ASSESSING THE IMPACTS OF IMPLEMENTING CENTRAL DISPATCH IN GB

A report for Centrica

21 June 2024

Introduction

The GB electricity system is currently operating under a 'self-dispatch' regime whereby resources can largely produce and trade energy on their own initiative without needing to take part in a centralised mechanism. The only centralised aspect to the market design is the balancing mechanism that operates after gate closure. As part of its on-going Review of Electricity Market arrangements (REMA), the Department for Energy Security and Net Zero (DESNZ) is considering a wide range of potential reforms, including a change from self-dispatch to central dispatch.

Central dispatch is a mandatory mechanism operated by the system operator which determines the ultimate dispatch of energy for key resources on the system. There are many different versions of how central dispatch could be organised in practice. However, at a high-level, such a system relies on an algorithm to optimise the dispatch of all key resources on the system, instead of through bilateral trading in an electricity market.

In its REMA consultation, DESNZ recognises the implementation challenges and risks of central dispatch, and therefore the need for confidence that the benefits more than outweigh the costs. Centrica has asked Frontier Economics to assess the impacts of central dispatch for the GB system and ultimately for customers, in the context of a Net Zero electricity system characterised by a high share of Renewable Energy Sources (RES) and a significant need for short term flexibility.

In this report, we first assess the impact of central dispatch relative to today's market arrangements, before then going on to consider the extent to which any apparent benefits of central dispatch could equally well be achieved by reform to the status quo.

Our assessment suggests that overall it is difficult to be certain as to the balance of benefits and costs of central dispatch compared to today's market arrangements.

- *On the one hand*, we have identified some potential benefits of central dispatch. For example, there is some potential to increase the efficiency of outcomes by enabling co-optimisation of energy and reserve, although the materiality of this is uncertain. Similarly, central dispatch could more easily facilitate a shift to shorter Imbalance Settlement Periods (ISPs) or more granular zones in a zonal market, to the extent that such interventions were judged to deliver societal benefits. It would also allow ESO to take pre-gate closure actions based on more certainty as to the physical position of assets compared to today, and can potentially improve the transparency to the market of ESO's activities.
- *On the other hand*, the extent to which central dispatch can achieve more efficient dispatch than the current system (and deliver the efficiency benefits noted above) is entirely dependent on the design of the algorithm, its inputs and the timing of markets, all of which need to remain appropriate to the system as it evolves. Therefore, overall

efficiency is very much dependent on the skills and competency of the algorithm designers at the outset, and then on the industry processes put in place to keep the algorithm relevant to the resources it is despatching. Put another way, efficiency would become more materially dependent on centralised processes rather than competition between traders.

Our assessment also suggests that, to the extent that benefits could exist relative to the current, approach a significant proportion (though not necessarily all) of these benefits could be secured through incremental market reform. In the table below we summarise the potential area of benefit, should the centralised processes set-up be capable of delivering it, and then highlight whether there are options that could replicate some or all of the benefits in a self-dispatch market.

Table 1 Assessment of incremental reform options against potential central dispatch benefits

Potential area of advantage	Nature of central dispatch benefit	Reform options available?
Co-optimisation	Increased efficiency as a result of algorithm simultaneously dispatching for energy and ancillary services. Scale of benefit depends on algorithm's efficiency and scale of inefficiency today.	Yes, reform options available to improve the coordination and optimisation of separate energy and reserve markets intra-day relative to the status quo, though limits in terms of complexity of the market arrangements required to replicate an idealised algorithm
Sharper price signals – time & location	Improved ability to move to 5 minute ISP and to more granular zonal definition. Scale of benefit depends on ability of market to respond to more granular price signals and broader implications (e.g. increased participant risk, liquidity)	No – while an ISP of 15 minutes is clearly achievable with self-dispatch, achieving 5 minute ISP and/or highly granular zonal market likely to be very difficult.
Accuracy of ESO information	Closer link between ESO data and cost drivers of connected resources	Yes, information supplied to ESO could more closely match underlying cost drivers of assets, similar to that supplied to a central dispatch algorithm, though a significant change to

Potential area of advantage	Nature of central dispatch benefit	Reform options available?
		ESO and participant systems required
Firmness of ESO information	Greater certainty for ESO of positioning of asset ahead of gate closure	Yes, range of options including longer gate closure and incentives to supply more accurate forecasts to ESO. However, efficiency of energy balancing may be reduced by moving to longer gate closure.
Efficiency of interconnector redispatch	Centralised process and timetable more likely to catalyse harmonisation of intraday interconnector capacity and redispatch arrangements, but unlikely to change SO to SO arrangements	Yes, no clear reason why the timing and number of auctions could not be aligned with what would be expected under central dispatch (key constraint, as is also the case for central dispatch, is likely to be agreement of interconnected TSOs)
Accessibility for smaller flexible resources	Centralisation of optimisation away from participants means that (especially smaller) players with flexible assets may face lower barriers to entry e.g. they simply have to provide bids with costs and technical characteristics to single algorithm.	No – no clear way to achieve the same outcome in self-dispatch market
Transparency of market and ESO actions	Greater link between cost drivers and pricing may increase transparency for the market. Use of algorithm may reduce (some aspects of) ESO judgement	Yes, if information supplied to ESO is changed to more closely reflecting underlying cost drivers (as noted above) though a significant change to ESO and participant systems required

Source: Frontier Economics

Any decision to move to central dispatch will, by its nature, be highly judgement based. However, given the balanced position emerging from our assessment, in our view it will be difficult to conclude with confidence that the potential benefits of central dispatch are sufficiently strong to outweigh the implementation costs and risks highlighted by DESNZ.

This report is structured as follows. We:

- define what we mean by central dispatch, and set out any assumptions that we carry through into our assessment;
- carry out an assessment of central dispatch against a counterfactual of the current arrangements, considering a range of criteria;
- consider the potential for reforms under the current framework to capture any benefits we identify for central dispatch; and
- draw conclusions from our analysis.

Central dispatch arrangements

An important first part of our assessment is to define what we mean by a centrally dispatched system. At a high-level, such a system relies on an algorithm to optimise the dispatch of resources on the system, instead of relying on bilateral trading in wholesale electricity markets followed by mechanisms to allow the ESO to balance the system. In a competitive process, the algorithm would be supplied with information from:

- generation and storage resources,[1] with data being structured in a manner to represent the underlying cost drivers of their operation; and
- consumers (including retailers and aggregators) representing the expected demand and the price at which they would be willing to undertake any demand side response.

The algorithm would then set a price per settlement period at an estimate of the marginal value of electricity on the system, with participants settled on a ‘pay as clear’ basis. This would mean that, provided there is sufficient competition, market participants would simply be incentivised to bid their costs into the algorithm. The algorithm would typically be run multiple times ahead of real-time to allow new information to be incorporated into the optimisation.

Overall, a move to central dispatch would represent a large and complex change to the current system, requiring license changes and code modifications. It is likely that, in line with other recent industry reforms, it would ultimately need to be directed through legislative change.

The broad differences between the structure of a self-dispatch market and a central dispatch market is illustrated in Figure 1.

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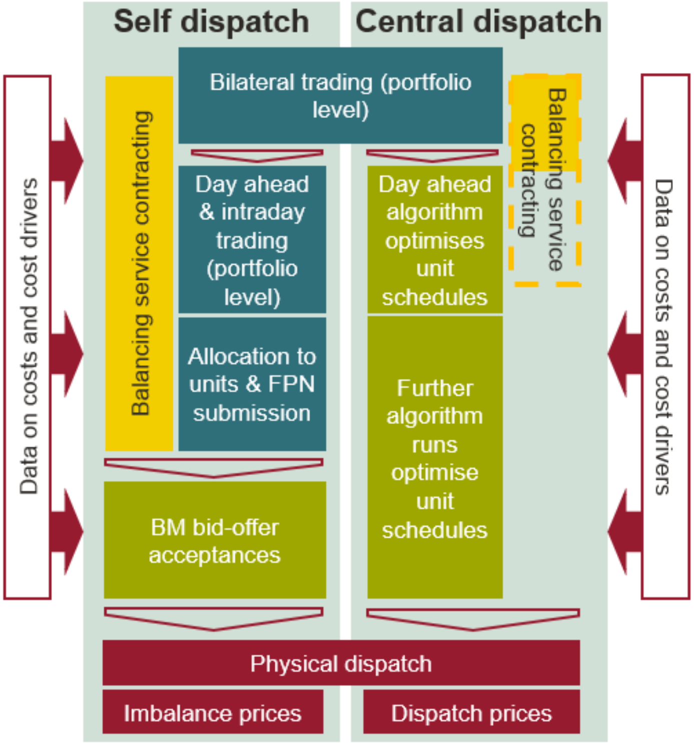
[1] Interconnector users could provide information either as a source or demand for power.

Figure 1 Illustration of key differences between self-dispatch and central dispatch



Source: Frontier Economics

Beyond this high-level design, there is no single approach to designing a centrally dispatched system:

- The nature of the algorithm is likely to depend on the resources on the system. For example, in Brazil there is a substantial amount of storage hydropower, which means they have a combination of algorithms that optimise over monthly, weekly and daily periods. In contrast, in a number of US markets and in Australia, which have been historically more dominated by dispatchable fossil fuel plants, daily algorithms based on mixed integer programming are used.
- Some markets leave a role for participants to self-commit resources prior to the algorithm determining dispatch, to allow for forward trading for physical delivery. This is the approach taken by many of the markets we have considered (such as US markets and Australia). The liquidity of forward trading would be dependent on market participants understanding and having confidence in the algorithmic price formation process.
- Some markets in the US and the Australian market co-optimise energy and reserve services during the scheduling process, while in Ireland the dispatch algorithm only considers energy.

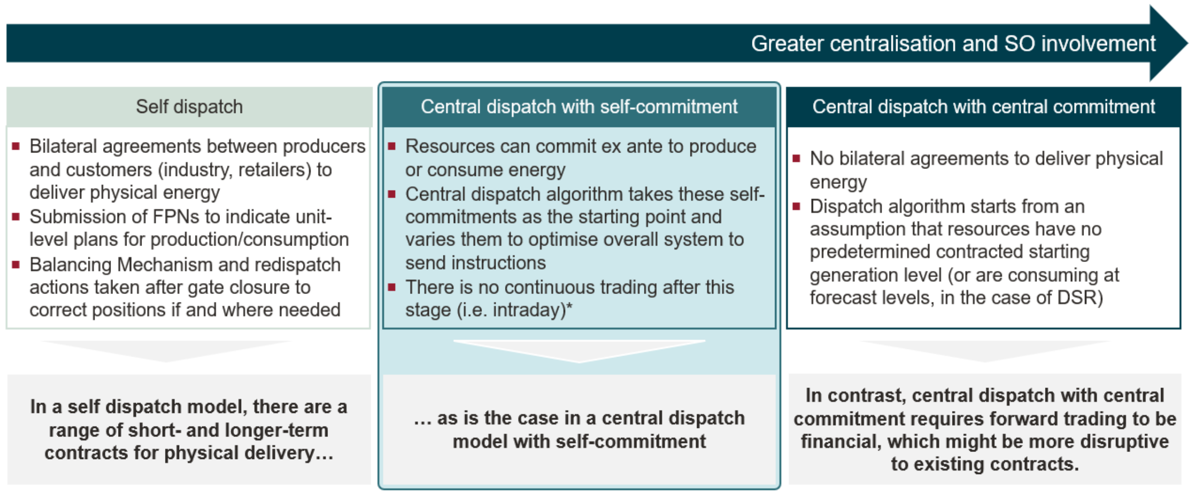
- Some markets in the US, Australia and Brazil have day ahead and real time auctions only. Other countries, such as Ireland and Italy, have intraday auctions. However, even in countries with intraday auctions, there are different approaches to how intraday trading is structured: in Ireland, auctions are the only way plants can be physically scheduled while in Italy, there is continuous trading with an arrangement to allow for changes to unit commitment as a result.

The variety of approaches means that it is difficult to identify a precise design that would clearly be relevant for GB from international benchmarks. It is also important to note that none of the systems that we reviewed yet have very high levels of intermittent renewable energy sources, storage, smaller decentralised resources or demand-side response. There is no clear precedent for implementing central dispatch for the system context likely to be experienced by GB on the transition to net zero.

For the purposes of our assessment, we need to make a number of assumptions regarding key design elements of central dispatch. We therefore assume that:

- central dispatch with self-commitment is implemented, given it is likely to result in fewer transitional issues relating to existing contracts (see Figure 2). In practice this means that bilateral, portfolio-based trading for physical delivery can take place up to the day ahead stage. After this point the centralised algorithm takes over, taking into account the starting position for assets committed to produce or consume in the electricity market.

Figure 2 Central dispatch with self-commitment is likely to result in fewer transitional issues



Self dispatch

- Bilateral agreements between producers and customers (industry, retailers) to deliver physical energy
- Submission of FPNs to indicate unit-level plans for production/consumption
- Balancing Mechanism and redispatch actions taken after gate closure to correct positions if and where needed

In a self dispatch model, there are a range of short- and longer-term contracts for physical delivery…

Central dispatch with self-commitment

- Resources can commit ex ante to produce or consume energy
- Central dispatch algorithm takes these self-commitments as the starting point and varies them to optimise overall system to send instructions
- There is no continuous trading after this stage (i.e. intraday)*

… as is the case in a central dispatch model with self-commitment

Central dispatch with central commitment

- No bilateral agreements to deliver physical energy
- Dispatch algorithm starts from an assumption that resources have no predetermined contracted starting generation level (or are consuming at forecast levels, in the case of DSR)

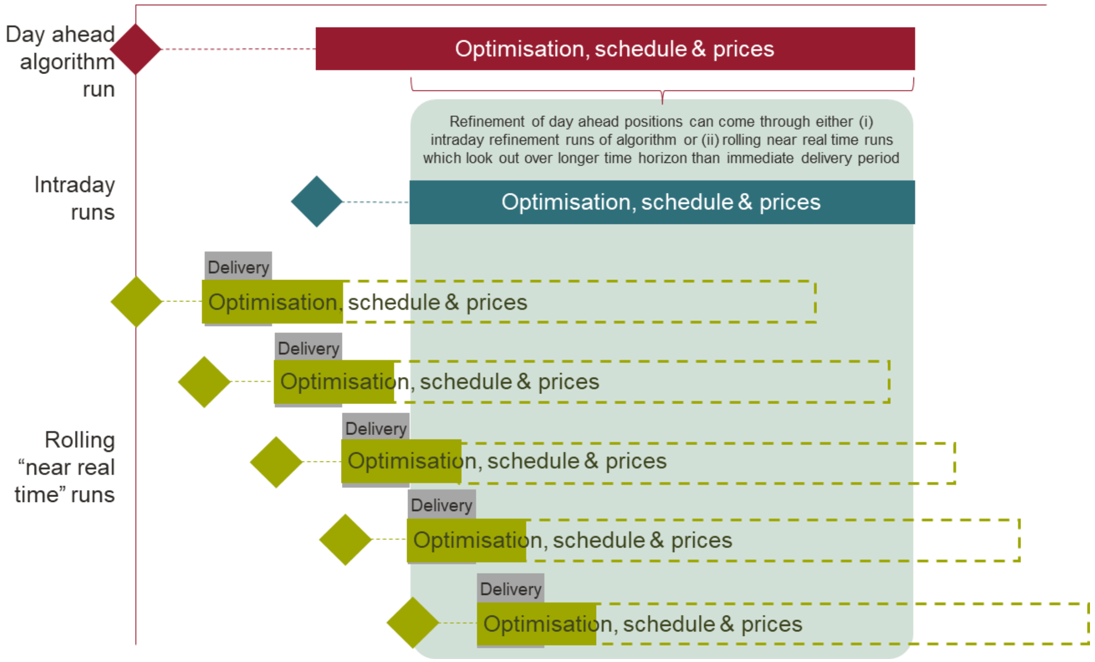
In contrast, central dispatch with central commitment requires forward trading to be financial, which might be more disruptive to existing contracts.

Source: Frontier Economics

Note: Our description of central dispatch with self-commitment is consistent with assumptions made by FTI in their work for ESO, see page 22 of FTI's assessment document: https://www.nationalgrideso.com/document/258876/download

- ESO operates day-ahead and intraday arrangements to account for updated information and provide near real-time instructions. There would be no intraday bilateral trading. All updated schedules and prices after the day ahead stage would rely on re-running the dispatch algorithm, and many different options exist as to how this would work in practice, e.g. in relation to the number of intra-day optimisations and their timing. Optimisations could also either be through intra-day refinement runs of the algorithm, or rolling near real-time optimisations that look out over a longer time horizon (see Figure 3). We do not differentiate between these options in this assessment but note where less effective arrangements might have an impact.

Figure 3 Intra-day optimisation under central dispatch



Source: *Frontier Economics*

- the central dispatch algorithm co-optimises energy and reserve services, based on information provided by market participants and ESO's forecast requirements. In a single process, the algorithm can then determine which assets should provide reserve and which should be scheduled to generate.

Finally, we note that we assume that customers, retailers and aggregators are able to participate actively by submitting bids and offers to the algorithm. Other than potentially in relation to changes to the ISP, we assume that the implementation of central dispatch does not materially impact on arrangements for retail settlement (including the move to market-wide half hourly settlement).

Assessment of central dispatch

In this section we assess the benefits of central dispatch against a counterfactual of the current self-dispatch arrangements. We consider the efficiency impacts and some broader considerations such as transparency and the impact on flexible resources. In the subsequent section we go on to discuss how any of the potential benefits identified could be addressed through alternative reforms to the counterfactual.

Efficiency of central versus self-dispatch

Efficiency of the algorithm

It is difficult to say *a priori* whether central dispatch, based on a yet to be defined algorithm, could deliver more or less efficient outcomes than the current bilateral trading and balancing mechanism arrangements (including the ESO's own optimisation processes to determine which bids and offers to accept). Clear inefficiencies within the current GB arrangements do exist. However, the extent to which central dispatch can address some or all these (today and in the future) is inherently uncertain because in large part it is dependent on the design chosen, and how well it evolves over time in response to the changing resource mix on the system.

That said, we have identified a number of key design considerations which would ultimately drive the efficiency of a central dispatch design:

- ***An algorithm appropriate for the system as it evolves***. Numerous examples of central dispatch algorithms exist around the world. However, as we have already noted, none are operating in a system with a generation mix similar to the one we either have now or expect in future in GB. Therefore, care will be needed to design any algorithm appropriately, and the algorithm is also likely to need to evolve over time, for example as the importance of long duration storage increases. As an extreme example, in Brazil where there is significant hydro storage, a combination of algorithms is used to optimise over multiple future periods, whereas a thermal based system (e.g. PJM) might only rely on a single algorithm optimising over relatively short timeframes.

- ***Inputs which correctly reflect participant costs and cost drivers as they evolve***. The ESO's BM Review highlighted that the structure of information provided in current BM bids and offers does not map well to the technical constraints and cost drivers of power plants and therefore may limit optimal dispatch in the BM today.[2] Central dispatch algorithms would typically require bids from participants which are structured in a way which better relates to the underlying technical capabilities and cost drivers of assets. The

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[2] ESO does not have an ability to run an asset in a manner that deviates from the limits participants submit, even when doing so might be technically feasible and might reduce overall balancing costs after taking into account any additional costs the alternative running pattern might induce.

efficiency of the algorithm depends on the extent to which the chosen structure of information truly reflects those cost drivers and hence the true flexibility of assets available to ESO. As the system evolves from large centralised units towards a system with more significant levels of storage and DSR, an efficient algorithm will need to be supplied with a more diverse set of data.[3] This issue is relevant in a self-dispatch market, but in a more limited way, as market participants can evolve their own optimisation of assets for the purposes of bilateral trading. Under central dispatch the role of the algorithm is much more fundamental, and the appropriateness of the information set all the more important.

- ***Rules defining efficient price formation given non-linear costs***. If all costs are continuously variable, the algorithm can calculate a well-defined system marginal price. However, in more realistic settings (e.g. if there are “integer” or non-linear costs such as those to start a plant and produce at minimum stable generation), all costs may not be covered by the algorithm’s assessment of the marginal cost of the marginal unit. In a self-dispatch market, participants decide how to include such costs in their prices (e.g. by increasing their sales price or BM offers above pure incremental costs, for example in periods of scarcity), with their strategy driven by competition in the market. However, given the typical structure of bids under central dispatch, rules are usually required to determine how these costs are added to prices. This might be achieved by adding a mark-up at peak (which is in a way analogous to how imbalance prices are adjusted for reserve and start costs today). The importance of such rules is greater under central dispatch given the resulting prices are likely to apply directly to a larger volume across the whole market.

- ***Intra-day runs timed to allow for efficient responses to new information on expected system conditions***. In a self-dispatch market, very flexible resources can self-schedule at any time up to gate closure, and ESO uses the BM to position less flexible assets ahead of time. In central dispatch, the timing of markets will determine the optimisation of partly flexible units, which may include storage if there is a need to adjust the state of store ahead of real time. This means it is important that there are either intraday or rolling near real time auctions (see Figure 3) which allow updates to scheduling of less flexible units based on new information on expected system conditions. The precise design will need to trade-off more frequent options for optimisation vs. complexity and cost of running multiple auctions.

Making the right algorithm design decisions in these key design areas will be critical to ensuring that a centrally dispatched market does not “bake in” inefficiencies, making it less likely to be more efficient than today’s market. Since central dispatch centralises the optimisation process, it will also be important that the question of the appropriateness of

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[3] It is worth noting that while this information set should include the costs associated with DSR, so that it can be optimised alongside generation and storage assets, the presence of an algorithm does not resolve the challenge that also exists under self-dispatch of accurately estimating the baseline from which any demand side response is measured.

algorithm design is addressed on an ongoing basis. Today, competition between participants should encourage continual innovation in optimisation techniques. Under central dispatch, industry process and/or regulation will be needed instead.

Co-optimisation

Assuming that a centralised algorithm can deliver efficient dispatch outcomes to start with, a key further benefit relates to the ability to ***co-optimise energy and reserve***.

In today’s self-dispatch market, participants face risks in reserving power to provide balancing services to ESO on the basis of their expectations as to the dispatch and pricing in short term electricity markets. For example, a mid-merit asset faces the risk that if they offer to provide upward balancing services and have their offer accepted (meaning they are restricted in how much electricity they can sell), they are unable to capitalise on higher electricity prices which might emerge should the system subsequently be tight (and they were in merit to generate electricity). Such forecasting errors could result in inefficient use of the system’s resources.

In a centrally dispatched market, participants would be incentivised to provide the algorithm with bidding information that reflects their costs. The algorithm would then determine, in a single process, which assets should provide reserve, and which should be scheduled to generate. Participants do not have to rely on forecasts of pricing in short-term markets. The algorithm’s output will only be as good as forecasts of demand and availability, and so the outcome may then be adjusted as new information arises. But to the extent that inefficiencies arise under the current self-dispatch arrangements due to participants without visibility of the total system making incorrect or inconsistent decisions as to whether to use their assets to provide reserve or electricity, co-optimised central dispatch should reduce or remove them.

The scale of potential efficiency gain depends partly on the efficiency of the algorithm, and partly on the extent to which incorrect or inconsistent forecasts of price at the point participants commit to provide balancing services result in inefficiencies today.

As a result, it is very difficult to evidence the extent of any co-optimisation benefits given such analysis would rely on assumptions about a yet to be defined algorithm, and the extent to which participants make price forecast errors.[4]

Sharper price signals

A move to central dispatch may also facilitate two further reforms more easily than under self-dispatch, which would in turn result in sharper temporal or locational price signals. Therefore,

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[4] The second REMA consultation states that ESO are currently assessing the case for reform to GB’s dispatch arrangements, with projects comparing how market parties schedule under self and central dispatch and quantifying the economic benefits of co-optimisation.

this could be considered an additional benefit of central dispatch if these options are also considered to be beneficial to society overall:

- In the REMA consultation, ***shorter Imbalance Settlement Periods*** (ISPs) are cited as one option to improve temporal price signals. In much of continental Europe, self-dispatch markets operate with 15 minute ISPs, meaning that the market can send a shorter term price signal to the whole market relating to the value of power. However, in some centrally dispatched markets (e.g. in North America), there are even shorter ISPs – many markets have a price signal for each 5 minute period.[5] Achieving such short term signals via bilateral trading is more difficult given there may be insufficient time and liquidity for bilateral trading to result in a reliable series of five minute prices.[6]
- In the REMA consultation, a ***zonal market*** is being considered, though the question of the number of zones is left open. A zonal market is consistent with both central dispatch and self-dispatch. However, with ***very small zones,*** it is less clear that prices could be formed through bilateral trading due to concerns as to low liquidity and market power. It would be easier for a limited number of parties in a zone to submit costs to an algorithm to form a zonal price, although market power concerns would remain and would need to be addressed.

In principle, sharper price signals (on a temporal or locational basis) to which participants are able to respond effectively could result in more efficient outcomes. However, in practice, other factors might influence any assessment of the overall benefit of such signals. For example, having very granular zonal prices may increase revenue risk for generators, and therefore increase the cost of capital. As such, any benefit of central dispatch as a facilitator of sharper price signals only exists to the extent that those sharper price signals are also considered beneficial in their own right.

Firmness of ESO information

Under the current arrangements, the BM (which operates post gate closure) is a key tool used by the ESO for energy and system balancing. However, not all of ESO's balancing decisions and actions in relation to a given ISP take place after gate closure for that ISP. For example:

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[5] It might be reasonable to assume that 5 minute ISPs are more relevant for generation, storage and larger demand side response than for smaller customers. This would be consistent with an approach to 5 minute dispatch which settled smaller customers on the basis of 5 minute profiles, applied to 15 or 30 minute metered consumption, thereby avoiding the need for mass meter replacement.

[6] Automation of trading processes under self-dispatch might result in sufficient liquidity to underpin 5 minute prices. However, this is by no means guaranteed. If there is a societal benefit of shorter ISPs, then its capture under self-dispatch would require investment in automation by participants, which in turn requires the private benefits to each participant to outweigh the costs of investment. In contrast, central dispatch removes or at least reduces the need for investment by participants to capture any societal benefits.

- ESO trades with market participants pre-gate closure (i.e. while wholesale trading in relation to the relevant ISP is still going on) to adjust the flows over interconnectors; and
- Due to the inflexibility of some assets and the short time available from gate closure until the start of delivery, ESO takes pre-gate closure actions to "position" plant (e.g. preventing desyncing) to ensure adequate reserve capacity is available later in the day.

In the future, with a more storage heavy system, positioning of shorter term storage (e.g. ensuring it has sufficient charge if it is to be relied on for system balancing) may become more important for the ESO.

Under self-dispatch, ESO is making these trades on the basis of what it *expects* the final physical position (or state of charge) of assets to be in the relevant ISP. However, it cannot be sure of those positions until gate closure. ESO therefore faces uncertainty when making pre-gate closure actions and may as a result incur cost unnecessarily (or fail to position an asset when it should have from a cost efficiency point of view).

Under central dispatch, the information available to ESO is "firmer" in the sense that the physical position of units cannot be adjusted between day ahead and real-time, other than if instructed by the algorithm. Given the expected increase in importance of ESO system actions (such as redispatch, which the market does not address), the benefit of allowing ESO to be in complete control of dispatch may increase.

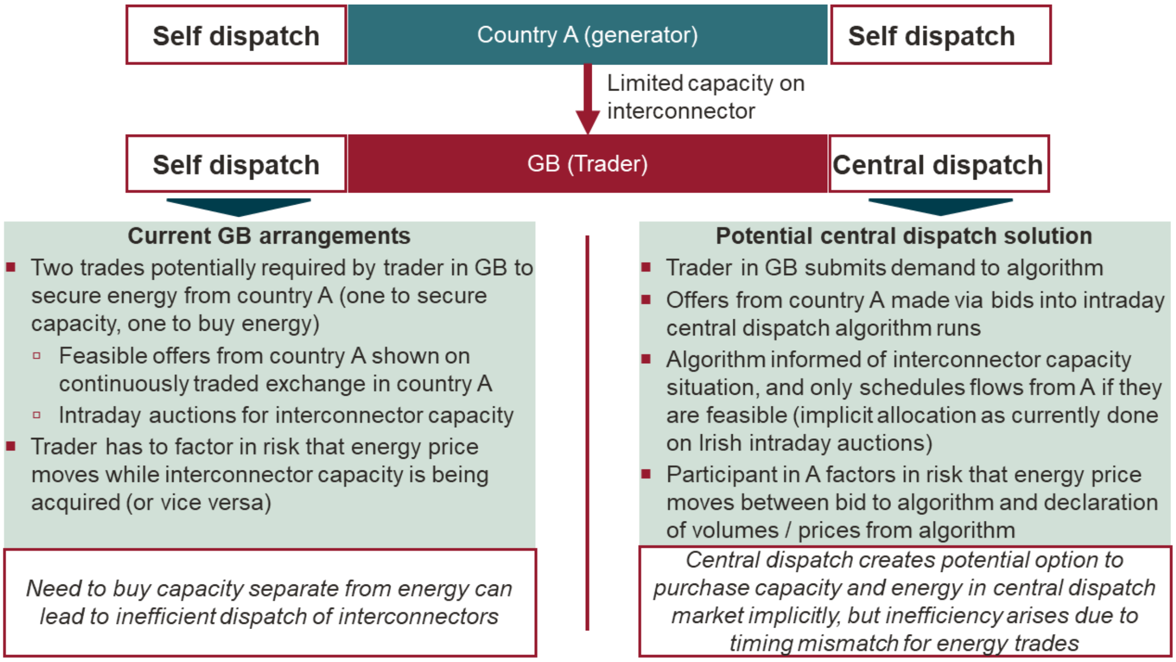
Any efficiency benefit resulting from more efficient ESO actions would need to be offset against the reduction in efficiency as a result of removing the ability of participants to optimise their own positions in relation to the overall supply and demand for energy. This reduction in efficiency depends on the relative efficiency of today's bilateral trading and the suitability a future optimisation algorithm, a subject we already discussed above.

Efficiency of interconnector redispatch

The efficiency of interconnector flows and interconnector redispatch has been acknowledged as a major issue for the GB market.

Central dispatch is likely to change cross-border trading outcomes relative to those that are currently achieved in GB. Post Brexit, both day ahead and intraday trading across continental interconnectors is explicit (rather than implicit in nature). Up to the day ahead stage we would not expect differences to arise assuming self-commitment is part of the central dispatch design. However, in Figure 4 we show the potential differences that could arise for intra-day cross-border trade if GB trades with a foreign self-dispatch market (which is prevalent for most European markets) as either a self-dispatched or centrally dispatched market. In each case inefficiencies are likely to exist. However, the source of the inefficiency would change and hence it is hard to determine *a priori* which is likely to be superior.

Figure 4 **Comparing cross-border energy trading for GB under central and self-dispatch**



Current GB arrangements

- Two trades potentially required by trader in GB to secure energy from country A (one to secure capacity, one to buy energy)
  - Feasible offers from country A shown on continuously traded exchange in country A
  - Intraday auctions for interconnector capacity
- Trader has to factor in risk that energy price moves while interconnector capacity is being acquired (or vice versa)

Need to buy capacity separate from energy can lead to inefficient dispatch of interconnectors

Potential central dispatch solution

- Trader in GB submits demand to algorithm
- Offers from country A made via bids into intraday central dispatch algorithm runs
- Algorithm informed of interconnector capacity situation, and only schedules flows from A if they are feasible (implicit allocation as currently done on Irish intraday auctions)
- Participant in A factors in risk that energy price moves between bid to algorithm and declaration of volumes / prices from algorithm

Central dispatch creates potential option to purchase capacity and energy in central dispatch market implicitly, but inefficiency arises due to timing mismatch for energy trades

Source: Frontier Economics

It is important to note that a continuously traded intra-day market with implicit capacity allocation (i.e. via XBID which operates across many EU borders) would only be feasible under self-dispatch. It is unlikely to be feasible under central dispatch given that intra-day re-optimisation would be carried out by way of a series of discrete runs of the algorithm.[7]

Central dispatch is also likely to create differences in the approach to ***interconnector re-dispatch arrangements***. Currently, ESO can run *ad hoc* auctions potentially multiple times a day to incentivise parties to redispatch interconnector flows (i.e. to nominate a flow against the direction of the expected commercial flows). The efficiency of such arrangements is likely to become increasingly important in ensuring efficient redispatch to manage congestion.

Under today's arrangements, despite actions being taken relatively frequently, there may be potential for ESO to make further efficient adjustments to interconnector flows. ESO typically acts during the evening peak, but further actions could be taken throughout the day where locational constraints still exist. While we cannot know precisely why ESO does not take more

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[7] We note that Italy does combine a continuously traded market (XBID) alongside its central dispatch algorithm. However, their approach undermines the benefits to ESO of being in complete control of assets intra-day, leading to potential inefficiencies in line with the current self-dispatch market.

actions, there are a number of reasons why, in principle, ESO might not be expected to achieve perfectly efficient flows. These include that:

- these *ad hoc* auction arrangements are not currently available across all interconnectors (specifically, they are not present on North Sea Link)[8]; and
- to the extent that the outcome of the *ad hoc* ESO auctions requires follow-on actions by some successful bidders to adjust their capacity holding, ESO auctions must be timed to allow such trades to be made in the intraday interconnector capacity auctions, the timing of which will vary by interconnector. This imposes a constraint on how close to gate closure these ESO auctions can take place.

A move to a central dispatch process of intra-day optimisation by re-running the algorithm could incorporate interconnector redispatch. At each stage, interconnector traders could:

- Provide ESO with their cost of importing or exporting power so that ESO can re-optimise the interconnector flows based on national prices; and
- Provide ESO with the cost of reversing the market-based flows for the purposes of redispatch for locational reasons.

Aligning intra-day runs of the algorithm and interconnector re-dispatch creates the potential for more regular and consistent redispatch actions relative to under the current arrangements. It would remain the case that, to the extent that traders have their energy cross border trades adjusted, they would need to ensure they had appropriate interconnector capacity to facilitate the change in flows.

Broader considerations

Alongside potential changes in the efficiency of outcomes, there are a range of other areas where a move to central dispatch could have an impact.

The impact on flexible resources

Given the increasing importance of flexible resources in the GB market now and in the future, any assessment should consider the impact on flexible resources and their efficient use. This is particularly important given the ongoing consultation into how to allow smaller resources and storage to operate most effectively in the balancing mechanism.

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[8] ESO currently has an exemption to their license condition which can restrict the capacity of the NSL interconnector. This can be used to help ESO balance the system. However this approach may not lead to efficient dispatch as it risks ESO deciding to reduce capacity and it then turning out that a flow over the interconnector could have been accommodated.

Central dispatch could facilitate improved market access for smaller flexible assets, particularly those which are independently owned, subject to the timing of markets:

- Under current arrangements, flexible resources may be constrained by liquidity in bilateral wholesale markets, particularly during intraday trading periods before gate closure. Intraday liquidity constraints should be removed in the central dispatch markets, subject to markets being timed in a way that ensures assets can provide flexibility.
- The need for separate participation in ESO's reserve markets may increase risk and administrative cost for smaller flexible assets. With central dispatch, co-optimisation can simplify bidding, which may reduce risks and barriers to entry for smaller storage assets.
- To the extent that central dispatch enables shorter ISPs, meaning stronger temporal price signals to resources across the market, flexible resource profitability may improve.

The transparency of market and ESO actions

A move to central dispatch may improve transparency for the market in some areas:

- Auditing the link between underlying cost drivers and pricing in bilateral markets is difficult under the current arrangements and would be likely to remain so under central dispatch. However, the link between costs and bids and offers to the algorithm would arguably be easier to review ex-post under central dispatch where bids and offers linked to individual resources would be more structured to underlying cost drivers.
- Currently, day ahead and intraday prices are observable but it is difficult to know which parties have traded at which price. If parties are settled in a centralised market (i.e. in central dispatch) there would be greater visibility of both prices and who has traded.
- Under the current arrangements, ESO takes actions across a range of balancing services markets, which may be perceived as a source of non-transparency. A single, consistent optimisation algorithm for determining co-optimised energy and balancing services should both reduce the scope for judgement in the optimisation process and improve transparency.

That said, in assessing such transparency-based benefits, it is important to bear in mind that the link between greater transparency for the market as a whole and efficiency of outcomes and prices is complex (in the extreme, transparency can be damaging for efficiency, for example if it leads to opportunities for tacit collusion). Attributing a clear benefit to improved transparency for the market is therefore difficult.

Equally, while there may be greater transparency of outcome, the dispatch algorithm itself is likely to remain subject to concerns of being a “black box”. Put another way, while outcomes may be more transparent, it may remain unclear precisely how they have been determined.

There will also inevitably remain a need for significant ESO judgement in relation to requirements for co-optimised and non-co-optimised balancing services. In this regard, it is important to note that an algorithm that is not well-understood may tend to discourage participants from forward trading for physical delivery, which requires confidence in the price associated with such delivery. Concerns in relation to the transparency of the algorithm may therefore have implications for forward liquidity.

ESO capabilities

Under central dispatch it is clear that ESO would bear responsibility for many more aspects of the market. While ESO currently undertakes some analogous processes in the balancing mechanism, the role of its systems and processes would be placed under greater scrutiny.

- Given the stronger link between its systems and the overall efficiency of outcomes, there would be more emphasis on ESO keeping the arrangements under review and developing changes to the systems when those are required to ensure ongoing efficiency.
- As the market develops and changes, there would need to be more emphasis that ESO systems and processes do not act as a barrier to change.
- There would be increased direct commercial implications flowing from ESO systems (compared to imbalance prices) and so there would be a greater need for transparency and audit.
- There are likely to be significant one-off costs associated with implementing a central dispatch system as well as costs for participants to ensure they are able to participate.

As a result, it would be important that alongside its implementation a new Governance framework is developed to ensure that the continued development of the system of central dispatch is transparent and subject to an appropriate level of industry engagement and consultation e.g. through open governance.

Alternative measures under the current framework

In the previous section, we have set out some of the key potential implications of central dispatch relative to the current self-dispatch arrangements. Given a move to central dispatch is such a significant intervention, it is also important to understand to what extent any potential benefits can be achieved through incremental reform of the current arrangements.

Based on our assessment of the potential benefits of central dispatch in the previous section, we focus on three key areas for potential incremental reform:

- Options to enable ESO to more efficiently **coordinate the energy dispatch, with its purchase of reserve and locational balancing requirements** in the period from day-ahead trading to gate closure, to achieve outcomes closer to co-optimisation under central dispatch.
- Changes to the **type and firmness of information** currently collected by ESO on costs and cost drivers to improve the basis on which ESO makes dispatch decisions in the BM and pre-gate closure.
- Changes to the way in which ESO carries out its **optimisation in the BM**, which includes pre- and post-gate closure actions and optimisation of reserve.

Below we discuss potential reform options in relation to each of these areas before considering the extent to which incremental reform could substitute for the identified potential benefits of central dispatch in the final section.

Coordination of markets

We identify market co-ordination reform options in two areas: the first related to securing benefits akin to those available from co-optimisation, the second related to interconnectors.

Co-optimisation

Above we identify potential efficiency benefits due to co-optimisation, although we note their scale is unclear. By comparing the market processes in a centrally dispatched co-optimised market with those in the current self-dispatch market we can identify three key areas of potential reform that could narrow differences in outcomes.

First, under co-optimisation, ESO takes into account a range of its potential reserve needs (across locations) when optimising dispatch at the day ahead stage.[9] Under self-dispatch ESO needs to identify these products and develop separate reserve markets. Currently, ESO

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[9] In theory, procurement of reserve services could take place before the day ahead stage. For example ESO may choose to contract for some reserve services outside of the co-optimisation process.

procures balancing and reserve services at the day-ahead stage, operates a Local Constraint Market (LCM) both day-ahead and intraday, but only conducts interconnector redispatch intraday. It is unclear whether this represents an appropriate suite of products and markets today or going forward. However, to the extent it does not, there is no clear reason why ESO cannot reform the products and services that it would purchase to be similar to those under a central dispatch algorithm day ahead.[10] The addition of the LCM demonstrates that the merits of adding markets around the existing arrangements to ensure optimisation opportunities are captured is already recognised by ESO.

Second, central dispatch markets may allow for re-optimisation of energy and reserve during the intraday period. Under the current arrangements, only limited re-optimisation takes place intra-day e.g. in relation to some interconnectors and the LCM. It is not clear that ESO has a simple route by which capacity assigned to reserve at the day ahead stage but which is no longer required can be “released”, in order to allow them to trade bilaterally. However, it should be possible to design further markets or processes to offer assets the opportunity to refine their positions in different markets in the lead up to gate closure. This would reduce the risk of assets being held inefficiently in reserve markets.

Third, since participant error in forecasting prices is a key source of inefficiency relative to a co-optimised arrangement, there may be additional information on expected system conditions which it is possible to provide in order to reduce the risk.

Fourth, co-optimisation allows for the joint procurement across all products simultaneously as this is coordinated by a single algorithm. In contrast, under current self-dispatch arrangements while Frequency Response and some reserve markets are co-optimised under ESO’s Enduring Auction Capability (EAC), this does not cover all reserve products and no reserve products are co-optimised with energy.

To improve the coordination under self-dispatch, ESO could:

- expand the existing reserve co-optimisation to more products, which would involve expanding the EAC;
- expand opportunities for re-optimisation of reserve requirements intra-day; and
- develop contingent bidding between markets, for example allowing participants to submit offer curves for reserve which are a function of the energy price (so that a participant could

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[10] ESO would need to place requirements on the assets to commit to providing the specific product / service once it has cleared in the market. If assets take actions that are inconsistent with ESO procurement, then ESO would need some form of redress (typically significant enough to ensure it would not be worthwhile for the asset to deviate from the action agreed as part of clearing in the market).

offer its capacity for reserve below a certain energy price and not above that energy price).[11]

We note, however, that facilitating such optimisation across different markets and products increases the complexity of the bidding and clearing processes (certainly relative to a co-optimisation algorithm where participants submit cost information and the complexity is addressed within the algorithm).

Interconnection

Multiple studies have shown that efficient dispatch of interconnectors is an important driver of future system operational efficiency. While the current intraday trading arrangements facilitate opportunities for redispatch, incremental improvements to this framework are possible, including:

- agreeing cross-border arrangements where they do not currently exist (i.e. on North Sea Link) and ensuring that appropriate arrangements are in place as part of the development of all future interconnectors; and
- identifying an appropriate number of intraday auctions and aligning their number and timing, so that ESO has consistent options to consider across all interconnectors.[12]

In our view, there is no clear reason why the timing and number of auctions could not be aligned with what would be expected under central dispatch. On this basis, the expected outcomes under central and self-dispatch could be very similar. In this area, we note that ESO has produced a study on Cross-Border Balancing Market Design and is working on the "Creation of an Interconnector Framework" project which is targeting delivery of an agreed Interconnector Framework implementation plan by Q4 2024/25.[13]

It is also worth noting that under both central and self-dispatch, post gate closure SO-SO arrangements would be required (though under central dispatch the timing of this would be driven by the gate closure timing in the neighbouring market).

Inefficiencies exist with the current arrangements since they are only possible on some interconnectors, and pricing is not transparent or reflective of real-time market conditions. Improvements might include implementation of appropriate arrangements on all links, greater information sharing, more frequent updating of information intra-day, and each SO offering bids and offers in its balancing market. In any case, to the extent it is possible to create more efficient SO to SO arrangements, these benefits would equally apply to both central and self-

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[11] It is reasonable to expect that such contingent bidding, if it were introduced, would be optional for participants.

[12] For example, we understand that there are four daily auctions on NGV interconnectors, but only two on ElecLink

[13] Cross Border Balancing Market Design webinar and presentation, October 2023; https://www.nationalgrideso.com/calendar/cross-border-balancing-webinar

dispatch. Therefore, it is unlikely that there are any incremental efficiency gains in SO to SO interconnector redispatch as a result of moving to central dispatch.

ESO's information set

We identify reform options in relation to ESO's information set in two areas: the first relates to ensuring ESO has a more accurate information set in relation to the capability of connected resources, and the second relates to the firmness of information on asset positioning.

Accuracy of ESO data on resource cost and capability

Inefficiencies associated with the type of information collected by ESO are well understood as a result of the ESO's BM review. ESO's Balancing Programme is seeking to address these issues.

ESO has recently introduced the Balancing Reserve (BR), which in part mitigates some of the issues related to the current set of technical parameters. The BR is an auction for assets to commit to be available day ahead. This allows ESO to make simpler dispatch decisions, since asset owners are responsible for optimising their asset's availability, subject to their technical characteristics.

Similarly, ESO is working with stakeholders in the industry to identify the most relevant parameters that would help determine whether to dispatch storage. A final assessment of this proposed reform will be available at the end of 2024.

Another reform option, which would be closer to the approach under central dispatch, would be to require participants to submit a more complex set of parameters. These parameters would reflect the underlying cost drivers of assets and based on this information, ESO would accept offers that minimise overall system costs.[14] By providing ESO with information structured to reflect more accurately cost drivers, , the ESO should be better able to optimise dispatch. For example, it would be better placed to trade off shorter and longer run times for assets with high start-up costs, which would make it easier to judge the value of waiting to dispatch inflexible assets.

Firmness of ESO asset positioning data

Under the current arrangements, ESO does not always have the flexibility to wait until gate closure to make asset positioning decisions. It has to position some assets in advance of gate closure in relation to a particular ISP, often under some level of uncertainty as to what the eventual position of that asset would be based on energy market conditions alone. We note

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[14] For example, this might include start costs under different conditions, costs to run at the stable export limit, costs to run at maximum export limit, and others.

that this is not only relevant to a system with inflexible fossil fuel plants, but will also be relevant in the future system with other dispatchable assets, in particular given the expected increase in storage capacity on the system.

To the extent this remains an issue in the future, there are some ways by which the ESO can create more firmness around the information it receives in order to more confidently optimise the system.

One option would be to move gate closure further away from delivery. This would reduce opportunities for the market to trade energy intraday to optimise energy balancing for each ISP relative to national prices but would allow the ESO to take system balancing decisions over a longer time period[15] and with more certain information as to asset positioning (we note that, during the period to real time, ESO could continue to receive relevant information such as wind forecasts from participants[16]).

While this option might increase the ability of ESO to take efficient system balancing decisions (which are expected to increase in importance in the future), it would reduce the ability of the market to optimise energy balancing. If ESO's energy balancing decisions are less efficient than those that would have been taken by the market (and it is reasonable to argue that the market is likely to be more efficient at energy balancing), a judgement would need to be made on the relative importance of these two effects. If non-energy balancing actions become more prevalent in future, allowing ESO more time and firmer information may help resolve issues in a way which reduces overall system costs. However, this is a judgement which would also be implicit to any decision to move to central dispatch, as under such arrangements ESO would be undertaking all intraday optimisation (whether for system or energy balancing).

A second option, consistent with that discussed above, would be the introduction of nearer real time reserve and constraint management markets, allowing ESO either to increase or reduce reserve holding or reposition assets for constraint management purposes after the day ahead stage, through the run up to gate closure. This would similarly provide a mechanism for ESO to secure greater certainty as to the positioning of specific assets while allowing bilateral energy markets to continue to operate.

As we note above, operating such nearer real time markets and products would increase the complexity of bidding and clearing processes relative to an earlier gate closure or a central dispatch co-optimisation algorithm.

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[15] To address time constraints alone, ESO may be able to speed up its optimisation and dispatch processes. However, while time pressure is undoubtedly an issue, it is likely that the ability to have control over the state of assets is the more important factor, and improved processes would not address this issue.

[16] If participants are not facing the commercial consequences of their forecasting, these forecasts may be inaccurate, However, it may be possible to incentivise participants to submit accurate forecasts.

A further option might be to try to gather more accurate information in the period leading up to gate closure, in particular with respect to Initial Physical Notifications (IPNs)[17].

There are clearly valid reasons for differences between IPNs and FPNs, not least relating to changes in the information set available to participants over time. More systematic checks of movements in IPNs may help to identify situations in which IPN submission has not been consistent with Good Industry Practice. However, it would imply an extra cost burden for ESO and participants.

Direct financial incentives could also be introduced in relation to FPNs, including using the Information Imbalance Charge which, if set to a non-zero number, could financially penalise participants whose actual output deviates from their FPN. This would increase risk for participants, and so the benefit would have to be considered in this context.

ESO optimisation process

We identify two ESO optimisation reform options:

- First, as an improvement to its current approach in which ESO accepts BM bids and offers on the basis of a partial optimisation (informed by judgement as to the nature of the likely optimal actions), ESO could implement a system-wide nodal optimisation algorithm, and use it to identify efficient bids and offers to accept (for both energy and system balancing purposes). This would require the implementation by ESO of a new algorithm and (as discussed above) the inclusion of more technical information in BM bids and offers, but this would be no different to the implementation required in any case under central dispatch.

- Second, ESO could consider refinement of its optimisation approach to extend over longer time periods, in order to allow ESO to dispatch efficiently assets whose output in future periods depends on early actions (e.g. assets which require positioning, or storage assets). As more storage is expected on the GB system over the coming years, of increasing duration, this will become more and more important. The optimisation of storage (and any other time-limited dispatch options) will be important for any new algorithm that is developed under either market framework. However, the effectiveness of such an optimisation process may depend on some of the reforms discussed above related to ensuring ESO has more firm information in relation to the positioning of assets.

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[17] Improved information on Final Physical Notifications (FPNs) may also be of value

Conclusions

In the first part of our assessment, we note that the overall impact of a move to central dispatch on efficiency grounds depends on the design and ongoing evolution of the dispatch algorithm relative to bilateral trading and the operation of the BM, and conclude that it is therefore difficult to take any firm view. However, we also concluded that if we assume that an algorithm could be implemented which is as efficient as the current arrangements, there are further potential advantages from a move to central dispatch, albeit that there are important uncertainties in relation to the likelihood of achieving each.

In the second part of our analysis, we assess the extent to which reforms to the current arrangements could replicate all or part of these potential advantages. We summarise the potential advantages and scope for incremental reform to replicate them in Table 2.

Table 2 Assessment of incremental reform options against potential central dispatch benefits

Potential area of advantage	Nature of central dispatch benefit	Reform options available?
Co-optimisation	Increased efficiency as a result of algorithm simultaneously dispatching for energy and ancillary services. Scale of benefit depends on algorithm's efficiency and scale of inefficiency today.	Yes, reform options available to improve the coordination and optimisation of separate energy and reserve markets intra-day relative to the status quo, though limits in terms of complexity of the market arrangements required to replicate an idealised algorithm
Sharper price signals – time & location	Improved ability to move to 5 minute ISP and to more granular zonal definition. Scale of benefit depends on ability of market to respond to more granular price signals and broader implications (e.g. increased participant risk, liquidity)	No – while an ISP of 15 minutes is clearly achievable with self-dispatch, achieving 5 minute ISP and/or highly granular zonal market likely to be very difficult.
Accuracy of ESO information	Closer link between ESO data and cost drivers of connected resources	Yes, information supplied to ESO could more closely match underlying cost drivers of assets, similar to that supplied to a

Potential area of advantage	Nature of central dispatch benefit	Reform options available?
		central dispatch algorithm, though a significant change to ESO and participant systems required
Firmness of ESO information	Greater certainty for ESO of positioning of asset ahead of gate closure	Yes, range of options including longer gate closure and incentives to supply more accurate forecasts to ESO. However, efficiency of energy balancing may be reduced by moving to longer gate closure.
Efficiency of interconnector redispatch	Centralised process and timetable more likely to catalyse harmonisation of intraday interconnector capacity and redispatch arrangements, but unlikely to change SO to SO arrangements	Yes, no clear reason why the timing and number of auctions could not be aligned with what would be expected under central dispatch (key constraint, as is also the case for central dispatch, is likely to be agreement of interconnected TSOs)
Accessibility for smaller flexible resources	Centralisation of optimisation away from participants means that (especially smaller) players with flexible assets may face lower barriers to entry e.g. they simply have to provide bids with costs and technical characteristics to single algorithm.	No – no clear way to achieve the same outcome in self-dispatch market
Transparency of market and ESO actions	Greater link between cost drivers and pricing may increase transparency for the market. Use of algorithm may reduce (some aspects of) ESO judgement	Yes, if information supplied to ESO is changed to more closely reflecting underlying cost drivers (as noted above) though a significant change to ESO and participant systems required

Source: Frontier Economics

Our analysis indicates that while there are some areas in which it may be difficult to replicate the potential benefits of central dispatch, in the majority of areas there are incremental reform options which could be expected to partially or fully replicate the benefits identified. We note that some of these (such as changes to the information set received in BM bids and offers and changes to ESO’s approach to optimisation) would involve significant time and effort to achieve. However, these are still likely to be smaller than the effort required to move to a central dispatch regime. Furthermore, by continuing to leave a greater role for optimisation with the market, overall they would come with a lesser risk that market efficiency would be dependent on an as-yet undefined algorithm, and that the systems and processes of a new institution (NESO) would be moved to a much more pivotal role in commercial outcomes in the market.

Given this, while we recognise that the decision by its nature will be highly judgement based, in our view it will be difficult to conclude with confidence that the potential benefits of central dispatch are sufficiently strong to outweigh the implementation costs and risks highlighted by DESNZ.