Bidding Zones Literature Review

A review of literature on the configuration of bidding zones. This considers the theory and impact of a change in bidding zones as set out in the literature.

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1. Introduction

This paper reviews existing literature and empirical evidence related to the configuration of bidding zones; highlighting the key questions and challenges which would need to be considered in evaluating the delineation of bidding zones in GB. We explore the key issues related to the configuration of bidding zones and highlight the necessary considerations relating to the influence of bidding zone configuration on power markets and system operation.

The paper is intended to provide a background on the issue.

What is a bidding zone?

A bidding zone is the largest geographical area within which market participants are able to exchange energy without capacity allocation. Bidding zones in Europe are currently defined according to differing criteria. The majority are defined by national borders (eg, France or the Netherlands); however, some are larger than national borders (eg, Austria, Germany and Luxembourg or the Single Electricity Market for the island of Ireland) and some are smaller zones within individual countries (eg, Italy, Norway or Sweden). Figure 1 (overleaf) shows this, highlighting the current delineation of bidding zones in central, west and north Europe.

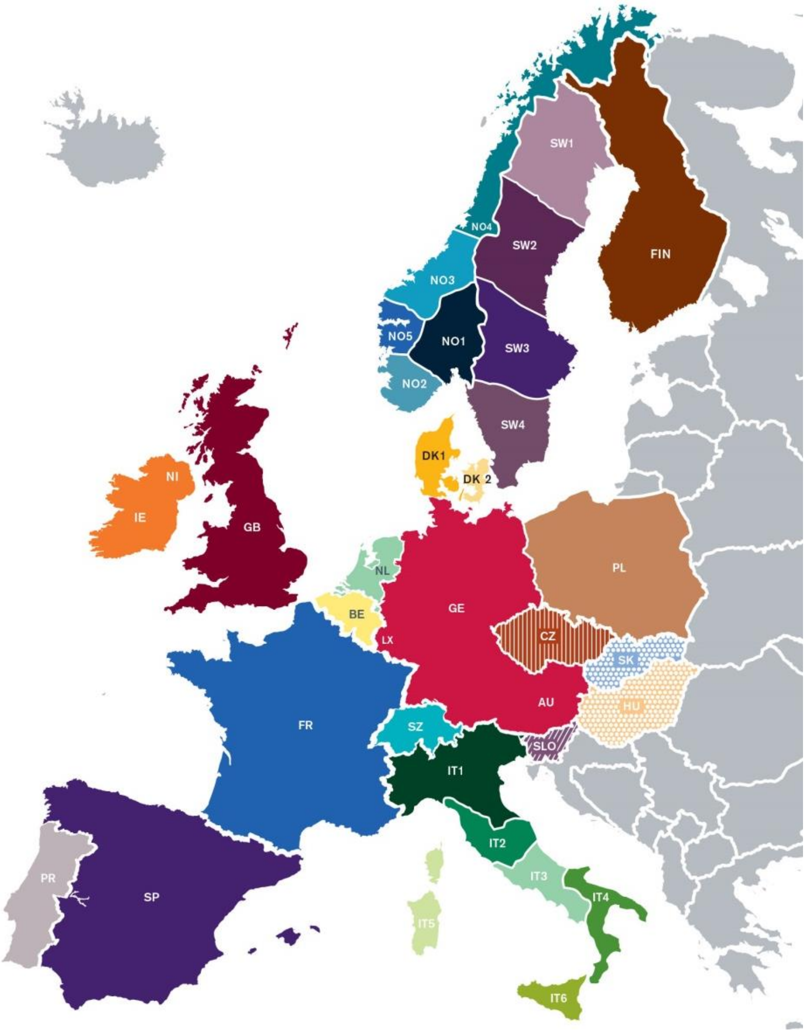

Figure 1

The European Electricity Target Model poses a challenge to Europe's status quo as it envisages coupled European Markets and bidding zones defined by network congestion rather than, for example, national borders. The Capacity Allocation and Congestion Management (CACM) Network Code[1] - although not yet finalised – is expected to require a periodic assessment of the efficiency of European bidding zones through the production of a Market Report and Technical Report, which may lead to a full review of Bidding Zones. The production of a Market Report and Technical Report will likely be required at least every three years.

Why does bidding zone configuration matter?

An optimal delineation of bidding zones should promote robust price signals for efficient short-term utilisation and long-term development of the power system, whilst at the same time limiting system costs, including balancing costs and re-dispatch actions undertaken by TSOs.

Delineating bidding zones according to the location of network constraints may be undertaken in a number of ways. A model that uses 'nodal pricing' implies that the price that any generator faces is localised to reflect the short run marginal costs of

[1] Further details can be found here: www.entsoe.eu/major-projects/network-code-development/capacity-allocation-and-congestion-management/

generation and transmission, taking into account network constraints. Baldick et al (2011) suggest that a nodal pricing system is most efficient when congestion patterns are more unpredictable and security constraints more complex, for example as the amount of intermittent and dispersed renewable generation grows.

While there are examples of the use of a nodal pricing approach (eg, the PJM market in the United States[2]), a more common approach is that of zonal pricing. This approach creates price zones where clusters of nodal prices are similar and delineates these as bidding zones. A zonal pricing model could therefore have one zone or many zones; the number of zones is dependent on prices at different locations and where these prices cluster. The aim is to reflect the short-term costs of generation and transmission by delineating zones according to network constraints, promoting efficiency both in investment and dispatch. Examples of markets delineated with multiple bidding zones include the Nordic countries and Italy, as shown in Figure 1.

The GB Context

The GB bidding zone configuration has already been reconfigured once in the recent past; in 2005 the introduction of the British Electricity Trading and Transmission Arrangements (BETTA) led to a merging of the England and Wales bidding zone with the Scottish bidding zone to become the single GB electricity market.

Since the introduction of BETTA, participants can trade bilaterally with any GB market player up to one hour before delivery (gate closure) and these trades are not limited by the available transmission capacity; trading is carried out as if GB was a 'copper plate' and there was unlimited capacity to facilitate the corresponding flows.

In having just one GB-wide bidding zone market participants are not required to take into account congestions on the transmission network when locating new generation. The 'Connect and Manage'[3] regime in GB gives generators firm access rights to the entire GB market, regardless of network congestions. These access rights allow electricity to be traded in GB freely, irrespective of the physical limitations of the network. Instead, after market participants cease trading the Transmission System Operator (National Grid) uses a variety of re-dispatch methods to maintain the balance between supply and demand across the network.

University of Cambridge (2011) suggests that these current market arrangements and the structure of charges paid by system users may not create sufficient short run and long run incentives for efficient trading and investment decisions, both for generation and transmission. It is suggested that increasing costs of managing constraints and the current changes in the generation mix and location lends weight to the argument that the optimal GB bidding zone design should be reviewed.

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[2] The PJM Market covers parts of 13 Eastern US states and Washington DC. Further details can be found here: www.pjm.com/

[3] Guidance on the Connect and Manage regime can be found here: http://www.nationalgrid.com/NR/rdonlyres/8D4A5CB7-EDAA-4AB3-99A7-85E9772C2C8/59263/CMversion50.pdf

Wider Considerations

For GB the issues regarding congestion and appropriate bidding zones delineation are predominantly considered to be intra-GB issues that may result in increasing costs for the system operator and potentially sub-optimal investment decisions. In continental Europe, the meshed AC networks mean that additional cross-border issues arise as a consequence of network congestions, whereby unscheduled flows (eg, loop flows[4]) travel from one bidding zone to another. However, more generally the implications of the configuration of bidding zones on flows across interconnectors provide a European context to this issue.

In undertaking this review we have been aware of the many subjective views that accompany the existing literature. It will be important for the FTA project that the work in this area is carried out using as objective an evidence base as possible.

2. Impact of the configuration of bidding zones

Purpose

Considering the configuration of bidding zones requires a complex set of trade-offs to be analysed. As shown by the evidence reviewed in this section, these trade-offs involve considering market efficiency, liquidity, issues with market power, investment signals for new generation, distributional impacts and the costs of transition.

2.1 Impact on efficient use of the network

The configuration of bidding zones has important implications for system operation, providing short run signals to users of the network that impact on the utilisation of available capacity and ultimately the overall efficiency of the system. These short run signals also have a long-term impact, influencing the long-term investment decisions of market players.

The introduction of multiple bidding zones in a region where constraints exist may sharpen short run price signals to network users and therefore encourage a more efficient use of existing or committed network capacity. This clear signal to network users could ensure that when the network is constrained the available capacity is allocated to those that most value it.

Delineating bidding zones according to network constraints would allow these constraints to be managed by capacity allocation rather than re-dispatch (ie, ex-post modifications of generation schedules undertaken by the SO), lowering constraint management costs for the SO. Burstedde (2013) suggests that there are potential short run inefficiencies if generation dispatch decisions are made on a short run basis without consideration of transmission capacity and if generators are not fully exposed to the full locational cost of these decisions, for example, if tariffs designed to cover these costs are levied at a flat rate across all generators.

Changing the delineation of bidding zones can, in theory, lead to the network being used more efficiently by reducing the volume of re-dispatch actions taken by the

[4] Loop flows are the physical flows resulting from an electricity exchange within one bidding zone occurring in another bidding zone

SO. Burstedde (2013) models the short and long-term efficiency of different re-dispatch designs and concludes that although a well-designed re-dispatch system is able to implement the optimal allocation of production, the mechanism does not induce *dynamically efficient* incentives for generators. The curative nature of re-dispatch payments provided by the SO act as short run incentives (static efficiency) and do not fully account for long run concerns or set long run incentives to change the behaviour of market participants (dynamic efficiency). Therefore, according to Burstedde, they do not alleviate the underlying causes of congestion.

Ea Energy Analyses et al (2008) assessed the case for further splitting the Nordic market, which was already split into seven bidding zones. The analysis compares the situation of more zones (11) and the situation of fewer zones (1, 4 or 6) with the baseline, the status quo. The analysis yielded overall socioeconomic benefits of between EUR 15 – 30 million a year depending on the situation but the 11 zone case, where the markets were split further, yielded the greatest benefit. These benefits were shown to be distributed differently between stakeholder groups and even between different countries; with the Nordic area having slightly higher prices and the Continent slightly lower prices due to better utilisation of interconnectors. The key finding is that an increased number of smaller zones was found to be more *allocatively efficient.* This concept refers to societal gain, where an allocatively efficient market yields maximum social surplus, with no deadweight welfare loss. The analysis indicates that the social surplus from clearer price signals to network users is increased in the 11 zone model compared with the other scenarios and the deadweight welfare losses that may arise from potentially inefficient re-dispatch actions are decreased, resulting in a more allocatively efficient outcome.

This is in contrast to analysis presented in Consentec, Frontier Economics (2013), which claims that lowering re-dispatch costs does not necessarily equate to greater efficiency and increased social welfare. This paper cites analysis from a 2008 Frontier and Consentec paper, which estimates the effectiveness of zonal and nodal congestion management. The analysis considers two exemplary German lines which are assumed to be typically congested and uses load flow simulations based on a realistic network model of the European transmission grid. Whilst the effectiveness of nodal congestion management is found to be markedly greater than zonal congestion management, the model shows very little difference in the effectiveness of congestion management when the numbers of zones is altered, from two to four to ten.

Although the impact on wholesale prices following a change in the delineation of bidding zones will likely be dependent on the location of those affected, the impact should be more allocatively efficient as the prices reflect better the value of scarcity and therefore social surplus is increased. In export-constrained regions, the average wholesale price of electricity is likely to fall. Conversely, the average wholesale price of electricity is likely to rise in those areas at the other side of the constraint, where demand is higher. There is therefore a distributional impact to be considered through any reconfiguration of bidding zones. However, the overall result should be a fall in the average prices for consumers across all zones due to increased net market efficiency.

In summary, when developing our frameworks to assess GB bidding zones configuration the literature suggests that we should take into account a number of potential impacts on the efficient use of the network. These include:

- the costs of re-dispatch;
- dispatch restrictions in the spot market;
- aggregated and disaggregated price levels.

2.2 Impact on market liquidity and hedging

The conventionally perceived impact on market liquidity arising from the configuration of bidding zones is that of falling levels of liquidity as the number of zones increases. This is a direct result of the smaller size of the markets, with fewer market players and as such a lower level of churn[5]. To support this, it is noted in the literature that large markets with a range of different participants tend to exhibit higher liquidity. Nevertheless, the Nordic markets provide an interesting example of smaller bidding zones which exist with strong levels of liquidity.

Consentec, Frontier Economics (2013) analyse liquidity using bid/offer spreads for 1-year ahead products, assuming that a lower bid/offer spread implies a more liquid market, as this difference represents the transaction cost of market participation. The analysis highlights the difference in bid/offer spreads between markets of different sizes, showing that smaller markets tend to have greater bid/offer spreads and hence are less liquid.

Lower liquidity results in increased transaction costs and subsequent 'frictional' welfare losses. Moreover, lower liquidity could mean a less clear indication of the future value of power from the market, which adds a layer of risk which could lead to inefficient investment, or efficient investment not taking place. A fall in liquidity could also mean an increase in the cost of risk, due to lack of trading partners; this could well have a knock on effect on investment.

The assumed decreased liquidity in forward contracts from creating smaller zones could lead to less efficient hedging. The forwards markets can be considered as a hedging market, where market players hedge against short-term uncertainty in prices, mitigating the uncertainty arising from price volatility. Bidding zones of one price allow participants to use the same hedging instruments and trade within the zone, but there is an acceptance that the larger the bidding zone, the higher the liquidity of these hedging instruments. In ACER (2013), it is noted that liquidity of hedging instruments in smaller zones is usually poor.

Even given the potential impact on the forwards market of an increase in bidding zones, there appear to be ways to mitigate this impact. In the Nordic market, contracts for differences (CfDs) have been used on Nord Pool since 2000 as a forwards market product used to hedge against the difference between the Area Price and the 'hub' price. CEPs, Mavir, PSE (2012) cite these experiences in the Nordic market using System Price Contracts and the 'highly liquid trade activities' in nodal markets in the US as examples to show that a greater number of smaller bidding zones does not necessarily amount to an obstacle to liquid trade.

There is also a need to consider not just trades inside a zone but also between zones as a reference for liquidity, which ACER (2013) highlights. It is also noted in ACER (2014) that while the negative relationship between the number of bidding zones and levels of liquidity is seen in the forwards market, the experience from

[5] Churn is typically measured as the volume traded as a multiple of the underlying consumption or production level of a commodity.

different markets in Europe does not show a clear link between the size of the zones and the liquidity of the day-ahead market. In this market, other factors other than just the physical limitations to trade could well influence liquidity, for example, market structure, market design and market concentration.

While there is no absolute consensus in the literature, and no clarity on the magnitude of impact on market liquidity that a change in the delineation of bidding zones would have, it is nevertheless a critical factor that is likely to be influenced by the configuration of bidding zones. It will be important for our assessment frameworks to fully consider the impacts on liquidity and the interactions with Ofgem's recent liquidity proposals. Specific areas to further consider include:

- the levels of liquidity in the short-term (day-ahead and intraday) markets;
- the levels of liquidity in the forwards market;
- the ability of market players to hedge against uncertainty.

2.3 Impact on investment

While the configuration of bidding zones is widely understood to impact on short-run signals for utilisation of existing capacity, it is also theoretically understood to provide long-run signals that may affect investment decisions. The more the bidding zones configuration reflects the physical network constraints, the greater the efficiency of the price signals for cross-zonal network development and the price signals for generation and load investments.

In the long-term, a configuration of bidding zones that seeks to accurately reflect network constraints could change the incentive structures so that generators would be discouraged from building behind heavily constrained boundaries. This sharpened locational signal, along with the signal provided by locational TNUoS charges, would incentivise generators to build where there is most value added to the system.

The literature suggests that any impact on investment may be somewhat mitigated by practical considerations. For example, lumpiness and economies of scale of transmission investments, uncertainties about future generation investments and demand growth and the difficulty of decentralising charges for reliability and quality of service are particular issues that might numb the effect of the more efficient price signalling fostered from a change in bidding zones configuration.

The design of the new Contracts for Differences (CFDs) introduced as part of the government's Electricity Market Reform (EMR) could also dampen the effect that changing the configuration of bidding zones would have on incentives for investment. Through the proposals in EMR, eligible low carbon generators receive a payment of the difference between a measure of the cost of investing in a particular low-carbon technology (the 'strike price') and a measure of the average market price for electricity ('the reference price'). While this provides investors with increased confidence as to their projected revenue stream when investing in low-carbon generation, it means that generators are not fully exposed to the market price.

The idea of a change in long run price signals as a result of a change in the delineation of bidding zones is explored in Consentec, Frontier Economics (2013). This paper supports the theory that investment signals could be sharpened if zones accurately reflect costs of using the network in their prices, but considers that this in itself does not remove barriers to efficient transmission investment. Practical barriers related to permitting procedures and lengthy lead times for projects, it is suggested, would still hold back efficient investment. In fact, it is argued that the main congested hotspots in the European network are already well known to TSOs and creating bidding zones with improved price signalling would not provide further information to TSOs, so the improved clarity of price signalling would only represent a benefit for generators.

These points highlight a key factor when considering the impact on network investment – improved price signalling may not result in a change in the location of investment as price signals are only one of a range of criteria that investors need to consider. Other considerations include: transmission charges, levels of RES support, incentives as a result of capacity markets, permitting procedures and planning considerations (including local opposition/support), and costs of factors of production at different locations – land, labour and capital.

The impact on investment must also be considered against alternative investment scenarios. Although bidding zones delineation may provide clearer signals to value reinforcement projects, the costs of delineation should be compared to those associated with alternative options for transmission reinforcement.

Whilst the sharpened locational signals may allow for more efficient investment, there is also a distributional impact to consider. A change in the configuration of bidding zones to account for network congestions would likely result in lower generation investment in export-constrained regions, where prices will fall as a result of over supply (ie due to limiting export through introducing capacity allocation). In addition, the overall impact on the investment climate should also be considered, where a change in bidding zone configuration may create risk and uncertainty for investors in terms of access to the market for existing and future market participants.

In summary, the delineation of bidding zones could potentially have wide ranging impacts both on TSO-led transmission investment and investment by market participants in generation, as well as investment in tools to provide flexibility to the grid, such as DSR, interconnection or electricity storage. The impact of potentially sharpened locational signals in the long run is a change in incentive structures for all market participants concerned, thus affecting the location of transmission and load investment, with a subsequent impact on costs. The literature stresses the multitude of considerations that investors have to take into account when making investment decisions, which may dampen the impact of any improvements in price signals. In developing our frameworks to assess GB bidding zones configuration, many impacts need to be considered, including:

- the degree to which locational signals are sharpened by a change in the configuration of bidding zones;
- the relative influence of price signals compared with other factors;
- the distributional effect on new investment in generation;
- the wider investment climate.

2.4 Impact on market power

The precise impact of the number of bidding zones on market power is unclear in the literature. On the one hand, THEMA (2013) argues that fewer, larger bidding zones imply a large number of market players in any market and as such greater competition and liquidity. This higher liquidity, it is argued, provides less scope for any single market player to exert market power, particularly in the short-term markets. Moreover, Consentec, Frontier Economics (2013) also argue that larger bidding zones will favour competition in the retail market, as retailers in larger bidding zones do not need to hedge against locational price differences (according to the paper), so this does not act as a barrier to entry.

On the other hand, ACER (2014) notes a lack of any consistent pattern between the size of bidding zones and the level of market concentration and suggests that larger bidding zones may create potential market power in re-dispatch markets, if it is assumed that larger bidding zones implies greater need for managing congestion through re-dispatch. As a consequence, generators may be incentivised to locate in export-constrained areas, further increasing aggregate prices, the need for congestion management and increased system costs that are eventually passed on to consumers.

In addition to the market power of individual market participants, the market power of the TSO may also be relevant. The Svenska Kraftnät (SvK) case[6] in Sweden highlights an interesting example in this respect. In November 2011 the Swedish TSO took the decision to divide the Swedish electricity market into four bidding zones based on the existence of significant network constraints. This followed a European Commission case under competition law that challenged SvK's actions in curtailing transmission capacity to neighbouring countries. The European Commission asserted that SvK may have abused its dominant position on the Swedish transmission market by curtailing export capacity on interconnectors when it anticipated internal congestion on the Swedish transmission system. SvK was proved to be curtailing on average 58% of available transmission capacity to neighbouring countries (notably Denmark, through the Oresund connection) in order to keep Sweden as a single price zone. It was argued that this amounted to an illegal segmentation of the market, discriminating against non-Swedish consumers without justification; going against the principles of the common European electricity market.

Overall, the impact of the delineation of bidding zones on market power can be dependent on a variety of factors that differ on a case by case basis, with the resultant effect on prices for consumers unclear. The impacts that should be considered in a framework for assessing the configuration of bidding zones are:

- The number of market players and degree of market power in markets of different timeframes;
- Incentives for investment and bidding behaviour resulting from network constraints;
- Market power in re-dispatch.

[6] http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=1_39351

2.5 *Impact on cross-border flows*

The impacts explored in this review so far, such as those on price signals and the use of network capacity, have several practical interactions when considering the use of interconnection capacity. The efficient use of the network and, in particular, the resultant impact on cross-border flows is explored by THEMA (2013) in the context of the Nordic bidding zones.

If bidding zones are not delineated according to network constraints, there is an inherent risk to the efficiency of power flows across borders. Prices in zones that are delineated according to network congestions are more reflective of local conditions whereas larger zones that suffer from internal network congestion do not tend to accurately reflect local conditions in their uniform wholesale prices, potentially resulting in sub-optimal interconnector flows. Optimal interconnector usage between countries would be more likely if both sides of the interconnector use zonal pricing, as long as the zones are configured according to network constraints.

Figure 2 (on the left) shows markets either side of an interconnector where there are significant network constraints within a bidding zone while Figure 3 (on the right) shows this situation altered such that bidding zones are delineated to take network constraints into account.

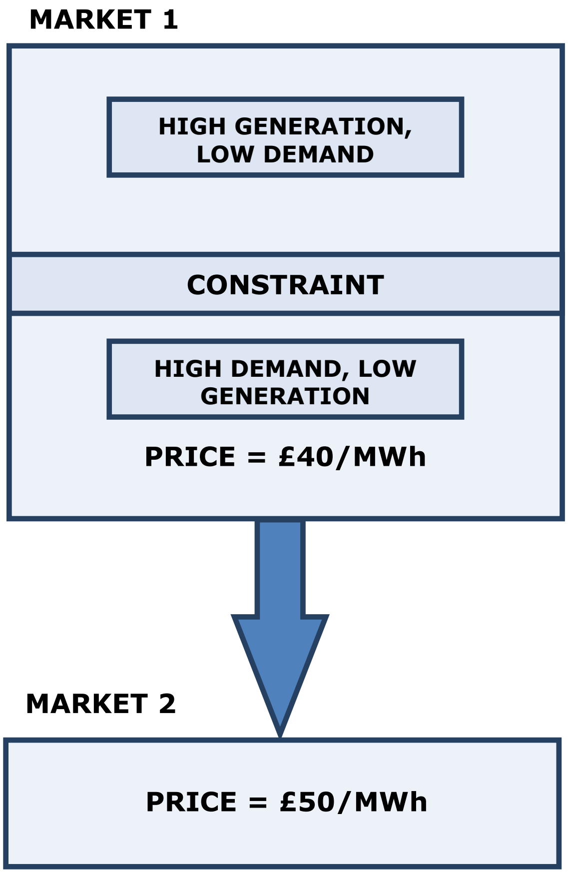

Figure 2

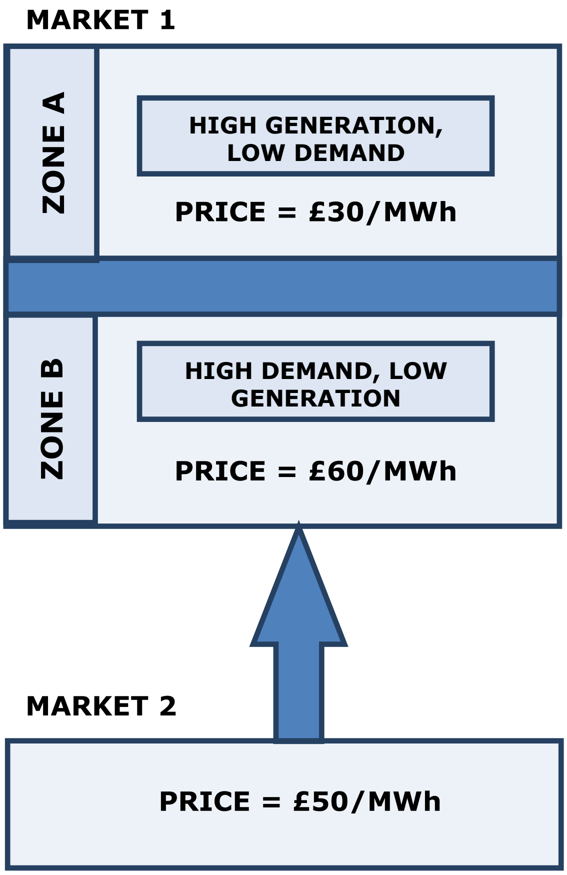

Figure 3

In Figure 2, Market 1 has a clearing price across the zone of £40/MWh, with generation and demand typically located far from each other and significant network constraints imposed in the middle. Market 1 is interconnected with Market 2 which has a clearing price of £50/MWh. This price arbitrage opportunity between markets dictates that electricity will flow from Market 1, where the price is lower, to Market 2, where the price is higher.

If Market 1 is delineated into two zones according to the network constraints between the typical locations of high/low generation and high/low demand, different clearing prices for the two newly formed zones emerge; a lower price of £30/MWh in Zone A, where there is now abundant generation to meet demand in that zone, and a higher price of £60/MWh in Zone B, where high demand is no longer able to rely upon the generation in Zone A. This situation is shown in Figure 3.

As a result, the clearing price in Zone B increases and subsequent arbitrage opportunities are altered such that interconnector flows would now flow from Market 2 to Zone B of Market 1, where prices are now higher than Market 2.
In Figure 2, the lower half of Market 1 (Zone B in Figure 3) is effectively passing on generation from the upper half of Market 1 (Zone A in Figure 3) to Market 2 and raising prices in the upper half of Market 1 above the efficient clearing price that their abundant generation should dictate. The efficient flow on this interconnector is distorted because the uniform price in Figure 2 does not reflect local supply and demand conditions.

Interconnectors could therefore worsen congestion if the prices at either end of the interconnector do not reflect local supply and demand (ie if bidding zones do not reflect network congestion). As discussed widely in the literature, zonal pricing may affect opportunities for arbitrage and alter cross-border flows, depending on the delineation of bidding zones.

The impacts that should be considered in a framework for assessing the configuration of bidding zones are:

- the effect on price signals for efficient use of existing interconnection capacity;
- the effect of the configuration of bidding zones on incentives for interconnector investment.

3. Summary

The variety of impacts covered in the literature reveals the wide reaching effects that the delineation of bidding zones has on incentives for the system operator, generators, market access, locational signals, competition levels and market liquidity. The benefits of uniform pricing on the one hand and zonal or even nodal pricing on the other hand depend on the trade-off between price signals, static and dynamic incentives, liquidity, competition and distribution effects.

The configuration of bidding zones implies a trade-off between a number of cross-cutting and complex impacts which are discussed in the literature and have been distilled in this paper. These impacts, summarised in Figure 4, would likely form the basis for further analysis in this work area.

EFFICIENT USE OF THE NETWORK	▪ The costs of re-dispatch ▪ Dispatch restrictions in the spot market ▪ Aggregated and disaggregated price levels
LIQUIDITY	▪ The levels of liquidity in the short-term (day-ahead and intraday) markets ▪ The levels of liquidity in the forwards market ▪ The ability of market players to hedge against uncertainty
INVESTMENT	▪ The degree to which locational signals are sharpened by a change in the configuration of bidding zones ▪ The relative influence of price signals compared with other factors ▪ The distributional effect on new investment in generation ▪ The wider investment climate
MARKET POWER	▪ The number of market players and degree of market power in markets of different timeframes ▪ Incentives for investment and bidding behaviour resulting from network constraints ▪ Market power in re-dispatch
CROSS-BORDER FLOWS	▪ The effect on price signals for efficient use of existing interconnection capacity ▪ The effect of the configuration of bidding zones on incentives for new interconnector investment

Figure 4

These impacts need to be assessed alongside more general questions principally related to the impact of the transition following a change in bidding zone configuration. Although not discussed widely in the published literature, the considerations noted below have become apparent to us as we have undertaken this initial work and would have to be further explored should we ever consider alternative bidding zones configurations. These considerations include:

- The treatment of existing interconnectors after a change in bidding zone configuration
  - *What would happen to an interconnector if a reconfiguration of bidding zones meant it was no longer connecting two different bidding zones?*
  - *How would this impact on revenues?*
  - *Would there be a case for existing merchant lines to need to be regulated?*

- The treatment of lines within zones that become zone to zone lines following a change in the configuration of bidding zones
  - *How would these lines be regulated (if they need to be)?*
  - *Would they sit under the regulatory regime for interconnection?*

- Reference prices
  - *What changes to reference prices would need to be made following a reconfiguration of bidding zones?*

- Access rights
  - *How would existing access rights be treated under a new configuration of bidding zones?*
  - *How would access rights that apply to a set size of bidding zone be applied to a bigger or smaller bidding zone?*
  - *Would physical or financial transmission rights be most appropriate?*

- Charging
  - *Would a change in BSUoS charging be required as a result of a reconfiguration of bidding zones?*
  - *What is the interaction with the locational nature of TNUoS charging? How would this interact with Project TransmiT?*

- Changes required to industry codes
  - *In what ways might industry codes need to be changed in order to accommodate a change?*
  - *How long would this take?*
  - *What is the scale of change required?*

- Regulatory and market rules
  - *How would these be accommodated if national borders are spanned by a bidding zone?*

- Implementation costs
  - *How much would a change in the delineation of bidding zones in GB cost to implement?*
  - *Who would incur these costs?*

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