**Market Access for Smaller Size Intelligent Electricity Generation (MASSIG)**

# Delivery 6.1

# Critical survey of requirements for market participation of small scale intelligent generators

**Version:** V 2.1 (2010-09-22)


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**Belongs to:** EIE/07/164/SI2.467618 - MASSIG

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**Abstract:**
In the EU-project MASSIG, http://www.iee-massig.eu/, one of the goals is to promote and increase the participation of small scale power producers in the electricity markets, e.g. in the Spot market and the balancing markets.
In this Delivery 6.1 is made a critical survey of requirements and barriers for this market participation in Denmark, Germany, Poland and UK.

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# 1 Introduction

Small and medium size distributed generation (DG), including renewable energy generators (RES) will play an increasing role in the overall system of energy supply in Europe in the upcoming years. When replacing more and more conventional power plants by DG / RES it becomes necessary to integrate those new generators both in the grid operation and the power markets and to make them more independent from subsidies and feed-in tariffs. Especially in energy systems with large amounts of fluctuating renewable energy productions it is important that all intelligent electricity generation participates in the integration of these fluctuating RES-productions. The importance of that the small scale power producers participate intelligently in the markets are well demonstrated in Figure 1.

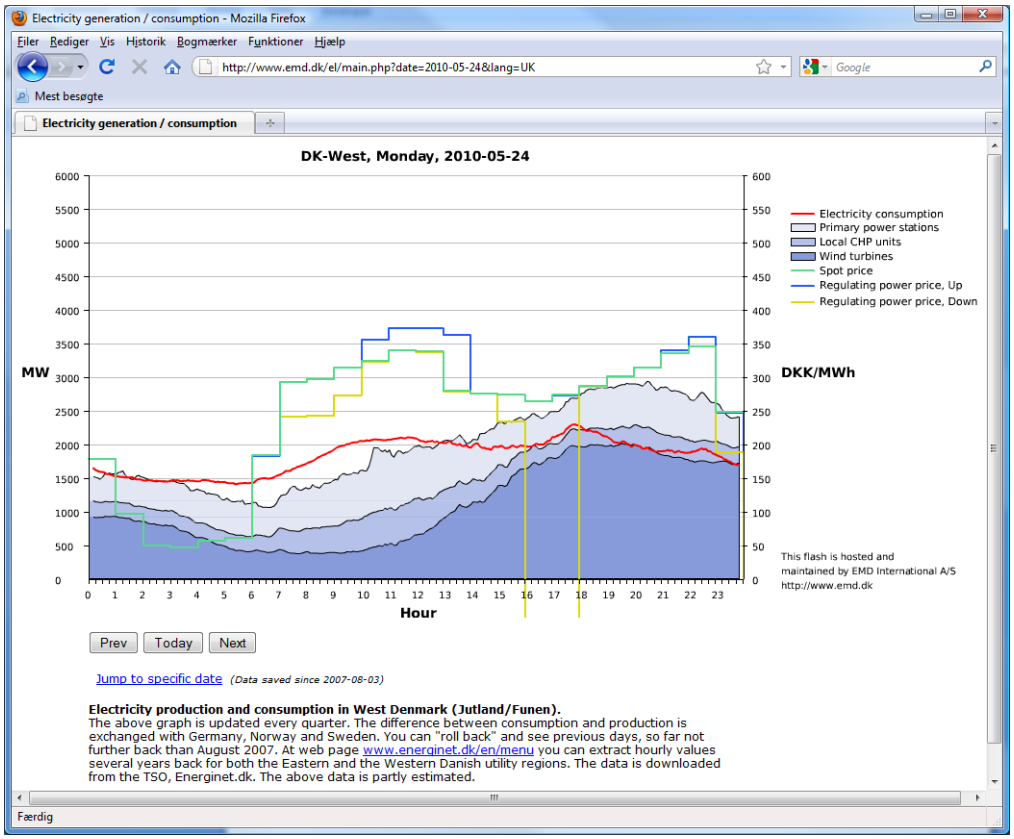


**Figure 1: Electricity production and consumption in West Denmark (Jutland/Funen) shown at the homepage www.emd.dk/el.**

In Figure 1 is shown the production from wind turbines, distributed CHP-plants and central power plants in West Denmark for 24 May 2010. This day the wind turbines in some hours produced the whole consumption. The distributed CHP-plants in West Denmark have a total capacity of around 1700 MW. In these hours most of this capacity had stopped producing due to the high share of wind.

The homepage also shows the spot prices (green line) and the activation prices in the regulating power market (Tertiary control).

## 1.1 The electricity directive creates the framework

The participation in the electricity markets of the Smaller Size Intelligent Electricity Generation units is regulated through the Electricity Directive.

The directive creates a framework for the participation. Just to mention a few examples from the directive:

"*Rules adopted by transmission system operators for balancing the electricity system shall be objective, transparent and nondiscriminatory."*

*"In order to ensure effective market access for all market players, including new entrants, non discriminatory and cost-reflective balancing mechanisms are necessary. As soon as the electricity market is sufficiently liquid, this should be achieved through the setting up of transparent market-based mechanisms for the supply and purchase of electricity needed in the framework of balancing requirements."*

"*Authorisation procedures should not lead to an administrative burden disproportionate to the size and potential impact of electricity producers."*

## 1.2 An intelligent splitting into more markets is needed

After the EU-Directive 96/92/EC went into force in 2001 EU-Member States had to gradually liberalize their power markets. As a consequence market places for the trade of electricity emerged, that offer trade of a variety of power products on different times scales. Below two markets typically offered by power exchanges (PXs) are briefly described:

- Day-ahead auction:
  The PX´s offer day-ahead auctions where hourly or block products can be traded for the following day.
- Intra-day market:
  If a wind power producer updates his forecasts with latest weather data and finds significant deviations from day-ahead forecasts he will like to trade differences in the short-term. The same need occurs for a power plant operator facing an outage. An increasing number of PXs therefore offer intra-day markets. They may be either organized in form of periodic auctions (each 3 hours) or in form of continuous trade (matching offers and bids are cleared immediately). Offers and bids can be submitted until few hours before physical delivery. An intra-day market is especially important for wind power given the high intra-day variability.

As electricity cannot be stored, in each instant supply must equal demand. It is however not possible to establish this power balance through a conventional market because actors would have to trade on a second per second basis. Therefore deviations between scheduled (traded) supply and demand are balanced by a third party – the so called System Operator (SO). In order to fulfill this task the SO purchases so called power reserves being activated when needed: When there is a lack of power so called upward-regulation is activated and in the case of excess power so called downward regulation is activated.
To balance the system different types of reserves are needed:

- Primary reserve:
  Primary reserves react immediately on imbalances to stabilize the system. A power plant or load offering primary reserve has to quickly up- and downward regulate. The activation is directly related to the frequency of the power system. If it exceeds the nominal value of 50Hz primary reserves downward regulate and vice versa. Primary reserves are shared among countries with interconnected power systems – e.g. a power plant outage in Germany is compensated by primary regulation in all countries belonging to the so called UCTE-system.
- Secondary reserve:
  The task of secondary control is to re-establish the local power balance. To compensate for the outage upward regulation will be activated in Germany and primary reserves in the UCTE area restored. Secondary control is activated automatically within few minutes and therefore requires dynamic changes of power output and demand respectively.
- Tertiary reserve:
  In order to restore the activated secondary control, so called tertiary control (also indicated as “Minutenreserve” in Germany) is activated manually. The offered

amount of tertiary reserve typically has to be activated within 15 min. This type of reserve can therefore also be offered by fast starting power plants.

The following figure illustrates the time-scales on which different reserves act exemplarily for the case of the Danish power market.

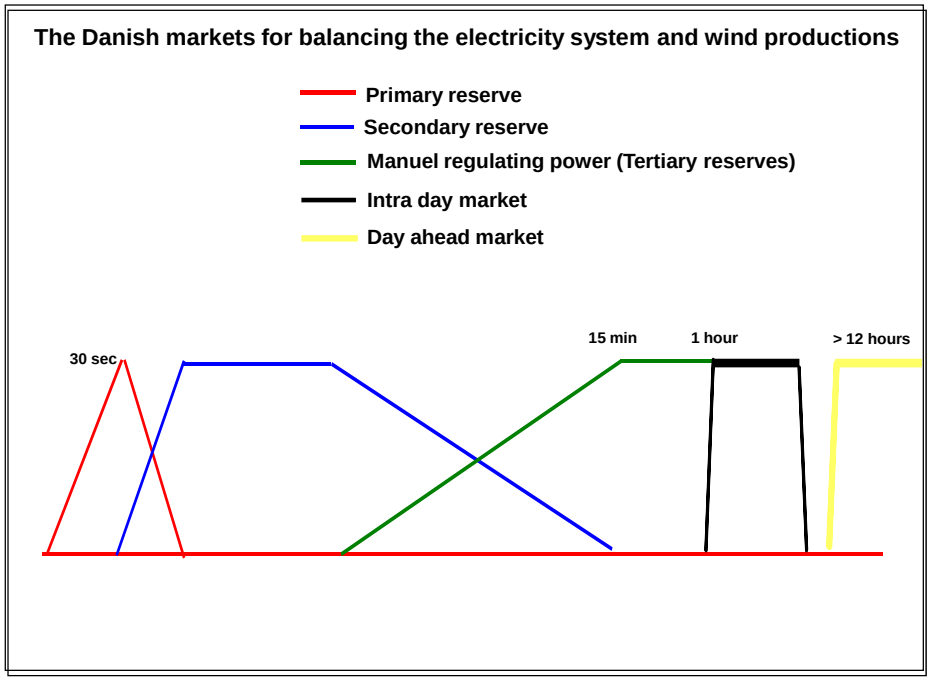


**Figure 2: The tasks of delivering Active power are in Denmark split into 5 markets.**

The SO has to pay the providers of reserves and to allocate costs after physical delivery to those market actors causing the system imbalance within the imbalance clearing. Besides the regulating power the SO and grid operators also need other ancillary services like voltage control, emergency start-up, etc. to securely operate the system and to re-establish system operation after a failure.

Intelligent splitting into more markets is needed, but it is also important that each market is organized in a way that makes it easy and affordable for small size generators to participate in the market. It seems clear that a market organized as a marginal price market (single price market) is easier for small size generators to participate in compared to a market organized as a Pay As Bid-market. In a marginal price market, where every accepted offer gets the same price, each small size generator can focus on calculating its own costs of participating when making its offer in the market.

In this Delivery 6.1 is made a critical survey of requirements, opportunities and barriers for the market participation of small scale intelligent generators in Denmark, Germany, Poland and UK.

# 2 Survey of requirements for market participation in Denmark

The task of delivering power in Denmark is split into the markets shown in Figure 2. In this section is made a critical survey of the requirements and barriers for small size generation units for participating in these markets, the Primary reserve market - the Secondary reserve market, the Regulating power market, the Intraday market (Elbas) and the Day ahead Spot market.

## 2.1 The Primary reserve market

Won Primary reserve in West Denmark has to be delivered at a frequency deviation up to +/-200 mHz from the reference at 50 Hz. This means in between 49,8-50,2 Hz, with a Dead band of +/-20 mHz, and it has to be delivered linearly between 20 and 200 mHz within 30 seconds.

The won Primary reserve must be maintained until Secondary reserves and the Regulating power takes over, not exceeding 15 minutes.

The Primary reserve market is a day ahead Marginal price market.

The Primary reserve market is split into two markets. One market for Positive Primary reserve and one market for Negative Primary reserve. The market is further split into 6 periods:
- Block 1: Kl. 00.00 - 04.00
- Block 2: Kl. 04.00 - 08.00
- Block 3: Kl. 08.00 - 12.00
- Block 4: Kl. 12.00 - 16.00
- Block 5: Kl. 16.00 - 20.00
- Block 6: Kl. 20.00 - 24.00

Gate closure for bidding is at 15.00 the day before.

Least offer is 1 MW, but can be made up of more units.

This way of organizing the Primary reserve market seems to offer Smaller Size Intelligent Electricity Generation fair conditions for participating.

As an example of the possibilities for participating in the Primary reserve market is in Figure 3 shown the spot market operation of a typical Danish CHP-plant with a big thermal store. The upper graph shows the spot price in a week in June. The lower graph shows the content in the thermal store.

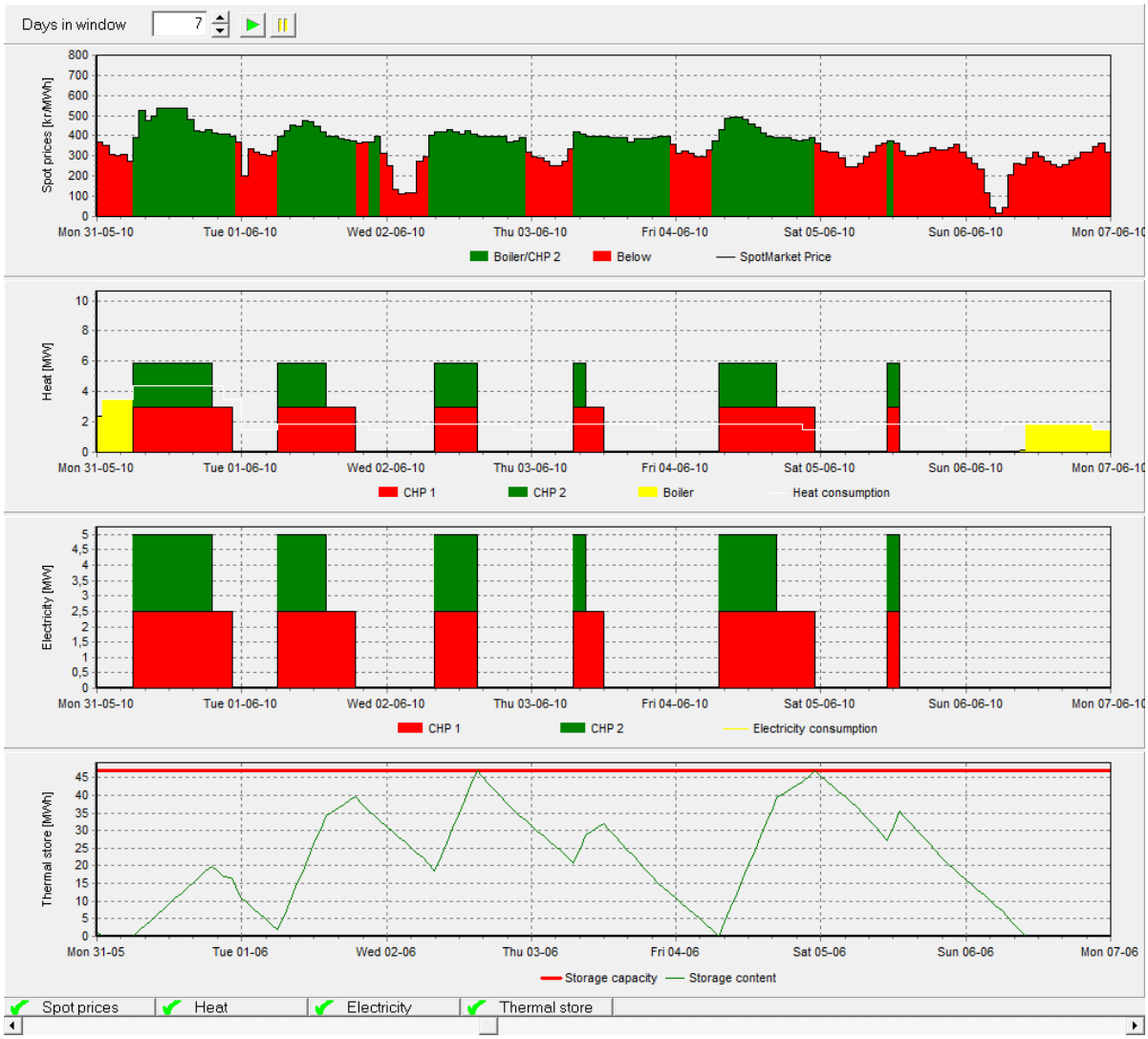


**Figure 3: In this figure is in energyPRO simulated the spot market operation of a typical Danish CHP-plant with a big thermal store in a week in June.**

Only when the CHP-units are running they are able to regulate in 30 sec. But due to the big thermal store it is possible to plan the operation in the spot market, so that it is running in some of the 4-hour blocks offering Negative Primary reserve. If not all of the capacity is traded into spot, also offering Positive Primary reserve would be possible.

Conclusions and recommendations

The Danish Primary reserve market is organized as a day ahead Marginal price market, split into two markets. One market for Positive Primary reserve and one market for Negative Primary reserve. The market is further split into 6 daily periods. Already today in more cases small and medium size distributed generation units are participating in the Primary reserve market. It seems as a well organized market, offering good opportunities for small and medium size distributed generation to participate.

## 2.2 The Secondary reserve market

The Primary reserve market and the Secondary reserve market are both automatic markets - only run by computers.

The main task for the Secondary reserve is in 15 minutes to bring the Primary reserve back from activation, so that the Primary reserve again is ready for frequency regulation.

The Secondary reserve in Denmark is badly organized in the way that it is a month ahead Pays As Bid market, where you have to offer both Positive and Negative Secondary reserve, leaving Smaller Size Intelligent Electricity Generation less good conditions for participating.

BUT the activation time is fair in this market. A plant that can regulate linearly in 15 minutes can participate in the Secondary reserve market.

Least offer is ±1 MW. But in principle it should be possible for e.g. a small CHP-plant to participate in this market, as shown in Figure 4 and Figure 5.

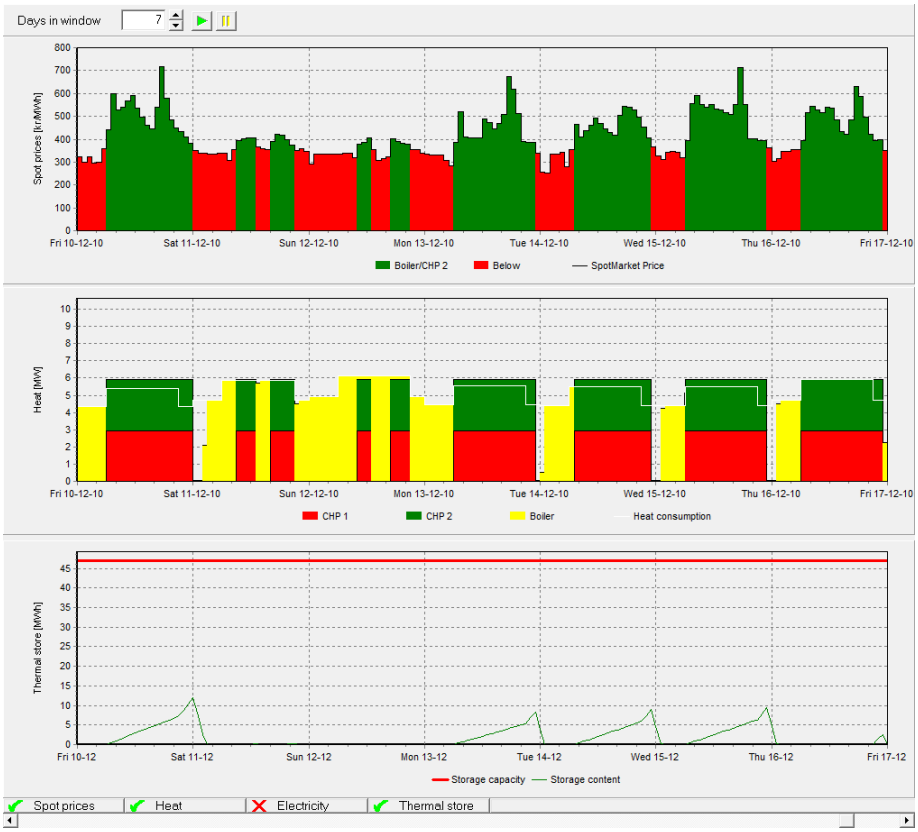


**Figure 4: This figure shows a simulation in energyPRO of a spot market operation of a typical Danish CHP-plant with a big thermal store in a week in December. In hours with low spot prices the boiler will produce the heat.**

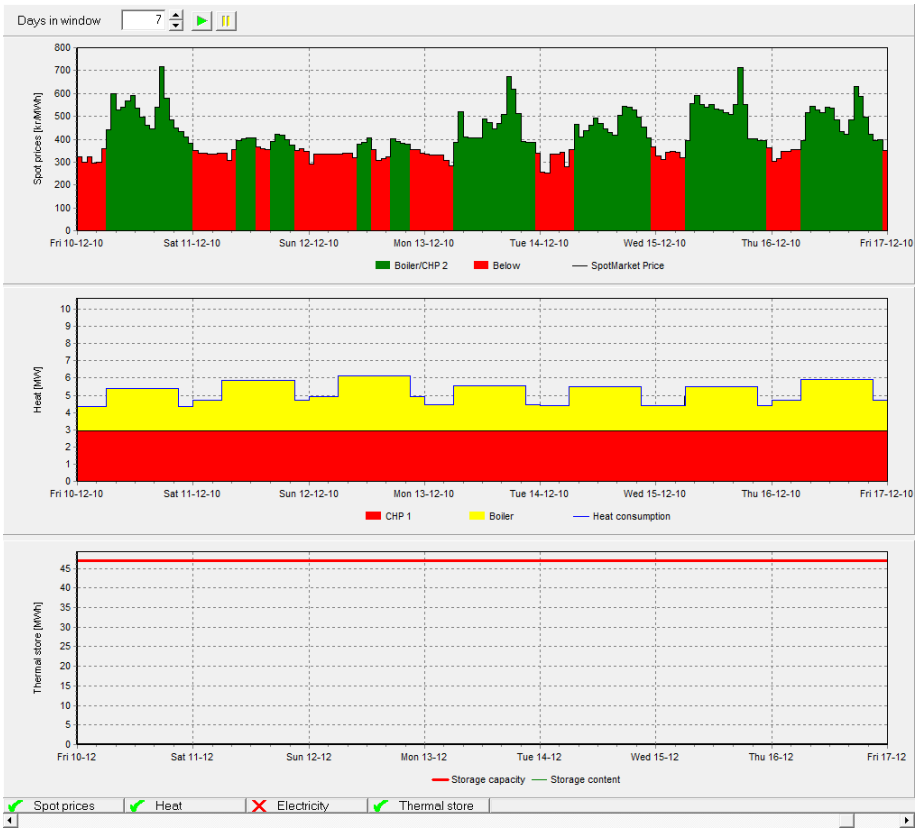


**Figure 5: In this figure is shown the simulated operation of the CHP-plant with a big thermal store in the same week in December. But the operation is planned so that only one of the CHPs is operated in the spot market.**

By planning the operation as shown in Figure 5 the CHP-plant can offer Positive Secondary reserve on the one CHP and Negative Secondary reserve on the other.

Conclusions and recommendations

The Danish Secondary reserve market is organized as a monthly market, and is not split into a Positive Secondary reserve market and a Negative Secondary reserve market. But the required activation time of 15 minutes seems fair.
It has not yet been seen, that small and medium size distributed generation is participating in the Secondary reserve market. It seems that organizing the Secondary reserve market more alike the Primary reserve market would offer better opportunities for small and medium size distributed generation to participate.
In Germany the required activation time in the Secondary reserve market is 5 minutes. Such a requirement would very much prohibit small and medium size distributed generation to participate in the Secondary reserve market – so the Danish TSO should document it very transparently, if it will reduce the Danish activation time for Secondary reserve down to the German activation time for Secondary reserve.

## 2.3 The Regulating power market

There are only three requirements for participating in the Regulating Power Market:

- The production unit shall be able to start in 15 minutes.
- The production unit shall be directly connected through the internet with the central computer at the energy trader, allowing this computer to start and stop the production unit.
- The least offer in the Regulating Power Market is 10 MW, so it needs to be aggregated with other production units.

In the Nordic countries the transmission system operators have established a common market for regulating power market.

The production units submit bids for increased production (upward regulation) or reduced production (downward regulation) to their respective Production Responsible Companies (PRC´s), who submit the bids to the TSO to this common Nordic regulating power market.

A production unit can change the bids up to 3/4 of an hour before the operating hour.

It is up to each production unit if and when they choose to be active on the regulating power market, provided they have not concluded an agreement about reserve capacity with the TSO (see section 2.3.1)

Only production units operating on market terms may submit bids to the regulating power market, thereby supplying ancillary services to the transmission system operator. Producers of Public Obligation production (e.g. time-of-day tariff) are therefore excluded.

The Regulating power market is organized as a marginal price market – that is to say that the most expensive offer needed determines the price for all.

Conclusions and recommendations
Already today many small and medium sized distributed generation units are participating in the Regulating power market. It seems as a well organized market, offering good opportunities for small and medium size distributed generation to participate.

### 2.3.1 Regulating Power Hourly Reserves

Notice that compared to Germany the Scandinavian Regulating power market ("Minutenreserve market") is split into two markets, the Availability market and the Activation market described above.

The availability market is called Regulating Power Hourly Reserves - market.

The transmission system operator purchase regulating reserves to be certain in advance that sufficient power will be offered by the PRCs in the Regulating power market. That is to say that if a PRC has won in the Regulating Power Hourly Reserves - market, it is obligated to offer the won capacity in the Regulating power market. But it is free to choose the bidding price for this capacity in the Regulating power market.

Most of the Regulating Power Reserves are bought on an hourly basis. The day before at 9:00 o'clock these hourly reserves are offered for each of the hours of the following day. The production units submit their bids through their PRC.
At 10:00 o'clock the CHPs are informed in which hours they have won.

The Regulating Power Hourly Reserves market is organized as a marginal price market – that is to say that the most expensive offer needed determines the price for all.

Conclusions and recommendations
Already today the supply of regulating reserves is not an insignificant part of the activities for several of the small and medium sized distributed generation units. It seems as a well organized market, offering good opportunities for small and medium size distributed generation to participate.

## 2.4 The Spot market

Due to bottlenecks in the electrical grid in Scandinavia the electricity market is divided into more price areas. All trade between price areas must take place via the Scandinavian Spot market NordPool (you cannot make a bilateral contract between to participants from two different price areas).

All trade between the price areas is allocated concurrently with electricity being traded.

At 12:00 noon is the bidding deadline for trade in electricity for the following day of operation (buying and selling bids for each of the 24 hours).
At 13:00 Nord Pool announces the traded volumes and prices for the following day.

The products traded on the Elspot Market are power contracts of one-hour duration and block bids. Participants use an Internet application for submitting bids to the Elspot trading system.

Minimum contract size is 0,1 MWh per hour, and prices are given with two decimals in DKK/MWh and three decimals in EUR/MWh.

Bidding: A bid is a sequence of price/volume pairs for each specified hour. Volumes are stated in MWh. In bidding, purchases are designated as positive numbers; sales

as negative numbers. The minimum price change between bid steps is 1 DKK or 0,1 EUR. A total of 64 price-steps are allowed including the required bids at the technical lower and upper technical limits that have been set by Nord Pool Spot. Participants who submit stepwise bids act with the understanding that Elspot will make a linear interpolation using the bid pairs to calculate prices and traded volumes for each participant.

Block bid is an aggregated bid for several consecutive hours with a fixed price and volume. The block bid price is compared with the average hourly price within the block period. A block bid must be accepted in its entirety; if accepted the contract covers all hours and the volume specified in the bid. The mean price condition is a comparison of the bid price to the Elspot price average for the hours in the block period.
If the bid price of a supply-side (sell) block is lower than the average Elspot area price, the block bid condition is said to be satisfied.
It is possible for participants to freely choose start and stop hour, the only restriction is that the duration of blocks must be a minimum of 3 consecutive hours.

Conclusions and recommendations
The Scandinavian Spot market NordPool seems as a well organized market, offering good opportunities for small and medium size distributed generation to participate.

## 2.5 The aftermarket to the Elspot Market, Elbas

Due to the lengthy time span of up to 36 hours between Elspot price-fixing and delivery, participants need market access in the intervening hours to improve their physical electricity balance. The Elbas Market enables continuous trading with contracts that lead to physical delivery for the hours that have been traded on the Elspot market and that are more than one hour from delivery. Its function is in other words to be an aftermarket to the Elspot Market. The Elbas market is open around the clock every day of the year.

The product characteristic of Elbas is quite simple. The products traded on the Elbas Market are power contracts of a one-hour duration.
At 14:00 when the Deadline for filing complaints on the Elspot market is closed, the hours for the next day are opened for trade. This means that there are at most 32 and always at least 8-10 hour contracts open for trade. The trade for a specific hour contract is closed one hour before its delivery.
The Elbas market is a Pay As Bid-market - that is to say, that if you win a bid, the payment is equal to your bidding price.
The Elbas trading System automatically controls the cross-border capacity in Scandinavia, which is given when the deadline for filing complaints on the Elspot market has elapsed and the cross border capacity that is left after Elspot is known. For example if there is no capacity from West Denmark to Sweden the participants in the Swedish market area cannot see the sale bids placed by participants in the West Danish market area in their Elbas price information window. If the bids are inside the given cross border capacity the different market areas are treated as one.

Conclusions and recommendations
The Scandinavian Elbas market is not very liquid and very little used by small and medium sized distributed generation - but not due to that it is difficult to participate. One reason may be that it is organized as a Pay As Bid-market. Another reason may be that the prices in the Regulating power market, used for punishing imbalances, are very equal to the spot prices, so that small and medium sized distributed generators do not see any benefit in participating in Elbas.

# 3 Survey of requirements for market participation in Germany

Energy markets in Germany can mainly be divided into the following categories:

- EEX markets
- Tertiary Control markets
- System services.

The latter point is no real market in Germany today but involves aspects of grid and congestion management, which are partly handled as market products in different countries or might become markets in near future. As this document is about requirements, opportunities and barriers, such market options will be mentioned here as well.

## 3.1 EEX markets

Generally the EEX comprises two markets: the futures market and the spot market. On the futures market contracts for next six years in advance can be closed, whereas on the spot market the 24 hours of the following day (day-ahead) and the current day (intra-day) are traded. Therefore the futures market offers the possibility to reduce price risks in the future.
For RES/DG with high fluctuations in generation output, the spot-market will be more relevant, although even in those cases the combined marketing on futures and spot market will be most common. For German electricity, trading is done within the Power EPEX Spot market.

Trading for the next day (day-ahead) takes place in auctions for the 24 hourly contracts to be fulfilled physically on the next day. This means, each day there is a closed auction at 12:00 that determines the prices for each hour. For the closed auctions on EEX the formation of prices follows the merit-order principle. That means that the demand is met by the offers beginning from the lowest offered price. The highest price that gets an award then determines the price for all the offers. So for an energy exchange the most expensive power plant to be awarded will determine the price for the rest of the plants. There is a number of standardized block bids (Figure 6).

| Standardised block bids | | | | |
|---|---|---|---|---|
| Block Baseload | covering hours 1 to 24 | Block Evening | covering hours 19 to 24 |
| Block Peakload | covering hours 9 to 20 | Block Rush Hour | covering hours 17 to 20 |
| Block Night | covering hours 1 to 6 | Block Off-Peak 1 | covering hours 1 to 8 |
| Block Morning | covering hours 7 to 10 | Block Off-Peak 2 | covering hours 21 to 24 |
| Block High Noon | covering hours 11 to 14 | Block Business | covering hours 9 to 16 |
| Block Afternoon | covering hours 15 to 18 | | |

**Figure 6: Standardised Block Bids of EPEX spot market [3.1]**

The Intraday market completes the day-ahead market by offering trade of contracts with physical fulfillment on the same or the next day. This makes it possible for sellers as well as buyers to meet their needs maybe due to fluctuations in production or consumption and therefore reduce the risk of deviations in their balancing area. The trading includes the hours of the current day until 75 minutes before the physical fulfillment. There's also the possibility of summarizing various hours to “blocks”. The minimal bid size is, like in the day-ahead market, 0,1 MWh, with increments of 0,1 MWh. After 15:00, the hours of the next day can be traded.
Unlike in the day-ahead case, there are no closed auctions in the intraday market, formation of prices works in the simple way that always if there's an offer matching a demand in price and volume this contract will be executed.

Participation of small scale generators in the EEX markets requires overcoming a number of barriers, which are summarized in Table 1.

| Technical | Legal |
|---|---|
| – 0,1 MWh least bid size per hour<br>– 0.1 MWh increment<br>– connection to EEX trading system (simplest way: WebAccess via internet)<br>– 1/4h power metering (standard) | – for a trading licence at EEX<br>  – trader must be allocated to an existing/ establish a new balancing area in one of the TSO's regulating areas → contract with BRP (with further obstacles (securities etc.))<br>  – 50,000 € equity capital<br>  – accreditation as clearing/ non-clearing member by ECC (securities required)<br>  – reliability and professional qualification of trader and CEO |

**Table 1: Summary of technical and legal requirements for EEX trade.**

In addition to technical and legal requirements a number of cost aspects need to be considered. A summary of EEX fees and Transaction fees can be found here: [3.2].

A very specific problem relates to balance group contracts. One basic requirement to start trading via EEX is to get allocated to an existing balancing area in one of the TSO's regulating areas or to establish a new one. This establishment has to be done

with the corresponding TSO and here the problem arises: Currently there's no common balance group contract, so the requirements of each special treaty can vary depending on the TSO. The main problem with this treaty lies in the sometimes required securities – basically to cover risks of imbalance cost due to plant outages.

Conclusions and recommendations

(1) For smaller size DG operators, in most cases direct participation at the EEX trade will not make sense, because it is too complicated and too expensive. From the MASSIG experience the recommendation is: go to some Service Provider or operator of a Virtual Power Plant and let them do all this job.

(2) There is an innovative approach in Germany to ease the situation for smaller size DG: the concept of “regional market places”. Regional market places are smaller size, decentralized market platforms, where regional market participants can trade electricity and other services. Access barriers as well as fees for such market places should be significantly lower than for the central EEX. One strategic advantage of regional market places could be that other products besides real power could be traded, especially products that reflect the physical situation in the local distribution grid. For example there would be a chance to trade reactive power to be fed-in into defined grid segments in order to influence the local voltage level. By this means it might become possible to delay grid extension work or increase susceptibility for distributed generation.
Regional market places are currently developed in Germany as part of the so called “e-Energy” initiative [3.3], funded by Germany federal Ministries. One of the projects is “eTelligence”, where for the region of Cuxhaven a number of market participants (including smaller size generation from CHP or a virtual power plant with wind energy and controllable loads) will trade a number of products at the market place, including reactive power or plant availability [3.4].

(3) An important subject for Renewable and Distributed Generation is to have equal rights in international trade like national generation capacities. Because of natural resources and historic development, some of the different European countries do produce cheap and clean excess energy (e.g. wind energy in Denmark), which could replace conventional generation in other countries by solely putting competing bids at the Power Exchange markets. An existing problem is that the assignment of transport capacities (both national and trans-national) must be organized in such a way, that strategic line capacity assignments favoring big national power producers need to be forbidden. A system needs to be established where line capacities should be assigned in free auctions or where there is a direct coupling of market trade and bottleneck handling, allowing a quite straightforward market coupling between the energy markets of different countries. Such an approach is illustrated in the following paragraph explaining an exemplary solution for organizing the trade between Denmark and Germany:

All traders wanting to make transnational business sell their electricity to the power exchange (PX) in their own country and buy the same amount of electricity in the country they want to sell to from the foreign PX. They do not care at all about bottleneck situations in any transmission lines. This task completely goes over to the two Power Exchanges involved, who buy as much as available adequate transmission line capacities from the TSO (with an independent organization like EMCC [3.5] helping them to do so).

The PX in Denmark will now offer a maximum amount of (cheap Danish wind) energy to the German PX (via EMCC) and the price building mechanism of the German PX "sees" no difference between kilowatthours generated in Denmark and kilowatthours generated in Hamburg. Without limitation of transmission lines, this procedure would lead to exactly the same fixing prices of German and Danish PX.
So, at the end, the cheap Danish wind energy has an unrestricted market position on the German market and German and Danish traders are bound to exactly the same price building mechanism - until the physical transmission capacity is exhausted (only then Danish trader loose money).

## 3.2 Primary reserve market

Primary reserve contracts (like any other reserve products in Germany) are sold within an open bidding process organized via the web page https://www.regelleistung.net/regelleistungWeb/.
The minimum bid size is +- 5 MW with an increment of 1 MW. Activation and deactivation must be possible within 30 s and the service must be maintained for up to 15 min. There are further requirements regarding frequency measurement precision, 100% availability and the frequency-power-characteristic. The bidding is done on a monthly basis. There is only a capacity payment (realized as Pay As Bid auction) and no activation payment.
Different from the situation in Denmark the market is not split into two sub-markets for positive and negative primary reserve, so every interested party needs to offer both.

Conclusions and recommendations

(1) Currently only a limited number of big power plants participate at the primary reserve market. Besides historical reasons this is due to the relatively high minimum bid size and especially the requirement to provide this service 100% of all time during one month. This latter requirement almost completely prohibits Smaller Size Intelligent Electricity Generation fair conditions for participating. It would be a good idea to define much shorter bidding periods and split the day into blocks of hours to allow participation of units which can run only a part of the day. The other knock-out criterion is the requirement to offer both positive and negative reserve, which is hardly to fulfill by DG/RES. Yet it is difficult to evaluate within the MASSIG project team, if such a split of primary reserve markets might lead to technical problems (e.g. counteracting of generators due to inertia effects).

From the technical point of view, modern power electronics of DG/RES systems would allow to define frequency-power-characteristics in correspondence to the requirements of primary control, so provision of the service would be no problem, if the units constantly maintain the adequate positive and negative power reserve.

## 3.3 Secondary reserve market

The main task for the Secondary reserve is in 15 minutes to bring the Primary reserve back from activation, so that the Primary reserve again is ready for frequency regulation.
Activation and deactivation must be possible within 5 minutes and the service must be maintained for up to 15 min. There are further requirements regarding power gradients, 95% availability and online-connection to the power dispatcher of the grid operator. The bidding is done on a monthly basis. As it is the situation for Primary Reserve, auctions are on a monthly basis. But there is a market splitting into positive and negative reserve power and furthermore there are high tariff and low tariff time periods. The minimum bid size is 10 MW with an increment of 1 MW. There is an availability payment and an activation payment. It is important to notice, that for winning the auction only the availability price is considered (a zero activation price is assumed). Actual activation is done via the merit-order principle, starting with the most cost efficient offers.

Conclusions and recommendations

(1) Like for primary reserve, only a limited number of big power plants participate at the secondary reserve market. With the minimum bid size being even higher and relatively stringent requirements regarding technical parameters and communication access, Smaller Size Intelligent Electricity Generation has difficult conditions for participating. Shorter bidding periods and different time blocks would make participation much easier. So currently there are in Germany first operators of smaller size DG thinking about participation in this market using aggregation of a number of individual units. Replacing the monthly bidding scheme by a daily bidding scheme could significantly improve the market position of the smaller units, because it would be much easier for them to predict the operation schedules for the next day.

From the technical point of view there is no problem for DG/RES to participate in secondary reserve markets. For both CHP and fluctuating generation a high quality forecasting of demand or production, respectively, would be a crucial factor.

## 3.4 Tertiary reserve market

The purpose of tertiary reserve (in Germany called “Minutenreserve”) is to replace secondary reserve and to compensate imbalances for a duration of maximum 1 hour. The activation of tertiary reserve is done by the TSO mostly by phone; also the definition of schedules is possible. Complete activation needs to be achieved within

15 min, the availability must be 100%. There are some further technical requirements like a certain power gradient or monitoring equipment.
Procurement of Tertiary reserve power in Germany is organized in a way most suitable from the position of DG/RES producers: there are daily auctions, separated into markets for positive and negative tertiary control and split into 6 time blocks of 4 hours each. Likewise for Secondary reserve capacity bidding and activation bidding are separated and acceptance of the bids depends on the capacity biddings only. Any necessary activation follows the merit order of activation prices. Unfortunately there is a quit high lower bid limit being 15 MW with an increment of 1 MW.
There is a distinct weekly profile of capacity prices – so for instance positive regulation power on Monday to Friday has more than the double price compared to the weekend.

Conclusions and recommendations

(1) For smaller and medium size DG/RES, the Tertiary reserve market is currently the most interesting market option besides the spot market. Certainly participation of smaller size units requires aggregation to reach the minimum bid size, yet there are already today a number of service providers on the markets offering this service. Operators owning a number of units themselves (like medium size utilities) might think of participating the market alone. In any case lowering the minimum bid size would facilitate the participation of smaller size units and make the market more liquid.

(2) Changing activation price closer to operating hour: In Denmark it is allowed to change the activation price (Arbeitspreis), up to ¾ of an hour before the operating hour. It might be a good idea to do the same in Germany. Two examples for the MASSIG showcase Badenova Weingarten should illustrate why:

Example 1:
When planning the biddings for tomorrow for Weingarten (see Figure 7), we could decide to offer 12 hours of spot market operation and 12 hours of Tertiary reserve, but leave no place in the thermal store for being activated in Tertiary reserve (a high activation price is offered). Tomorrow it becomes colder than expected and the heat demand goes up. The 12 hours of spot market operation is not enough to cover the heat demand. The thermal store will be emptied and it is necessary to start the gas boiler. In this situation it will be important to be able to lower activation price to win activation in the Tertiary reserve market, thus avoiding starting the gas boiler.

Example 2:
When planning the biddings for tomorrow for Weingarten (see Figure 7), we could decide to offer 12 hours of spot market operation and 12 hours of Tertiary reserve, and leave some place in the thermal store for being activated in Tertiary reserve. If the CHP-units tomorrow are activated more than expected, the thermal store will be filled and it will be necessary to cool away heat. It would be important to be able to rise the activation price in the hours, where we have to cool away the heat.

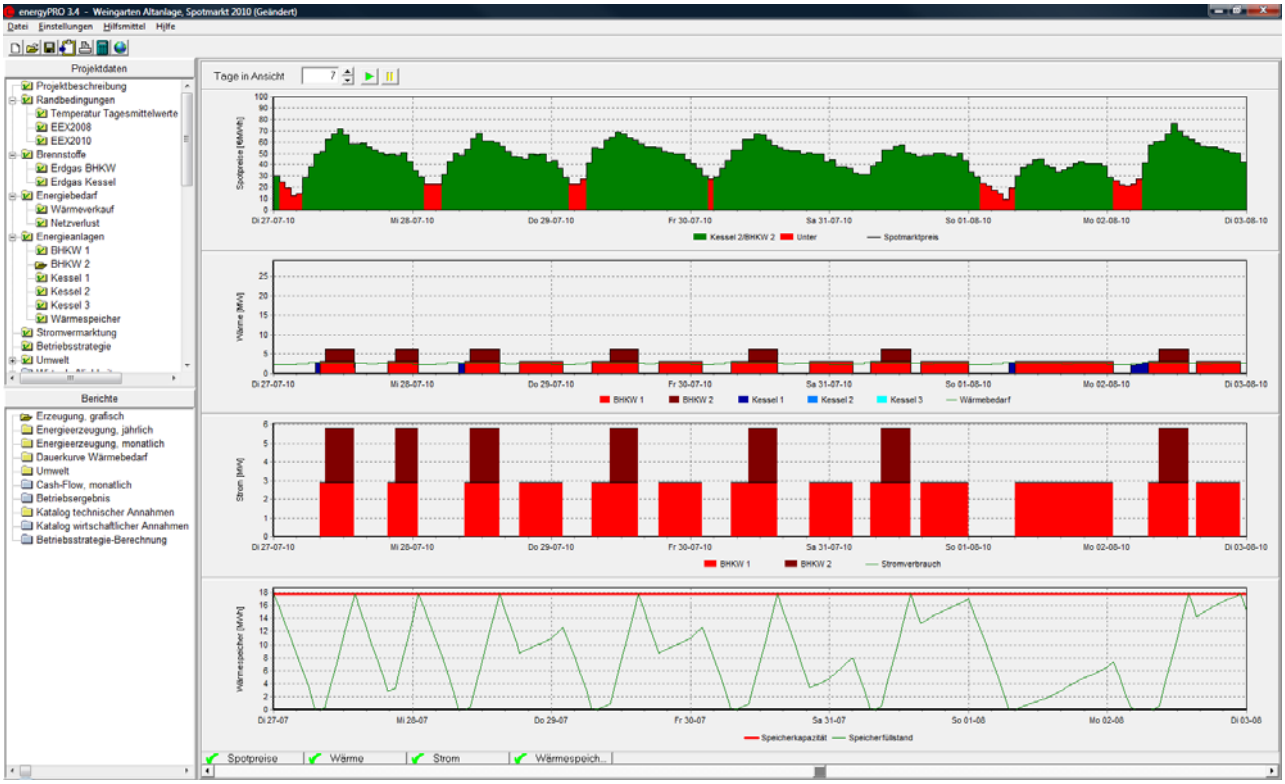


**Figure 7: Simulated operation in the Spot Market of Badenova WÄRMEPLUS´s 6 MW-Combined Heat and Power-plant in Freiburg-Weingarten.**

(3) Offering activation even if having not won tertiary control auction: Even if not having won offered Tertiary reserve, it is in Denmark allowed to make an activation-bid and to be activated. The same could be done in Germany. Two examples illustrate why:

Example 3:
For a plant participating in the Spot market and the Regulating power market, the Tertiary reserve bid for tomorrow are made before the Spot market bid. That makes it complicated to offer Negative Tertiary reserve, because offering Negative Tertiary reserve requires that the generator is running, but at the time of the Tertiary reserve bid it is not yet known, if the Spot market bid will be won. But if it is allowed to make an activation-bid closer to the operating hour and without having won Tertiary reserve, it will be known if the generator is running, so that downward regulation can be offered. E.g. if we have won 12 hours of spot market operation and it becomes warmer tomorrow than expected, then the thermal store will be filled and the CHP-units are not able to produce in all these 12 hours. In this case it is important to be allowed to offer downward regulation, so that the plant does not have to pay for imbalance.

Example 4:
Even if the plant has not won Tertiary reserve, it would be important to be allowed to be activated in Tertiary reserve of the same reasons mentioned in the upper example 1.

It is to be noticed, that in Denmark Negative Tertiary reserve power is virtually not bought by the TSO, probably because it is in Denmark allowed to maintain the activation-bid and to be activated as downward regulation even if not having won Tertiary reserve. It seems as if the Danish TSO are confident that enough will offer downward regulation, even if the TSO has not bought downward regulation capacity. If the same will be true in Germany, we estimate that it will save Germany an amount of 160 Mill. €/year.

| **Saved money for buying Negative Tertiary reserve** | | |
|---|---|---|
| Average bought Negative Tertiary reserve | 1825 | MW |
| Average Leistungsprice for Negative Tertiary reserve | 10 | €/MW/stunde |
| Estimated yearly payment for Negative Tertiary reserve | 160 | Mill. €/year |

(4) Increasing the share of Tertiary reserve of the balancing tasks: The fast and automatic Primary and Secondary reserves markets are very expensive for the TSO´s and due to the reasons mentioned above are difficult for small scale power producer's to participate in. It is easier for small scale power producer's to participate in Tertiary reserve.

The minimum volume of Primary reserve to be procured can not be chosen freely by the TSO since UCTE determines how much Primary Reserves each country has to deliver.

But it is to be noticed that in Germany the TSO´s buy more than half of the remaining balancing capacity as expensive Secondary reserves. In Denmark less than a fifth of the remaining balancing capacity is bought as Secondary reserves.
We estimate that when increasing the Tertiary reserve share of the balancing tasks in Germany, smaller intelligent power producers would increase their participation in the reserve market and in parallel the total costs for reserve power could be lowered.

| | **Positive Secondary Reserves (Sekundärreserve)** | **Positive Tertiary Reserves (Minutenreserve)** |
|---|---|---|
| **Germany** | 2955 MW | 3054 MW |
| **West Denmark** | 90 MW | 513 MW |

Data sources: Bundesnetzagentur (Germany), Energinet.dk (Denmark)

(5) Currently the Tertiary control market is organized as pay-as-bid market. This gives a significant uncertainty to especially smaller plant owners, since they do have

neither experience nor capacities to make “scientific guesses” about the achievable prices and corresponding risks. A single price market would be much more preferable, since smaller power plants could offer their service using marginal costs.

## 3.5 System services

System services are procedures or provisions necessary to enable or stabilize operation of transmission and distribution grids. Typical system services (in a wider range of understanding) are for instance:

- Maintaining grid frequency
- Maintaining voltage stability
- Handling of faults
- Availability of generators with black start capability
- Maintaining power quality in the grids (e.g. harmonics, flicker, voltage dips, voltage variations, unbalance)
- Management of reactive power demand

In the past such system services were either just bought by the grid operators in a quite intransparent way or utilities or regulations forced plant operators to simply provide such services without any compensation. Replacing this system by market mechanisms would be highly desirable, since:

- Competition would lead to a realistic price building and supposedly to lowering total costs.
- Competition would allow new actors to join the market.
- Intelligent DG / RES systems could identify additional ways of income making them more independent from subsidies or FIT tariffs. Systems behaving most “intelligently” (meaning: delivering services most wanted to the grid) would be rewarded adequately.
- With an increasing share of fluctuating renewable and distributed generation the overall need for system services will increase profoundly. Having a market for such services would allow a smooth balancing between changing demands and available offers.

A number of the system services relates to local conditions in certain sections in the local grid. In such cases it is necessary to limit the number of eligible market participants to those, which based on their geographic location and connection point to the grid would be able to provide the required service. As already discussed in Chapter 3.1, regional market places with a definition of “regional products” could serve this challenge. So, for instance, a market product could be to feed reactive power into a specific grid segment, with the amount of reactive power being dependant on the momentary voltage level.

In this context it is worth mentioning, that currently grid load management receives almost no attention by power plant operators in Germany, since electricity trade is organized via balancing groups, which are completely abstracting from the physical

properties of the grid. There is some doubt, if this concept can adequately handle the changes in the geographic location and altered generation characteristics of prospective power producers in future. Matters of congestion management might become more important in Germany in future as well. If so, this service should be organized as a free market, like it is already done today in other countries like Austria.

[3.1] EEX European Energy Exchange, Company and Products, January 2010
[3.2] Project MASSIG, Deliverable D3.1: “Pre-conditions for entering “big markets” by “small DG”, Freiburg, December 2008
[3.3] E-Energy Programme, Homepage: http://www.e-energy.de/en/ (2010)
[3.4] Project eTelligence, Homepage: http://www.etelligence.de/ (2010, German version only).
[3.5] European Market Coupling Company EMCC, Homepage, http://www.marketcoupling.com/ (2010)

# 4 Survey of requirements for market participation in Poland

## 4.1 The Status quo of the Polish electricity market

The current structure of the central, wholesale electricity markets in Poland is presented in the figure below and has been detailed explained in the MASSIG Work Package 2 Report.

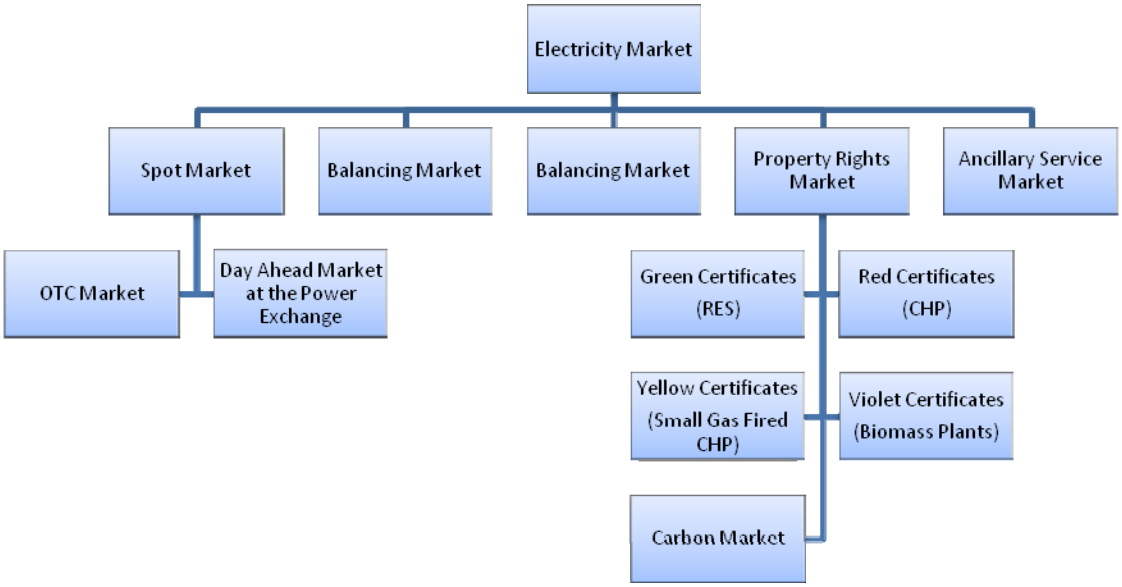


**Figure 8 The current architecture of the Polish electricity market**

At the moment only large and medium power producers and very large customers directly participate in the day ahead spot market, mainly trading their outputs in bilateral contracts. The largest generating units connected to the EHV provide balancing and regulating power, as well as, short term reserves and other ancillary services. An active participation of the demand side is rather poor and the switching rate among medium and small end-customers is extremely low.

The progress in the development of new renewable sources is very well stimulated by the TC (Tradable Certificates) system, however large wind projects prevail. The national targets concerning electricity produced in co-generation are met thanks to large, coal fired power plants. The development of micro generation, including small RES and CHP, is rather limited due to elevated investment costs and the lack of dedicated support schemes (for example special tariffs).

The overwhelming majority of RES and small CHP currently stay out of the competitive market and trade their outputs to local distribution companies (suppliers of last resort) for fixed price. Important flaws in the construction and the regulation of the Polish electricity market are the reason for this situation. The present architecture was implemented more than 10 years ago and in the meantime only minor adjustments have been introduced to the original market blueprint.

## 4.2 The day ahead spot market

The Polish power exchange, TGE – Towarowa Giełda Energii Elektrycznej, runs a day ahead trading floor, where the minimum bid volume and the minimum step change are 1MW. This unjustified barrier totally prevents smaller size generators from an independent participation in the power exchange trade and makes more difficult clustering of small units and trading of the aggregated output in the TGE day ahead market. This barrier could be easily lifted. Two Polish test cases analyzed in the Deliverable 5.1 show that even medium size intermittent power plants of 30MW might make substantial losses in the balancing market due to imbalances caused by the minimum bid volume of 1MW.

## 4.3 The intraday market

As it has been proven in the Deliverable 4.3 and Deliverable 5.3 of the MASSIG Project the length of time between the gate closure, when power producers inform the Transmission System Operator about their contractual positions and the delivery time is crucial for intermittent, renewable electricity sources. In the current schedule of the Polish electricity market operation power producers have to submit their production schedules before 12 o'clock on the day before the delivery day. It means that the production forecast period stretches over 36 hours and this results in increased forecast error and imbalance losses taken in the balancing market. However the new market design published by the TSO will shorten this gap by one hour, but this will not much influence the situation of small RES and DG plants.

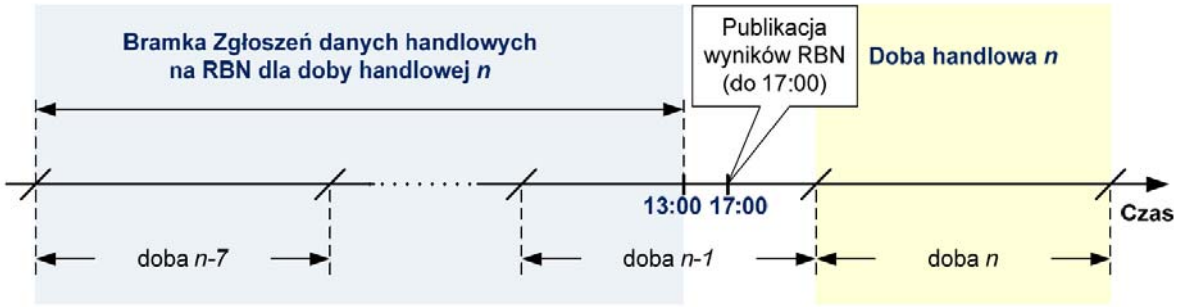


**Figure 9: The schedule of the day ahead market suggested in the new Polish electricity market design (source: PSE-Operator S.A.)**

The implementation of the intraday market and the shortening of the gate closure time to less than 1 hour before the delivery period seem to be the most urgent action, which should be taken by the Polish Regulator (Urząd Regulacji Energetyki) and the TSO (PSE-Operator S.A.). There are no apparent technical or economical obstacles to shift the gate closure time and to facilitate intraday trade. Stronger pressure from the regulating authority should be put on the TSO to accelerate the implementation of the market structure which has been already successfully tested around the world.


**Figure 10: The schedule of the intraday market suggested in the new Polish electricity market design (source: PSE-Operator S.A.)**

The idea of the intraday market included in the new market design revealed by the PSE-Operator (see Figure 10) cuts down the time lag between the gate closure and the delivery to just 75 min. The research conducted in the Work Package 4 of the MASSIG project and presented in the Deliverable 4.3 shows that this change should significantly decrease the forecast error and reduce the imbalance risk for intermittent RES.

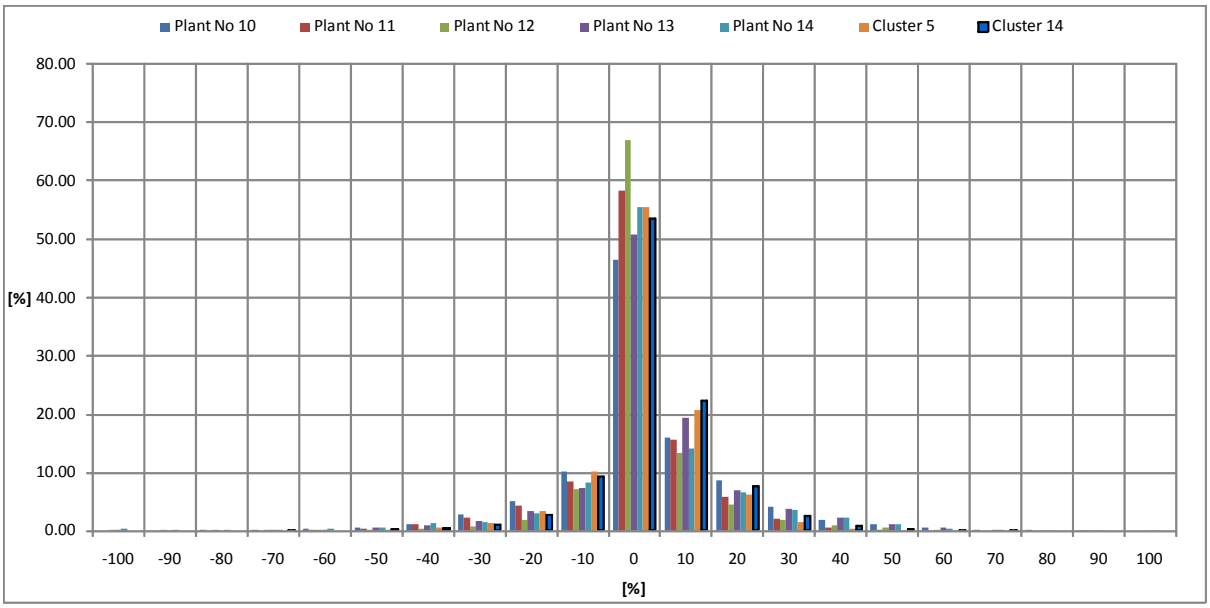


**Figure 11: The frequency distribution of the imbalance error of wind farm clusters (12 months of 2008), Austria, day ahead Market, 1 h settlement period.**

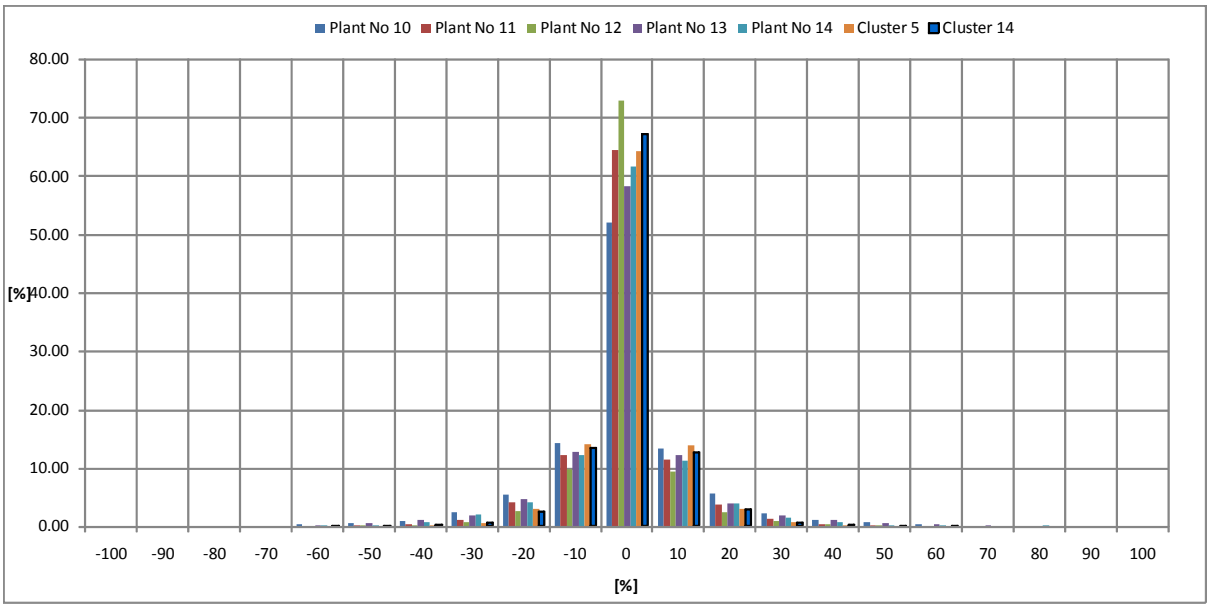


**Figure 12:** ***The frequency distribution of the imbalance error of wind farm clusters (12 months of 2008). Austria, intraday market, 1 h settlement period.***

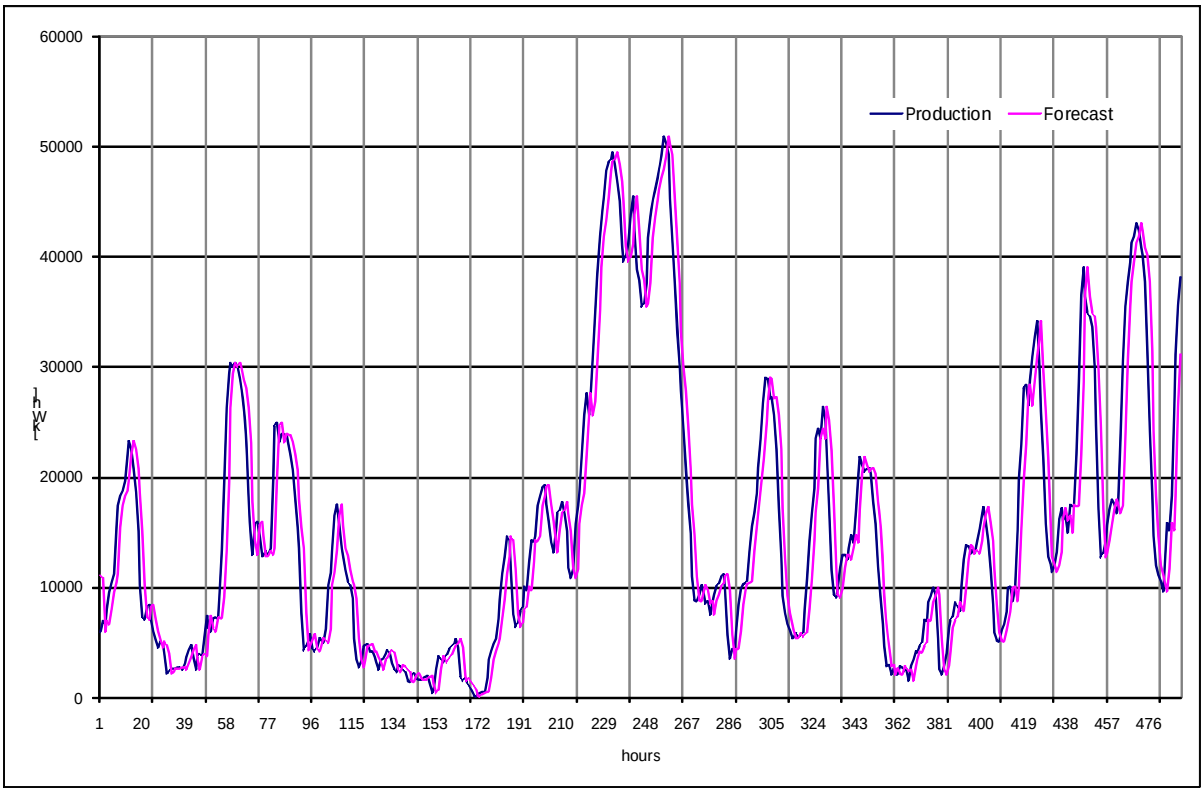


**Figure 13: The comparison between wind farm production forecast and its real output, 1h prediction horizon (Denmark).**

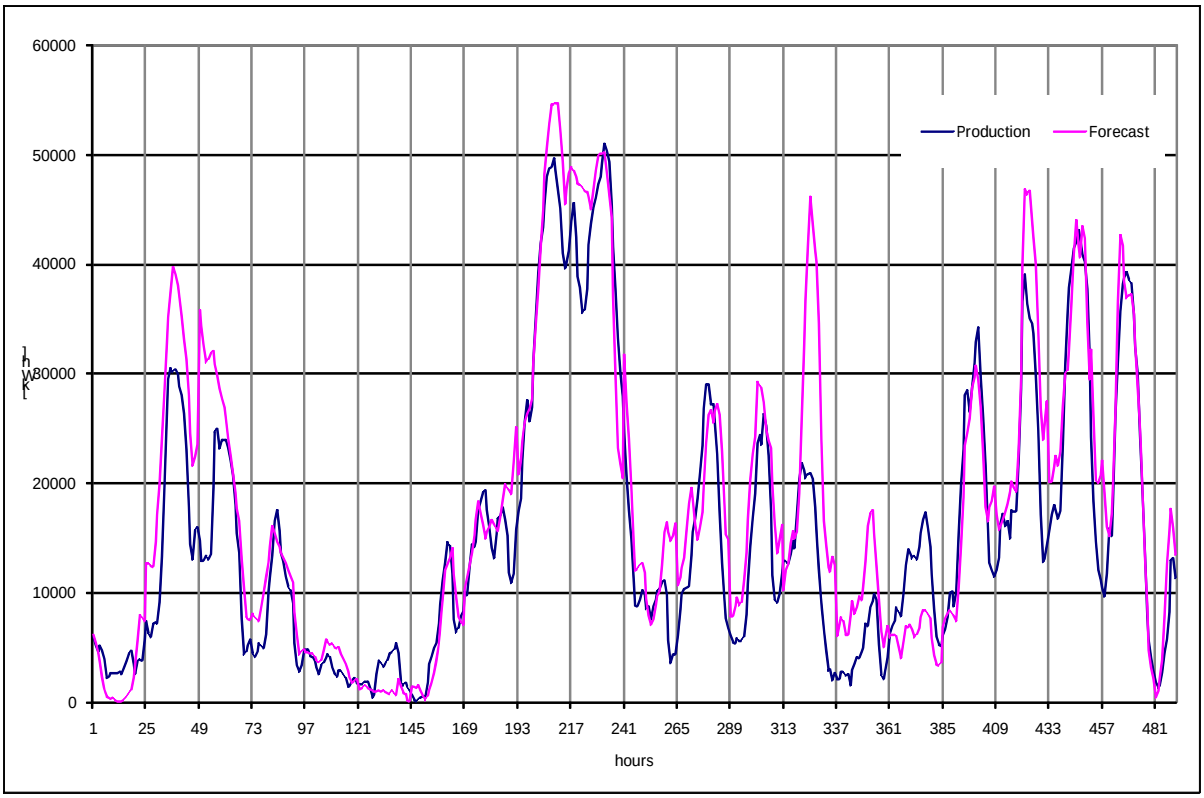


**Figure 14: The comparison between wind farm production forecast and its real output, 48h prediction horizon (Denmark).**

## 4.4 The balancing market

The Polish balancing system run by the TSO facilitates the tertiary control of the power system.

Only generating units directly controlled by the TSO can be active participants of the balancing market. It has been explained in the Deliverable 3.1 that this requirement results in the need of installation of sophisticated and very expensive ICT systems (WIRE, SOWE and SSMP). Therefore for small renewable power plants and small CHP units connected to the MV and LV distribution networks an active participation is not economically feasible.

Apart from technical and economical barriers, there is a regulation concerning the minimum bid size in the balancing market (1MW), which could be satisfied by large power plants only.

With the increasing share of electricity supplied by renewable plants of different generating technologies also a part of the balancing power has to be supplied by these plants. The transmission and HV distribution network grid codes set technical conditions (control and communication equipment), which help TSO or DSO to adjust an output of large wind plants, but they can't become active participants of the balancing market and provide negative power (generation shedding) and they are not rewarded for providing this kind of emergency service. This does not apply to small and medium size RES connected to LV and MV networks.

There is also another economic barrier for the active participation of renewable plants in the balancing market, which is the minimum bid price set in the grid code (approximately 20 €). This condition makes the participation in the provision of the negative control power infeasible for RES plants with variable production costs close to zero.

## 4.5 The ancillary service market

The ancillary service market in Poland is a central, single buyer market run by the TSO. The following kinds of services are included in this market:

- primary control
- secondary control
- operational reserve (hot reserve)
- operation of the thermal condensing power plant in underload or overload
- reactive power flow and voltage control services at generation nodes.

The detailed technical specification of the listed ancillary services and the rules of the settlement for provision of these services have been included in the Deliverable 2.1.
According to the grid code only large units, which can be directly controlled by the TSO are entitled to participate in the ancillary market. This approach is not compatible with the future structure of the power system, where a large share of energy will be delivered by small and medium size renewable power plants. Selected types of ancillary services should be also supplied by the distributed generation connected to MV and LV networks. Even fluctuating RES are capable of providing services like voltage and reactive power control, maintaining power quality or negative operational reserve. However, the opening of the ancillary market to RES and small CHP shouldn't contravene the rules of sustainable policy in the EU energy sector where the maximization of production of renewable energy is the top priority.
The difference between operational characteristics of the large power plants connected to transmission networks or to HV distribution networks and DG plants connected to the LV and MV distribution networks and their different sources of income suggest that they will be better off if their output will be traded at two different market places, a big, centralized, wholesale market and a small, local market

## 4.6 The need of the local electricity market

In the past the design and implementation of electricity markets was based on the **Top-down** approach, where centralized wholesale markets gather big market players, i.e. large power plants and large suppliers. Since the dawn of the power sector liberalization, this security driven approach was essential as the distributed generation was still at the nascent stage. Now with rapidly increasing share of RES in the total electricity generation in Europe, the **Bottom-up** approach to the market design is more and more expected.

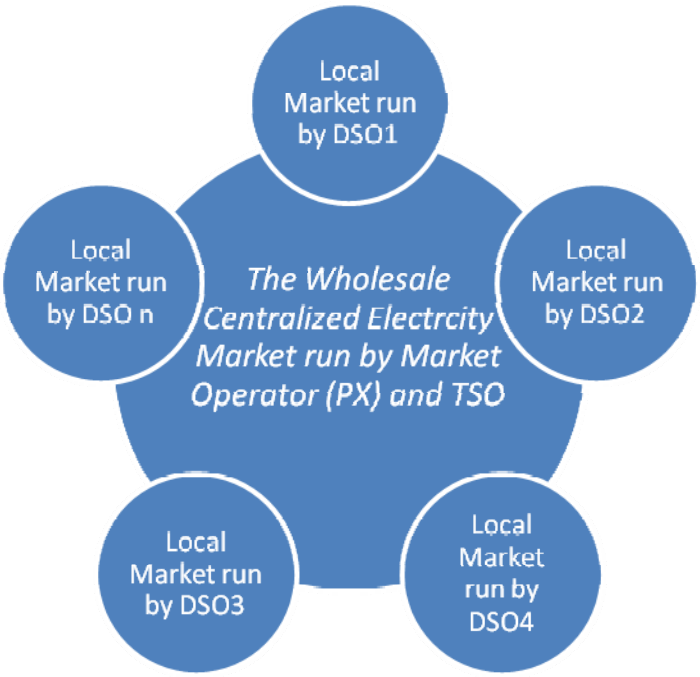


**Figure 15: The structure of the hierarchical electricity market split into wholesale central market and local distribution network markets**

There are compelling arguments for the creation of separate marketplaces for smaller size generators connected to the LV and MV network:

- The advancement of the dispersed generation results in the rapid increase of the number of active participants of the market. The centralized data acquisition and control by the TSO could be extremely difficult or even impossible. The regional and distributed control systems (SCADA) equipped with basic trade serving software should be the tools for the implementation of local energy and ancillary service markets.
- ICT systems which are required for the active participation in the wholesale market are often not scalable, expensive and complicated. Trading and provision of ancillary services at the distribution network level can be implemented using tailored tools and systems (regarding communication speed, data volume and access time) without jeopardizing reliability and security of the power system.
- The range and technical specification of products traded in the centralized market and in local markets could be different. The validity and the importance of services and reserves differs between EHV or HV networks and MV or LV networks.

The following products and services might be easily shared with or handed over to local markets:

- Electric power trade (independent),
- Dispatch and transmission constraint management (coordinate with TSO and DSOs),
- The voltage regulation and reactive power flow control (independent)

- System balancing and the tertiary control (shared between TSO and DSOs),
- Short-term reserve (independent),

while others, like for example system restoration or primary control, should be still the sole responsibility of the TSO.

## 4.7 Nodal pricing

The European electricity markets have been designed and implemented using copperplate paradigm, where the cost of the transmission and distribution system operation (including transmission constraint alleviation, losses and maintenance) is equalized among all grid nodes of the same voltage. This model results in very simple electricity pricing mechanism and acceptable predictability of electricity and ancillary services pricing.
However, looking at the real cost of the power system operation, including balancing of the production and consumption and the market signals, which should stimulate the behavior of market participants, the flat pricing is far from being efficient. On the one hand the copperplate model facilitates and simplifies market integration, cross border exchange and in the result creation of the common European electricity market. On the other hand the nodal pricing strongly supports generation located in the vicinity of load centers and this is particularly important for the competitiveness and the feasibility of market options for the distributed generation. Although many European regulators more or less successfully try to reduce this inherent inefficiency of the European model by implementing additional remuneration like for example Avoided Grid Utilization Payment in Germany, the static nature of such regulation does not reflect dynamic changes in the real time cost of the power system operation.

Recently the Polish TSO, PSE-Operator S.A. has published the new market design for the electricity market in Poland, which is based on the LMP concept (Locational Marginal Pricing). Since prices at network nodes will depend on three components:

a) electrical energy priced in the generating nodes,
b) marginal cost of network losses linked with the delivery of purchased electricity,
c) cost of the transmission constraints alleviation,

this market model should improve position of the dispersed generation as it helps to reduce two last price components mentioned above.

The LMP has also serious flaws, which must be considered and carefully analyzed:

- algorithms currently used for calculation of nodal prices simplify the physical model of the power system and the final results (prices) sometimes do not reflect the real cost of the power system operation (balancing, constraint management, etc.),
- LMP based electricity markets show greater price volatility and unpredictability. The locational marginal pricing methodology may lead to a step change when system load grows, creating higher financial risk, especially for small and medium-sized market participants.

## 4.8 Conclusions and recommendations

The Polish electricity market went life more than 10 years ago and from that point of time only minor adjustments have been done to the original market model. Meantime profound changes happen in the power sector in Poland. One of these changes is a rapid development of renewable energy sources, which is very well stimulated with a spectrum of TC based support schemes. The side effect of the implementation of TC support scheme is the advantage of large on shore wind farms, which are at the moment the most cost effective among all RES generating technologies. Owners of the majority of RES plants and all small CHP plants are fairly satisfied with the income earned at the support scheme (green certificates and yellow certificates) and express little interest in the active participation in the wholesale electricity market considering it too risky and thinking that the game is not worth the candle. One of the reasons for this situation is the current model and the operation schedule of the wholesale Polish electricity market, which has been developed mainly with the cooperation and consultation with large power producers.

On the brink of the implementation of the new market design, the Regulator together with the TSO, who stimulation the discussion about the new model, are strongly encouraged to consider the following issues which are crucial for the paving the way for small RES and CHP plants to the participation in the electricity market.

In the short term perspective, the following changes ought to be done, which are relatively easy to implement:

- Minimal bidding volumes in the Polish power exchange and in the balancing market should be lowered to 0.1MW or less, to facilitate independent participation of smaller size power producers.
- The intraday market should be implemented at the power exchange as soon as possible. This will result in the decrease of imbalance costs incurred in the balancing market by intermittent renewable power plants.

In the long term perspective, the following changes in the market design might be considered and analyzed in depth:

- Local electricity and ancillary service markets, operating in parallel with the big, wholesale market, should incentivize small power producers to participate actively in the competitive electricity trade.
- Nodal pricing system, which will better reflect the value of the distribute (local) generation of electricity might bring additional benefits to small power producers.

# 5 Survey of requirements for market participation in UK

The survey of requirements and barriers for the participation of small and medium sized distributed generation in the UK-markets are focused on the spot markets and bilateral contracts. One of the balancing markets, the STOR-market, is also discussed.

## 5.1 Participation in the spot markets

Within the last two years (2008-2010) significant changes in the UK power market operation took place. Among them Day Ahead and Intraday (Continuous) Markets appearance initiated by APX-ENDEX commodity and Day Ahead Market launching initiated by N2EX commodity.

The latest event aiming to increase electricity market trading options is the upgrade of EuroLight® 5.0 trading system-the exchange's trading platform for APX-ENDEX electricity spot market came in operation on Tuesday 9 February 2010.

The new upgraded version of EuroLight® 5.0 allows the market participants to trade UK power until 15 minutes before gate closure which in its turn allows traders to analyze the latest information on weather conditions that influence the production of renewable energy.

These events have increased the number of options for smaller size renewable power generation to sell their product in a "big" electricity market.

To become a participant of the "big" electricity market every smaller size energy producer has to assess in a right way its own technical, legal and economic position in order to find the right electricity market sector for successful power trade and to choose a skilled trader, taking care of trading the small and medium sized distributed generation into the market,

To sell the generation product to and/or through the licensed trader there are a number of licensed companies in UK offering their service and help for small renewable power producers to sell generated power and claim their Renewable Obligation Certificates (ROCs) or, for instance, to take care of obtaining permission from the local electricity network supplier (DNO) to attach a small wind turbine to the grid.

The most common procedure concerning establishing business relations between small power producers and licensed companies includes following steps (usually these steps lasts no longer than one week):

- Power Producer should use a complete application form from the website of the chosen Company as a request

- After request is received Company sends out an information pack (complete with application form for the purchasing scheme) to Power Producer
- Once the application form returned Power Producer signs up to the scheme and sends a confirmation of this to the Company
- After finalizing all formalities Power Producer must provide the Company with meter readings in accordance with Company requirements (e.g. every six months) to calculate how much Company must pay for the power purchased.

As examples of traders in UK are to be mentioned:

- EDF Energy, www.edfenergy.com
- Good Energy, www.goodenergy.co.uk
- Ecotricity, www.ecotricity.co.uk
- Scottish and Southern Energy (SSE), www.scottish-southern.co.uk

Conclusions and recommendations

Presently in the UK there are no prohibitions or restrictions for participation in the "big" nationwide electricity market for the smaller energy producers- generators of less than 5 MW output at a single metering point. But the trader, taking care of trading the small and medium sized distributed generation into the market, has to fulfill the normal requirements for trading.

## 5.2 Additional options to sell small and/or micro- sized power production

In UK there are several other options available to sell small and/or micro- sized power production:

- To be a third party (subcontractor) in electricity market trade for large power producers.
- To be included in a common electricity trade package (portfolio) of large power producer.

The only precondition for the smaller size generator is to be provided with the smart metering device - meter that measures both electricity import and export

To be a third party (subcontractor) in electricity market trade for large power producers and to be included in a common electricity trade package (portfolio) of large power producer) do not require any additional comments as their implementation is based on signing of bilateral contracts between two (or more) parties and contract conditions for different contracts as usual are not similar to each other and strictly confidential.
Power produced and transferred by small generators can then be applicable for further electricity export carried out by subcontractor or large power producer in accordance with their power sell agreements.

Another opportunity is to be a Micro-grid:
Micro-grids are self-sufficient aggregations of micro power generation sources (< 500 kW), loads and energy storage devices, operating as a single system.

Micro-grid is connected to the distribution network through a single Point of Common Coupling (PCC) and appears to the network as a single unit composed by locally controlled loads and locally controlled generators.

In a generic hour of the year (month or day) when load demand is low and wind speed is high and sale price is also high, micro-grid can sell energy to the network by using all mentioned above options, exploiting the wind generator at its maximum limit while other generation units remain switched off.

## 5.3 Participation in the STOR market

STOR is a contracted Balancing service providing an additional active power generation amount and/or power demand reduction.

A STOR provider must satisfy the following technical requirements:

- To offer a minimum of 3 MW or more of generation or steady demand reduction (this can be from more than one site)
- To deliver full MW within 240 minutes or less receiving instructions from National Grid; To provide full MW for at least 2 hours when instructed
- To have a Recovery Period after provision of Reserve of not more than 1200 minutes (20 hours)
- To be able to provide STOR at least 3 times a week

A STOR provider can choose between two forms of STOR service:

1. Committed Service
Committed service providers must make the service available for all Availability Windows periods during which the service provider is required to be available to operate at Contracted MW within the contracted term. National Grid commits to buy all services offered
2. Flexible Service
Flexible Service (FS) allows providers to make themselves available for particular – time periods of each day when FS is required which is set up by National Grid for some future period, for example, for the period of 1st of April 2010 – 31st of March 2011

Once at 10:00 hours on each Friday Flexible Service availability is being declared in respect to Availability Window(s) in the following week, National Grid will assess whether to accept or reject the declared Flexible Service availability.

National Grid may reject any Flexible Service availability up to 16:00 hours, in which case no Availability Payments will be made in respect of such rejected Window(s).

Where availability in any Availability Window(s) is offered as at Friday 10:0 hours, and is not rejected by National Grid, the service provider is then committed to providing the service in such windows.

The availability may only then be withdrawn for technical reasons.

Where availability was rejected by National Grid, the service provider (energy producer) may continue to offer the availability.

This availability is then assessed by National Grid on a week-ahead basis and providers are notified if their service is required.

If STOR FS is accepted, providers are paid by National Grid on a £/MWh basis.

There are two types of payments:

- Availability Payment are paid to STOR providers for the availability of their units (or sites) within an Availability Window
- Utilisation Payments are paid to STOR providers for the energy delivered as instructed by National Grid

A provider has to fulfill the pre-qualification by signing the framework agreement before participating in Tender.

In order to take part in STOR each provider must use STOR Invitation to Tender Pack, STOR Market information Reports and STOR Relevant Documents which can be obtained trough
http://www.nationalgrid.com/uk/Electricity/Balancing/services/reserveservices/STOR

To set up availability and utilization prices and also optional utilization price (only for non-BM) £/MWh, providers (tenders) must also submit Tender Sheets 2&3 Availability, Level of Reserves and Prices for year A&B.

To fulfill this participants must complete tables of correspondent prices in £/MWh for each season in which they wished to be paid by National Grid for service provided.

Further these offered prices are assessed by National Grid and either accepted or rejected.

Conclusions and recommendations:
There are no real problems in participating in the STOR-market.
Since STOR market gives additional income compared to your normal income it typically will be a profitable way of increasing profits, but it is important for a small and medium sized distributed generation to choose a competent provider at this market.