

First Scottish forum on future electricity markets - Report

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1 Key points

1. The forum brought together experts from academia, policymakers and a range of stakeholders to discuss the design of the electricity market and its role in enabling a least cost and equitable transition to a net zero power sector in Scotland.
2. Participants discussed locational pricing in wholesale electricity markets. A proposal to split the integrated GB market into separate pricing zones has been put forward by the UK Government in its recent Review of Electricity Market Arrangements (REMA).
3. The measure is designed to improve the operational efficiency of the electricity system and to reduce the costs to consumers of curtailing renewables.
4. A fundamental change to the current market design and the introduction of locational pricing would likely have large impact on Scottish consumers and investors.
5. The forum discussed key opportunities and challenges of electricity market reform for Scotland, drawing on the best available evidence and international expertise.
6. There were over 40 participants from across a range of stakeholder groups, including consumer bodies, the energy industry, the Scottish and UK Governments, the National Energy System Operator (NESO) and representatives from Highlands and Islands communities.

2 Executive summary

The main topic addressed at the 'Scottish forum on future electricity markets' in December 2024 was locational pricing in wholesale electricity markets. This is a particularly complex and contentious area that forms a key part of the UK Government's ongoing Review of Electricity Market Arrangements (REMA) programme.

Locational pricing would involve separation of the GB power market into multiple pricing zones, which are defined around the most significant constraints on the transmission grid. This would contrast with the current national pricing model where the revenues electricity generators earn from selling into the wholesale power market do not reflect their impact on the transmission system.

The argument for locational pricing is that it would reduce constraints on the network and therefore also reduce payments to generators to adjust their output due to network congestion, thus benefiting consumers. Incorporating scarce transmission network capacity into the wholesale electricity price would also improve overall system efficiency as market participants would be incentivised to locate assets and operate them more in line with the physical realities of the power system.

A fundamental change to the current market design and the introduction of locational pricing would likely have a significant impact on Scottish consumers and investors. The high level of renewables located in Scotland relative to its electricity demand means that locational pricing could see Scottish consumers benefit from significantly lower bills. This could help accelerate the electrification of heating and transport. Meanwhile, the availability of cheap, reliable and clean power could attract substantial inward investment by energy intensive industries and data centre operators.

However, fundamental market reform brings risks. If these cannot be managed by investors, the cost of financing large scale wind projects will increase, putting in jeopardy a key pillar of Scotland's energy and economic strategy. On this basis, some argue instead for a 'reformed national market', which would involve NESO – the National Energy System Operator – making substantial improvements to its current approach to balancing and redispatch.

Scottish and UK Government representatives opened the forum by setting out policy priorities and the latest developments in the REMA programme. Participants then heard from Scottish and invited international experts who outlined the operation of locational pricing in European and US markets. The forum discussed what lessons have been learned, what relevance these market designs may have for the specific Scotland/GB context and the challenges faced in meeting net zero.

In the final part of the day participants were divided into thematic discussion groups, which addressed different questions and challenges relating to the implementation of electricity market reforms from a Scottish perspective. During the discussions, participants identified several key questions and issues pertaining to the Scottish Government's net zero, just transition and economic strategy, which need to be addressed:

- **Aligning market reform and the clean power mission:** Stakeholders expressed concern that the multiple and highly complex reform processes ongoing at the UK level may not be complementary and could conflict with one another, thus exacerbating investment risk and putting Scotland's net zero target in jeopardy.
- **Impacts on the cost of capital:** The modelled socio-economic benefits of locational pricing are highly sensitive to changes in the cost of capital. The evidence base on the extent to which locational pricing could increase the cost of financing large renewables projects in Scotland and for how long this premium may endure is not sufficient.
- **The relationship between locational pricing and industrial policy:** There are conflicting claims in the debate about the extent to which lower wholesale electricity prices influence investment decisions in electricity intensive industry. For some, this could be a key advantage of locational pricing, whereas others argue that power prices are only one, relatively minor, factor in industrial siting decisions. The economic impacts of different

electricity pricing scenarios should be analysed and modelled to inform the Scottish Government's industrial and foreign direct investment policy.

- **Delivering large transmission projects:** The benefits of locational pricing diminish as more capacity is added to the transmission system, in a way which alleviates constraints. More work could be done examining recent experiences of delivering large transmission projects on time and budget, exploring key challenges such as supply chain coordination, public acceptability and optimism bias.
- **Updating the counterfactual:** The next phase of REMA and the decision about a zonal or reformed national market will require an updated counterfactual to locational pricing. There is a need to investigate how a package of reforms to the current market, including transmission network charging reforms and better management of interconnector flows, can be delivered and implemented.
- **Understanding zonal markets:** Zonal markets have been in operation across the EU/EEA, in the US and Australia for more than three decades. More and better evidence could be gathered on these international experiences, particularly recent cases of creating zonal markets and the legacy/transitional arrangements introduced.
- **Open access and transparent modelling:** Much of the electricity market modelling expertise is within economic consultancies, only accessible by governments and large energy companies. The need for open access and more transparent modelling tools was cited in the discussions, along with the need to build electricity market modelling capabilities within Scotland.
- **Socio-economic welfare impacts:** Socio-economic welfare impacts of different market design options need to be studied from a Scottish perspective, requiring a detailed analysis of impacts on consumer groups and regions.
- **Ongoing dialogue:** Finally, REMA should not be seen as a one-off reform. Regardless of the preferred option – zonal pricing or a reformed national market – there will need to be an ongoing dialogue between the Scottish Government, the UK Government and the wider stakeholder community regarding implementation and future reforms as the electricity system evolves over the coming decades.

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3 Abbreviations

BETTA	British Electricity Trading and Transmission Arrangements
CfD	Contracts for Difference
DESNZ	Department for Energy Security and Net Zero
EEA	European Economic Area
EV	Electric Vehicle
FERC	Federal Energy Regulatory Commission
GB	Great Britain
NESO	National Energy System Operator
PJM	Pennsylvania-New Jersey-Maryland Interconnection
REMA	Review of Electricity Market Arrangements
SG	Scottish Government
TCA	Trade and Cooperation Agreement
TNUoS	Transmission Network Use of System
TSO	Transmission System Operator

4 Background

This report was written by University of Edinburgh academics and is based on discussions at the forum along with their own background research. The forum was held under the Chatham House Rule.

4.1 Scotland and the British electricity market

Although electricity markets policy is a reserved policy area, under direct control of the UK Government, Scotland is at the heart of the clean power transition as it has an abundant wind resource and a significant energy industrial base.

Since 2005 Scotland has been part of an integrated power market known as the British Electricity Trading and Transmission Arrangements (BETTA). BETTA, in essence, is a set of technical rules and codes governing the relationship between the physical transmission grid and commercial transactions in the wholesale power market. Its function is to ensure that the operation of the market through which power is transacted respects the physical limitations of the grid and that the electricity system remains in continual balance.

Participation in BETTA has largely been beneficial for Scottish electricity generators and consumers. It has created an effective route to market for the growing renewables industry in Scotland, while the diversity provided by a wider market has improved competition and trading liquidity, thus providing a benefit for Scottish consumers. It's a generally accepted principle that larger and more diversified markets improve the efficiency of electricity systems and help deliver security of supply.

BETTA is a decentralised market, meaning that buyers and sellers of power are free to enter commercial transactions, as would be the case in any commodity market. Across timeframes, from years ahead to just before physical delivery, market participants can adjust their positions as more information about supply and demand is revealed. Trading can take place via bilateral contracts, brokerages and auctions organised by power

exchanges. Across these markets, contract durations can range from short increments of 30 minutes to an entire year.

A decentralised power market based on ‘self-dispatch’ is not unique to Britain and is the standard model across the EU. The philosophy underpinning these markets is that to as great an extent as possible, risks are managed through the operation of the free market and the role of central coordination is minimised.

Even in such a model however there is still a requirement for a central system operator who takes actions to ensure that generation output and demand across the integrated market stays in balance. In Britain, the National Energy System Operator (NESO), a public body, has recently taken over this role from the National Grid Group. NESO’s primary means of ensuring an alignment of market trading and the physical constraints of the system is the balancing mechanism. This is a centrally coordinated real-time market operating close to delivery for each half hourly trading period through which bids and offers to adjust generation and demand are accepted.

Market participants wishing to participate in the balancing mechanism – the Balancing Market Units – are required to notify NESO of their contractual positions in advance and any deviations between their physical and contractual positions are subsequently charged at energy imbalance prices. These prices relate to the costs incurred by NESO in adjusting generation and demand in the balancing mechanism and, depending on the tightness of the market, they can provide strong incentives on market participants to operate in line with the needs of the system.

However, while imbalance pricing provides an incentive on generators to operate in line with system needs, it is not a cost recovery mechanism. Under the current ‘connect and manage’ transmission regime, generators on the system receive financially firm access rights, and thus need to be compensated for any lost revenue resulting from NESO’s balancing actions. As a result, the costs of NESO’s redispatch through its balancing actions need to be recovered through network tariffs; they are effectively socialised across all electricity consumers.

The costs of the balancing market have increased substantially in recent years, as has the volume of traded energy in the balancing mechanism. NESO estimates that redispatch costs could be c.£3bn annually by the end of this decade and stress that operating the system under the current market arrangements is proving increasingly difficult.

4.2 The case for change

In recent years, several factors have coalesced to create momentum behind reforming Britain’s electricity market. The Scottish and the UK Government have committed to reach net zero by mid-century, requiring significant new investments in low carbon generation, networks and storage capacity. Meanwhile, the 2021-2023 energy crisis exposed an over-reliance on volatile gas markets which have a direct impact on electricity prices. The current electricity market design was introduced in the early 2000s when these challenges were not as acute and there is now a consensus that fundamental reform is required. A key case for changing the current market arrangement is that the role of the balancing mechanism has had to expand greatly in recent years.

When the balancing mechanism was first introduced in the early 2000s, it was intended to play relatively a minor residual balancing role, focusing on the general supply-demand balance across the GB market. However, the technological composition of the electricity system has changed, with a rapid increase in renewables and interconnector capacity. This requires the system operator to address locational constraints (locational balancing) in instances when power flows exceed the physical capacity of parts of the transmission network.

Given the rapid penetration of wind power in Scotland, much of the congestion problem has been concentrated at the Scottish-English border.¹ The geographic concentration of renewables, combined with the historic underdevelopment of the transmission network, often results in wind plants in Scotland being paid to turn down at times when there are constraints on the system.² At the same time, generators south of the border are paid to increase their output to compensate for the lost wind power. This has obvious negative cost impacts on consumers, but also damaging environmental impacts as generation capacity in the south is more carbon intensive due to the concentration of gas-fired generation in England. Previous work (Barnes & Brauer F, 2024) showed that the high level of renewables located in Scotland relative to its electricity demand means that locational pricing could see Scottish consumers benefit from significantly lower bills.

Central to this debate is whether NESO continues to take responsibility for managing congestion through the balancing mechanism and passes the costs of this redispatch onto consumers. If locational pricing is introduced, these system costs would be incorporated into the wholesale electricity price and market players would be incentivised to operate their assets in line with the physical realities of the system.³

Within these two broad options there is much to discuss and evidence before a final decision can be made. The key question rests on whether the benefits of lower redispatch costs and increased transparency about network congestion delivered through locational pricing outweighs the potential costs of fundamental market reform. A transition to locational pricing would introduce new risks and potentially lead to an increase in the cost of financing the net zero transition.

4.3 REMA – The next phase

The UK Government published a first consultation on the Review of Electricity Market Arrangements in October 2022. This set out a wide range of options, including a switch to a

¹ The B6 boundary separates Scotland and England. In summer 2024, B5 – further north – was the most problematic because of outages due to maintenance.

² Although generators lose their support payments when they are curtailed (either their ROC or CfD top up payment) this is generally outweighed by the need to compensate them (based on their bid prices and volumes) in the balancing mechanism along with the payments required to compensate generators south of the border for increasing their output (based on their offer prices and volumes in the balancing mechanism).

³ It should be noted that even fully nodal pricing does not completely remove the need for balancing actions, but it reduces them to the extent that the revenues involved are not significant.

qualitatively different market model based on centralised dispatch and nodal pricing. A second consultation in March 2024 narrowed down the options to two – zonal pricing and reformed national pricing:

- **Zonal pricing:** This would involve the separation of the GB power market into multiple pricing areas which are defined around the most significant transmission constraints. Zonal pricing would contrast with the current national market model where generator revenues from the wholesale market do not reflect their impact on the transmission system. On average, the north of England and Scotland would see lower wholesale prices relative to other regions.
- **Reformed National Market:** This option would involve NESO making substantial improvements to its current approach to balancing and redispatch. Key elements of a reformed national market would include managing interconnector flows more efficiently and transparently, improving dispatch software and processes such that battery storage participates more effectively in balancing, and taking actions outside the balancing mechanism to manage constraints.

The Labour Government has committed to achieving ‘clean power’ by 2030, requiring an accelerated delivery of low carbon investments, most significantly in wind, solar and large transmission projects. While electricity market reform is a longer-term programme, and fundamental changes to the market would not be implemented until the end of the decade at the earliest, the interactions between these two policy processes – REMA and Clean Power 2030 – will be an important factor in the UK Government’s final decision which is due in mid-2025. Key considerations will be the impacts of different reform options on investor confidence and how the economic benefits of lower electricity prices arising from less gas-fired generation can be exploited.

5 Discussion 1: Zonal or national pricing?

The forum involved an in-depth discussion of the two main options for electricity market reform – zonal and reformed national pricing. In evaluating these options, the importance of understanding trade-offs between investor and consumer interests was stressed by many of the participants. Also, there was a widely held view that decisions around wholesale power market design – whether zonal or national – cannot be considered in isolation. Interactions between the wholesale market, existing and future contracts for difference and transmission charging, along with a range of other market design parameters, need to be considered as part of an overall reform package.

Zonal market design options discussed at the forum included the degree to which different consumer groups would be shielded from locational prices variations, the methodology for setting and revising zonal boundaries, and the design of trading and dispatch arrangements. Although a reformed national market may be less disruptive, it was stressed that there would still be substantial changes required to NESO’s processes and software systems to improve its approach to redispatch and operation of the balancing mechanism, along with the potential expansion of constraint management measures and improved management of interconnector flows. Across both options there will need to be further consideration of transmission access and pricing rules, particularly transmission network (TNUoS) charging.

5.1 Unpacking zonal pricing

Participants heard from international experts on the design of locational markets in Norway, Germany and the US. Professor Mette Bjørndal of the Norwegian School of Economics outlined the operation of the Nord Pool zonal power market which has been in place since the mid-1990s. It was outlined that zonal pricing has a long history. However, it's a complex market arrangement, requiring continual monitoring and updating. For example, the procedure through which cross-zonal capacity is allocated by transmission system operators has recently been updated with the introduction of a 'flow-based' methodology. While this improves the overall efficiency of the system as the use network capacity is optimised, its introduction has been difficult and characterised coordination challenges between the participating TSOs and market operators.

A particular issue in the Nordic context is the definition and revision of zonal boundaries. There is a trade-off between liquidity and efficiency in this respect. Dividing the market into many small zones may be efficient from a technical point of view as the resulting zonal prices are more reflective of transmission constraints, thus reducing the need for redispatch. However, this fragmentation can negatively impact market liquidity, resulting in a lack of opportunities for generators and suppliers to hedge against volatile spot prices.

Another issue recently experienced in the Nordic region was the impact of price shocks and the exposure of retail consumers to increasingly volatile prices, particularly during the 2021-2023 energy crisis. A feature of the Norwegian electricity market is the high proportion of domestic consumers on spot market-linked retail contracts. While this has encouraged flexibility and played a role in Norway's successful roll out of EVs, it does expose consumers to price shocks. During the energy crisis, politicians in Norway came under strong pressure to reduce electricity exports and to halt the development of new interconnectors. Politicisation of the market was exacerbated by increasing divergence in prices across the various zones, with those in the southern regions more exposed to gas price volatility. This cross-zonal divergence then put Nord Pool's risk management systems under stress. There is an ongoing discussion in the Nordic context about the need to improve risk management and hedging opportunities such that consumers can be offered long-term contracts which can – at least partially – insulate them from extreme price volatility.

The forum also heard from Professor Karsten Neuhoff, head of the Climate Policy Department at the German Institute for Economic Research. Professor Neuhoff outlined the German picture with respect to locational pricing. Within Germany there has been a similar debate about how to address congestion arising from power flows between northern Germany, where the wind resource is abundant, and demand centres in the south. Germany, like Britain, has become over-reliant on expensive redispatch measures. Professor Neuhoff was sceptical about the extent to which proposed zonal configurations, for example dividing Germany into two or three bidding zones, would fundamentally address the problem. He argued instead for a local pricing approach, more akin to the US model of nodal pricing. A feature of his proposal is the high level of importance attached to consumer engagement with their respective local marketplaces to maximise flexibility potential. Such a model, he argued, could be introduced across the EU on a gradual basis, following successful trials and pilots.

Scepticism about zonal pricing was also expressed by Dr Richard O'Neill, former Chief Economic Advisor at the US Federal Energy Regulatory Commission (FERC). Dr O'Neill outlined that prior to the introduction of nodal pricing the Pennsylvania-New Jersey-Maryland (PJM) and California market regions had introduced zonal markets, but it was found that this led to market power problems and inefficiencies as transmission scarcity within each zone was not accounted for in the model. Many US jurisdictions have now adopted a standard market model based on centralised dispatch and more refined nodal pricing, a market design which was initially considered as part of REMA but since ruled out.

Dr O'Neill stressed that, despite the demonstrated benefits of the US model, the question of long-term investment signals has recently come to the fore. While locational markets have a track record of delivering significant operational efficiencies, Dr O'Neill argued that further revisions to pricing methodologies are required to ensure that the full value of investments in new generation capacity can be captured by investors. It was also stressed that long-term transmission planning has been neglected in the US, requiring FERC to step in and require states to standardise their approaches to transmission planning and cost allocation.

Based on the contributions of the international speakers at the forum, we can see that there are different variations on locational market designs. The Nordic approach of small zones and spot-price linked retail contracts seemed to work well until the energy crisis, which exposed consumers to extreme price volatility and resulted in pressure being put on politicians to intervene. The experience has raised questions about the need for new measures to support liquidity and expand hedging opportunities as a means of reducing exposure to short-term price swings. This will be an issue in a British zonal market given the continued reliance on gas-fired generation and the likely high levels of price volatility as weather-dependent renewables form the backbone of the electricity system.

Larger price zones, along the lines of the German and continental European model, would deliver higher levels of market liquidity, but the trade-off would be a continued reliance on expensive redispatch measures. There is a view amongst some EU electricity market analysis that, given the limitations of centralised redispatch, in the long-term zonal pricing will prove inadequate for accessing the flexibility opportunities emerging at the demand-side of electricity systems, particularly in relation to heat and transport loads. As the system becomes more decentralised, with the electrification of heating and transport, many of the assets capable of providing flexibility to the system will not be participating in the balancing mechanism. Redispatch can only go so far and generally is only applicable to large assets and aggregated loads. However, as decentralised generation, storage, EVs and heat pumps become more common, the potential to tap into this decentralised flexibility may be substantial and may only be achieved through locational pricing.

The forum also discussed the complexity of zonal markets. They are evolving constructs that need periodic adjustments to address issues such as zonal boundary definition, capacity allocation between zones, how to manage inter-zonal price variability and the design of financial markets for risk hedging. If a zonal market was to be introduced in Britain, there would need to be robust procedures and supporting institutions to ensure that the market could evolve in line with the changing dynamics of the electricity system. While much of the REMA debate has been centred around the modelled benefits of zonal pricing, there needs to be a much more sophisticated and evidence-based discussion of the practicalities of implementing a zonal pricing model in the British market context. There are lessons to be

learned from the Nord Pool and EU markets. Lessons can also be learned from the negative experience of zonal pricing in California and PJM. Mistakes were made; for example poor design of auction software, capacity markets not functioning well, and federal-state regulation that was unclear and problematic.

Finally, a common challenge across all locational markets is incentives for long-term capital investment and coordinated transmission planning. These market models were designed in the 1990s and 2000s when the main priority was operational efficiency. However, delivering net zero is in large part a capital investment challenge. Accompanying reforms to the contracts for difference (CfD) scheme and integrated network planning will be required to ensure that the consumer and efficiency benefits from locational pricing do not come at the expense of achieving net zero. Britain should not make the same mistakes as the US regarding the expansion of the transmission grid and putting too much faith in short-term markets to deliver a wide range of energy system needs.

5.2 Reformed national pricing: Updating the counterfactual

Dr Simon Gill of the Energy Landscape presented his work on proposals to reform the existing national market as an alternative to zonal pricing. The early modelling studies underpinning Ofgem's and DESNZ's analysis of the benefits of locational pricing were based on a comparison with the status quo – essentially the BETTA model that has been in operation for almost 20 years. However, proponents of a 'reformed national market' argue that there is scope to significantly improve aspects of the current market design. As part of the next phase of REMA, modelling studies need to compare locational pricing against a realistic model of the national market. This would include incremental reforms such as improvements to NESO's current approach to redispatch, the design of the balancing mechanism, how interconnector flows are managed and revising the methodology underpinning the TNUoS regime.

During the forum discussions the topic of interconnector redispatch was raised by several participants. Under the current national pricing model, it can be the case that interconnectors exacerbate congestion within the GB system. An example cited is flows on the system from the Norwegian interconnector – the North Sea Link. Flows based on wholesale price differentials will often see exports from the low-price Norwegian hydropower system to Britain, but as the link comes into the north of England, at times of high wind this interconnector can exacerbate locational constraints within GB. If zonal pricing was in place, price differentials between Norway and Britain would be more reflective of scarce capacity on the grid, likely resulting in more exports to Norway during high wind periods and reduced north-south flows within GB.

Under the current market arrangements interconnectors do not participate in the balancing mechanism. To alter flows NESO must either hold separate intraday auctions or enter direct agreements with neighbouring system operators during the balancing timeframe. These interventions can be costly and there is a lack of transparency on the extent and cost of these short-term trades. The practicalities of changing interconnector flows have been made more difficult by the fact that Britain no longer participates in the EU single market for electricity and has thus far failed to implement a long-term trading arrangement which was agreed under the Trading and Cooperation Agreement (TCA). An important question is whether, given the high transaction costs involved in redispatching interconnectors, flows

can be altered sufficiently in the absence of the clear signal that would be provided by locational pricing.

The UK Government has recently concluded (Department for Energy Security and Net Zero, 2004) that there is limited scope to improve how interconnector flows are managed as unilateral action by NESO would conflict with the UK's agreements regarding electricity trading with the EU and Norway. This is problematic for proponents of a reformed national market as modelling has shown that improved management of flows across the interconnectors could significantly diminish the benefits of a transition to zonal pricing. A failure to improve this aspect of the national market would see a continued reliance on expensive redispatch measures, at least until the UK can implement a more efficient trading regime with the EU and Norway.

A reform of the current TNUoS regime was also identified as a key component of a reformed national market. Under the existing market arrangement, investors are exposed to TNUoS charges on a locational basis; they are thus a key driver of siting decisions for generators and other large assets. However, several participants outlined that TNUoS charges are increasingly volatile and unreliable, and unrepresentative of the future electricity network configuration. While under a zonal market, TNUoS will still be required to recover the capital costs of network reinforcement, these charges would play a less significant role in locational investment decisions. Under a reformed national market they would remain a key driver of siting decisions; there would therefore be a need to redesign the methodology by which TNUoS charges are calculated. Ofgem recently advised that a cap and floor be introduced as the difficulty of estimating the long-term trend of TNUoS charges has become a barrier to investment (Ofgem, 2024).

Alongside reforms to TNUoS, developments in long-term transmission planning were cited by proponents as a key argument in favour of a reformed national market. Scenarios which see a significant expansion of capacity on the transmission system, particularly between Scotland and England, have been shown to reduce the benefits of zonal pricing (LCP Delta, 2024). A key question which needs to be addressed in this argument is the extent to which NESO's ambitious network plans – the Holistic Network Design subsequent updates – can be delivered. Large scale transmission projects are challenging to deliver, with multiple regulatory, planning, financial and supply chain constraints. If ambition does not match reality, the case for a reformed national market would diminish. Several participants cited the need for a better understanding of the realistic timeframes for reinforcing the transmission system as this forms a key part of the argument for a reformed national market.

Participants also pointed out that improved dispatching of assets in the balancing mechanism would enhance the current national market. Although this is based on the logic that the least cost mix of bids (to turn down) and offers (to turn up) are selected by NESO, there are often cases when certain technologies are not selected, or 'skipped'. This is a particular issue for battery storage, a technology which will play a crucial role in optimising a largely renewables-based system. It was outlined at the forum that improving storage and skip rates has been a priority for NESO and this will require updated dispatch software and processes.

6 Discussion 2: Key challenges and opportunities for Scotland

Forum participants formed smaller discussion groups to identify opportunities and challenges from a Scottish perspective. The context for this discussion was the high-level principles for market reform, as previously set out by the Scottish Government in its response to the second REMA consultation: “Achieving a transition to net zero and ensuring a fair and just transition.”

6.1 Investor certainty

A theme which emerged from the group discussions was the need for investor certainty for achieving these aims. A key question which emerged was the extent to which locational pricing would significantly increase the cost of financing the net zero transition, a cost which would ultimately be borne by electricity consumers and wider society. Modelling results show that the benefits of locational pricing are highly sensitive to changes in the cost of capital (Ofgem, 2023), (LCP Delta & Grant Thornton, 2023). One argument is that transferring locational risk to generators – away from consumers – will increase uncertainty and make it more difficult to convince investors to deploy capital in Scotland. While applying to all technologies, this is a particular issue for offshore wind in Scotland which is highly capital intensive and reliant on a broad, international investor base. An issue with the current modelling is that there is a wide range in estimates of possible cost of capital increases resulting from an introduction of locational pricing.

The evidence base on investors is limited, with little work investigating the views of the international investment community. Zonal pricing may not be a concern for some investors who are significantly diversified across geographies and technologies. As one respondent outlined, we are currently treating investors as a black box. International investors who supply most of the capital into UK infrastructure is a diverse actor group, with different considerations, levels of willingness to accept risk, and different capabilities for risk management and diversification. The key concern for these actors may not be the fact of zonal pricing, rather how it's introduced – over what timeframe, with what legacy and transition arrangements in place and with what potential for risks to be diversified through trading and hedging mechanisms?

An issue raised in this discussion was that the current system is overly complex from an investor point of view and suffers from a lack of transparency. Investors need to operate across multiple markets, imposing high transaction costs, leading to a loss of efficiency and a potential misallocation of capital. Therefore, whether the preferred option is zonal or reformed national pricing, an overall simplification of the system from an investor point of view should be a priority.

6.2 Managing the transition

Participants pointed out that a key challenge for the UK Government is to manage its clean power mission and REMA project in a complementary way. With multiple overlapping and interdependent reforms taking place (TNuOS, CfD and capacity market reform, planning and connection reform, constraints collaboration, the development of spatial and centralised

network plans), it's crucial that investors do not get conflicting messages and that the timeframes for these reforms are aligned with the overall objective of accelerating investment.

A particular concern raised was the interaction between the upcoming Allocation Round (AR) 7 and the expected REMA white paper. The UK Government has since clarified that all CfDs awarded in the AR 7 auction will be on the same terms as existing agreements and that any substantial changes to CfD design would not take effect until subsequent rounds. It has also been announced that financially firm access rights will remain in place, that self-dispatch would continue under a zonal or reformed national market, and that CfD generators' reference price will be their zonal price, continuing to shield them from price risk. This will likely reduce the incentive under locational pricing but it will likely see more offshore wind located in Scotland under zonal pricing as siting decisions would be based on achieving the highest load factors. However, depending on the design of the future CfDs, risk related to the output of plant which can be sold – or volume risk – will remain, and it will likely be exacerbated under either option as the number of negative pricing hours increases. Addressing this volume risk will be a crucial component of the overall REMA package.

6.3 Communicating and capturing the benefits of electricity market reform

While there are challenges associated with investment certainty, locational pricing could position Scotland as a low-cost hub for clean electricity. The benefits of locational pricing in terms of lower electricity prices can be modelled, but for Scottish society to fully benefit, industry and consumers would need to make the right decisions about investments and electricity consumption.

Participants discussed what communication may be needed before, during and after a rollout of zonal pricing. Important questions identified were: What information may be needed for the different types of stakeholders? How can the specific needs of regions and communities across Scotland, particularly vulnerable consumers in cities and rural areas, be addressed?

It was stressed that if consumers aren't on side – and they haven't been considered at the outset – there is potential for bad press which undermines the market reform project. It was highlighted that lessons can be learned from other significant reforms, e.g. the mistakes made in the smart meter rollout which suffered from poor communication and coordination across industry.

Several forum participants stressed the need to understand how demand can help optimise the system and where it can help to most efficiently utilise renewables. Zonal prices, if passed through to all consumers, could have a significant impact on investment decisions in heating, transport and industrial energy systems. If that demand is to become a driver for the future energy system and deliver on flexibility potential, the need to build capabilities for this and open consumer access to innovative products and services should be prioritised. This should align with future reforms of the retail market associated with the introduction of market-wide half-hourly settlement.

The potential economic benefits of this in terms of lower bills and economic competitiveness ought to be fore-fronted. The Norwegian case was cited in this context. Here people closely watch the power price and change their behaviour as a result. This is a culture of engaging with and understanding the electricity system and the dynamics of the market.

At a broader level, it was discussed how transitioning away from fossil fuels will change the macroeconomic picture for Scotland. All parts of government need to understand the electricity market in terms of their connections into it. The combination of low carbon power, efficient market design, certainty and reliability should be fore-fronted by the Scottish Government in its wider macroeconomic and FDI strategy. If this was prioritised, it was felt that Scotland could gain a competitive advantage.

6.4 Improving the evidence base

A key challenge identified for Scottish stakeholders at the forum was understanding the evidence base for market reform and accessing analytical tools to evaluate the impacts of REMA on Scottish consumer groups, industry, and regions. Regardless of which reform option is taken, the electricity market is becoming more complex and it's crucial that Scottish stakeholders – both public and private – can evaluate these changes and develop appropriate strategies. During the discussions, several specific aspects of the locational pricing debate were highlighted as requiring more evidence:

Aligning market reform and the clean power mission: Stakeholders expressed concern that the multiple and highly complex reform processes ongoing at the UK level may not be complementary and could conflict with one another, thus exacerbating investment risk and putting Scotland's net zero target in jeopardy. There is a need for a high-level risk assessment framework for market reform, looking across the entire landscape of electricity and net zero policy. It was suggested to identify and categorise key risks in a hierarchy which could be communicated to investors. Developing such a framework would require a close alignment of workstreams across DESNZ, Ofgem and NESO.

Impacts on the cost of capital: The modelled socio-economic benefits of locational pricing are highly sensitive to changes in the cost of capital. The current evidence base on the extent to which locational pricing could increase the cost of financing large renewables projects in Scotland and for how long this premium may endure is not sufficient. Whilst the expressed views of large energy companies are well known to policy makers, there is a need to also understand the full ecosystem of international and domestic investors. It's these actors, together with energy companies and developers, who will ultimately finance the net zero transition. It should be recognised that, given the stakes involved, the internal strategies and policies of the relevant companies and investors cannot be known externally with certainty.

The relationship between locational pricing and industrial policy: There are conflicting claims in the debate about the extent to which lower wholesale electricity prices influence investment decisions in electricity intensive industry. For some, this could be a key advantage of locational pricing, whereas others argue that power prices are only one, relatively minor, factor in industrial siting decisions. More work is needed to examine specific regional cases, for example, northern Sweden where zonal pricing has been in operation and there has been success in attracting green steel production, battery

manufacturing and data centres. The macroeconomic impacts of different electricity pricing futures should be modelled to inform the Scottish Government's industrial and foreign direct investment policy.

Delivering large transmission projects: The benefits of locational pricing diminish as more capacity is added to the transmission system, in a way which alleviates constraints. NESO has made impressive progress in developing and updating its Networks Options Assessment and Holistic Network Design processes, while Ofgem has introduced flexible mechanisms to approve strategic investments. However, a dose of realism is required in understanding the practical challenges of financing and delivering a highly ambitious programme of transmission investment. More work could be done examining recent experiences of large transmission projects in Britain and internationally, exploring key challenges such as supply chain coordination, public acceptability and optimism bias. Also, the potential for reduced network investment required under a zonal approach needs to be quantified and incorporated into the overall socio-economic appraisal.

Updating the counterfactual: The next phase of REMA and the decision about a zonal or reformed national market will require an updated counterfactual to locational pricing. As many participants have stressed, the status quo is not an option. Therefore, work is required to investigate how a package of reforms to the current market – TNUoS reforms, more efficient redispatch, better management of interconnector flows and operation of the balancing mechanism – can be delivered and implemented. Along with the overall design of a reformed national market, there needs to be further analysis of how the costs of the various interventions associated with this option are allocated across the consumer base. This will require careful consideration to balance the policy priorities of efficiency and equity.

Understanding zonal markets: Zonal markets have been in operation across the EU/EEA, in the US and Australia for more than three decades. Better evidence could be gathered on these international experiences, particularly recent cases of creating zonal markets and the legacy/transitional arrangements introduced, e.g. the split of Sweden into separate bidding zones in 2011 and the separation of the former German-Austrian single bidding zone in 2018.

Open access and transparent modelling: Currently, much of the electricity market modelling expertise is within economic consultancies, and this can only be accessed by governments and large energy companies. The need for open access and more transparent modelling tools was cited in the discussions, along with the need to build electricity market modelling capabilities within Scotland. While there are large sums being spent on model development, not enough of is being spent on the transparency of modelling. Open sourcing can be expensive as it involves paying the developers enough to make IP open. Another point referenced was whether it's better to have one good study or multiple studies in which there may be less confidence individually.

Impacts on electricity demand: An area highlighted in these discussions on market modelling was the need for a more demand-led approach to the modelling. Currently, only very high level and aggregate assumptions about future demand are being included in the modelling studies. Participants discussed the need to more fully investigate the impacts of different market reform options on demand-side transitions, particularly how the roll-out of

heat pumps and EVs across regions of Scotland might be impacted under different market design options.

Socio-economic welfare impacts: As part of its Locational Pricing Review, Ofgem has produced an analysis of consumer impacts of locational pricing which concludes that zonal pricing would benefit most electricity consumers. The main driver of this is the reduced payments currently being made to generators located behind transmission grid constraints. If locational pricing is to be pursued, this work will need to be updated as the REMA team in the UK Government provides more details on zonal configurations, transition arrangements and any measures to shield consumer groups from zonal price variations. Socio-economic welfare impacts also need to be studied from a Scottish perspective, requiring a more detailed and refined analysis of impacts on consumer groups and regions.

7 Getting the balance right

The decision of whether to reform the existing national market or transition to a zonal design can be informed by further technical and modelling studies but it is, in essence, a political judgement about the distribution of costs and risks across society. The argument in favour of a zonal market hinges on a judgement that the consumer and efficiency benefits of more accurate pricing in the wholesale market would outweigh the risks of transitioning. Given the diversity of the investor community and uncertainty around the extent to which market participants would adapt to the new regime, evidence around this issue will not be definitive in advance of a final decision.

There are also uncertainties on the side of the reformed national market. While this option will likely involve higher redispatch costs, the transitional risks and impacts on the cost of capital will likely be lower. However, given the vested interests and inherent uncertainties, it's impossible to verify the claims of proponents of this option in advance. The impacts of reforms to the transmission charging regime (TNUoS), and NESO's efforts to improve its approach to redispatch and the management of interconnector flows would only be demonstrated in practice, with the latter likely requiring deeper collaboration with neighbouring TSOs in the EU/EEA.

REMA should not be seen as a one-off reform; regardless of the preferred option – zonal pricing or a reformed national market – there will need to be an ongoing dialogue between the Scottish and UK governments, and the wider industry and stakeholder community, regarding implementation and future reforms as the electricity system evolves over the coming decades. There are no perfect answers in electricity market reform; it's about balancing multiple and sometimes conflicting objectives in the real-world context.

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