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Research Report

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Empirics of Intraday and Real-time Markets in Europe: POLAND

Report on behalf of DIW Berlin

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1. Executive summary

Production of electrical energy and the balancing of the Polish power system is predominately based on large coal firing units, centrally dispatched, which are also responsible for provision of critical regulation and reserve services.

Operation of the Polish electricity market is based on a relatively seamless integration of spot market (the power exchange - TGE, Towarowa Giełda Energii and the OTC-bilateral market), and technical markets including balancing and ancillary service markets operated by the Polish TSO, PSE Polskie Sieci Elektroenergetyczne S.A.

Spot trading is divided into the day ahead and intraday markets. An vast majority of the consumed electricity is traded through the power exchange and OTC contracts concluded up to day ahead of the delivery day. Due to obligations linked with participation of large generating in the technical market, the volume of the intraday market is negligible. The balancing and ancillary service markets play also minor roles regarding traded energy volume.

Short term planning of the power system operation including allocation of ancillary services and information about system constraints, starts two days before the delivery day. The final preliminary schedule for the whole system and individual units is published 5 p.m. day ahead and is updated every 15 minutes till the end of a delivery day. The settlement period and delivery period, both for spot market, balancing market and ancillary service market, is one hour. The dispatch period for generating units are is $\frac{1}{4}$ hour. Within this time adjustments of unit's output are done with regulation services.

The submission of individual units production schedules based on producers contract positions taken in the long term and medium term trading (up to day ahead) ends at 2.30 p.m. day ahead, which is also the gate closure time for balancing bids. The continuous trading at the intraday market starts at 3.30 p.m. day ahead and continues till the end of the delivery day with possible modifications of contract position up to one hour before the delivery period. The fact that balancing market and the final selection of ancillary services and reserves are arranged before the beginning of the intraday market limits the possibilities to use the intraday market for final tuning of large generators' market position.

The balancing market is used by the TSO to balance the system every 15 minutes, to minimize the cost of the total system load supply (with substituting more expensive bids with cheaper ones), to alleviate transmission constraints resulted from bilateral and power exchange transactions. Regarding the first two tasks, balancing market participants are paid or charged using single marginal price, both regarding instructed and uninstructed deviations. To prevent gaming, the TSO has the right to introduce penalisation component, which will replace single marginal price with double pricing system (system sell price, system buy price). For their participation in constraint management generators are remunerated using their individual variable costs. Large flexible loads can actively participate in the balancing market, but their current role is insignificant.

Territorial aggregation of imbalances is possible only in the case of wind generation (physical offsetting of imbalances). Otherwise balancing responsible parties are settled against individual imbalances of their members at physical metering/grid connection points and only financial offsetting of imbalances is possible within a group.

The balancing market is coupled with the ancillary service market by units selected ex ante for the provision of operating reserves and primary and secondary regulations. Similarly to the balancing market, also the ancillary services engaged in real time or at very short notice are delivered by large centrally dispatched units equipped with special monitoring and electronic information exchange

systems. The ancillary services are contracted by the TSO using public tenders. Providers are remunerated separately for activation of the regulations and for energy exchanged due to the regulation. The first component is settled using price defined in the agreement between a generator and the TSO in bilateral Grid Connection Agreement. The second component is settled using balancing market prices. For delivery of the operating reserve generating units are paid using single marginal price as for the capacity payment. This price is a trade-off between the reference average fixed cost of generating units providing operating reserve and the TSO budget allocated to ancillary services.

Beyond primary or secondary regulations and operating reserve, the TSO uses a number of additional short term, medium and long term products to support system balancing (must-run contracts, underload, overload, intervention operations).

For all ancillary services the TSO is a single buyer bearing the final responsibility for overall system balancing, maintaining system frequency and the implementation of cross-border exchange.

The cross-border trade of electricity is possible in the day ahead market and in the intraday market. During the delivery day import/export schedules can be adjusted with six intraday gate closures taking into consideration results from long term transmission capacity auctions and intraday explicit capacity auctions.

From a short term perspective the present electricity market model is satisfactory. Spot prices and transmission tariffs are kept under control. The availability of reserves and regulation power, as well as management of network constraints is satisfactory regarding the reliability of the system. But from a long term perspective, the balancing and ancillary service markets are overregulated and they don't send price signals reflecting approaching scarcity of generating resources that will be linked with decommissioning or mothballing of large number of old units, which that do not satisfy new emission/pollution standards.

Remuneration for the provision of ancillary services depends largely on an available budget. Must – run payments are based on units' variable costs. Services acquired by the TSO in bilateral contracts do not send transparent price signals fostering new investments.

A deeper integration of the Polish market with neighbouring markets would increase the availability of balancing power. Unfortunately flow-based methods for cross-border capacity allocation, successfully implemented in other regions, do not improve the situation in the case of complicated load-flow patterns (loop flows) in Central-East European (CEE) region of the ENSTO-E transmission network. With wider and deeper integration of electricity markets across Europe an alternative real time, nodal market model need to be considered.

At the moment the main point of discussion regarding changes in the market model deals with an introduction of the capacity payment mechanism to combat deteriorating system adequacy and shrinking operational reserves.

2. The elements of Intraday and Real-time Markets in Poland

2.1. System forecast

The operational planning for the Polish power system consists of number or iterative nested procedures including coarse annual planning (PKR), monthly planning (PKM), which is followed by detailed short term daily planning.

PSE - Polskie Sieci Elektroenergetyczne (the Polish TSO) starts short-term operational planning six days before the delivery day. Daily Technical and Market Balance (BTHD) covers 6 consecutive days and it is published recursively at 4 p.m., starting 9 (D-9) days before the first delivery day. The last update is published 3 days before the delivery day (D-3). Preliminary Daily Co-ordination Schedule (WPKD) is published only once, 2 days before the delivery day (D-2), at 4 p.m. Daily Co-ordination Schedule (PKD) is published once, one day ahead of the delivery day (D-1), at 5 p.m. Current Daily Coordination Schedule (BPKD) is published recursively. The first version is published day ahead of the delivery day (D-1), at 7 p.m. and it is updated every 15 minutes till the end of the delivery day (D). The entire planning cycle is illustrated in Figure 1.

An involvement of owners of power plants in the planning process begins with a submission of maintenance and overhaul schedules, updates of units' operating parameters. In daily planning (BTHD, WPKD and PKD) information about generating units must be submitted by the owner of the plant by 10 a.m D-9 (nine days before the delivery day). Daily planning is recursive and continues until D-1 (day ahead the delivery day). In the course of the delivery day (D) information about changes in technical parameters of generating units must be submitted immediately.

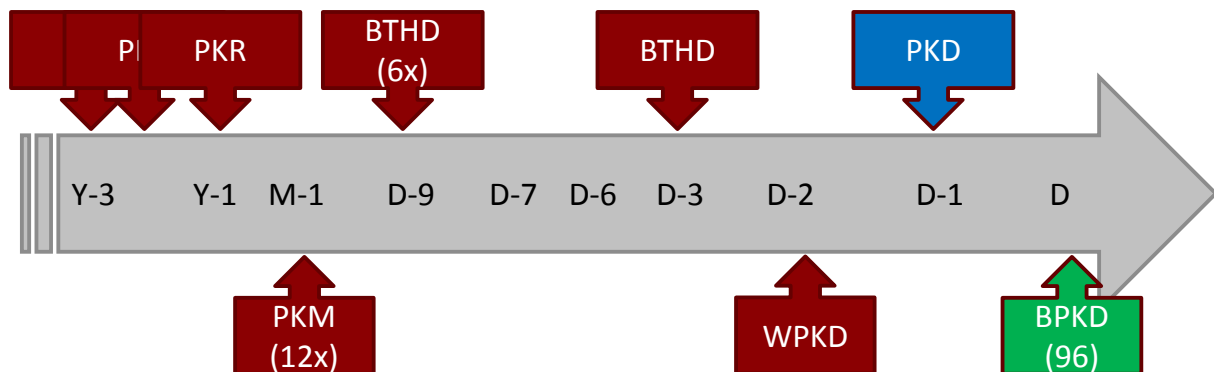


Figure 1 Full range of the operational planning in the Polish power system.

Information on system constraints and must-runs imposed on generating units are included in BTHD (from D-6 till D-3) and it is updated in WPKD (D-2).

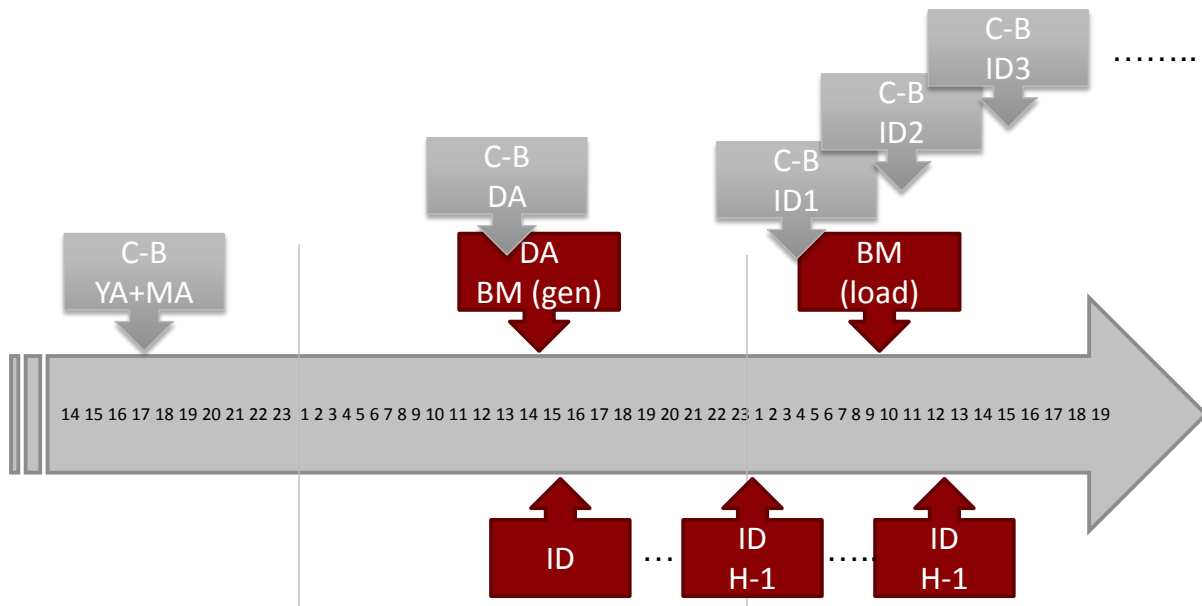


Figure 2 The timeline of gate closures of day ahead market, intraday market, balancing market and cross-border exchange notifications.

A description of the detailed hourly operation plans are included in PKD and BPKD schedules. These two documents are based on contract positions reported by all participants of the wholesale market. Contract positions allocated to individual generating units or load nodes are submitted to the Day Ahead Market (DAM, obligatory) and the Intraday Market (IDM, optional). For DAM the gate opens at 9 a.m., D-1 (day before the delivery day) and closes 2.30 p.m., D-1. DAM consists of 24 delivery periods of one hour and schedules presented for DAM should cover all 24 hours. For IDM the gate opens at 3.30 p.m., day ahead (D-1) and closes at 10 p.m. of the delivery day (D). The adjustment of the contract position for delivery hour H must be submitted at least one hour before (H-1). Adjustments submitted in IDM must respect obligation made in the ancillary service market (regulation and reserve) on D-1, for example unit's generating capacity reserved for upward and downward regulations, maximum power, etc (see Figure 3). Otherwise such changes are rejected by the TSO.

As for the generating units, the schedules derived on the basis of contract positions allocated to individual generating units should be consistent with unit parameters listed in their Grid Connection Agreements (respect technical parameters of the unit, like for example ramp rates, minimum and maximum output, start-up time, etc.), feasible and coherent with schedules presented by counterparts (no open position is allowed for large centrally dispatched or coordinated generating units). Schedules, which do not meet these requirements, are rejected, but they might be still corrected before the gate closure (verification of submitted schedules is run continuously when the gate is open). Generation or consumption related to infeasible schedules will be settled via the balancing market (BM).

Uninstructed deviations from submitted schedules during the delivery day (D) are normally settled through the balancing market separately for each individual generating unit.

Operating schedules of generating units are not shared with operators of neighbouring systems.

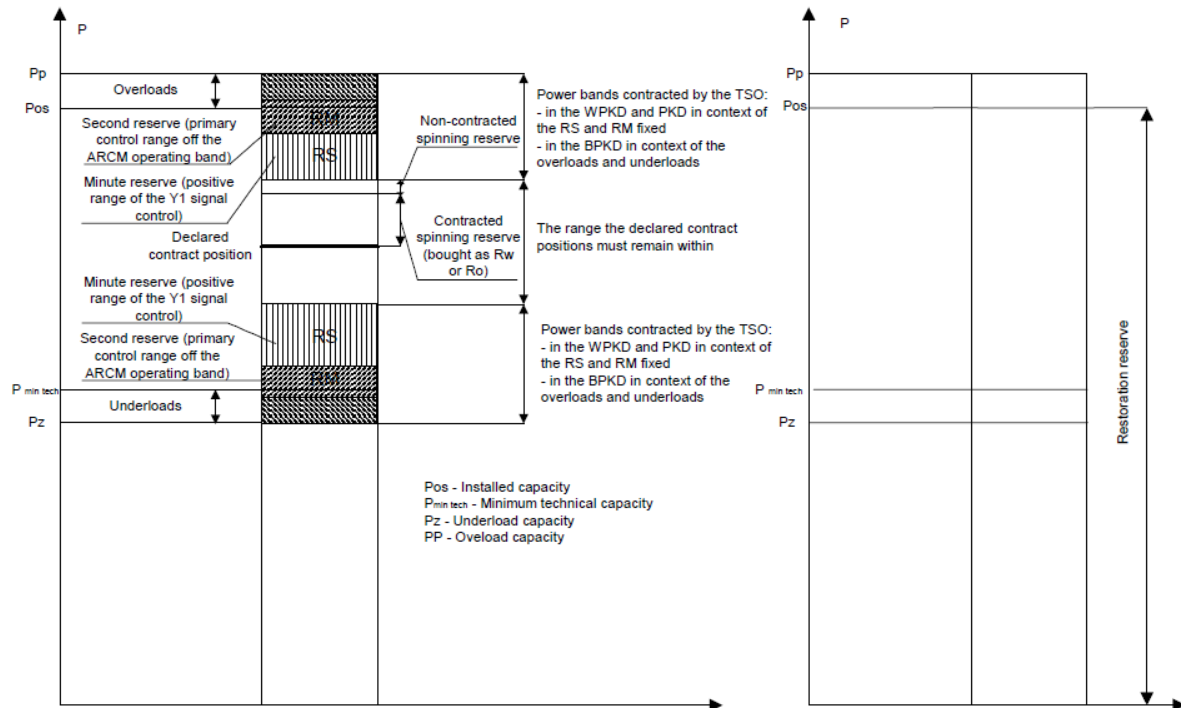


Figure 3 Illustration of the physical ranges of power control at the generating units found in the thermal power plants providing primary and secondary reserve and for generating nominated for the operating reserve [7].

2.2. Balancing responsible parties

Aggregation of generators or/and loads is generally not allowed at the Polish wholesale electricity market. One exemption is made for wind farms connected to the transmission network. The whole area of the transmission network is divided into 5 predefined regions (OAZW), where wind farms might be clustered together to offset their physical imbalances. Wind farms can't be clustered together with other types of participants (e.g. thermal generating units, passive or active loads).

For other participants, large generating units and reducible loads - active participants of the balancing market, physical aggregation of imbalances is not permitted. For passive participants of the balancing market, i.e. generating units and loads, the settlement of imbalances is defined by selection of metering points. Both metering points and formulas for calculation of imbalances using meter readings are included in the Grid Connection Agreement. In the overwhelming majority of cases, a participant of the balancing market is settled against deviation at individual metering point. Virtual grid connection points are generally used only in the case of cross-border trade and the power exchange.

Participants of the wholesale electricity market can directly participate in the balancing market or they can be represented by Balancing Responsible Party (POB). Without territorial aggregation permitted between generation and/or loads, presentation of balanced schedules by Balancing Responsible Parties is not possible and not required. Benefits linked with the provision of balancing services by POB are related only to financial compensation of opposite cash flows within the whole group, but not with physical offsetting of deviations among different metering points inside POB's balancing group.

Market participants or POBs cannot adjust their submitted generation or consumption schedules ex post (after the delivery period).

2.3. Re-dispatch

In normal power system conditions a re-dispatch of generating units and flexible loads is conducted by the TSO in BM and in IDM by generators themselves. However, the freedom of the trading at IDM² is limited by the position taken in the balancing market and ancillary service market, which are fixed by the TSO day ahead. It means that adjustments to the allocation of a power producer portfolio to specific generating units must not violate unit's nominations for BM or AS markets announced by TSO day ahead.

The first complete information about schedules of individual generating units is published in PKD, day ahead (D-1), at 5 p.m. After this moment till the end of the delivery day (D), a new version of BPKD is published every 15 minutes and the updating of the original BPKD might cover both all remaining dispatch periods or only selected hours. Changes to BPKD are made due to a fluctuating demand, fluctuating production of generating units including intermittent renewables, outages and other technical problems concerning generating units or the grid. BPKD are communicated to generating units using dedicated information exchange system (SOWE). A new version of BPKD must be delivered to active participants at least 15 minutes before the start of next BPKD dispatch period. The new versions of BPKD account also for corrections in contract positions made in IDM.

Remuneration for re-dispatching is based only on bids submitted by market participants. No additional compensation is provided for generating units re-scheduled by the TSO after the publication of PKD (Daily Coordination Schedules).

In emergency conditions, when balancing of the system is at risk, the TSO has the right to suspend operation of the balancing market and ignore market rules. In this situation both active and passive balancing market participants (not obliged to submit balancing bids) might be involved in system balancing.

2.4. Balancing reserves: procurement

In the final daily schedule (PKD) the operational reserve available within 1 hour must amount to minimum 9%.

A negative reserve is defined as a surplus of the total demand to be covered by domestic power plants over the total of technical minimum levels of centrally dispatched generating units and loading of centrally coordinated units. The negative reserve must amount to at least 500MW with an access time of less than one hour.

The catalogue of ancillary services addressing system balancing and frequency control includes the following products:

- a. **Operating power reserve.** An ability to render the operating reserve service is understood as the power range declared in the bid, not covered by electricity sale contracts and production bids accepted at the balancing market, remaining at disposal of the TSO. The operating reserve is contracted by the TSO for peak hours (7 a.m – 10 p.m., week days and weekends). This product is used by the TSO to maintain additional short term operating reserve during the delivery day (D). Since balancing market's gate closes day ahead, the TSO need this product to keep units ready for a re-dispatch during the delivery day. Otherwise units not selected in PKD might withdraw its capacity from the market and load following or compensation of fluctuating renewables might be impossible for the TSO
- b. **Second reserve** falls into time horizon of the primary control with a minimum range of ± 170 MW. This product is used for direct local control of the system frequency. TSO's plan to

² More details about operation of the Polish wholesale commodity market are included in Section 3.2.

activate a primary control at a specific unit is first published in the Preliminary Daily Schedule (WPKD, D-2), confirmed in Daily Schedule (PKD, D-1) and then adjusted throughout the delivery day in BPKD. Only large, centrally dispatched units, active participants of the balancing market, provide second reserve. Producers are notified by the TSO about the planned use of individual units with WIRE - electronic information exchange system (used for broadcasting WPKD, PKD). Real time control signals activating primary control are transmitted via SOWE information exchange system (used to broadcast BPKD). Additionally, units participating in the primary control must be connected to TSO's SCADA and SMPP systems, which monitors in real time technical parameters of generating units (i.e. activation of regulators, active and reactive production), etc. Requirements concerning technical parameters of generating units and regulators, commissioning and periodical technical tests, are defined in the Grid Code and detailed in Grid Connection Agreements between the TSO and owners of plants. According to the Grid Code, large active generating units (JWCD, above 100MW) must be equipped with primary reserve controllers.

- c. **Minute reserve** falls into time horizon of the secondary control, with a minimum range of ± 500 MW. This product is used to restore the volume of the second reserve and it follows guidance provided by ENSTO-E. TSO's plans for using secondary control at specific units is first published in the Preliminary Daily Schedule (WPKD, D-2), confirmed in the Daily Schedule (PKD, D-1) and then adjusted throughout the delivery day in the Current Daily Schedule (BPKD, 15 minute resolution). Only large, centrally dispatched units, active participants of the balancing market, provide minute reserve. Producers are notified by the TSO about the planned use of particular units with WIRE information exchange system. Control signals to activate secondary control are sent via SOWE information exchange system. Power plants and individual units participating in the secondary control must be connected also to TSO's SCADA and SMPP systems, which monitor technical parameters of units. Requirements concerning technical parameters of generating units, regulators, commissioning and periodical technical tests, are defined in the Grid Code and detailed in Grid Connection Agreements between the TSO and producers. According to the Grid Code, large active generating units (JWCD, above 100MW) have to be equipped with secondary reserve controllers.
- d. **Operation of power plants in underload or overload.** The ancillary service called underloading consists in operation of a generating unit with a load at below its technical minimum. The ancillary service called overloading consists in operation of the generating unit with a load at above its nominal installed capacity. This product is delivered only by JWCD. Both for underload and overload operation the unit must guarantee a stable output at least 5MW below its nominal minimum technical capacity and 5MW above its nominal maximum technical capacity respectively. Temporary violations of nominal technical limits caused by the actions of primary controller are not qualified as underload or overload operation. This product is usually used to minimize number of starts and shut downs of generating units in the balancing market, and for maintaining necessary regulation volume during periods of low demand in the system. Information about planned operation of generating units in underload or overload is published within PKD (D-1) and updated in subsequent BPKD.

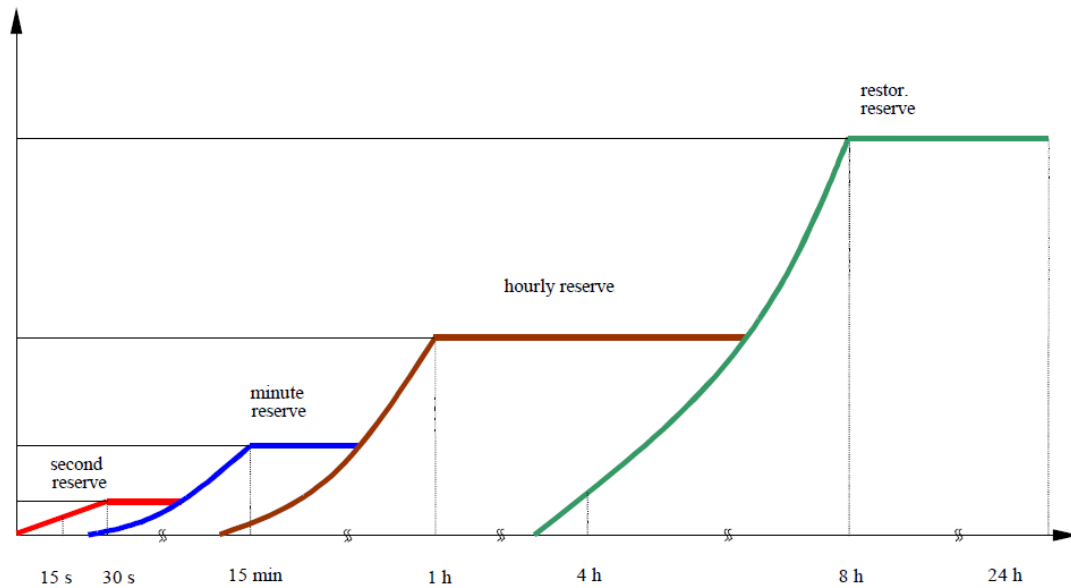


Figure 4 Classification of second, minute and hourly reserves of the condensing power plants according to the time of access to reserve capacities. The tertiary reserve became now part of the balancing market and the restoration reserve is renamed now to the operating reserve [7].

In addition to regulation ancillary services related to active power, the TSO purchases **voltage regulation/reactive power regulation (AVR)**. This service is delivered by large centrally dispatched generating units, active participants of the balancing market (JWCD). Activation flags for AVR control are included in BPKD schedule (D-1 and D) and are broadcasted to generating units using SOWE system. All JWCD units have to be equipped with automatic voltage regulators with remote control capabilities. The range of reactive power generation is defined for each unit in its Grid Connection Agreement (P-Q characteristics).

All services described above are purchased from specific generating units and they can't be transferred to other units. Therefore no back-up resources are required from the owner of the power plant. The TSO bears solemn responsibility to substitute a unit that is not able to deliver ancillary services and reserves with other unit and for that TSO need to keep adequate operating reserve.

Generating unit, which is not able to maintain the quality of regulation for more than 5 consecutive hours is deprived of the payment for the provision of primary or secondary regulation and the purchase of these services from the unit is suspended till it will pass again technical tests, but not earlier than next delivery day.

Failure to deliver one of the listed services or violation of the rules for provision of the services not justified by an evidence of technical problems duly reported to the TSO, is considered breaching of operating discipline and loss of declared capabilities. The TSO is free to impose penalties to be paid by producers whose generating units failed to comply with operating discipline or declared capabilities. Penalties are determined on the basis of energy imported from and exported to the grid linked with uninstructed deviations and on the basis of the number of days when violations of conditions for reserve or regulation provision have been detected. For the first case double balancing market marginal price ($2 \times \text{CRO}$) is applied. For the second case the price for regulation service provision agreed in the Grid Connection Agreement is used.

Large hydro plants deliver a wide spectrum of ancillary services. Participation of intermittent renewable energy sources and flexible loads in the ancillary service market is very limited and in

practice regulation capabilities of these participants are used only in emergency situations (for example reduction of wind farm's output triggered by significant change in the system frequency).

2.5. Balancing reserves: dispatch

Selection criteria and remuneration methods for the balancing reserves listed in Section 2.4 are described below.

- a) **Operating power reserve.** The final selection of generating units to deliver operating reserve is integrated with the balancing market using LPD (Linear Programming Dispatch) software. The selection criteria are based on submitted balancing bids. Prices from balancing bids are used by LPD during minimization of the cost of system operation (balancing and transmission constraints alleviation). The selected generating units are remunerated for delivery of operating reserve independently using single marginal market price for capacity payment. This price is fixed in long term agreement between TSO and power producers (on annual basis) and it is a trade-off between a reference unit average fixed cost and TSO's budget assigned to ancillary services. In practice currently all free capacity of active, centrally dispatched units is purchased by the TSO (capacity not covered by bilateral contracts and accepted balancing bids). The minimum requirement for the operating reserve volume amounts to 4 GW per hour.
- b) **Second reserve.** The payment for participation in the primary control is split into separate remuneration for activation of the control device and for an energy component related to deviations from submitted schedules due to primary frequency control. The first component is settled using fixed price CW defined in the Grid Connection Agreement and based on the variable cost of the unit. The payment for activation of the primary control equals to 5% of the reference price CW. Settlement of the energy component is based on general rules of the balancing market applied for instructed deviations. Generating units are not remunerated for their readiness, i.e. in case the second control is not activated the owner of the unit does not receive any payment.
- c) **Minute reserve.** Remuneration for participation in the secondary control follows the same rules as in the case of primary control.
- d) **Operation of power plants in underload or overload.** Remuneration for this kind of service is based on a fixed price, PLN/(MW*h) agreed in the Grid Connection Agreement between the TSO and the producer. It depends on the magnitude of underloading or overloading and on the number of quarter hours (15 minutes), when the unit was working in such conditions.

Nomination of particular generating units to deliver the above services does not depend on the location and the only criterion is the least cost rule³.

AVR remuneration is also based on a fixed price per hour paid for activation of voltage/reactive power regulator. The price is agreed in the Grid Connection Agreement. Within the agreed P-Q characteristics no additional compensation for reduced active power generation capability of the unit is offered. Selection of generating units delivering AVR is mostly determined by the location of a unit and the cost of service delivery. In practice all large centrally dispatched generating units (JWCD) and significant part of large centrally dispatched generating units (nJWCD) are used for voltage regulation.

³ Contracts for the provision of ancillary services are signed between TSO and power producers in long term agreements (one year or longer) with all financial conditions (prices) fixed. A nomination (selection) of generating units for provision of ancillary services on daily basis follows terms included in the long term agreements.

2.6. Market for balancing energy

Balancing bids from all active generating units obliged⁴ to participate in the balancing market, are submitted day before the delivery day (D-1). The gate opens at 9 a.m. and closes at 2.30 p.m. Bids must cover the whole currently available technical capacity of the unit, from P^{MIN} to P^{MAX} , with 10 bids (pairs: volume & price). The volume of the first bid (the lowest price) must be equal to P^{MIN} . The bids with the total volume equal to unit's contract position represent reduction bids (reduction of generation) and bids above contract position should be interpreted as increase bids (increase of generation). The bids are ranked according to the asked price.

Balancing bids (reduction of the consumption) from active, flexible loads participating in the balancing market on a voluntary basis are submitted day before the delivery day (D-1) and during the delivery day (D). The gates opens at 9 a.m. day ahead (D-1) and closes at 9.30 p.m. on the delivery day (D). Load reduction bids for delivery hour H must be submitted at least one and half hour before the delivery hour (H-1½).

Both for active generating units and flexible loads there is price floor and price cap imposed on balancing bids, 70PLN/MWh and 1500PLN/MWh respectively.

Selection of winning bids is automated using LPD (Linear Programming Dispatch) software, which minimizes the total cost of system balancing, accounts for nodal constraints (must runs of single units), alleviates transmission constraints and minimizes the total cost of customer supply, all using balancing bids. System requirements regarding operating reserve volume, pre-selection of providers of upward and downward regulations are accounted for in the LPD algorithm. The LPD software produces the original dispatch schedule for all centrally dispatched generating units and loads, as well as it creates ranking lists for future adjustments of the original dispatch schedule (increase and decrease of generation, start-up priority list). The output of the LPD algorithm is published in the Daily Coordination Schedule (PKD, D-1, 5 p.m.) and the modifications based on ranking lists or subsequent runs of LPD, are published in Current Daily Coordination Schedules, (BPKD, through the rest of D-1 and till the end of D, every 15 minutes).

Participants of the balancing market are remunerated according to energy volumes exported or imported from the market. As regarding system balancing and optimization, remuneration is based on a single marginal price, the highest accepted bids used to balance the system. In normal market conditions and within reasonable deviations from submitted or adjusted schedules, also passive market participants are charged or paid using the same single marginal price derived from PKD (using day ahead accepted balancing bids from generating units). This makes the TSO cash-flow neutral and pricing system symmetrical. However, when balancing market shows symptoms of price manipulation or excessive traded volume, the TSO has the possibility to introduce different prices for energy imported from and exported to the market.

Balancing bids and bids accepted to manage network or power plant constraints are settled using fixed price CW (the same price used for primary and secondary control payment).

All generating units and flexible loads, active participants of the balancing market, must be equipped with at least two information exchange systems SOWE and WIRE, which are used for submission of balancing bids, for broadcasting details of coordination schedules and control commands to dispatchers of the power plants and flexible loads.

⁴ All large centrally dispatched units have to offer all available generating capacity to TSO, unless they are exempted for scheduled maintenance (accepted by TSO) or excluded due to technical problems (outages, unexpected plant constraints).

2.7. Reserve

There are the following additional reserves and ancillary services currently used by the TSO to improve the security of the system operation or to minimize the cost of system operation:

- a) **Intervention reserve services.** This ancillary service consists actually of three different short term emergency reserves:
- Hot intervention operation provided by quick-start gas firing units,
 - Cold intervention reserve provided by the selected group of centrally dispatched, old generating units, whose operation is restricted to a predefined number of hours due to violation of emission standards (SO₂, NO_x, dust),
 - Load shedding provided by flexible loads.

The intervention reserve services are supposed to be used by the TSO in situations, when system operation planning indicates that required reserve might not be met using normal ancillary products listed in Section 2.4. These products are purchased by the TSO using tenders and bilateral contracts with producers or large consumers. In the case of generating units, remuneration is split into payments for readiness and payments for the use of the intervention reserve. In case of flexible loads remuneration is based only on the usage of intervention services.

- b) **Start-up service.** In the situation when a generating unit is put into operation by the TSO and the start-up wasn't planned in the self-schedule presented by the owner of the plant, the owner is entitled for a compensation of the start-up cost. The cost depends on thermal conditions of a unit and the cost function is defined in its Grid Connection Agreement. The information about start-ups is included in the Daily Coordination Schedule (PKD, D-1) and is updated within subsequent publications of Current Daily Coordination Schedules, (BPKD, D).
- c) **Must run contracts.** This service is provided by centrally coordinated, passive⁵ generating units (nJWCD) connected to the transmission network or by large units connected to the distribution networks. The service is called to increase security of power system operation, to alleviate transmission constraints, to balance the system, especially during emergencies. Remuneration is based on a special "must run" price defined individually in a Must-Run Agreement signed between the TSO and a producer. The must-run contracts are prepared according to public procurement rules (e.g. transparent open public tenders) and they might cover period of several years. The must run contracts are made out of the system planning and market operation schedule.
- d) **Emergency purchase of balancing power from neighbouring systems.** In the case of a shortage of domestic generating capacity, the TSO has bilateral agreements with neighbouring TSOs (SEPS, CEPS, 50Hz and Svenska Kraftnät), which allow emergency import of balancing power from the neighbouring systems.
- e) **Readiness for restoration of the power system.** This service is used to rebuild integrity and operation of power system after a blackout. The sources of this service are power plants adapted to self-start-up, in the first place hydro and thermal peaking-gas plants. Contracting of this service by the TSO is made out of the system planning and market operation schedule. Bilateral contracts with particular power plants are prepared according to public

⁵ In normal grid conditions passive generating units are not used by the system operator at the balancing market. They do not submit balancing bids, but they report their scheduled derived from their contract positions.

procurement rules (e.g. transparent open public tenders) and they might cover period of several years.

3. Common groups of elements / interactions across elements

3.1. Background

The first part of the liberalisation of the Polish power sector happened almost in the same time when the transformation of the whole country economy took place (1993-1997). Initially the burning ambition of the Polish government was to follow the British example (pool, single buyer), but finally very popular that time Californian market model has been implemented (1998-2000).

As regarding restructuration, privatisation and fostering of competition, before 2004 the government and the Regulator tried to build “a perfect picture” with a decent number of relatively independent generators (16), good HHI factor (second best after the UK) and ambitious plan to privatize significant part of the generation and distribution assets.

After first years in the EU (2004-2006), the Polish government realized that in old member states there is a little different perception of the power sector reforms. Large vertically integrated groups are tolerated, market power and competition is assessed mainly at the European level and power plants are considered strategic assets influencing an economic development of the country. The new Polish government took a U-turn. The discussion about further privatization was finished and vertical and horizontal integration in the Polish sector started (2006). Four state controlled vertically integrated large power groups have been created and currently further consolidation is still under consideration.

During the period of power sector transformation significant investments in generation have been deferred mainly due to significant surplus of generation capacity related to the significant drop in the power consumption, as well as due to the uncertainty regarding the target market model and the ownership structure. After 1990 only three large investments in power plants have been implemented, all with coal firing units. In the same time, the consumption of electricity took off. In years 2008-2013, among the largest electricity consumers in the European Union, Poland recorded the highest average annual growth in volumes of electricity consumed, amounting to 2.64%. It is planned that by year 2020 the total consumption of electricity will reach the level of 220TWh/year.

In the same time the Polish producers started experiencing constraints related to new European legislations related to the air pollution and decarbonisation. Due to environmental constraints 7GW of installed generating capacity will be decommissioned or put in a cold reserve⁶.

The development of distributed generation including renewables was relatively slow. To curb the increase of the energy bill for end customers with, TGC (green certificates) renewables support system was oriented on just meeting EU targets. A large share of renewable energy was produced from biomass co-firing in large coal firing power and CHP plants. The share of intermitted renewable generation (mainly large wind farms) approaches 11% of the total system installed capacity and the contribution of PV plants is almost negligible.

⁶ Instead of being modernized or shut down immediately these old units have been granted certain number of hours they can still produce without respecting environmental requirements. This is for the price of an obligatory decommissioning at the end of derogation period, i.e. without the possibility to modernize the units to make them satisfy the new emission standards.

3.2. Operation of the wholesale internal market

Electricity trading in Poland is conducted both in the bilateral contract market and at the Polish Power Exchange Towarowa Giełda Energi (TGE). Day ahead power exchange trading floor is run using both auctions (24 independent auctions for the next day), as well continuous trade (limited volume). Intraday electricity trading in the Polish market is implemented both using short term bilateral contracts (OTC) and the power exchange platform at TGE. Power exchange intraday floor is based on continuous trading mechanism, first in – first served.

Until 2010 trading of electricity was predominately based on bilateral contracts and the share of the power exchange volume ranged between 1,5 and 3,5% of the total consumption. With the consolidation and vertical integration of the power sector inside trading within individual groups increased and in 2009 the share of the power exchange trade volume dropped to as little as 0,9%. Poor liquidity undermined the credibility of power exchange price formation and opened spectrum of possibilities for market abuse with trading inside vertically integrated groups (pumping up prices without disclosing them in the market). Such situation triggered Regulator’s decision to introduce a requirement of selling at least 15% of generated volume of electricity in the power exchange and maintain the transparency in the trading within vertically integrated groups. This resulted in rapid increase of power exchange volume reaching now 55-60% of the total wholesale market volume. The OTC market covers 35-40% of the total demand and the balancing market (BM) contributes with less than 10%.

A single price zone is applied at the power exchange for the whole Polish power system.

Both regarding the power exchange and OTC market, intraday trading plays minor role (see Figure 5 and Figure 6). Such situation is caused by a faulty coordination of the balancing market and the intraday market. As explained in Section 2, gate closure time for balancing bids is 2.30 p.m., D-1. This reduces chances of self-re-scheduling. Units with submitted balancing bids and providing regulation or reserve services bidding in the intraday market must respect their positions taken in the balancing market and ancillary service market.

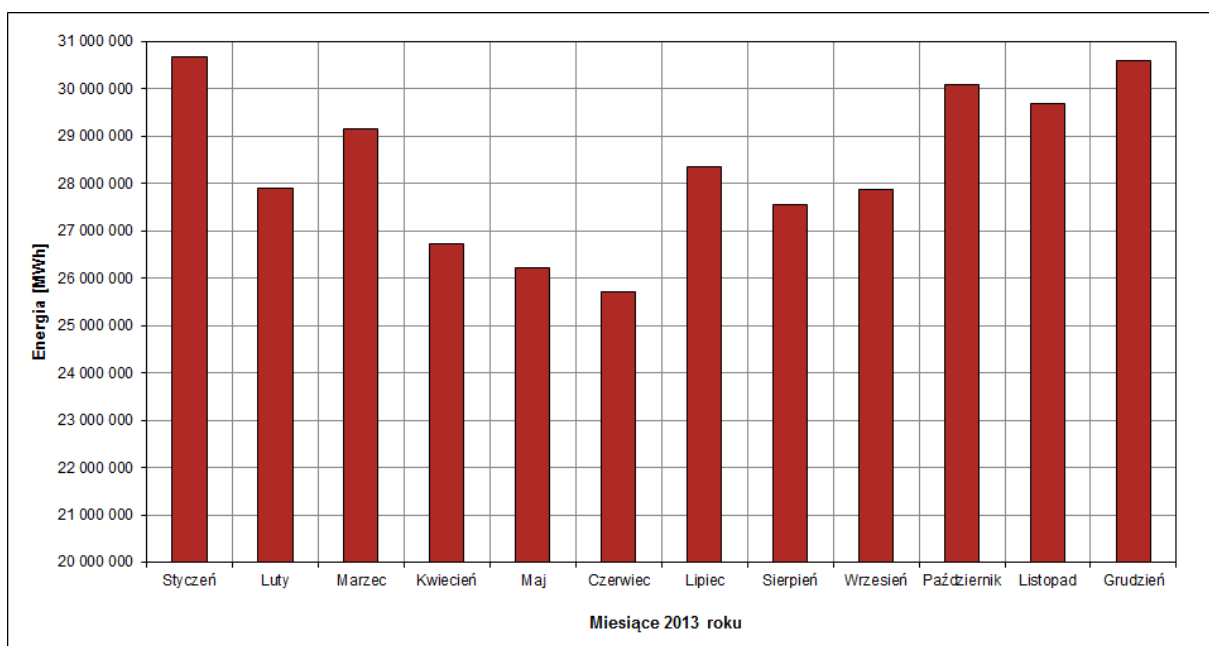


Figure 5 Monthly electricity volumes of day ahead trading, [Source: PSE].

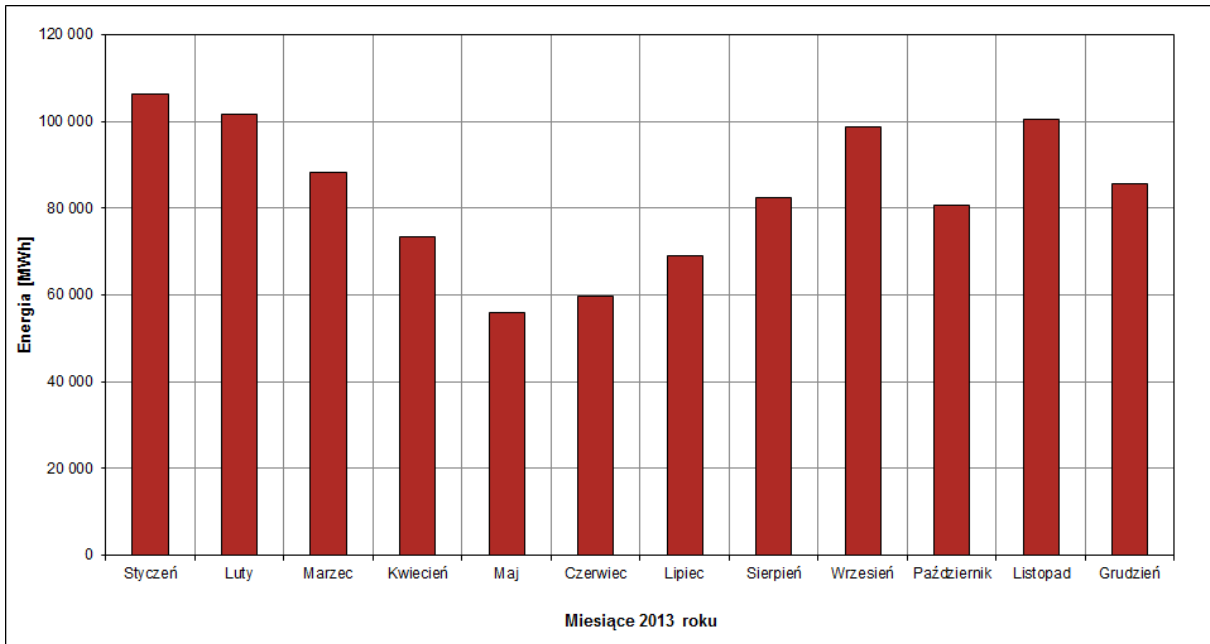


Figure 6 Monthly electricity volumes of intraday trading [Source: PSE]

In practice unlimited intraday trading is possible only in the case of passive participants of the balancing market (nJWCD). A comparison of trading volumes for active and passive thermal units (see Figure 7 and Figure 8) shows that the influence of passive units on market liquidity and on formation of market prices is very limited.

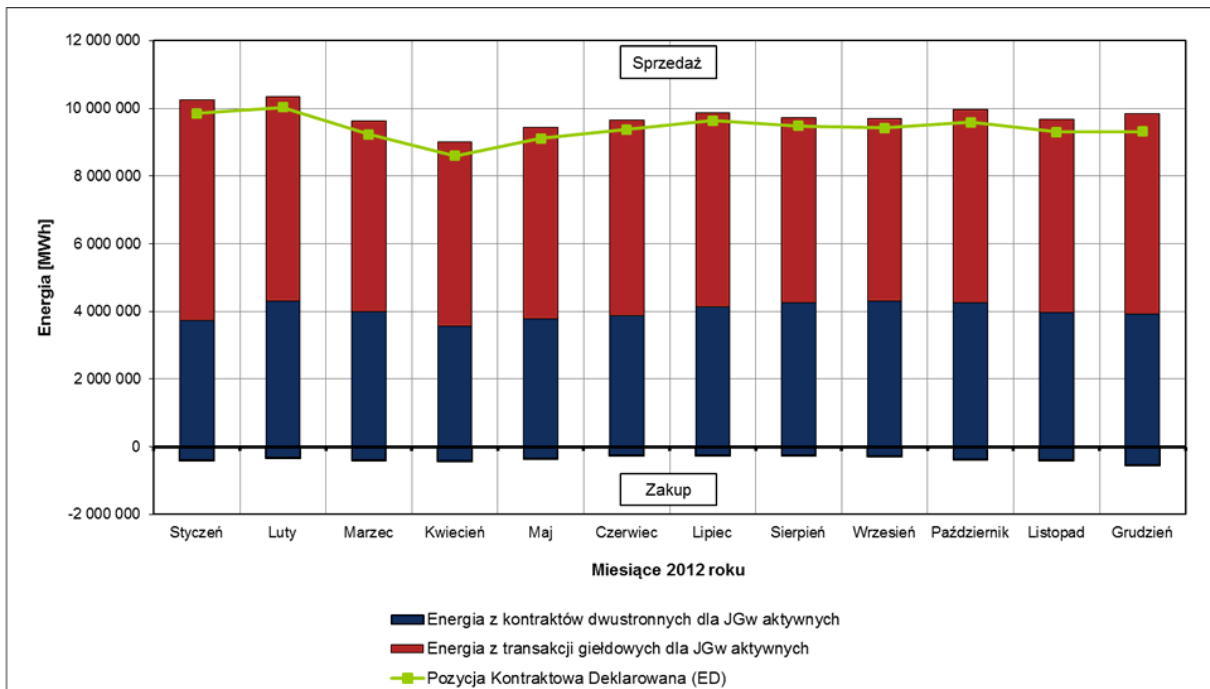


Figure 7 Volume Energy traded at OTC and power exchange spot in the case of active participants of the balancing market, thermal power plants [Source: PSE]. Blue colour – energy traded in bilateral contracts, red colour – energy traded at the TGE (power exchange), green colour – final contract position wholesale market volume.

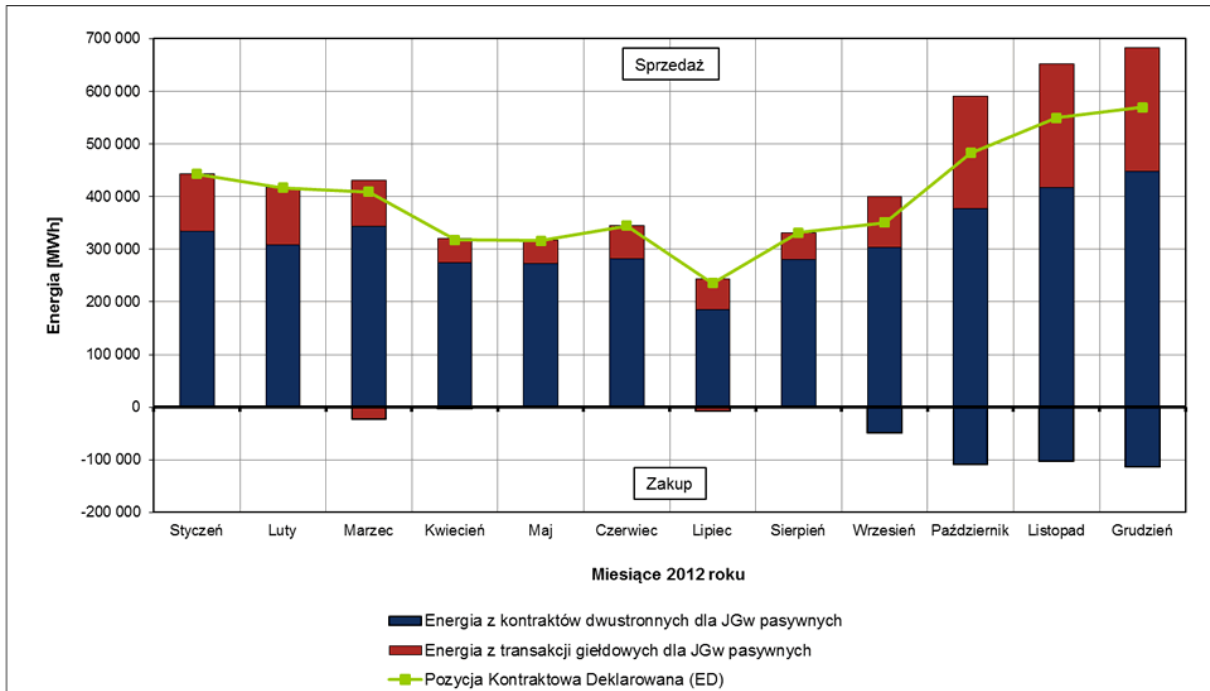


Figure 8 Volume Energy traded at OTC and power exchange spot in the case of passive participants of the balancing market, thermal power plants [Source: PSE]. Blue colour – energy traded in bilateral contracts, red colour –energy traded at the TGE (power exchange), green colour – final contract position wholesale market volume.

Such market design does not fulfil recommendations published by ENTSO-E Draft Network Code on Electricity Balancing. It will make a future integration of the national balancing market into a regional market structures more difficult.

Likewise other transmission operators also the Polish TSO tries to discourage market participants from using the balancing market for spot trading and price manipulation. Penalties for using balancing market as a trading platform are strong. The risk of unexpected and undefined losses in BM trading keeps effectively producers out of the balancing market.

The balancing market is also used for network, system and power plant constraints management. A substantial share of the balancing market volume is linked to this functionality (see Figure 9). According to BM rules generators are remunerated for these energy using their cost based fixed prices (CW). This means that their income comes from quasi regulated business and generators are rather forced to produce instead of being stimulated with encouraging market prices. Since the calculation of the CW price includes only variable cost components, such incentive is not sufficient to make producers participate in the balancing market on a voluntary basis.

To improve the management of network constraints with proper stimulation of market participants bidding and investments, as well as to increase transmission tariff transparency, the Polish TSO is considering zonal or nodal pricing, but there is stiff opposition from power producers to such revolutionary change.

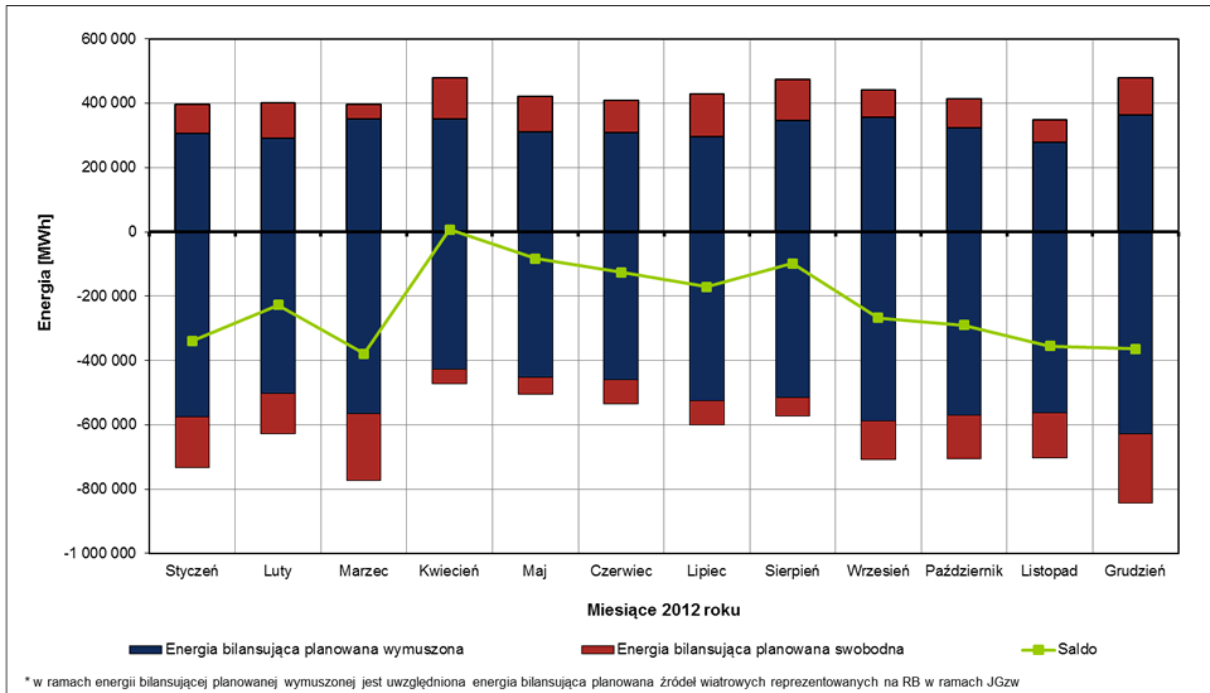


Figure 9 Volume of energy for scheduled deviations, sold and bought at the balancing market: red - energy related to system balancing, blue - energy related to alleviation of constraints, green line - net energy volume; both by active and passive participants [Source: PSE]. Blue colour – energy traded in the balancing market to alleviate transmission constraints, red colour – energy traded in the balancing market to balance demand and generation, green colour – net balancing market energy volume.

Similar situation is observed regarding provision of ancillary services. To keep transmission tariff under control, the TSO as a single buyer negotiates prices with generators taking into consideration available budget. Transparent and reliable economic models for pricing of selected ancillary services are currently under development and subject of discussion between the TSO and producers.

All this means that the technical market (balancing, ancillary services) is in Poland overregulated and not based on a sound economy. Although strict regulation prevents gaming, but in the same time it reduces incentives to participate in the market and to invest in new generating resources.

With rather quickly rising demand and slowly growing installed capacity, largely linked with the new intermittent wind generation, the available power remains at roughly the same level, but the operating power reserves are shrinking (wind generation is not considered for a provision of reserve and regulation power under normal grid conditions), from 7000 MW in year 2000 to 4000 MW in year 2013. The security of the system is jeopardized mainly during periods of high demand and low generation from CHP units and renewables. The problem is particularly pressing during hot summer months and around Christmas/New Year peak. Since the blackout in 2006 in northeast part of Poland, the TSO took actions to address the issue of insufficient upward operating power reserve. Maintenance and overhauls of generating units are now scheduled for spring and autumn. CHP units connected to the distribution network and operating in the condensing mode can be call for action also during summer time, flexible large consumers can now provide load shedding services. Allocation of cross-border capacity for export is now shifted more towards day ahead and intraday auctions. In emergency situation the TSO can import balancing power from their systems.

Although new coal projects are discussed for several years, final decisions are often postponed waiting for clarifications regarding further path of decarbonisation of the EU power sector. Therefore, before finally the new generating assets will be brought on-line, a quick solution would be

an faster integration of the Polish day ahead, intraday market and balancing market with neighbouring countries.

3.3. Interaction with cross-border trading

Cross border connections of the Polish power system can be divided into three groups:

- Single HVDC line to Sweden. The cross border capacity to/from Sweden is allocated under market coupling mechanism between TGE (the Polish power exchange) and NordPool Spot.
- Recently reactivated a HVAC link with Ukraine. The transmission capacity from and to Ukraine is allocated using non-coordinated (unilateral) explicit monthly auctions.
- Multiple 220 and 400 kV HVAC lines to 50Hz, CEPS and SEPS power systems.

In the last group (Germany, Czech Republic and Slovakia) common capacity sharing mechanism based on NTC method is applied for all these countries. Explicit yearly monthly and daily auctions are run by CAO (<http://www.central-ao.com/>). Intraday cross-border capacity allocation auctions for CEE region are run by CEPS (Czech TSO) with six independent sessions per delivery day. Long term auctions are traded with the formula “use it or sell it” (including daily auction). Intraday auctions are organized according to the formula “use it or lose it”.

Holders of the transmission rights are obliged to submit schedules concerning their planned use of the reserved capacity. For yearly, monthly auctions their import/export schedules must be submitted by D-2, 12 o'clock. After corrections requested by TSO are introduced, the schedules are finally confirmed by 5 p.m., D-2. For daily auctions schedules must be submitted by D-1, 1.30 p.m. For intraday schedules the gate opens D, H-4 and closes D, H-1½.

In parallel schedules from yearly, monthly and daily allocation auctions have to be submitted via the DAM and schedules from intraday auctions have to be submitted to the IDM. Like in the case of the internal intraday market, participation in the intraday cross-border trade is constrained by positions taken day ahead (D-1) in the balancing market and the ancillary service market.

For all listed modes of cross-border trading submitted schedules concerning particular cross-border connections are confirmed with neighbouring TSOs.

4. Envisaged developments

With growing demand, expected decommissioning of oldest generating units, with growing share of the intermittent wind generation and with the TSO, the Regulator and government being reluctant to accept price spikes, an implementation of a capacity mechanism became the most discussed modification to the current market model. Following the example of the UK market and other EU countries, the Polish government supported by power producers opened discussion on the design and implementation of advanced capacity auctioning system.

The second burning issue directly linked with operation of the intraday market and balancing market is the regional integration of the Polish electricity market. NTC method is considered obsolete and implicit auctioning of cross-border capacity using simplified network model (large zones, one country one zone) is recommended by ENTSO-E. This method is expected to facilitate short-term effective and fair allocation of transmission capacities. Unfortunately the flow-based approach to the allocation of transmission capacities does not work well for the CEE regional network when simplified network models are used. Comparative studies show that simplified flow-based methods often yield worse results than NTC method. It delays the implementation of flow-based methods between four countries (Germany, Poland, Czech Republic and Slovakia). Planned installation of phase shifters on

HVAC lines between Germany and Poland should improve the situation, but also more advanced flow based integration with zonal or nodal pricing might be necessary to solve the problem

In the past generation of renewable electricity was based on large hydro plants and biomass co-firing in large coal firing power plants. Now the share of intermittent wind generating capacity is growing, but for couple of years the TSO rejects new application for grid connection of large wind farms, mainly due to the insufficient transmission capacity. The new regulations and the implementation of feed-in tariffs for small, dispersed generation is expected to facilitate investments in small PV installations. This will further increase the demand for ancillary services and the operational reserve.

5. Short summary and conclusions

It seems that from a short term perspective the present electricity market model is satisfactory, both for generators, for the TSO and for the Regulator. Spot prices and transmission or distribution tariffs are kept under control. Provision of reserves and regulation power, as well as management of network constraints still satisfy requirements of the power system reliability. But looking into details the current win-win situation is not sustainable in longer terms, the balancing and ancillary service markets are overregulated and don't send price signals reflecting emerging scarcity of available generating capacity.

Remuneration for the provision of ancillary services depends on an available budget rather than on market competition or on comprehensive cost analysis. Must – run generation payments are based on variable costs only and bilateral contracts between the TSO and owners of power plants. This approach does not send transparent price signals encouraging new investments.

Balancing and ancillary services are delivered by large power plants. Flexible load can participate in the balancing market, but distributed generation is used mostly during emergencies. Incentives for broader participation of flexible customers in balancing and regulation, are not encouraging.

The current intraday and balancing market models are not consistent with recommendations given by ENTSO-E and it will hamper the future integration of the Polish wholesale market with regional and European structures. Reversed order of the balancing market and intraday internal and cross-border markets gate closures makes last minute trading difficult.

A deeper integration of the Polish market with neighbouring markets would help to increase the availability of balancing power. Since flow-based methods for cross-border capacity allocation do not improve the situation in the case of CEE region an alternative real time regional market model with zonal pricing using small and cross-border zones need to be considered.

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