UK Energy Research Centre

Locational signals in a reformed national market

A review of options

EXECUTIVE SUMMARY

UKERC Working Paper

Simon Gill

Callum MacIver

Rob Gross

Keith Bell

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Simon Gill runs the independent consultancy The Energy Landscape and is an associate of Regen.

Callum MacIver is a Research Fellow in the Department of Electronic and Electrical Engineering at the University of Strathclyde.

Keith Bell holds the ScottishPower Chair in Future Power Systems in the Department of Electronic and Electrical Engineering at the University of Strathclyde.

Rob Gross is Professor of Energy Policy and Technology, director of UKERC and is a member of the UK Government's Clean Power 2030 Advisory Commission.

Introduction to UKERC

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It is a focal point of UK energy research and a gateway between the UK and the international energy research communities.

Our whole systems research informs UK policy development and research strategy.

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Executive Summary[1]

In December 2024 the UK Government published its *Clean Power 2030 Action Plan*. This ambitious document sets out the actions needed to ensure 95% of Great Britain's electricity comes from clean energy in only six years. Alongside the Action Plan the Government published an 'Autumn Update' to the Review of Energy Market Arrangements (REMA), ongoing since 2022. The Autumn Update provides important new information across multiple aspects of the REMA decision-making process. It emphasises that "no decision has yet been taken between zonal pricing or reformed national pricing" – which has become the most hotly contested aspect of the REMA programme. This report explores a wide set of options that could enhance locational signals to market participants in a reformed GB-wide wholesale energy market.

Our report aims to inform the UK Government's upcoming decisions, but not to determine whether a reformed national market or a move to zonal pricing are most appropriate in the long term. Instead, it starts with two observations. The first is that a good decision requires a well-articulated vision of what each option would look like in practice. This needs to factor in both price *and volume* risks, viewed from the perspective of market participants. The second is that zonal pricing will take several years to introduce, so there is value in introducing incremental reforms to current market arrangements that can improve locational signals for investment and operation in the meantime. This second point is important: improving signals within a national market is the only option to better manage system limits through to the early 2030s.

REMA considers a range of options beyond the wholesale electricity market, most notably changes to the design of the capacity market, contract for differences (CfDs) for renewable generation, and the way the costs of the transmission network are recovered. However, in considering the options for a reformed national market, the latest iteration of REMA focuses only on transmission network charges and balancing arrangements. It pays little attention to the potential for the wider set of regulatory arrangements, secondary or ancillary markets, or other factors that may deliver locational signals relevant to market participants.

To reach a good decision on how to reform locational signals in the electricity system, it is important not to neglect important interactions between different aspects of the commercial and regulatory landscape and to take a sufficiently broad and comprehensive approach. Many of the options discussed in this report lie outside the wholesale energy market *per se.* However, market participants respond to regulatory rules, markets, policy incentives, and wider project considerations *in the round.* Taken together, these determine the value stack that different market participants can access, and what risks they face in doing so. This report therefore considers all the prospective changes that could be made to the regulatory, market and incentive

[1] This report was completed ahead of the publication of UK Government's REMA Autumn update, published in December 2024. It does not include that update in its review of the national debate on REMA and it does not respond to or reflect in detail the minded to decision in that document.

structures that bear upon market participants' decisions about where to locate, and how to operate. Whilst there is a large literature on each of the various regulations, interventions and incentives we discuss below, there has been very little attention to how they individually and collectively affect locational investment and operational decisions. This report therefore seeks to fill a gap, by discussing a wide array of rules, incentives and procedures with a locational lens.

How to think about locational signals

Locational signals are diverse, both in terms of where they come from and in the form they take. They include both: incentives on market participants to align their dispatch with system limits; and rules that limit or require operation based on location. Changes to incentives, rules, markets and mechanisms need to take account of different sources of risk – volume as well as price risks – and to consider both initial market dispatch and the actions taken by the system operator to redispatch the system.

The following overarching points emerge from our analysis of the factors affecting locational decisions reviewed in this report:

Locational signals cannot be neatly divided into those that affect only operation and those that affect only investment. Rather each timescale affects the other. For example, operational-timescale signals can only help dispatch assets that already exist, therefore the fleet of assets capable of responding to operational signals is defined by investment timescale signals. Conversely, some assets, particularly those like batteries that don't rely on explicit investment support mechanisms, will build an investment case largely from the aggregate revenues, and risks thereof, from operational timescale signals across the asset's life.

Improved locational rules and mechanisms can give the National Energy System Operator (NESO) improved ability to support effective dispatch and redispatch. This includes making improvements to the balancing mechanism, moving gate closure to allow greater time for NESO to use the balancing mechanism effectively, and the introduction of pre-gate closure constraint management markets. It could also include giving NESO a formal role in dispatching the market, for example through a move to a more centralised dispatch.[2]

Locational incentives on market participants to align their dispatch with system limits are possible but can introduce significant risk and uncertainty, which can affect the investment case. Whilst incentives may be cost reflective in theory, to be so in practice, market participants need to forecast those signals sufficiently in advance and be capable of responding to them. In many cases, on operational timescales, this is not practically possible.

There are significant locational signals beyond the electricity system's commercial and regulatory framework. These are out of scope for REMA. But

[2] The REMA Autumn Update, published in December 2024, indicated that DESNZ are note minded to use centrale dispatch due to concerns over deliverability, investor confidence and value for money.

they mustn't be ignored. These include the strength of renewable resources, geographical considerations such as seabed depth for offshore wind farms, and planning and consenting rules different aspects of which are under the control of national, devolved or local government.

Strategic spatial planning has a profound impact on location decisions, and it is essential to consider how other locational signals will work with the plan. The Strategic Spatial Energy Plan will have a profound impact on the geographical distribution of the electricity system. If the plan is to be delivered, it is important that the overall set of commercial and regulatory arrangements fits together to ensure that the assets identified as being needed in different locations are delivered in the timescales, volumes and places required by the plan. For example, if TNUoS charges for generators are higher in locations favoured by the plan for generation capacity, then consideration will have to be given to how incentives for those generators are provided, so they are not deterred from operating in those locations.

It is important to distinguish between cost reductions through more efficient system operation and a transfer of costs to other cashflows where they are less transparent and could even increase overall costs. For example, removing constraint payments could result in higher CfD strike prices, with increases reflecting both the *expected* reduction in revenue and an additional *risk premium* associated with the difficulty in forecasting future constraints.

Revisit the merits of locationally differentiated CfD and capacity mechanism auctions, and introduce locational dimensions to ancillary/system service contracts. The second REMA consultation partly ruled out some options, such as locational elements in future CfD auctions and capacity market contracts, but this report suggests that these options offer considerable scope to improve locational signals for both renewable generators and providers of flexibility.

Interconnectors are a special case and aligning their operation with system needs could reduce costs. It is possible to develop improved arrangements for redispatching interconnectors, but this needs NESO to work proactively with connected system operators. For example, Danish and German Transmission System Operators collaborate on an intraday cross-border redispatch mechanism which manages significant volumes. GB interconnectors are unusual in that they are treated as GB market participants, whereas cross-border capacity between most EU countries are treated as regulated network assets. There may be value in reviewing the status of interconnectors and how they receive revenue in our market.

Reform options

The report reviews a wide range of reform options that could be implemented alongside a nationally priced market. The options include signals that would provide incentives for market participants to invest in particular places or operate in location-specific ways. They also include rules and mechanisms which allow NESO to take

more control of either the initial market dispatch, or the redispatch processes required to align operation with system limits.

Reflecting the need for reform to look right across the electricity system's commercial and regulatory framework, the reforms include consideration of regulated charges such as transmission network use of system charges (TNUoS), and adaptation of system services such as response and reserve, technical ancillary services, the capacity market and policy support schemes.

Figure ES1 groups the different options that we have considered and Tables ES1 to ES5 summarises our conclusions. The report does not attempt to rule specific options in or out; rather, it provides a considered view on the value of exploring each further. Some, such as improvements to NESO's IT and control room processes are extremely likely to be valuable and are, at least to some extent, already in train. Others, such as dynamic locational Balancing System Use of System Services (BSUoS), are, whilst useful in theory, unlikely to be practically viable.

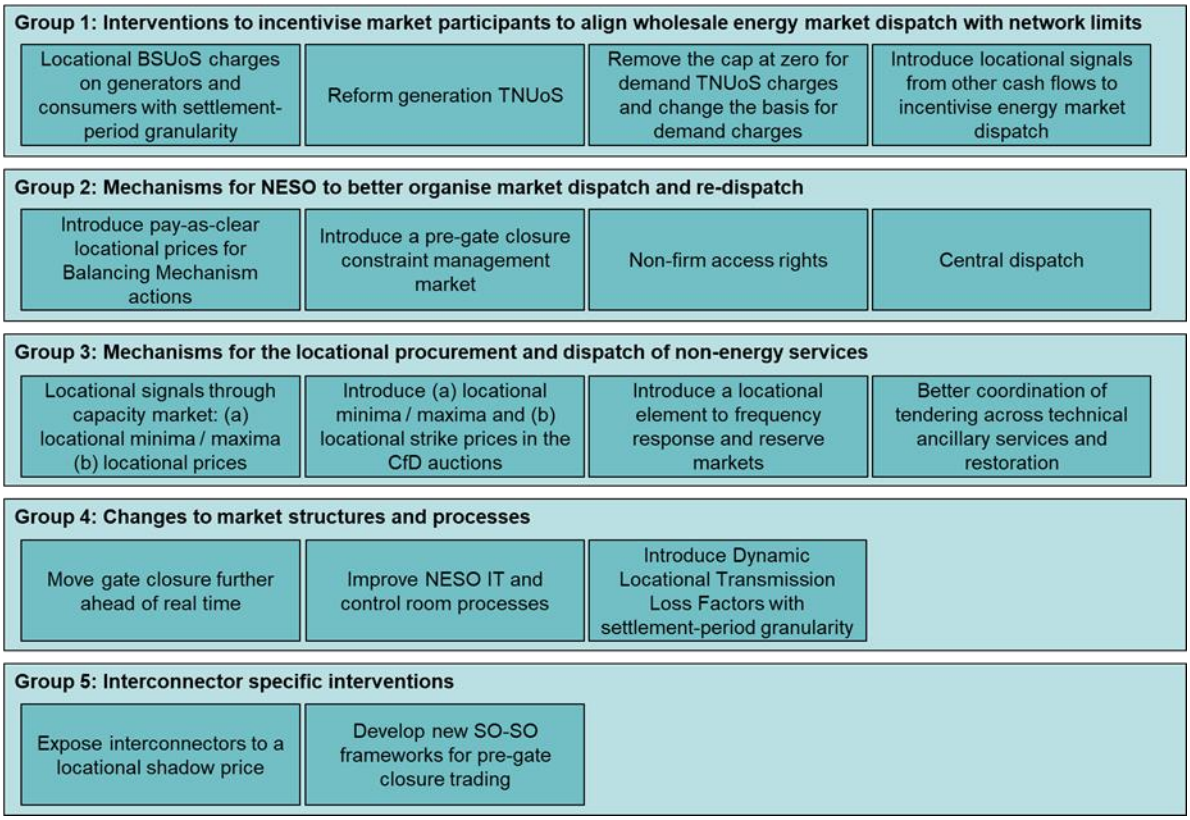

Figure ES1: Summary of options considered in the report

Table ES1: Summary of conclusions from the review of interventions based on incentivising market participants to align wholesale energy market dispatch with network limits (Group 1)

Intervention	Conclusion
Locational BSUoS charges on generators and consumers with settlement-period granularity	For the reasons identified by the two recent BSUoS taskforces (primarily: major practical challenges to cost-reflective BSUoS delivering a useful signal) there does not appear to be value in taking this forward.
Reform generation TNUoS	Generation TNUoS is primarily an investment-timescale locational signal and is likely to stay that way. As noted in Ofgem's recent open letter on strategic transmission charging, it currently has high levels of locational differential and uncertainty in future charges. Ofgem has recently argued that these work against delivery of net zero and has suggested a temporary cap and floor to deal with them in the short term in their current form. There is a risk that future TNUoS based on the current methodology (based on the long run marginal cost of investment in the transmission network) will be mis-aligned with a strategic plan for some technologies, particularly renewables and storage, where it creates high charges in areas where a Strategic Spatial Energy Plan (SSEP) requires investment. A full review of the principles on which TNUoS is based should be conducted alongside proposals for how an SSEP would be implemented (e.g. cost reflective vs cost recovery; reflective of the cost of what?)
Remove the cap at zero for demand TNUoS charges and change the basis for demand charges	There could be significant value in removing the floor at zero for demand TNUoS and realigning the basis on which demand is charged locational TNUoS. This would better reflect the impact that demand has on transmission investment in areas which are generation dominated. Although Ofgem has expressed a view that neither generator nor demand TNUoS should be used for operational signals, this report suggested there may be value in exploring the possibility of delivering improved locational operational signals through demand-side flexibility.

Intervention	Conclusion
Introduce locational signals from other cash flows to incentivise energy market dispatch (e.g. capacity market, CfDs, Transmission Loss factors)	This is unlikely to deliver suitable operational signals: most cash flows are primarily investment- rather than operational-timescale, and except for BSUoS and TNUoS (discussed separately), don't directly reflect market participants' contribution to locational issues such as transmission constraints. Therefore, any alignment is coincidental rather than cost-reflective and could change as the cost drivers and cash flows are inherently uncoordinated. The most promising approach would be to adapt dynamic, locational transmission loss factors which are currently likely to show correlation with transmission constraints. However, they would be difficult for market participants to forecast and are likely to suffer many of the same difficulties as BSUoS reform.

Table ES2: Summary of conclusions from the review of interventions based on providing better tools for NESO to organise market dispatch and redispatch (Group 2)

Intervention	Conclusion
Introduce pay-as-clear locational prices for balancing mechanism actions	There is value in investigating this as a way to deliver stronger locational signals to market participants in redispatch, allowing easier forecasting and assessment of likely balancing mechanism revenue streams and allowing assets to build business cases to locate in places favourable to the system and actions taken at or after gate closure to balance it.
Introduce a pre-gate closure constraint management market	Has the potential to provide an important new tool for NESO capable of supporting better outcomes for the technical and financial aspects of redispatch. If market participants can forecast future NESO actions through constraint management markets, or the extent to which the market might offer long-term contracts, the reform also has the potential to inform locational investment in flexible assets located in places favourable to the system.
Non-firm access rights	Reductions in the cost of operating the system might be expected through removal of the entitlement to compensation for denial of access which is associated with firm access rights. However, such changes would also change network users' expected revenues and introduce uncertainty, with a potential impact on those users' other costs. Those costs would need to be recovered and risks hedged via some other means if they are to continue to use the network. There is most likely to be value in exploring non-firm

Intervention	Conclusion
	access rights for two-way energy storage assets as an approach to maximise the connection of flexibility without unduly limiting network access for other assets.
Central dispatch	Has the potential to deliver a system dispatch which better aligns both with system and network limits from the day-ahead stage onwards, helping to reduce the volume of redispatch significantly and utilise the fleet of assets more optimally. The utilisation of individual assets may differ from the way existing owners optimise their positions under current decentralised arrangements as the central dispatch aims to optimise against system-wide objectives rather than optimising each asset individually. However, there is some risk that the central dispatch algorithm isn't fully capable of optimising the operation of individual assets and the wider system; the impact on network users' revenues will depend primarily on access rights.

Table ES3: Summary of conclusions from the review of interventions based on providing mechanisms for the locational procurement and dispatch of non-energy services (Group 3)

Intervention	Conclusion
Locational signals through capacity market: (a) locational minima / maxima (b) locational prices	Despite the second REMA consultation's position not to introduce locational capacity market signals "as a standalone option", we think there is value in exploring them further, considering the locational need for assets capable of delivering on future definitions of 'stress events' (including multiple types of event over longer and shorter timescales). The capacity market at present procures simply capacity. An ability to deal with stress events in a system with a significant capacity of variable renewables should also entail procurement of sufficient energy. However, an ability to access the energy depends on there being sufficient network capacity. A reformed, locationally aware capacity market could ensure energy resources are placed where there already is, or is expected to be, enough network capacity or it can be aligned with further network expansion and wider strategic infrastructure planning through the SSEP.
Introduce (a) locational minima /	Despite the second REMA consultation's position not to take forward the introduction of locational CfD auction signals as a "primary option", this report concludes that there is value in

Intervention	Conclusion
maxima and (b) locational strike prices in the CfD auctions	exploring further, either to support delivery of a locational SSEP or to reflect the value of a geographically diverse fleet. As in the case of capacity market reforms, locationally aware CfD auctions could be aligned with the needs of an SSEP, ensuring new capacity is built where network capacity is, or is expected to be, available or it can be aligned with future network expansion. This would need to be delivered through coordination with future plans for seabed leasing.
Introduce a locational element to frequency response and reserve markets	There appears to be significant potential for some response and reserve capacity to be procured in areas where it cannot deliver the system-services required, e.g. where response 'headroom' is 'sterilised' behind a transmission constraint. Therefore, there would appear to be value in considering how to introduce locational considerations into the procurement and scheduling arrangements for response and reserve provision in the future.
Better coordination of tendering across technical ancillary services and restoration	Individual system services tend to have strong locational signals through zonal tendering rounds. However, improving the coordination and visibility of tenders over the coming years would allow assets to more easily combine contracts to build a business case where there is locational correlation between service needs.

Table ES4: Summary of conclusions from the review of interventions based on changing market structures and processes (Group 4)

Intervention	Conclusion
Move gate closure further ahead of real time	Providing more time to NESO for balancing mechanism-based redispatch following gate closure will relieve the technical challenge and may allow a lower-cost lower-carbon redispatch to be organised. The argument against this – that removing time for the intraday market to optimise the initial market dispatch would increase costs – appears unproven.
Improve NESO IT and control room processes	Improvements have been made, particularly regarding improved non-locational energy balance, through the introduction of the Open Balancing Platform. NESO should prioritise improvements to locational balancing, e.g. Bids and Offers to solve network constraints.

Introduce Dynamic Locational Transmission Loss Factors with settlement-period granularity	There are significant implementation challenges for dynamic TLFs and it is uncertain how effective the intervention would be. This would depend on the ease with which market participants would be able to forecast TLFs. The approach is likely to suffer similar challenges to those identified for dynamic, locational BSUoS.

Table ES5: Summary of conclusions from the review of interventions based on providing interconnector-specific interventions (Group 5)

Intervention	Conclusion
Expose interconnectors to a locational shadow price	Theoretically, this intervention can deliver a locational price signal to interconnectors whilst leaving other assets facing the national wholesale price. However, it is likely to face significant practical challenges, create significant barriers to market-participants trading across interconnectors, including regulatory risk arising from uncertainty over how such a system might be 'tweaked' in the future. It is likely to struggle to align with the Trade and Cooperation Agreement and European Internal Energy Market rules, as such, there may be limited value in developing the idea further.
Develop new SO-SO frameworks for pre-gate closure trading	There appears to be significant potential for the NESO to work proactively and cooperatively with connected System Operators to deliver a more transparent and predictable trading framework utilising (NE)SO to SO pathways (rather than the current NESO to market-participant pathway). There is an apparently successful example operating within European Internal Energy Market (IEM) rules between Germany and Denmark.

Conclusion

In summary, we believe that there is a strong case to consider the full range of factors that might provide opportunities to enhance locational signals. The regulatory, market and policy context as a whole is what affects market participants' risks and revenues, and hence investment and operational decisions. The feasibility and materiality of many options requires additional investigation, but the analysis presented in this report demonstrates that there is a strong case for undertaking this additional work. We are concerned that REMA has taken too narrow a view on what could be implemented as part of a reformed national market, and as the review moves through the next phase of assessment, the UK Government needs to

broaden that perspective to ensure that the best possible reformed national market model is considered.