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Report

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Workshop of the Future Power Market Platform, held at Autorità Energia, Milan, October 30th 2015

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Balancing Responsibility

What model works for Europe?

Draft report from a Workshop of the Future Power Market Platform,
held at Autorità Energia, Milan, October 30th
Karsten Neuhoff¹

We first discuss different rules for pricing and provision of balancing across EU member states and their implications. Some member states face significant transmission constraints inside their pricing zone(s). In principle, this can be avoided with smaller pricing zones and in some instances transmission expansion. We discuss in the second part, how in practice different strategies are pursued to accommodate internal transmission constraints within balancing mechanisms. European market integration has to date focused on enhancing day-ahead trading. We discuss in a third part the experience, benefits and perspectives for better integrating balancing mechanisms across EU member states before we conclude.

1. Balancing market versus mechanism

Power systems typically only have limited flexibility to adjust production or demand on very short time frames. Hence all power markets need to ensure that supply and balance is closely matched – in planning horizons, day-ahead markets and intraday markets. In the European market model with separate balancing market segment (by contrast with the old UK Pool or USA market design), this is achieved with a combination of imbalance pricing and penalties for imbalances or deviations from contract positions. They differ across EU member states (Table 1, column 5-6). For remaining or emerging deviations at real time, TSOs can use three mechanisms (Table 1, column 2-4):

- TSOs contract frequency regulation and reserve services in auctions usually weeks or months in advance involving a capacity payment to guarantee availability for dispatch in balancing market.
- TSOs can (in addition) purchase balancing bids and other short term service bids like for constraint management at day-ahead and intraday stage and which may comprise in addition to variable price at which flexibility is offered additional information on ramping rates, start-up times etc.
- Finally, TSOs may provide real time information (e.g. for last 5 minute interval) about system imbalances or balancing price, so as to encourage self-activation by market participants to system imbalances.

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Table 1: Balancing mechanism approaches in selected countries

	How TSOs balance the system?			What price to charge for imbalance?	
	Contracted reserves	Balancing bids	Self-activation	Pricing	Penalty
Dutch	Yes	Energy	System balance published every 5 min	Zonal marginal price from balancing bids.	Non, but option imbalance penalty (not activated)
Belgium			.. every 2 min		Non
Poland	All qualified units obliged to bid	Multi Part Bid	Not possible, no information provision, but no penalty under normal market conditions, double pricing penalization in BM price deviates from PX price	Zonal marginal price from balancing bids (calculated excluding bids used to resolve transmission constraints). (Poland is one price zone)	Penalization in the form of dual pricing (penalty component) can be introduced ex post with an administrative procedure, but to date occurrence of abuse not reported and provision not activated
Italy	No		No (information on imbalance published monthly for settlement purpose)		
Germany	Yes	No	Not allowed, but arbitrage likely	Zonal average price of accepted balancing bids or day ahead price (dependent on whether imbalance helps system)	To avoid arbitrage with intraday market, legal requirement for balanced portfolio
USA		Multi Part Bid	Balance price published every 5 min	Nodal marginal price from balancing bids (including in Texas scarcity mark-up)	Non

As set of factors will determine, to what extent market participants will retain flexibility for balancing within their portfolio creating costs for provision of extra reserves or realize synergies from use of most efficient flexibility from an integrated system by offering and using all flexibility through the market:

- In Germany legal requirements for balanced schedule (at portfolio level) including reserves to compensate any outage within one hour encourage large-scale private reserve holding. However, TSOs cannot rely on this reserve provision, and thus in parallel contract almost 5 GW

compared to France that does not require portfolio based reserve provision and only contracts 2GW of reserves centrally.

- Financial penalties and dual pricing at unit level creates incentives for accurate information provision. If financial penalties and dual pricing is applied at the portfolio level of companies (balancing responsible parties), then this encourages private reserve holding in addition to the reserves contracted at system level and thus can increase overall costs for reserves.
- The Netherlands has liquid balancing market including self-activation in response to published imbalances. However, after introduction of flow-based market coupling, less international transmission capacity remains commercially available at intraday stage, and without international trade, the depth of the intraday market based on energy only bids is too small. This creates incentives for market participants to privately contract reserves.
- In Poland the objective for balancing market is to provide large depth (e.g. response capacity) based on multi part bids that allow generation units to offer all their flexibility, at little liquidity (e.g. good intraday forecasts limit need for real-time adjustment). BRPs have very limited possibility to rearrange the generation and consumption within their portfolio. Imbalance volumes are calculated using individual network node measurements or individual generating unit output and can't be aggregated. This encourages market participants to plan well their schedules and later on to stick to these schedules. Fostering balanced and credible schedules at very grainy level of the network results in effective balancing of the whole system. Clustering of imbalances at the HV network is possible only in the case of wind farms.
- A lack of robust reference price for financial contracts to hedge against imbalance can encourage market participants to hold physical reserves (basis risk of average price derived from continuous trading).

Issues to consider in the design of balancing markets:

Risk of oscillations in quantity based self-activation

The Dutch/Netherlands approach of publishing system imbalances at 5 minute intervals to encourage all market participants to contribute to resolve these imbalances. This has been working well to date with limited adjustment needs and available adjustment capacity. However, if adjustment needs are big, then the flexibility that conventional power stations can offer for 5 minute intervals is insufficient, and therefore systems with additional flexibility have to offer the opportunity for balancing bids that reflect inter-temporal constraints like ramping or start-up of power stations (Poland, Italy). Likewise, if adjustment capacities grow, for example with increasing demand side flexibility, then a 5 minute signal about system imbalance could trigger too strong a reaction and oscillations.

Price based self-activation mechanisms have been implemented in US power markets, effectively remunerating all imbalances at the real-time balancing price. The ISOs in the US anticipate the price response of demand side in dispatch algorithms.

Question: Is it possible to combine the option for self- activation in a European context? Would for example information on a (recent) imbalance price allow for same level of self-activation while also facilitating international participation and enhance predictability of response (avoid oscillation)?

Depth versus liquidity of markets

Liquid intraday and balancing markets with large transaction volumes can indicate a functioning balancing market with wide participation. However, large liquidity might also indicate a lack of opportunity for market participants to balance their position during the intraday period. Therefore also other indicators need to be considered.

Market participants and TSOs are particularly concerned about the depth of the market – e.g. what is the total volume of offers available in the market that can be accessed to accommodate for example the failure of a larger power station. The depth of the intraday and balancing markets is also influenced by the bidding format. Multi-part bids allow all generation units to offer the full physical flexibility to the market, compared to energy only or block bids, which only allow for the provision of some of this flexibility. Multi-part bids also allow smaller units to submit standing orders and thus reduce transaction costs and increase participation. Without a deep intraday and balancing market, market participants and system operators may prefer to separately contract for reserves thus increasing total reserve procurement and system cost.

Some markets require mandatory participation of units. Italy requires that all qualified units submit bids to the balancing market, while Germany empowers the TSO to directly dispatch any unit. While in principle mandatory participation may not be necessary in competitive markets, due to internal transmission constraints within these countries the level of competition is limited and thus mandatory participation might be warranted.

Question: Why not combine depth and liquidity – combining for multi-part balancing bids and self-activation?

Demand side flexibility: Pooling or economies of scale

Realizing flexibility from demand side including industry, heating and transport is important for power systems with increasing shares of renewables. Thus the must-run operation of conventional power stations can be reduced and the value of non-dispatchable resources to the system is increased.

A portfolio of for example a set of wind parks allows for pooling across regional differences in wind patterns. If pooling is extended to cover some additional generation assets or demand side flexibility, then this can reduce imbalances and allow for the choice of more efficient options. Thus with additional resources integrated into the pooling arrangement, efficiency is increased as least cost flexibility option can be accessed and the law of large numbers reduces the amount of flexibility reserve that need to be retained. Ultimately, reserve pooling is more valuable at the system level than at decentralized level as this can integrate the full portfolio of all flexibility options. An efficient market design hence needs to facilitate pooling of all resources of across the system.

However, if market design does not support resource pooling at the system level, then individual firms, utilities or other aggregators will pool resources within their portfolio. This may result from insufficient deep, liquid or competitive intraday markets that motivate market participants to keep flexibility reserves within their portfolio, or where product definition for balancing markets are not aligned with

the technical capabilities of flexibility providers. Thus pooling of reserves at the level of aggregators is better than no pooling, but inferior to a market design that facilitates pooling at the system level.

Economies of scale are available for demand side management firms where they can develop systems to access flexibility of individual customers and bring this to the market. This can save transaction costs that would be incurred if each customer would individually have to contract. To realize these economies of scale, demand side management firms need to develop a skill set to identify and realize flexibility options while limiting administrative costs and reaching the size limits often required in organized markets.

Short-term markets that fully remunerate the value of flexibility can be particularly effective for unlocking demand side potentials, as they allow existing and new companies to engage with consumers and tailor products to implement demand side and energy efficiency programs rather than develop sophisticated strategies to package flexibility to access the wholesale market. France further advanced this approach by separating the responsibility of energy suppliers and demand side management companies, making it possible for independent aggregators to offer services to customers without the explicit agreement of the customer's energy supplier.

Question: What is the value of aggregation to the system – pooling or economies of scale?

2. How to ensure compliance with transmission constraints?

A combination of small pricing zones, strong transmission networks and restrictive allocation of cross-zonal transmission capacity, results in very limited internal transmission constraints (e.g. Belgium and Netherlands or Sweden and Norway). In pricing zones with one dominant player, this player may dispatch its power stations so as to avoid creating internal constraints and thus the need for congestion management and closer monitoring (possibly France). Other zones exhibit significant internal transmission constraints, with 2-3% of total generation being centrally reconfigured (example Germany and Poland but also within Italian pricing zones). In such instances, the textbook solution is a reconfiguration of pricing zones so as to internalize transmission externalities in all market outcomes. However, for a transition period (until reconfiguration of pricing zones or network), it might be necessary to accommodate transmission constraints within pricing zones for day-ahead markets.

Three approaches can be identified:

- **Balancing market based on nodal granularity.** This is combined with measures to avoid gaming of differences between zonal resolution of day-ahead market and nodal resolution of balancing market. Qualified units will not benefit from imbalance as they obtain the less favorable of day-ahead and balance price (dual pricing). The remaining challenge relates to potential gaming by small units / demand, e.g. nominations that differ from expectations so as to arbitrage expected price difference between zonal day-ahead and nodal balancing price (Italy).
- **Balancing market based on shadow nodal pricing.** In Poland accepted balancing bids are separated into bids used for system balancing at the national level (assuming Cooper Plate model of the network) and those used for constraints alleviations. The first type of bids are remunerated using System Marginal Price (in case balancing market price does not differentiate significantly from DA or ID market price). The second type of bids reflect (static) must-run

contract prices. Bids are selected based on a nodal representation of the network. Nodal prices help to identify which bids to accept, but are not explicitly used or published

- **Ex-ante re-dispatch to allow for zonal balancing price.** Reserves and balancing bids are procured and balancing prices calculated ignoring transmission constraints. This is made possible by TSOs that implement (ex-ante) re-dispatch measures to free-up transmission capacity. Thus it is possible that reserves or balancing bids can also be accepted from (export constraint) generation pockets. Units mandated to start-up or change production levels are remunerated based on cost (estimates), so as to avoid inc-dec game.²

Approach:	Does market participants price response support system stability
Balancing market based on nodal balancing price	Yes
Balancing market based on shadow nodal pricing	Non-qualified units may contribute to transmission constraints (but currently not responsive)
Ex-ante re-dispatch to allow for zonal balancing price	No, therefore ex-ante re-dispatch measures to free up transmission capacity.

In principle incentives from balancing market should encourage market participants to support the system stability with their behavior. However, to the extent that balancing prices deviate from nodal prices, this may not be the case.

In the case of shadow nodal pricing, non-qualified units will respond to zonal price, and may thus contribute to transmission constraints. This is of limited concern in the current Polish case, because demand side response and scale of non-qualified units is small and all active balancing market participants, including demand response are centrally dispatched.

In case of zonal balancing mechanisms like in Germany, reserves are dispatched without considerations of the impacts on transmission flows. This may influence flow patterns and result in violation of transmission constraints. TSOs have to be prepared for the worst case, typically combining an increase of security margins (e.g. making less capacity available for commercial transactions) and (ex-ante) redispatch-measures to free up capacity. Accepting balancing bids in large pricing zones without consideration of location furthermore implies that any balancing action can have significant impacts on flow patterns, and thus may contribute to unanticipated loop flows in neighboring countries.

In zones with transmission constraints a balancing mechanism can enhance the use of transmission capacity and increase system security by facilitating an early provision of generation and load patterns to the TSOs. The approach also reduces system costs, as it allows TSOs to implement technical measures (grid topology) to avoid or reduce constraints. Furthermore, with early information, it is also possible to engage less flexible units in dispatch measures, and thus increase the pool of flexibility, reducing the overall costs of measures.

² Court has requested German regulator to propose a new approach for remuneration of re-dispatch measures as current cost based approach does ignore opportunity costs.

Avoiding gaming of transmission – not arbitrage of markets

Arbitrage of markets is generally helping to improve efficiency: Market players observe that a good is expensive in one and cheap in another market, and with a trade can benefit from the difference and help to provide resources to where they are most needed. This also applies to electricity markets as is well established for trade between countries. More controversial is arbitrage of day-head and intraday or intraday and balancing prices. If a market participant observes that intraday prices are systematically lower than balancing prices and takes an open position in intraday to be remunerated in the balancing market then this reduces balancing needs for the system and improves the quality of the price signal. In US systems market participants can explicitly nominate such bids as virtual bids, thus increasing transparency for the system operators.

However, a caveat applies. If markets design does not reflect the physical fundamentals, then arbitrage by market participants may deteriorate the performance of the system. This is an inherent challenge in the case of transmission constraints within pricing zones. For real-time operation these transmission constraints need to be respected, and are therefore considered by the dispatch of the German, Italian or Polish TSOs. In the day-ahead market in all three countries constraints within pricing zones are however not considered in the zonal market clearing³.

Thus in principle market participants could anticipate the differences between day-ahead market clearing prices and final dispatch choices based on nodal representation of the network. If they anticipate balancing prices for a specific unit (at a node) to be above the zonal price, then they would not offer power from this unit in the day-ahead market to obtain the remuneration in the balancing market. This would reduce production at the parts of the network where it is most needed and require a further increase of prices in these nodes. Therefore it is usually referred to as gaming.

Hence all three design types discussed above have implemented specific measures to avoid gaming of transmission situations of the network. In Spain and Poland qualified units are required to bid available capacity into the balancing market which is repeatedly cleared already at intraday stage. In Poland units at locations typically required to resolve transmission constraints have to bid prices negotiated ex-ante with the TSO (must run units). Furthermore, dual balancing prices are used for qualified units, such that if for example they have to increase production they will not obtain a better price than if they had already offered this capacity in day ahead market. In Germany a TSO that mandates units to adjust production will only remunerate at costs so avoid incentives for firm to contribute to congestion so as to benefit from re-dispatch.

3. European cooperation

3.1 state of integration

To date national balancing markets reflect a legacy inherited from historic market structures (balancing within portfolios within Germany versus access to balancing services with balancing bids in other

³ In Germany the zone includes Austria, in Poland covers the country, Italy comprises several zones.

countries), flexibility constraints (resulting in multi-part balancing bids in Poland and Italy but not in Netherlands, Belgium and France), and network topology (transmission constraints have to be addressed in Polish and Italian balancing mechanism or corrected for in German case) (Figure 1)

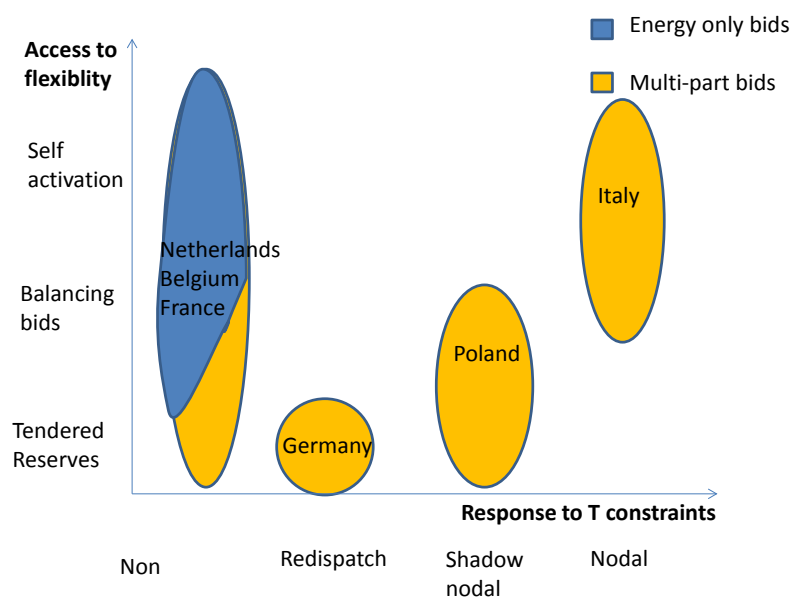


Figure 1: Illustration of different balancing approaches

As a result of these differences, very limited cooperation is visible in balancing markets. Germany, Netherlands and Denmark jointly tender some of the reserves. This is based on Netherlands and Denmark accepting to use the German product definition. France contracts some replacement reserves in Switzerland.

3.2 Benefits of a common European approach to balancing

A study commissioned by the EU Commission to quantify the value of market integration attributed on the short term 0.1 billion and in the 2030 perspective 0.3-0.5 billion annual savings to an integration of balancing services. These were defined more narrowly than in our discussion as short-term adjustments to voltage and frequency, excluding the effect of major plant outages.⁴

An integrated approach to balancing will also result in a better alignment of operational protocols and information exchange cross TSOs. This would allow for better use of transmission capacity and thus allow unlocking a larger share of the 10 billion annual benefits projected for better integration of day-ahead and intraday markets (same study).

Cross border trade will benefit from aligned balancing markets. The starting point for any power price formation is the imbalance price. Thus it matters how national market design defines the imbalance price, for example in the case of brown-outs (not all load can be served). In principle, market participants

⁴ David Newbery, Goran Strbac, Danny Pudjianto, Pierre Noël, Leigh Fisher (2013) Benefits of an integrated European Energy Market, Study for EC quantify the benefits of shared balancing as 0.1 billion Euro/year.

that are in imbalance can help systems, and already do so, by taking an open position in one country to resolve the imbalance in another country. However, if transmission constraints may be binding then they need to be considered in the market design.

Most importantly, balancing markets directly deal with the power system. And therefore discussions on balancing markets have for the first time opened an explicit discourse on the operational paradigm in different EU member states. Common rules for operation are important for effective information exchange and to avoid distortions. Arguable with increasing shares of intermittent renewables, in a couple of years it will no longer be possible to run the systems independently and save.

3.3. Experience with integration of balancing markets

The process about integrating European balancing markets is still at its infancies. This may be seen as surprising – as compared to day-ahead-markets there is to date less money at stake and thus it might be anticipated that the politics are easier to manage. However, even the new network code on balancing does only provide limited clarity, providing options for member states on central aspects like the definition of imbalance price areas and calculations of imbalance prices and volumes. Alignment is currently only envisaged, but not yet agreed on imbalance settlement periods and product definitions for reserves that are tendered. Arguable the only way to agree on a network code was to leave the central questions open.

One potential explanation for this outcome is that the target model was started in the spirit that there is only one vision for power market designs based on self-dispatch of power stations and large pricing zones as previously practiced in Central Western European countries. In this vision TSOs serve rather a reactive role, correcting for violations of transmission constraints and as provider of last resort for balancing services. As outlined earlier in this summary, this vision is not compatible with the physical reality of the power system in several European countries. Hence the code was extended to also allow these countries to operate their system according to their needs.

In practice the operational requirements of all power systems are similar and a safe operation requires centralization of information and control. For example the Polish system that may be classified as centrally dispatched actively (re-)dispatches on average 3% of generation assets, the German TSOs actively redispatches 2% of generation assets despite the claim of operating in a decentralized power system. Could it be that the discourse on the balancing code failed to converge to a common approach, because its political advocates argued for paradigms of system operation that are no longer relevant in a world with increasing shares of intermittent renewables?

3.4 A shared perspective for integration of balancing markets

This raises the question how a shared vision for the design of European balancing markets may emerge. Perhaps it is important to start with the requirements for a safe and efficient operation of the power system in different member states, rather than from a stylized model. A European approach should therefore get it right for countries that have lots of problems with their network and flexibility. Based on this, a framework might be developed that may allow countries with fewer transmission and flexibility requirements to implement simplifications.

Unfortunately this does not seem to be the approach of the current debate. This debate is either focused on improving national markets, without ultimate goal of making something unified, coherent, working together. Alternatively it is focused on regional approaches, for example in Central Western European countries. An approach that merely reflects the transmission and flexibility requirements of these countries is unlikely to be suitable for other European countries.

While the balancing network codes promises little guidance in this situation it may create an additional risk. Before its introduction, stakeholders could challenge differences in member states so as improve the situation. If differences are codified, such challenges and therefore progress is more difficult. For example Nordic TSOs requested to allow for the implementation of ramping constraints for international flows. Once they are part of the CACM network code, it will be more difficult for other NRAs to challenge such codes that effectively impose constraints on the flexibility that the European grid can provide to member states.

Perhaps the experience of the US system can be of help. The operational paradigm embedded in the Standard Market Design reflects a common vision compatible with the physical reality and progressively more and more states are following this design.

5. Conclusion

A common European approach to balancing markets can offer multiple benefits in terms of system costs, effective use of transmission capacity, and safety of system operation.

To be viable at European scale, such an approach will have to accommodate the physically defined needs of all member states with respect to flexibility and transmission constraints.

Self-activation allows for participation of flexibility in several European countries while also ensuring energy balance at the relevant system rather than portfolio level. To date self-activation is informed by a frequency (every 2-5 minutes) publication of system imbalances and remunerated based on the clearing price that emerges from balancing bids. For a wider use and international sharing of self-activation across EU member states while avoiding risks of oscillations, it may be considered to provide to market participants information about the recent market clearing price instead of imbalance volumes.

Balancing bids (in contrast to tendered reserves that also receive capacity payments) are a central element of most European market designs. Particularly if they comprise multi part bids like in Poland and Italy they can contribute to deep intraday and balancing markets. However, some concerns are voiced that balancing bids, particularly in combination with strong market power monitoring procedures, may result in insufficient scarcity signals. This suggests that the market clearing algorithm needs to be clearly defined so as to avoid that discretionary choices of TSOs (e.g. adjustment of reserve margins) reduce scarcity signals. It may be considered that mark-ups are applied to reflect the system externality if reserves held for system stability purposes are being depleted.

Tenders for system reserves have received most attention in attempts to harmonize products, time lines and allow for joint procurement. However, it seems warranted to assess whether the current focus on standardized products reflecting capabilities of traditional technologies is compatible with emerging

system needs, or whether different bid formats are necessary. Furthermore, several generation and demand technologies jointly offer energy and system services – and could thus offer more flexibility in tenders for joint procurement of energy and reserve.

With respect to all three dimensions of balancing markets mentioned above, the spatial resolution does matter. If pricing zones do exhibit internal transmission constraints or dispatch patterns within zones impact flow patterns in other zones, then in principle it is necessary to adjust pricing zones. Past experience suggests that such adjustments could be delayed. Nevertheless, transmission constraints have to be considered in the balancing mechanism to ensure safe system operation. Across European countries, this is achieved with (i) ex-ante redispatch, (ii) the use of shadow nodal pricing or (iii) nodal pricing for the balancing market.

(Ex-ante) redispatch applied in Germany contributes to significant volumes of unannounced loop flows from the dispatch of balancing resources. The effect will be stronger with increasing liquidity linked to self-activation and balancing bids. As it also lacks transparent procedures and price signals that are necessary for international cooperation in balancing markets, it may be necessary to shift to a more market based approach.

Shadow nodal pricing and nodal pricing for the balancing market address system needs in real time while providing an interface to zonal pricing at day-ahead stage. This requires some structure to avoid gaming of different pricing mechanisms at day-ahead, intraday and real-time. It usually involves mandatory participation and ex-ante negotiated or audited bids for qualified units. These anti-gaming measures are of similar nature to the redispatch procedures in Germany, but can allow for the remuneration of opportunity costs (Italian design). For non-qualified (e.g. small scale) units it is either possible to avoid any locational signal (Poland) or to provide a real time nodal price signal with a dual pricing structure to avoid gaming. The merits and challenges of the two designs warrant further investigation.

The Polish and Italian experience suggests that it is possible to maintain for a transition period a higher level of spatial aggregation at day-ahead and intraday stage, while using a higher disaggregation in balancing markets to reflection physical reality and ensure safe system operation. For countries (or pricing zones) with insignificant transmission internal transmission constraints or interactions with internal and external flows, it could be considered to simplify the market design by excluding this spatial dimension.

This initial discussion suggests that a common vision for a balancing market design in Europe can built on multiple experiences in Europe, but would likely require some adjustments for each of the current designs.

Reports from the Future Power Markets platform can found on www.diw.de/fpm.