IMPACTS OF ZONAL PRICING ON CONSUMERS AND SYSTEM FLEXIBILITY

Report for SSE

JUNE 2025

WWW.FRONTIER-ECONOMICS.COM

Contents

1 Executive summary

As part of its ongoing Review of Electricity Market Arrangements (REMA) programme, the UK Department for Energy Security and Net Zero (DESNZ) is considering the introduction of a zonal wholesale electricity market in Great Britain (GB). This would fundamentally change the nature of the locational signals in the GB electricity system from those embedded in network charges and the Balancing Mechanism today to signals which are embedded in wholesale electricity prices.

In this report, we discuss two key questions raised during the course of discussions on zonal pricing:

- Will all consumers benefit from the implementation of a zonal market?
- Will a zonal market better support demand-side flexibility?

We conclude that:

- **It cannot be relied upon that all consumers would benefit from a zonal market.** It would be dangerous for policymakers to rely on suggestions that all consumers in GB benefit. There are credible scenarios where the outcome for different groups of consumers becomes a locational lottery, with some winners and some losers. The sensitivity of modelling results to small changes in assumptions is magnified by a tendency for claimed efficiency benefits to be overstated; and

- **A zonal market is unlikely to lead to improved signals for flexibility.** While there is no doubt that demand-side flexibility is important for managing congestion, we do not see any fundamental reason why this flexibility will develop better in a zonal market than in a Reformed National Market.

We briefly expand on each of these points below.

It cannot be relied upon that all consumers would benefit from a zonal market

There are credible scenarios where the outcome for different groups of consumers becomes a locational lottery, with some winners and some losers. This is because:

- Given the nature of the modelling and the different impacts being assessed, small changes in the scenarios and assumptions modelled (e.g. commodity prices and the impact of market power) can flip the outcome for individual groups of consumers. A modelled scenario in which all consumers gain can easily switch to one where some gain and some lose;

- The sensitivity of modelling results to such small changes is magnified by a tendency for claimed benefits of zonal pricing to be overstated. Proponents of zonal pricing have typically:

- overstated the efficiency benefits by overstating the extent to which market participants can respond to investment signals in zonal market, not appropriately assessing the improvements in a Reformed National Market, and not fully considering the impact of the latest transmission network investment plans and the role of strategic planning (which would reduce congestion, and therefore reduce the potential benefits from zonal pricing);
- not assessed the potential impact of zonal pricing on investor cost of capital and hence ignored the fact that even a small increase in cost of capital on its own may remove all benefits;
- failed to assess other increased industry costs caused by the move to a zonal market, such as costs of reduced liquidity and/or higher costs of hedging and route to market; and
- failed to assess whether all of the assumed transfers from producers to consumers will materialise, in particular given the likely policy direction to protect existing investors from the change.

A zonal market is unlikely to lead to improved signals for flexibility

It is unclear that flexibility provided through consumers altering their demand will develop better in a zonal market than in a Reformed National Market because:

- locational signals for flexibility already exist (and are arguably more accurate than those from zonal wholesale prices alone). These signals could develop further going forwards (supported by reform to the national market, which could be implemented more quickly than zonal pricing);[1]
- given most consumers will access the market by way of a third party, there does not appear to be a fundamental reason why responding to a locational signal delivered through zonal pricing would be easier than responding to signals embedded in tools that the NESO can deploy (Balancing Mechanism, Local Constraint Market, etc) whilst maintaining a national wholesale price. We are already seeing the development of innovative supplier tariffs encouraging consumer flexibility and this is likely to continue (supported by reforms to the national market, such as market wide half-hourly settlement); and
- various broader factors (including the need for increased intervention to address the impact of market power) could limit the flexibility benefits of a zonal market.

1 DESNZ has recently stated that zonal pricing could be implemented by 2032.

2 Will all consumers benefit from the implementation of a zonal market?

Some[2] (but not all[3]) modelling exercises have claimed that, in the scenarios studied, consumers in all GB regions would benefit from the implementation of a zonal market (i.e. irrespective of where they are located).

In this section, we discuss the extent to which such findings can be relied upon. We explain that in our view, it is not possible to draw definite conclusions as to whether all consumers will benefit since:

- *Estimating the impact on groups of consumers is a complex balancing act* across different cost and benefit categories, and small changes in assumptions, in particular related to the shape of the merit order, commodity prices, and the presence or not of market power, are likely to significantly influence the final outcome for individual consumer groups;
- *Estimated overall GB consumer benefits rely on improvements in overall system efficiency which are often overstated*. If these are overestimated, then it is more likely that some groups of consumers lose out, making it less likely that consumers overall benefit. As we have noted elsewhere, system efficiency benefits may not exist at all under certain scenarios. In particular, the assumed network scenario matters, as has been demonstrated by LCP Delta's analysis, with any remaining efficiency benefits having the potential to be more than offset by minimal impacts on investors' cost of capital;[4] and
- *Benefits to both consumers as a whole and individual groups of consumers rely heavily on significant wealth transfers from producers.* If these are overestimated, again it is more likely that some consumer groups lose out, and less likely that consumers overall benefit. Modelling assessments of these are likely to have been overstated with key considerations having been overlooked, including (typically) not taking full account of the

2 For example, a key finding of FTI's 2023 assessment of locational pricing for Ofgem is that "…*all consumers in all regions of the country benefit from a move to locational wholesale pricing, under all three modelled scenarios*." See FTI and ESC (2023) "Assessment of locational wholesale electricity market design options in GB", available here: https://www.ofgem.gov.uk/sites/default/files/2023-10/FINAL%20FTI%20Assessment%20of%20locational%20wholesale%20electricity%20market%20design%20options%20-%2027%20Oct%202023%205.pdf. A 2022 ESC study for Octopus Energy also estimates benefits for consumers in "*all regions*". See ESC (2022) "Location, location, location: reforming wholesale electricity markets to meet net zero".

3 FTI's 2025 analysis for Octopus Energy estimates net consumer cost of £3.6 billion (NPV 2030-50) for the GB12 zone (covering South East England). See https://www.linkedin.com/posts/jason-mann-7722722_workshop-slides-activity-7306279680007950336-A8J6/ , slide 38.

4 LCP Delta estimated that a small increase in cost of capital of 0.6% would be sufficient to wipe out the benefits assuming Beyond 2030 network build https://www.lcp.com/en/insights/publications/zonal-pricing-in-great-britain

cost of legacy and transitional arrangements. These have emerged as a key part of a move to zonal pricing, but DESNZ is yet to confirm their design.[5]

2.1 Estimating consumer impacts is a complex balancing act

Estimating the impact of a move to a zonal market on consumers requires the estimation of all aspects of a typical consumer bill across all regions. This is a complex exercise.

In this subsection, before considering any potential effects of zonal pricing on dispatch or investment (which we go on to discuss in section 2.2) we show that:

- It is reasonable to expect **wholesale costs to rise on average following a move to zonal pricing**.
- Taking into account other key factors such as the change in constraint costs and congestion rents, **the overall impact on consumers is likely to be sensitive to small changes in assumptions** e.g. in relation to commodity prices, (before considering policy choices such as introducing transitional arrangements for existing capacity – which we discuss in section 2.3).

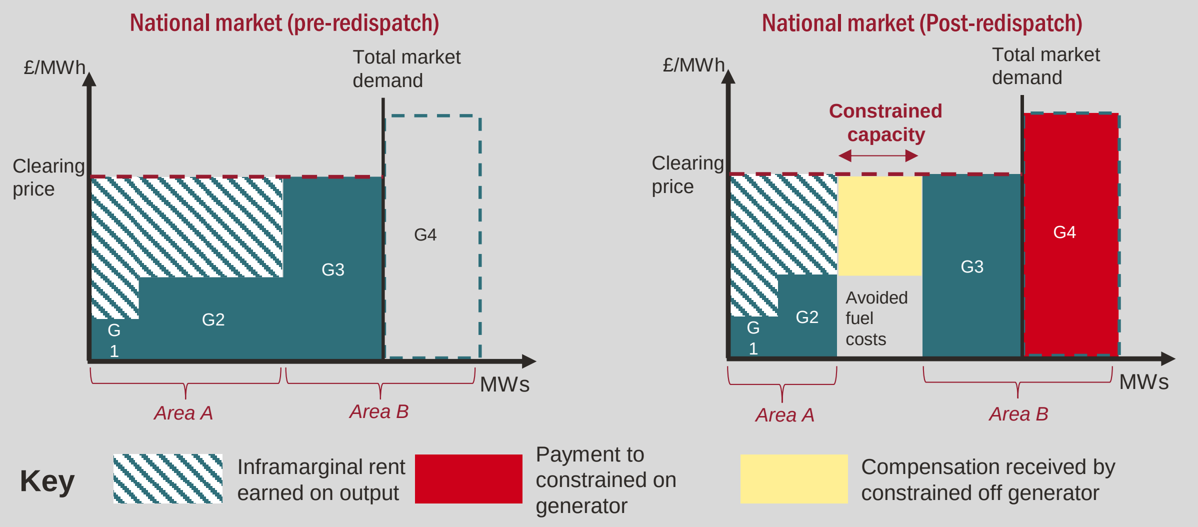
Understanding the impacts of zonal pricing

The figure below sets out a very simple illustrative generation merit order with assumed congestion between two zones. There are two lower marginal cost plants ("G1" and "G2") located in Area A, and two higher cost plants ("G3" and "G4") located in Area B. Transmission capacity is limited between Areas A and B.

A national market assumes unlimited capacity between areas A and B when setting wholesale prices. As a result, in the national wholesale market, a single clearing price is set that balances national supply and demand. In the example below, the marginal plant in the national market is G3. This is shown in the left hand panel of the figure below.

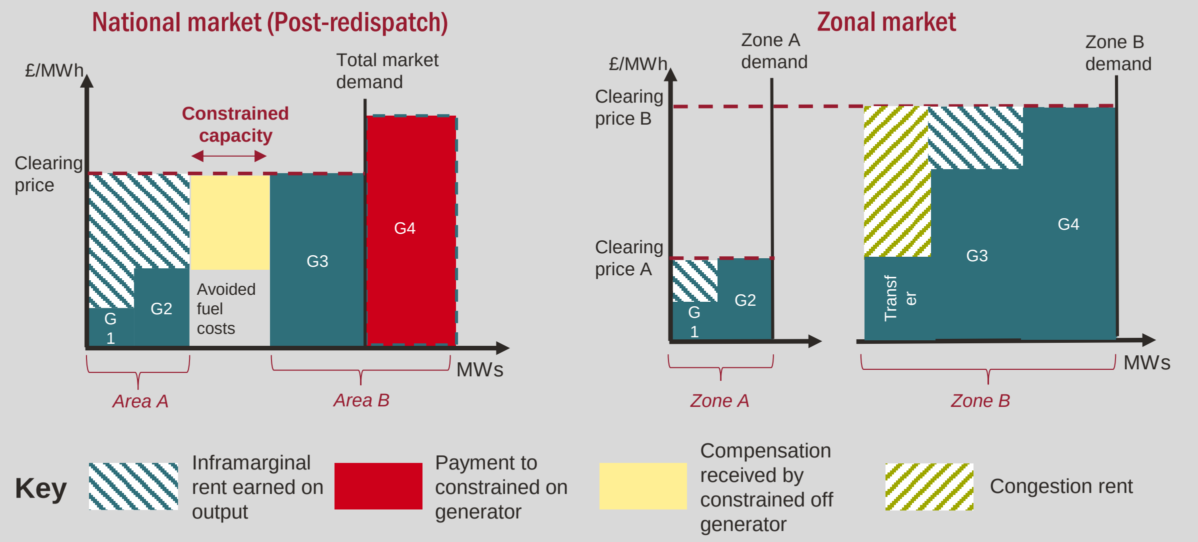
In the national market, the system operator must subsequently redispatch plants, to account for the limited physical transmission capacity between areas A and B. G2 in area A must be (partially) constrained off, since generation in area A can only serve demand in area A plus exports to area B. G4 must be constrained on to ensure demand is met in area B. This "redispatch" leads to an incremental cost, which customers pay for. However, there is no change to the market clearing price as a result. The outcome of this redispatch is shown in the right hand panel of the figure below.

[5] REMA Autumn Update, DESNZ said that "Transitional arrangements are being considered under both potential market designs"…and that interventions related to zonal "are likely to be different and more substantive than those under reformed national pricing".



The figure below contrasts the post-redispatch outcome in a national market (left hand panel) with that in a zonal market (right hand panel). In the zonal market, the same physical dispatch is achieved as the post-redispatch outcome in the national market. However, there are the following changes in consumer costs:

- Wholesale costs: in a zonal market, the cost of G4 sets in the clearing price in area B, increasing the wholesale cost to all demand in zone B (while the zonal price in area A is lower than under a national market). If G4 is a gas (or gas linked) plant, this means that zone B, which covers a larger share or demand is more exposed to gas price volatility;
- Constraint costs: the costs of redispatch are avoided under a zonal market; and
- Congestion rent: the difference between zonal prices can, in principle, be refunded to consumers.



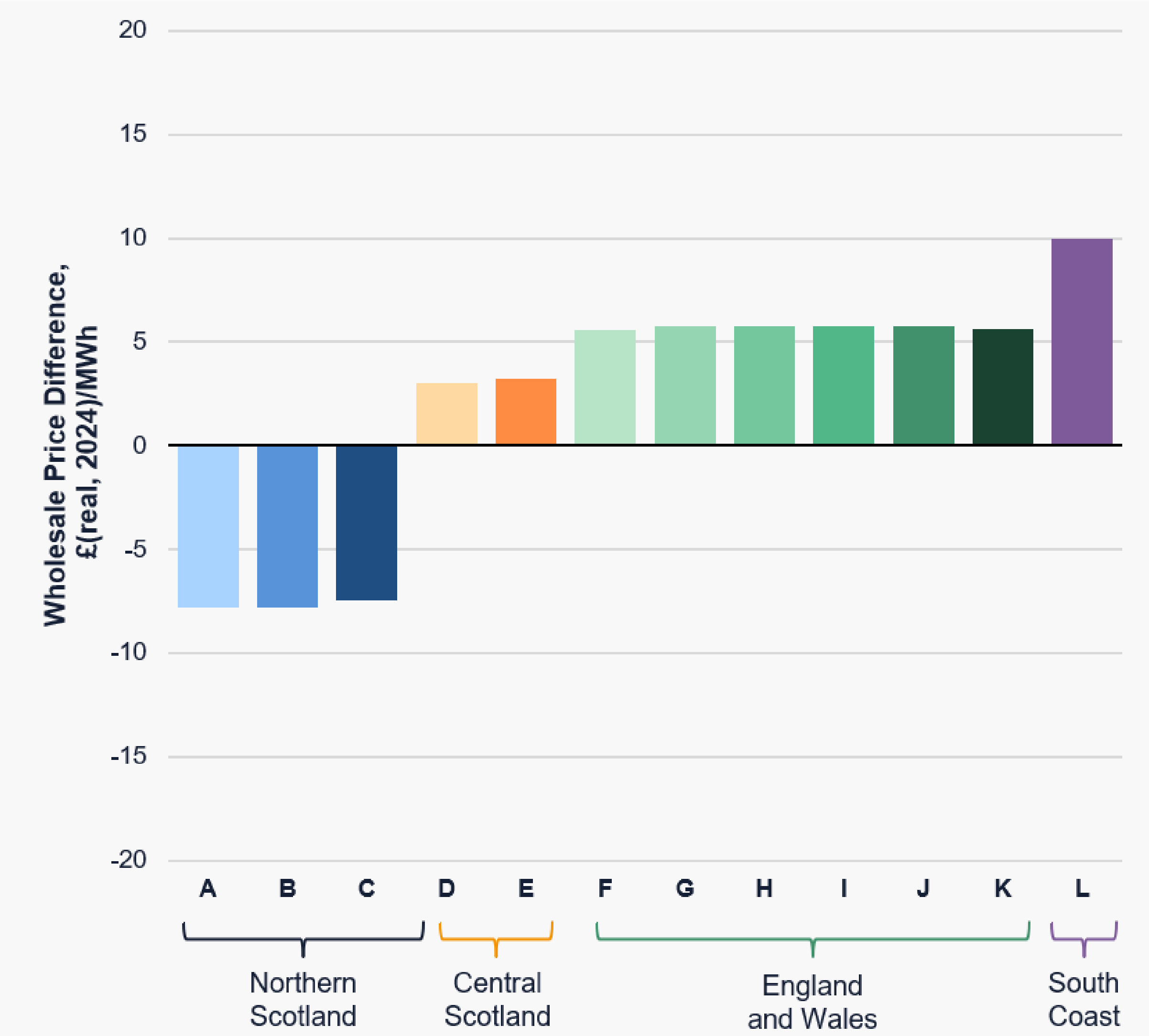
The net impact of the three changes above will depend on the precise scenario. The simplified illustrations above do not account for any potential efficiency gains under zonal pricing, or for factors that may add costs to customers, such as policy choices to compensate existing capacity in the transition to a zonal market.

In a steady state it is reasonable to believe that, following a move to a zonal market, average wholesale costs would increase, with consumers in import constrained zones seeing a greater increase in costs than the savings seen by consumers in export constrained zones. Given the major constraints in GB run from north to south, the zones with excess supply which might see lower prices (e.g. in Scotland) are also the zones with lowest demand. Zones with excess demand which might see higher prices (e.g. in southern parts of GB) are those with the highest demand. Given the relative size of Scottish demand compared to the rest of GB, it would only be possible for average wholesale prices to fall if the reduction in prices in Scotland was very large, and the increase in England and Wales was very small.

The conclusion that wholesale costs increase on average is consistent with the quantitative analyses of a zonal market: for example this is the case in FTI's analysis and more recent analysis from LCP Delta.[6] In 2035, while average wholesale prices are estimated to fall under zonal pricing in Northern Scotland, LCP Delta estimated an increase in wholesale prices on average in other zones, which together account for 97% of GB power demand (see Figure 1).

[6] LCP Delta's analysis based on outputs from their previous report for SSE assessing the impact of moving to zonal pricing under 'Beyond 2030' network plans and DESNZ's Net Zero Higher Demand scenario.

Figure 1 Difference between zonal and national wholesale prices in 2035, by zone



Source: LCP Delta (2025) *"Zonal pricing in Great Britain: Differences in regional wholesale electricity prices – A deep dive"* https://www.lcp.com/en/insights/publications/zonal-pricing-in-great-britain

However, while wholesale costs for consumers increase with zonal pricing, this is one part of the overall bill – zonal pricing will impact on other areas of consumer cost:

- *Reductions in constraint management costs*, as a result of not having to pay compensation to generators whose output cannot be accommodated on the system; and
- *Intra-GB congestion rents* which accrue to NESO as a result of differences in prices between zones. These could benefit consumers depending on how they are re-distributed and to what extent they are used to fund other policies linked to implementing zonal pricing such as transitional arrangements (which we discuss later in section 2.3).

Before considering any wider impacts on operation or investment (which we go on to discuss), it is the balance of these things that determines the extent to which consumers may benefit overall or in different locations. **The key question therefore, is whether policymakers can rely upon changes in wholesale costs being offset by other factors for all consumers in all, or even in the majority of scenarios.** In our view, the **answer is likely to be "no",** because:

- small changes in commodity costs may result in changes to the pattern of zonal prices[7], leading to a change in the overall balance between changes in wholesale cost, congestion rent and balancing costs (for example, a change in gas costs which disproportionately affects electricity wholesale prices in regions where gas is more frequently at the margin);
- customer benefits are typically highest with high-levels of assumed congestion and, as we go on to discuss below, some of the recent modelling has adopted assumptions that drive levels of congestion that, in turn, are likely to be unrealistic;
- the implementation of transitional arrangements increases the likelihood of losses for consumers in some regions; and
- policy decisions regarding how to distribute costs and income (compensation for existing capacity, policy costs, congestion income, etc.) across regions will also affect the distribution of any net benefit from zonal pricing across GB regions.

Given this, it should not be surprising that FTI's most recent modelling[8] no longer shows benefits to customers in all GB regions (before considering the impact of transitional arrangements).

These impacts are not merely theoretical: uncertainty regarding the impacts of market splitting has been borne out in practice. Prior to the Austrian bidding zone being split from the Germany-Luxembourg zone in 2018, market expectations were that it would lead to an approx. EUR 2-3.50/MWh Austrian premium over the German price.[9] Following the split, EFET

7 With the exception of Northern Scotland, all zones are likely to see an increase under zonal pricing in the frequency at which gas-fired generation sets the wholesale price. See https://insights.lcp.com/rs/032-PAO-331/images/LCP-Delta-Zonal-Pricing-in-Great-Britain-Differences-in-regional-wholesale-electricity-prices-2025.pdf

8 See https://www.linkedin.com/posts/jason-mann-7722722_workshop-slides-activity-7306279680007950336-A8J6?utm_source=share&utm_medium=member_desktop&rcm=ACoAAAiMCqMBnvJkA-7AQJSpBixqf1IgO88Ctw0, slides 37-28. Based on FTI (2025) "Impact of a Potential Zonal Market Design in Great Britain" https://octoenergy-production-media.s3.amazonaws.com/documents/FTI_-_Octopus_-_Impact_of_zonal_design_-_Final_report_-_24_Feb_2025.pdf

9 Eight European TSOs (2018) "Report on SPAIC results for the integration of the DE-AT border into CWE Flow Based", available at: https://www.jao.eu/sites/default/files/2020-04/20180601_Annex%2015_28-EXT%20SPAIC%20for%20CWE%20Approval%20Document_0.pdf . "*[Data on derivatives products] allow to conclude that market parties are expecting a price difference between DE and AT of 2.50 Euro/MWh in 2019, and 3.00 Euro/MWh in 2020 (trading day was 30/04/2018)*" suggested a premium of c. €2-3/MWh. Similarly, parallel runs of the EU market coupling algorithm prior to splitting, based on actual bid/offer data over 2016-2017, indicated that market splitting would have led to a premium of EUR 3.5/MWh.

reported a consistent EUR 5-10/MWh spread in annual baseload products.[10] This is before accounting for the impacts of the split on forward market liquidity, which is likely to have further increased costs for Austrian consumers.[11] This illustrates that the impact on wholesale prices of moving to a zonal market can be difficult to predict.

The impact of market power

In the discussion above, and in the modelling assessments which have been carried out, it has been assumed that the market is perfectly efficient and there is no exercise of market power.

However, this is unlikely to be the case. Although we do not know what zonal configuration might be implemented, LCP Delta has analysed the maximum percentage of generating capacity owned by a single company in each zone in a reasonable configuration (see Figure 2). In six of the 11 zones, the percentages are above 30%, and in three zones they are above 45%.

This concentration exists in the locational Balancing Mechanism (BM) today, and it is important to understand that a zonal market will not make the *existence* of market power any more or less likely. However, it does potentially change the *impact* of any exercise of market power:

- today, it is only the producers that are redispatched in the BM to address a constraint that are potentially able to benefit from higher prices. Wholesale prices (received by all producers) are unaffected by the cost of redispatch actions, so other producers do not benefit. The BM cost is spread across all consumers (not just those in the zone); but

- under a zonal market, the exercise of locational market power would directly impact the zonal wholesale price. All producers in the zone would benefit (meaning the total cost would be higher), and this higher cost would be paid by all consumers in the zone in question.[12]

This might be particularly concerning for zone J in Figure 2, where a single company owns 45% of capacity primarily through 12-price-setting CCGTs and OCGTs. In principle, this concentration could significantly affect prices in the zone. Zone J represents 37% of national demand.

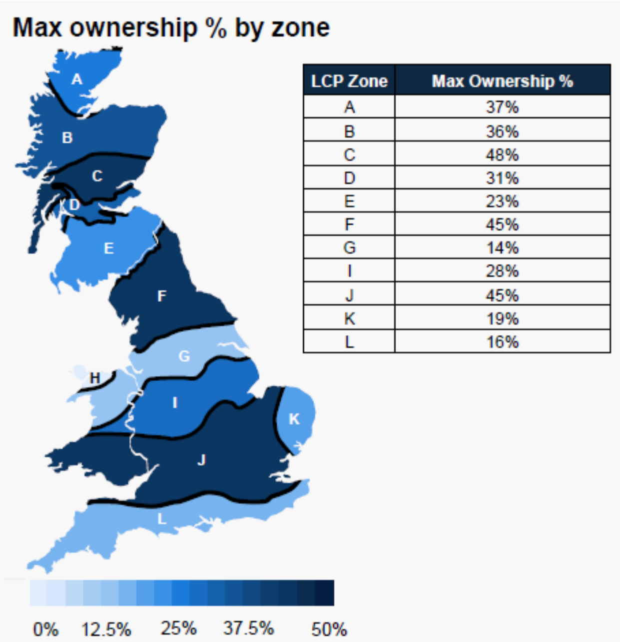
10 See: https://eepublicdownloads.entsoe.eu/clean-documents/Network%20codes%20documents/Implementation/stakeholder_committees/MESC/2019-09-17/5.2_EFET%20position%20paper_%20BZ%20review_16092019.pdf?Web=1. In the first four months of splitting, average monthly day-ahead prices in Austria were in the range of EUR 3-9/MWh higher than German prices. See the following report from Austrian regulator e-control at the time: https://www.e-control.at/branchen-newsletter/-/asset_publisher/0wTTT16KsQRv/content/strom-aktuell-entwicklung-nach-der-preiszonentrennung-deutschland-osterreich

11 Ibid.

12 This cost may be offset in part by an increase in congestion rents depending on how they are redistributed.

While this analysis is based on the current mix and ownership, it would be unreasonable for policymakers simply to ignore the potential impact of market power.

Figure 2 GB electricity generation market concentration



LCP Zone	Max Ownership %
A	37%
B	36%
C	48%
D	31%
E	23%
F	45%
G	14%
I	28%
J	45%
K	19%
L	16%

Source: LCP Delta produced for SSE. Data procured from LCP Enact platform for short term power market intelligence which holds data on all GB power plants with a BMU.

2.2 Modelled efficiency benefits may be overstated

The discussion so far has assumed the same generation mix and dispatch (i.e. ignoring potential efficiency benefits). In FTI's analyses, the reductions in constraint costs are always significant enough to outweigh the change in wholesale costs because it is also assumed that the dispatch pattern and (in FTI's 2023 analysis) the location of investment are more efficient in a zonal market. If these efficiency benefits are overstated, the conclusion that all consumers benefit is more likely to be unsafe.

As we have noted previously, **in our view these claimed efficiency gains are typically unrealistically large, sensitive to the choice of scenario, and potentially outweighed by increases in the cost of capital.**[13] We summarise these arguments below.

[13] Other impacts that affect overall efficiency gains that are typically less significant and covered in less detail in the studies showing benefits from zonal pricing. These are implementation and ongoing costs, and impacts on liquidity and financial risk management. For example, a zonal split could lead to increased costs of hedging if it were to lead to reduced liquidity within zones (and therefore higher transaction costs) and/or increased exposure to basis risk related to price differences between zones (or between zones and any GB system "average" price). Liquidity impacts have been an important consideration in other jurisdictions e.g. Germany.

2.2.1 The modelled efficiency benefits are unrealistic

Proponents of locational wholesale pricing cite two principal drivers of efficiency savings, with claims of quantified benefit linked to each typically being overstated.[14]

Optimised investment

It is claimed that investors respond more efficiently to locational signals in a zonal market than in a national market (*status quo* or reformed). This assumes, without evidence, that investors have perfect foresight i.e. meaning they are more able to efficiently respond to a volatile and unpredictable zonal locational signal (that is sensitive to policy decisions by Ofgem, DESNZ and NESO) than to locational transmission charges.[15] The analyses also typically do not account for other factors (such as wind farm concentration effects) that may affect siting choices. Simply assuming that one type of signal is more efficient than another provides little insight.

More broadly, this assumption of optimised investment also ignores the role of strategic planning – commissioned by the UK, Scottish, and Welsh Governments – in driving locational investment decisions and setting the *blueprint* for GB's energy infrastructure.[16]

---

14 We set out our critique of FTI's claimed efficiency savings here: https://www.frontier-economics.com/uk/en/news-and-insights/news/news-article-i20234-locational-marginal-pricing-assessing-the-benefits/

15 Reform to current network charges is also being considered as part of a Reformed National Market

16 The Strategic Spatial Energy Plan (SSEP) will assess "optimal locations, quantities and types of energy infrastructure required to meet our future energy demand" https://www.neso.energy/what-we-do/strategic-planning/strategic-spatial-energy-planning-ssep

Locational investment signals for data centres

Some of the recent debate has also focused on the role of locational signals in the siting decisions of data centres, with claims that zonal pricing could provide improved incentives to locate in constrained parts of the grid such as in Scotland.[17] It is not clear that the arguments on data centres are materially different to the arguments in relation to other generation, storage and large demand such as electrolyser loads.

There are a range of factors that are likely to influence the location of a data centre, including electricity costs. However, other factors may dominate any decision. For example, proximity to users is particularly important for applications such as cloud computing, which is evident in the clustering of data centres around more densely populated areas, such as the south-east of England and Dublin.[18] However, locational signals may play a more important role for other types of applications, particularly those that do not require low latency.

In situations where locational signals play an important role in the locational decision of a data centre, it is unclear why a zonal signal would lead to a more efficient outcome. To the extent data centres can respond to zonal wholesale prices, they can also respond to the improved signal from a locational transmission demand charge in a Reformed National Market, and even secure low cost energy through the Balancing Mechanism.[19]

Optimised dispatch

It is claimed that in a national market NESO fails to take efficient (i.e. lowest cost) redispatching actions available to it, while dispatch would be efficient to start with in a zonal market (at least in relation to the zonal boundaries, and given forecasts of generation, demand and network capacity). But in principle there is no reason why the same dispatch cannot be achieved under both national and zonal markets.

There are some existing inefficiencies in today's market, particularly in the way interconnectors are redispatched. While NESO can and does redispatch interconnectors on most days of the year, as we have set out in a recent report for ScottishPower,[20] there is potential to improve the efficiency of these arrangements. Our report highlighted the need for harmonisation of the current arrangements across all existing and future interconnectors, as well as the potential

17 Social market foundation (2025) "How to power AI: Boosting compute capacity for UK AI" https://www.smf.co.uk/wp-content/uploads/2025/01/How-to-power-AI-Feb-2025.pdf

18 https://www.frontier-economics.com/uk/en/news-and-insights/articles/article-i21028-data-centres-and-clean-power/. See also https://www.sse.com/media/jmxhsinw/aquaicity-zonal-nordics.pdf in relation to large energy user siting decisions more generally.

19 In the case of transmission charges for demand, potential reforms could consider whether maintaining the current floor of zero is still appropriate.

20 https://www.frontier-economics.com/media/leuh5cod/balancing-reforms-final-summary.pdf

for improved intraday SO to SO arrangements.[21] By definition, given these arrangements relate to interconnectors, new redispatch arrangements will require international discussions and cooperation (a point which DESNZ recognised in its Autumn Update). However, similar arrangements were developed pre-Brexit, and therefore it is not unreasonable to assume improvements can lead to more efficient redispatch actions in the BM.

There are also current inefficiencies with the way storage is redispatched in the Balancing Mechanism. Again, in principle there is no reason why storage cannot face accurate locational signals in the Balancing Mechanism, and reforms are being considered by NESO (e.g. changes to reduce "skip rates") and as part of REMA in a Reformed National Market.

Finally, it is not necessarily the case that aligning price zones with congestion means that dispatch will automatically be efficient to start with. In reality, a zonal market will be less efficient than modelled due to imperfect foresight of transmission constraints at the day-ahead stage. As with a national market, redispatch will be required due to changes in conditions following the day-ahead and intraday timeframes.

We discuss in more detail in section 3 the extent to which efficient locational signals for flexibility exist in the current Balancing Market.

2.2.2 Any efficiency benefits are sensitive to the choice of scenario

Any system modelling needs to be interpreted with care, and in particular it is important to understand how sensitive the results are to the choice of assumptions and scenarios. In the case of a zonal market, benefits are likely to be closely linked to network congestion, which in turn will be driven by factors such as:

- the extent to which the network can be built out in line with the expansion of generation capacity;
- the assumed location of new investments in generation, demand, storage and interconnection; and
- assumptions regarding the extent to which existing network capacity might be optimised to maximise flows and minimise constraints.

Comparing some of the studies in this area make this sensitivity clear. The table below summarises some of the modelling which has been published to date.

- It is evident that the more transmission network capability is assumed, the lower the overall efficiency benefits from zonal pricing (consistent with additional transmission network reducing congestion volumes). NOA7 assumes less transmission than NOA7(Refresh) – reflected in reduced benefits estimates for NOA7(Refresh) in FTI's

21 Other studies have also looked at this, including this study for Scottish Renewables https://www.scottishrenewables.com/assets/000/004/348/SR_Interconnector_Paper_-_ISSUED_-_V1_1_original.pdf?1734001805

analysis. NOA7(Refresh) in turn assumes less network build than Beyond 2030 – reflected in reduced zonal benefits estimates for Beyond 2030 in LCP's analysis.

- While estimated benefits increase in FTI's 2025 analysis based on Beyond 2030, compared to its 2023 analysis based on NOA7(Refresh), this appears to be largely driven by changes to other assumptions that lead to higher congestion (despite greater network build) compared to the 2023 analysis (including the amount of assumed wind generation in Scotland). The assumptions on generation and demand location on the one hand (based on FES), and on network build on the other are unlikely to be internally consistent (i.e. optimised for one another). In a subsequent analysis,[22] AFRY have tried to account for the dynamic of ongoing co-ordination between investment in generation, interconnection and network and found that doing so would materially reduce estimated benefits from zonal pricing.

Table 1 Societal benefit estimates from published studies (£ billion, net present value)

Transmission build assumption	*Industry* **AFRY**	***Ofgem*** **FTI / ESC**	*DESNZ / SSE* **LCP Delta**	*Octopus* **FTI**
NOA7 (from January 2022)	N/A	15.3 (LtW)	N/A	N/A
NOA7 (Refresh) (from July 2022)	4.2 (CT/ST)	7.1 (LtW)	5-15 (DESNZ)	N/A
Beyond 2030 (from March 2024)	3.3 (HT)	N/A	0-11 (DESNZ)	25.5 (HT)

Note: *Parentheses indicate generation and demand scenarios assumed in each study:*

Original AFRY study (published Aug 2023) uses Consumer Transformation (CT) and System Transformation (ST) scenarios from ESO Future Energy Scenarios (FES) 2022. Recent Feb 2025 AFRY study for Beyond 2030 based on NESO FES 2024 Holistic Transition (HT) scenarios. Original AFRY results in 2021 prices; 2025 AFRY study results in 2023 prices. Assessment timeframe for all AFRY studies is 2028-50.

FTI/ESC analysis (published Oct 2023) is based on FES 2021 Leading the Way (LtW). Figures are 2024 prices, net present value (NPV) calculated over 2025-40.

LCP Delta analysis (carried out in March 2024, with update in October 2024) is based on DESNZ data, with LCP Delta assumptions where DESNZ has not published relevant data. Figures in 2023 prices with NPV calculated over 2030-50.

FTI Feb 2025 study is based on FES 2024 HT scenario, with results in 2024 prices and NPV calculated over 2030-50.

NESO's Clean Power documents also make the link between transmission network and zonal benefits clear. NESO says that constraints reduce with the delivery of the transmission network they say is needed for 2030, with unabated gas use reducing from around 8% with the 2024 transmission network to 5% or less with the recommended network.[23]

---

22 AFRY (2025) "Sensitivity analysis on the modelled benefits of zonal electricity markets in Great Britain", https://afry.com/en/sensitivity-analysis-modelled-benefits-zonal-electricity-markets-in-great-britain

23 NESO, Clean Power 2030, Advice on achieving Clean Power for Great Britain by 2030, page 36

GB's current plans for network development are set out in NESO's Beyond 2030 report.[24] If these plans are achieved, at least based on LCP Delta analysis,[25] then, even before considering additional zonal costs such as higher costs of capital (see next subsection) and higher cost of hedging and/or reduced liquidity, the overall benefits of zonal could be very low or zero.[26] This would increase the likelihood that some or all consumers would be worse off under zonal pricing.

2.2.3 Any remaining efficiency benefits could be eliminated by modest increases in the cost of capital

Typically, the discussion and assessment of the benefits of zonal has not focused on the costs of legacy and transitional arrangements or the increase in the investor risk inherent in a zonal market. Proponents of zonal have tended to argue that there is no change in risk, or that if there is an increase, it can be diversified away by investors.

LCP's analysis of a zonal market for DESNZ concluded that the estimated societal benefits could be removed with an increase in the cost of capital of between 0.3% and 0.9%. However, LCP recently updated this analysis to take account of updated grid plans, Beyond 2030, and showed a reduction in benefits from £5-15bn to £0-11bn, as shown above, and that relatively modest increases in the cost of capital (down to between 0% and 0.6%) would remove all the modelled benefits of zonal pricing in GB. A 1% increase in the cost of capital resulted in a move to zonal pricing being a net system cost of £8-19bn.

Our analysis has found that zonal pricing is likely to have an important impact on earnings volatility, particularly for plants facing significant uncertainty about the pace of generation, demand and network development in their zone. Given this, increases in the cost of capital (especially in the context of time-bound net zero targets) can be reasonably expected. Simply assuming that risks can be diversified arguably places more reliance on the theoretical underpinnings of the Capital Asset Pricing Framework[27] than is reasonable in the real world.

2.3 Claimed consumer benefits are reliant on significant transfers from producers that may not materialise

The modelled benefits to consumers result from a combination of claimed efficiency gains (which, as discussed above, may be overstated) and significant transfers from producers to

24 https://www.neso.energy/publications/beyond-2030

25 https://www.sse.com/media/x3ehjdpg/lcp-d-sse-impacts-of-beyond-2030-network-plans-on-zonal-pricing-october-2024.pdf

26 This increases the likelihood that overall benefits are negative assuming even very modest increases in the cost of capital

27 Such as 1) rational investors hold perfectly diversified portfolios; 2) the market has perfect divisibility and liquidity; and 3) there are no transaction costs.

consumers. These transfers sit within each of the major categories of wholesale prices, constraint costs, and congestion rents and are not straightforward to disentangle.

Nevertheless, taking account of likely policy responses, (e.g. legacy arrangements), these transfers are likely to have been overstated. Accounting for potential policy and investor responses to the implementation of zonal pricing would reduce them further.

2.3.1 Any transitional arrangements for existing investors should be accounted for

At the point of investment, investors form certain expectations of the potential risks and the possible returns on their investment, and in part these will be based on reasonable expectations related to the market design. Under the current regime, generators have invested on the basis of a national market price and 'firm' access to the network (i.e. if generators are asked to curtail their output by NESO, they will be compensated). In other words, they will have invested on the basis of accepting a particular nature of price and volume risks. Firm access rights have been in place since privatisation, and it was explicitly recognised that consumers would bear the risk of the potential disconnect between network investment and the roll-out of low carbon generation under the 'Connect and Manage' policy.[28]

In a zonal market the nature of these risks fundamentally changes:

- **Price risks** – in a zonal market investors are exposed to differences between their local zonal price and the national price; and
- **Volume risks –** in a zonal market generators that are unable to sell power due to congestion limiting export capacity from a zone in a zonal market would not receive any compensation (i.e. their rights would not be 'firm').

For existing investors, the new and increased price and volume risks represent a transfer to consumers. However, DESNZ noted in its REMA Autumn Update that existing and past investors are also the investors of the future, thereby recognising that perceptions about the fairness of such transfers will be important for the cost of future investment as well. As a result, transitional arrangements that mitigate this impact are being considered by policymakers.

Government has already confirmed that existing CfD and AR7 investors would be insulated from zonal price risk and have announced their aim to insulate AR7 investors from zonal volume risk.[29] However, the extent to which government will be successful in insulating AR7 investors from zonal volume risk will depend on the approach taken, which is still being

28 Connect and Manage allowed windfarms to connect to the network prior to the completion of wider network reinforcement, with consumers bearing any increase in constraint costs as a result.

29 https://www.youtube.com/watch?v=Y9yz9AN7I_E

developed.[30] While there are clear challenges to make such a major intervention workable so close to AR7, and it may rely on investors having to take a lot on trust, the government's intention to offer protection is clear. More comprehensive transitional arrangements that aim to return all existing investors to what they would have earned in the national market could be consistent with an objective of fair treatment for existing investments, and so may be considered by government.

While it is not possible to determine the extent to which the transfers estimated in any of the various studies relate to transfers from existing (rather than new) investors due to limitations on the availability of disaggregated results, it is likely to be a significant share of the total benefits. As a result, consistent with current government indications, it is important to recognise that the contributions of these transfers may need to be discounted significantly in any customer benefits assessment of zonal pricing.

2.3.2 New investors would require higher support payments

New investors after a cut-off date may not benefit from a transitional arrangements scheme (on the grounds that they would be investing in knowledge of the revenue and risk implications of the zonal market). However, such investors would need to adjust their bids into competitive mechanisms (such as CfD auctions and the CM) to reflect additional costs and risks. For example, CfD plants in potentially export constrained zones are likely to require a higher strike price to compensate for lower expected wholesale prices,[31] the fact that some of their potential production volumes would no longer earn any revenues (as a result of network congestion), and the fact that their revenues are more uncertain (as a result of the likelihood of greater price volatility in a smaller market).

A higher strike price reflecting increased investor risk would, other things equal, result in higher costs for consumers, offsetting the extent of transfers from consumers under zonal pricing. This is likely to be important given the likely clustering of wind resources.

However, it is worth noting that these transfers may be limited if a move to zonal pricing is accompanied by CfD reform. For example, if future CfDs have a reference price based on the zonal price (rather than a system wide price) and if they are based on deemed output (rather than metered output),[32] then new investors will be partially protected from lower zonal market prices and (at least on their support payments) from the risk of loss of generation volumes. Adjustments to strike price bids would likely still take place due to changes in the value of the

30 We had previously highlighted the risk that leaving new zonal volume risk with AR7 investors could lead to higher CfD clearing prices and additional cost borne by consumers. See https://www.frontier-economics.com/uk/en/news-and-insights/news/news-article-i20983-assessing-the-implications-of-zonal-pricing-for-support-payments-in-the-gb-electricity-market/ This was risk was also highlighted by UKERC. See Zonal Pricing, Volume Risk and the 2030 Clean Power Target | UKERC | The UK Energy Research Centre

31 We have not considered potential options for how CfD support payments are distributed across GB consumers in a zonal market, but this would clearly also affect final outcomes for consumers.

32 DESNZ have indicated they are considering a moved to a deemed output model, though any reform would not take place until AR9 at the earliest.

'merchant tail'. But overall, such an approach to CfDs would also mitigate some of the key uncertainties for investors in a zonal market reducing the impact on the cost of investment from a zonal market.

3 Will a zonal market better support demand-side flexibility?

Even in a scenario of some winners and some losers, some proponents argue that a zonal market is necessary to drive an efficient demand response to support the management of congestion. This potential benefit is really just a part of the wider set of potential efficiency benefits that we discussed in Section 2.2 above.

In a zonal market, households and small businesses which have arrangements with their retailers which pass through actual wholesale prices on a relatively short term basis[33] can in theory respond to their local wholesale price by increasing demand (e.g. charging EVs) during periods of congestion and associated low zonal prices, and reduce their demand (e.g. vehicle to grid discharging) during uncongested periods with higher zonal prices. Such responsiveness could improve the efficiency of the system and could reduce the need for potentially more expensive back-up flexible generation to help manage congestion.

However, when considering any potential efficiency benefit related to the introduction of zonal pricing, it is critical to consider the appropriate counterfactual (specifically, what can reasonably be achieved in a reformed national market). This should then be compared to what we expect to happen in a zonal market. Discussion of this specific efficiency benefit is no different.

We draw a number of conclusions about the potential for a zonal market to develop more consumer flexibility over and above that which could be achieved in a national market:

- *Locational signals exist in both market designs,* although to the extent the impact of market power is a greater problem in a zonal market that needs to be addressed, there is a risk that *stronger (ex post or ex ante)* regulation distorts the signals for flexibility;
- *Consumers could engage as effectively with locational signals in a national market.* Large consumers have participated in demand response historically, including via direct participation in markets. For smaller consumers, engagement with short term price signals (including those relating to location) is most likely to be via a third party. The need to participate in the BM is unlikely to act as a barrier to third parties offering smaller consumers locationally-based value for their flexibility, and indeed such offers are beginning to appear in the market already today; and
- *There are reforms which could be made to the national market to make it even easier for third parties to secure value from consumer flexibility*. Against such a counterfactual, it is therefore not clear that a move to a zonal market is likely to result in increased exploitation of demand-side flexibility relative to a Reformed National Market.

33 In the limit, per settlement period

We discuss these points in turn in order to identify the extent to which the degree of flexibility available may differ between the zonal and national markets.

3.1 Locational operational signals would exist under a Reformed National Market

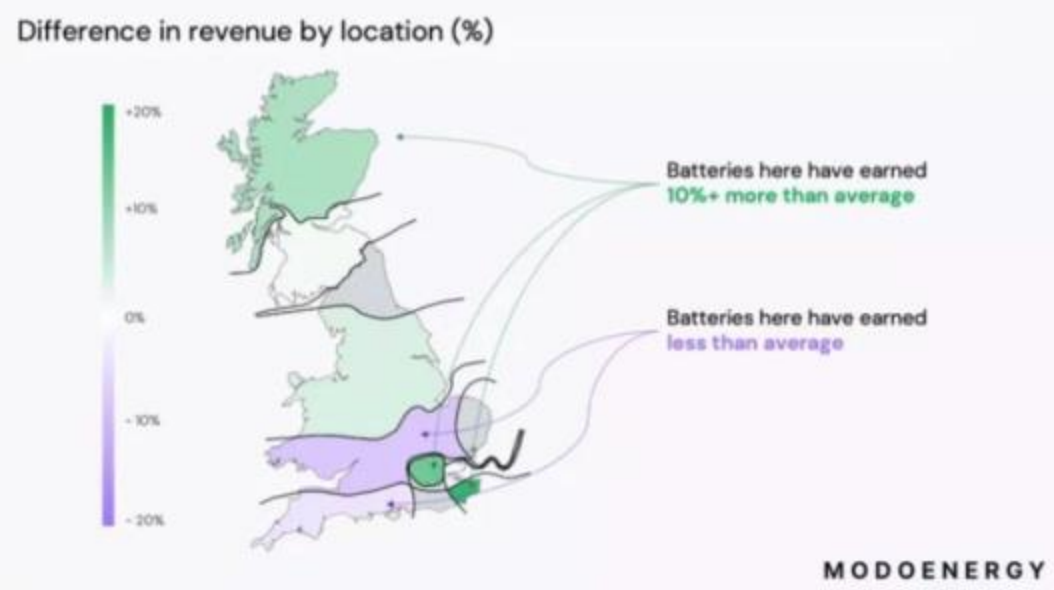
In a zonal market, the locational signal is embedded in the wholesale electricity price. Efficient responses to this signal should contribute towards the efficient resolution of congestion on the system. In a national market, the wholesale price does not include a locational signal. However, it is not correct to say there is no operational locational signal. Operational locational signals exist in the BM.[34] Participants in the BM are able to:

- *Submit a bid to increase their consumption in a zone experiencing excess supply* of generation e.g. due to excess wind generation. Consumers (or a third party acting on their behalf) must choose the price at which they would be willing to increase their consumption, but additional power should be purchased in the BM as long as the bids are better value to NESO than those from generators to reduce production; and
- *Submit an offer to reduce their consumption in a zone experiencing excess demand* e.g. due to constraints preventing the transfer of power from areas with greater wind infeed. Consumers could submit an offer to reduce consumption which should be accepted as long as it is better value than offers to turn up flexible generation or storage.

The existence of a locational signal in the BM is clear and can be seen in market outcomes. For example, data from Modo Energy show that NESO can and does redispatch batteries to manage congestion (as a result of differential balancing mechanism acceptances, a battery in Scotland will have different revenues to a battery in Cornwall).

34 Operational locational signals may also exist in other products, e.g. Local Constraints Market.

Figure 3 Locational value in the BM



Source: Modo Energy

Indeed, while potentially less transparent,[35] the BM locational operational signal is arguably more accurate than that from zonal wholesale prices alone. The geographic configuration of a zonal market is likely to be fixed over multiple years based on the forecasts of congestion. In contrast, BM bids and offers are accepted by NESO based on the specific locational constraints at any point in time. In reality, as noted in section 2.2.1 above, even in a zonal market there will also be a need for an intra-zonal BM to fully resolve all constraints.

It is also relevant to consider the potential impact of market power on locational signals. As we noted in section 2.1, a zonal market might increase the impact of market power on individual groups of producers or consumers, which may increase the degree of regulatory intervention needed.

Such regulation could be (as now) *ex post* monitoring,[36] or *ex ante* restrictions on the level of bids and offers in a zone. Any regulation of bids is challenging and likely to result in some degree of distortion, whether *ex post* or *ex ante.* However, it is particularly challenging when storage and demand-side flexibility are considered since these resources are likely to bid on the basis of opportunity costs, which are by their nature more difficult to estimate. For example:

- Storage plants are energy constrained and therefore the cost of generating relates to the lost opportunity to dispatch the stored energy in an alternative period. An efficient bid

35 In part due to the absence of defined zones and in part due to the BM's "pay-as-bid" nature (i.e. there are no published "zonal clearing prices").

36 The approach followed under REMIT and the Transmission Constraint Licence Condition

would therefore reflect the expected value of the stored energy that could be achieved in the expected next highest value period i.e. its opportunity cost.

- Demand-side response providers would price their bids based on the value of the lost opportunity to consume in that hour i.e. for a business, the opportunity cost of lost or delayed production.

Ex post regulation would likely become increasingly burdensome with the increase in the impact of market power in a zonal market and the increase in storage and demand-side flexibility. Ex ante regulation may reduce the need for excessive regulatory investigation. However, the risk with *ex ante* bid caps is that they are less able to reflect changing market conditions. If *ex ante* caps are set below opportunity cost, this is likely to distort the locational signal and prevent the efficient dispatch of consumer flexibility.

The purpose of this paper is not to debate which of these approaches to mitigating market power is most effective. We simply note that if the impact of market power is of greater concern in a zonal market, locational signals may be more distorted than in today's national regime.

In summary, locational signals exist under each market design, even if they differ in the way in which they are transmitted, their potential accuracy in each half-hour, and their transparency to the market. However, the presence of an accurate locational signal is not relevant unless consumers are willing and able to engage with it.

3.2 Consumers could engage as effectively with locational signals in a national market

Consumer engagement in demand-side response has historically been low, and has focused on large (e.g. industrial and commercial) consumers. However, with expected increased deployment of low carbon technologies for consumers of different scales, and greater digitalisation, it is reasonable to believe there may be greater involvement going forward from smaller commercial and even domestic consumers. This is because there will be more obvious means through which to adjust consumption (e.g. the storing and dispatching of onsite solar or wind, or the charging and discharging of EV batteries).

In practice, even if consumers are keen to engage, most consumers (particularly households and smaller businesses) will not track wholesale prices in real time in order to adjust their consumption behaviour given the likely complexity and transaction costs of doing so. They will make use of third parties (i.e. retailers or aggregators) to support and simplify their participation. There is no fundamental reason why this would be any different under a zonal or reformed national market. Therefore, the question becomes whether the market design affects the extent to which third parties offer to engage with the locational signal on behalf of consumers.

In this regard, there are some relevant differences. Under a national market, a third party must be able to access the BM and submit bids and offers in order to be able to use profitably a consumer's flexibility. In contrast, in a zonal market, a third party can do so via trading directly in the wholesale market.

In principle, participating in the BM may be more complicated. However, in practice it is not obvious this will constitute a material barrier. Indeed, we see already this sort of engagement today. For example:

- Octopus Energy has launched a "Power-Up" service, enabling consumers in certain locations to use additional power free of charge during periods of locational surplus.[37] Even if this tariff is not based on Octopus BM trades, there is no reason why it couldn't be;
- EV and V2G tariffs such as those trialled by OVO[38] and offered by Octopus Energy[39] also indicate the potential for retailers to provide consumers with access to time-of-use signals, which could also include locational operational signals from the BM; and
- Similarly, Pod Point offers a contract under which they pause charging of EV chargepoints during times of peak demand and shifting it to greener off-peak times.

The transition to market wide half-hourly settlement in 2026 is likely to further support the development of these innovative business models.

In summary, given a locational signal exists, and third parties can and do use it to exploit the value of consumer flexibility, it is not clear that a zonal market could materially increase this activity.

To the extent that there are barriers limiting this behaviour by third parties, there are also a number of potential reforms to the national market that could support further development, and may deliver efficiency benefits more quickly than zonal pricing (see Figure 4 below for an illustration):

- **Reduced "skip" rates**: owners of smaller assets (in particular batteries) in the BM have raised concerns that NESO "skips" over their assets when they could economically be used. NESO says this is because its IT and internal processes struggle to send instructions to large numbers of users on the short timescales required in the BM. This is also likely to be a problem for demand-side response from suppliers and aggregators. However, NESO has recognised these challenges and is currently working actively to bring down skip rates. In time, it is not obvious that NESO will not be able to achieve efficient BM dispatch.
- **Pay as clear market:** the current BM is based on a pay as bid market, where participants are paid the bid or offer submitted. This means that rather than bidding at their short-run

37 https://octopus.energy/power-ups-scotland/

38 https://www.ovoenergy.com/guides/electric-cars/vehicle-to-grid-technology

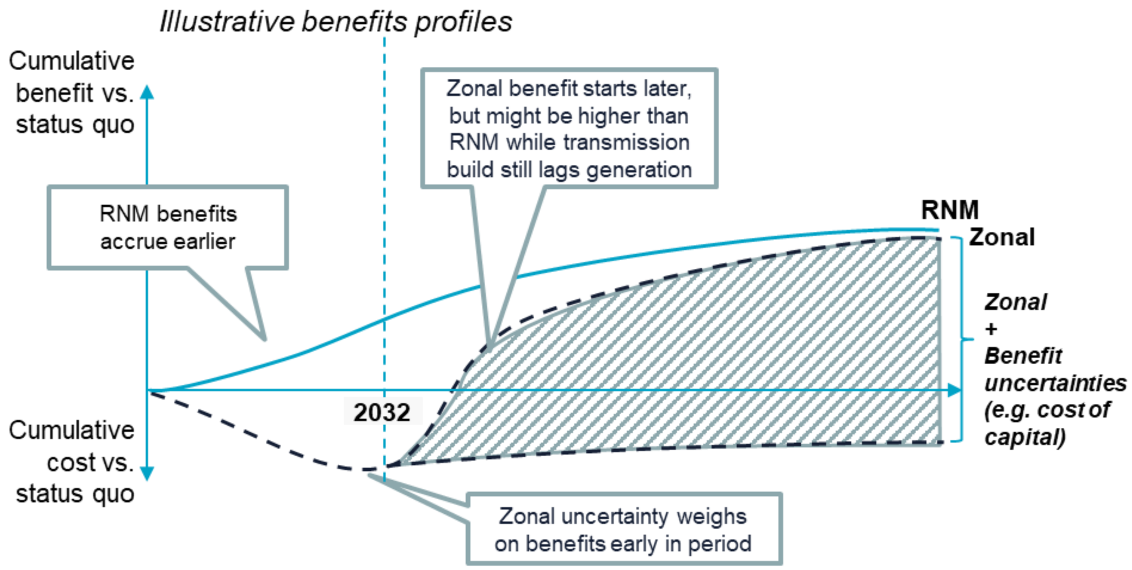
39 https://octopus.energy/power-pack/

marginal costs, they are incentivised to bid at (or just below) the expected marginal bid or offer that would be accepted, in order to capture infra-marginal rents. This creates the risk that a market participant, which otherwise would be in merit, makes an error forecasting the marginal bid, meaning they appear out of merit. This can lead to inefficiencies in NESO's dispatch. The additional complexity and risk on participants may also discourage some entry into the market to act as third parties for consumers. Moving to a (zonal) pay as clear BM could potentially remove some complexity as participants only have to bid their costs in order to receive the market clearing price.

- **Increased use of forward trades to manage constraints**: the majority of redispatch actions are undertaken post gate closure, although we know that some actions to resolve transmission constraints does already take place earlier in the day i.e. interconnectors are redispatched pre-gate closure by NESO and NESO has recently started a Local Constraints Market day-ahead and intraday to stimulate demand-side options for managing constraints. The status quo may not represent an optimal balance between pre and post gate closure actions. While it is true that post gate closure, NESO has more certainty with regard to the physical position of plants on the system, pre-gate closure the market has more time to offer potential services to NESO, enabling a broader base of participants to respond.

- **Earlier gate closure:** the BM currently operates after gate closure which is one hour ahead of "real time" i.e. the start of the 30-minute settlement period. This means participation requires submission and acceptances of bid and offers very close to real time. This may create barriers to participation for some parties, who might need more time to plan and facilitate their demand-side response or generation offer. Earlier gate closure, which is being considered by NESO, might enable a broader set of participants to respond, while maintaining NESO's certainty over the physical position of plants on the system.

Figure 4 Illustration: System benefits accrue earlier under reforms to a national market



Source: Frontier Economics

Note: Government has stated that zonal pricing implementation in 2032 is its realistic working assumption.