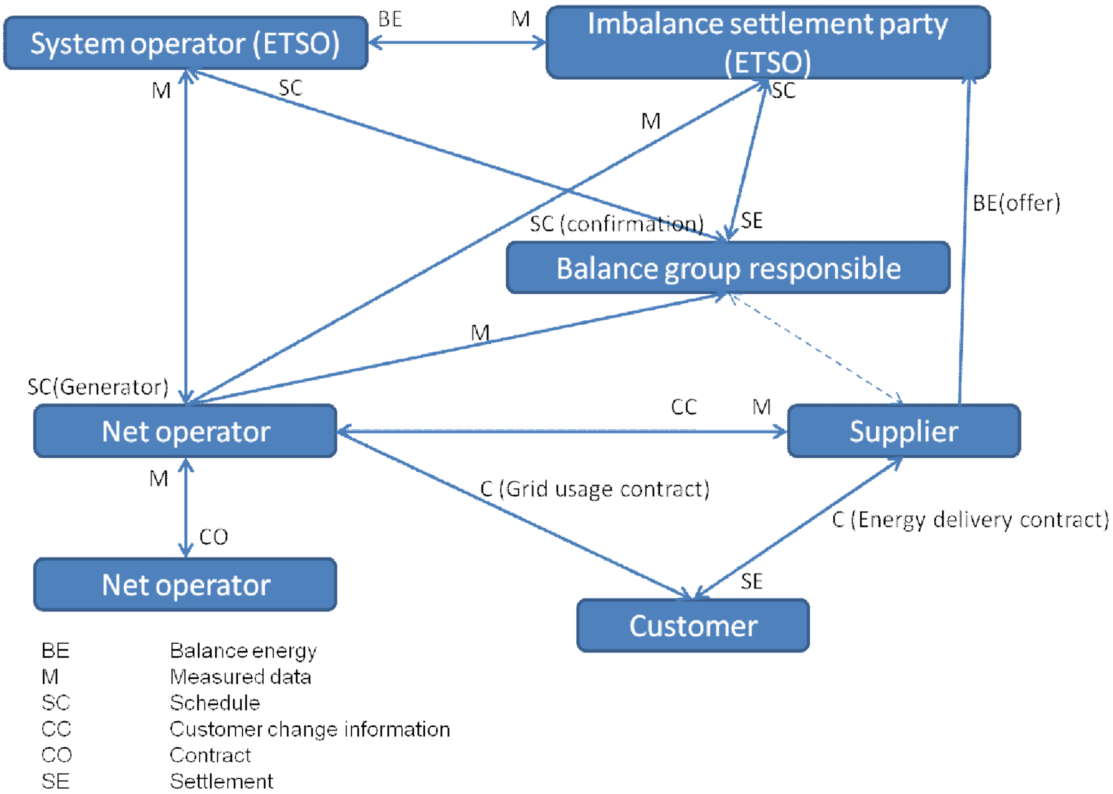

Figure 24: Relations of market participants in Austria

A customer has an energy delivery contract with a supplier and a grid usage contract with a net operator. When a customer changes the supplier, the supplier informs the net operator about this change. The customer settlement is done by the supplier.
A supplier offers balance energy to the Imbalance settlement party. The system operator uses the balance energy.

The net operator sends measurements to the system operator, the imbalance settlement party and the balance group responsible.
The balance group responsible sends the schedule for demand and supply to the system operator. The system operator confirms the schedule. The balance group responsible sends the schedule also to the imbalance settlement party which then settles imbalances based on the measurements received from the system operator.

3.2.6.4 Market organization

EXAA Energy Exchange Austria is the energy exchange of Austria. The EXAA Spotmarkt Strom executes an auction for the day-ahead market to determine the market clearing price [EXAA]. The 24 hours of a day are defined as single products. Also block products that combine consecutive hours are traded. The minimum energy amount for the trading is 0.1 MWh. Larger amounts can be traded in steps of 0.1 MWh. EXAA does not operate an intra-day market.

3.2.6.5 Balancing the production/consumption

The balance group responsible forecasts the demand of the participants in the balance group and plans together with the suppliers the production. It organizes and clears the balance energy of the balance group.
The system operator measures the electricity exchange between balance groups and accesses reserves.

3.2.6.6 End user business relations

End users have an energy delivery contract with a supplier. The electricity demand is charged once a year. Since there are only a few smart meters installed in test projects, there are no advanced tariff systems in the mass market. The projects are run by Energie AG, Stadtwerke Feldkirch, Linz AG, Salzburg AG and Bewag [Bolt2009]. 40.000 customers take part in these projects.
A customer can chose on average among 10 suppliers depending on its location. The tariff calculator offered by E-Control (http://www.e-control.at/de/konsumenten/service-und-beratung/tarifkalkulator) determines the best supplier based on the location of the customer and the yearly demand.

3.2.7 Summary

Originally, one of the aims of Section 3.2 had been to provide the basis for synthesis, i.e. to define the Miracle roles and processes model in the “best cross-section” of the national models.
With the advent of the Harmonized model (cf. Section 3.3. below), this aim has been rendered superfluous. However, there are still sufficient reasons to inspect these models from the point of view of Miracle:

- To establish the link between the abstract categories of the Harmonized model and the real entities in the electricity markets, even though transitory. Also, through inspection of various countries, a feeling for more or less mainstream solutions can be obtained, which can influence the solutions in Miracle (e.g. one sided and two sided pools markets, cf. Section 3.1).
- To provide the real world link and the basis for Miracle trial cases; this is true for both Germany (TSO and LDE trial case) and Greece (Households trial case).
- Furthermore, it may be remarked that the Harmonized model will continue to evolve. The current national models may give us some indication as to what directions the evolution might take.

3.3 Harmonized role model

The three major stakeholders on European market

- ETSO - European Transmission System Operators (presently named ENTSO-E),
- ebIX - European forum for energy Business Information eXchange,
- EFET - European Federation of Energy Traders,

started cooperation on preparing a coherent model of the electricity market in Europe, as a prerequisite to a feasible concept which could be gradually put into practice. Work on the ETSO side started already in 2001 with other two partners joining subsequently; the algorithm for defining the accepted solutions was voting (40:40:20, respectively). The model has been termed the “Harmonized role model”, but it comprehensively addresses on the one hand organization and structuring of players and on the other hand the processes which (should) constitute the electricity market and the processes which are necessary to assure the operational capability of the electricity grids in the new circumstances.

Prompted by European directives, the evolution of the Harmonized role model has been accompanied by gradual diffusion into national role models and national regulations covering the organization of national electricity markets.

In 2009, the year of the current issue of the model, the model has been harmonized on lower levels but not yet on top level(s). The work is being continued and further evolution of the model is envisaged. Since other stakeholders from the major industry players and other configurations of stakeholders are also active, e.g. European Electricity Grid Initiative [EEGI09], we may foresee additional incentives towards further modifications of the model.

The basic documents describing the model are:

- The Harmonized Electricity Market Role Model version 2009-01, by ENTSO-E [ENTS09]
- UMM 2 Business Requirements View for structuring of the European energy market, by ebIX[EBIX09]

which are further detailed in collection of documents collectively called “Implementation guide” [ENTS09a] (for the Harmonized Electricity market Role model). The Implementation guide documents address major segments and processes of the Harmonized model, mainly through a series of use cases for major processes, e.g. scheduling process, settlement process etc.

Present list of documents in the Implementation guide is the following:

- ETSO Acknowledgement Document 3 (EAD) 4 Implementation Guide
- ETSO Balancing Process 4 Results Document 5 6 Implementation Guide
- ETSO Capacity Allocation and Nomination System (ECAN) Implementation Guide
- ETSO Problem Statement Document 3 Implementation Guide ETSO Reserve 2 Resource Process (ERRP) 4 CROSS-BORDER REDISPATCH 5 Implementation Guide
- ETSO Reserve 2 Resource Process 3 (ERRP) 4 Implementation Guide
- ETSO Status Request Implementation Guide
- ETSO 2 Scheduling System 3 (ESS) Implementation Guide
- ENTSO-E Capacity Auction Specification Document Implementation Guide
- ETSO 4 Outage Document 5 6 Implementation Guide
- ETSO Publication 2 Document 3 Implementation Guide
- ETSO 2 Scheduling System 3 (ESS) 4 Implementation Guide

- ETSO 2 Scheduling System 3 (ESS) 4 Implementation Guide
- ETSO Capacity Allocation and 2 Nomination System
- 3 (ECAN – Total Allocation Results) 4 Implementation Guide
- Implementation Guide for the 3 ESS (ETSO Scheduling System) 4 in the UCTE processes

The model is represented by roles, domains, their inter-relations and interactions, as shown in the Figure 25.

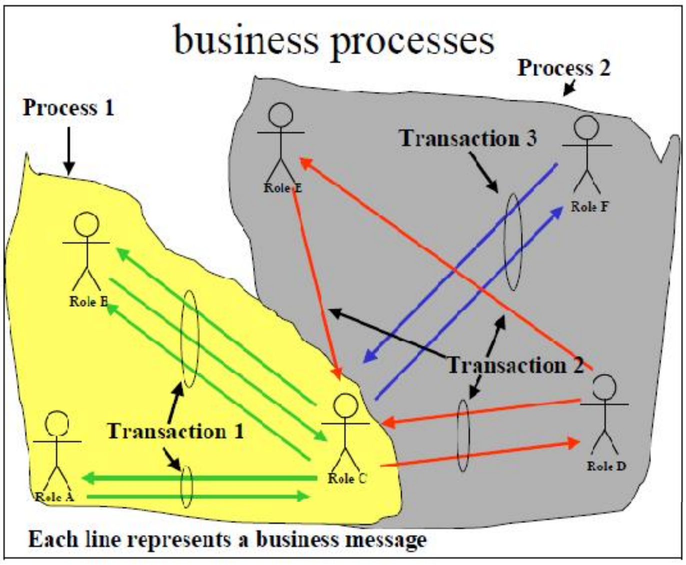

Figure 25: Business processes, transactions and messages [ENTS09]

The diagram in Figure 25 provides an example of different relationships that can appear in the role model.

It can be seen that role C participates in both Process 1 and Process 2.The intent of the role model is not to define the business process of both process 1 and 2 in all transactions. The role model will only provide the principle business messages that are exchanged between two roles. The business messages provide the main justification for the roles presence in the role model.

In [ENTS09], a business transaction is defined as “a predefined set of activities that are initiated by a role to accomplish an explicitly shared business goal and terminated upon recognition of one of the agreed conclusions by all the involved roles”. It is therefore composed of one or more information flows, which are termed business messages, exchanged between roles.

The summarized view of the role model is presented graphically in Figure 26 and .Figure 27.

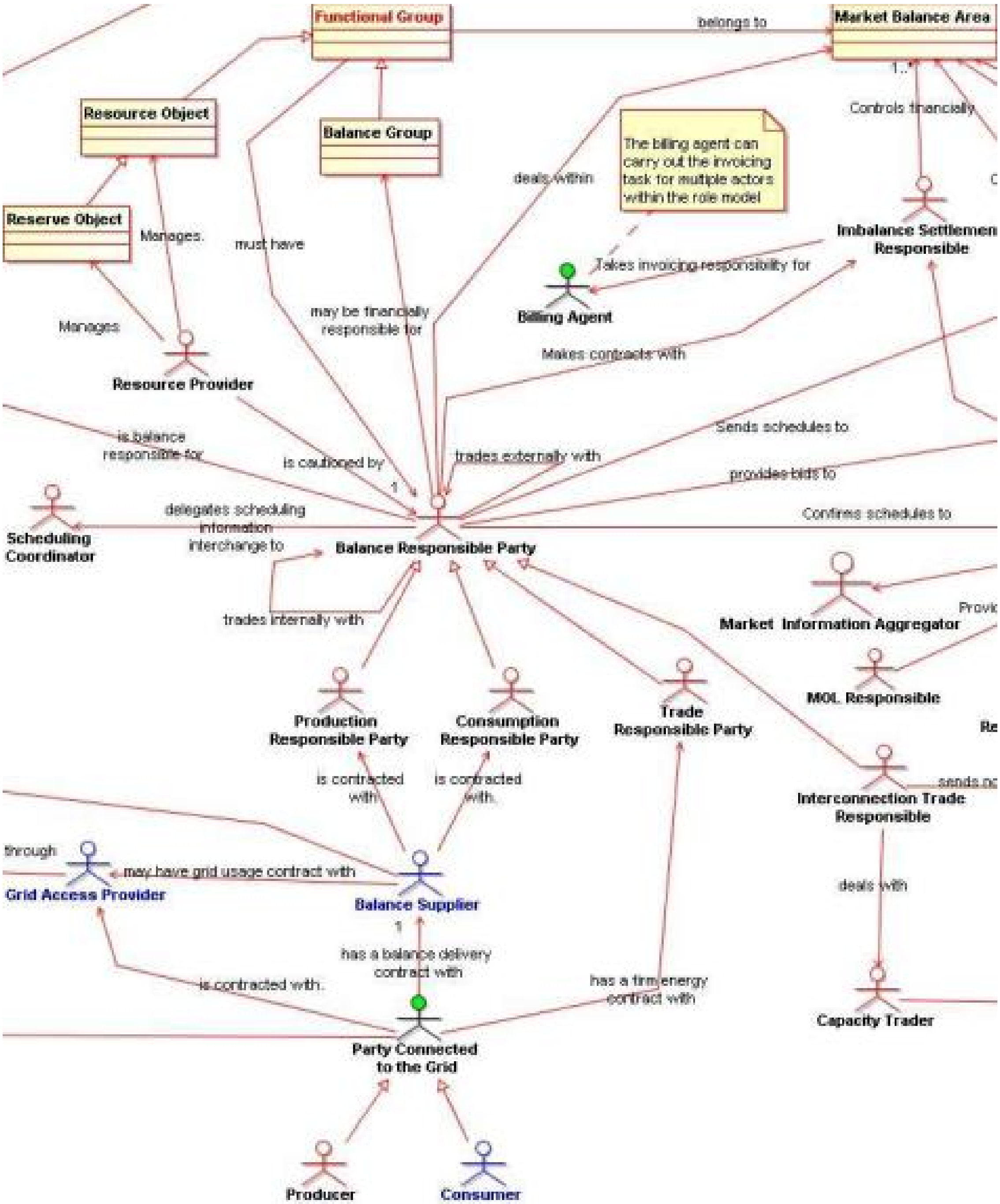

Figure 26: ETSO-ebIX-EFET Harmonized role model, BRP part [ENTS09]

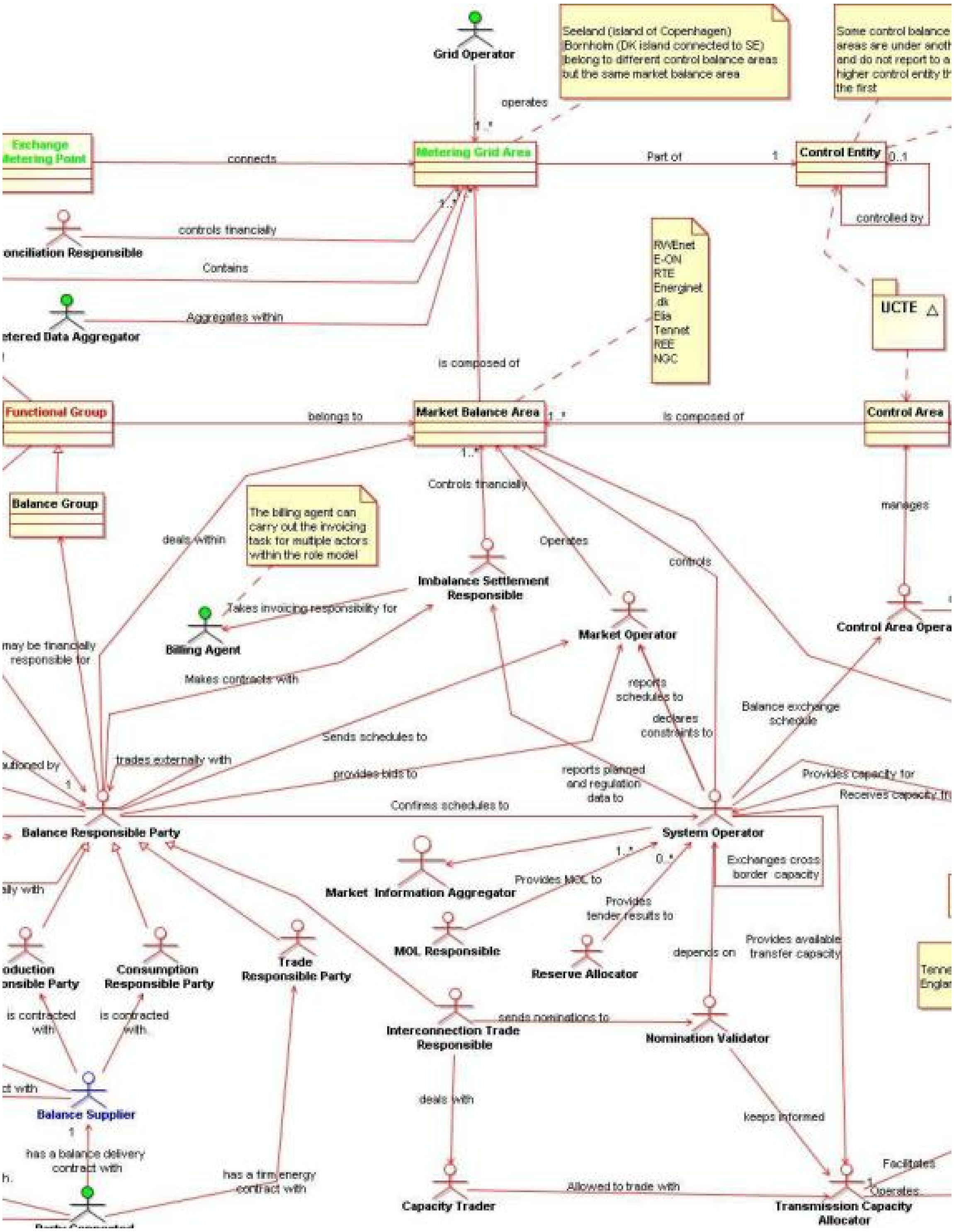

Figure 27: ETSO-ebIX-EFET Harmonized role model, Market and System operator part [ENTS09]

The roles and domains are defined in tabular form in the same document.
Due to the length of the table, only two sample parts of the table are presented in Table 9 and Table 10, for roles and for domains definition; complete table is available in the original document.

The model is conceptually inclusive, i.e. a union of all accepted national/regional models. For this reason there are two consequences:

- on the lower levels the structuring of roles exceeds the actual structuring of roles in individual countries. Effectively this means that the roles in individual national/regional models may integrate several roles of the Harmonized model
- on the upper level(s), specifics of the markets in major countries (Germany, etc) and regions (e.g. Nordic) are recognized and not harmonized; also the market or trading aspect of the market is not fully defined on this level as yet.

While the basic representation of the Harmonized role model focuses on organizational aspects of the market (roles and domains), it is important to note that the ebIX document focuses on structuring the processes of the Electricity market. The basic view from this viewpoint is depicted in Figure 31.

ROLES		
TYPE	ROLE/DOMAIN NAME	DESCRIPTION
Role	Balance Responsible Party	A party that has a contract proving financial security and identifying balance responsibility with the imbalance settlement responsible of the market balance area entitling the party to operate in the market. This is the only role allowing a party to buy or sell energy on a wholesale level. <u>Additional information:</u> The meaning of the word "balance" in this context signifies that that the quantity contracted to provide or to consume must be equal to the quantity really provided or consumed. Such a party is often owned by a number of market players. Equivalent to "Program responsible party" in the Netherlands. Equivalent to "Balance responsible group" in Germany. Equivalent to "market agent" in Spain.
Role	Balance Supplier	A party that markets the difference between actual metered energy consumption and the energy bought with firm energy contracts by the party connected to the grid. In addition the balance supplier markets any difference with the firm energy contract (of the party connected to the grid) and the metered production. <u>Additional information:</u> There is only one balance supplier for each metering point.

Table 9: First sample segment of the roles model definition table [ENTS09]

As already mentioned, the ebIX European energy market domain model is defined using the method of the UseCases (phases). As can be seen in the Figure 28: The phases of the European energy market in ebIX model are structuring, trade, planning, operation (production, consumption and transport), measure (meter reading), settlement (physical and financial, including reconciliation) and billing.

The repartition of tasks between the three partners is as follows:

- Modeling of the Structure, Measure, Settle (partly) and Bill UseCases are mainly ebIX responsibility, while
- Modeling of the Plan and Settle (partly) UseCases are mainly an ENTSO-E responsibility,
- (Modeling of the Operate UseCases is manly an IEC responsibility) and
- Modeling of the Trade UseCases is mainly an EFET responsibility.

DOMAINS		
Domain	Allocated Capacity Area	A market area where the transmission capacity between the balance areas is given to the balance responsible parties according to rules carried out by a transmission capacity allocator. Trade between balance areas is carried out on a bilateral or unilateral basis. <u>Additional information:</u> This is a type of Market Area
Domain	Balance Group	A collection of metering points for imbalance settlement <u>Note:</u> Equivalent to "balance group" (Bilanzgruppe) in the Austrian market or (Bilanzkreis) in the German market German definition: It is composed of a various number of metering points within a Market balance area. <u>Additional information:</u> This is a type of Functional group.
Domain	Capacity Market Area	A market area where the transmission capacity between the balance areas is given to the balance responsible parties in a price based process separated from trading carried out by a transmission capacity allocator. Trade between balance areas is carried out on a bilateral unilateral basis. <u>For example,</u> The auctioning system between TenneT and RWE Net. <u>Additional information:</u> This is a type of Market Area

Table 10: Second sample segment of the roles model definition table [ENTS09]

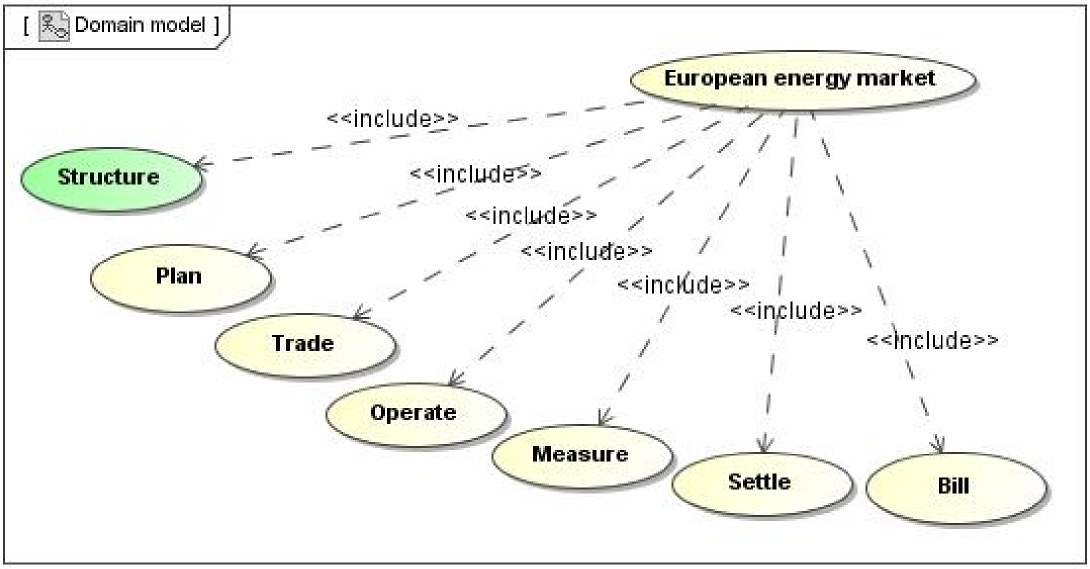

Figure 28: The phases of the European energy market in ebIX model [EBIX09]

The following summary description of the phases is taken from [EBIX09].

Structure. In the structuring phase, the actors exchange information (master data) necessary for the later business processes. The different parties request creation of, changes to or deletion of energy market business objects, such as metering points, meters, contracts etc, or to its attributes. Thereafter the information related to the created, changed or deleted business object or its attributes is exchanged between relevant parties (roles). The alignment of master data between the actors in the energy market should result in all participants having the needed information to fulfill their obligations to the market.

Plan. The messages defined in these business processes enable *Balance responsible parties* (i.e. Trade responsible, Production responsible and Consumption responsible parties) to send their schedules (planned consumption, production, capacity, transport, exchange etc.) to the *System operators* and/or the *Transmission capacity allocator* (congestion management) the day ahead. The messages may also be used for the transmission of intraday schedules associated with day-ahead schedules.

Trade. In the trading phase, the *Balance responsible parties* are buying and selling energy for fulfilling their contractual obligations. The trading phase includes trade through the *Market operators* (e.g. Power exchanges).

Operate. The business process operate includes the message exchanges to handle the Balance regulation market and Ancillary services markets, e.g. the *System operator* orders up and down regulation to keep the balance in the system.

Measure. The measure phase (Exchange of metered data) covers all stages from the collecting of the metered data until the settlement and reconciliation phase, with a focus on the exchange of information between *Metered data collectors, Metered data aggregators, Imbalance settlement responsible* and *Balance responsible parties*. E.g. the *Metered data collectors* read *Registers* (within *Meters*) and distribute metered data (transport, production, consumption). Thereafter the metered data are validated, aggregated and distributed to relevant roles.

Settle. The messages defined in this phase enable *Imbalance settlement responsible parties* to receive aggregated executed schedules, regulation- and metered information, and to send imbalance reports and bills (invoices) to the *Balance responsible parties* (consumption, production, capacity, etc.). The *Reconciliation responsible party* make the final reconciliation and distribute data to relevant roles.

Bill. The billing phase is the final process in the chain and includes all message exchange needed for billing the Consumers and the internal billing in the upstream energy market. I.e. invoicing and related basis documents needed for controlling purposes.

It may be relevant to note that neither **Trade (**nor **Operate)** has been so far elaborated by any common European projects.

In line with this view, in the Implementation guide documents, individual processes are presented and analyzed. Such viewpoint differs from the static viewpoint of the role model schematic, as can be seen from the example in Figure 29.

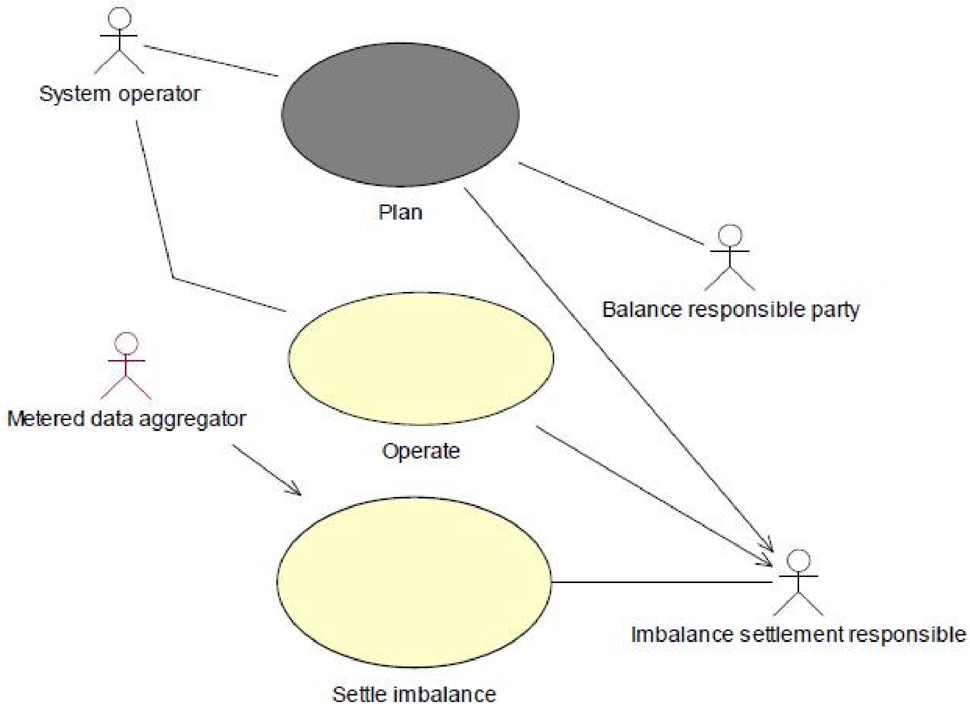

Figure 29: Example of process time-flow scheme from ETSO Scheduling system guide [ENTS09]

3.4 Summary

It is clear that the viewpoint of ebIX model and this viewpoint is closer to the viewpoint of the Miracle project, which is management of the processes, and contains vital complementary information for setting up appropriate roles and processes model for developing the Miracle technology.

In summary, the Harmonized role model is the common denominator for all evolving national role models and provides guidance for future evolution of national role models towards a coherent European electricity market. Consequently, it represents the basis for Miracle role model.

4 Description of Miracle system and processes

The introduction and development of the special role and process model in the Miracle project is necessary due to several reasons:

- There is no common or general role model in force in EU. Each country has some own specifics and it would be unreasonable to favor one of them by choosing it for the basis
- The Miracle approach, by introducing the new concept of ”flex-offer” into the business process, provides new relationships between roles and consequently changes the existing and introduces new processes into the system.

As The ETSO harmonized model [ENTS09], the result of joint undertaking of major stakeholders on the electricity market in Europe aimed at unification of various national electricity markets in European countries, (cf. Section 4.3), thus represents the ideal base for the Miracle role and process model.
The roles in the role model are described by the processes they perform and transactions through which they are connected. It was decided that processes which are closely related or are even the result of the Miracle flex-offer concept, are determined through the analyses of the use cases.
The setting up the Miracle role model has gone through the following process:

- first the structure of the electricity market system is described, and the concept of primary processes introduced, which is a necessary background for the use case definition,
- the use cases are formed in a way to present the essential Miracle characteristics,
- the unit processes extracted from the use cases are listed and described, and finally
- the Miracle role model with role description and responsibilities is set up.

4.1 System description

4.1.1 Systemic approach, requirements and conventions

In describing the framework for Miracle project, we shall use the point of view relevant to the task of managing and controlling the electrical energy market system – the viewpoint of system engineer. There are three main constituents to this approach:

- the structure of system itself and its environment,
- the roles of the entities that constitute the system, and
- the processes that occur in these roles

We shall consider that the requirements which are relevant to Miracle system design are:

- those which stem from the requirements of the electrical energy grid market and electrical energy grid system on the one hand, and
- those which we have set as project objective for the Miracle system. Of these, scalability of the Miracle system is an important systemic requirement.

In describing the constituents, we shall use:

- conventions, terms and categories, used in the Harmonized Electricity Market Role model
- terms and categories, required by the Miracle technology; this only if they are not in contradiction with the previous requirement.

To provide a consistent system, we shall build a glossary of definitions of the conventions, terms and categories used in the Miracle project, consisting of entries from both Harmonized Electricity Market Role model and internal Miracle descriptions and nominations.

4.1.2 Structuring of Electricity Market System

Based on observation of the Harmonized Electricity Market Role model and related documents, we make the following basic assumptions:

- The electrical energy market system can be vertically and horizontally decomposed – structured.
- The main line of vertical decomposition follows the concept of nested fractal subsystems, with each nested subsystem having essentially the same functions as "parental subsystem" on the next higher level but as consistent with its level of decomposition. For reasons of convenience, we shall refer to these type of subsystems as "primary subsystems" and the processes that occur in them the "primary processes".
- Horizontal decomposition refers principally to a number of fractal-like subsystems, i.e. systems with exactly the same functions, which exist in parallel on the same level;
- Additionally to this structure of vertically and horizontally decomposed primary subsystems there exists a specific subsystem, which does not have the same functionality as fractal-like primary subsystems but specific functions of joint and supportive processes, necessary for operation of the electricity market, mainly processes for maintaining the electricity grid, in technical and business sense.
  This subsystem is not vertically structured in levels or rather its structure does not follow completely the structure of the primary subsystems. However, for the purpose of management of processes in the primary subsystems, it can be considered as the "environment" of the primary subsystems on each vertical level, defining the boundary operating conditions of these systems. For convenience, we designate this type of subsystem as "structural subsystem"; and the processes within the structural subsystem as "joint and supportive processes".

Schematically and conceptually, this vertical and horizontal decomposition of the electricity market is illustrated on Figure 30. On each vertical level, a number of similar primary subsystems exist, with one modeled structural subsystem, depicted as hexagonal, containing the part of joint and supportive processes interacting the processes in all the primary subsystems on this vertical level. On the graphic, four levels of vertical decomposition are sketched.

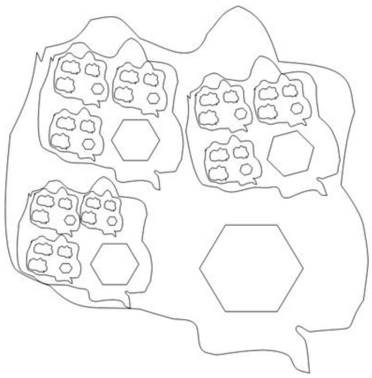

Figure 30: Schematic representation of vertical and horizontal decomposition of electrical grid system into nested subsystems.

This concept of the electricity market system structure has the following major advantages:

- Scalability: each fractal subsystem has essentially the same set of functions, and Miracle solutions in principle apply to all of them; this does not apply to "structural subsystem" on each level; if it exists, it is defined separately and does not make part of the Miracle technology
- Scalability implies usage both on the level of a single subsystem as on the level of several subsystems and system levels. The concept imposes transparent and consistent requirements on system architecture and system communication
- The electricity market system with the electricity grid system on each it is imposed are a complex system, which is through the act of European regulators in actual practice being decomposed vertically and laterally; we are trying to do the same with our management and control system of the electricity market system, in a consistent way. Decomposition greatly facilitates the task of management or governance of the system. Each lower level consists of a number of subsystems which reduces the size of the entire system, and, what is more important, makes the concept of market on the lower levels a viable concept: competition between various subsystems for increasing the number of members of the subsystem, competition between members of the same subsystem.
- It accommodates existence and growth of complex business entities, i.e. subsystems
- Through inter-level consistency, it supports further systemic evolution and integration of the electricity market and grid system in Europe.

4.1.3 System, process and roles

Generically, a process consists of transformation of energy, material and information occurring in a system.
The process in the electricity market and grid system consists of energy production, (transmission – flow of energy), consumption and trading. The primary process in the electricity market system is trading of energy.
The control and management process is a sub-process of complete process occurring in the system.
The Electricity market system is vertically and horizontally structured into subsystems. The control and management system is a subsystem of the complete system.
In Harmonized Electricity market role model, subsystems are represented by *domains.* This term, while explainable in the context of complete electricity market and grid system, is somewhat misleading from the point of view of functionality of a management and control system such as Miracle. For this reason, the term *subsystem* will be used unless referring to the correspondence with the Harmonized model.
Electricity market and grid system is distributed and occurs concentrated in points (except for transmission) – active components, each with a specific function or a set of functions. This refers to both »process« part and to the control and management part of the system. Usually, the control and management subsystem is clearly delineated from the process part of the system. In the case of the electrical market and grid systems, many system components have been institutionalized through the operation of the system and their function may not be clear due to the system complexity. However, in the course of restructuring the complete system and concurrently designing a new management and control system, the functions of the existing system components have to be identified. What is more, since the restructuring of the system involves decomposition of the existing system, the existing components have to be decomposed into primary (atomic) units to

enable new types of integration. To make this procedure transparent and consistent, we shall use the following nominations:

- *Unit component* of the system: part of the system which performs unit process or several unit processes and which can be institutionalized i.e. assume the form of a separate business entity. In line with the convention of the Harmonized model, we shall call such unit component role component or role player - shortened *role*, thus somewhat misleadingly equating the system and the process
- *Unit process* is the process which performs a unique function in the context of Miracle process and role model. We shall call such process a *unit process* and characterize it as “atomic”.

Some additional clarifications and conventions referring to the atomic character of a *unit process:*

- Unit processes cannot consist of or include other processes, which are defined otherwise as unit processes in the model
- Unit processes must be mutually exclusive. In a role and process model, each unit process should be defined only once; there must not be any overlap between different unit processes
- A role and process model should include all unit processes that are needed to describe the complete process covered by Miracle; the list of unit processes must be therefore exhaustive. If a unit process is missing, the Miracle management and control system as a whole will not work, rendering the other unit processes useless.

Some additional clarifications and conventions referring to the character of a *role*:

- Roles cannot consist of or include other roles, which appear otherwise as roles in the model
- Roles must be mutually exclusive. In a role and process model, each role should be defined only once; there must not be any overlap between the functions that different roles fulfill
- Exhaustive. A role model should include all roles that are needed to describe the complete system. If a role is missing the model as a whole will not work, rendering the other roles useless
- Black box. Roles should only be described in terms of their responsibilities and in and output with respect to other roles. In other words only the service portfolio that a role offers to other roles matters. The internal implementation of a role is not relevant for the description of a role model.

The control and management system must have certain functions to fulfill the requirements stemming from the process and necessary for its (optimized) operation.

4.1.4 Processes in primary subsystems

In each primary subsystem, processes (unit processes) are carried out by the roles (in the roles!) which make part of the subsystem.
The processes in the subsystem interact (“roles communicate”) with the processes in the subsystem environment:

- Processes in other primary subsystems
- Processes in structural subsystems

Processes in primary subsystems will be defined and analyzed with the aid of Use Cases. For this reason, use cases will be selected to cover complete EEM system addressed by Miracle, and also to cover the 3 trial cases of Miracle:

- Household community
- LDE (Local Distributor of Energy)
- TSO

4.2 Unit processes

4.2.1 Unit processes on the level of each primary subsystem

In each primary subsystem, the primary processes are carried out. In Electricity market system these are processes of trading the energy. They have to be broken down into unit processes according to the need of the Miracle technology but also consistently with the boundary conditions of the Harmonized model.
The following types of unit processes occur in each primary subsystem:

- Production (supply) of energy
- Consumption (accepting) of energy
- Requesting for the energy (supply for consumption)
- Requesting for production of the energy (for supply)
- Aggregation of flex-offers for energy
- Aggregation of flex-offers for production
- Trading the energy
- Negotiating
- Auctioning
- Contracting
- Scheduling of flex-offer for energy
- Disaggregation for energy
- (Assigning the scheduled flex-offers for energy)
- Scheduling the flex-offers for production
- (Assigning the scheduled flex-offers for production)
- Disaggregation for production
- Measuring the consumption data
- Measuring the production data
- Forecasting the aggregated production
- Forecasting the aggregated consumption
- (Forecasting the transmission losses)

Proper structuring of the overall primary process into unit processes and showing that these unit processes occur at different levels of the vertically decomposed system makes it possible to use the technology to be developed on different levels of the system – i.e. scale it simply to the system where it is used: there is no (appreciable) difference for the unit process if different roles are involved – at least there should not be if the unit processes are properly defined (e.g. negotiation process is negotiation process whether performed between consumer and BRP or between BRP and BRP, etc.).
For this reason, the above list of unit processes is tentative in scope and generic in formulation, and may not be exhaustive as required The final scope of the list and the specific nominations of unit processes will be made in analysis of the market system processes through Use cases, in chapter 5 of this document. The Use case analysis shall also provide the check that the final unit processes are exhaustive.

A specific question unresolved at the time of the draft model is whether the transmission line is active or passive component of the system: the reason for this dilemma is that with changing ambient conditions the transmission lines behave as »changing energy consumer«; the losses influence the energy balance and have to be taken into account and settled. The distance between two production and consumption points influence the energy loss:

- If it is an active component; this is equivalent to introduction of role of »line consumer« (or transmission loss, etc). Such role would enable/accommodate future change of the method of settling the transmission losses – assigning them to the concrete transaction. It would also enable forecasting of these losses due to weather conditions
- If passive component: the transmission loss is not part of the Miracle roles and process model, the loss is a fixed external datum, occurring in calculating the costs of DSO/TSO or of whoever covers these costs.
- It may be important to note that transmission is physically not structured into fractal-like subsystems, but exists at precisely defined level of the system, although its function is carried out at each subsystem level. The exception to this rule is micro-grid subsystem, which is fractal-like subsystem of the complete system as a whole.

4.2.2 Unit processes on the level of joint and supportive subsystems

The following unit processes occur in structural subsystems:

- Measuring the consumption data
- Measuring the production data
- Forecasting the aggregated production
- Forecasting the aggregated consumption
- (Forecasting the transmission losses)
- (Transmitting the energy)
- Operating the (low voltage) distribution system
- Operating the (medium voltage) distribution system
- Operating the (high voltage) transmission system
- Regulating – system rules setting
- (transmitting the energy)
- Operating the (low voltage) distribution system
- Operating the (medium voltage) distribution system
- Operating the (high voltage) transmission system
- others

The above list of joint and supportive unit processes is very sketchy and is presented only as indication of type of processes that belong into these subsystems.
However, the joint and supportive processes as such are not of interest to Miracle project and will not be modeled. They are interesting only to the extent to which the primary processes interact with them. For this reason, we shall only define points of interaction of these processes with the primary processes inside the primary subsystems. This means that we limit ourselves to indentifying the interacting roles, without looking into processes carried out by the role, and we only consider immediately adjacent roles.
The mode of interaction is message, document and similar type of “non-process” transaction.

4.3 Primary Subsystems

Subsystems are represented in the Harmonized model by *domains*. Based on the above model, we identified the following vertical structure of primary *subsystems* in the present state of the Harmonized Electricity Market role model:

- 1st level: Balance group
- 2nd level: Market balance area
- 3rd level: Market area (Local market area)

There may be further subdivision of the 1st level into Balance Subgroups (in some countries this already happened), but it is reasonable to assume that the level of common European regulation will not set this sublevel as a separate level from BG's and will leave it to intra-BG arrangements, providing that they "stay within" the regulatory constraints imposed on BG level.
Also, a 4th – unified European level is logical extrapolation for the future. However, close inspection of the model shows that already the 3rd level is unharmonized and incomplete – it does not include complete range of primary processes and it is reasonable to assume that further evolution of the system is dependent on implementation of the existing scope of the model.
In parallel with this structure of primary subsystems, there is in Electricity market a subsystem with a *potential* of becoming a primary subsystem but the processes in the present state of Harmonized model do not define it as such. This is the subsystem in which the Reserve Resource Process takes place [ETSO09a]. The process is under jurisdiction and control of System operator and is not explicitly linked to other primary processes. Taking notice of the need to improve the management of the transmission capacities between different Market Balances Areas, as witnessed by the project started in Germany in 2010 (cf. section 3.2.4.8), it seems possible that these processes could also be organized into a vertical structure of nested subsystems, a "secondary" structure in parallel with the "primary" structure of primary processes, with a link between them – theoretically at each level, but logically at the levels where the interaction enhances the operation of both structures, organized market level and capacities trading (cf. Section 5). However, presently such a view upon such evolution of these processes is largely hypothetical, and an extension of Miracle roles and processes model into these *domains* is not planned.
For this reason, Miracle is in practical terms concerned with the first two levels (bottom up), 3rd level is introduced mainly for the sake of completeness and model consistency. When referring to an electricity market system or to an energy grid system, we shall therefore mainly talk about the electricity market system within one Market Balance Area or the energy grid system on the territory of one TSO; with the environment of the system extending into Market Area (Local Market Area).
However, for Miracle this is important as a message to define the role and process model in a way to accommodate consistent vertical decomposition: when the Harmonized model is extended consistently as fractally structured system to the pan-European level and put into practice, the 3rd level, and at least conceptually also the 4th level, could be supported by Miracle:

1. The basic Miracle structure could accommodate it without undue problems
2. Unless and until fully deployed in complete system , the level of support of Miracle technology would be reduced to use of piecewise functionalities such as

forecasting, (aggregation), scheduling, as decision support in trading but could play some on-line role in on-line/short term trading inter-MA (Local Market Area)
3. For the time being, this possible extension of the Miracle technology can be kept feasible by maintaining formal fractal consistency of the system and architecture, thereby making it easier to apply the solution to this level.

In this concept, supported by the Harmonized model, the Balance Group is a *new* subsystem, which within the constraints imposed by the Harmonized model may form its own rules for participation in costs or revenues from trading on the inter-BG level.
In principle, the rules for intra-BG trading could be the same as the rules used in inter-BG trading (on MBA level) or different.
It is reasonable to assume that based on the needs of its majority users a BG system will have simplified rules for its members, especially if it includes households. They will continue to evolve on the tariff system concept with various benefits, but with elements of the market which can be introduced by dynamic pricing concept
On the other hand, to simplify the transformation between the two levels, the traders (BRP's) will tend to make the energy trading products in the BG similar to the energy trading products on the inter-BG trading level. This assumption leads us to assume that the energy trading products in the intra-BG trading will tend to become similar at least in structure to those on the grid level, but their variety will tend to remain limited – emulating some of the characteristic of a multi-tariff system.
The BG subsystem is therefore the natural user of automatic trading technology, due to the fact that major part of it are households with little capacity for continuous active trading. The BRP's trading partners are unlicensed actors – predominantly households and small to medium companies; their number is very large, they will trade in a limited number of energy products and time horizons which emulate tariff systems (e.g. a daily arrangement for fixed hours, agreed on for a longer period).
By way of prediction, they will use complete functionality of the Miracle system, including automatic trading.

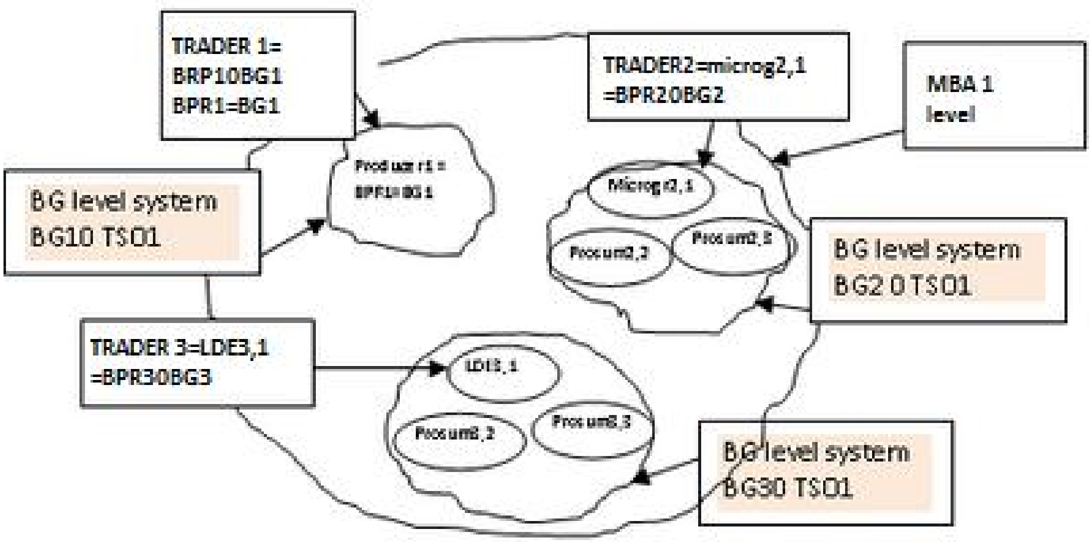

Figure 31: The concept of the MBA level system with three sample types of BG level systems

Conversely, in inter-BG trading, the energy products are traded between licensed traders (BRP's); the number of traders is comparatively small, they trade in all kinds of energy products and time horizons (long term, medium term, short term). By way of prediction, they will use the Miracle technology as information exchange system and a decision support system in trading but with further harmonization of the upper levels of the Electricity Market system could eventually play active role in on-line/short term inter-MA (Local Market Area) trading.

5 Miracle Use case analysis

As already mentioned in the previous Section, to define and analyze the processes in primary subsystems the Use Case analysis will be used.
The use cases described and analyzed in this document were chosen and formed in the way to follow the Miracle project goals. The use case scenarios, its boundary conditions and roles involved were determined in the way to expose the main characteristic of Miracle project – energy scheduling and delivery on the basis of the prosumers flex-offers.
The following use cases have been defined to analyze and define the primary processes of the two complete primary subsystems of the electricity market:

- Balance Group Use Case, structured into 3 scenarios (sub cases)
  - Market Area Use case, structured into 3 scenarios (sub cases)

In selecting these use cases, two main criteria were adhered to:

- The use cases should together describe complete area of the electricity market where the Miracle solution can be used
- The use cases within each subsystem (Balance Group, Market Balance Area) are selected in a way to establish clear understanding of interdependencies and causality, i.e. to act as a yardstick for establishing the requirements for development. The complete use case for BG is use case 3, the complete use case for MBA is use case 2, while the MBA use case 3 provides the necessary inputs and descriptions to introduce the Miracle technology into the inter-TSO energy trading.

It is important to note also that by respecting the first criterion the two groups of use cases cover the trial cases planned for Miracle (see DoW [Mira]):

- BG Use case covers: household community, and sufficiently the LDE trial
- MBA use case covers sufficiently the TSO trial

It was decided that the ETSO Reserve Resource Process (ERRP) system will not be modeled as there is no Miracle functionality involved as yet.

5.1 Overview of use cases

The described use cases were chosen according to the physical and economical specifics of electricity trading.

5.1.1 The Balance Group Use Case basic description

There have been 3 use cases selected to describe the processes occurring in balance group subsystem, which is the 1st level primary subsystem (domain) in the electricity market system:
The BG Use case 1 describes the process of selling the electric energy as goods with no real environment restriction (like physical network). This use case should enable isolation of the flex offer concept for detailed analyses.
The BG Use case 2 introduces the physical property of the electricity transporting – imbalances. The electricity cannot be stored therefore the consumption must be equal to the production at every moment. These facts have significant influence on the roles of the market players and trading processes.

The BG use case 3 introduces the economic component - the competition which was introduced during the evolution of the electricity market from the hierarchic organization to open market.

5.1.2 The Market Balance Area Use case basic description

The Use cases were selected to describe the processes occurring in the Market Balance Area (MBA) subsystem, which is the 2nd level primary subsystem (domain) in the Electricity Market system:

MBA Use case 1: Scenario addresses **Internal Energy Bi-lateral Trading** processes between two BRPs. All the energy produced/consumed within the Market Balance Area (MBA) is matched internally within the same market balance area; a possible surplus of production/consumption is not modeled, so there is no energy transfer between different MBA’s and no energy trading between different MBA’s. Additionally, there is no difference between contracted and actually delivered/consumed energy by the BGs, so there is no imbalance settlement process involved.

MBA Use case 2: Scenario introduces the **Imbalance processes**. Additionally to the use case 1, there are now differences between planned and actually consumed/purchased energy. Also, instead of bi-lateral trading, auctioning trading is introduced. This implies more than two BGs, although for the scenario, only 2 BGs will be actively modeled with the other BGs implied.

MBA Use case 3: Scenario introduces to MBA system **External energy trading** processes. Additionally to use case 2, the energy traders - BRPs - cannot supply all the energy for the consumers or vice versa from the supply/demand within the BG’s in the MBA; or alternatively the price of energy within MBA is not competitive/adequate as compared to other MBA’s; consequently, the BRP’s have to engage in trading externally to MBA as well.

5.1.3 Definitions

5.1.3.1 Definitions stemming from Harmonized Electricity Market model

BRP Responsibilities include intra-BG and inter-BG energy trading i.e. trading of energy with corresponding BRP's from other BG’s.
Financially responsible role for intra-MBA trading is the Balance Responsible Party. BRP is also responsible for external energy trading, i.e. trading of energy with corresponding BRP's from the other MBA involved.

Closed (firm) contracts define quantity, profile and time (essentially we can consider them as type of energy products); price; and contractual penalty.
Closed contracts in energy trading are contracts for the period ahead in time: day ahead or intra-day. The closed contracts are between the balance responsible parties or between balance responsible party and market organizer when trading the energy.
In the Miracle project the closed contract is also introduced between prosumer and balance responsible party on the basis of the successful match between consumption and production flex-offers.

There are two **types of contracts** closed (firm) and open contracts.

<u>Intra BG contracts</u>
In energy trading **intra-BG,** there are both closed contracts and open contracts.

Closed contracts define

- quantity, profile and time; to facilitate trading, a certain number of energy profiles vs. time have been shaped, termed energy products;
- price; and
- contractual penalty

For the closed contracts, imbalances are established. These internal imbalances constitute one part of total imbalances of BRP contracts on the extra-BG, i.e. inter-BG level.
Majority of present contracts of the prosumers are open contracts with the fixed (or at most fixed time interval multi tariff) price. Smart metering enables do provide dynamic pricing of the end prosumer what reflects the market situation.

<u>Intra- and inter- MBA contracts</u>
In energy trading on the MBA level, both internally to MBA and externally, there is only closed (firm) type of contracts. There are no open contracts in organized energy trading on MBA level.
Closed contracts define

- quantity, profile and time; to facilitate trading, a certain number of energy profiles vs. time have been shaped, termed energy products;
- price; and

The contractual penalty is a subject of a separate contract between BRP and Imbalance Settlement responsible.
Closed contracts in energy trading are contracts for the period ahead in time: day ahead or intra-day. The closed contracts for energy are between the Balance responsible parties and with inclusion of ISR: the contractual penalty is category dealt with between BRP and ISR. Similarly, the closed contracts for capacities in inter-MBA trading involve Transmission Capacity Allocator.
For these contracts, imbalances are established.

Imbalance is the difference between contracted and really consumed (or produced) energy. The really consumed or produced energy is the metered and aggregated energy to the level defined by the closed (firm) contract. These data have to be supplied by the metering part of the system, which is not a part of the primary system (BG, MBA or BA), the relevant part of which can be emulated as joint and supportive subsystem of the primary system.

<u>Imbalances in BG</u>
The imbalances in intra-BG trading constitute one part of reason for total imbalances of BRP contracts; the other part of the reason occurs in BRP's inter-BG trading. These two types may add or subtract (through optimized management). The business goal of BRP is that the total sum of imbalances as measured on the grid is zero – the BRP operation is balanced.

<u>Imbalances in MBA</u>
The imbalances in BRP's trading on the MBA level result from three types of trading:

- BRP's trading on the MBA level:
- intra-MBA trading
- inter-MBA trading and
- BRP's intra-BG trading.

These three types may add or subtract (through optimized management). The business goal of BRP is that the total sum of imbalances as measured on the grid is zero – the BRP operation is balanced.

Imbalance settlement refers to financial settlement penalty for not fulfilling the contractual obligation and not to supplying or accepting the energy.
The imbalances are established in periodic time intervals for past time intervals and billed in normal business intervals (e.g. monthly).

Imbalance settlement in BG
The imbalance settlement in BG for consumers and producers (and Balance suppliers) is carried out by BRP – Settlement responsible. The imbalances are/may be charged by BRP to prosumers.
In inter-BG trading, the penalties due to imbalances are settled between Balance responsible party and Imbalance settlement responsible (ISR), for all BPR's contracts in Market balance area. These imbalances are charged by ISR (or its Billing agent) to BRP.
Responsible role for closed contract trading is the Balance responsible Party. BRP is also responsible for external energy trading, i.e. wholesale trading for the BG. The wholesale contracts, i.e. inter-BG trading, are closed contracts.
For closed contracts in intra-BG trading the contract is between

- Producer and BRP
- Consumer and BRP

The missing energy is supplied by the role balance supplier. Additionally, there is a contract between balance supplier and BRP. This contract is necessary because the conditions in open contracts and the conditions in closed contracts have to be interdependent to stimulate responsive behavior of the prosumers in closed contracts.
This contract does not have to be closely analyzed, because it is not based on flex offers, but transformation of information on trading conditions on interface would have to be realized, to use it as a boundary or reference condition, e.g. how expensive has to be energy in open contracts as to preference the closed contracts.

Imbalance settlement in MBA
The imbalance settlement in MBA is carried out by ISR – Imbalance Settlement responsible. The penalties due to imbalances are settled between Balance responsible party and Imbalance settlement responsible (ISR), for all BRP's contracts in Market balance area.
The imbalances are charged by ISR (or its Billing agent) to responsible BRP's
The imbalance settlement process is carried out in three phases.

i) Planning phase, in which the BRP's calculate in advance the consumption/production of all the parties involved for the day ahead. At the completion of this phase, the system operator informs all the BRP's of what of the planned schedules has been accepted and informs the ISR of all the accepted schedules (further elaborated in the ess guide, ref ESS guide)
ii) Operational phase, in which the planned and accepted schedules are executed. The System operator takes care of any deviations between planned and executed schedules of consumption and production
iii) Imbalance Settlement phase, in which - following the date of execution – the Metered data aggregator sends the data to the ISR, who compares the data to aggregated

executed schedules and then carries the imbalance settlement itself. (further elaborated in settlement-guide, ref Settlement guide)

Open contracts define price and optionally time, quantity is not defined.
Open contracts regulate the trade of the energy that is not covered by the closed contracts. The energy covered by the open contract is the difference between the total metered energy consumed (or supplied) and the energy actually consumed (or supplied) covered by closed contracts.
In open contracts there is no concept of process control involved; this is completely assigned to closed contracts. The open contracts are between consumer and balance supplier.
As opposed to the closed contracts, open contracts could be considered as an approximation of continuous trading in real time; for proper continuous trading, the pricing method would have to be based on actual situation which occurs in the system at the time of delivery of energy.
If the pricing method is not based on actual situation but is rather predefined based on fixed model, these contracts can hardly be classified as trading contracts because delivery and acceptance of the energy is unconditional within and the closing of the contract is not the result of market action (negotiation, auctioning) or its emulation. Majority of present contracts are of this class.

5.1.3.2 Definitions introduced by Miracle methodology

Miracle methodology introduces some new categories and concepts, which are not part of the existing processes within Harmonized electricity market. To avoid loose interpretations and facilitate understanding, the following concrete terminology has been adopted and used:

Acceptance before period is the time interval between “Acceptance Time” and “Operation Start Time”

Acceptance before time is the absolute time until which the flex offer must be accepted or refused.

Activation period is the time interval between the end of No Request period and the beginning of Traded period for any instance of trading process. The shortest possible Activation period is zero, i.e. the No flex-offer period and the Trade period are adjacent.

Assigned flex-offer is a flex-offer with fixed flexibilities.

Assignment before period is the interval between Assignment before Time and Start Operation Time.
If the assignment-before period is defined as a parameter in a flex-offer then the "Assignment before time" cannot be calculated before matching. One can only estimate its position between "Min Assignment Before Time" and "Max Assignment Before Time".
After the matching process this quantity is used to calculate the Assignment before time, because the "Operation start time" is known then ("Assignment before time" + "Assignment before period" = "Operation start time").
Figure 32 shows the relation between input parameters, known values (as black) and calculated quantities (as grey) at the reception of the flex offer reception and at the flex offer matching. The actual assignment (defined as "assigned time") must be earlier than "Assignment before time".

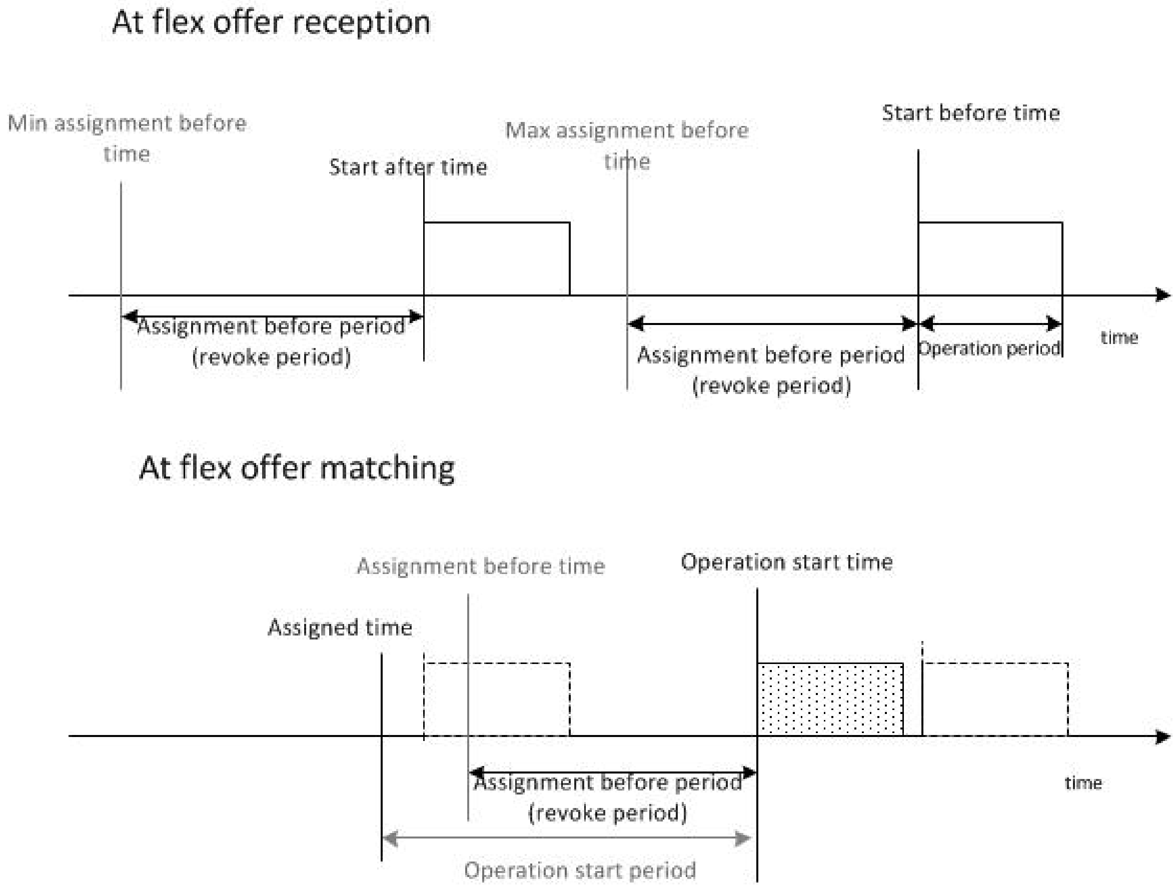

Figure 32: Assignment before period

Assignment before time is the absolute time until which the flexibilities must be fixed.
If the assignment-before time is defined as a parameter in a flex-offer then the "Assignment before period" cannot be calculated before matching.
Figure 33 shows the relation between input parameters, known values (as black) and calculated quantities (as grey) at flex offer reception and flex offer matching. The actual assignment (defined as "assigned time") must be earlier than "Assignment before time".

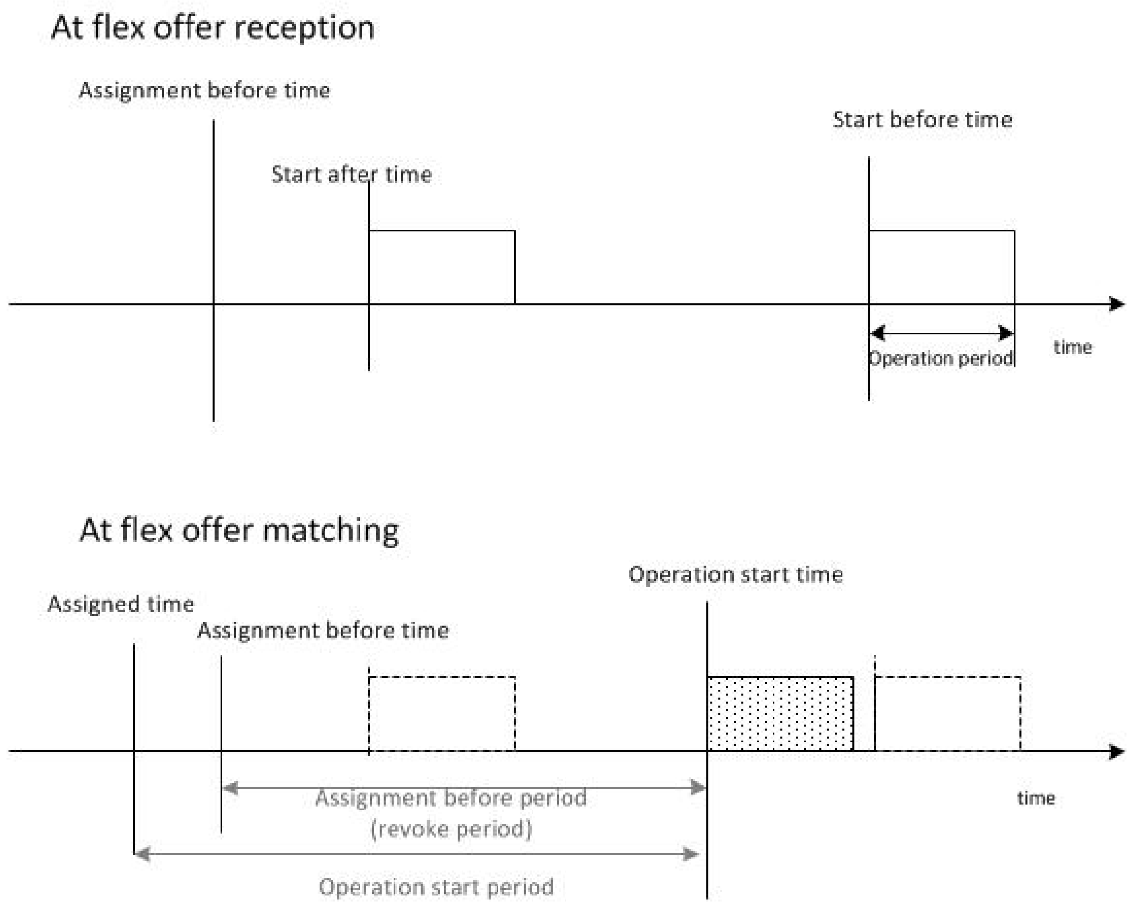

Figure 33: Assignment before time

Assigned Time is the absolute time at which the Flex- offer has been actually assigned, i.e. its flexibilities actually fixed.
Constraint: Assigned Time < Assignment time

Communication period is the time interval following the flex-offer processing interval, during which the communication with the senders of the flex-offers takes place the information exchange with SO for approving the schedules is performed.

Energy data management system (EDMS) is organized in a multi-level hierarchy of Nodes of the Energy data management system (NEDMS).

Flexible Energy products as defined by the Miracle roles and process model can be used in bilateral trading between two BRP's and could be traded in future at MO's auctioning process. The parameters that define these products are the parameters defining the flex offer (cf. WP2). If the parameters defining the flexibilities in the flex offer are fixed, the flexible energy products can be transformed to fixed energy products.

Fixed energy products are traded in existing auctioning processes at MO's according to Harmonized Electrical energy market model. The parameters that define these products are: predefined power profile over a fixed time interval and associated price.

Flex-Contract Assignment of the flex-offer produces the flex-contract. It contains a traded energy with fixed amount, price and time history.

Flex-offer is issued by the sender (prosumer or BRP), which has defined flexibilities in time and energy for a given price. It is further defined in deliverable D2.2 and D2.3.

Flex offer processing period is the time interval used for flex offer processing, i.e. for carrying out the processes of aggregation, scheduling and matching, and disaggregation. It lasts from the Request Collection deadline till the beginning of the Communication period.

Interval unit is the unit time interval for which the contracting, i.e. fixing the flexibilities during the matching of the consumption and the production flex-offers, is performed at auctioning process occurring at some time before the time of the interval unit. It is the duration of the Traded Period. The interval unit is defined by BRP (in BG) or MO (in MBA).

A **Node of the energy data management system (NEDMS)** is a autonomous subsystem of the Energy data management systems (EDMS). Each role/actor of the energy market has at least one node. A node provides the functionalities for forecasting, aggregation, scheduling, data persistence, and communication. For each functionality there is one component. The control component orchestrates the other components and tailors the node for a type of actor/role.

Matching period is the time period for which matching production/consumption is performed. The matching period consists of one or several Traded periods. It starts at the end of the last “no request period” (cf also flex-offer activation interval), and ends with the last Traded period, which contains the latest flex-offer Operation end time. .

No request period is the time interval from the flex-offer collection deadline until the start of the matching period or another No request interval before the matching period. During the No request interval, the applicable flex-offers are processed (cf. Flexoffer processing interval) and resulting information communicated to the senders of the offers and to SO (cf. Communication interval). During No request interval the offers received cannot be matched for the “traded interval 1”.
For example at the “day-ahead market” the “no request interval” lasts from the noon of the present day till the 24:00. This time is reserved for the contracting and balancing and it is not allowed to accept any offer for the day-ahead period (but it might be allowed to accept the offer for the period after the day-ahead period).

Operation period is the time interval between the start of the energy delivery according to the schedule in the flex offer till end of the energy delivery according to the schedule.

Operation start period is the time interval between Assigned time" and Operation Start time.

Operation start time is the absolute time moment at which starting the consumption (production) of the energy – it is known after matching.

Start after time is the earliest operation start time.

Start before time is the latest operation start time

Operation end time is the absolute time at which ends the consumption(production) of the energy – it is known after matching.

Period-ahead interval is the defined time interval in present organized trading for which a concrete trading process is being carried out. All trading processes are carried out for period-ahead intervals; e.g. in day-ahead trading, and with flex-offer collection deadline set ot 12:00, the period-ahead interval is next day from 00:00 - 24:00; in intra-day trading, the period-ahead interval could be any 1-hour interval "ahead", in each case respecting the defined flex-offer collection deadline for that interval.
In Miracle flex technology, *Period-ahead interval* corresponds to *Matching period*.

Request collection deadline is the moment until when the flex-offers are collected and may be fixed in the Trade period; for conventional organized trading at a "day ahead market" the offers are collected till noon of the present day (flex-offer collection deadline) for the period from 0:00 till 24:00 of the next day (period ahead interval)

Revoke period is the time interval between the Assignment Time and the operation start time; synonym for Assignment before period.

Assignment before period/revoke period is a parameter for the flexibility management at BRP.

Traded period is the time interval for which the organized trading process, i.e. auctioning, is performed. In present organized trading, this is equivalent to Period-ahead interval. The relation of Traded period and the Operation period is the following: Operation period belongs to the Traded period if its Start operation time falls within the Traded period.

5.1.3.3 Requirements to time relations

The following constraints to basic time relations between parameters are necessary to establish consistency of the Miracle process modeling with the actual processes in the Electricity market:

- Acceptance before time <= Assignment before time
- Assignment before time < Operation Start time
- Assigned Time < Assignment time
- the start of traded (fixed offer) period > the end of last »No request period«

Additional time relations will be ascertained when the actual specifications of unit processes are defined, in WP2, WP3, WP4 and WP5.

5.1.4 Use of Miracle technology in trading processes in Electricity Market

5.1.4.1 Use of Miracle technology in BG trading process

The balance group is the basic domain where the Miracle functionalities are applied. It consists of the basic roles like producers and consumers which are controlled by the BRP. The main purpose of the balance group is to equalize the inflows and outflows of the electrical energy at its endpoints (producers, consumers and connections to the external network). The Miracle functionalities may be much at help fulfilling the BG goal.
The BRP as a BG responsible must be capable to predict the energy flows for the specific time ahead. The energy flow schedule is sent to and controlled by the responsible party

on the level of the transmission system (market operator). During the energy delivery it is important that BRP sticks its energy flows with the plan otherwise it is affected by the imbalance penalties.

The Miracle technology helps the BRP to sustain the initial prediction with the

- Forecasting of the consumption – using the historical metered data from the smart meters installed at consumers. The precise consumption forecast helps BRP to improve the energy schedule.
- Forecasting of the production of the RES. The RES production forecast which includes also weather forecasts makes the production more predictable
- Demand side management – the pool of consumers which are willing to adapt their consumption helps the BRP to control unpredictable events and sustain with the initial energy flow forecast.

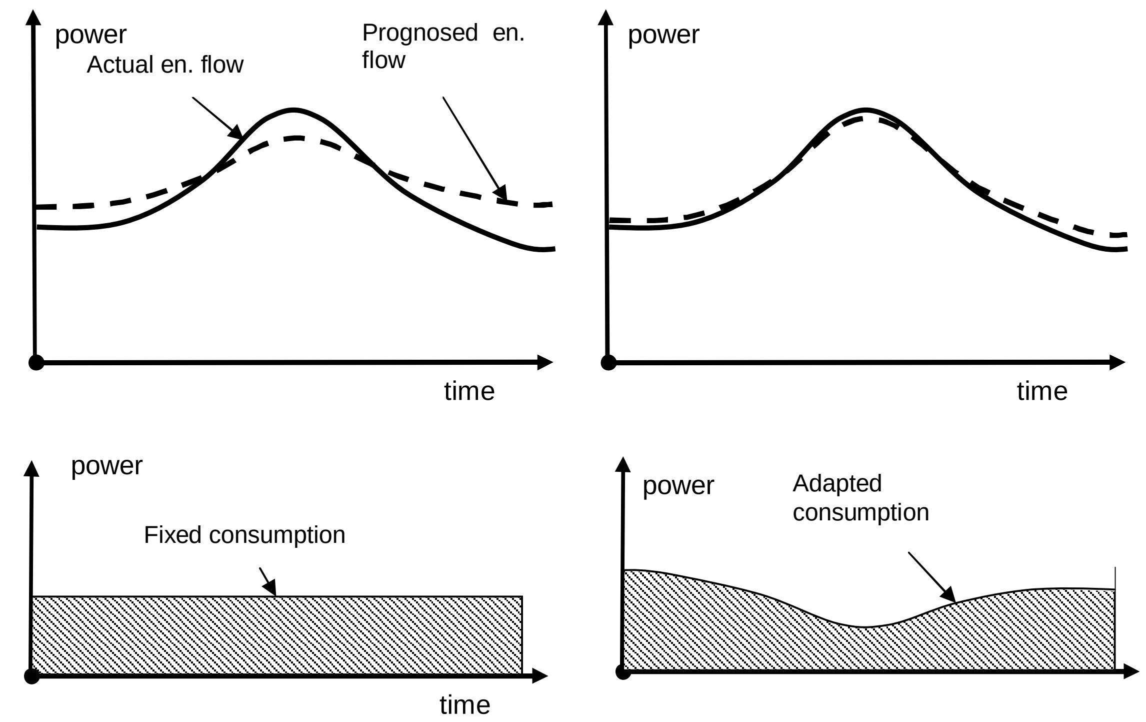

Figure 34: Handling the imbalances by BRP

The Figure 34 shows the sample when the BRP deviates from the initial schedule (left) and how the imbalances are reduced by activating the demand response (right) by affecting the consumption distribution.

The combination of all Miracle functionalities gives the Balance responsible party a strong tool which

- Efficiently reduces the imbalances
- Is capable to control imbalances automatically
- Exploits the RES with higher efficiency

5.1.4.2 Use of Miracle technology in trading on organized market

5.1.4.2.1 Basic premises of use of Miracle technology in the organized market

In the present state of EEM harmonization, of the two primary subsystems analyzed, the organized market trading takes place mostly in the MBA, while the trading in BG

subsystems is largely undefined and not standardized as yet. The following analysis therefore concerns mostly MBA, but is relevant for the BG to the extent in which the unit primary processes in it will be carried out in a similar way as in the MBA.
The basic premises of use of Miracle technology in the organized market are as follows:

1. Energy trading is in closed (firm) contracts.
2. Flex-contracts are closed contracts: Flexibilities are part of the flex offer (or bid) but are fixed at the time of the contact
   This implies several requirements or constraints on the use of the Miracle technology:
   - that the flexibilities are not carried through from the offer into the contract; if that were done, we would not have a closed contract but an open one. The closed contracts are obligatory on the level of the Market operator, because they are the basis for the generation of the operating schedules, requested and confirmed by the System operator
   - that the sequence in the trading process goes through the following conceptual phases:
     - flex offer,
     - aggregation,
       - scheduling, evaluation and negotiation of conditions (or auctioning), in the process of matching with the opposite side,
       - (acceptance) (if necessary as a separate phase),
       - Disaggregation
       - flex-contract
   - The specific way of carrying this sequence out depends on the concrete processes to be defined in further developmental work – in BG it will be different than in MBA.
3. Flexibilities in the flex-offer are defined in terms of time, price and energy of the offered/demanded energy. They cannot be separated and traded separately from the “firm part” of the flex offer; the firm part of the offer meaning the lower bound of the offer, with flexibilities “removed”:
   - It would mean a new type of flex-offer (bid) for the MBA level, which is unacceptable from the viewpoint of the scalability requirement of Miracle.
   - Even if this constraint were removed, separate trading could be done only for flexibility in energy; it would physically not be possible to trade the flexibility in time separately from the “firm part”, as there is no associated flexible part of energy, just displacement of the same energy in time.
4. We decided that within Miracle, we shall not attempt to re-model the processes in the MBA system in a way that would require changes in the joint and supportive processes of the EEM as defined by the Harmonized model, but rather attempt to i) provide solution for further extension of the MBA trading processes into the flex-offer domain, at the same time ii) make provisions to enable application of the Miracle technology to the processes as defined within the existing Harmonized model.
   There are two basic reasons for this decision.
   - the existing MBA processes are also part of the Harmonized model, which means that they are going to stay for some time and that we would – contrary to our “strategic” decision – go outside the Harmonized model
   - With consistent adherence to the principle of scalability based on vertically nested fractal-like subsystems, the functionality of the Miracle project will not be constrained.

Using the flex-offer within existing auctioning process in MBA implies that we have to design the flex-offer specifications in such a way that it can be used also as fixed offer (bid).

- This will be done by fixing all the flexibilities in the flex offer before sending it to the “classical” MO for traditional auctioning process.
- All the infrastructure for flexibility in the flex-offer is in this case fixed – inactive/latent.
- This strategy allows spreading the use of Miracle system in the existing auctioning processes and later – when threshold Miracle market penetration is achieved - modify the processes to flex-offer technology.

5. Use of flex-offer in its full functionality requires that the flex-offer sent by a BRP is auctioned. This requires a changed auctioning process, which involves aggregation of flex-offers and “two-side pool” scheduling and pricing; a process similar to the process in the BG, where “one-side pool” scheduling and pricing will take place.

5.1.4.2.2 The concept of flexibility management - how does a BRP use the flex-offer technology to its advantage in organized trading processes, such as in MBA system?

The advantage is derived from business strategy of BRP, for whom the flexibilities in flex offers are an additional instrument for trading:

- First, it is important to note again that once the contract is signed, the flexibilities in a flex offer are fixed.
- The important parameter is the flex-offer assignment before period (revoke period).
    - o If this period is short, the flex-offer can be kept open close to operation start time.
    - o Flex-offers with short revoke period are in principle kept for intra-day trading close to the operation interval.
- In real situations on the market, on which the Miracle technology is only partially deployed, BRP has its portfolio of offers filled with
    - o Fixed offers
    - o Flex-offers with revoke periods from very short (one hour) to very long (maybe more than a day or a week)
- When trading far before the operation start time (e.g. in day ahead or further ahead market), first firm offers and then flex-offers with long revoke periods are traded.
- Flex-offers with short revoke periods are kept for trading closer to operation start time, such as in the present intra-day trading. The advantage of flex offers is that they enable compensation of imbalances. Since with Miracle, the status will be calculated periodically in short time intervals (Flex-offer processing period, cf Section 5.1.3.2) minimizing the time difference to the operation interval (No request period, cf. Definitions in Section 5.1.3.2) as much as possible, e.g. 1 hour, BRP can come with its latest forecast close to the operation start time as much as possible (e.g. 1 hour) – providing the system imposed constraints as expressed allow it - and compensate the imbalances to a very high degree. A similar strategy is used for including more RES on the grid.
- The flex-offers have to be accepted sufficiently before the matching period, i.e. until flex-offer collection deadline, to enable flex-offer processing; and schedule checking and confirmation.

An additional parameter in flex-offer management is therefore the time difference Acceptance before period (c.f. Section 5.1.3.2), which has to be larger than the Flex-offer Operation start period, or in its minimum length one No request period. Additionally, the minimum Revoke period has to be larger than the Communication period.

Thus the No request period and the Communication period can seriously limit the effect of Miracle functionality in actual state of organized market trading and electricity market operation; concentrated action of all stakeholders will be necessary to improve the processes involved and reduce these time periods to times made possible by the use of state-of-the-art information and communication methods and systems.

5.1.4.2.3 Parameters of flex data structure for flexibilities management

Flex-offer revoke period and flex-offer acceptance before period are two important parameters for BRP's decision making process in flexibilities management and have to be provisioned for in the flex-offer data structure and flex-contract messages. Both are defined in Section 5.1.3.2.

5.1.4.3 Basic Description of organized trading process

1. For a given time interval in time for which the energy will be traded – *traded period* (in present organized trading *period-ahead interval*), our BRP has a portfolio of flex-offers with flexibilities in time and energy, and with various offer revoke times.
   1.1 At a certain point in time before *the operation start time* within the *traded period)*, flex-offers with similar revoke periods are used for trading. These offers represent the set of flex-offers that will be (aggregated and) scheduled in the auctioning process; when scheduled, the flexibilities will be fixed and the contract closed, i.e. the message communicated to the flex-offer sender.
   A normal auctioning process involves many BRPs with their offers, so the aggregation and scheduling will be performed on all these flex-offers.
   The process of aggregation and scheduling on the side of our BRP will be similar to this process in BG.
   However, the auctioning will be double-sided, and similar process of aggregation and scheduling will be performed on the opposite side of the »auctioning line«, i.e. both sets of flex-offers will be matched. This is different from BG case, where the opposite side is a BRP with »preferred demand energy-price curve« - a kind of one-sided auctioning (current Miracle term: »price setting with scheduling«).
   In this process in organized market such as in MBA, the aggregation and scheduling at the auctioning line is – has to be performed by the MO. This is the trading process.
   Additionally to this »main« aggregation and scheduling, a BRP may – if it has a large set of flex-offers – do internally its own aggregation and scheduling as a kind of »preferred supply curve«, the result of which it sends to the MO as one or several aggregated flex-offers;
   1.2 At another point in time preceding the operation start time within the traded period, but closer to it than the point in time in paragraph 1.1 above, the whole trading process is repeated for the same traded period; at this point, the flex offers with correspondingly shorter revoke times will be used.

These two trading events (in paragraph 1.1 and in paragraph 1.2) for the same traded period can be thought of as day ahead (the first one) and intra-day (second one). Of course, several more successive trading events can be performed, each time moving closer to the defined operation period – i.e. towards the operation start time.

2. For another traded period, following the time interval in section 1 above, the same trading processes are performed, with the same /similar series of auctioning.

   The BRP strategy in using flexibilities can be further explained with the help of **Figure 35**.

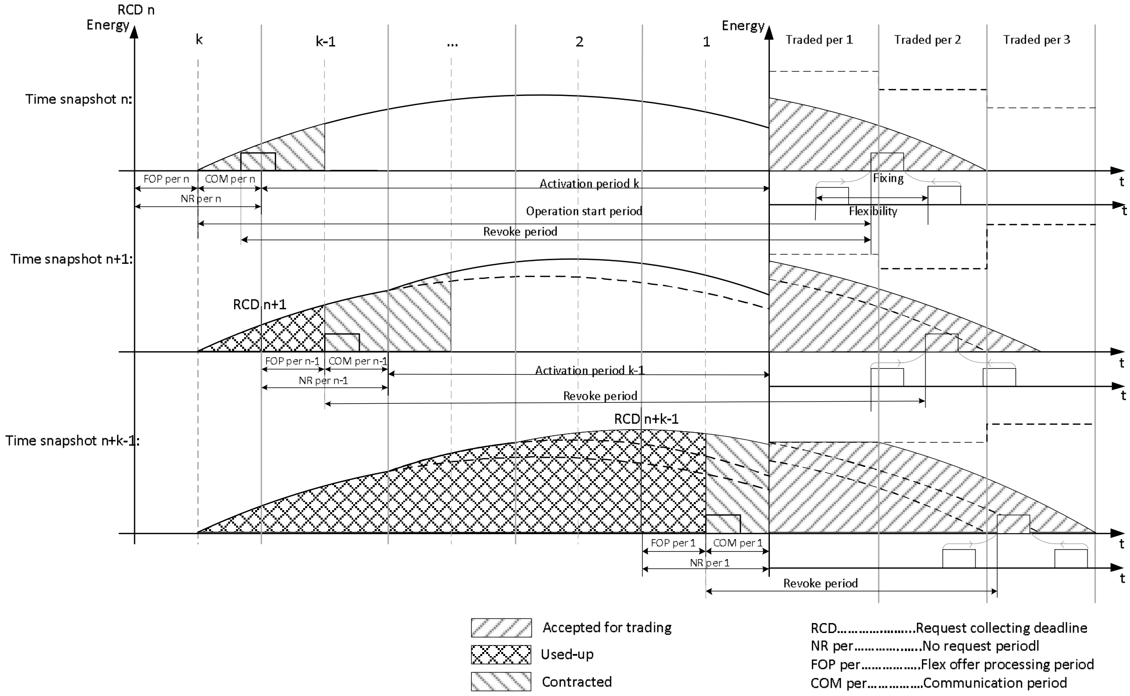

Figure 35: Contracting the flex-offers

For each operation period (cf. definition in Section 5.1.3.2), the applicable flex-offers are arranged according to their revoke periods. Only the flex-offers with revoke periods longer than the "available time" are matched and contracted (cf. definition in Section 5.1.3.2), i.e. their flexibilities fixed (on the schematic, "used-up" area) . The "available time" is the *activation period* (cf. definition in 5.1.3.2). The other flex-offers for this operation period with shorter revoke periods are left for the next instance of matching and contracting – one(1) *No request interval* closer to the operation period.

The schematic shows the basic logistics of trading process with the flexibilities management:

- the three horizontal axes represent three different snapshots in the trading process, each one closer in time to the time of operation, for which the trading process is being performed
- on each horizontal axis, the part of the figure on the left-hand side of the ordinate "Energy" depicts the timeline of events which make part of the trading processes: from accepting the flex-offers to assignment ("flex-offer processing period") and communication of results to stakeholders (prosumers, SO)(communication period); the part on the right-hand side shows the time period(s) for which the trading is being performed ("Traded period(s)").
- On each axis, two viewpoints are shown: the viewpoint of the aggregated processes of flex-offer processing and scheduling, and the viewpoint of individual flex-offer events within these aggregated processes. While these

two viewpoints cannot be drawn on the same timeline precisely, this mixed viewpoint sketch has been decided upon to point out the difference between different categories and thereby to ease the understanding of the relations between them.

Trading (in the schematic termed “flex-offer processing”) is done periodically at various times approaching the Traded period; in principle, the period depends on the length of the "No request period". Each time, all the flex-offers in the BRP's portfolio are processed but only those with revoke period exceeding the threshold assignment before times are considered for assignment:

- Time snapshot n: At point in time k, only flex-offers with revoke periods longer than k-1, i.e. those extending to the left of the k-1 line, are processed (i.e. assigned and contracted); these flex-offers are “used up” - taken out of portfolio. For additional instances of flex-offer processing, activation period k is available.
- Time snapshot n+1: At the next flex-offer processing instance, k-1, only flex-offers with shorter revoke periods than k-1 are left and out of these, only those with revoke periods above threshold assignment before time, to the left of k-2 line, are assigned. For additional instances of flex-offer processing, activation period k-1 is available.
- Time snapshot n+k-1: this the closest flex-offer processing instance to the Traded period, and the flex-offers with shortest revoke periods are used. The activation period here is equal to zero.

Several quantities defined in Section 5.1.3.2 are depicted on the figure and their relations defined (cf also respective definitions): the assignment before period (revoke period), operation start period, operation period etc. It therefore sets the basis for proper understanding of the sequence and logistics of the unit processes involved in flex-offer trading, necessary both for developing functional modules of aggregation and scheduling and for proper integration of individual modules into Miracle management system.
It is important to point out again that the trading processes depicted in Figure 35 refer only to one particular Traded period. For other Traded periods, similar trading processes can be carried out concurrently. In fixed energy products trading, these trading instances are independent; in flexible energy products trading, these processes will become a continued train of trading for adjacent Traded periods.

3. In these trading processes, flex-offers are used on demand and on supply side of the auctioning line. Presently, it is reasonable to assume that on the supply (production) side there will be less flexibilities available, and that the portfolio of supply offers of a BRP will have a number of fixed energy product offers (if BRP does not use Miracle) or flex energy product offers transformed into fixed energy products (if BRP uses Miracle). However, with evolution of prosumer class, small CHP units in households will bring flexibility also to dispersed supply side, unless the production will be used to manage the part of consumption based on energy from the grid.

5.2 Balance Group system, processes and roles

The processes where the Miracle system is involved are described with use cases common on the electrical energy market.

The use cases were chosen to isolate the influence of the particular Miracle elements on trading processes therefore the background system where the use cases are processed, is expanding.- from the first with limited system elements to the last with all real elements with of the electric energy trading system.

- The first use case "internal energy sale process" introduces The Miracle main feature – flex-offer in abstract system where only BG is involved as domain.
- The second use case introduces limit number of real elements like open contracts, imbalances, etc, but no external trading is foreseen in the system

The third use case "external trading" involves the Miracle features in the complete "real" system with external trading.

5.2.1 Internal energy sale process

This use case about the internal energy sale process is strictly limited to the transactions and processes, which are consequences of the flex offers. Its intention is to describe the mechanism of handling the prosumers flex offers and resulting closed contracts.

5.2.1.1 System description

In the system there is only one isolated balance group with:

- "n" producers (classical and/or RES and DER),
- "m" consumers,
- 1 Balance responsible party.
- The network and network operator are responsibility of the balance responsible party (BRP), but actually they are not important in this case.

It is assumed that there are no imbalances. The prosumers strictly provide production and consumption according to the contracts (schedules). Since all the energy is sold on closed contracts no metering is needed. Therefore there is no need to involve the network relevant party as a role (for example grid operator, …).
No external trading is provided - all the necessary energy which is produced internally is consumed by the consumers in BG.

5.2.1.2 Process description

The producer and consumer offer their production capacities and consumption needs in the form of a flex-offer.
The Balance Responsible Party (BRP) is collecting the flex-offers from the prosumers till the "request collection deadline" (see definitions). The flex-offers contain the power time history for the "matching period" (see Figure 36). For example in the case of the "hour ahead", the BRP collects till 1.00 pm the flex-offers with latest possible execution - "start before time" later than 2.00 pm. Therefore, there is always a time gap between the completion of the flex-offer collection and actual consumption of the electricity.
The "interval ahead" may be continuous or discrete (that depends on implementation in the following WPs). For example in the discrete option, the offer arriving at 1.05 pm cannot be activated earlier than 3.00 pm, while in the continuous option it cannot be activated earlier than 2.05 pm (see Figure 36).

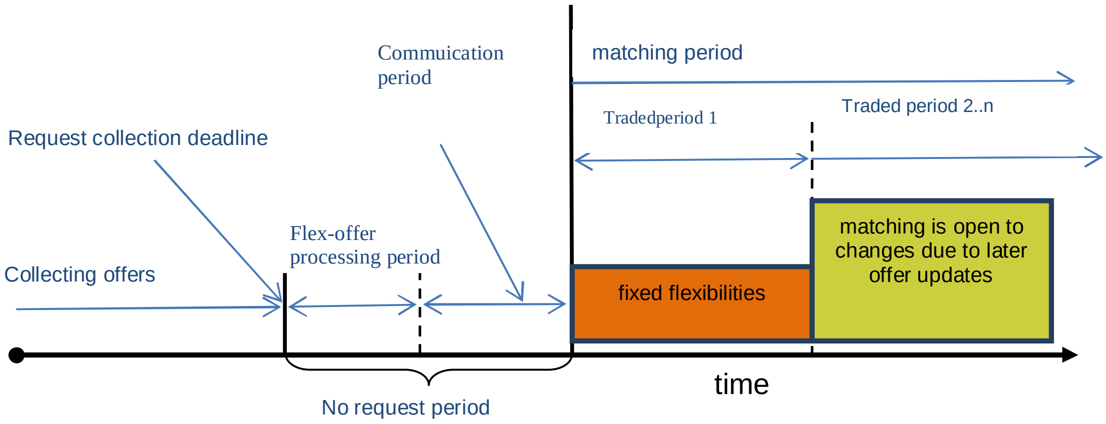

Figure 36: Processes of the BRP

The BRP is collecting the flex-offers from producers and consumers concurrently. Having completed the collection, the BRP provides the matching between production and consumption. The "matching" means trying to cover the consumption with the production. The matching process involves the scheduling of the production and consumption flex offers, negotiation and price setting. Due to the flexibilities these processes are closely connected and depend on the matching criteria. The matching criteria may be

- Maximal profit of BRP
- Minimal price achieved
- Maximal involvement of RES
- Combination of the criteria above
- Etc.

The matching is provided for the time interval started at "interval ahead" start time (traded period). For example the flex-offer processing which started after 1.00 p.m., provides matching for the interval from 2.00 pm on.

The matched production – consumption is fixed for the very beginning of the "matching period" – Traded Period 1. For example the matched production and consumption for the interval from 2.00 pm till 3.00 pm is fixed and cannot be changed. The matching after the "interval ahead" time is not fixed yet and may be changed due to the new flex offers or their updates. To provide the system efficient and flexible then the duration of the interval with fixed offer must tend to be short

Once the flex-offer is matched, the initiator may be informed that its energy shall be delivered. This message is optional and depends on the initiator's requirement and infrastructure possibilities.

Once the matching is fixed, the initiators of the flex-offers might be informed about the execution plan. This message is optional and depends on the initiator's requirement and infrastructure possibilities.

The fixed matched production/consumption is contracted. On the bases of the contracts the disaggregation is provided separately for the producers and the consumers and final schedules are sent for the execution.

The scheduling information contains the energy time schedule for the production/consumption.

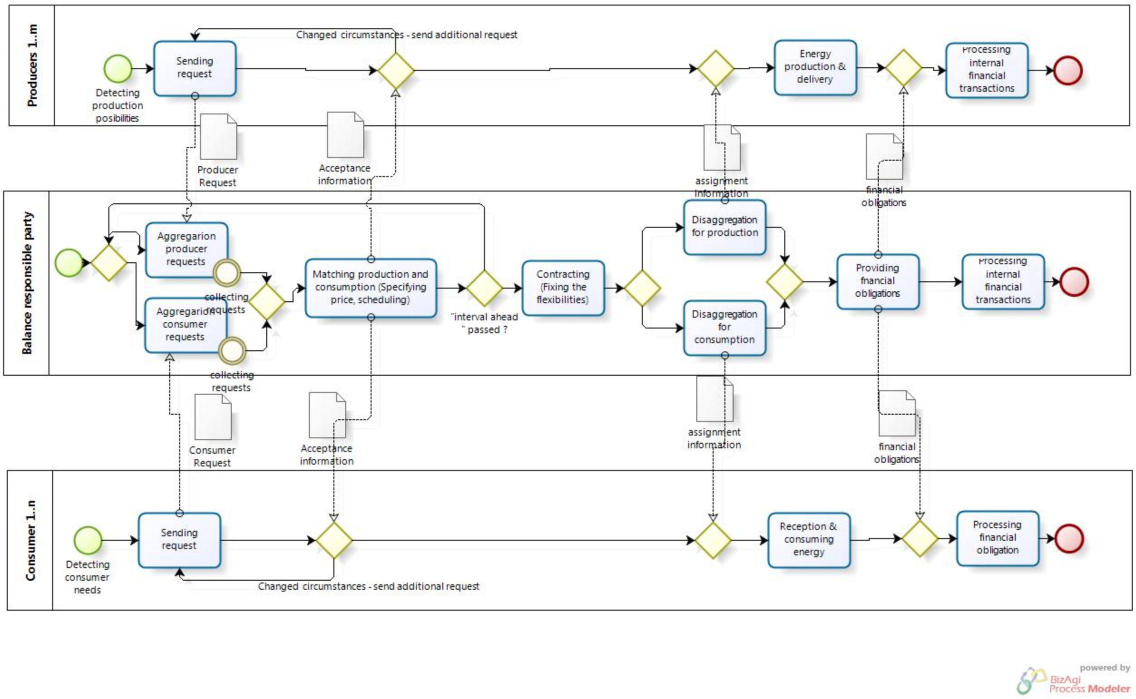

Figure 37: BPMN presentation of the use case balance group 1 process

The BPMN presentation in the Figure 66 shows the processes and messages exchanged between the roles involved in the use case.

The time interval in sample described above is one hour but the actual implementation should use the interval, which depends on

- Time characteristic of the flex offers
- External processes (external trading is described in balance group use case 3)
- External parameters (see subsection bellow).

In general the basic process interval should be maximal duration which still guaranties the maximal efficiency. For example if process interval 5 minutes makes the same efficiency as 15 minutes then the later one should be used.

Prosumer parameters

The process described above depends on the time constants defined by BRP. But on the other hand the prosumer may also have demands about the time progress of the matching and contracting process. For example the prosumer may define

- when the flex offer must be matched the latest
- when the flexibilities must be fixed and the prosumer must receive the energy flow schedule the latest

Figure 39 shows a snapshot of the matched energy from production/consumption flex offers during the matching process. After each matching iteration, the BRP has a certain population of flex-offers in the matched energy. Figure 39 shows the distribution of the matched energy dependent on the proposed operation start time with the gray bars. The matched energy distribution is recalculated periodically with the period, which is internal BRP parameter. For flex-offers with an “operation start period” which is smaller than the “assignment before period”, the flexibilities must be fixed and this energy cannot be redistributed during further matching iterations (see Figure 38). The fixed offers are presented with the hashed bars.

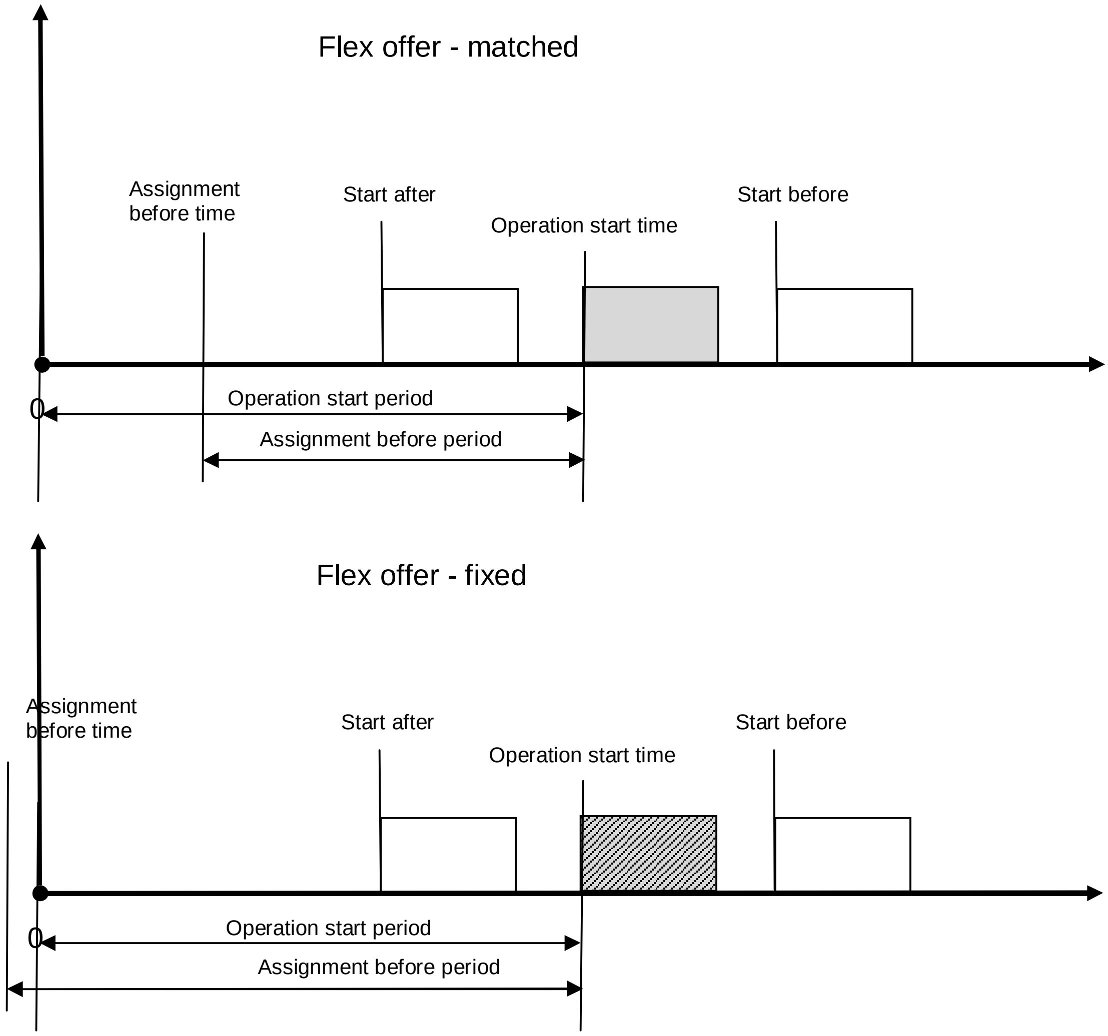

Figure 38: Matching and fixing the flexibility

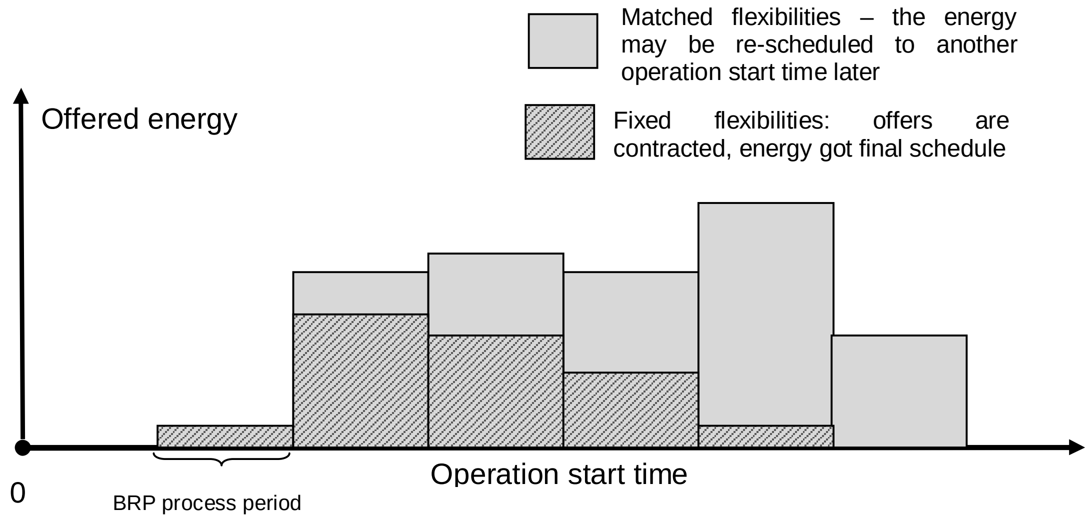

Figure 39: Snapshot of the BRP matched offers

It is recommended that the prosumer parameters are synchronized with the BRP process parameters ("traded period", "no request period").

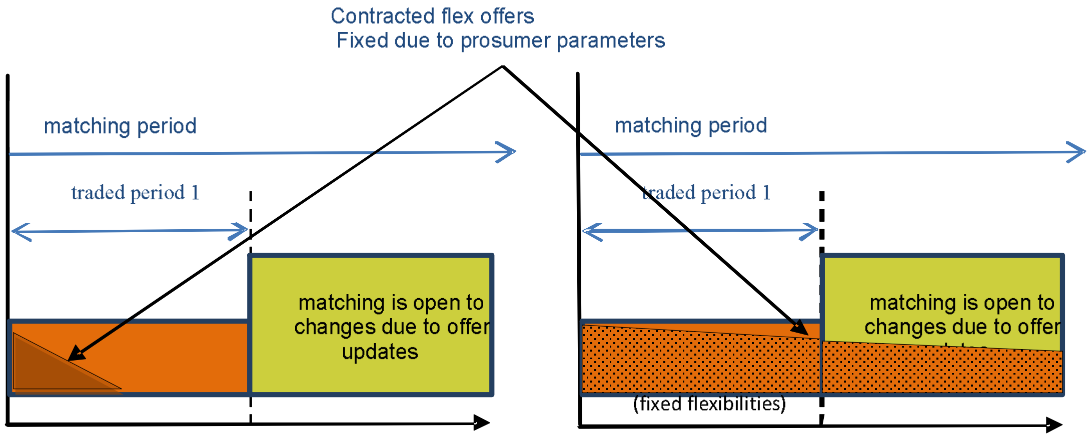

Figure 40: Comparing the flex offer parameter with the BRP process parameters

In the case the average revoke interval is shorter than the No request period (Figure 40 left), the flexibilities are lost because the BRP internal process needs to contract the offers much before it is required by the prosumers.
In the opposite situation, when an average revoke time is longer than the BRP fixed offer interval (Figure 40 right), the processing capacities of the BRP are spent effectively to a lesser degree, because prosumers parameters force the BRP to fix the flexibilities several fixed offer intervals ahead and small adaptations can be provided from one to another iteration.

Flex-Offer Rejection

The decision about the acceptance or the rejection of the flex-offer is provided during the matching process. If the production flex-offer does not get covered by the consumption flex-offer (or vice versa) during the matching process, it is rejected.
On the other hand, if the production flex-offer finds its match in consumption (or vice versa), then it may be accepted. The accepted flex-offer can still change its time and energy allocation according to the flexibility parameters. The contract (and assignment) is provided when the allocated energy of the flex-offer falls into the Traded period 1 and the flexibilities become fixed.
It may happen that the accepted flex-offers fall out of matching during the forecasting and flex-offer updates. For example, the flex-offer is accepted due to the good weather forecast, which has changed later and no energy is foreseen from RES. The substitution with the alternative resources may not be possible for example due to the price constraint of the consumption flex-offer (i.e. alternative energy sources are more expensive). This problem should be resolved by the contract between BRP and prosumer. It may be covered by some internal (financial) resources of the BRP or handled in some other way.
The rejection means that it is either turned to the open contract consumption or the energy is not delivered at all.
The rejection results when there is a lack of consumption (production flex-offer is rejected) or the lack of production (consumption flex-offer is refused, but this should not happen in reality). The rejection might also result when there is enough production or consumption but the price constraints in the flex-offer do not allow the contracting.

5.2.1.3 Messages

Domain model Phase	Message/ document	From/by whom	To/by whom
Plan	Producer flex-offer	Producer	BRP (Balance responsible party)
Plan	Consumer flex-offer	Consumer	BRP (Balance responsible party)
Plan	Production schedule	BRP	Producer
Plan	Consumption schedule	BRP	Consumer
Plan	Assignment information	BRP	Prosumer
Plan	Delivery information	BRP	Prosumer
Operate	Energy Delivery	Producer	Consumer
Billing	Producer financial obligation	BRP	Producer
Billing	Consumer financial obligation	BRP	Consumer

Table 11: List of messages at internal energy sale process

Producer/consumer flex-offer
The production and the consumption shall be described with the same data structure – flex-offer. The BRP needs the following information the flex-offer to provide matching:

- Amount of Energy with its variation and variation constraints
- Energy flow time history with its variation and variation constraints
- Price with its variation and constraints

To cover various production and consumption devices a flex-offer needs to contain several types of flexibilities.

Consumption flex-offer samples
One sample is the load with the fixed energy flow consumption (i.e. dish washer). The user will set for example only the operation end time. The node of the MIRACLE Energy data management system will then send the flex-offer with manufacturer settings and user constraints to the BRP. The consumer flex-offer will contain the information about the energy amount (which is fixed), prescribed consumption time history (constant energy flow) and the variation of the consumption starting time (defined by the user and part of a flex-offer parameter, see Figure 41). The user will probably not set the price, because it wants the load to do the job in any case. It is up to the BRP business model to give the consumer some discount on the regular price in exchange for flexibility.

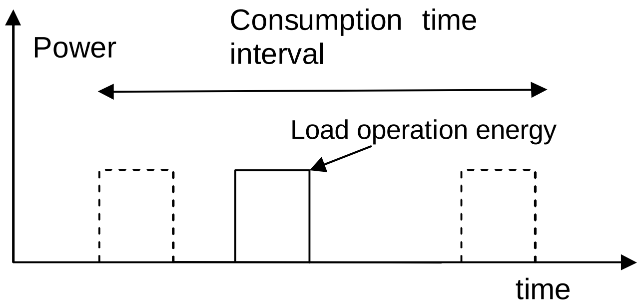

Figure 41: The consumer flex offer with the usage time interval variation

Another sample is the load with the fixed energy amount but variable consumption flow (i.e. electric vehicle). The load controller is installed in the plug in device shell detect the status of the battery and according to the user input, when the vehicle must be "full", send the flex offer with the corresponding filling constraints. There must be some communication between plugin device and vehicle to exchange the filling constraints or there must be standardization on the vehicle batteries to achieve the common filling characteristics for Miracle application. The Figure 42 shows the constraints of the filling power for the electric vehicle.

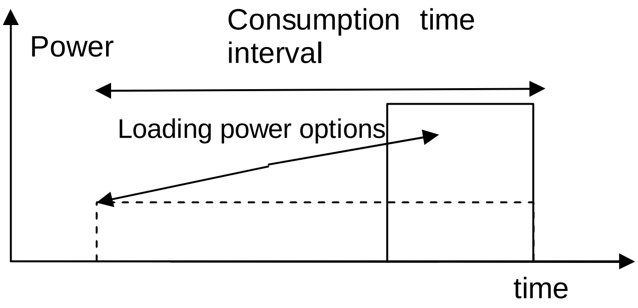

Figure 42: The consumer flex offer with the energy flow variation

It would be possible for the consumer to put constraints about the price in the flex offer. He may set the preferable moment when the load should be started by setting the maximum price for that moment, while for the rest of the interval its flex-offer price is lower.

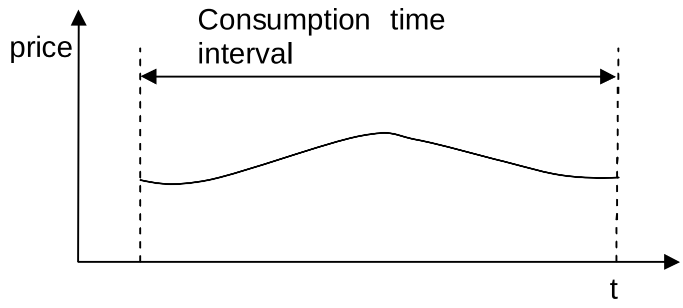

Figure 43: The consumer flex-offer constraint between time of usage and price

Production flex offer sample

Compared to the consumer the producer flex offer shall probably not contain the time variation parameter because it is offering its capacities rather than its needs.

The classical production units have known their production characteristics in advance. Therefore their flex offers shall contain the information about the time history of the maximal production and constraints about partial or minimal production.

At the RES the flex offer content depend on the weather forecast. The irregularity of the energy produced is expected to be much higher than at the classical production units. Beside that also an uncertainty about the amount of produced electricity is expected. The closer the production time is the more accurate is the forecast and the parameters in the flex offers. It is a subject of the further investigation whether it is feasible to put the production uncertainty into the flex offer.

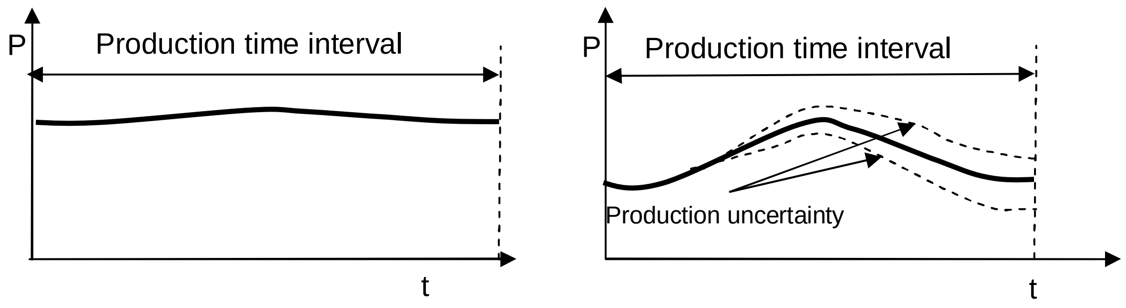

Figure 44: The offer of the classical production unit and from RES

The production flex offer shall contain also the price parameter which shall be set according to the production cost.

Assignment information

This message is optional and is sent if it is required by the prosumer and if the informational infrastructure is set (the prosumer holds the proper device for messaging). Its purpose is informing the user.
The message is sent when BRP finds the resources for covering the prosumer flex offer during the matching.
The flex offer may hold the information, till when the assignment information must be sent. If the matching at BRP does not provide the resources to cover the flex offer in time (due to the assignment moment parameter in the flex offer or by over lasting the time flexibilities), the BRP sends “No assignment information” and eliminates the flex-offer from its resources.

Delivery information

This message is optional and is sent if it is required by the prosumer and if the informational infrastructure is set (the prosumer holds the proper device for messaging). Its purpose is informing the user.
The message is sent when BRP fixes the parameters of the flex offer. The message contains energy flow time history profile and price for the production or consumption.
The flex offer may hold the information, till when the delivery information must be sent.

Production/Consumption schedule

The production/consumption schedule is a required message from BRP to the production/consumption device. The schedule is formed as a result of disaggregation after the matching provided after the “flex offer collection deadline” for the “interval ahead period”. For example at “hour ahead market” the flex offer collection deadline is at 12:00 am for the time interval from 01:00 pm and further in the future. In the time 12:00 am – 01:00 pm the schedule is formed for the period 01:00 pm – 02:00 pm. Meanwhile the flex offers for the period from 02:00 pm and further in the future are being accepted.
The schedule must be within the flex offer constraints and contains all the information necessary to produce/consume energy.

5.2.1.4 Unit processes

The process description bellow is used to illustrate the necessary processes from collecting the flex offers to contracting and scheduling. They are used for presentation purpose for listing the processes which are necessarily involved in the energy trading with flex offers and interactions among them.

Generating flex offers

The producers and consumers shall send their data in the same data structure. The content of the data sent may differ due to the physical differences of the production and consumption devices.

The consumer flex-offer

The consumer will send the consumption flex-offer when its device is connected to the Miracle informational/communication infrastructure. The flex-offer will be sent automatically or manually on the user request. The user-consumer will be capable to set particular flex-offer parameters but the flex-offer itself will be generated by the device (manufacturer settings) reflecting its consumption capabilities.

The producer flex-offer

The producer shall send its flex-offers according to its physical characteristics and business model. The producer with RES shall be connected to the forecasting tool, which shall according to the technical characteristic of the RES and weather forecast generate corresponding flex offers.

On the other hand the classical facilities, which have a very predictive production, will send the flex-offers mainly according to the aggregation algorithm characteristics in the BRP. For example if the aggregation is provided on the daily bases, the flex-offers needs to be send with one day characteristic time interval.

Aggregation

The aggregation of the flex-offers is used to reduce (compress) a number of (similar) flex-offers before entering the scheduling. The aggregation is based on regional criteria, prosumer type (RES, industry, residential), or any other criteria. The aggregation process usually reduces the flexibility of the aggregated flex-offers.

The aggregation is provided separately for the production and the consumption. In the description bellow the common example, when the production is fixed and the consumption contains flexibilities is described. One may consider also the alternative situation.

Aggregation of the production flex-offers

The production usually does not contain the time flexibility and in some cases also no energy flexibility. Therefore their aggregation is rather straightforward cumulating the production capacities based on the similar price.

The aggregated production flex-offer is actually the maximal capability of the electricity production for the certain period.

Aggregation of the consumption flex offers

The consumption flex-offers aggregation is not so straightforward as the production, because they contain the time variation parameter like the start of operation.

The aggregation result is aggregated flex offer, which is based on reduction of flexibilities, should follow

- To keep or even enlarge the restrictions from the input flex offers
- To keep the input flexibilities as much as possible.

The most important parameters which must be preserved in the aggregation result are

- Acceptance time moment – must be the minimal of the input flex offers
- Assignment time moment– must be the minimal of the input flex offers
- Start of the operation – must be within common start after-start before period
- Amount of the energy

The Figure 45 shows the aggregation of the “Acceptance time”, the “assignment before period” and energy for the constant energy profile.
The figure shows the aggregation result with the hashed area, what means that several profiles are possible (two examples are presented with the dotted squares bellow). It is a challenge of the aggregation to provide the description of the aggregation result which

- Enables adequate disaggregation
- Does not reduces the flexibilities crucially.

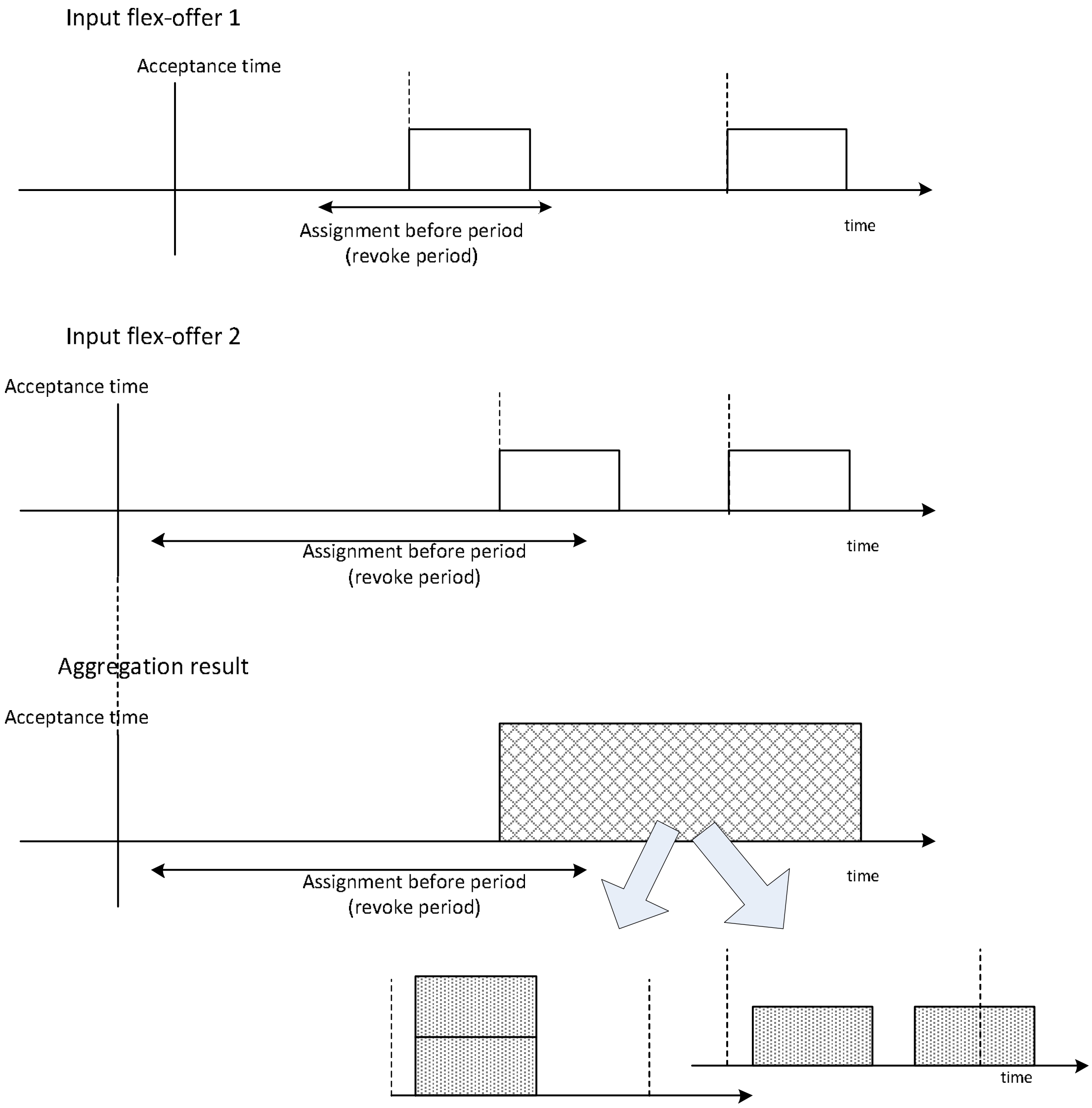

Figure 45: Aggregation of the flex-offers

Matching with Scheduling production-consumption

Figure 46 presents the schedule of the production before the matching. The production is presented as an accumulation of the power production sorted by price over the certain time period. The white area shows the time line of the power of the cheapest production facility, and the darkest shows the most expensive production unit capacity.

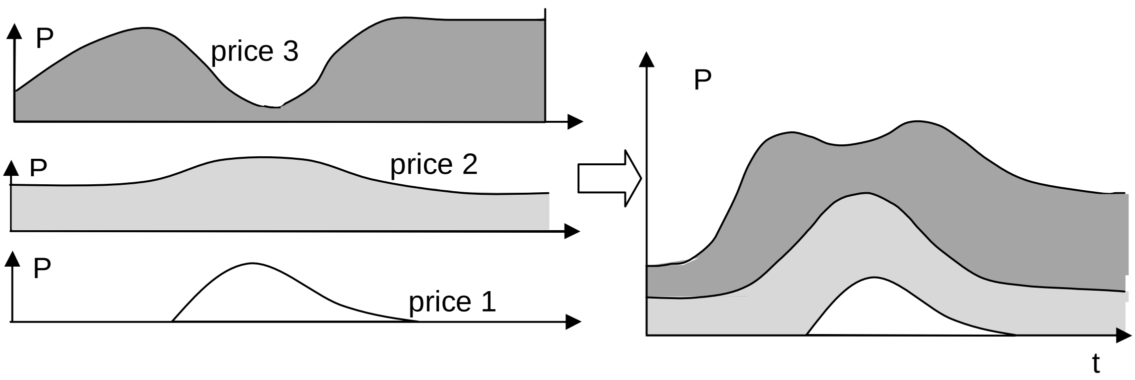

Figure 46: A sample of aggregated production flex-offers

On the consumption side the Figure 47 shows one possibility of the consumer flex-offer scheduled result after the matching when the most preferable moment of the consumption indicated by the highest price was taken (it might happen that everyone prefer to wash the clothes at the same time). This has resulted in a very irregular consumption. The figure shows the scheduled result of the flex-offers as a cumulative power consumption sorted by price over the certain time period. The white area shows the time line of the power of the cheapest consumption offer, and the darkest shows the consumption offer with the highest price (or no price set at all).

Figure 47: A sample of irregular aggregation of consumption flex-offers

Figure 48 shows another possible result of the consumer flex-offer scheduling, where the it was tended to provide the regular consumption.

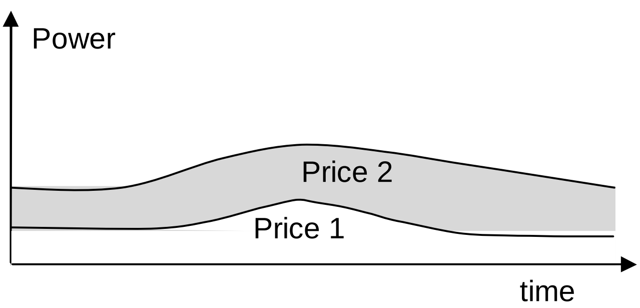

Figure 48: A sample of regular aggregation of consumption flex-offers

While the sample in the Figure 47 might be quite problematic for the producers to fulfill it, the sample in the Figure 48 might be very suitable for the classical production units, but it is still not suitable for the RES with its irregular production. There might be infinite possibilities to schedule the consumer flex offers and one should get some criteria to choose the most proper one, which shall be used for matching the production with the consumption and the scheduling. To establish the matching criteria one should follow the interests of the parties involved in the process:

- The producer wants to sell the largest amount for the highest price
- The consumer wants to buy the needed amount (as small as possible) for the lowest price
- The BRP wants to make the largest profit, i.e. get the producer's electricity as cheap as possible and sell it to the consumer for the highest price

The irregular aggregation in Figure 47 does not follow the interests of the parties involved, which is seen when matching to the production capacities with the consumption needs (Figure 49):

- Some consumers did not receive the electricity despite they were willing to pay for it and there are enough production capabilities but not at that moment.
- Producer could sell more if the consumption would be more regular.
- The BRP could make more money by shifting part of the consumption to the time when the production is not exhausted to maximum capacity.

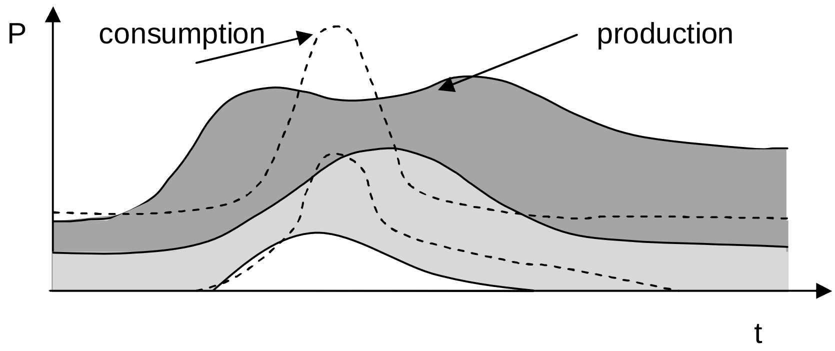

Figure 49: Matching the production with the irregularly aggregated consumption

Schedule of the consumption flex-offers, which follows the production flex-offers schedule, is following more satisfactorily the interests of the parties involved (see Figure 50).

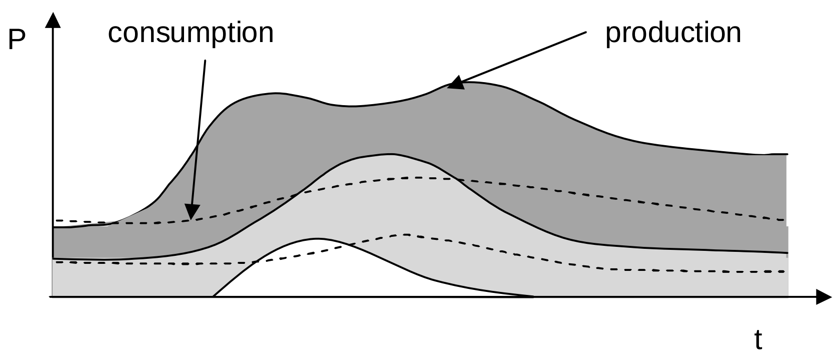

Figure 50: Matching the production with the regularly scheduled consumption

The criterion that the BRP makes the largest profit is provided when it finds the cheapest electricity producers and delivers their energy to the consumers willing to pay the highest price for it. This criterion may not follow the interest of the consumer to obtain a low price neither the criterion of maximal use of the renewable sources.
The last two criteria are included by calculating the common price (for example by auctioning) which is synchronized with external trading (see Balance group use case 3) and introduction of open contracts (see use case 2).
Scheduling aggregated consumption flex-offers in the way that they match production is a complex combinatorial problem which should follow the criteria listed in the Section 5.2.1.2.
If the production side also provides the flex-offers with time variation parameter, they are included in the aggregation/scheduling process in the same way as the consumption.

Contracting
The contracting is provided after matching the production and consumption for the time period, which cannot be affected by flex offers updates any more. The flexibilities are fixed and the contracting result is the input for the disaggregation and energy delivery. The production or consumption which is not covered with the opposite party is not scheduled.

Disaggregation
After the contracting the contracted energy amounts is disaggregated according to the involved flex offers so each producer receives the schedule for the production and consumer receives a signal and information about the energy flow time line to start the consumption.

5.2.1.5 Role model

As a result of the use case balance group 1 the role model involves the following roles

- Producer,
- Consumer,
- Balance responsible party

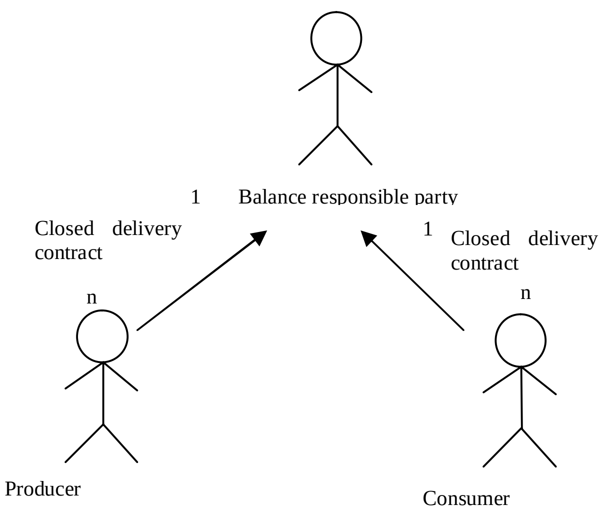

Figure 51: Miracle role model base on the balance group use case 1

5.2.2 Imbalance process

The balance group use case 2 describes the situation, which is closer to the reality than balance group use case 1. In the real electro energy system the electricity production must be balanced with the consumption all the time. The network has no internal capacity to store the energy. In the balance group use case 1 this fact was artificially prescribed, while in reality there are dedicated roles and complex mechanisms to sustain the stability of the network. The balance group use case 2 therefore tries to represent how the Miracle approach with flex offers faces the imbalance situation.

5.2.2.1 System description

Additionally to the system of balance group use case 1

- “n” producers (classical and/or RES and DER),
- “m” consumers,
- 1 Balance responsible party,

the following two main items were added

- The prosumers are allowed to produce/consume the energy on open contract
- There might be a difference between the contracted and actually consumed energy, which is called imbalance

The consumer in present electro energy system consumes their energy on open contract, what means they are allowed to consume as much they need at the contracted price (which is usually fixed). This needs to be introduced in the Miracle application in the system because the consumers shall probably not want to put all their consumption on closed contract flex offer system but shall rather leave part (more likely majority) of it on open contract.
The balance supplier is capable to market the imbalances i.e. it is responsible for the open contracts which are treated as imbalances.
The imbalances involves additional roles and domains into the system

- System operator, which is responsible for the safety of the network and online balancing the production and consumption.
- Network, which is a subject of balancing
- Meter data responsible, which provides the measured data to calculate the imbalances
- Imbalance settlement responsible, which calculates the penalties

This use case is dedicated to imbalances and corresponding activities, therefore no external trading is included, which is a subject of the balance group use case 3.

5.2.2.2 Imbalance Process

Additionally to the balance group use case 1 here is a balance supplier, which collects the data from the meter responsible party. Beside the flex offer and firm contracts for the energy delivery there is also the production and consumption on open contracts, which are the responsibility of the balance supplier.
The sources of imbalances are

- the differences between energy with the prosumer on the closed contract and actually metered energy on the meter for the consumption on the closed contract,
- the difference between the energy consumed on the meter for the open contract and forecasted energy.

The balance supplier introduces the forecasting in the system, which is used to forecast separately the production and consumption on the open contract. The balance responsible party includes the received forecasted result from the balance supplier into the aggregation/scheduling process.
The function of the system operator to check the balance group consumption schedules is not relevant in this use case because due to the self sufficiency of the balance group (there is no external trading). Therefore the aggregation/scheduling and contracting the process is continued similarly as balance group use case 1.
When the energy is delivered the imbalances in the network are balanced:

- internally within the balance group when the imbalances of the prosumers have opposite sign. These imbalances are the matter of the balance responsible party and are not exposed outside the balance group,
- externally by the system operator, when the imbalances of the prosumer have the same sign and the system operator needs to start the intervention system.

The imbalances are measured and penalized:

- the internal imbalances are calculated as a difference between metered consumption/production on a meter for the closed contracts and amount of energy on the closed contract
- the external imbalance is calculated as a difference between scheduled consumption/production and metered one.

The system operator is active only by balancing the network and the energy delivery. The eventual imbalances are penalized by imbalance settlement responsible.

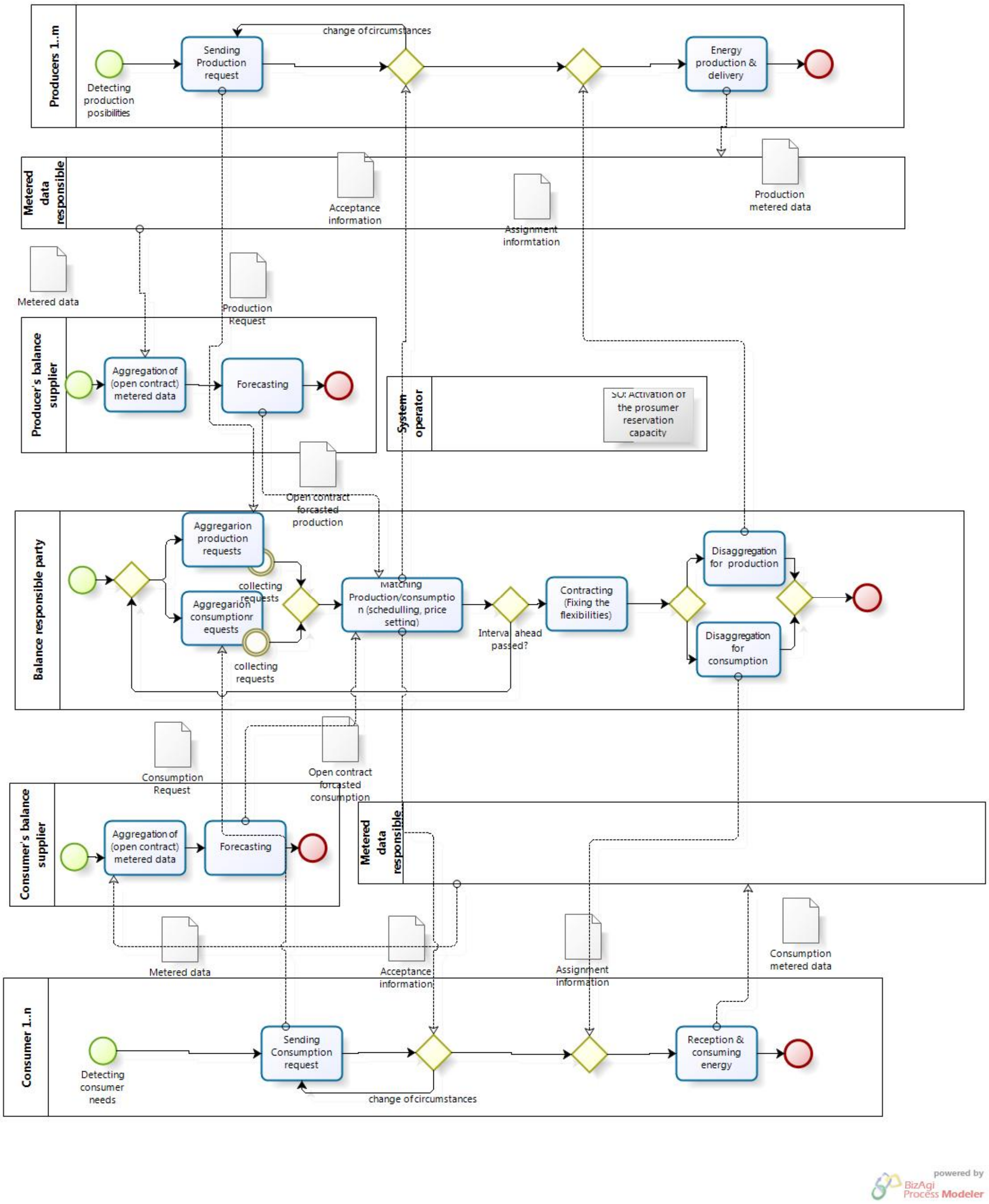

Figure 52: BPMN diagram for BG use case 2

5.2.2.3 Messages

In this subsection only messages which are different or new compared to the balance group use case 1 are described. All the messages are listed in Table 12 for consistency with the BPMN diagram in the Figure 52.

Forecasting the production/consumption on the open contract

The responsibility of the balance supplier is to collect the measured data of the prosumers, combine it with some other parameters (weather report) and provide the prognoses of the consumption and production.

The result of forecasting contains no flexibility therefore there is no need to use the same structure as at flex offers. The result of forecasting is an input into the scheduling process and is not involved into the aggregation.

Since one of the goal of the Miracle project is an efficient usage of renewable electricity sources it is recommended to put them on the open contract production. Such relation between producer and balance supplier/BRP means that the balance supplier (or BRP) is responsible to use (buy) all the energy produced by the RES.

Production/consumption measured data

For the exact calculation of the imbalances the consumer should have two separated measurement lines

- Measurement of the consumption on the open contract – the consumer is not limited to specific quantity and the consumption usually reflects the consumer characteristic behavior (Figure 53 left)
- Measurement of the consumption on the closed contract – the consumption may be compared to the contracted energy quantity and the difference (imbalances) may be penalized (Figure 53 right)

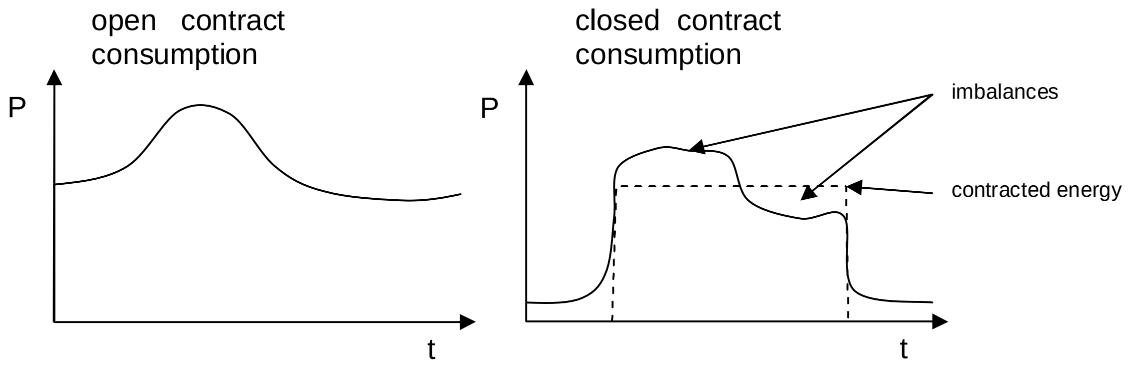

Figure 53: A sample of separate measurements of the open and closed contract consumption

Such installation enables to measure and penalize the consumer's consumption on closed contract.

The same is valid for the producer. Therefore the actor which acts in both roles – producer and consumer – needs the equipment which is capable to measure four separated data.

It might be very difficult to install the smart meter which would separate the consumption on open and closed contract. The simplified configuration would contain only one meter for both types of consumption (see Figure 53).

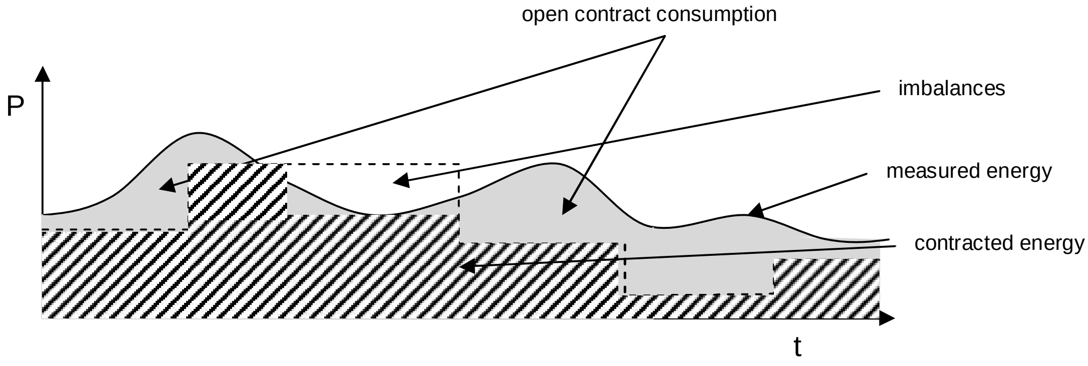

Figure 54: Measurement of the open and closed contract consumption on one line

In this case the contracted energy is taken as a base for measuring the open contract consumption. The open contract consumption is the difference between the measured consumption and the contracted energy on the closed contract. If the consumer exceeds the closed contract energy he will pay the difference by the open contract price which should be higher than the closed one. Therefore there is no need for the additional penalization.

On the other hand if the measured energy is lower than the contracted one then the imbalance can be detected by the meter and the consumer may be penalized.

At the option with the common measurement of the open and closed contract consumption the consumer may manipulate the process by sending the false flex-offer which results in contracted energy and then it covers the contract by the open contract consumption achieving the lower price for it. This manipulation cannot be detected from the measurements but alternative mechanism should be implemented (for example smart meter is capable to detect the turning on/off the devices on the closed contract). On the other hand such manipulation is not necessary bad, because the consumer managed to prove larger part of the consumption under the closed contract what makes the system more reliable in its prediction (smaller part of the open contract consumption results in more accurate forecasting).

Domain model Phase	Message/ document	From/by whom	To/by whom
Measure	Production measured data	Metered data responsible	Balance supplier
Measure	Consumption measured data	Metered data responsible	Balance supplier
Measure	Producer flex-offer	Producer	BRP (Balance responsible party)
Measure	Consumer flex-offer	Consumer	BRP (Balance responsible party)
Measure	Production forecast	Balance supplier	BRP (Balance responsible party)
Measure	Consumption forecast	Balance supplier	BRP (Balance responsible party)
Settle	Production/consumption schedules	BRP	System operator

Settle	schedule conformation/refusal	System operator	BRP
Settle	Finalized Production/consumption schedules	System operator	Imbalance settlement responsible
Plan	Production schedule	BRP	Producer
Plan	Consumption schedule	BRP	Consumer
Operate	Energy Delivery	Producer	Consumer
Settle	Production metered data	Producer	Measured data responsible
Settle	Consumption metered data	Producer	Measured data responsible
Billing	Producer closed contract financial obligation	BRP	Producer
Billing	Consumer closed contract financial obligation	BRP	Consumer
Settle	Producer open contract metered data	Measured data responsible	Balance supplier
Billing	Producer open contract financial obligation	Balance supplier	Producer
Settle	Consumer open contract metered data	Measured data responsible	Balance supplier
Billing	Consumer open contract financial obligation	Balance supplier	Consumer
Settle	Summarized measured data	Measured data responsible	Imbalance settlement responsible
Billing	Imbalance penalties	Imbalance settlement responsible	Settlement responsible
Billing	Producer closed contract penalties	Settlement responsible	Producer
Billing	Consumer closed contract penalties	Settlement responsible	Consumer

Table 12: List of messages for the balance group use case 2

5.2.2.4 Unit processes

In this section only processes which are different or new compared to the balance group use case 1 are presented.
The processes in roles "Metered Data Responsible", "System Operator", "Imbalance Settlement Responsible" shall not be analyzed for this use case because their activity in this use case is the same as in "classical" circumstances (without Miracle flex-offers). Therefore the role "Metered Data Responsible" is not modeled. The other two roles are modeled as a boundary condition as an endpoint for the interactions with active roles.

Forecasting
Forecasting is used when providing the

- Aggregation strategies at prediction of the open contract consumption and production
- aggregated forecasted RES supply.

The forecasting is provided separately for the production and consumption.
Based on measurements and other relevant data (weather) the forecasting at Balance Supplier predicts the consumption of the open contracts. The predicted open contract schedule is sent to the balance responsible party, where it is included into the matching

of production and consumption. The same is relevant for the production on the open contract.
The RES supply on closed contracts needs its own forecasting to provide the production flex-offers, which is used by the BRP. These forecasts include the physical characteristic of the RES facilities, the weather forecasts and the actual measurements.
In the case the prosumer uses both – open and closed – contract option the forecasting process must take into the account the contracted energy at collecting the measured data. The contracted energy must be subtracted from the measurement before making the forecast.
The consumption on closed contract relationship does not need the forecasting.

Matching production/consumption
In addition to the use case 1 the matching process includes also the data of the forecasted open contract production and consumption separately.
The forecasted production (for example wind mills) might be included as a separate production unit (in the same way as it is presented in balance group use case 1). Its predicted energy time history is included as a maximal power capacity.
At the forecast consumption there is no variation of the energy (with the exception of the prediction uncertainty), start time parameter and consumption duration; therefore, it may be included into the matching as a fixed energy profile, which is not affected during finding the optimal consumption scheduling.

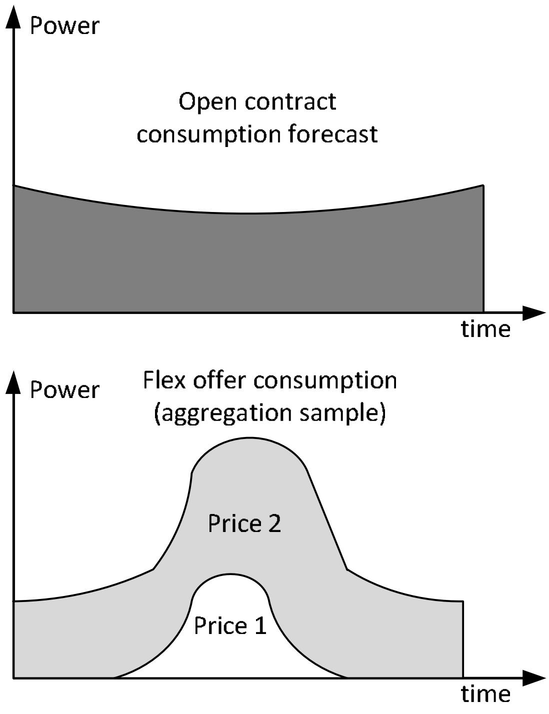

Figure 55: The example of open contract consumption forecast (top) and flex offer aggregation sample at preferred consumption option (bottom)

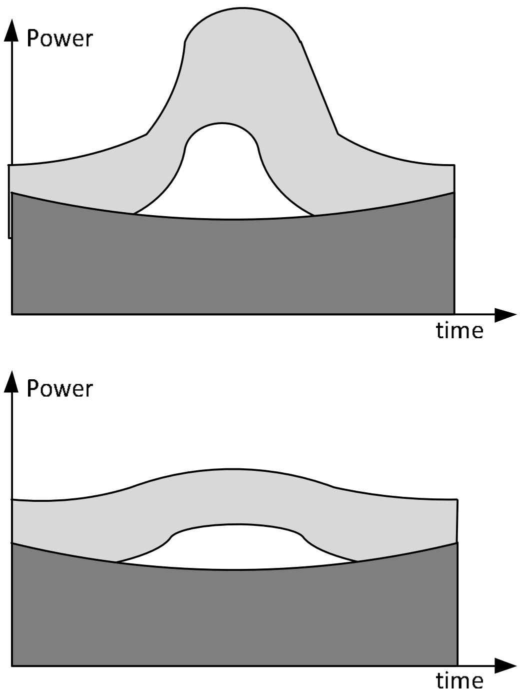

Figure 56: Aggregation of the open contract forecast with a) preferred consumption option (top) and b) regular total consumption flex offers (bottom)

Figure 55 shows an example of the open contract consumption forecast and a sample of aggregated closed contract flex offer which is an input for common aggregation at BRP.

The possible BRP aggregation results depends on the production offer and probably on the BRP business model. Figure 56 shows two possible matched solutions

- Top sample shows the aggregated result correspond to the RES availability which depends on the weather conditions (i.e. there was a strong wing in the morning).
- Bottom sample shows the aggregation result of the constant consumption which is suitable for the classical production units.

The open contract price has to be higher than the closed contract price, otherwise the consumer shall not be motivated to transfer their consumption to the closed contract.

Disaggregation

The disaggregation for the producer is the same as at balance group use case 1.
At the disaggregation for the consumer the open contract part is not relevant and must be subtracted before sending to the schedule to the consumer.

5.2.2.5 Role model

As a result of the use case balance group 2 the role model involves the following roles (see also Figure 57):

- Producer,
- Consumer,
- Balance responsible party
- Balance supplier

In addition the following roles are involved as a boundary

- Metered data responsible
- Imbalance settlement responsible
- System operator

5.2.3 External energy sale process

Additionally to the balance group use case 2 at BG use case 3 the balance group is not isolated but is capable to provide trading and exchange energy with other balance groups. It communicates with the market operator, which is a central point for the trading among balance groups.
Trading with BRPs in other balance groups enables the BRP to transfer the surplus of production capacities and/or consumption demands on the external market. That enlarges the possibility to make scheduling for the exceeded capacities of the energy which was not scheduled in the BG use case 2. This scenario 3 actually concerns the Energy market on the level above BG, but we are interested in it only from the point of view of processes in the roles within BG.
The balance group use case 3 tries to represent how the Miracle approach with flex offers faces the trading with other parties.

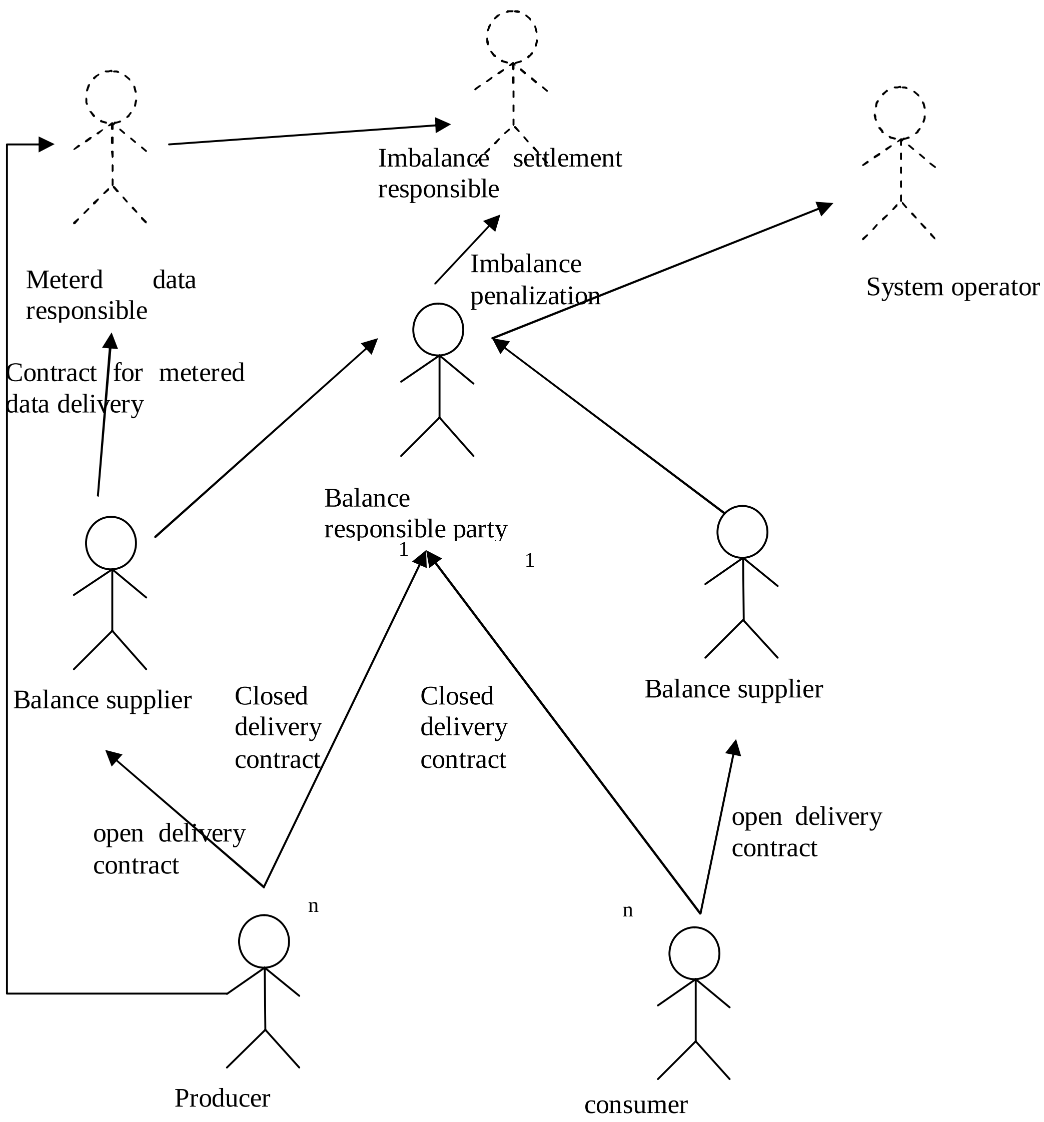

Figure 57: Miracle role model base on the balance group use case 2

5.2.3.1 System description

The BG use case 3 in addition to the use case 2 introduces:

- Market operator is a role which organizes the trading among the BRPs
- Market balance area is a domain controlled by the market operator.

The market operator defines the trading products, trading time and other rules connected with trading. In this document the exchange market is assumed with two types of energy trading products

- Classical energy products (i.e. one hour energy packet)
- Market operator is capable to handle the flexibilities.

5.2.3.2 External energy sale process

The process of sending the flex offers, prognoses the open contract consumption, aggregation and metering the imbalances is the same as at balance group use case 2. Additionally to those processes in this use case there are importing and processing the market data about production/consumption into the matching processes and sending bids to the external market.

Basic sample description

The market information about the production/consumption prices should improve the exploitation of the renewable energy sources (RES). Describing the external trading process an example of the two balance groups is used, where one has the exceed of the production with RES and the other the exceed of consumers on closed contracts generating the flex offers.

The BRP in the first BG with exceed of the energy needs to sell it on the external market (Figure 58). After the internal matching it will form the production bid according to the weather forecast and internal business policy. According to the situation on the market the bid may be either put on the sell list for trading or might be immediately transformed into the contract.

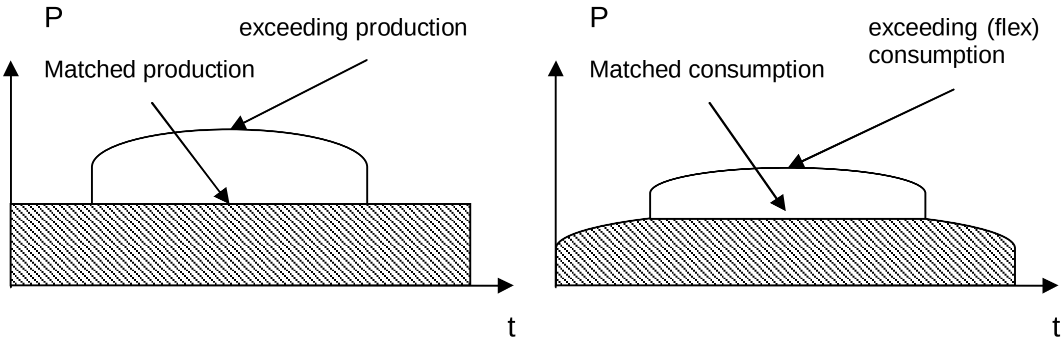

Figure 58: The exceeding production sent to MO (left), adapting the overhead flex consumption according to the market situation (right) of the BG

The BRP of the second balance group needs to buy the energy on the external market. During the internal matching of the production/consumption process it will extract the non-matched flex consumption which needs to be covered by external trading. After inquiry of the market situation the BRP shall reschedule the consumption to follow the external market lowest price what should be close to the production schedule (production prognoses) of the BRP from the previous paragraph. After the matching it will form the consumption bid and send it to the MO for contracting.

Once the status of the bid is changed due to the external contraction, the BRP is informed about that through the data retrieval from the MO.

The external bid may be updated till the contracted moment.

The market operator is obligated to provide the operating schedule and send it to the system operator for the conformation (see Figure 59). It detects the imbalances and congestions in the network and may reject part of the contracts and returning it to the BRP for the reformation. The (un)conformation is sent over the market operator to the BRP, which adapt the matching before internal contracting.

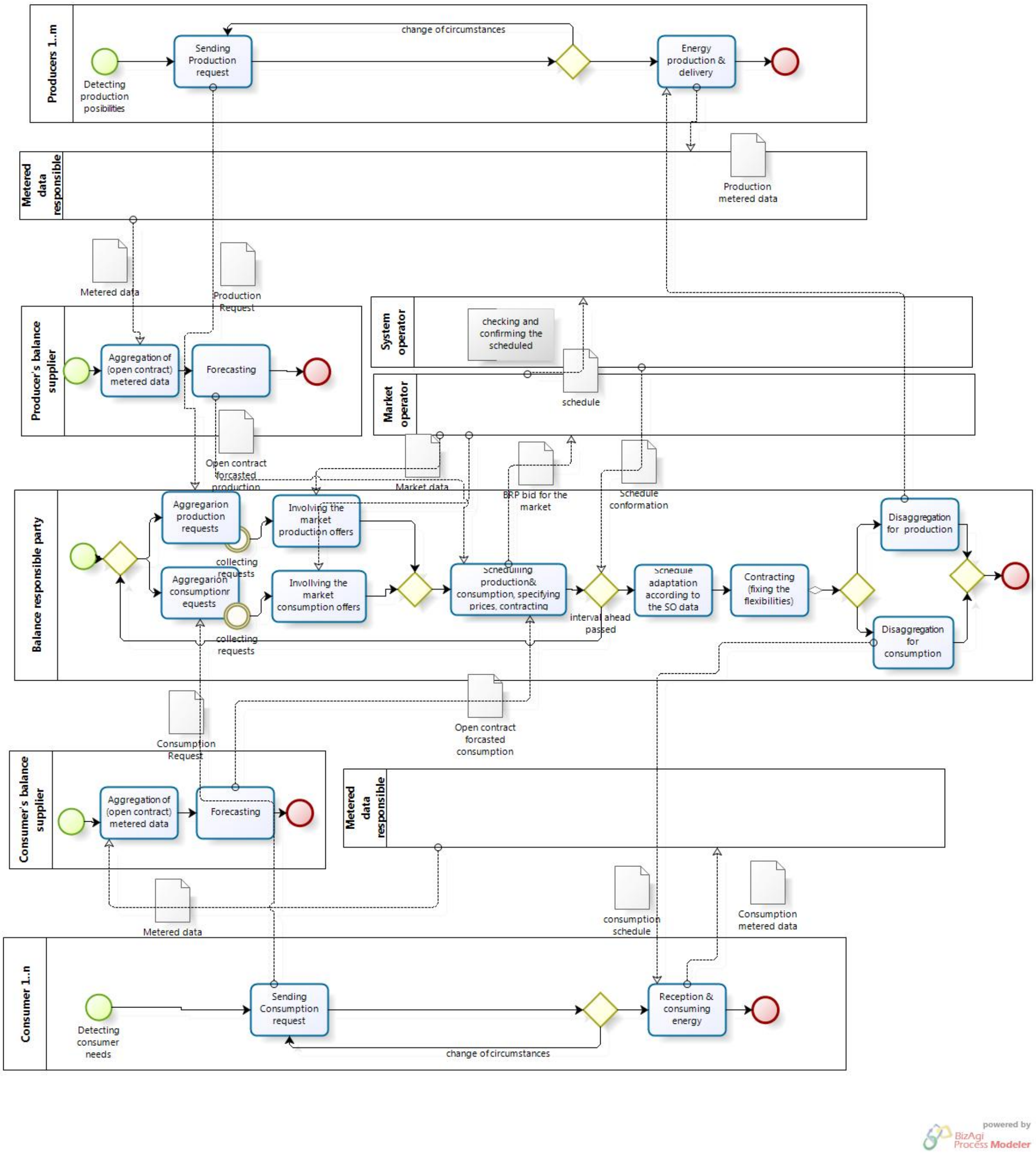

Figure 59: BPMN diagram for BG use case 3 – external trading

In the case there is only day ahead external market then the BRP with the Miracle functionalities may have the "traded period" much smaller than the market operator ones. In this case the internal processes of the BRP during the operation day do not include the external interaction and is very similar to the BG use case 2 (Figure 52).

Influence of the external market data on the internal matching process

The inquiry on the market situation might have essential influence on the matching process within the BRP. For example the BRP, which covers internal consumption with internal production has found extremely high price on the market. If it contains some flexible consumers in its portfolio and if its business model is dedicated to the speculative

profit, it can reschedule the consumption later to the low price time interval and sell its production capacities on the market.
The similar process is at opposite situation – if the BRP detects extremely low price (due to the high production of the RES in favourable weather conditions) for the specific period it shall reschedule the consumption and cancel its own expensive production (see Figure 60).

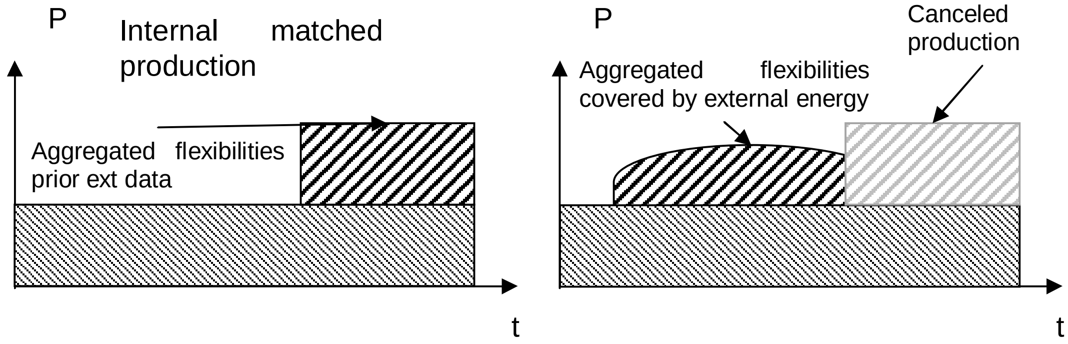

Figure 60: Internal aggregation of the flexibilities according to the internal production (left), aggregation of the flexibilities according to the business opportunity on the external market (right)

Flexibilities of the external bid
The Miracle flex offers functionality with the combination with external trading is effective only when it enables to retrieve the price data for a certain period ahead (for example at online trading). If the trading with auctions is provided there is no advantage in flexibilities anymore because the BRP needs to fix the flexibilities and form the classical trading product to participate in trading.
Another option is that the market operator poses Miracle features and is capable to receive and handle the flexibilities from the BRP. This option is described in the MBA use case 2 from the stand point of the market operator. Here it is described from the stand point of the BRP.
The BRP sends the flexibilities to the market operator. The market operator is the party which makes the matching and contracting. The fixed energy schedule is returned to the BRP in the form of the classical trading contract.

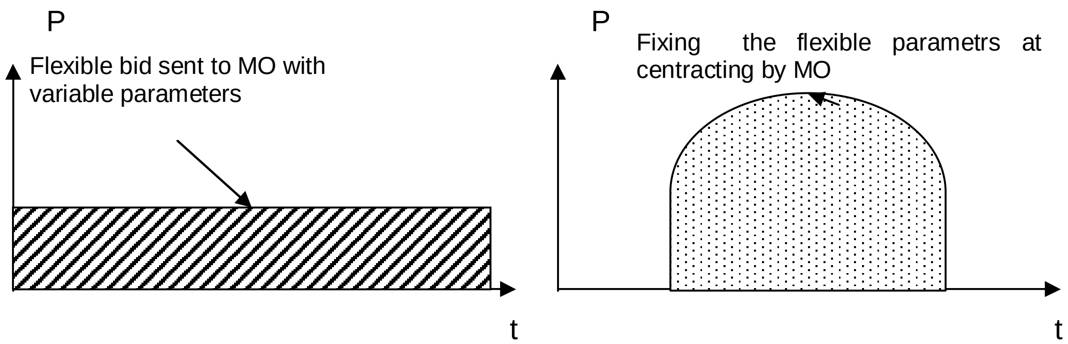

Figure 61: The flex-offer sent to MO (left) – presented is one possibility of the aggregation, result at fixing the flexibilities at contracting (right)

Influence of the market operator “interval ahead” duration
The Miracle project might have the “no request period” and “trased period” much shorter than the market operator (at the day ahead market the corrections of the external

contracts are not possible during the operation day). The period of the one day might be much too long to handle the RES efficiently.
The problem occurs for example when the weather forecast changes and reduces the predicted RES production, while the energy is already sold:
The problem occurs also in the reversal situation when no RES energy was foreseen initially and the BRP of the second BG has bought the energy from the classical sources. Then suddenly the forecast changes and the cheap RES electricity is available.
The source of the problems above is that BRP has much shorter "traded period" than the market operator and by fixing the flexibilities on the external market the BRP loose the adaptation possibility at the RES production change.
The BRP must be careful at providing the external bids to form only offers with the revoke interval similar to the BRP traded period.
To handle the situations above it is good that BRP has a lot of flexibilities in its portfolio and keeps a certain ratio unscheduled as long as possible – also when the external contracting is already closed. When the external trading is closed the process in the BRP is similar to in the BG use case 2.
If the BRP is not capable to handle the situation, the system operator must balance the network, and the BRP must pay the imbalance penalties.
For example, if the BRP has at the day-ahead market not enough flexibilities during the operation, then it cannot efficiently react on the effects of the weather changes on RES, which very often changes during intraday. The network is balanced by the system operator resources.

5.2.3.3 Messages

In this subsection only messages which are different or new compared to the balance group use case 2 are presented.

Market data
The BRP takes the market data into account during the matching the production-consumption process. The market data contains the price and the offered amount of the energy on both – production and consumption – sides.

External contracts
At the data retrieval also the results of the external contracts from the bids the BRP sent to the market operator are received. The results are either

- Classical trading products or
- In the case the MO has applied the Miracle features the time schedules of the energy flow from the flexibilities sent to MO.

BRP bids
BRP shall decide which part of its capacities and demand offers shall be offered to the exchange market. The offer must be put in the form of the market selling products (i.e. one hour packet of energy) with fixed flexibilities.
In the case the market operator is capable to handle the flexibilities, the BRP may send also offers containing thee flexibilities (the power profile variation).

5.2.3.4 Unit Processes

In this section only processes which are different or new compared to the balance group use case 2 are presented.

Matching the production with consumption

The market data are included onto the iteration process of matching the production with consumption to find the optimal consumption scheduling. The market data are included as:

- a (virtual) production unit maximal capacity on the production side
- an aggregated open contract consumption on the consumption side

The matching is provided in the same way as in balance group use case 2.

Contracting
At contracting to the external party (market operator) the BRP must consider different value of the “contracting period” as at internal trading, It is very important that the BRP uses only the flexibilities with the revoke time similar to the MO ones at external contracting to exploit the Miracle features maximally.
Before the contracting in the BRP the result of the external contracts check from the system operator must be considered. In the case the check is negative the corresponding contracts are cancelled/adopted.

Exporting bids to the external market
The BRP shall send the following offers to the external market:

- surplus of the production/consumption capacities
- a part of the unscheduled production capacities –depends on the market price and BRP policy
- a part of the unscheduled consumption capacities –depends on the market price and BRP policy
- It depends on the MO Miracle functionalities whether also flexibilities are sent externally.

5.2.3.5 Role model

As a result of the use case balance group 3 the role model involves the following roles:

- Producer,
- Consumer,
- Balance responsible party
- Balance supplier

In addition the following roles are involved as a boundary:

- Metered data responsible
- Imbalance settlement responsible
- System operator
- Market operator

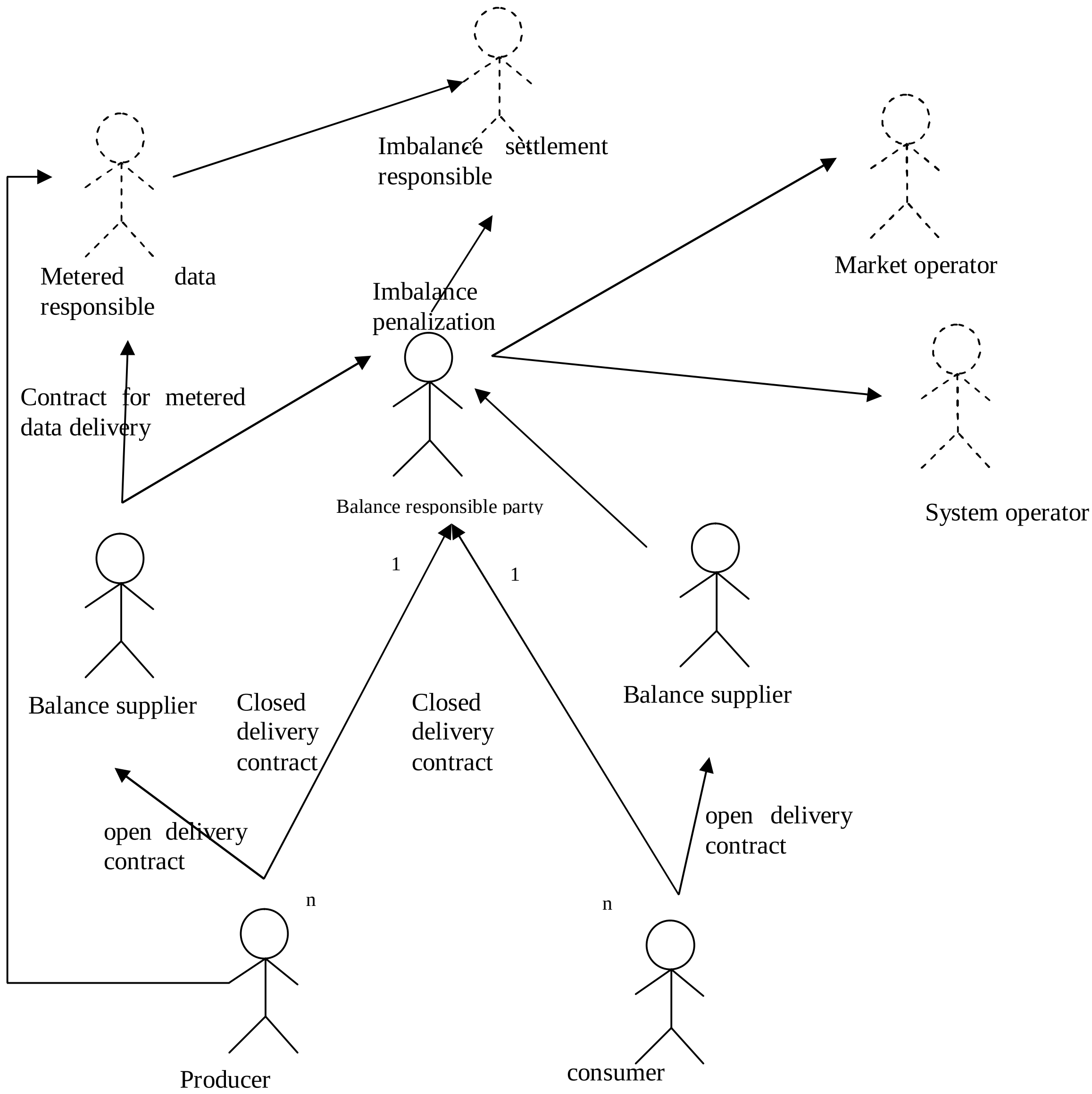

Figure 62: Miracle role model base on the balance group use case 3

5.3 Market Balance Area system, processes and roles

5.3.1 Market Balance Area use case 1: Internal energy bi-lateral trading

This use case scenario addresses trading processes within a MBA. The MBA is able to match consumption and production internally. Any possible surplus or shortage is not modeled; i.e. there are no fixed energy products or Flexible Energy products (FlexEnergy[5]) based products in consumption and production traded and transferred between different MBA's. Additionally, there is no imbalance; i.e. no difference between contracted and actually produced /consumed energy and there is thus no imbalance settlement process modeled.

[5] FlexEnergy products are based on flexibility in when and how much energy is consumed; c.f. D2.2.

5.3.1.1 System description

This use case is focused on the market balance area; the system in scope consists of two types of (sub) systems: the Balance Group (BG) and the Market Balance Area (MBA). BG's are specializations of Functional Groups (FG); other specializations of FG's are out of scope for this use case, for more information the reader is referred to Section 3 on role model analysis and [ETSO09].
These systems and the roles which relate to these systems within the scope of this use case are shown in **Error! Reference source not found.**[6]. Each FG has a BRP which is responsible for it. A BRP may be responsible for a BG; a BG has exactly one BRP which is responsible for this BG[7]. All FG's belong to a Market Balance Area, which is 'operated' by a Market Operator (MO, not shown in this diagram since it plays no active part in this use case).

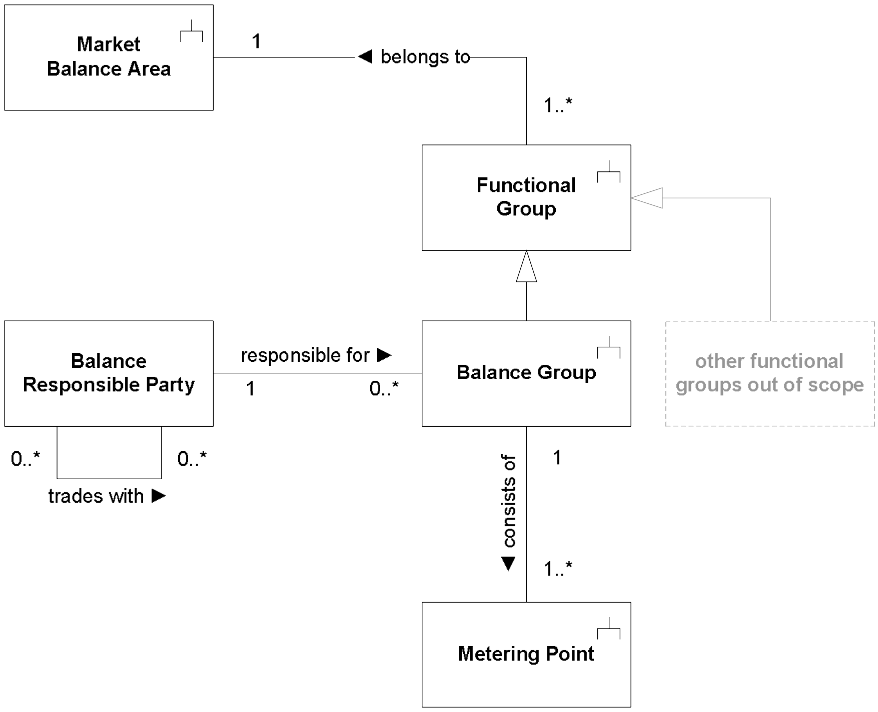

Figure 63 Systems and roles within MBA use case 1

BRP's can trade bilaterally between themselves and/or via the MO. Within [ETSO09] only trade of fixed energy products is considered. In this and the other MBA use cases this is extended with the possibility to trade energy products with flexibilities. I.e. to leverage (possibly aggregated) flexibility expressed by Producers and Consumers; Section 5.1.4 describes how this flexibility is expressed.
The constraints imposed by the System operator, require that the energy trading be performed by closed contracts to enable schedule planning, as described in section 5.1.4. The processes involved are essentially described in the Section 5.1.4.2, and the flexibilities management, applicable also for this case is analyzed in Section 5.1.4.2.2 and Section 5.1.4.2.3.

6 **Error! Reference source not found.** shows the relationships as in [ETSO09]; in this document the relationship between BG and BRP is made explicit while it is implicitly available in the model by the relationship between the FG and the BRP.
7 This can be inferred from the FG to BRP relationship.

However, in this Use case, the assumption used is that the flexibilities could be passed over on the trading process, from the seller to the buyer. In order to highlight this possibility, at variance with the Harmonized model, the term “flexibility” is used in the following subsections, analyzing these processes.

5.3.1.2 Use case processes

This section describes a number of use case processes which can occur within the market balance area use case 1 regarding MBA internal trading. Figure 64 shows the main unit processes within the use case. They are the main processes performed by Balance Responsible Party in this use case.

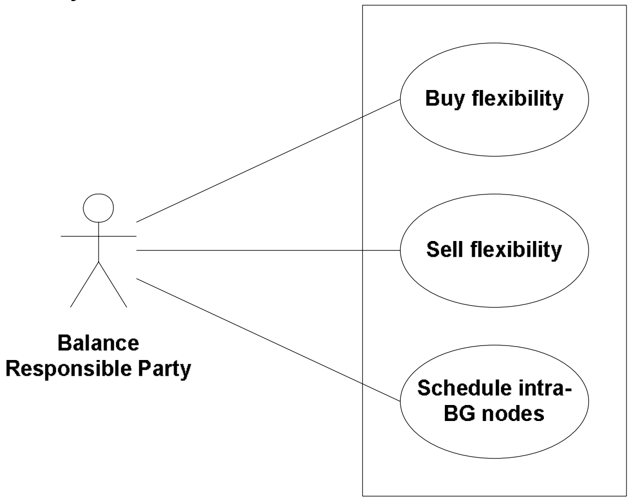

Figure 64 Unit-processes and roles within MBA use case 1

Figure 65 indicates the specializations and relationships between these unit processes. The specializations are that selling and buying of energy products with flexibility can be done either bilaterally among BRP’s or by other methods of trading (described in the remaining two MBA use cases).

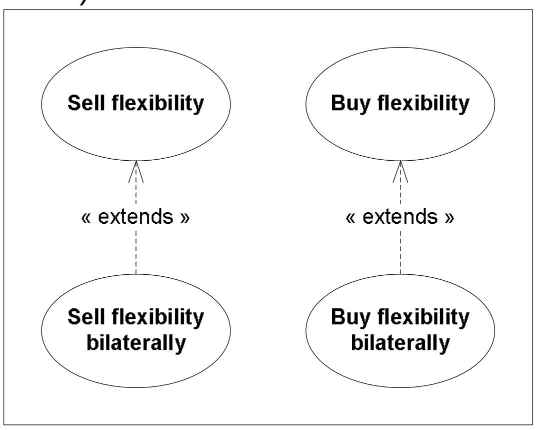

Figure 65 Specializations of and relationships between unit-processes

The following sections describe how these processes can be performed by the BRP’s and MO and interact.

In the processes of bilateral trade only two BRP’s are included, but as a MBA can consist of any number of BG’s, any number of BRP’s can potentially perform these processes in parallel. The BRP’s are referred to as BRP1 and BRP2, where BRP1 is the party initiating the process and interactions with the other party.

5.3.1.2.1 Sell energy products with flexibilities via bilateral trade

Figure 66 shows the BPMN representation of the of 'sell energy products with flexibilities via bilateral trade' process. First BRP1 performs an analysis of its position, consisting of trade agreements already made and expected production and consumption which cannot be influenced. It selects the flexibility which it does not need to 'protect' its own position. Subsequently it performs an analysis of flexibilities and select the ones with an acceptable level of certainty that the can be used[8]. Based on the BRP's position and the selected flexibilities an offer is formulated (including pricing bounds, deadlines e.g. before which a response should be provided, and other conditions) and is sent to a selected BRP, here BRP2. The selection mechanism is not detailed further in this section.
BRP2 receives the offer of flexibility, performs an analysis of its position and determines the need for flexibility. It then judges whether the offer can improve the BRP's position and whether the conditions of the offer are acceptable. BRP2 responds either with acceptance or rejection.
BRP1 receives the acceptance or rejections and the process is completed. BRP1 can then decide to start this process again (not shown) or not.

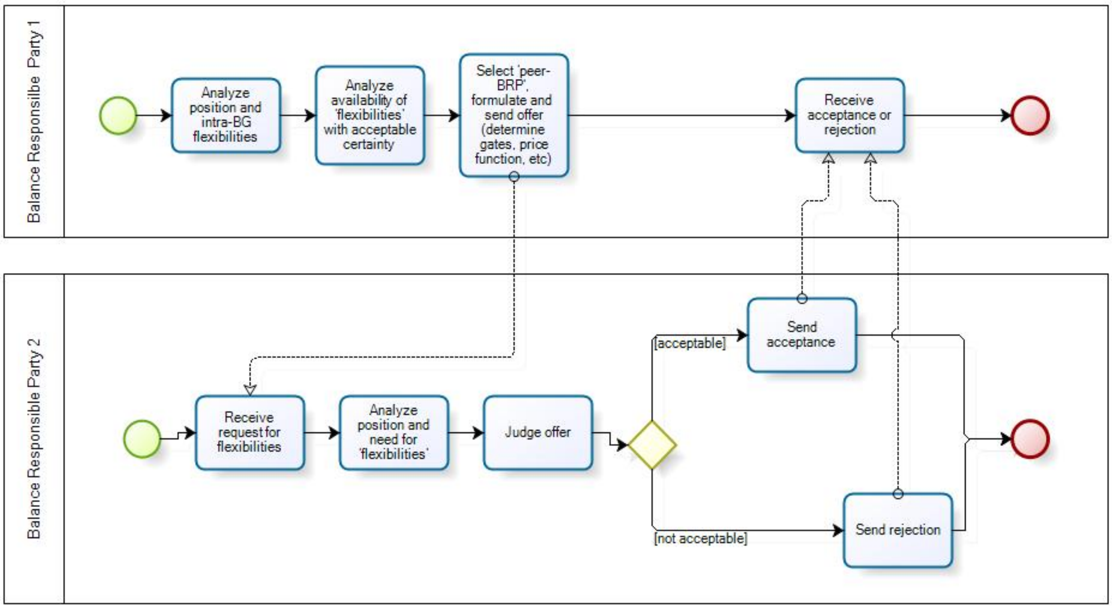

Figure 66: BPMN representation of 'sell flexibilities via bilateral trade' process

5.3.1.2.2 Buy flexibilities via bilateral trade

Figure 67 shows the BPMN representation of the of 'buy flexibilities via bilateral trade' process. This process is similar to the process described in the previous section 0 but here the initiative of BRP1 is caused by a desire to buy instead of sell flexibility.
First BRP1 determines the need for flexibility, e.g. based on the risk of imbalance between planned and actual production and consumption. It then formulates a request for flexibility and sends it to a selected BRP. The flex-offer includes constraints on topics such as price and deadlines e.g. regarding when a response should be provided and by when the (final) schedule for the flexibility must be provided.

[8] This depends on the chance that a Consumer or Producer will revoke or alter the offering flexibility.

BRP2 receives the flex-offer and formulates and sends an offer; based on an analysis of its position and available flexibilities (including with which certainty the flexibilities can be offered). BRP1 receives and judges the offer based on conditions of the offer such as price, etc. and informs BRP2 of acceptance or rejection.

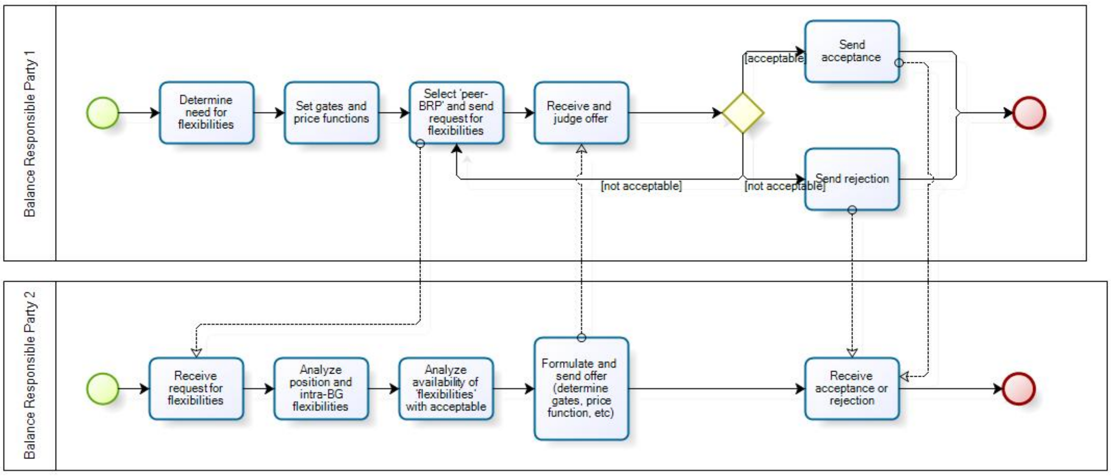

Figure 67: BPMN representation of 'buy flexibilities via bilateral trade' process

5.3.2 Market Balance Area use case 2: Imbalance processes

Use case two presents a scenario closer to reality of energy trading at the MBA level, as it models also the differences occurred between the planned and the real energy consumed/ purchased expressed by the imbalance process.

5.3.2.1 System's description

System comprises several BG's controlled and operated by the respected BRP's, but in this use case two BG's will be modeled. One with a profile made for extracting/ purchasing energy from the MBA while the other one for supplying/ selling energy in the MBA. Moreover, conditions from the MBA use case Scenario one apply here, as all energy produced/consumed is matched internally within the MBA and there is no energy trading between different MBA's. Additionally, energy trading in the MBA, between those two Balance Responsible Parties, is being executed by double side auctioning of flex-offer products controlled by the Market Operator. The imbalances detected in the system are derived from the differences between the contracted energy traded between the BRPs in the MBA area and the real one produced/consumed by the same BRPs.
The roles participating in the use case are the following:

- the Balance Responsible Parties (BRPs) trading by declaring/offering flex-offer bids through double-side auctioning
- the System Operator (SO) responsible for overall controlling processes, setting constraints, accepting schedules, covering energy imbalances through reserves for maintaining the MBA's network
- the Imbalance Settlement Responsible (ISR) is responsible for financial settling the differences between the energy contracted and the real energy consumed
- the Market Operator (MO) for performing auctioning, receiving BRP's consumption/production bids, solving day-ahead or intra - day schedules resulting to System's Marginal Price (SMP)
- the Metered Data Responsible for metering the real energy produced/ consumed within the metering points/nodes allocated to the BRP's.

5.3.2.2 Use case processes

In this section, the individual processes which occur in the MBA use case scenario two and do not occur in previous use case scenario one are described.

5.3.2.2.1 Declaring/Offering Day Ahead Flex-offer Bid

Additionally to the MBA Use Case one where there is bilateral trading between BRPs, here the BRPs use the flex-offer bids for declaring and offering their energy products to be traded on an organized wholesale MBA market. Flex-offer bids can be either for purchasing energy for consumption or for selling energy production.

The BRP which addresses itself to the Market Balance Area for buying energy for its BG members declares its energy demand through consumption bids. BRP has collected all the load requests for the interval-ahead periods available from its BG members till the request collection deadlines for these interval ahead periods respectively. These requests include also the micro-requests which can be displaced to different time operation intervals for consumption from the most preferable to the least preferable. Aggregation of these load requests results in formation of energy objects with flexibilities on it. The sum of these objects in time comprises the flex-offer consumption bid of the BRP to the MBA along with the bid constraints, which has to do with the maximum price for payment (purchase) of the energy for satisfying the load requested.

Respectively to the flex-offer consumption bid, BRP addresses to the Market for selling the energy of their BG members offering their production through the flex-offer production bid. BRP collects all the production offers from the BG members, producers and prosumers, for the interval-ahead period requested to be assigned. Along with the traditional producers having conventional power units which operate on a specified schedule and RES producers which operate according to the weather conditions forecast, the existence of numerous prosumers with small CHP units enable BRP to have production offers available to be assigned on different time operation intervals for production from the most preferable to the least preferable one. Aggregation of productions offers possible to be assigned only in specific time operation intervals results in fixed energy products offers, where aggregation including productions offers possible to be assigned on different time operation intervals results on flex energy products offers. These flex energy products offers are declared to the MBA as the BRP's flex-offer production bid containing also minimum price constraint for selling ensuring a minimum sales limit for the BRP.

According to the available flex-offer a BRP has, it aggregates them forming the flex-offer bid in a way that suits its business criteria most. The range of flexibilities formed in each energy object, has derived from the aggregation of the flex-offer that the BRP has chosen to place in each interval ahead period in order to be traded. Off- course, there are various aggregation possibilities of the flex-offer. The more flex-offer the BRP has, the more different options it has to aggregate them in a way to suit its needs and purposes.

On the MBA, flex-offer production bids offered from numerous BRPs, are matched with the respective flex-offer consumption bids declared by other BRPs on a double side auctioning process performed by the Market Operator providing schedules where the production offered satisfies the load declared on a specific interval ahead period and on a price equilibrium calculated. When scheduled, existing flexibilities of the flex-offers are fixed and a contract between the BRP and the producer/prosumer and/or BRP and the consumer is finalized in terms of quantity, price and time of execution including operation start time and operation end time. So, trading of flexible part of a flex-offer bid occurs simultaneously with the fixed part of the offer and not separately.

Through the flex-offer bid, BRP has the opportunity to better manage its portfolio by trading on the MBA wholesale market across a number of different time intervals ahead of time of operation. BRP, by trading on the day ahead market, will typically aim to cover its physical position – i.e purchase electricity to cover their forecasted customers demand or sell the electricity of their producers' generation units over the whole day for a certain period. The day ahead of energy operation, BRP has a picture what their customers demand or supply is likely to be, a picture that is being improved as the time heads forward.

Various aggregation possibilities of the flexibilities allow BRP to fine-tune its portfolio in line with the updated forecasted information received by adjusting its bids through re-allocating the flex-offers of its bids in another way in order to match as good as possible this latest updated forecast. This procedure is performed by BRP before the request collection deadline of each interval available on the day-ahead market.. After the request collection deadline every bid that has been declared /offered from the BRP to the Market Operator to be traded is being controlled by the Market Operator of the MBA for the better scheduling of those flex-offers bids for consumption and production through the double side auctioning. Market Operator having under its control the allocation of the flex-offers on a preferred time operation interval available and under the price constraints specified by the BRP, can better aggregate the flex-offer bids for production and consumption from the various BRPs participating on the MBA market in a way to provide more feasible and accurate schedules resulting to less imbalances the next day of operation (execution).

However, when scheduling the concluded flex-offer bids are finalized in terms of quantity of energy requested and offered matched, operation start time, operation end time and price and become fixed. The schedules notification to the BRPs triggers the contracting between BRPs and their BG clients fixing the flex-offers to fixed flex-offers for consumption or production with no longer possibility of changing its characteristics.

In day - ahead market because of the long delay between the assignment before time where flexibilities are fixed and the operation (execution) start time where real energy begins to executed, major inaccuracies to the demand/supply forecasting may occur. Taking this fact into consideration, BRP is better not to place (schedule) its available flex-offers, especially those with short revoke time (i.e. the time between the end of the offer's validity and the operation start time). These flex-offers are needed to be assigned within short time interval close to operation start time after their declaration./offer through the flex-offer bids. So by declaring them on the day - ahead market and having being scheduled on a time so long before the operation start time, BRP loses the flex-offers' advantage to be kept flexible till a time close to operation start time in order to have the possibility of having them scheduled on a preferred way having available the latest forecast on demand and/or supply.

However when trading on day ahead market, long term from yearly to monthly base load energy products, the possibility of major discrepancies to be occurred on the forecast of such quantities is big. The existence of flex-offers, mainly with long similar revoke time on the flex-offer bid is important on such occasions. This is because the forecast updates of such load requests or generation offers even during the day ahead from operation (execution) is significant enough to bring BRP out of its physical position to satisfy the purchase for its clients or sale of energy of its clients. By having available flexibilities on its flex- offer bid, BRP has the possibility of having them scheduled on a different time operation interval in order the discrepancies on the previous forecasts to be compensated.

As illustrated in Figure 68, using Miracle on day-ahead market extends the time interval of the flex-offers, with long revoke time, to be kept flexible until the final schedules provided by the Market Operator. On day-ahead the advantage of this extended time interval is not clear as the operation start time of the scheduled offers remains far, but it can be critical in cases as the above mentioned.

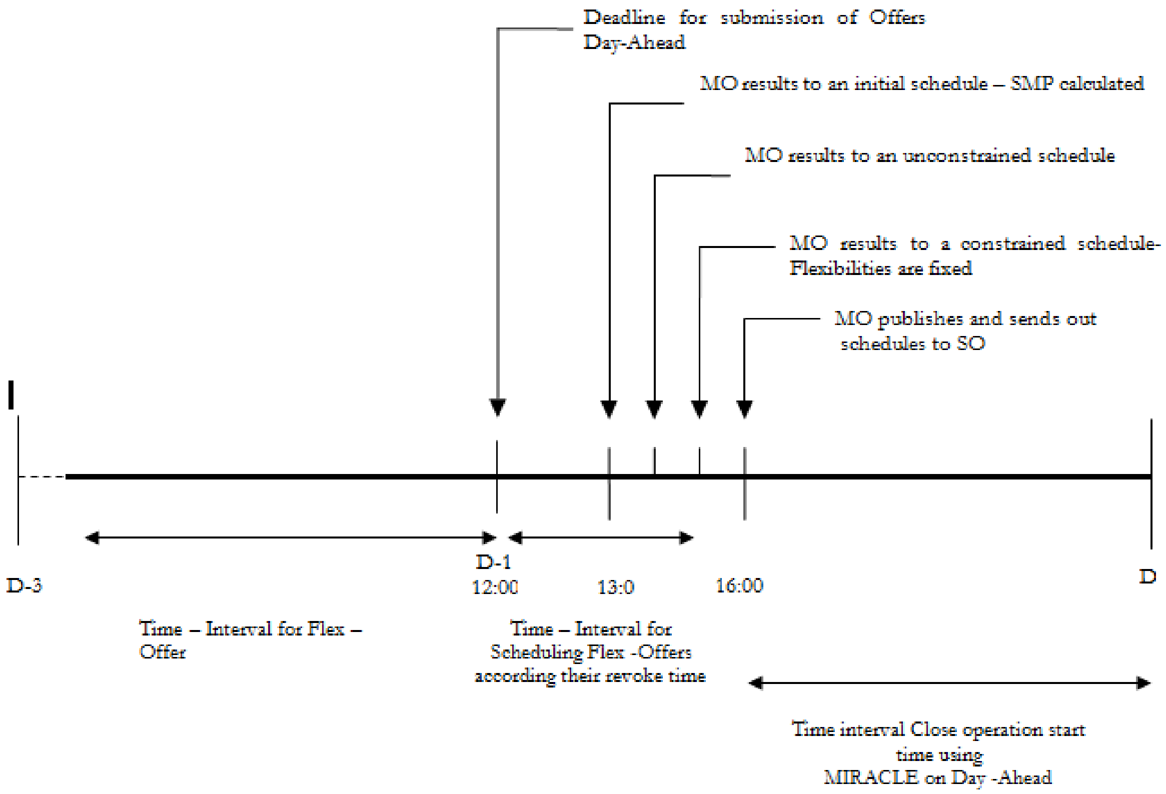

Figure 68: Time interval available for fixing flex-offers on day-ahead market

5.3.2.2.2 Declaring/Offering Intra-day Flex-offer Bid

In comparison with the existence of only a day-ahead market, the intra-day market existence allows BRP to trade more accurately energy volumes from the MBA market, as it has updated forecasted information from its members load requests and production offers from one hour ahead to near real time to the operation (execution) start time. Moreover, on intra-day markets BRP can obtain information from the system's overall position especially on the 15 minutes ahead and real time market where intra-day takes the form of a continuous trading market. So in contrast to the situation of the day-ahead market, on intra-day market BRP can improve its position by making its bids with less uncertainty as the shorter the delay between the intra-day offers' collection deadline and operation start time of energy delivery, the less uncertainty BRPs are confronted with when deciding on the final composition of their portfolios.

Moreover, BRP for taking advantage of the better forecasting of the load requested and production offered needs to adjust its position based on previous forecasts. For doing so, it needs to have available flex-offers into its bids for having them scheduled in different interval-ahead periods possible according to their revoke time. BRP by sending its flex-offers distributed to their short revoke time on its flex-offer bids declared before the offers' request collection deadline of interval ahead period of the intra-day market (one hour, 15 min, real time, etc.) manages to have them traded by the MO closer to the operation start time. As shorter the revoke time of the flex-offer is, more closely to the operation (execution) start time the flex-offer can be scheduled and traded more accurately incorporating all the latest forecast available regarding consumption requested and production offered. With that way BRP can have the latest forecast data included resulting to a smother flex-offer bid fine-tuned with the latest forecast data available that

can be traded and scheduled to the MBA more easily with less cost compensating the imbalances would have been derived if flex-offers hadn't been available.
Therefore, the existence of an intra - day market leads BRP to a different approach on its bids to the MBA from the one that would use if only a day-ahead market would be applicable. That means that BRP could declare basic predictable repeating load or production from conventional units easily forecasted to its nominal output through the day-ahead market leaving the bigger part of unpredicted peak load or RES production for the intra-day market.
Also, in intra-day market, there is updated information not only for each BRPs position to the MBA but from the overall market. A close to real time forecast for RES production available on the MBA on a specific time interval would lead MO to allocate flexible load requests to that time interval in order to be traded. Respectively, a close to real time load peak available on the MBA on a specific time interval would lead MO to allocate flexible production offer derived by small CHP units on that time interval to be traded. Off course these flex-offers' allocation should be satisfying the price constraints set by the respective BRPs.
As in day-ahead market, the process of the BRP forming their flex–offers bids along with its maximum purchase price constraints or minimum sale price constraint needs to be done before the offers' request collection deadline for each time ahead interval of intra – day market. When flex-offers on each time ahead interval of the intra-day market are being scheduled then are become fixed as part of the fixed energy products to be traded and referring to the finalizing terms of the respective contract signed between BRP and its clients.
Also, in contradiction with the display of time interval available for fixing flexible – offers in the day – ahead market, the respective time – interval available on intra- day markets is put so close to the operation start time of the scheduled offers that the advantage of using MIRACLE on intra-day is much more obvious as depicted in Figure 69.
Where without MIRACLE production and consumption offers would be fixed at the end of the collection deadline on the intra –day market, using MIRACLE on hour ahead market extends the time – interval of the flexible – offers, with short revoke time, to be kept flexible very close to the execution time (e.g 15 to 20 min ahead on an hour ahead interval) making viable the inclusion on late forecasted RES production , where such time differences are critical, to be traded by allocating flexible offer for consumption available.

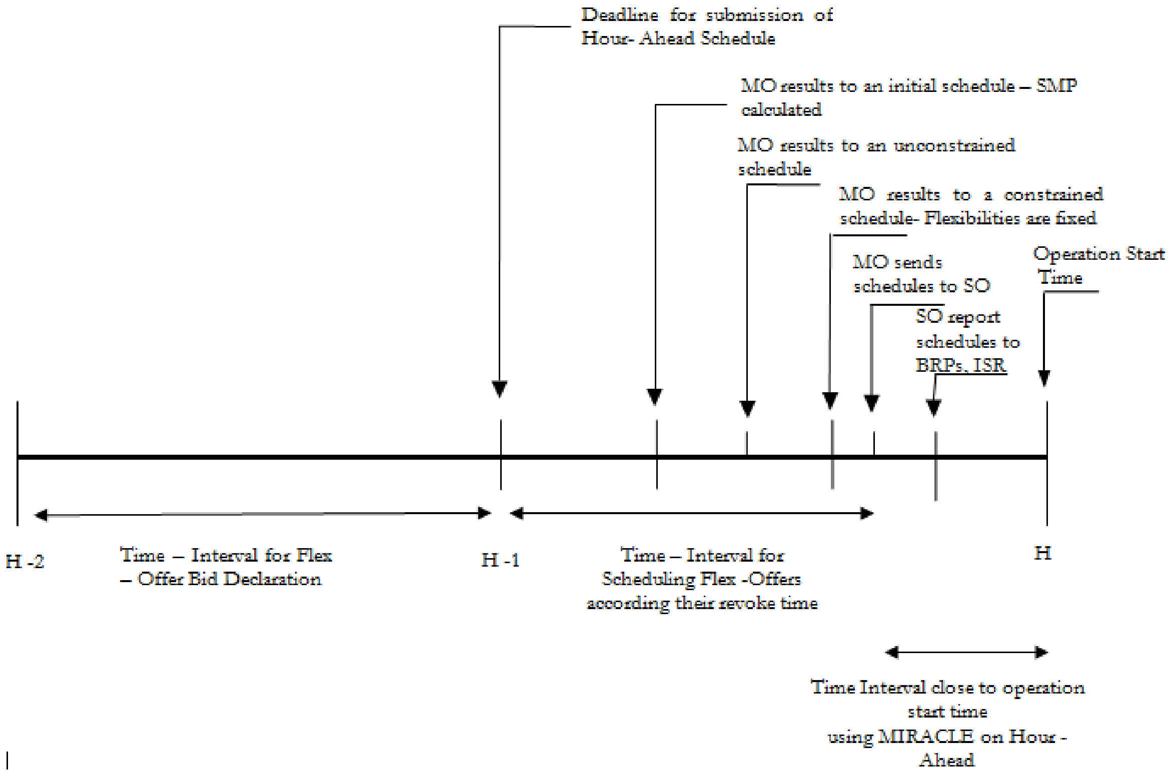

Figure 69: Time interval available for fixing flex-offers on hour-ahead intra-day market

5.3.2.2.3 Imbalance Process

Additionally to MBA use case one, in use case two there are differences occurred between the planned and the real energy consumed/ purchased expressed as imbalances. Also, there is the Imbalance Settlement Responsible (ISR) role which collects the measured real energy consumed and generated in the respective metering points within MBA from the metered parties responsible.

Imbalance is defined as the difference between the energy contracted after the scheduling process through auctioning in the MBA between BRP and its clients and the energy really consumed or generated by the respective clients of the BRP. The really consumed or produced energy is derived from the real metered data from each metering point aggregated to the level of scheduled trading products exchanged on the MBA market by each BRP.

These data are firstly collected on each metering point by Metered Data Collector, validated from the codes allocated to each BRP at the physical delivery of the electricity by Metered Data Responsible and aggregated to the level of the total energy consumed or produced to the members of each BRP by the Metered Data Aggregator.

The roles involving to the metering process of the real energy consumed and generated such as Metered Data Collector, Metered Data Responsible and Metered Data Aggregator are supportive additional roles to this case and the metering process itself is out of scope of this MBA use case. So only the imbalance process is modeled taking as fact the possession of the real energy consumed and generated measured data for each BRP by the Imbalance Settlement Responsible.

Taking into consideration that no energy is being traded outside the MBA system through external trading on MBA use case two as only intra–MBA trading occurs, imbalances

may derive as the differences between the energy defined at the closed contract for production or consumption between the BRP and its clients prosumers and the real energy produced or consumed by the prosumers as measured by the allocated measures as a consequence of BRP's intra – MBA trading.
The imbalances are established in the day of delivery of electricity for the day ahead intervals and financially settled till a future period that reaches a month's time. The System Operator is active only by balancing the network and the energy delivery for each operation time-interval referring to the respective trading time-interval. The eventual imbalances are calculated and settled by the imbalance settlement responsible.
The imbalance process is carried out in three phases.

- Planning phase, in which the BRP's calculate in advance the consumption/production of all their members involved for the day ahead through flex-offers. At the completion of this phase, the system operator informs all the BRP's of what of the planned schedules has been accepted and informs the ISR of all the accepted schedules
- Operational phase, in which the planned and accepted schedules are executed. The System operator takes care of any deviations between planned and executed schedules of consumption and production
- Imbalance Settlement phase, in which - following the date of execution – the Metered data aggregator sends the data to the ISR, who compares the data to aggregated executed schedules and then carries the imbalance settlement itself.

When energy is delivered imbalances can be balanced:

- internally within the MBA when the imbalances of the BRPs participating have opposite sign regarding their position which is positive (long) for having generation (injection) surplus or negative (short) for having load request (take–off) surplus. These imbalances are to be compensated into the MBA system border and are not exposed outside MBA
- externally MBA when the imbalances of the BRPs have the same sign regarding their position and system operator needs to initiate reserve capacities for balancing the system

Moreover, internal imbalances on the MBA are calculated as the sum of the absolute differences between the energy metered for consumption and metered for production on meters allocated to each BRP to the respective energy contracted for consumption and energy contracted of the BRP for all BRPs participating.
The external imbalance is calculated as the difference of the algebraic differences between the energy metered for consumption and metered for production on meters allocated to each BRP to the respective energy contracted for consumption and energy contracted of the BRP for all BRPs participating.
More specifically:

$$Internal\ imbalance = \sum_{BRP=1}^{n} (|P_{G-metered} - P_{G-scheduled}| + |P_{L-metered} - P_{L-scheduled}|)$$

$$External\ imbalance = \sum_{BRP=1}^{n} ((P_{G-metered} - P_{G-scheduled}) - (P_{L-metered} - P_{L-scheduled}))$$

where $P_{G-metered}$ is the energy for production metered, $P_{L-metered}$ is the energy for consumption metered, $P_{G-scheduled}$ is the energy for production contracted, and $P_{L-scheduled}$ is the energy for consumption contracted.

The external imbalance final sign, positive or negative, determines the final sign and position of the whole MBA system. When positive, then the MBA system is in long position having more injections that off – takes and needs to have energy subtracted from the system. When negative, the MBA system is in short position having less injections that off – takes and needs to have energy added to the system

As it is shown on Table 13, there are different options regarding a BRPs position on the imbalance process along with the MBA system's overall position as well. The combination of two determines the imbalance settlement posed for each BRP.

More specifically, under a single imbalance pricing scheme or 'one-price system', the imbalance settlement prices correspond to the marginal price of balancing services of the System's Operator reserves, i.e. either upward for adding energy to the system or downward regulating services for subtracting energy from the system depending on the overall status of the system. The imbalance price is applied for the remaining short and long positions of the BRPs either balanced internally by SO through matching their opposite positions either for reserves capacity intervention injecting or off-taking energy according to the MBA system's overall position, making the imbalance settlement a zero-sum condition for the MBA's System Operator.

Although, there is a difference on the imbalance pricing posed by the MBA's Imbalance Settlement Responsible regarding upward or downward balancing from the system operator to the BRP depending on the BRP's position and how this position contributes or not to the MBA system's overall position. For example, when a BRP's position is negative contributing to the MBA system's negative position, its imbalance settlement price for purchasing energy would be bigger that the system's marginal price derived from the scheduling process for the energy contracted. This is essential for purchasing the extra energy added to the system either from SO reserves capacities either from BRP's having positive sign and position, which means there is available injections to the MBA which is internally balanced by the SO. Same rule applies respectively when MBA system is on negative position as shown on Table 13.

According to each market's characteristics and code of operation for trading and imbalance settlement, the imbalance pricing scheme can be more complex incorporating penalty fees and having different price applied to BRPs having same position to the system's position and to BRPs having opposite position to the system's position.

		MBA SYSTEM IMBALANCE	
		MBA SYSTEM NEGATIVE Injections < off-takes	MBA SYSTEM POSITIVE Injections > off-takes
BRP IMBALANCE	NEGATIVE (short position) Injections < off-takes	Purchases on Imbalance Marginal Price (IMP) > Contracted System's Marginal Price (SMP)	Purchases on Imbalance Marginal Price (IMP) < Contracted System's Marginal Price (SMP)
	POSITIVE (long position) Injections > off-takes	Sells on Imbalance Marginal Price (IMP) > Contracted System's Marginal Price (SMP)	Sells on Imbalance Marginal Price (IMP) < Contracted System's Marginal Price (SMP)

Table 13: BRPs Imbalance Settlement depending to their position to the MBA position

For intra-day markets on the MBA level possible for BRPs participating to trade energy into one-hour-ahead intervals ahead of operation start time, the same process for imbalance settlement is followed as day-ahead. Imbalance Settlement Responsible calculates the imbalances established for each period ahead interval of the delivery day where the System Operator is balancing the MBA network.
However, on intra – day market, the planning phase interval closes the operational phase in time intervals of one hour or less (15 min) according to the market. Especially, with the use of flex-offers with short revoke time on intra-day market the planning phase can virtually coincide with the operational phase resulting to schedules with limited imbalance to their operation (execution). On such occasion the imbalance process doesn't change its conceptual, but differentiates the imbalance pricing scheme, posing bigger penalties for imbalance on intra – day which are related to the extent of imbalance occurs as major discrepancies on one hour ahead scheduled volumes are difficult and costly to be covered.
As extension of the above mentioned, the more closer the planning phase time interval comes to the operational phase time interval on MBA intra-day markets (e.g. 15 min ahead, 5 min ahead, or close to real time), then the intra-day market takes the form of a continuous trading market. One such case the imbalance process as described on the day ahead even on the hour-ahead market becomes even more indiscernible. This is because trading on time intervals such as 5 min close to operation start time takes the form of a continuous trading which balances the previous trading positions of time intervals ahead of the operation start time such as 15 min or one hour ahead. However, as still there is a time delay between the planning phase time interval and the operational time, imbalances will occur resulting to the imbalance process to be followed.

5.3.2.3 Messages

In this subsection only messages exchanged between roles participating on the MBA group use case are described. All the messages are listed in Table 14 for consistency with the BPMN diagram in Figure 70.
Messages exchange and processes perform by the participating roles on this MBA use case two occur on the different domain phases such as Plan, Trade, Operate, Measure Settle, and Bill. The domain phases although generally they have a successive sequence in which they occur in time, specific messages and processes occurring in previous times can be part of latter phases. So, the ending point of each phase doesn't initiate the starting of another, where mostly phases are overlapped for suiting the processes purpose.

Domain model phase	Message	From	To
Plan	Flex-offer Production Bid	BRP (Production RP)	Market Operator
Plan	Flex-offer Consumption Bid	BRP (Consumption RP)	Market Operator
Plan	MBA System Constraints	System Operator	Market Operator
Plan	Constrained Production Schedule	Market Operator	System Operator
Plan	Constrained Consumption Schedule	Market Operator	System Operator
Trade	Constrained Production	System Operator	BRP (Production

	Schedule Approval		RP)
Trade	Constrained Consumption Schedule Approval	System Operator	BRP (Consumption RP)
Settle	Constrained Production/Consumption Schedule Report	System Operator	Imbalance Settlement Responsible
Measure	Metered Production Data	Metered Data Aggregator	BRP (Settlement RP)
Measure	Metered Consumption Data	Metered Data Aggregator	BRP (Settlement RP)
Settle	Metered Data for Production/Consumption	Metered Data Aggregator	Imbalance Settlement Responsible
Bill	Energy Produced according to Schedule Financial Obligation	Imbalance Settlement Responsible	BRP (Settlement RP)
Bill	Energy Consumed according to Schedule Financial Obligation	Imbalance Settlement Responsible	BRP (Settlement RP)
Bill	Imbalance for Production Financial Obligation Penalty	Imbalance Settlement Responsible	BRP (Settlement RP
Bill	Imbalance for Consumption Financial Obligation Penalty	Imbalance Settlement Responsible	BRP (Settlement RP

Table 14: List of messages for the MBA use case 2

During Planning Phase, BRPs declare their production/consumption flex-offers bids to the MBA for satisfying their planned (forecasted) production/consumption of their BG members on time intervals of the day ahead or the hour ahead. Moreover, MBA's Market Operator solves the day ahead or hour-ahead schedule under the constraints posed by the System Operator. The moment the Market Operator has scheduled the flex-offers available on their time interval in a way to satisfy the constraints posed resulting to a viable schedule solution, the flexibilities are fixed and this is the moment where trading phase is intersected with the planning phase. Trading phase for each period ahead interval of the day ahead or hour-ahead markets is confirmed with the approval of the schedules by the System Operator and their exchange to the BRPs participating.
However, sending of approved schedules to Imbalance Settlement Responsible is part of the Settle phase as energy volumes scheduled are the reference for calculating the imbalances.
Trade phase is concluded with the contract verification between BRPs and their prosumers but this message exchange is out of this use case scope as prosumers role are existed on the BG level. The same applied for the operation phase which includes the physical delivery of energy from producers' members to consumers' members of the respective BRPs trading on the MBA. During execution of energy production/consumption of the operation phase schedules, the imbalances identified leads to the activation of System's Operator Reserves Capacities for the physical energy compensation of the

imbalances. These processes are included to the settle phase but are also out of scope of this case as they belong out of MBA borders.

Moreover, the metering processes performed by the Meter responsible roles are occurring on a supportive level of this case, resulting to the exchange message of the Metered Data produced/consumed by the BRPs prosumers from the Metered Data Aggregator to the Imbalance Settlement Responsible (ISR) and the respected BRPs. The sending of Metered Data produced/consumed to the ISR is part of the Settle phase as it is used for calculating imbalances, where the sending of Metered Data produced/consumed to the respective BRPs are subject of the Measure phase.

Finally, the financial obligation of each BRP participated to the trading phase is being proceeded by the ISR on the billing phase. The financial obligation (charge or payment) of each BRP for the energy produced/ consumed according to the schedule is exchanged first between the ISR and BRPs respective settlement responsible parties. The sending of financial obligations (extra charge/ payments and penalties) derived by the imbalances occurred for each BRP follows from the ISR to the BRPs respective settlement responsible parties. The logistical clearance of scheduling – contracting volumes and imbalances lasts about four to five days for each operation interval respective to the period ahead intervals of day-ahead and intra-day markets available after the energy delivery day, where the money transfer can last longer.

The following messages as displayed on Table 14 as well as the processes illustrated on the BPMN diagram are referred also for day ahead and intra-day trading of BRPs on MBA market area. Messages and Processes on day-ahead and intra-day do not change their conceptual. The same messages are delivered and the same processes are performed with the same hierarchy by the same roles. Although, what can be differentiated is the content of messages and the extend of processes which the participant roles form and perform respectively depending on their operation to the conditions and requirements varying from the day-ahead to the intra-day market.

For example, due to the big difference on the time interval delays between declaring the flex-offer bid and operation start time of the offer on day-ahead and hour-ahead markets, scheduling process and the messages exchanged for it is become more straightforward. But, intra-day markets with very limited time interval delay between declaring the flex-offer bid and operation start time (e.g. 15 min ahead or less) lead to a scheduling process which produces schedules of the offered bids without the intervention of the SO, as so close to the operation start time the offered bids are scheduled, traded and served (executed) as they arrive from the BRP’s.

Also, the scheduling process as depicted on BPMN diagram is integrating the initial scheduling solution to the valid and constrained solution to a straightforward constrained solution as the system constraints so such a close operation start time are already known. The final message of MO to SO and the BRPs is the confirmation on not of the scheduling of their offers arrived minutes ago. Any imbalance detected is relatively small, as the error margin in forecast is low and even in RES production where is relatively higher it would be on energy volumes offered and traded that can be compensated on imbalance settlement. Otherwise, the offered bids are rejected when arrive.

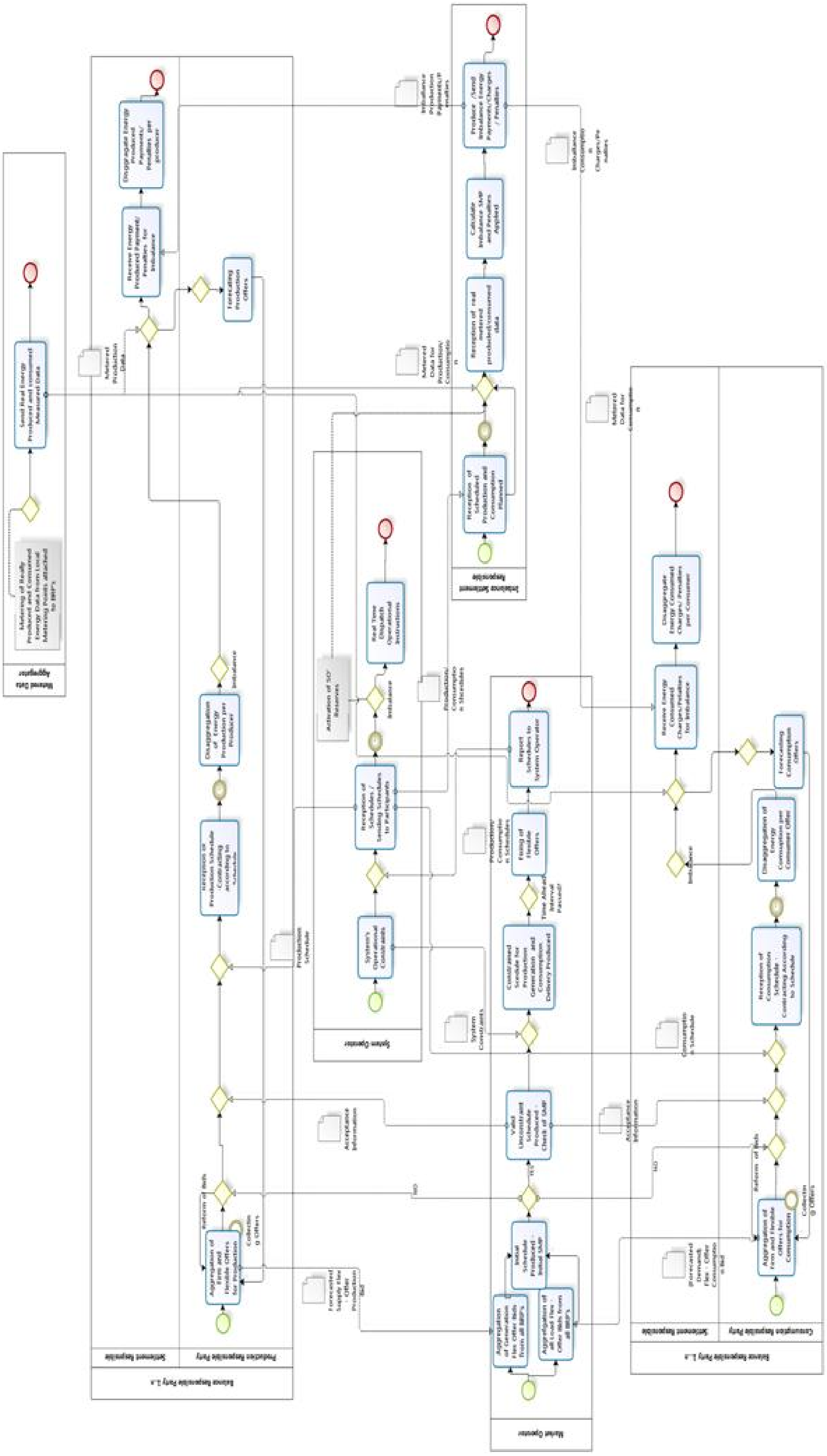

Figure 70: BPMN diagram of the MBA use case 2

5.3.2.4 Unit processes

In this section only processes which are different or new compared to the MBA use case 1 are presented. The roles "Metered Data Aggregator", "System Operator" and "Imbalance Settlement Responsible" participating on the processes, perform the same activity as already described and shall not be analyzed. Also the role "Metered Data Aggregator" is not modeled, as this is a role acting outside the MBA borders, whereas the other two roles are modeled as supportive roles having interactions with the active roles in MBA use case.

Forecasting

The Metered Data derived by the measurements of the Metered Data Aggregator, are used by the BRPs for better prediction of their consumption/production offers which through the aggregation process will result in their bids to the Market Operator. On the production side, the producers on closed contracts need the forecasting to provide the production of flex-offers into their bids. Specifically for the flex- offers for production forecasting of RES, meteorological data along with historical time series data are used.
On the consumption side for the flex-offer for consumption forecast, long chronological series are used in order to estimate the deviation of energy products offered for consumption on closed contracts which are used on a repeated trend having base and peaks.

Aggregation

There are in principle two levels of aggregation in the MBA system.
The first aggregation may be carried out by the BRPs aggregating he collected great number of flex-offers for consumption/production of various sizes. BRP aggregation results in the flex-offers (flexible energy products) for consumption/ production declared to the market as “flex-offer bids”. The BRPs allocate the flex-offers to the most preferred operation interval according to their revoke times and depending, inter alia, on the forecast data available the moment they declare their bids to the MO. We can treat this operation as “pre-processing” by BRPs, before submitting the flex-offer bids to the Market Operator for auctioning.
The second level aggregation is implemented by the Market Operator receiving all the different (aggregated) flex-offer bids for consumption and production by the respective BRPs. This process is similar to the aggregation of flex-offers of prosumers in the BG, with the constraints imposed by the type of trading process, which is modified two-side pool auctioning.

Matching with Scheduling

All the flex-offer bids collected up by the MO are sorted according to their price bid constraint and scheduled to get a market flex-demand on the one hand, and flex-supply curve on the other, for every hour. The MO processes the different flex-offer bids for consumption and the flex-offer bids for production, scheduling them in a preferred flexible operation interval (Traded period), with their revoke times allowing minimizing the gap till their operation start time. In this way, the best matching of supply/demand can be achieved. Best matching of supply/demand takes into consideration the latest MBA system’s position negative or positive, referring to production surplus or consumption surplus, targeting for less imbalances.
Any forecast change that modifies the overall situation in the MBA, can be covered with a different allocation of flex-offer bids. That leads the MO to perform different scheduling of flex-offer bids for improved matching results.

As described above, the Market Operator allocates the declared flex-offer bids for production sale and consumption purchase, according to the latest data for the MBA system position. The result of all the flex-offer bids scheduled, are MBA flex-demand and flex-supply curve for every period – ahead interval in question (hours mostly).
Therefore, the demand and supply curves are matched providing schedules for each period ahead interval, either for the day ahead or for the hour ahead (intra-day) market at a single price through a modified double-sided auction process. For a different allocation of flexible offers (i.e. for different Traded period), another price may derive. Generally, the displacement of flex-offer bids within their flexible operation interval (Traded period) may produce an area of price equilibriums for each hour ahead interval in question and of course to different energy volumes matched.
The Market Operator proceeds with the auction steps to get the final schedules with the preferred allocation of flex-offer bids depending on the data reflecting the trading situation in the MBA system. If MBA system trading situation becomes balanced under different flex-offer allocations, MO will confirm the one satisfying all bids and system constraints maximizing the volumes traded on the least price.
On each flex-supply curve and each flex-demand curve with the preferred flex-offer bid allocation, the MO performs the auction steps to provide

- Initial schedule solution
- Valid schedule solution
- Constrained schedule solution as depicted in Figure 71.

The initial schedule solution is derived through a simple bid matching of the flex-offer bids, ignoring any operational conditions or grid system constraints. The result is an area of initial market clearing prices (or auction prices or SMPs) for every hour and an area of trade volumes for every consumption flex-offer bid matched with a respective production bid as depicted in Figure 72. The area of different market clearing prices is the area formed at the intersection of the flex-demand and supply curves reflecting the different possibilities of the flex-offer allocation . Each SMP price at intersection of the flex-offer curves results to a maximized trade volume. For the area of SMPs formed, a respective area of maximum volumes traded exists. If there is no intersection for another allocation of flex-offer at the market level aggregation, this means that there is no initial solution provided and this may trigger a second round of submitting flex-offer bids by the BRPs.
Subsequently, the initial solution has to be checked against all the conditions added to the bid. For a block of flex-offer bids matched, an average of the market clearing prices for the hours included in the bid is calculated. This price has to be equal or better than the price limit stated by each of the participating BRP to satisfy the bid included in the block bid matched (minimum income (sales) or maximum payment (purchases) condition). Respectively all set of average clearing prices derived by the different flex-offers allocations of the aggregated block bid should satisfy that bid constraint as well; for those that do not satisfy it, the specific schedule which will derive, will not be valid.
Consequently, if not all conditions are satisfied for any flex-offer allocation of the flex-offer bid in question, the price solution is not valid. In this case one of the unfulfilled flex-offer bids is eliminated and the price calculation is run again. This checking process is iterated until all the remaining flex-offer bids can be fulfilled.
The trade volumes of the matched flex-offer bids have also to be checked against the transmission grid constraints set by SO. If there are transmission constraints for maximum energy volumes transmitted through the MBA network not satisfied, the valid schedules have to be balanced either by only adjusting the trade volumes or by adjusting the trade volumes and re-running the iterative bid matching or by splitting the market into several areas.

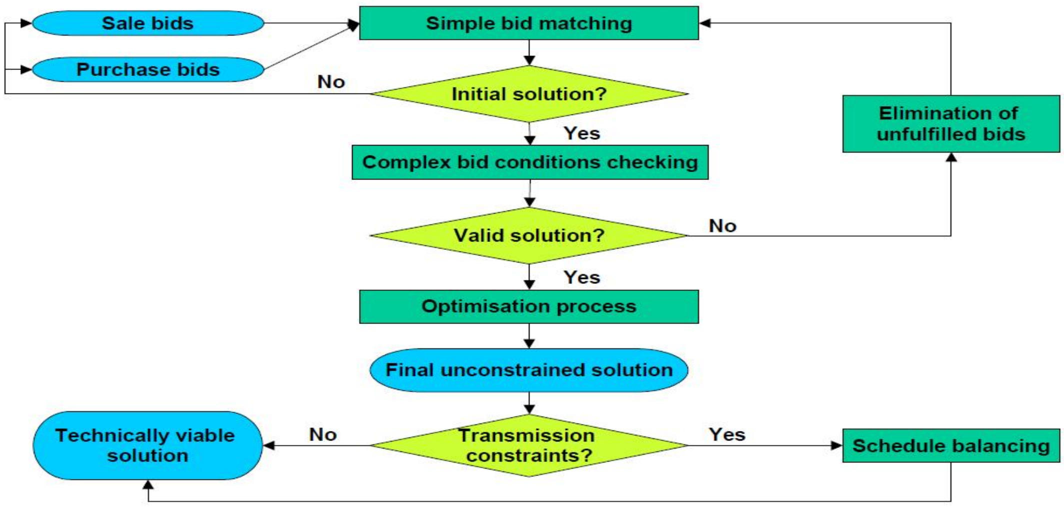

Figure 71: Auction process steps

The optional valid schedules due to the different flex-offers allocations have also to satisfy the SO constraint, otherwise they are rejected. When MO has come to a result of a constraint schedule derived from the preferred flex-offer allocation during aggregation of the bids and the flex-offers revoke time hasn't been violated, then the flexibilities become fixed and the schedules are definite.

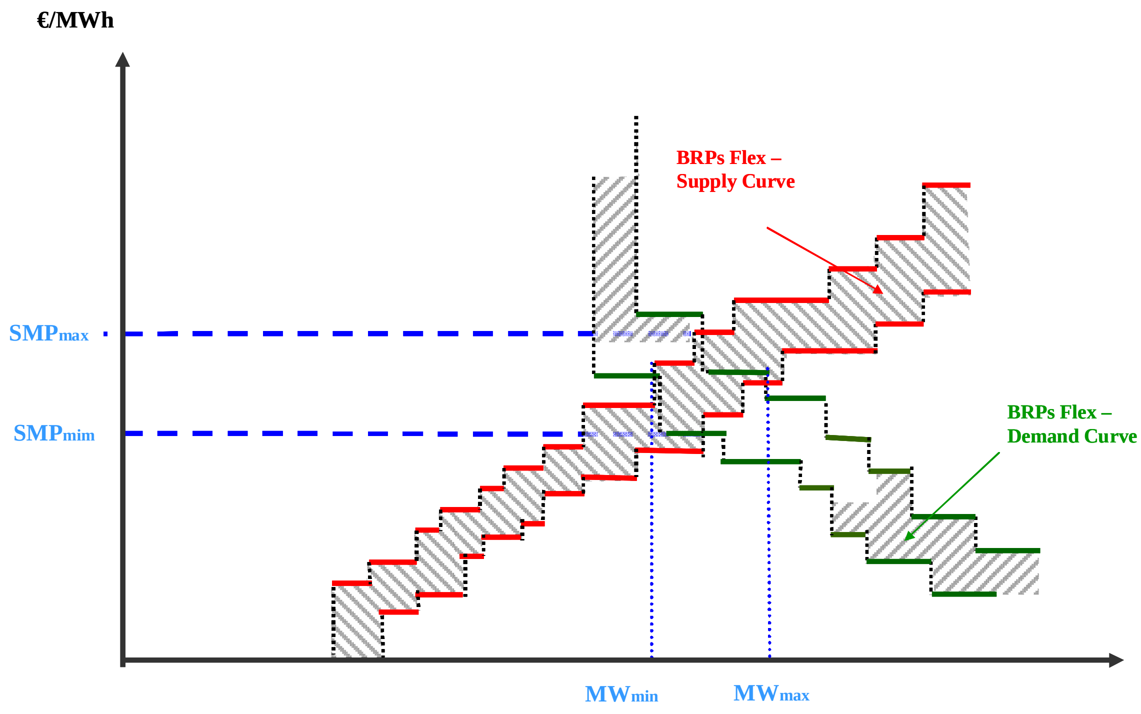

Figure 72: Double Side Auction Simple Bid Matching

Contracting

The contracting is provided after the double side auctioning process has been completed resulting to final schedules where the production and consumption for each period ahead interval in question is matched, having the flex-offers fixed. With the flexibilities fixed, the final schedules along with the closed contracts are used for disaggregation and energy delivery.

Disaggregation
After the final schedule has defined the flex-offer bid offered by the BRP to the MBA market to be fulfilled at a SMP price with the flexibilities fixed at a certain way, BRP has to disaggregate the included firm and flex-offers to each producer and consumer of the BG, respectively.

5.3.2.5 Role Model

The role model in Market Balance use case 2 involves the following roles

- Balance responsible party for production side
- Balance responsible party for consumption side
- Market Operator
-

In addition the following roles are involved as a boundary

- Metered data responsible
- Imbalance settlement responsible
- System operator

Role Model for MBA use case 2 is depicted on Figure 73.

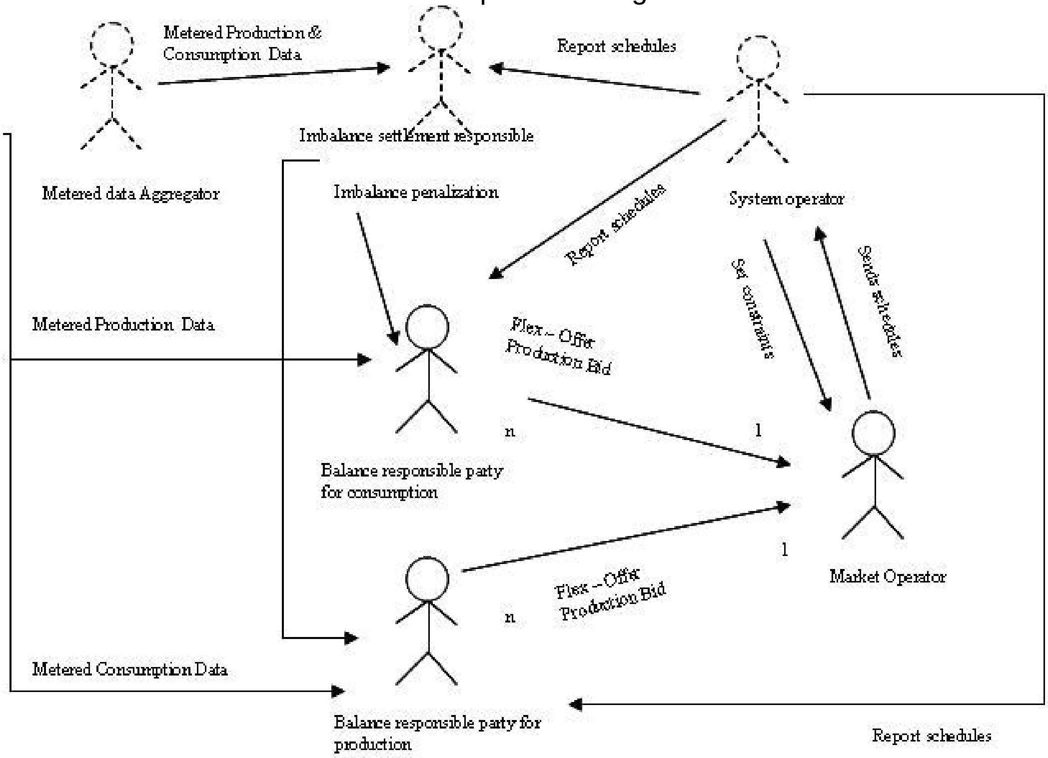

Figure 73: Role Model of MBA use case 2

5.3.3 Market Balance Area use case 3: External energy trading

5.3.3.1 Process

The external trading with other MBAs has to be introduced because of the following reasons.

- Internal energy sale process is not capable to match all the production offers with the consumption.
- Market price situation significantly differs from the internal price situation - i.e. there is a lot of (surplus low priced) wind energy on the market
- All inter-BG trading within the MBA could not balance the MBA.

Scenario 3 concerns the view of Energy market between different MBAs. The inter-MBA trading process involves trading of capacities, besides trading of energy.
The involved roles of the Harmonized model in these processes are:

- BRP - Interconnection Trade Responsible (ITR)
- Capacity Trader
- System operator
- Nomination Validator
- Transmission Capacity Allocator

Besides the roles already introduced in the use cases MBA Use Case 1 and MBA Use case 2, the additional roles in this Use case are related to capacity trading:

- Transmission Capacity Allocator, which acts at the interconnection between two Market Balance Areas
- Capacity trader, which performs bidding of capacities on behalf of BRP's-ITR's
- Nomination Validator and System Operator perform the necessary joint and supportive functions for these trading processes

Energy trading and capacity trading is done either separately (explicit auctioning of capacity) or together (implicit auctioning of capacity). In the EbIX model, only auction-based trading of capacities is defined [ECAN08].
Allocated transmission capacity, which can be on a long-term daily or intraday basis, is validated during the final day ahead or intra-day scheduling process for cross-border transactions.

The external trading is introduced into the MBA internal process in the same way as it would be a result of aggregation of another prosumer’s flex-offer. Actually, the external offers would be the result of processing the prosumer’s flex-offers if another external MBA on this market area were using the Miracle. Therefore it is very important that the outputs of particular processes in the Miracle are similar to the present market standards, i.e. that Miracle should set up some internal market situation on the level of the MBA. For example, the following situations should be handled by Miracle at external trading:

1. The MBA has a balanced electricity production and consumption. On the market there are more expensive supply (producers') offers and lower demand (consumers’) offers. The Market Operator of MBA shall provide internal matching of production and consumption but before that, the BRPs in the MBA can launch all their offers to the external market for reducing the price gap between production and consumption offers and catching the chance for some profit when the market situation changes.

2. In the MBA there is a balanced electricity production and consumption. On the market there is a lot of cheap energy. The ensemble of the relevant roles in the MBA should be capable of reducing its own (expensive) production and rescheduling the consumption to consume the cheap electricity. The reduced expensive electricity from its production can still be launched on the market, but probably will not be sold. It may be sold on the external market, providing there is a proper price difference.
3. In the MBA there is a balanced electricity production and consumption. On the market there is a lot of high consumption offers. The ensemble of the relevant roles in the MBA should be capable of selling its production on the market and rescheduling its consumption for a later time, when the electricity is expected to be cheaper and put their offers to the market.
4. If in the MBA there is an excess of production, then this shall for certain be launched on the market. In the case it is not sold, the production shall not be scheduled and consequently started. It may be sold on the external market, providing there is lack of production there.
5. If in the MBA there is an excess of consumption, then the consumption offers must be put on the market in the form when the cheapest price is expected. That is of course relevant in the case when the consumption was aggregated from flex-offers and it is possible to reschedule it.

It is important to note that a number of these cases can incorporate the policy of increasing RES absorption on the grid, notably 2, 4 and 5.

These situations require the following items from the systems, roles and processes in the MBA:

- MBA needs to settle the reference prices for the production and consumption
- MBA needs some forecasting tool to forecast the electricity market price.
- MBA needs to organize interconnection capacity

In the above paragraphs, to systemic functions of roles and processes within the MBA system has been stressed: while individual roles (BRPs, prosumers, ..) and processes taking place in them are autonomous, their functions are subject to goals, needs and constraints of the MBA system – as a subsystem in the Electricity Market System.
The energy trading of the MBA therefore corresponds with MBA Use Case 1: it is done bi-laterally between 2 BRPs from two different MBAs. The relevant roles and processes are not yet harmonized on MBA level but this process is under development.
By trading between different Market Balance Areas the energy trading is one part. In this specific case also the capacity of the interconnection between different MBAs is a very important factor which has to be taken into account: in order to do the energy trading, transmission capacities for inter-MBA energy flow have to be assured. The transmission capacity auctions are usually done some hours before closing of the electricity market auctions. This increases the uncertainty the trader has when valuing transmission capacity (which he has to do before submitting his bid). This means that capacity auctions can be organized according to MBA Use Case 2. All relevant information on today's situation of capacity auctions can be found in [WGS10].
Transmission capacity trading is organized by the Transmission capacity allocator, which therefore play a function similar to the function of Market operator within MBA.
As already mentioned, while energy trading is done directly by the BRPs (ITRs), the capacity trading is done through the intermediary of capacity traders.

Since two MBAs are involved, the energy flow schedules and capacity allocation schedules have to be monitored and approved on both sides by respective System Operator and Nomination Validator, which is the role taking care of the capacities.

5.3.3.2 Definition of terms and acronyms

Additionally to definitions in Section 5.1.3, some specific definitions and acronyms related to capacity trading, as defined by the Harmonized model document [ECAN08] are described here.

AAC: Already Allocated Capacity is the total amount of allocated transmission rights, whether they are capacity or exchange programmes depending on the allocation method.

Allocated capacity market: A market area where the transmission capacity between the balance areas is given to the Balance Responsible Parties according to rules carried out by a Transmission Capacity Allocator. Trade between balance areas is carried out on a bilateral or unilateral basis.

ATC: Available Transmission Capacity is the part of NTC that remains available, after each phase of the allocation procedure, for further commercial activity. ATC is given by the following equation: ATC = NTC- AAC.

Bid: A bid represents a request for a given capacity at a given price made by a Capacity Trader and corresponds to a single time series within a Bid document.

Bidding period: The date and time when an auction opens for bidding until the date and time when bidding is stopped.

Capacity Trader: A party that has a contract to participate in the capacity market to acquire capacity through a Transmission Capacity Allocator. Note: The capacity may be acquired on behalf of an Interconnection Trade Responsible or for sale on Secondary Capacity Markets.

Explicit auctioning: signifies that what is auctioned is the transmission capacity rights to transfer energy.

Flow-based Offered Capacity: signifies that no ATC is calculated prior to auction. The Offered Capacity is calculated with an optimisation process based on the bids (price driven).

Implicit auctioning: signifies that what is auctioned is both the energy itself and transmission capacity rights together.

Interconnection Trade Responsible: Is a Balance Responsible Party or depends on one. He is recognized by the Nomination Validator for the nomination of already allocated capacity.

Long term contract (LTC): A binding agreement that gives the right to use capacity for a period superior to one whole day.

Nomination Validator: depends on one or more System Operators and has the responsibility of ensuring that all capacity nominated is within the allowed limits and confirming all valid nominations to all involved parties. He informs the Interconnection Trade Responsible of the maximum nominated capacity allowed. Depending upon market rules for a given interconnection the corresponding System operators may appoint one Nomination Validator.

NTC: Net Transfer Capacity is defined as NTC = TTC – TRM and corresponds to the maximum exchange between two areas compatible with security standards applicable in both areas and taking into account the technical uncertainties on future network conditions.

Offered Capacity: Is a part of or equivalent to the ATC that will be offered by the Transmission Capacity Allocator to the market. Depending on Market Rules, the calculation of the Offered Capacity may include the consideration of firm exchange programs in one direction, to increase the Offered Capacity in the other direction. This is generally known as Netting aimed at maximizing Offered Capacity.

Rule based allocations: These cover the allocation of capacity based on a given algorithm such as first come, first serve or proportional to request. This is a particularity for the allocation of intraday capacity when local market rules do not require an auction allocation.

Transmission Capacity Allocator: Manages, on behalf of the System Operators, the allocation of available transmission capacity for an Allocated capacity area. He offers the available transmission capacity to the market, allocates the available transmission capacity to individual Capacity Traders and calculates the billing amount of already allocated capacities to the Capacity Traders.

TRM: Transmission Reliability Margin is a security margin that copes with uncertainties on the computed TTC values arising from:
a) Unintended deviations of physical flows during operation due to the physical functioning of load-frequency regulation
b) Emergency exchanges between SOs to cope with unexpected unbalanced situations in real time
c) Inaccuracies, e.g. in data collection and measurements

TTC: Total Transfer Capacity TTC is the maximum exchange program between two areas compatible with operational security standards applicable at each system if future network conditions, generation and load patterns were perfectly known in advance.

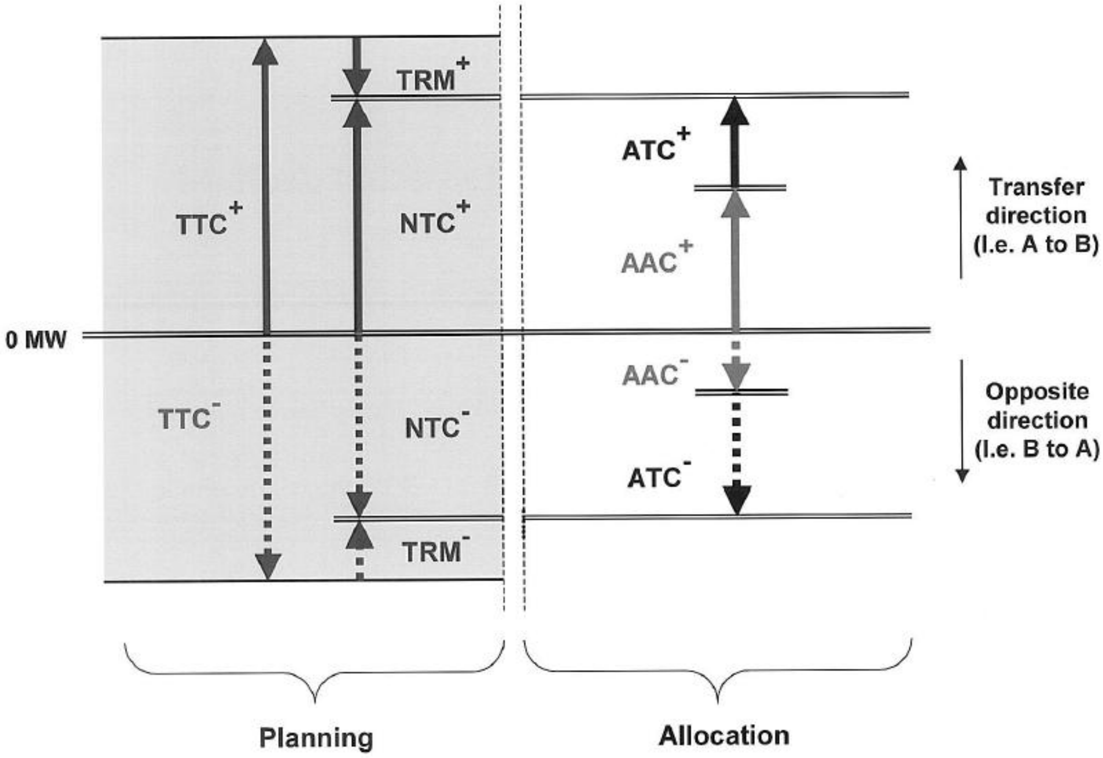

Figure 74: Transfer capacity definitions [ETSO01c]

5.3.3.3 Overview of capacity allocation and nomination

5.3.3.3.1 Introduction

There are some network grids within the ETSO domain which are affected by structural congestion. Various congestion management methods such as, explicit auctioning, implicit auctioning, explicit auctioning involving two or more System Operators, etc. have been devised and implemented.

The prerequisite for each of these methods is a transparent, non-discriminatory capacity allocation process in compliance with European regulations in particular EC 1228/2003.

Allocated transmission capacity, which can be on a long-term daily or intra-day basis, is validated during the final day ahead or intra-day Scheduling process for cross border transactions.

Generic information models adopted by the Harmonized model for the data exchange between the Transmission Capacity Allocator, the System Operators and the various market players participating in the capacity market for cross border scheduling are provided by implementation guide document on capacity allocation and nomination [ECAN08]. The information models in question cover the essential requirements of all the congestion management methods identified above.

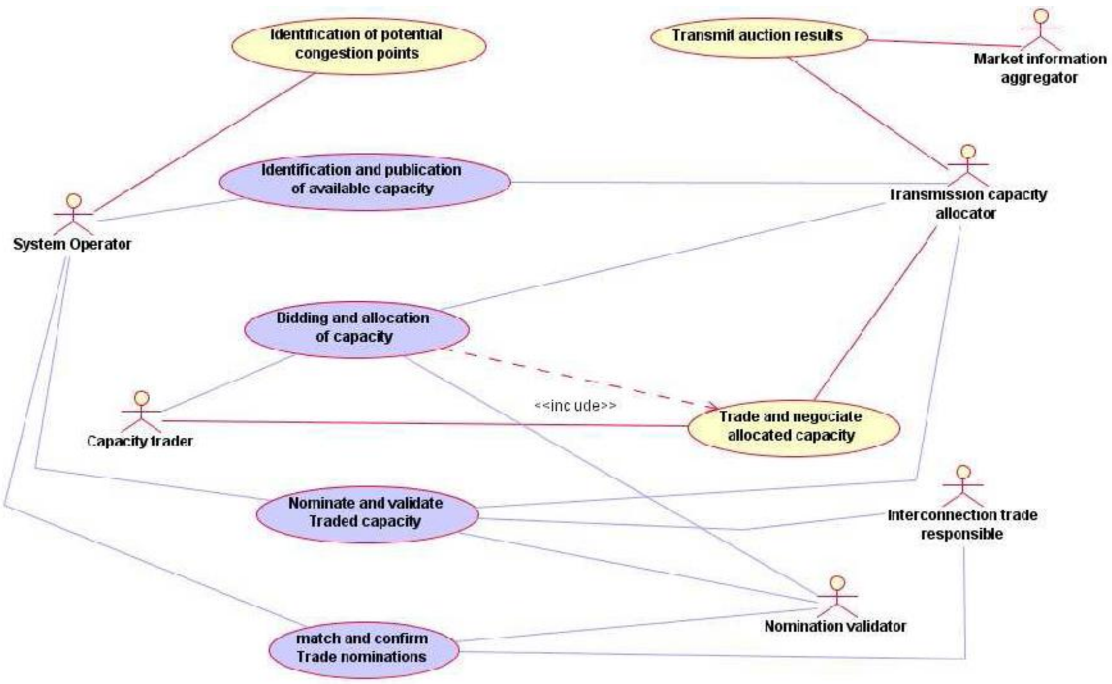

Figure 75: Use case of the transmission capacity allocation process

Figure 75 outlines the generic steps that are required in a capacity allocation process. The capacity allocation and nomination process is carried out in four steps [ECAN08]:

1. Identification and publication of all available transmission capacity that can be allocated: The available capacity has initially to be agreed between the System Operators. Once agreed it is made available to the market participants. The main actors in the process are the System Operators and the Transmission Capacity Allocator.
2. The bidding and allocation activity itself: This is done by Capacity Traders through the intermediary of Transmission Capacity Allocator. The principle actors are the Capacity Trader and the Transmission Capacity Allocator.
   The Capacity Trader has a capacity trading contract with the Transmission Capacity Allocator. Trading is done on behalf of Interconnection Trade Responsibles (ITR is a sub-role of BRP) based on trading and negotiation of allocated capacity between or Capacity Traders and ITR's. The Capacity Trader generally buys capacity on behalf of an ITR or sells allocated capacity to an ITR in a trading and negotiation process of allocated capacity.
   The Interconnection Trade Responsible makes use of capacity on the MBA border. The Capacity Trader provides the information to the Transmission Capacity Allocator of any evolutions to his original capacity contract.
3. Nomination is the activity of declaring the long term and daily capacity to be used. This involves the ITR, the Nomination Validator and the System Operator. The Nomination Validator ensures that all nominations presented are coherent.
4. Validation and final confirmation of all nominations: This step includes cross border matching. The principle actors are the Nomination Validator and the System Operators on both sides.

As already observed, this procedure defines the information flows on the day ahead capacity allocation market for explicit auctioning. It caters for the daily and long term capacity allocation markets. It is sufficiently generic to permit its use in several other market contexts.

5.3.3.3.2 Determine Offered Capacity

In the various auction implementations throughout Europe, the ATC is being interpreted in a wider sense than the definition provided above. Indeed, the ATC may be the available capacity from one *or more* Market balance Areas to one *or more* Market Balance Areas. The NTC definition is extended in a similar manner. The Offered Capacity is part of this ATC.
The Roles that take part in the ATC calculation are:

- System Operators who perform all network security calculations and has the overall responsibility for the definition of Offered Capacity between Market Balance Areas;
- Nomination Validator who provides data on confirmed nominations;
- Transmission Capacity Allocator who provides data on the AAC.

The basic data to be exchanged are:

- The NTC from one or more Market Balance Areas to one or more Market Balance Areas;
- The nominations of all allocated transmission capacity rights between the Market Balance Areas;
- The allocated capacity in all previous auctions that affect the given allocation period;
- The Offered Capacity for confirmation purposes.

There are three major steps in the determination of the Offered Capacity:

1. System Operator agreement on the NTC;
For each concerned allocation period (multi-annual, annual, quarterly, monthly, daily, etc.) each System Operator carries out independent studies in order to calculate the corresponding NTC. As long as each System Operator uses different models, data and hypotheses for this calculation, different NTC values are expected. This data must be exchanged between System Operators in order to track the calculations.

2. System Operator agreement on the ATC;
Each System Operator must receive information: from the Transmission Capacity Allocator regarding the capacity auctioned/sold in the previous allocation periods if applicable. This information is pertinent only in the case where this capacity is not required to be nominated before the auction of the given allocation period. This ATC is sent to all involved System Operators. If necessary, and depending on the auction organization, one System Operator is responsible for determining the minimum ATC from the values provided and communicating this value to all System Operators concerned.
3. System Operator agreement on the Offered Capacity.
Each System Operator must receive information from the Nomination Validator regarding firm nominations of capacity previously allocated if applicable; these nominations must be agreed between System Operators as required by the market rules.
The principles of establishing ATC and Offered Capacity must be agreed between the System Operators. Once agreed, the ATC and offered values are calculated based on the agreed NTC without exchange and agreement of the new quantities between the system operators.

5.3.3.3.3 Bidding and capacity allocation

Receive bids

Bids must have been received by the Transmission Capacity Allocator during the bidding period on the day of the Auction. A predefined validation window will verify that the correctness of all bids for the auction in question (for example an bidding period of two months where the Offered Capacity is not necessarily known and a validation period of five days before the auction closure). At the end of the bidding period, allocation is determined based on auction rules.

Determine allocation

The Transmission Capacity Allocator allocates the capacity to the Capacity Traders according to applicable auction rules.

For example in the case of TSO Auction if the sum of the capacity for which valid bids have been submitted is equal to or less than the amount of the capacity available for the auction, the Clearing Price is nil. If the total amount of capacity for which valid Bids have been submitted exceeds the available capacity for the Auction in question, the highest Bid(s) for Capacity in an amount that does not exceed the available Capacity is (are) accepted. The then remaining capacity is awarded to the Capacity Trader(s) which has (have) submitted the next highest bid(s) for capacity in an amount that does not exceed the remaining capacity; and so on for capacity remaining after that.

Provide information of auction results

Each Capacity Trader is informed of the outcome of its bid(s) after the bidding period in compliance with auction rules.

The results of the Auction are made available by the Transmission Capacity Allocator.

Rule based allocations

Rule based allocations cover the allocation of capacity based on a given algorithm such as first come, first serve or proportional to request. This follows in an identical manner the auction process with the exception of the requirement for a bid price in the Bid document. This is a particularity of the allocation of intraday capacity when local market rules do not require an auction allocation.

Inform System Operator of allocated capacity

The Transmission Capacity Allocator informs the relevant System Operators of the allocated capacity being the outcome of the auction.

Nominate use of border capacity

In previous stages Interconnection Trade Responsible did not participate at all and it is in this phase where they must nominate capacity to the Nomination Validator.

Already Allocated Capacity (physical rights) has been acquired in the different auctions by the Capacity Traders, but responsibility of using that capacity is with the Interconnection Trade Responsible. So, in cases where the Capacity Trader has sold his allocated transmission rights, partially or completely, on a secondary market, it is necessary that the Capacity Trader informs the Transmission Capacity Allocator. The Capacity Trader shall also keep informed the Interconnection Trade Responsible involved of the capacity that is planned for nomination. The Transmission Capacity Allocator informs the Nomination Validator of the volume and identification (transfer identification, contract …) of the capacity which can be used by the Interconnection Trade Responsible. The nomination Validator informs the Interconnection Trade Responsibles of the capacity that they are authorised to nominate.

Interconnection Trade Responsibles declare to the appropriate Nomination Validator the capacity they are going to use (long term and daily Nominations). The mechanisms to declare the use of the acquired capacity may vary from interconnection to interconnection (i.e. the capacity can be declared as the execution of an energy exchange program in the interconnection or by means of a specific capacity use declaration).

Validate nominations
With the complete list of the Interconnection Trade Responsibles who have the transmission rights for nomination, the Nomination Validator must check that nomination from Interconnection Trade Responsibles do not exceed the amount of capacity that the Capacity Traders have communicated. So, the Nomination Validator will reject nominations if they exceed the amount of capacity.

Inform System Operator of nominations
Valid long term and daily Nominations are then sent to the System Operator by the Nomination Validator.

Match nominations between System Operators
Regional matching rules are applied, for example, in the UCTE area this process is carried out in compliance with the UCTE Operation Handbook Policy 2 ESS implementation.

Confirm nominations
After the nominations have been matched between System Operators each System Operator confirms nominations to the Nomination Validator. The Nomination Validator confirms capacity nominations to Interconnection Trade Responsible.

5.3.3.4 The explicit transmission capacity allocation process sequencing overview

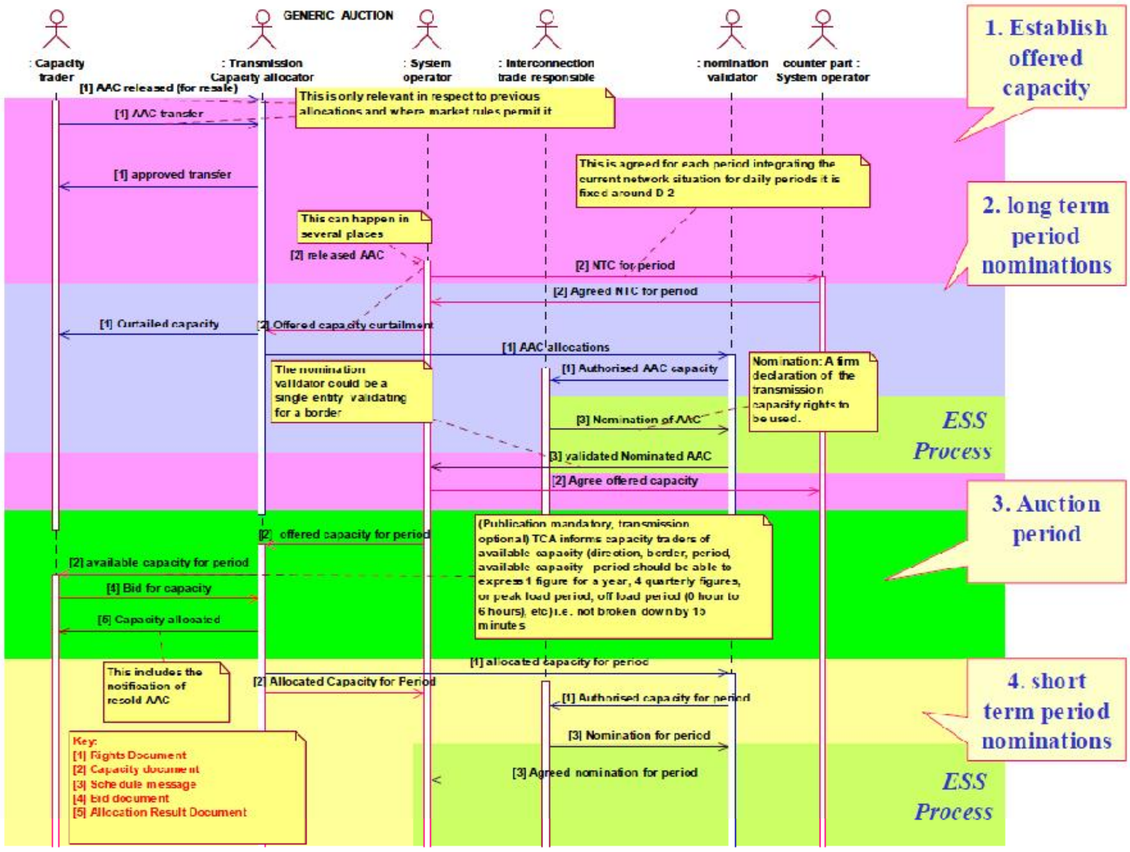

Figure 76: Information sequence flow – Periodic auction sequence

The sequence diagram shown in Figure 76 provides a basic overview of the information requirements for the allocation of capacity through a periodic explicit auction.

The auction process is initialised by the two System Operators on the border who mutually agree to the NTC that is to be available for the border and period in question.

If in order to ensure network security, the System Operator found necessary to curtail the AAC from a previous auction, the System Operator informs the corresponding Transmission Capacity Allocator of the curtailment that will have to be imposed. The Transmission Capacity Allocator informs the Capacity Traders of the new curtailed AAC.

Once all the relevant information concerning the AAC from previous auctions are known, the Transmission Capacity Allocator informs the Nomination Validator of the final AAC allocation values that are available for nomination by Interconnection Trade Responsibles. The Interconnection Trade Responsibles are then informed of the AAC they are authorised to nominate. The AAC nominations are then submitted by the Interconnection Trade Responsibles to the Nomination Validator who verifies their coherence and informs the System Operator of all approved nominations.

The System Operators are informed by the Nomination Validator of the agreed nominated AAC. From the agreed NTC values the System Operators separate the ATC values into different classes per period depending on the profile that they have mutually defined and after deduction of any “Historical contracts” that they may have to honour and deduction of any reservations to comply with market rules. The AAC nominations are also taken into consideration at this stage. This results in the available capacity for auction. The System Operators agree from this value the capacity that is to be offered to the market for auction. The resulting Offered Capacity is transmitted to the Transmission Capacity Allocator who makes the information available to the market.

The Capacity Traders that are registered with the Transmission Capacity Allocator bid for the different capacities that are available. At the closure of the auction the Transmission Capacity Allocator determines the capacity allocation depending on the agreed auctioning process.

Each Capacity Trader is then informed of his successful and unsuccessful bids. In cases where the Capacity Trader is permitted to release AAC that he holds from a previous auction to be integrated into the capacity auction the Transmission Capacity Allocator informs him of the amount of released AAC that has been successfully sold during the auction. The System Operator and the Nomination Validator are informed by the

Once all the relevant information concerning the AAC from previous auctions are known, the Transmission Capacity Allocator informs the Nomination Validator of the final AAC allocation values that are available for nomination by Interconnection Trade Responsibles. The Interconnection Trade Responsibles are then informed of the AAC they are authorised to nominate. The AAC nominations are then submitted by the Interconnection Trade Responsibles to the Nomination Validator who verifies their coherence and informs the System Operator of all approved nominations.

The System Operators are informed by the Nomination Validator of the agreed nominated AAC. From the agreed NTC values the System Operators separate the ATC values into different classes per period depending on the profile that they have mutually defined and after deduction of any “Historical contracts” that they may have to honour and deduction of any reservations to comply with market rules. The AAC nominations are also taken into consideration at this stage. This results in the available capacity for auction. The System Operators agree from this value the capacity that is to be offered to the market for auction. The resulting Offered Capacity is transmitted to the Transmission Capacity Allocator who makes the information available to the market.

The Capacity Traders that are registered with the Transmission Capacity Allocator bid for the different capacities that are available. At the closure of the auction the Transmission Capacity Allocator determines the capacity allocation depending on the agreed auctioning process.

Each Capacity Trader is then informed of his successful and unsuccessful bids. In cases where the Capacity Trader is permitted to release AAC that he holds from a previous auction to be integrated into the capacity auction the Transmission Capacity Allocator informs him of the amount of released AAC that has been successfully sold during the auction. The System Operator and the Nomination Validator are informed by the Transmission Capacity Allocator of all the AAC for the period. Finally the Nomination Validator informs the Interconnection Trade Responsibles of the authorised capacity resulting from the auction [ECAN08].

5.3.3.5 Use of Miracle flex technology and flexibilities management

As the trading processes of both energy and capacities is essentially the same as the intra-MBA trading processes of Use case 1 and 2, we assume that the Miracle flex technology could be used also in these trading processes.

Based on the five situations in external trading, described in Section 5.3.3.1 above, the basic scenario for flexibilities management will involve: i) maximizing (or minimizing) the inter-MBA energy transfer, and ii) minimizing the mismatch between the traded energy and allocated capacities.

For this scenario, we envisage two cases for the use of flexibilities:

1. Only flexibilities in energy trading can be used

In this case, the trading of capacities is done as presently defined by the Harmonized model and fixed capacities are allocated to the ITR (BRP). This seems to be the realistic case, as long as capacities market is not established on the SOs‘ level between different SOs, as heralded by the German project (cf. 3.2.4.8).

The ITR uses flex-offer only in energy trading: he starts capacities trading with accepted flex-offers and

- For capacity trading it fixes the flexibilities, i.e. transforms flex-offer into fixed offer, at values it estimates as best strategy
- after the allocated capacities are known, it assigns the flex-offer, i.e. fixes the flexibilities for energy trading. In this way it reduces the mismatch between the allocated capacities and the capacities needed for the energy flow.

2. Flexibilities both in energy and in capacity trading can be used

   In this case, trading of capacities is also done using the Miracle flex-technology. This case we do not foresee as realistic until further evolution of Harmonized model is attempted by the major stakeholders in the European Electricity Market.

   The ITR uses flex-offer both for capacities trading and for energy trading. In this case, the ITR will use combined strategy for Use case 1 and for use case 2. The ITR’s flexibilities management strategy will make use both of Revoke periods for capacities trading and for energy trading. For that, a „conditional“ or „cross“ strategy for optimum use of revoke periods in capacities trading and in energy trading will have to be defined. We think that defining these processes is outside the scope of the Miracle project.

Leaving the task of allocating interconnector capacity to the market (in the sense of using at least 3 different auctions, at least one for capacity and two for day-ahead markets, each with different gate-closure times and therefore inconsistent expectations), does often not lead to optimal (or even ‘good’) allocation decisions.

The reason for this is uncertainty in expectations: electric power prices are very volatile in nature and thus is the spread between two power prices an arbitrator would have to estimate in order to express his valuation for cross border capacity between those market areas. As already mentioned, capacity auctions are usually done some hours before closing of the electricity market auctions. This increases the uncertainty the trader has when valuing transmission capacity (which he has to do before submitting his bid).

To improve this mechanism, implicit auctions can be used—meaning that cross-border capacity is allocated implicitly within the auctioning of energy in the interconnected electricity markets. Therefore trading electricity becomes less complex, the aforementioned inefficiencies are avoided and scarce interconnector capacity is used more economically.

The main terms used to describe the implementation of implicit auctions are ‘market splitting’ and ‘market coupling’. The definitions for the two approaches found in the literature [ETSO 2001a; Grim08; Dieck08] vary, but market splitting is used to describe a market operated by a single power exchange, whereas market coupling refers rather to a co-operation of multiple power exchanges.

Under both set-ups, the market participants simply place their bids on the respective market, if necessary including a related area. The clearing of the market(s) is then done considering transmission capacity and local bids simultaneously, leading to an optimal allocation.

In a bi-lateral environment, the market coupling is —theoretically—easy to implement. However, today’s electricity grids are highly meshed and coupling projects do often incorporate more than two areas. This is exhibited in Figure 77: The physical result of withdrawing 100 MW in Region A intending to deliver it in Region B may lead to physical flows totally different from what could have been intuitively expected. This leads to the insight that cross-border capacity has to be carefully assessed, it is therefore not possible to offer the full physical capacity of the line to the market.

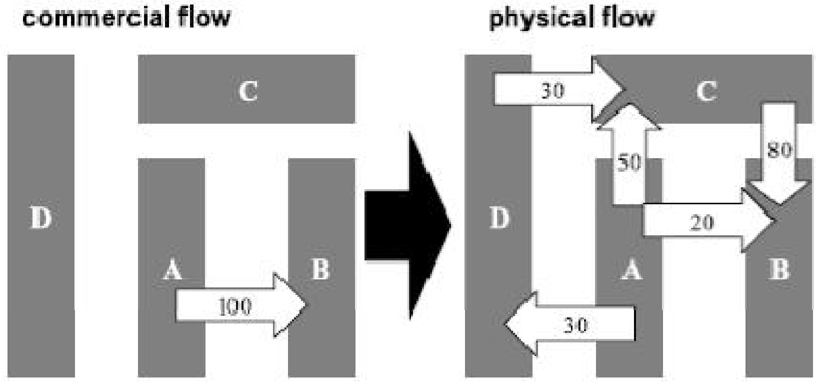

Figure 77: In highly meshed grids, a commercial flow of 100 MW from Region A to B might lead to a totally counter-intuitive physical result [WGS10]

Not only would possible loop flows be neglected, operational security would also be put at stake since some physical capacity is always needed to safely cope with contingencies. The assessment of the capacities which can safely be offered to the market is commonly done by load-flow calculations which assume a “base case” scenario (of plant dispatch and consumption).

Then, production is shifted from one region to another to examine whether operational security can still be guaranteed in that case. The maximum value not affecting static system security is then reduced by a reliability margin to cope with loop flows and contingencies.

Capacities are related to the problems of balancing the energy flows on the grid, which is not a process within the primary systems as defined by Miracle roles and process model, but it constitutes one of the primary goals that has to be better assured by Miracle by better balancing through the flexibilities management.

However, the problems of balancing the energy flows on the grid are catered to also by SO’s reserves capacities. In the present state of Harmonized model, this segment of the EEM is not yet harmonized – i.e. it is not yet treated as a market but left to individual countries SO’s. This segment represent a logical next step in harmonization efforts, which has already been considered and also undertaken in some countries; the project in Germany seems to be forerunner in these efforts (c.f. Section 3.2.4.8).

5.4 Conclusion

The process descriptions and analyses in the use cases showed that processes like “aggregation”, “scheduling” and “price setting” are closely coupled and cannot be described independently on either Balance group or Market balance area levels. The “capping” process was named “matching” and it suggests that an iterative procedure is needed to reach the optimization criteria. The “contracting” process is confirming the matching result and fixing the flexibilities.

The analyses of the flex-offer content suggested to enhance it with additional parameters “acceptance” and “assignment”, which are necessary for the prosumer to control the load or the production unit. These parameters have also important influence on the matching algorithm process. In the present electricity market system, the Market operator defines the “trading period” (day-ahead, hour-ahead…) and the users (suppliers) need to adapt the timing of their offers to it. On the other hand, on the level of the BRP the acceptance and assignment of the flex-offers define the trading period.

The use of the Miracle technology on the level of the Market Operator transfers the flexibilities to the higher level for external trading. The present Electricity Market System rules obligates the fixed energy flow at contracting point, therefore it is suggested that Market Operator is assigned to a new task of the scheduling the flexibilities before they are finally fixed at the point of contracting. In order to carry this active function out properly, the Market Operator will need to have some optimization criteria, which are necessary for the matching process.

6 Miracle Role and process model

The primary goal of Miracle role model is to make it suitable for largest possible energy market.
With the advent of the Harmonized model of the Electricity market in Europe, the task of defining the Miracle role model is facilitated, since the harmonization process under way is striving towards coherent union of national markets on pan-European level.
The Miracle role model is therefore limited to identifying those parts of the complete Harmonized role model which participate in carrying out or interacting with the primary processes as defined and used by Miracle. Thus, the Miracle role model is defined by the following main conventions and boundary conditions:

- The relation of Miracle System components and systems to categories of Harmonized market model
  Inspection of the Harmonized role model documents [ETSO09] shows that the following relations hold between these categories
  - system components in Miracle = roles in Harmonized model
  - subsystems in Miracle = domains in Harmonized model
- Identification of roles used in Use cases
  As already discussed, these roles fall into two categories:
  - Roles carrying out primary processes: Intra BG, intra MBA
  - Roles carrying out primary process in MA, if they directly interact/communicate with roles in the paragraph 1 above
  - Roles carrying out joint and supportive processes if they directly interact/communicate with roles in the paragraph 1 above
- In some cases the Harmonized model allows for further structuring of roles functions by defining a set of new roles which are “a kind of” the original “envelope” or generic role. In these cases, the Miracle model will use the generic role unless the finely structured functionality is deemed necessary for modeling the processes in Miracle.
  An example of such generic role is Trade responsible Party with further possible structuring into Trade responsible party, Consumption responsible party, Production responsible party and Interconnection responsible party.
  This “integration” is principle suitable for roles in joint and supportive processes, which we do not model, but in some case also for primary processes.
- Conversely, in some cases the roles in the Harmonized model might be too generic for the purpose of developing the Miracle technology. In such cases a part of the functions of the role can be modeled separately as an additional role within Miracle. Such a role will functionally always be a sub-role of the original role in the Harmonized model.

In the following subsections, the Miracle roles will be defined for each primary subsystem:

- Balance Group, as use case
- Market Balance Area, as use case
- Market Area; for this subsystem only in the extent that these roles participate in the other two primary subsystems.

6.1 Roles involved in the Balance Group use case

The roles inside BG carry out the primary process, structured into unit processes and interact with the processes in the environment of the BG carried out by the neighboring roles.

For the Balance group use cases, the roles which participate in the processes, and the subsystem of the Electricity market system which they are part of, are presented in Table 15.

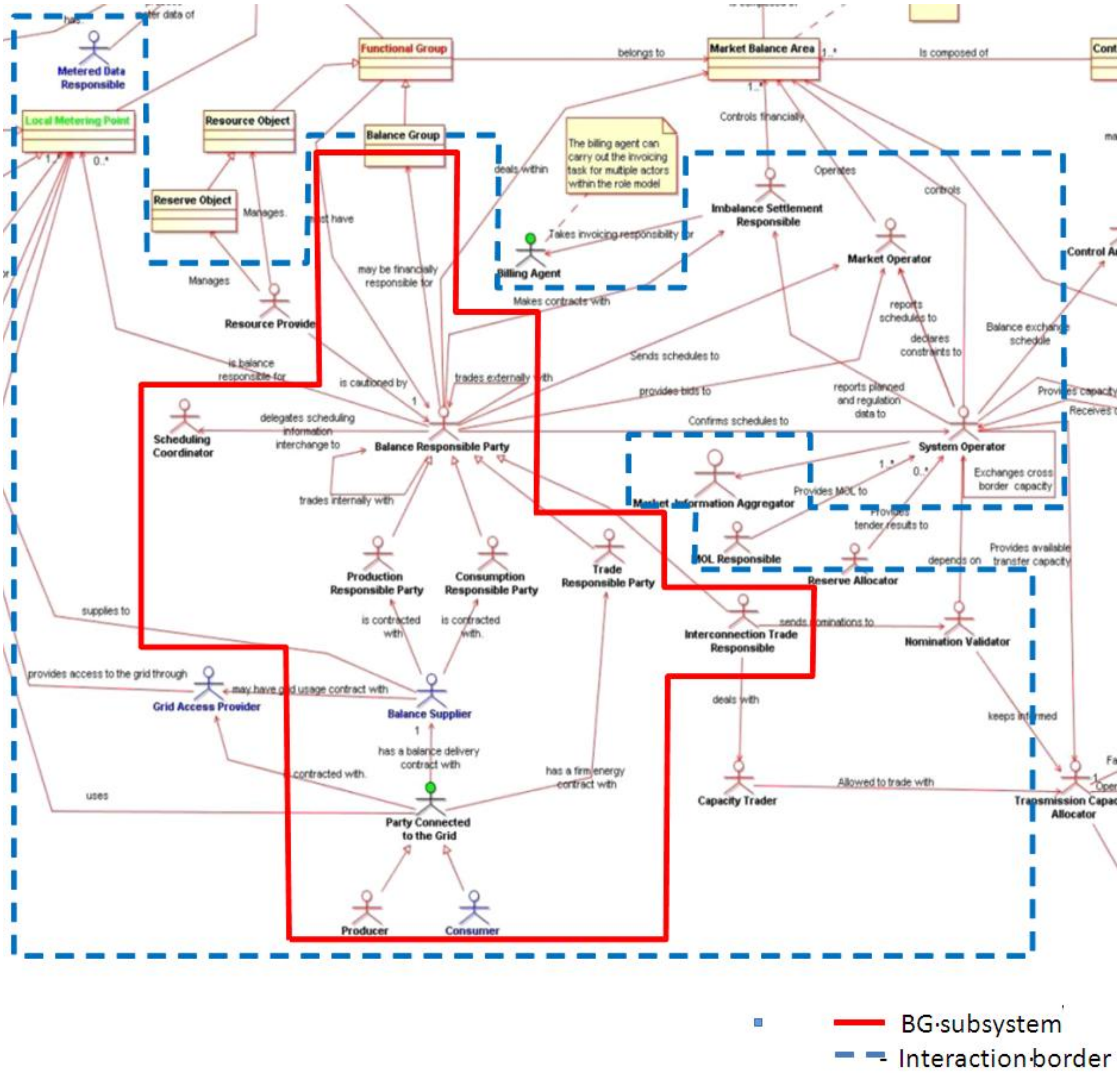

Figure 78: Delineation of the Balance Group subsystem and its interaction border with the surrounding part of the Electricity Market of the Harmonized market model

Subsystem (domain)	Type of subsystem	Role	Note
Balance Group	Primary	Consumer	
Balance Group	Primary	Producer	
Balance Group	Primary	Balance supplier	
Balance Group	Primary	Balance responsible party (BRP)	
Balance Group	Primary	Settlement responsible	Miracle role, sub role of BRP
Market Balance Area	Primary	Market operator	

Market Balance Area	Primary	Imbalance Settlement responsible	
Control Area, Market Balance Area	Joint and supportive	System operator	
Local Metering Point	Joint and supportive	Metered data responsible	

Table 15: Roles participating in the Balance group use cases and their domains

6.2 Roles involved in the Market Balance Area use case

The roles inside Market Balance Area (MBA) carry out the primary process, structured into unit processes and interact with the processes in the environment of the MBA carried out by the neighboring roles.

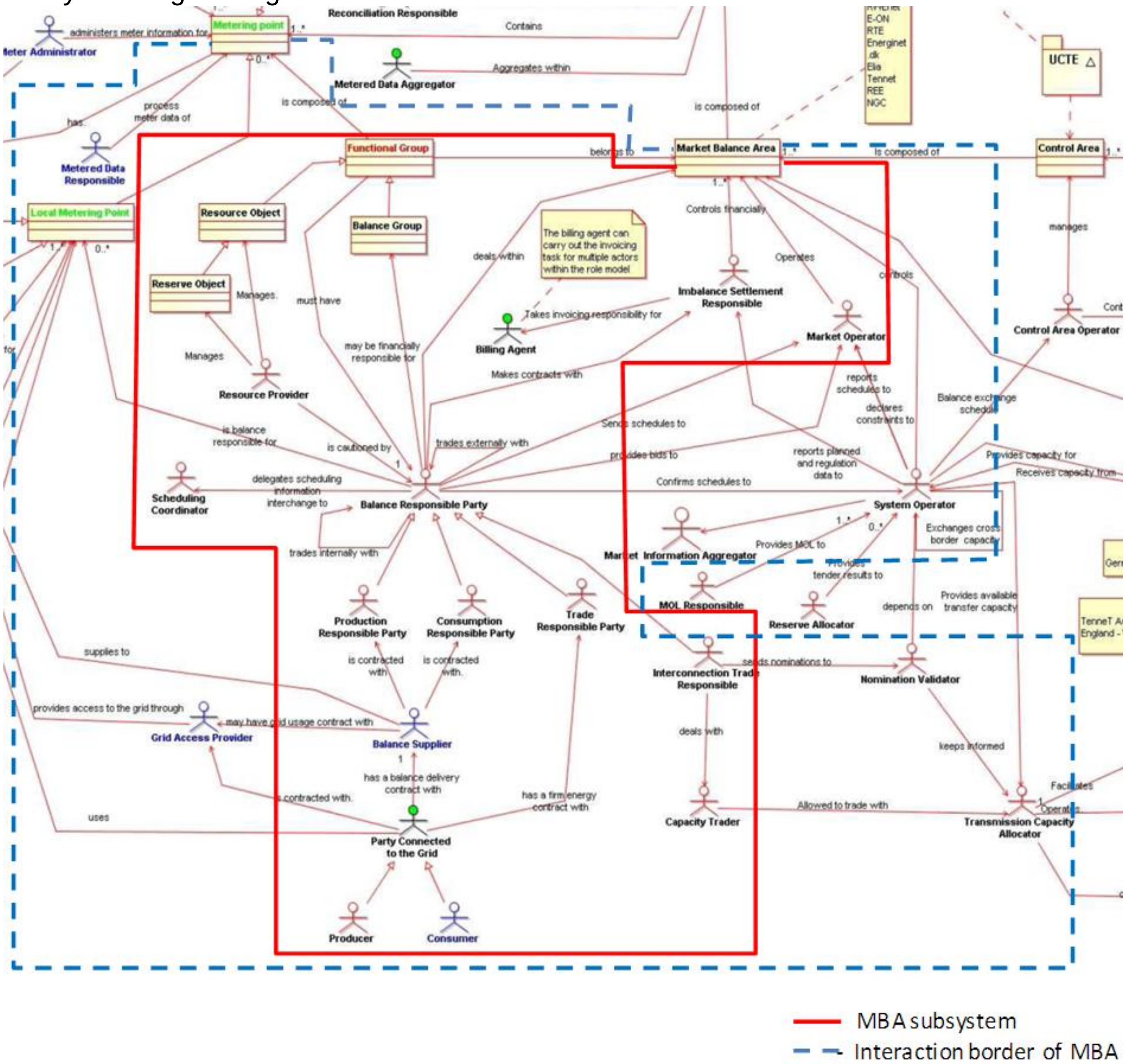

Figure 79: Delineation of the Market Balance Area subsystem and its interaction border with the surrounding part of the Electricity Market of the Harmonized market model

In the Figure 79 above, it can be noticed that the roles and domains of the Reserve Resource Process System are delineated from the MBA use cases. This system is part of the Market Balance Area and in it there is an electricity market process carried out, but it is a separate process organized by TSO for the purpose of maintaining the grid reserves and apart from the mainstream market processes taking place between BPR's. Presently, it is felt that the Miracle model will not be applicable for this market (secondary market); it would have to be modeled as a separate use case, which does not seem to be justifiable.
For the Market Balance Area use cases, the roles which participate in the processes, and the subsystem of the Electricity market system which they are part of, are presented in Table 16.

Subsystem (domain)	Type of subsystem	Role	Note
Balance Group	Primary	Balance responsible party (BRP)	
Market Balance Area	Primary	Market operator	
Market Balance Area	Primary	Imbalance Settlement responsible	
Market Balance Area	Primary	Capacity Trader	
Control Area, Market Balance Area	Joint and supportive	System operator	
Control Area	Joint and supportive	Control Area Operator	
Metering Point	Joint and supportive	Metered data responsible	
Market Area (Common Capacity Area, Allocated Capacity Area, Capacity Market Area)	Primary	Nomination validator	
Market Area (with variants)	Primary	Capacity trader	

Table 16: Roles participating in the Market Balance Area use cases and their domains

6.3 Roles involved in Market Area

This level of the Electrical Energy Market is not yet harmonized in the Harmonized model: specific types of MA's are recognized and the trading process is not completely developed. For this reason, this level is not fully addressed by the Miracle roles and processes model and we do not analyze it in a separate use case; only roles interacting in MBA use case are considered.

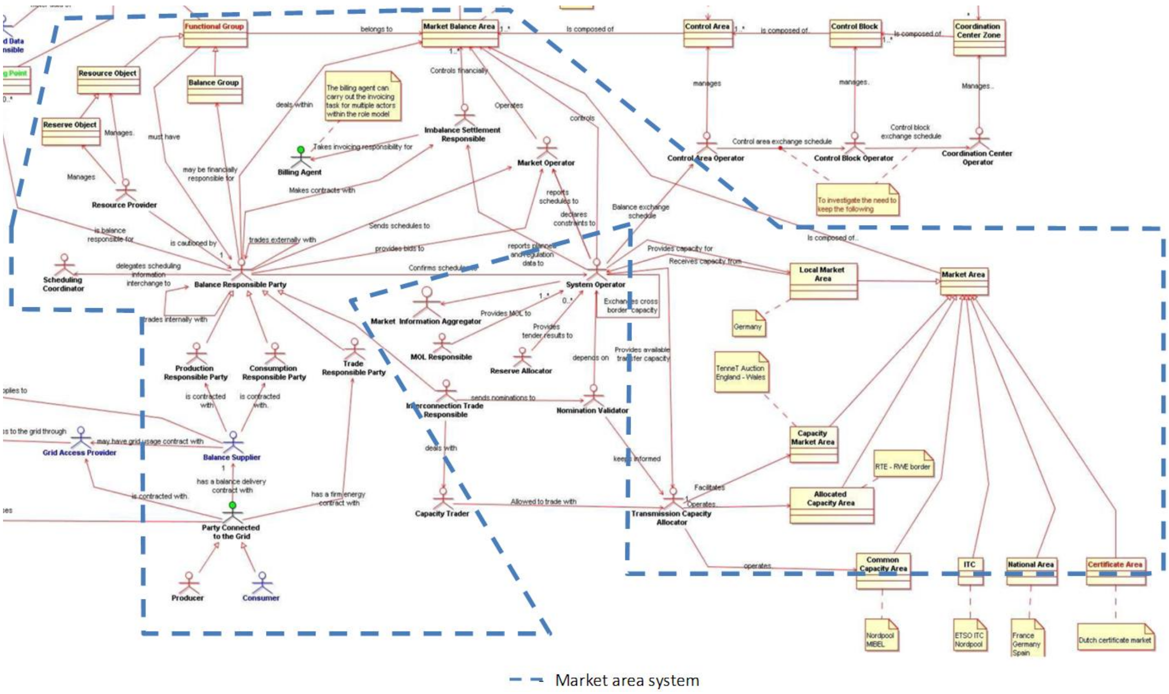

Figure 80: Delineation of the Market Area subsystem in the Electricity Market of the Harmonized market model

Subsystem (domain)	Type of subsystem	Role	Note
Market Balance Area	Primary	Market operator	
Market Balance Area	Primary	Imbalance Settlement responsible	
Market Balance Area	Primary	Capacity Trader	
Control Area, Market Balance Area	Joint and supportive	System operator	
Control Area	Joint and supportive	Control Area Operator	
Metering Grid Area Point	Joint and supportive	Reconciliation responsible	
Metering Grid Area Point	Joint and supportive	Metered Data Aggregator	
Market Area (Common Capacity Area, Allocated Capacity Area, Capacity Market Area)	Primary	Nomination validator	
(Local) Market Area (with variants)	Primary	Capacity trader	

Table 17: For the Market Balance Area processes, typically the following roles participate

As already mentioned, this subsystem is not yet sufficiently harmonized to model it with the same process model as the previous two subsystems; what is more, it is functionally incomplete as a primary subsystem in terms of intended Miracle technology. For these reasons, it is not included in the use case scenarios; the roles of this system are important only insofar as they represent the interacting environment of the Market Balance Area subsystem.

6.4 List of roles and domains in Miracle model

The complete list of the roles and domains involved in the three primary subsystems, as described in the previous subsections, constitutes the roles and domains of the Miracle model. As already described in Section 5.1.3., the domains in the Harmonized model represent subsystems of the Electricity market system. The complete list of these roles is presented in Table 18, and the list of domains in Table 19. For comparison, both the description of their functions in the Harmonized model [ETSO09] and additional description of their functionality in terms of processes carried out within the scope of Miracle are included.

Roles		
Role name	Description	
	The Harmonized Electricity Market Role Model	Additional Miracle
Balance Responsible Party	A party that has a contract proving financial security and identifying balance responsibility with the imbalance settlement responsible of the market balance area entitling the party to operate in the market. This is the only role allowing a party to buy or sell energy on a wholesale level. ***Additional information:*** The meaning of the word "balance" in this context signifies that that the quantity contracted to provide or to consume must be equal to the quantity really provided or consumed. Such a party is often owned by a number of market players. Equivalent to "Program responsible party" in the Netherlands. Equivalent to "Balance responsible group" in Germany. Equivalent to "market agent" in Spain.	Responsible role for closed contract trading (intra-BG) is the Balance responsible Party. BRP is also responsible for external (inter-BG) energy trading, i.e. wholesale trading for the BG.
Balance Supplier	A party that markets the difference between actual metered energy consumption and the energy bought with firm energy contracts by the party connected to the grid. In addition the balance supplier markets any difference with the firm energy contract (of the party connected to the grid) and the metered production. ***Additional information:*** There is only one balance supplier for each metering point.	Balance Supplier buys/sells the necessary energy of the prosumers on open contracts. The necessary energy is sold to/bought from balance responsible party.
Billing Agent	The party responsible for invoicing a concerned party. ***Note:*** This role has been introduced into the role model in order to underline the fact that the Imbalance settlement responsible has not the responsibility to invoice. However this role is not specific to the settlement process and may be used in other processes as required.	This role is not modeled separately from Imbalance Settlement responsible.
Consumer	A party that consumes electricity.	A party which makes closed

	Additional information: This is a Type of Party Connected to the Grid	contracts with BRP, sends the consumption flexibilities and consumes energy according to the received schedule
Consumption Responsible Party	A party who can be brought to rights, legally and financially, for any imbalance between energy bought and consumed for all associated metering points. ***Additional information:*** This is a type of Balance Responsible Party	This role is not modeled separately from BRP in Miracle, but it is useful for proper structuring of unit processes performed by BRP
Control Block Operator	Responsible for : 1. The coordination of exchanges between its associated control blocks and the organization of the coordination of exchange programs between its related control areas. 2. The load frequency control within its own block and ensuring that its control areas respect their obligations in respect to load frequency control and time deviation. 3. The organization of the settlement and/or compensation between its control areas.	The role is part of the joint subsystem, not modeled by Miracle, and not directly interacting
Coordination Center Operator	Responsible for : 1. The coordination of exchange programs between its related control blocks and for the exchanges between its associated coordination center zones. 2. Ensuring that its control blocks respect their obligations in respect to load frequency control. 3. Calculating the time deviation in cooperation with the associated coordination centers. 4. Carrying out the settlement and/or compensation between its control blocks and against the other coordination center zones.	The role is part of the joint subsystem, not modeled by Miracle, and not directly interacting
Grid Access Provider	A party responsible for providing access to the grid through a local metering point and its use for energy consumption or production to the party connected to the grid.	The role is part of the supportive subsystem, not modeled by Miracle, and not directly interacting
Grid Operator	A party that operates one or more grids.	
Imbalance Settlement Responsible	A party that is responsible for settlement of the difference between the contracted quantities and the realized quantities of energy products for the balance responsible parties in a market balance area.	
Interconnection Trade Responsible	Is a Balance Responsible Party or depends on one. He is recognised by the Nomination Validator for the nomination of already allocated capacity. ***Additional information:*** A party that is responsible for settlement of the difference between the contracted quantities and the realized quantities of energy products for the balance responsible parties in a market balance area. This is a type of Balance Responsible Party	This role is not modeled separately from BRP in Miracle, but it is useful for proper structuring of unit processes performed by BRP

Market Operator	The unique power exchange of trades for the actual delivery of energy that receives the bids from the Balance Responsible Parties that have a contract to bid. The market operator determines the market energy price for the market balance area after applying technical constraints from the system operator. It may also establish the price for the reconciliation within a metering grid area.	At Miracle project in MBA use case the MO has additional functionality of handling the flexibilities what includes the aggregation scheduling and contracting the BRP flexibilities.
Meter Administrator	A party responsible for keeping a database of meters.	The role is part of the supportive subsystem, not modeled by Miracle, and not directly interacting
Meter Operator	A party responsible for installing, maintaining, testing, certifying and decommissioning physical meters.	The role is part of the supportive subsystem, not modeled by Miracle, and not directly interacting
Metered Data Collector	A party responsible for meter reading and quality control of the reading	The role is part of the supportive subsystem, not modeled by Miracle, and not directly interacting
Metered Data Aggregator	A party responsible for the establishment and qualification of metered data from the Metered data responsible. This data is aggregated according to a defined set of market rules	
Metering Point Administrator	A party responsible for registering the parties linked to the metering points in a grid area and its technical specification. He is responsible for creating and terminating metering points.	The role is part of the supportive subsystem, not modeled by Miracle, and not directly interacting
Nomination Validator	Has the responsibility of ensuring that all capacity nominated is within the allowed limits and confirming all valid nominations to all involved parties. He informs the Interconnection Trade Responsible of the maximum nominated capacity allowed. Depending on market rules for a given interconnection the corresponding System Operators may appoint one Nomination Validator.	
Party Connected to the Grid	A party that contracts for the right to consume or produce electricity at a metering point.	
Producer	A party that produces electricity	A party which makes closed contracts with BRP, sends the production flexibilities and produces energy according to the received schedule. Additionally the producer may make an open contract with the balance supplier,
Production Responsible Party	A party who can be brought to rights, legally and financially, for any imbalance between energy sold and produced for all associated	This role is not modeled separately from BRP in Miracle, but it is useful for

	metering points.	proper structuring of unit processes performed by BRP
Reconciliation Accountable	A party that is financially accountable for the reconciled volume of energy products for a profiled Local metering point.	The role is part of the joint subsystem, not modeled by Miracle, and not directly interacting
Reconciliation Responsible	A party that is responsible for reconciling, within a Metering grid area, the volumes used in the imbalance settlement process for profiled metering points and the actual metered quantities.	The role is part of the joint subsystem, not modeled by Miracle, and not directly interacting
Resource Provider	A role that manages a resource object and provides the schedules for it	
Scheduling Coordinator	A party that is responsible for the schedule information and its exchange on behalf of a balance responsible party. For example in the Polish market a Scheduling Coordinator is responsible for information interchange for scheduling and settlement.	This role is not modeled separately from BRP in Miracle
Settlement Responsible	N/A	The imbalance settlement in BG for consumers and producers (and Balance suppliers) is carried out by BRP – Settlement responsible. In Miracle, we model it as a separate role (sub-role of BRP)
System Operator	organization of physical balance) through a transmission grid in a geographical area. The SO will also determine and be responsible for cross border capacity and exchanges. If necessary he may reduce allocated capacity to ensure operational stability. Transmission as mentioned above means "the transport of electricity on the extra high or high voltage network with a view to its delivery to final customers or to distributors. Operation of transmission includes as well the tasks of system operation concerning its management of energy flows, reliability of the system and availability of all necessary system services." (definition taken from the UCTE Operation handbook Glossary).	
Trade Responsible Party	A party who can be brought to rights, legally and financially, for any imbalance between energy bought and consumed for all associated metering points. ***Note:*** A power exchange without any privileged responsibilities acts as a Trade Responsible Party.	This role is not modeled separately from BRP in Miracle, but it is useful for proper structuring of unit processes performed by BRP

Table 18: Roles in Miracle model

Domains (subsystems)		
Domain (subsystem) name	Description	
	The Harmonized Electricity Market Role Model	Additional Miracle
Allocated Capacity Area	A market area where the transmission capacity between the balance areas is given to the balance responsible parties according to rules carried out by a transmission capacity allocator. Trade between balance areas is carried out on a bilateral or unilateral basis. ***Additional information:*** This is a type of Market Area	3rd level primary subsystem of the electricity market system (incomplete
Balance Group	A collection of metering points for imbalance settlement ***Note:*** Equivalent to "balance group" (Bilanzgruppe) in the Austrian market or (Bilanzkreis) in the German market German definition: It is composed of a various number of metering points within a Market balance area. ***Additional information:*** This is a type of Functional group	1st level primary subsystem of electricity market system (analyzed in BG Use cases)
Capacity Market Area	A market area where the transmission capacity between the balance areas is given to the balance responsible parties in a price based process separated from trading carried out by a transmission capacity allocator. Trade between balance areas is carried out on a bilateral unilateral basis. ***For example,*** The auctioning system between TenneT and RWE Net. ***Additional information:*** This is a type of Market Area	3st level primary subsystem of electricity market system (a type of, conceptually analyzed in MBA use case 3)
Common Capacity Area	A market area where the available transmission capacity between the balance areas is given to the balance responsible parties based on their bidding to the market operator. Trade between balance areas is carried out through the market operator. ***Additional information:*** This is a type of Market Area	3st level primary subsystem of electricity market system (a type of, conceptually partially analyzed in MBA use case 3)
Control Area	The composition of one or more market balance areas under the same technical load frequency control responsibility ***Note:*** In some cases there may be some metering points that belong to a market balance area that is not a part of the control area. However these do not impact the general definition, for example, a village in one country connected to the grid of another.	Joint subsystem, not modeled by Miracle, but interacting
Local Metering Point	The smallest entity for which there is a balance responsibility and where a Balance supplier change can take place. It may be a physical or a logical point.	Supportive subsystem, not modeled by Miracle but interacting

	Additional information: This is a type of Metering Point.	
Local Market Area	A market area where there is no transmission capacity restrictions between the balance areas. ***Additional information:*** This is a type of Market Area	3rd level primary subsystem of electricity market system (a type of, incomplete)
Market Area	An area made up of several balance areas interconnected through AC or DC links. Trade is allowed between different balance areas with common market rules for trading across the interconnection.	3rd level primary subsystem of the electricity market system (incomplete)
Market Balance Area	A geographic area consisting of one or more metering grid areas with common market rules for which the settlement responsible party carries out a balance settlement and which has the same price for imbalance. A market balance area may also be defined due to bottlenecks	2nd level primary subsystem of electricity market system (analyzed in MBA Use cases)
Metering Grid Area	A metering grid area is a physical area where consumption, production and exchange can be metered. It is delimited by the placement of meters for period measurement for input to, and withdrawal from the area. It can be used to establish the sum of consumption and production with no period measurement and network losses.	Joint subsystem not modeled by Miracle but interacting
Metering Point	Metering Point	Supportive subsystem not modeled by Miracle but interacting

Table 19: Domains in Miracle model

The list of roles and their functions in the context of Miracle roles and processes model is tentative, at the phase of model draft. The additional description of their functions within the context of Miracle role and process model and the final list of roles will be arrived at through completion of the use case analysis and refinement of process modeling concepts.

7 Correspondences with current role models in selected countries

7.1 Greece

Greece's vertically integrated electricity market model derived from the public ownership of the Public Power Company (PPC) responsible a few years ago for almost all the roles and activities performed on the market from mining of fuel and electricity production to transmission and distribution, supply and pricing to consumers, made Greece's model to have little correspondence with not only the ETSO harmonized role model but also to EC directives about liberation of electricity markets.

However, the reconstruction work on legal framework about liberation of electricity markets has brought Greek electricity market steps forward to an EU convergence. Especially with the institution and operational independence from PPC of the Hellenic Transmission System Operator (HTSO) taking over responsibilities and activities from PPC, the Greek model distributed the roles to these players and along with the legal reforming the prerequisites of more roles participating is viable.

Greek electricity market can be divided in two areas. The Interconnected System Area part of the whole integrated interconnected synchronous European System of UCTE and the Non – Interconnected System Area which includes most of the Greek islands. Day Ahead Programming wholesale markets are available for both areas. For the Interconnected System more BRPs can participate offering their productions or declaring loads, where for the Non – Interconnected System only PPC can participate as the sole BRP for production and consumption as its own generation units are operating on the islands and the all the Non – Interconnected System's consumers are under PPC's responsibility. RES production derived by Independent producers have their production absorbed by the market for the Interconnected and Non – Interconnected System as well by law obligatory, so they only need to declare their units availability and forecast to the system and not to have a BRP responsible for selling their production as it happens with the conventional units production by independent producers.

The Hellenic Transmission System Operator (HTSO) took over the role of Market Operator organizing the operation of the wholesale market for the interconnected system as the non-interconnected system remained under the PPC operation. HTSO also set the operation codes for trading, operating and settlement of the transactions made between the participants. HTSO performs the role of System Operator setting the constraints for the interconnected system but also having under its operation the High Voltage Transmission network controlling all the energy transferred from PPC or independent producers or through interconnections to the distribution network. Moreover, HTSO controls the metering on the TSO level allocating metering registers to the market participants for the energy physical delivery through the TSO network. Finally, HTSO settles all the imbalances derived and facilitates the financial transactions performing the role of the Imbalance Settlement Responsible.

PPC remains the major supplier in Greek Electricity Party responsible for the load coverage of the consumers on the Interconnected System as well as the sole supplier of the consumers on the Non -Interconnected System of the Islands. Moreover, PPC supplies the Market with generation capacity of its own generation units. So PPC performs the role of the BRP offering production for the units under its ownership and the role of the BRP declaring the consumption for the consumers under its contractual responsibility on the Interconnected System and Non -Interconnected System on the respective Day Ahead Electricity Markets for both system areas. PPC also has under its responsibility the Distribution System Operation Network for Medium Voltage and Low Voltage, meaning that other BRPs for supplying their consumers have to make additional contract with PPC for using their DSO grid. Also for every consumer of producer connected to the DSO network a contract with the PPC is made. Regardless how the consumer will be supplied energy for its consumption or the producer will offer its production this contract with the PPC enables consumers to consume energy outside of the closed contract of the consumer with its BRP and producer to have unpredicted energy not offered for its BRP to the market absorbed by the PPC acting as a Balance Supplier the only available for the Greek Electricity Market. PPC also perform all the roles related to the metering on the DSO level.

The BRPs apart from PPC, that have license for participating on the Day Ahead Market of the Interconnected System, are mostly represent independent producers having conventional production units under their ownership offering their production to the market or exporting them through the interconnections available. There are also a few major consumers that have their load declared by BRPs other than PPC, for ensuring them energy supply imported from the Interconnections or from the independent producers but they represent a very small stake on the market (3 to 5 %).

On the following table it is shown how the roles identified by the harmonized model are distributed to the Greek electricity market players.

Greek Market Players	Roles
Electricity Consumer	Consumer
Independent Electricity Producer	Producer
Independent Supplier	Balance responsible party
Independent Supplier for production	Production responsible party
Independent Supplier for trading	Trade responsible party
Independent Supplier for consumption	Consumption responsible party
Independent Supplier for Importing/Exporting Energy	Interconnection responsible party
HTSO	Market Operator
	System Operator
	Imbalance Settlement Responsible
	Transmission Capacity Allocator
	Grid operator on the TSO level
	Meter operator on the TSO level
	Metered data collector on the TSO level
	Metered data responsible on the TSO level
	Metered data aggregator on the TSO level

Greek Market Players	Roles
PPC	Balance responsible party
	Production responsible party
	Trade responsible party
	Consumption responsible party
	Interconnection responsible party
	Balance Supplier
	Grid access provider
	Grid operator on DSO level
	Metering point administrator on DSO level
	Meter operator on DSO level
	Metered data collector on DSO level
	Metered data responsible on DSO level
	Metered data aggregator on DSO level

Table 20: Role distribution on the Greek electricity market players

The Greek role model can be illustrated on Figure 81.

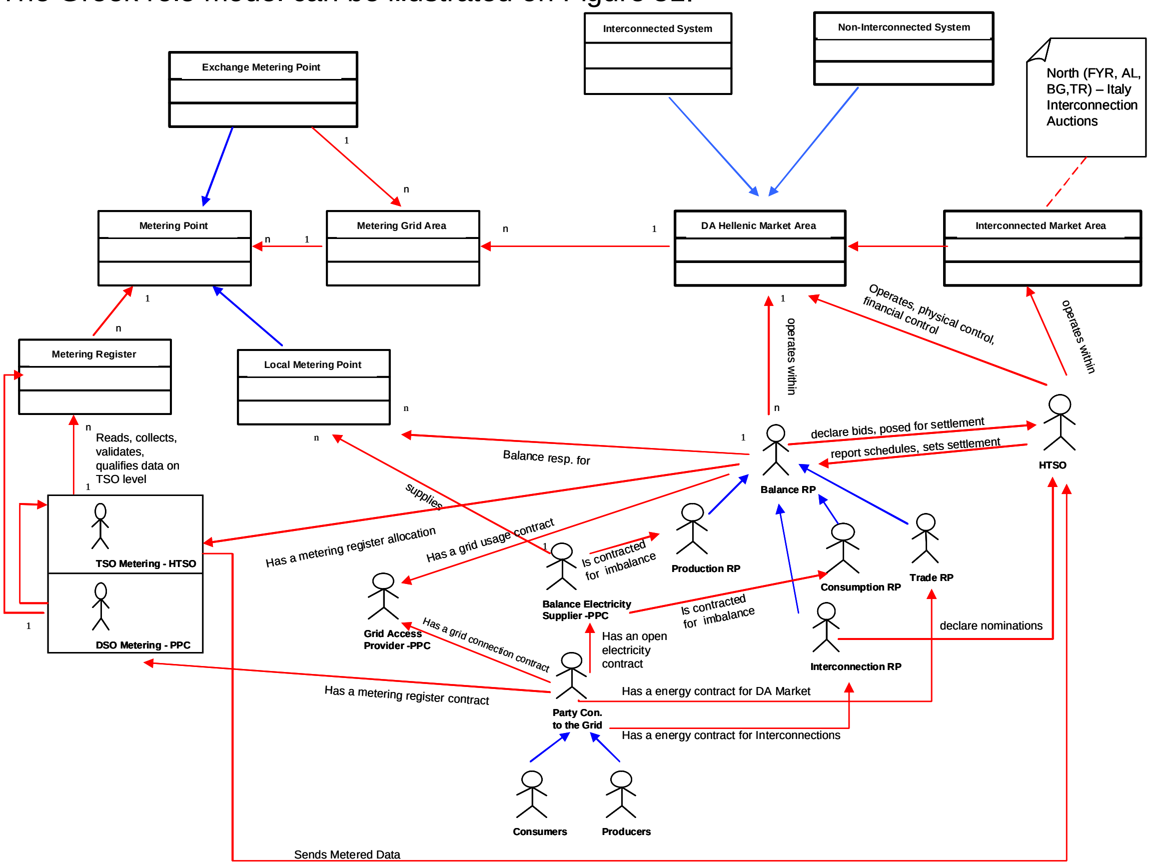

Figure 81: The Greek Role Model

7.2 Slovenia

Market player	Description and Correspondence with the harmonized model
Producer	Legal or physical entity connected to the distribution or transport network with its own metering point. It corresponds to the to the role “producer” in the harmonized role model.
Consumer	Legal or physical entity connected to the distribution or transport network with its own metering point. It corresponds to the role “producer” in the harmonized role model.
Trader	Legal or physical entity, which is participating the energy exchange by selling and buying the energy. It is trading with closed contracts. It does not poses any metering point. It is either the balance group responsible or the balance subgroup responsible. It corresponds to the role “Trade responsible party” in the harmonized role model. The difference is that the trader does not poses any metering points.
Supplier	Legal or physical entity, which is participating the energy exchange by selling and buying the energy. It is trading with closed contracts. It poses at least one (production and/or consumption) metering point. It is either the balance group responsible or the balance subgroup responsible. It corresponds to the role “Balance responsible party” in the harmonized role model.
Market operator	The Market Operator manages the organized market as a public utility. The market operator is service provider of the organized electricity market, where his basic functions are setting up the Rules for the operation of the electricity market and risk management of the organized market as a whole. The market operator sets up and manages the energy flow operating schedule and sends according to the inputs from the balance group responsible. It is also responsible for the Imbalance settlement. The market operator corresponds to the market operator and Imbalance settlement responsible in the harmonized role model
Transmission system operator	The transmission system operator is responsible for the stability and security of the electricity transport network. It is also responsible for the interconnection between neighboring transmission network. It also organizes the trading for the interconnection capacities. The TSO is also responsible for the for the metering points and data in the transport network The TSO corresponds to the System operator, Capacity trader and transmission capacity allocator in the harmonized role model.
Distribution system operator	The distribution system operator is responsible for the responsibility and stability of the distribution network. It poses the metering points and is responsible for the metering data on

	the endpoints. The DSO corresponds to the Grid Access provider and roles connected to the Metering point
Balance group	Balance group is a group of Balance Scheme Members. Its peak is represented by a Balance Responsible Party which is followed by any number of hierarchically inferior Balance Group Members. A Balance Group is formed on the basis of the Balancing Agreement for the purpose of delivering balancing energy, operation of the Balance Responsible Party on the organized market with regulation of balance responsibility, risk management and control of imbalances of the Balance Responsible Party and of the hierarchically inferior Balance Group Members. The balance group corresponds to the balance group in the harmonized role model.
Balance subgroup	Is a group of Balance Scheme Members. It is represented by a Sub Balance Responsible Party which is followed by any number of hierarchically inferior Balance Subgroup Members. A Balance Subgroup is formed on the basis of a Compensation Agreement for the purpose of delivering balancing energy and settlement of imbalances. It has the same characteristics and responsibilities as the Balance group except its imbalance responsibility is a subject of the agreement to the upper level Balance (sub)Group and not the market operator. The balance sub group corresponds to the balance group in the harmonized model with the expectance of the imbalance responsibility.
Balance responsible party	Is a legal or physical entity which heads the Balance Group and is responsible to the Market Operator in the process of reporting Closed Contracts and operational forecasts, in the process of electricity balancing, and for the exchange of relevant information with the Market Operator. It might be a trader or a supplier. The Balance responsible party corresponds to the balance responsible party in the harmonized model
Balance subgroup responsible party	Is a legal or physical entity which heads a Balance Subgroup and is responsible to hierarchically superior Balance Scheme Member and to the Market Operator in the process of reporting Closed Contracts and operational forecasts, in the process of electricity balancing, and for the exchange of relevant information with the Market Operator. It might be a trader or a supplier. The Balance responsible party corresponds to the balance responsible party in the harmonized model except at of the imbalance responsibility.
Special balance Group	Beside commercial balance groups for trading the energy there are special balance groups established for the activities of the transmission system operator, distribution system operator and market operator. These balance group are used

	for handling of the technical loses, including the ecological non-profit production, etc.

- **Balance Scheme:** Is the hierarchically structured organized market where the relations among Balance Scheme Members and the management of their balance of inflow and outflow are uniformly defined by the Balance Scheme Membership agreements.
- **Balance scheme member**: Are Balance Responsible Parties and Balance Subgroup Responsible Parties.

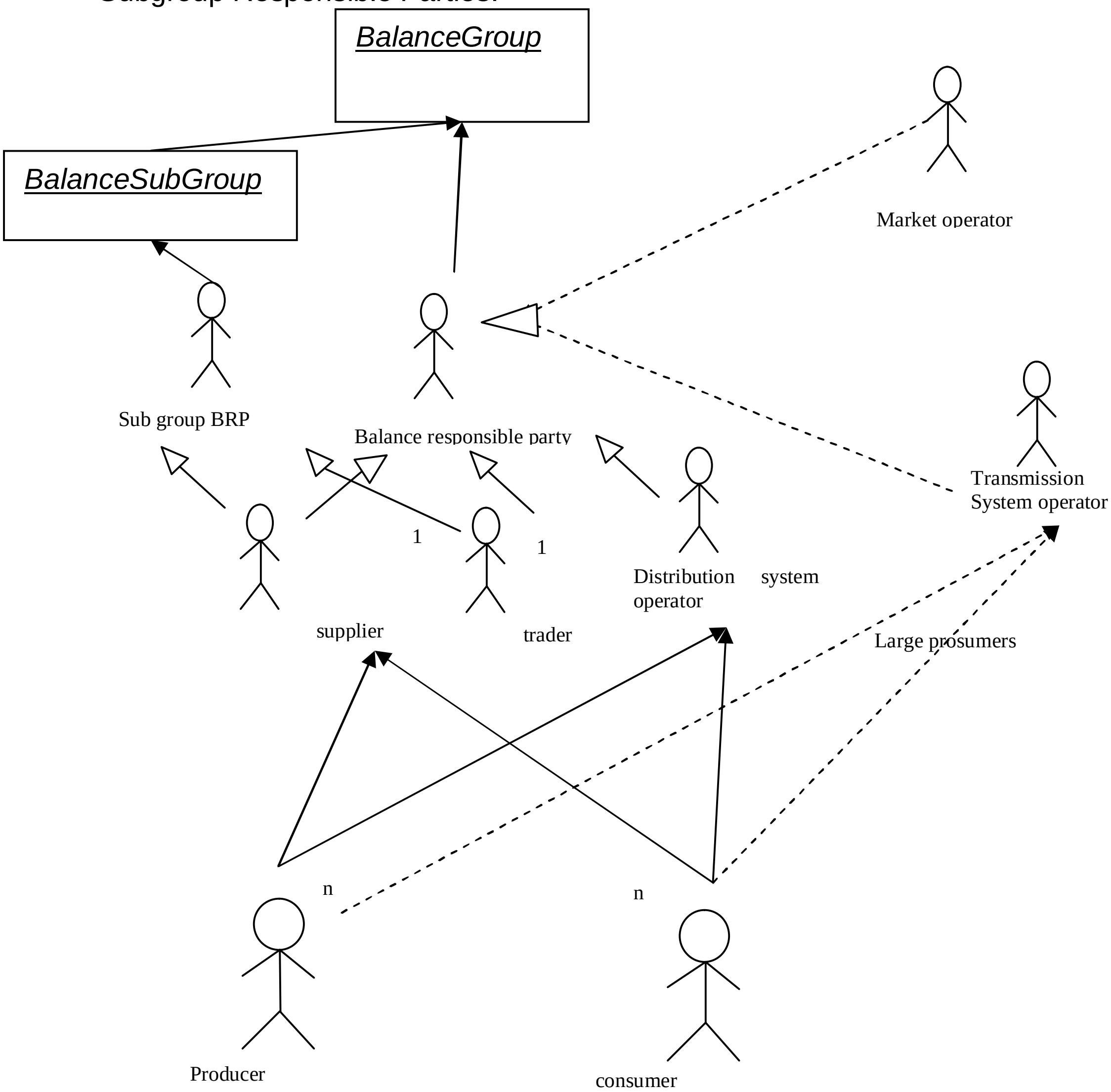

Figure 82: Slovenian relationship among EE system market players and domains

7.3 Denmark

Stakeholders in the Danish electricity market are captured by the ebIX/ETSO methodology based role model [Energinet.dk]. The table below defines the players (i.e., the generalization of existing stakeholders) in the Danish electricity market, elaborating on the ebIX/ETSO roles they cover.

Danish player	ETSO/ebIX roles	Comment
Electricity consumer	Consumer	
Electricity producer	Producer	
Balance responsible party (BRP)	Balance responsible party	Among the BRPs are production, consumption, and trading companies, including purchase organizations and traders. The BRPs have agreed with Energinet.dk to assume responsibility for a specific activity (production, consumption and/or trade).
BRP for production	Production responsible party	A balance responsible party has one or more types of duties and may cover one or more of the roles mentioned to the left.
BRP for consumption	Consumption responsible party	
BPR for trade	Trade responsible party	
Electricity supplier	Balance supplier	Electricity suppliers are responsible for servicing end users and enter into agreements on electricity supply. An electricity supplier must be approved by, or have made an agreement with, a BRP to be able to operate on the market.
	Reconciliation accountable	
Transmission company	Grid operator	A transmission company, as a player, is not responsible for system operation and has no direct customer connection. The player's responsibility is best compared to that of a grid company, yet without direct contact with the electricity consumer.
	Meter operator	
	Metered data collector	
	Metered data responsible	
	Transmission company	
	Metered data aggregator	
Transmission system operator (TSO / Energinet.dk)	System operator	The transmission system operator is also a *transmission company* and therefore has the same roles.
	Responsible for balance settlement	
Grid company	Grid operator	Grid companies are authorized to operate a distribution grid. All grid companies operate as
	Grid access provider	

Danish player	ETSO/ebIX roles	Comment
	Metering point administrator Meter operator Metered data collector Metered data responsible Metered data aggregator Reconciliation responsible	monopolies with an obligation to ensure that registration equipment is installed and metered data supplied to all legitimate parties. Grid companies must also keep track of which BRP the end user has chosen.
Transmission capacity allocator (performed by E.ON – German TSO/transmission company south of the Danish-German border)	Transmission capacity allocator	
Meter operator (may be part of grid company)	Metered data collector Metered data responsible Meter operator Metered data aggregator	In rare cases, some of the grid company's duties are delegated to a meter operator. In these cases, the meter operator's duties include collecting, storing, and qualifying metered data. The meter operator takes over the duties – responsibility remains with the responsible grid company. The ETSO/ebIX roles of the two players therefore overlap.
Public service obligation (PSO) company/ Electricity supplier (with special obligations).	Balance supplier	These companies are authorized to supply end-users who have not exercised their right to choose an electricity supplier. They have the same rights and obligations with regard to balance responsibility as do other market players with grid access.

Table 21: Danish electricity market players and their roles

7.4 Germany

German player	ETSO/ebIX roles	Comment

German player	ETSO/ebIX roles	Comment
Transmission system operator	• System operator • Responsible for balance settlement • Transmission capacity allocator	
Distribution system operator	• Grid operator • Grid access provider	
Metering point operator	• Metering point administrator	
Metering service provider	• Metered data collector • Metered data responsible • Metered data aggregator	
Load consumer	• Consumer	
Supplier	• Balance responsible party • Production responsible party • Consumprion responsible party • Trade responsible party • Balance supplier • Reconciliation accountable • Producer	
Energy service provider		

Table 22: German electricity market players and their roles

7.5 Netherlands

Based on the description of the Dutch electricity sector in subsection 3.2.5 and analysis of [ETSO09] it can be concluded that generally the harmonized role model and the Dutch electricity sector are in line. However in exact terminology in e.g. system or grid code a different structure is used and the harmonized role model makes some additional distinctions, e.g. between balance responsibility for consumption and production. Furthermore it must be noted that [ETSO09] provides very limited definitions of the terms used. Also the graphical modeling performed ambiguous constructions, or at least constructions with semantics implicitly added on top of the use of UML, e.g. certain constraints are expressed in non-formal text, the multiplicities seem to be zero to more in relationships instead of the UML standard exactly one multiplicity.

Role in harmonized role model	Role in The Netherlands
Balance Responsible Party	Equal, ‘programma-verantwoordelijke’ in Dutch
Balance Supplier	Equal, ‘leverancier’ in Dutch
Billing Agent	Equal, TenneT, the Dutch TSO, performs this role in The Netherlands
Capacity Trader	A trader on the explicit auction by the Dutch TSO for cross-border capacity. With the CWE market coupling in many cases an implicit trade is performed.

Consumer	In principle there is no distinction in The Netherlands between parties connected to the grid which only consume, only produce or do both.
Consumption Responsible Party	In The Netherlands the only distinction in Balance Responsible Parties is the distinction between BRP's which only trade and those which are responsible for a connection on the grid.
Control Area Operator	Unclear, seems not to be an explicit responsibility in the Dutch electricity sector.
Control Block Operator	Unclear, seems not to be an explicit responsibility in the Dutch electricity sector.
Coordination Center Operator	Unclear, seems not to be an explicit responsibility in the Dutch electricity sector.
Grid Access Provider	In The Netherlands some parties connected to the grid receive a bill for their grid access from the party which is also their Balance Supplier. Then this party takes on the Grid Access Provider role, otherwise this role is taken by the party who is also the Grid Operator.
Grid Operator	Equal, 'Netbeheerder' in Dutch
Imbalance Settlement Responsible	Equal, TenneT performs this role in The Netherlands
Interconnection Trade Responsible	In The Netherlands this role is performed by parties which are also BRP in case of an explicit auction of interconnection capacities. In case of an implicit auction (as with TLC and now CWE) this role is performed by the markets.
Market Information Aggregator	Unclear, seems not to be an explicit responsibility in the Dutch electricity sector.
Market Operator	Equal, in The Netherlands this role is performed by APX-ENDEX.
Meter Administrator	In The Netherlands this role is performed by an organization named EDSN.
Meter Operator	In The Netherlands this role is performed by the party which also performs the Grid Operator role.
Metered Data Collector	Equal, in The Netherlands this role is called 'meetverantwoordelijke', mostly performed by the parties which are also Grid Operator.
Metered Data Responsible	Equal, in The Netherlands this role is called 'meetverantwoordelijke', mostly performed by the parties which are also Grid Operator.
Metered Data Aggregator	Equal, in The Netherlands this role is called 'meetverantwoordelijke', mostly performed by the parties which are also Grid Operator.
Metering Point Administrator	In The Netherlands this role is performed by an organization named EDSN.

Nomination Validator	Equal, TenneT performs this role in The Netherlands
Party Connected to the Grid	Equal, ‘aangeslotene’ or ‘afnemer’ in Dutch
Producer	In principle there is no distinction in The Netherlands between parties connected to the grid which only consume, only produce or do both.
Production Responsible Party	In The Netherlands the only distinction in Balance Responsible Parties is the distinction between BRP’s which only trade and those which are responsible for a connection on the grid.
Reconciliation Accountable	In The Netherlands the parties which are BRP and are responsible for a connection (thus not a trade responsible party) perform this role.
Reconciliation Responsible	Role is jointly performed by the national grid operator and the regional grid operators.
Reserve Allocator	Equal, TenneT performs this role in The Netherlands
Resource Provider	Equal, ‘regel-, reserve- en noodvermogen leverancier’ in Dutch.
Scheduling Coordinator	Seems not to be part of the structure of the Dutch electricity sector.
System Operator	Equal, TenneT performs this role in The Netherlands
Trade Responsible Party	Equal, ‘handels erkend programma-verantwoordelijke’ in Dutch.
Transmission Capacity Allocator	Equal, TenneT performs this role in The Netherlands

Below a model is presented of the roles and domains which can be distinguished in the Dutch electricity sector; see **Figure 83**. The model is based on [EW10], [SCE09], [NCE10], [MCE10], [BLE10], [OPS05] and [EiN10]. It must be noted that this model is by no means to be considered exhaustive; it is a selective representation of the information enclosed in the aforementioned references. Also this representation does not include all constraints.

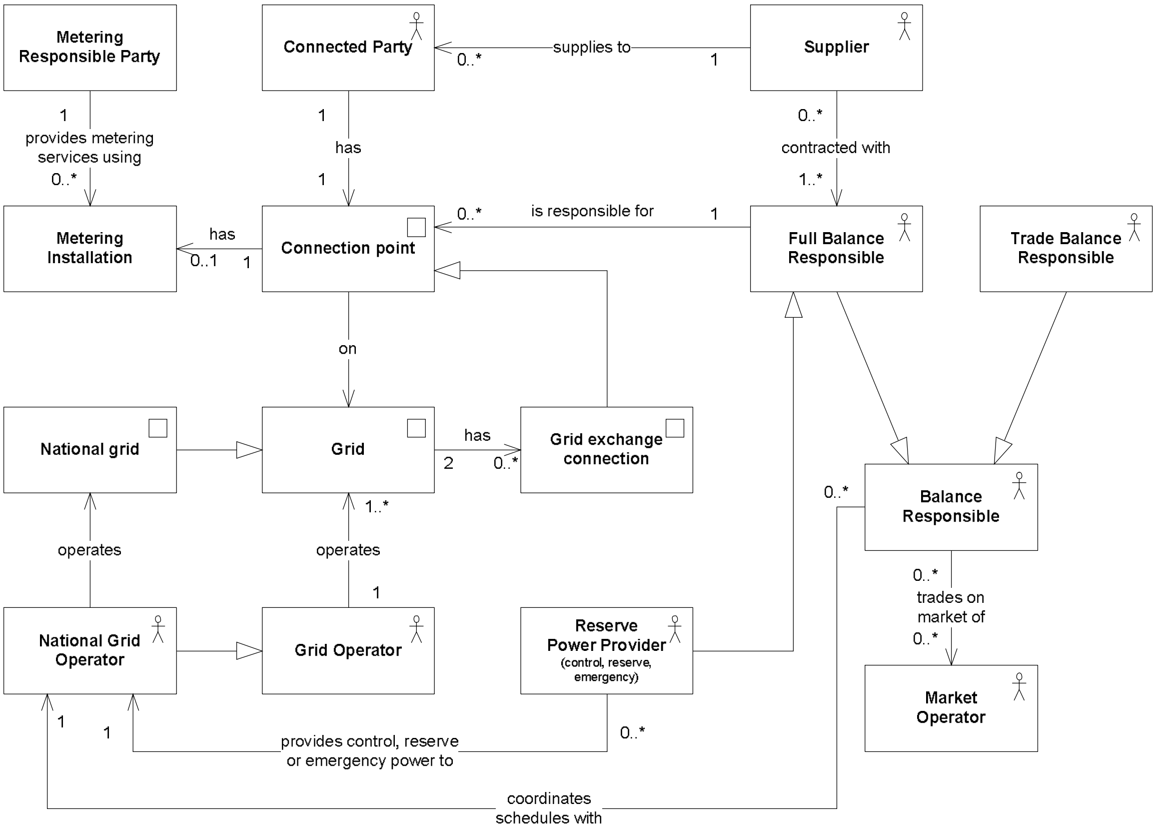

Figure 83: Role and domain model of Dutch electricity sector

7.6 Austria

The mapping between the roles in the Austrian market and the ETSO roles [Econ3] is shown in Table 23. The ETSO roles Consumption Responsible Party and Balance Responsible Party are currently not used in Austria. However, the role Bilanzgruppenverantwortlicher is similar to the role of a Balance Responsible Party.

Austrian market model	ETSO Model
Regelzone (RZ)	Balance area (BA)
Regelzonenführer (RZF)	System operator (SO)
Bilanzgruppe (BG)	(Balance Responsible Party (BRP))
	• Trade Responsible Party (TRP)
	• Production Responsible Party
	• (Consumption Responsible Party (CRP))
	Bilanzgruppenverantwortlicher (BGV)
Imbalance Settlement Responsible Party (ISPR)	Bilanzgruppenkoordinator (BKO)

Table 23: Mapping of roles in the Austrian market model to roles in the ETSO model

8 Conceptual architecture

In this section, we describe the requirements to the Energy data management system (EDMS) which we will develop in the MIRACLE project. The EDMS reflects the hierarchy of subsystems (domains) in the electrical energy market. We describe the domain hierarchy and based on that the conceptual architecture of the hierarchically distributed EDMS. The EDMS consists of a set of nodes. Each node belongs to a role, i.e. an actor in the harmonized energy market. The conceptual architecture of a node and the main functionality of its components are also outlined. Based on the role and process model and the conceptual architecture described in this deliverable and the data model specified in D2.2 "Data model, specification of request and negotiation messages and contracts" a detailed architecture and an updated estimation of data sizes, message volumes, and amounts of flexible energy will be described in the next deliverable D1.3 "Conceptual draft of the request management architecture and its design".

8.1 Requirements

Requirements are derived from the goals of the EDMS (operational requirements) and the role and process model described in the previous sections (system requirements).

The system requirements comprise the following.

- Realization of primary processes and structuring into unit processes
  The functionality of a node has to reflect the primary processes. It has to be structured into unit processes.
- Consistency with role and process model
  A node has to be specialized for each actor. It has to implement the processes in which the roles which are fulfilled by the actor take part. For the prototypical implementation, we will group roles to existing actors.
- Explicit management and processing of open and closed contracts
  Prosumers have currently open contracts for demand and supply (RES) i.e. contracts in which the amount of energy is not specified. The assignments that are associated to flex-offers are closed contracts. Therefore on prosumer side, i.e. on one metering point, a node has to deal with one open and a few (types of) closed contracts at the same time.
- Support free parameters of flex-offers
  Flex-offers have three free, flexible parameters which are energy, price and time. The functionalities of the EDMS and nodes have to be able to deal with these flexibilities.
  To adapt to any number of real situations, the EDMS has also to be able to fix any number of flexibilities.
- Price setting
  Since price setting is not part of our project, we will use a preferred demand/supply curve of the corresponding actors (BRPs,) as a pricing and scheduling criterion; the corresponding two-side pool pricing and scheduling, appropriate for organized trading in MBA will be modeled, but will not be developed and tested.

The operational requirements are listed here:

- Scalability

The EDMS has to be *scalable* in order to be able to process growing data loads from the mass of households.
The EDMS as a whole system has to scale up to the level of a continent (e.g., Europe) and handle flex-offers from nodes of all prosumers within. Hence, it must be efficient enough to handle up to a billion connections from nodes simultaneously (i.e. one per prosumer in Europe) and process up to few billions of flex-offers from prosumers' nodes per day (assuming that there are a few flex-offers per prosumer). However, a single node within the EDMS has to deal only with all prosumers that are managed by a BRP. So the number of connections and flex-offers per node are much smaller (up to a few millions).
Furthermore, it has to store historical electricity consumption and production data (i.e. measures) in various granularities for certain time period, e.g. 1.5 years, resulting in approx. 1,8 MB (96 measures per day* 365 days * 1.5 years * 36 Byte) of data per prosumer and up to 8.6 TB of data per BRP (1.8 GB *5,000,000).

- Performance/Near real-time processing

  Since the EDMS will be applied for operational control of energy use, it has to satisfy various time constraints. In particular, it has to provide a time guaranties for prosumers from issuing a flex-offer until the assignment. Furthermore, to enable a BRP to operatively react on changing conditions e.g. concerning the production of renewable energy, near real-time aggregation, (re-)scheduling and forecasting of mass data are essential and these operations need fast data access and fast data processing. Therefore the core functionalities i.e. aggregation, forecasting, and scheduling have to be designed in a way that they support near-real time processing of mass data and do not represent any appreciable additional off-set from the real time to the off-set imposed by the logistics of the processes on the Electricity market themselves. This is a dominant requirement which influences the effects of the Miracle flex-technology.

- Decentralization and autonomy

  The EDMS is decentralized because participants/users are supposed to act to a great extent independently. Each participant/user has one or more nodes of the Energy Data Management System (NEDMSs). A node acts autonomously to a high degree. It follows defined rules/guidelines such as the definition of a time until when flex-offers have to be entered.

- Distribution and hierarchical organization

  The EDMS has to be distributed because of the participants/users maintaining their own computing infrastructure but also for efficient handling and processing of raw and processed data, such as forecast data, aggregated data etc. The hierarchical organization of the electricity market system has to be applied to the EDMS system.

- Data integration

  The messages of lower level nodes have to be integrated into nodes on the next higher level. The messages include discrete flex-offers and forecasts as well as continuous flows of measured data. In addition, external data such as weather forecasts have to be integrated.

- Operations

The EDMS has to support both *transactional* and *analytical* operations on data (i.e. OLTP and OLAP workload). Transactional operations are needed to process and store incoming data. Aggregation, forecasting and other complex data processing tasks require analytical operations. The operations must be able to deal with uncertain data that result e.g. from forecasting.

- Fault tolerance

  In a distributed system of highly-autonomous nodes, mechanisms that can detect and/or prevent message losses as well as mechanisms that can deal with partitioning and the non-reachability of nodes are needed.
  Some of the messages exchanged between participants/users and specified in D2.2 are essential for the operation of the system. An example is the message which contains the scheduled time for flexible energy. The system has to support a mechanism that detects and/or prevents the loss of such messages.

8.2 Architecture

In Miracle, we manage two types of electricity data which are “schedulable” flex-offers for electricity demand and supply and “continuous”, non-schedulable electricity demand and supply. Examples of schedulable demand and supply are combined generation of heat and power (supply) and appliances such as washing machine, dryer, refridgerator, dish washer, electric car (demand). Examples of continuous electricity are lighting (demand) and renewable electricity sources that use wind or solar energy (supply).

8.2.1 Energy data management system (EDMS)

The electricity market system hierarchy in Europe is shown in Figure 84. In Europe there are a few Market Areas. A Market Area can be a national area such as Germany or a Common capacity area such as Nordpool. A Market Area contains one or more Market Balance Areas. A Market Balance Area is operated by a Market Operator. For example, EEX operates the market for Germany and Austria. A System Operator such Energinet.dk controls a Market Balance Area. A Market Balance Area comprises one or more Balance groups. The representative of a Balance Group is a Balance Responsible Party. One or more prosumers belong to a Balance Group. A prosumer belongs to exactly one Balance Group.

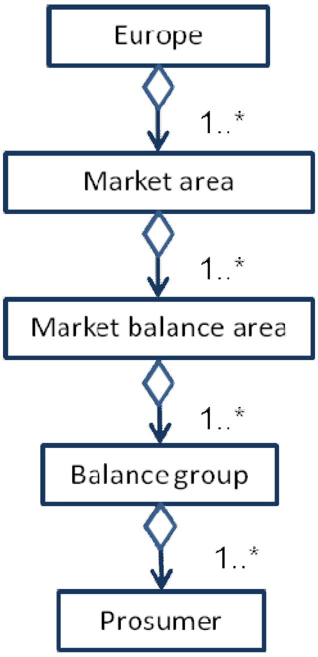

Figure 84: Electricity Market system hierarchy

The Miracle Energy data management system (EDMS) is organized in a multi-level hierarchy of nodes. The EDMs hierarchy reflects the electricity market system hierarchy. In the MIRACLE project we focus on the three lowest levels. However, the system can potentially be extended to the full hierarchy.

A node is called a Node of the Energy data management system (NEDMS, see Figure 85). On each level of the hierarchy another type of role, i.e. harmonized actor, owns the nodes. Every node in this hierarchy communicates with multiple associated nodes on the next lower level (if there are some) and a node on the next higher level (if there is one).

The consumers and producers that issue the basic or “micro” flex-offers and consume and/or produce electricity are actors on level 1, the prosumer level. The roles on next levels issue flex-offers aggregated from the flex-offers from the next lower level. A node on level 1 communicates with smart meters. A smart meter measures energy consumption or production. Balance Responsible Parties (BRPs) are actors on level 2, the Balance Group level. Market operators act on level 3, the market balance area.

On level 4 Transmission Capacity Allocators and Capacity Traders could use and host nodes. A future European institution might own a node on the European level.

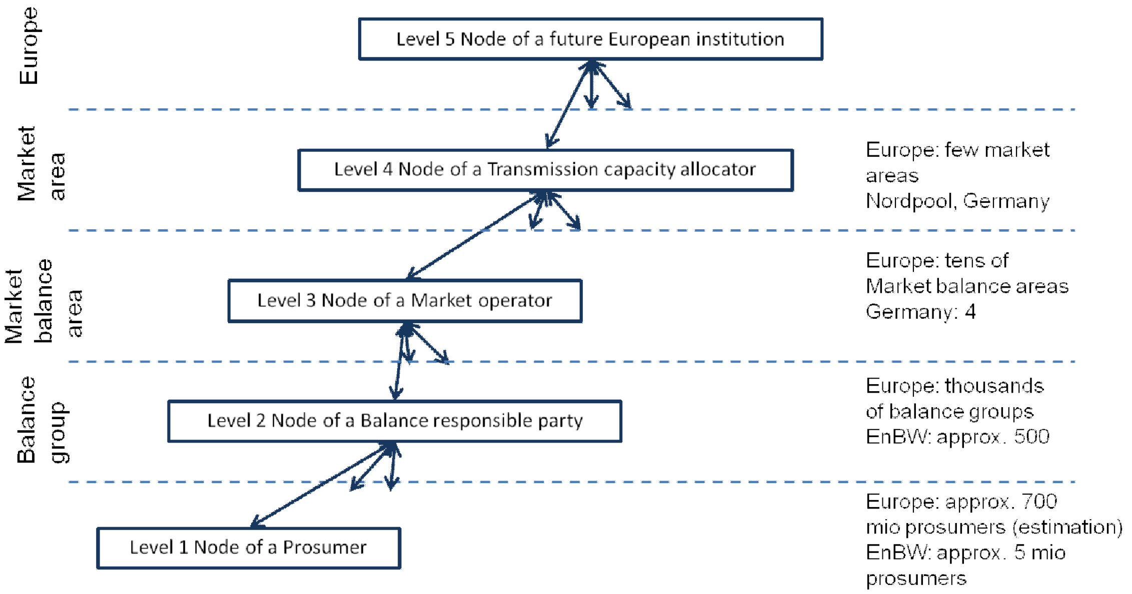

Figure 85: Hierarchical architecture of energy data management systems

8.2.2 Node of the energy data management system (NEDMS)

Each node has the same conceptual architecture (see Figure 86). It has the following components:

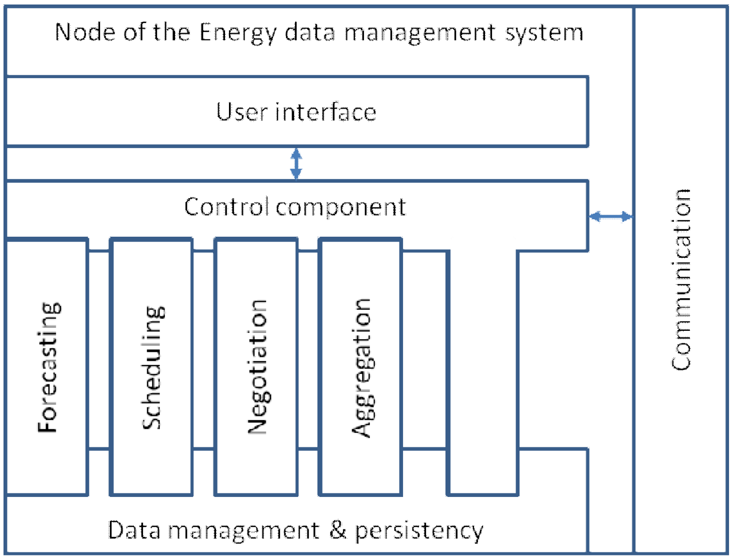

Figure 86: Architecture of a Node of the Energy data management system

- Control component,
  The control component orchestrates the functionalities of the other components to provide the functionality which is specific for a type of actor i.e. Prosumer, BRP or Market operator. It is responsible for the communication with the nodes of other actors.
- Forecasting component,
  The forecasting component predicts non-schedulable demand and supply. It selects and applies forecasting models automatically.
- Aggregation component,

The aggregation component aggregates flex-offers to aggregated flex-offers and disaggregates them. The goal of the aggregation is to reduce the number of flex-offers for further processing. An aggregated flex-offer should keep as much flexibility provided by the lower level flex-offers as possible.

- Scheduling component,
  The scheduling component schedules assignments. Scheduling is used by the actors to achieve their business goals e.g. to balance demand and supply (BRP, MO), to minimize the cost of electricity which must be bought (BRP) or to maximize the profit of electricity which can be sold (BRP), or to manage and provide active organized trading process (MO, Transmission Capacity Allocator) .
- Negotiation component,
  The negotiation component controls the communication protocol which turns flex-offers into accepted flex-offers and concluded closed contracts. Within the negotiation procedure, the flex-offer matching is achieved and the price is set.
- Data management and persistency component,
  This component manages all data of the node. It processes data-intensive operations efficiently. The data management system stores incoming and outgoing flex-offers, assignments, forecast models and the history of electricity measurements.
- Communication component,
  The communication component processes incoming and outgoing discrete messages (such as flex-offers, weather forecasts) and continuous data streams (such as measured electricity demand and supply).
- User interface.
  The user interfaces (UI) are tailored to the actor. For the prototype, we plan to implement UIs for selected scenarios.

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