

6<sup>th</sup> August 2025

# Net Transfer Capacity Innovation Project

Final report

Report by FTI Consulting for NESO



## Disclaimer

This report has been prepared by FTI Consulting LLP ("FTI") for the National Energy System Operator ("NESO") under the terms of the Agreement dated 27 January 2025 (the "Contract").

This report has been prepared solely for the benefit of NESO in connection with assessing the feasibility of a Net Transfer Capacity market and alternative options to reduce the usage of Net Transfer Capacity restrictions.

The report can be disseminated as provided for under the relevant terms of the Contract, but no party other than NESO is entitled to rely on it for any purpose whatsoever.

This report is not to be referred to or quoted, in whole or in part, in any registration statement, prospectus, public filing, loan agreement, or other agreement or any other document, or used in any legal, arbitral or regulatory proceedings without the prior written approval of FTI.

FTI accepts no liability or duty of care to any person (except to NESO under the relevant terms of the Contract) for the content of the report. Accordingly, FTI disclaims all responsibility for the consequences of any person acting or refraining to act in reliance on the report or for any decisions made or not made which are based upon such report.

The report contains information obtained or derived from a variety of sources. FTI does not accept any responsibility for verifying or establishing the reliability of those sources or verifying the information so provided.

Nothing in this material constitutes investment, legal, accounting or tax advice, or a representation that any investment or strategy is suitable or appropriate to the recipient's individual circumstances, or otherwise constitutes a personal recommendation.

No representation or warranty of any kind (whether express or implied) is given by FTI to any person as to the accuracy, completeness, reliability or adequacy of the report or of the information provided therein.

The report is based on information available to FTI at the time of writing of the report and does not take into account any new information which becomes known to us after the date of the report. We accept no responsibility for updating the report or informing any recipient of the report of any such new information.

All copyright and other proprietary rights in the report remain the property of FTI and all rights are reserved.

Copyright Notice

© 2025 FTI Consulting LLP. All rights reserved.

# Contents

Disclaimer .....	2
1. Introduction and context.....	5
A. Purpose of this report.....	5
B. Report structure .....	7
2. NESO's role in managing the GB electricity system.....	9
A. NESO's obligations.....	9
B. System management tools at NESO's disposal .....	9
C. NTC restrictions.....	11
3. Drivers of need for NTC restrictions in GB.....	14
A. Network constraints .....	14
B. Largest system loss.....	17
C. Margin extremes.....	19
D. Implications for NTC restrictions.....	20
4. Current GB NTC restriction arrangements .....	21
A. GB NTC Calculation Policy .....	21
B. NTC Commercial Arrangements methodology .....	24
C. Intraday Trading/Transfer Limits .....	25
D. Summary of current NTC restriction and ITL arrangements by IC.....	25
5. Benefits and drawbacks of the status quo .....	27
A. Assessment principles .....	27
B. Assessment of the status quo.....	28
C. Conclusion on the status quo arrangements.....	35
6. The potential for an NTC market in GB.....	36
A. Overview of a potential NTC market .....	36
B. Quantitative assessment of a possible NTC market.....	47
C. Design considerations for a potential NTC market in GB .....	66
D. Assessment of an NTC market.....	71
E. Conclusions on the NTC market.....	78
7. Alternative mechanisms to reduce reliance on non-market NTC restrictions .....	80
A. Options to reduce reliance on non-market NTC restrictions .....	80
B. Trades.....	81

C. Quantitative analysis of an Extended Trades market.....	85
D. Challenges of Trades .....	94
E. Assessment of an Extended Trades market.....	96
F. Conclusions on Extended Trades.....	102
8. Conclusions.....	104
A1. NTC Calculation Policy by system issue.....	108
A2. Example NTC compensation methodologies .....	110
A3. Summary of ICs' views on the current NTC restriction arrangements .....	112
A4. Illustrative examples of savings in an NTC market .....	114
A5. Historical data on NTC restriction/ITL usage.....	118
A. Historical data used in our analysis.....	118
B. Historical data limitations.....	118
A6. FTI modelling outputs.....	119
A7. NTC market sensitivity analysis.....	124
A8. Battery price received assumption .....	126
A9. Illustrative examples of savings in an Extended Trades market .....	128
A10. Extended Trades market sensitivity analysis.....	130
A11. Glossary .....	132

# 1. Introduction and context

- 1.1. In common with many other jurisdictions, the electricity network of Great Britain (“GB”) is undergoing a fundamental change in pursuit of Net Zero ambitions. The growth of renewable generation capacity, and the geographic dispersion of that generation capacity, is causing the supply of electricity to become increasingly intermittent and to worsen operational constraints on the electricity network.
- 1.2. Interconnectors (“ICs”), transmission cables connecting GB to neighbouring jurisdictions, can play an important role in the transition to Net Zero, by helping to manage the intermittency and stability of supply. At times, ICs act as a source of additional supply to the GB network (when flowing electricity into GB), while at others they act as a source of additional demand (when flowing electricity out of GB). This means that, by varying the flow of power into or out of specific points on the network, ICs can help alleviate or worsen intra-GB transmission congestion.<sup>1</sup> ICs can also, at times, represent the largest source of demand or supply on the GB network, and can therefore have implications for system management in the event of a sudden IC outage.
- 1.3. The interplay between the operation of the GB internal transmission network and the cross-border ICs is complex and challenging. National Energy System Operator (“NESO”),<sup>2</sup> which is responsible for operating the GB electricity system, must actively consider the role of ICs in the day-to-day operation of the system. Concretely, NESO currently uses a range of tools to manage constraints and ensure compliance with the Security and Quality of Supply Standard (“SQSS”) in line with its licence. For example, it can call on a suite of ancillary services to meet system needs and utilise the Balancing Mechanism (“BM”) to redispatch generators post gate closure. NESO also has specific system management tools for ICs.

## A. Purpose of this report

- 1.4. One specific system management tool that NESO can use in relation to ICs is Net Transfer Capacity (“NTC”) restrictions. This is a tool that allows NESO to adjust the maximum capacity an IC can offer to market participants, thereby

---

<sup>1</sup> For more detail on both the system need for and the potential impact of ICs, from a system operability perspective, please see: NESO, ESO analysis to support Ofgem’s Third Cap and Floor Window and MPI Pilot Regulatory Framework, August 2022 ([link](#)).

<sup>2</sup> National Grid Electricity System Operator was separated from National Grid and acquired by the government, becoming NESO on 1 October 2024. See DESNZ, National Energy System Operator and Elexon: Decision notice, 13 September 2024 ([link](#)). In this report we use the term NESO to refer to both the current organisation and its predecessor forms (for example, National Grid ESO) in prior years, always in the role of a system operator.

restricting the envelope of maximum import and/or export of power into or out of GB.

- 1.5. Since the tool was introduced in 2021, NTC restrictions have been used to help manage the increasing operational challenges faced by NESO as part of the Net Zero transition.
- 1.6. NTC restrictions are a non-market-based mechanism, meaning NESO's use of the tool does not utilise a competitive procurement process. Instead, NESO calculates and applies NTC restrictions to meet system needs without consideration of cost, which is only determined ex-post, in line with a predetermined methodology (referred to as the "NTC Commercial Arrangements methodology" in this report). NESO is also required to spread NTC restrictions across each IC that is deemed to contribute to a particular operational challenge (for example an intra-GB transmission constraint) equitably, without considering the cost of doing so.
- 1.7. However, NESO's licence requires that balancing services are procured via market-based procedures.<sup>3</sup> NTC restrictions, in GB, are considered to be non-frequency balancing services.<sup>4</sup> To use NTC restrictions, NESO has therefore been required to seek multiple derogations from this licence condition, which Ofgem most recently granted in September 2023.<sup>5</sup>
- 1.8. As part of granting the derogations, Ofgem has stipulated several requirements and expectations for NESO, for example that NTC restrictions should only be used when all other (non-emergency) options are exhausted. NESO is also required to:<sup>6</sup>
  - i. *"re-evaluate the continued need for NTC"; and*
  - ii. *"provide evidence to us on where it is developing alternative solutions which reduce reliance on non-market-based balancing options".*
- 1.9. In this context, NESO has commissioned FTI Consulting ("FTI") to i) examine the current framework that governs NESO's use of NTC restrictions and its merits, and ii) assess the feasibility of potentially allocating NTC restrictions via a

---

<sup>3</sup> Specifically, Electricity System Operator Licence Condition C1 ([link](#)). Previously, this was Standard Licence Condition C28 ([link](#)).

<sup>4</sup> Ofgem, Decision to grant the Electricity System Operator an extension to derogation from Standard Licence Condition C28.4(h)(i) for Net Transfer Capacity, 28 September 2023, page 1 ([link](#)).

<sup>5</sup> Ofgem, Decision to grant the Electricity System Operator an extension to derogation from Standard Licence Condition C28.4(h)(i) for Net Transfer Capacity, 28 September 2023 ([link](#)). This is now Licence Condition C1.5(a)(i) of the Electricity System Operator Licence ([link](#)).

<sup>6</sup> Ofgem, Decision to grant the Electricity System Operator an extension to derogation from Standard Licence Condition C28.4(h)(i) for Net Transfer Capacity, 28 September 2023 ([link](#)), pages 7-8.

market (that is, an “NTC market”) and other alternative options to reduce NESO’s reliance on NTC restrictions in their current form.

- 1.10. Our analysis is undertaken on the assumption that the existing GB market design and regulatory frameworks will broadly persist in its current form (for example, excluding the possibility of a fundamental evolution in GB-EU cross-border trading relationships such as rejoining the Internal Energy Market “IEM”). We have also not considered whether modifications to the Grid Code could be used to remove the requirement for NTC restrictions to be market-based.
- 1.11. We understand from NESO that it will soon conduct a ‘call for input’ and seek views from key industry stakeholders on the current NTC Commercial Arrangements methodology, which determines how ICs are compensated for being subject to an NTC restriction. We do not focus our analysis on the detail of these arrangements within this report.

## B. Report structure

- 1.12. The remainder of this report is structured as follows:
  - i. In **Section 2**, we discuss NESO’s role in managing the GB electricity system and the tools, including NTC restrictions, it utilises to do so.
  - ii. In **Section 3**, we set out the drivers of need for NTC restrictions and the factors NESO considers when deciding whether to use NTC restrictions, as well as how these drivers are expected to evolve in the future.
  - iii. In **Section 4**, we summarise the specific arrangements that currently govern NESO’s use of NTC restrictions and how ICs are compensated.
  - iv. In **Section 5**, we evaluate the benefits and drawbacks of the current NTC restriction arrangements.
  - v. In **Section 6**, we assess the potential for an NTC market in GB, as a possible alternative to the current status quo.
  - vi. In **Section 7**, we explore the prospects for enhancements to NESO’s existing trading activities to provide an alternative mechanism to reduce reliance on the status quo NTC restriction arrangements.
  - vii. In **Section 8**, we conclude on the current arrangements, the potential for an NTC market, and enhancements to NESO’s trading activities.

- 1.13. This report is accompanied by eleven appendices, covering topics as follows:
- i. Additional detail on NESO's NTC restriction policies (**A1 and A2**).
  - ii. An anonymised summary of IC owners' views on the current NTC restriction arrangements (**A3**).
  - iii. Illustrative examples to support our analysis of an NTC market or alternative options to (**A4 and A9**).
  - iv. Additional detail on our quantitative analysis, including the historical data, assumptions and model used, as well as our full results (**A5, A6, A7, A8 and A10**).
  - v. A glossary of defined terms (**A11**).



## 2. NESO's role in managing the GB electricity system

- 2.1. In this section, we discuss at a high-level NESO's obligations in relation to managing the GB electricity system (Section 2.A), and briefly describe the suite of system management tools at NESO's disposal (Section 2.B). We then describe in further detail NESO's system management tools which relate specifically to ICs, including NTC restrictions (Section 2.C).

### A. NESO's obligations

- 2.2. As part of maintaining the security of the GB electricity system, NESO is obliged to ensure compliance with SQSS, which sets out the criteria and methodologies for planning and operating the GB transmission system.<sup>7</sup> This includes, for example, limits on frequency deviations and voltage levels that NESO must adhere to when operating the system.
- 2.3. NESO must also operate within certain conditions as part of its Electricity System Operator licence. Electricity System Operator Licence Condition C1.2 stipulates that *"In carrying out its responsibilities in relation to operating the National Electricity Transmission System [...] the licensee must use its best endeavours to promote economic and efficient overall expenditure with respect to actions taken to operate the Total Electricity System"*.<sup>8</sup> In particular, under Electricity System Operator Licence Condition C1.5(a)(i), NESO is required to ensure that the procurement of balancing services is *"subject to transparent, non-discriminatory and market-based procedures"*.<sup>9</sup>

### B. System management tools at NESO's disposal

- 2.4. When a system operation issue arises, NESO chooses between the variety of tools it has at its disposal to ensure system security. In some circumstances, there may be multiple options to solve an issue. For example, a thermal constraint could potentially be resolved in the BM by constraining off one resource ("behind constraint") and instructing another resource elsewhere on the system ("in front of constraint") to replace the energy. Depending on the specific demand, supply and transmission conditions, the choices available to NESO may be more or less limited.

---

<sup>7</sup> Ofgem, Security and Quality of Supply Standard (SQSS) ([link](#)).

<sup>8</sup> Electricity System Operator Licence Condition C1.2 ([link](#)).

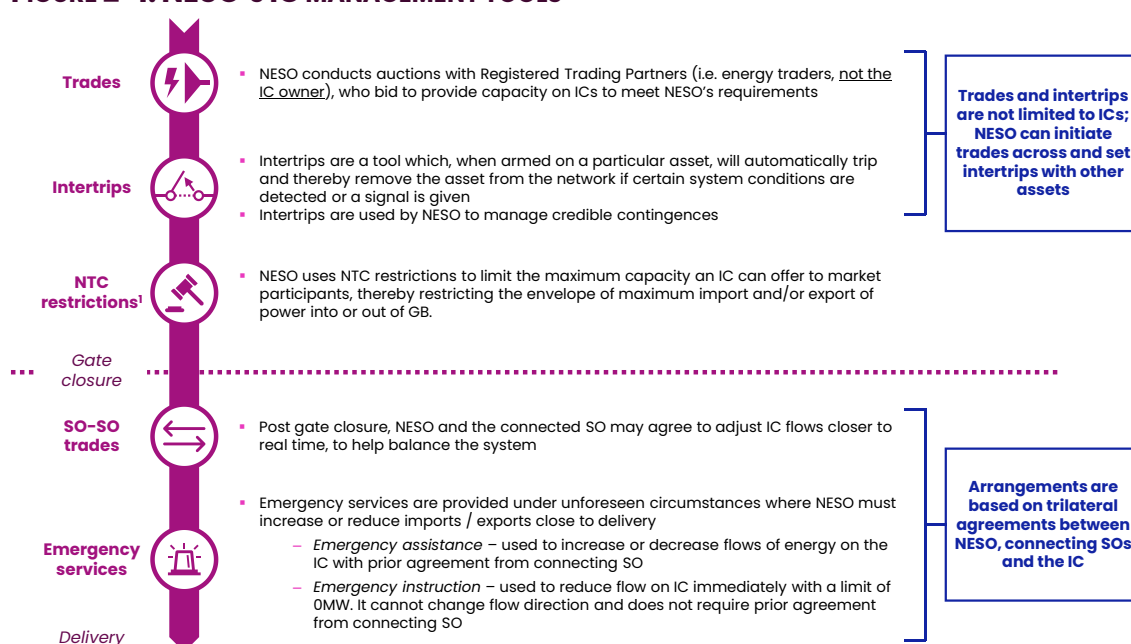
<sup>9</sup> Electricity System Operator Licence Condition C1.5(a) ([link](#)).

- 2.5. Key system management tools that NESO can currently use include:
- i. **The BM**, which is NESO's primary system management tool, is a post-gate-closure process in which NESO can buy and sell electricity from market participants in order to manage the GB electricity system in real time. This process is often referred to as "redispatch", as it involves participants changing their intended output (or consumption), as determined through the wholesale electricity market, in line with NESO's instructions. In making such decisions, NESO will consider the cost of bids and offers of market participants, as well as the technical, operational and locational characteristics of each participant.<sup>10</sup>
  - ii. **Ancillary services** are a suite of services procured by NESO to target specific system needs. For example, frequency response services are used to maintain system frequency by increasing or reducing the generation or demand of market participants, either in response to specific system conditions or instructions from NESO.<sup>11</sup> Ancillary services are procured through a range of mechanisms, including daily auctions and long-term contracts. There are also services which are associated with technical or operational requirements rather than market-based procurement decisions. These are mandated to ensure compliance with the Grid Code and to maintain system security.
- 2.6. Importantly, ICs are currently unable to participate in the BM and therefore cannot be redispatched in the same way as most other types of generation or demand. Instead, NESO can call upon a collection of other system management tools that can alter the flows across ICs. Figure 2-1 below summarises the IC management tools that NESO can currently utilise.

---

<sup>10</sup> NESO, What is the Balancing Mechanism? ([link](#)).

<sup>11</sup> NESO, Frequency response services ([link](#)).

**FIGURE 2-1: NESO's IC MANAGEMENT TOOLS**

*Note: Some ICs may be subject to Intraday Transfer/Trading Limits, effectively an older version of NTC restrictions. See paragraph 4.19 for details on the differences.*

*Sources: (1) Methodology for GB Commercial Arrangements relating to Interconnector Capacity Calculation, September 2023 ([link](#)); (2) Interconnector Trading Procurement Framework ([link](#)); (3) NESO: SO-SO Trades ([link](#)); and (4) P443 Workgroup Meeting 4, Elexon ([link](#)).*

## C. NTC restrictions

- 2.7. NTC restrictions are a tool that allows NESO to adjust the maximum capacity an IC can offer to market participants (for example to energy traders via explicit IC capacity auctions), thereby restricting the envelope of maximum import and/or export of power into or out of GB.<sup>12</sup> NTC restrictions are set for hourly periods, in line with the current minimum duration offered by GB ICs via capacity auctions.<sup>13</sup>
- 2.8. The ability for NESO to use NTC restrictions to define an envelope of possible flows, without necessarily impacting the scheduled or planned flows of the IC, means the tool is particularly useful in planning for and mitigating against credible contingencies (for example, a generator fault or a sudden reversal of

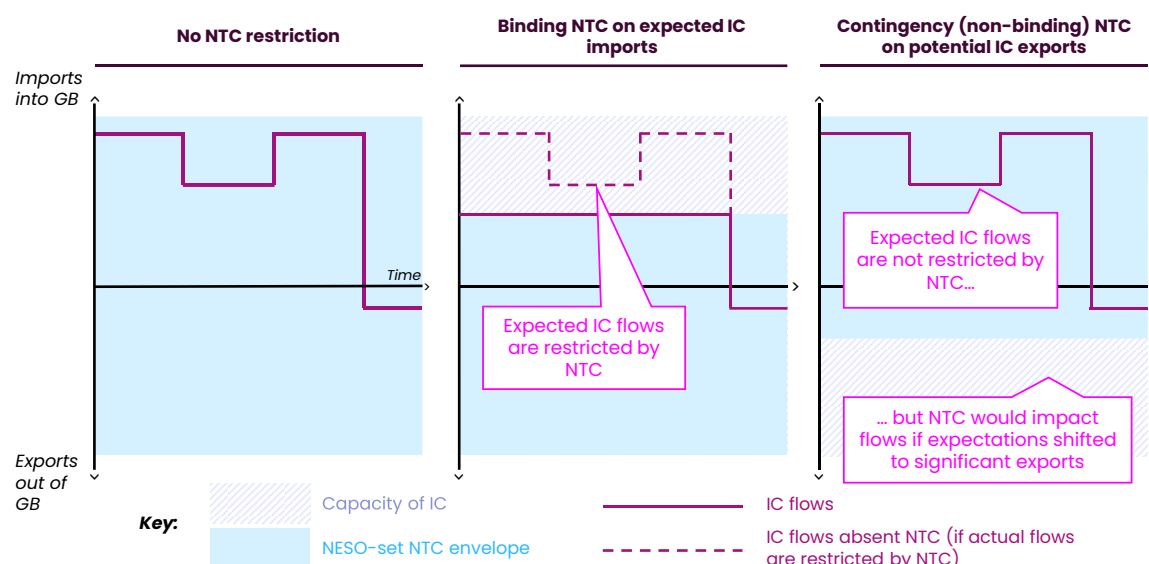
<sup>12</sup> As noted in Figure 4-2, some ICs use ITLs instead of NTC restrictions. These differ slightly and we discuss this in more detail later on in Section 4.

<sup>13</sup> Some GB ICs are exploring the possibility of introducing 30 minute capacity products in future. For example, see the 30-Minute Intraday Product Design Request for Feedback ([link](#)).

IC flows)<sup>14</sup> ahead of time. In these circumstances, NESO may set NTC restrictions that are ‘non-binding’ (that is, set in the opposite direction to scheduled or expected direction of IC flows based on current market conditions). Such restrictions are deployed in situations where NESO has identified that a change in the IC’s scheduled or expected flows would result in a system security issue that cannot be solved by other means.<sup>15</sup> These non-binding restrictions contrast with ‘binding’ restrictions, where scheduled or expected flows based on the current market conditions are restricted by the NTC restriction.

- 2.9. In Figure 2-2 below, we illustrate different scenarios of NTC restrictions, including whether or not the restriction is binding (impacting scheduled or expected flows) or set for contingency reasons (set opposite to the scheduled or expected direction of flows).

**FIGURE 2-2: ILLUSTRATION OF BINDING AND CONTINGENCY NTC RESTRICTIONS**



Source: FTI analysis.

- 2.10. NTC restrictions are also used by other System Operators (“SOs”) in Europe, governed by the Capacity Allocation and Congestion Management (“CACM”) regulation.<sup>16</sup>

<sup>14</sup> For example, consider a situation where GB wholesale prices are forecast to be relatively high compared to its connected market, meaning GB ICs are scheduled to import into GB. Suppose that closer to delivery, a significant generator failure in a connected country, such as France, occurs, increasing French wholesale prices significantly above GB’s. This would drive reversal in the direction of IC flows (from imports into GB, to exports out of GB) potentially driving intra-GB import constraints.

<sup>15</sup> For example, it could be the case that an IC is scheduled to import at full capacity into GB, but that if it were to instead fully export out of GB, a network constraint limit would be breached. In this circumstance, NESO may be required to set an NTC restriction on the export flows of this IC, despite this restriction having no impact on the planned operation of the IC.

<sup>16</sup> We do not consider the use of NTC restrictions by SOs other than NESO in detail as part of this report.

- 2.11. An IC's available capacity for any given time period is therefore set at the minimum of three factors:
- i. the IC's technical capability, as determined by the IC owner, which depends on the asset rating, condition and any relevant outages;
  - ii. the NTC restriction calculated by NESO to manage largest system loss, network constraints or margin extreme related system issues;
  - iii. the NTC restriction calculated by the connecting SO.
- 2.12. As set out earlier in paragraph 1.6, in GB, NTC restrictions are a non-market-based mechanism. However, NTC restrictions are classed as a non-frequency balancing service, meaning they fall within the scope of Electricity System Operator Licence Condition C1, which requires market-based procurement of services (as set out in paragraph 2.3 above). NESO has therefore been required to seek derogations from its licence to use NTC restrictions,<sup>17, 18</sup> which have been granted by Ofgem on the expectation that NESO will only utilise NTC restrictions as a last resort when other (non-emergency) options, such as Trades, have been exhausted and one of the following issues remain:<sup>19</sup>
- i. Network constraints, including thermal, voltage or stability constraints;
  - ii. Largest system loss in the context of frequency management; and
  - iii. Margin extremes.
- 2.13. In the following section, we further explain the three system issues outlined above which are the drivers of need for NTC restrictions and discuss how these needs are likely to evolve over time.

---

<sup>17</sup> As explained in paragraph 1.7, NESO's licence requires that balancing services, such as NTCs, are procured via market-based procedures.

<sup>18</sup> Ofgem, Decision to grant the Electricity System Operator an extension to derogation from Standard Licence Condition C28.4(h)(i) for Net Transfer Capacity, 28 September 2023 ([link](#)).

<sup>19</sup> We explain each system issue in more detail in Section 3.

### 3. Drivers of need for NTC restrictions in GB

- 3.1. As set out in Section 2, NESO uses NTC restrictions to manage three specific system issues, namely: i) network constraints; ii) largest system loss; or iii) margin extremes.
- 3.2. In the following sections, we explain each system management issue and further discuss how each issue is likely to evolve over time given the transition to Net Zero.

#### A. Network constraints

- 3.3. Network constraints refer to physical constraints on the transmission system.<sup>20</sup> For example, thermal constraints, which occur when the volume of energy that is scheduled to flow through a given transmission line based on wholesale market outcomes (which, under GB's national market design, do not consider network constraints) exceeds the thermal capacity of that transmission line. Without intervention from NESO to reduce the scheduled energy flows, the line would be overloaded, causing damage to equipment and potentially equipment failure.
- 3.4. ICs, as large sources of both demand or supply of energy, can exacerbate or mitigate thermal constraints in GB's transmission network. NTC restrictions can therefore be used to manage and secure these constraints by limiting potential changes to IC flows and, in turn, the energy flowing through the GB transmission network.

#### Evolution of network constraint management requirements

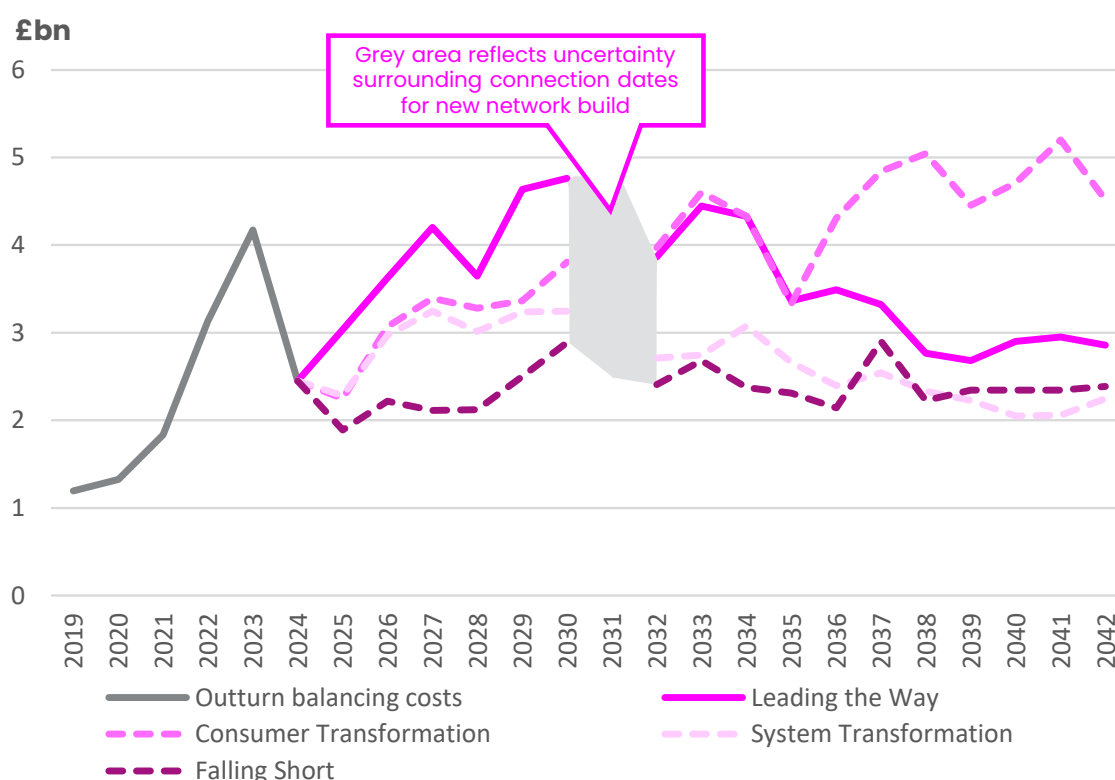
- 3.5. As GB's generation fleet decarbonises, with gas increasingly being displaced by renewables such as wind and solar, capacity is now often located away from centres of demand. Consequently, there is a need to transport a growing volume of energy through the transmission system from where it is generated to where it is consumed.
- 3.6. For example, significant volumes of offshore wind have been constructed off the coast of Scotland (at the northern end of the network), far from centres of demand in the South. At times, the volume of generation from these plants that is scheduled in GB's wholesale energy market exceeds both local Scottish demand and the capacity of the transmission network to transport it

---

<sup>20</sup> There are four forms of network constraints that NESO can use NTC restrictions to manage: thermal, voltage, stability and inertia.

southwards to other regions of GB.<sup>21</sup> Consequently, NESO is now increasingly required to intervene to ensure the capacity of the network is not exceeded, which typically includes BM actions, but may also include the use of NTC restrictions in the event that other tools are not sufficient. Given GB's ambitious offshore wind targets,<sup>22</sup> network constraints (and, in particular, the North-South constraints described here) are expected to continue to grow in future.

**FIGURE 3-1: NESO HISTORICAL AND PROJECTED BALANCING COSTS**



Source: FTI analysis of NESO, *Balancing Costs: Annual Report and Future Projections*, May 2024 ([link](#)).

- 3.7. In addition to generation capacity becoming more geographically dispersed, GB's electricity demand is also evolving. IC capacity has grown significantly over recent years, particularly in the South East of GB. When GB wholesale prices are low relative to continental Europe, these ICs represent a large additional source of GB demand (c.5GW in the South East of GB as of the start of 2025),<sup>23</sup> which can drive network constraints in the immediate surrounding areas and/or exacerbate the North-South constraints discussed above (for example, by acting as sources of demand, effectively 'pulling' generation from the North

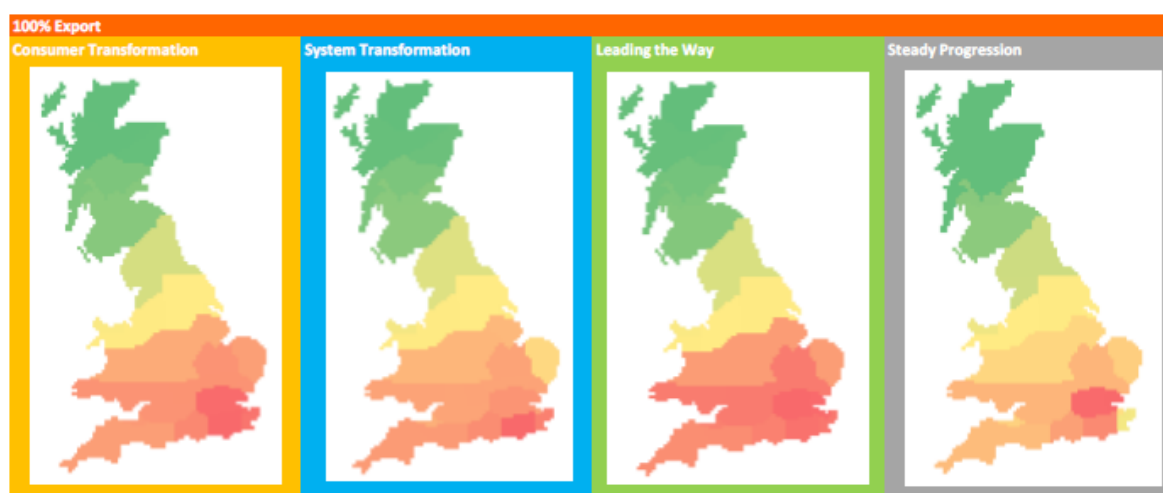
<sup>21</sup> For example, in our recent assessment of a zonal market design in GB, we found that significant volumes of wind generation are constrained off (that is, for their generation to be turned down) in North GB in the BM to manage constraints. See FTI Consulting, *Impact of a Potential Zonal Market Design in Great Britain*, 24 February 2025 ([link](#)): pages 21, 28 and 29.

<sup>22</sup> Clean Power 2030 requires material growth in offshore wind (from 15 GW in 2023 to 43-50 GW in 2030). See NESO, *Clean Power 2030*, page 18 ([link](#)).

<sup>23</sup> See Ofgem, *Interconnectors* webpage ([link](#)). Includes IFA, ElecLink, BritNed, and Nemo Link.

of GB to be exported to Europe). In turn, this can, at times, increase the need for NESO to intervene to manage network constraints and credible contingencies, with IC-driven constraints in particular potentially necessitating NTC restrictions to solve. The impact of IC flows on constraints was examined by NESO in the context of the Third Cap and Floor Window, as set out in Figure 3-2 below.

**FIGURE 3-2: HEAT MAP FOR CONSTRAINT COSTS FOR IC WITH 100% EXPORTS**



Source: NESO, *Analysis to support Ofgem's Third Cap and Floor Window and MPI Pilot Regulatory Framework*, August 2022, page 11 ([link](#)).

- 3.8. Following Ofgem's recent Window 3 decision, IC capacity in the South East could increase to 13 GW by 2032,<sup>24</sup> potentially driving greater volumes of network constraints and resulting NESO actions. Indeed, NESO's own analysis as part of Cap and Floor Window 3 has identified that additional ICs, when primarily exporting, can exacerbate intra-GB constraints.<sup>25</sup>

<sup>24</sup> Includes IFA, IFA2, BritNed, Nemo Link, ElecLink, NeuConnect, LionLink, Nautilus, Tarchon and ElecLink 2. Excludes Ofgem Cap & Floor approved ICs to France (GridLink and FAB Link) due to the French energy regulator determining that only 1 GW of additional capacity would be beneficial, and naming ElecLink 2 as the most interesting option. See CRE, Public consultation no.2024-01, 5 March 2024, page 1 ([link](#)).

<sup>25</sup> NESO, *ESO analysis to support Ofgem's Third Cap and Floor Window and MPI Pilot Regulatory Framework*, August 2022, page 11 ([link](#)).



- 3.9. However, the exact future evolution of network constraints is uncertain and will be impacted by a variety of factors, most critically the extent to which the capacity of GB's transmission network is increased (for example, under the recent Clean Power 2030 and Beyond 2030 plans) and possible market reforms to introduce greater locational signals through the Department for Energy Security & Net Zero's ("DESNZ") Review of electricity market arrangements ("REMA") process.<sup>26, 27</sup>

## B. Largest system loss

- 3.10. A sudden large loss from the GB network, such as following a generator fault, disrupts the balance between generation and demand. In turn, this mismatch causes deviations in system frequency. If a deviation in system frequency is too large, it can lead to equipment damage and potentially even cascading impacts on the wider system (in extreme cases potentially leading to power outages). NESO therefore manages system frequency, including by deploying frequency response products which are designed to automatically adjust power output in response to deviations.<sup>28</sup>
- 3.11. The rate of change of frequency ("RoCoF") is impacted by the size of the loss: a larger loss will result in higher RoCoF. However, RoCoF is reduced if there is high inertia in the system (that is for any given imbalance between supply and demand of energy, the higher level of inertia<sup>29</sup> on the system, the lower the RoCoF will be).
- 3.12. If, at the prevailing level of inertia, the frequency response services available to NESO are not sufficient to contain system frequency in the event that the largest loss on the system unexpectedly trips offline, it may be required to reduce the size of that largest loss.<sup>30</sup>

---

<sup>26</sup> NESO's recent Clean Power 2030 publication states that to meet the Clean Power 2030 target, twice as much transmission network buildout is required in the next five years than was achieved in in the last decade. See NESO, Clean Power 2030, page 4 ([link](#)). See also NESO, Beyond 2030 ([link](#)).

<sup>27</sup> DESNZ, Review of Electricity Market Arrangements: Summer Update, 10 July 2025, page 5 ([link](#)).

<sup>28</sup> NESO is required to maintain frequency across GB's electricity network within one percent (0.5 Hz) of 50 Hz. Routinely in normal conditions, NESO set a tighter internal requirement of maintaining frequency within 0.2 Hz of 50 Hz. See NESO, What is frequency? webpage ([link](#)).

<sup>29</sup> Inertia refers to the store of kinetic energy within rotating masses that are synchronised to the network. Commonly, it is provided by synchronous thermal generators (for example gas and nuclear), although it can also be produced by machines that produce no electrical output, such as synchronous condensers. High inertia is beneficial for system management because it means system frequency is less sensitive to imbalance in supply and demand.

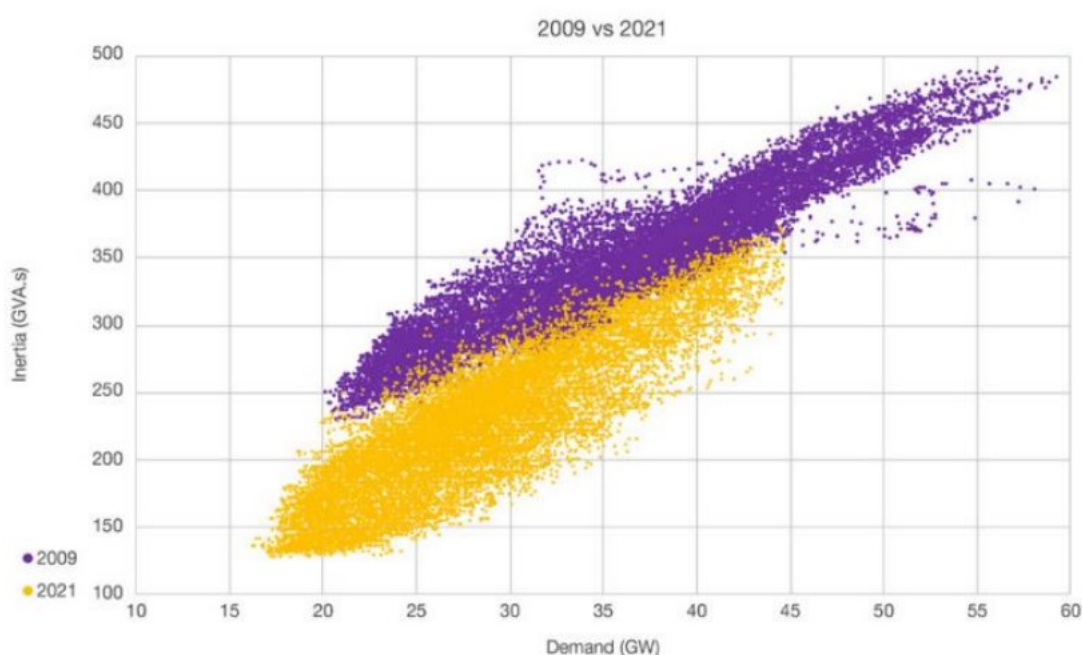
<sup>30</sup> Alternatively, NESO could also choose to increase system inertia, for example by synchronising additional thermal generators.

- 3.13. NTC restrictions can be used to limit the largest system loss in instances where the sudden loss of an IC (either importing or exporting) would breach frequency limits and operating thresholds set out in the SQSS.

### Evolution of largest loss system management requirements

- 3.14. As set out above, the sensitivity of GB's system to large losses is broadly a function of three factors:
- the level of inertia in the GB network and the resulting RoCoF in response to a disturbance;
  - the size of the largest loss on the system; and
  - the availability of frequency response services.
- 3.15. Synchronous generation technologies, such as nuclear and gas, produce significant inertia as a by-product of generation. Inverter-based generation such as wind and solar, however, produce no significant inertia when generating. The shift towards inverter-based renewables that is occurring as part of the energy transition is therefore driving a fall in GB inertia levels, as shown in Figure 3-3 below.

**FIGURE 3-3: COMPARISON OF INERTIA LEVELS IN GB IN 2009 AND 2021**



Source: NESO, *Stability deep dive*, 28 March 2023, page 6 ([link](#)).

- 3.16. Consequently, NESO has over recent years been increasingly required to intervene to ensure that the largest loss on the system would not result in frequency limits defined in the SQSS being exceeded. Concerning NTC restrictions specifically, the North Sea Link ("NSL") IC became operational in October 2021 and represented the largest loss on the system.<sup>31</sup> NESO therefore

<sup>31</sup> NESO, *Operability Strategy Report 2022*, December 2021, page 27 ([link](#)).

utilised NTC restrictions to reduce the size of the (potential) loss, by restricting NSL's capacity when required.

- 3.17. The use of NTC restrictions for largest loss management has since reduced due to actions taken by NESO. This includes an increase in the procurement in frequency response services (for example, Dynamic Containment) and the second Frequency Risk and Control Report, which widened statutory frequency limits.<sup>32</sup> These reforms have lowered the minimum level of inertia required on the GB network. NESO has also entered into long-term contracts for the provision of inertia through its stability pathfinders, which are expected to meet NESO's inertia needs until the end of 2027,<sup>33</sup> and is developing stability markets to meet its longer term needs.<sup>34</sup>

## C. Margin extremes

- 3.18. NESO acts to ensure there is a sufficient amount of generation capacity headroom, or margin, available to the system at any given point in time to provide system reliability in the event of unforeseen changes in generation (for example, due to forecasting errors) or demand.
- 3.19. NESO can use NTC restrictions to help maintain this 'cushion' of spare generation capacity and prevent margin extreme events caused by, for example, unexpectedly low wind speeds during a period of high demand, by reducing IC exports out of GB.

### Evolution of margin extreme management requirements

- 3.20. As discussed in paragraph 3.5, GB's generation fleet is expected to be increasingly comprised of weather-dependent renewables, and so the share of GB supply coming from dispatchable generators will fall.<sup>35</sup> Ensuring a sufficient margin is therefore, at times, becoming more challenging – particularly during prolonged periods of low wind speeds and solar irradiation.
- 3.21. Margins will also be impacted by the future evolution of demand, with significant increases in the consumption of electricity expected as heating and transport electrify through the adoption of technologies such as heat pumps and electric vehicles. In recent policy scenarios, GB ICs are also expected to transition from a net import position, to a net export position by the 2030s, as GB wholesale prices are expected to fall relative to continental Europe.<sup>36</sup> As such,

---

<sup>32</sup> NESO, Annual Balancing Services Spend Report 2023 / 2024, 18 June 2024, page 30 ([link](#)).

<sup>33</sup> NESO, Markets Roadmap, March 2022, page 53 ([link](#)).

<sup>34</sup> NESO, Markets Roadmap, March 2025, page 84 ([link](#)).

<sup>35</sup> The fall in dispatchable generation generators is expected to be offset to an extent by the growth in batteries and other dispatchable low carbon technologies such as thermal generators fitted with carbon capture storage.

<sup>36</sup> Ofgem, Window 3 Decision, 12 November 2024, page 6 ([link](#)).

there may be a growing need for NESO to manage margin extremes in the future, including potentially through the use of NTC restrictions.

## **D. Implications for NTC restrictions**

- 3.22. The energy transition to Net Zero is altering the characteristics of the GB electricity system and, in turn, is making NESO's role in managing the system even more challenging. The specific issues examined in the preceding sections provide NESO with potential reasons to increase its use of NTC restrictions specifically: all three system management issues could become more prevalent in the future.
- 3.23. These pressures make it important for NESO to examine the status quo arrangements for NTC restriction usage and evaluate the benefits and drawbacks associated with this tool. NESO is aware of these pressures and is considering how it should best prepare for managing the system as it evolves, which could include reforms to the NTC restriction tool to ensure it best meets GB consumer and wider stakeholder interests.
- 3.24. To support this assessment, in the following section we set out the specific arrangements and processes that govern NESO's use of NTC restrictions under the current status quo arrangements.

## 4. Current GB NTC restriction arrangements

- 4.1. Details on how and when NESO can utilise NTC restrictions and the costs associated with doing so are set out in two key policies:
  - i. the GB NTC Calculation Policy;<sup>37</sup> and
  - ii. the NTC Commercial Arrangements methodology.<sup>38</sup>
- 4.2. In the following sections, we describe these two key policies in turn. We then also briefly describe Intraday Trading/Transfer Limits (“ITLs”), a similar tool NESO uses to manage IC flows, and discuss how NESO have used NTC restrictions and ITLs to address the three system issues outlined in Section 3.
- 4.3. In preparation of this report, NESO has also gathered views from several IC owners regarding the current NTC restriction arrangements (as described in a preliminary version of this report), which we have reviewed and reflected throughout our analysis and summarise in Appendix A3.

### A. GB NTC Calculation Policy

- 4.4. The GB NTC Calculation Policy was introduced in 2024 and sets out why and how NESO can use NTC restrictions, to help ensure consistency of NTC restriction usage across ICs. Prior to 2024, guidance on NTC restriction usage was provided in the NTC Commercial Arrangements methodology and briefly in NESO’s Procurement Guidelines only.<sup>39</sup>
- 4.5. NESO’s NTC restriction calculations can be carried out at day-ahead (“DA”) and intraday (“ID”) timeframes, during which time the connected SOs can submit or update their NTC restrictions and the IC owner can update its capability declaration. The specific process for each IC is agreed trilaterally between the IC owner and both connected SOs.<sup>40</sup>

---

<sup>37</sup> NESO, GB NTC Calculation Policy, March 2024 ([link](#)).

<sup>38</sup> NESO, Methodology for GB Commercial Arrangements relating to Interconnector Capacity Calculation, September 2023 ([link](#)).

<sup>39</sup> NESO, Procurement Guidelines, 1 April 2024, page 14 ([link](#)).

<sup>40</sup> NESO, GB NTC Calculation Policy, March 2024, page 2 ([link](#)).

### Overarching principles of NTC restriction use

- 4.6. NESO's use of NTC restrictions is governed by a set of overarching principles:<sup>41</sup>
- i. restrictions will only be applied if required to ensure system security;
  - ii. calculations are based on the best forecast of system conditions available at the time and the best view of credible alternative actions;
  - iii. NESO will not submit DA NTC restrictions on an IC where suitable ID options are available;<sup>42, 43</sup>
  - iv. NESO will first seek to adjust flows via trading or other SO-SO Trades;
  - v. ID NTC restrictions will be applied to ensure system security is maintained even following further ID (re)nominations, market trading, or SO-SO trading actions; and
  - vi. where multiple ICs jointly contribute to a particular constraint, the total NTC restriction will be spread across the ICs equitably.<sup>44</sup>
- 4.7. Under these overarching principles, the specific approach to setting NTC restrictions varies by the type of system issue. We discuss these issue-specific approaches in Appendix A1.

### Summary of NTC restriction calculation process

- 4.8. In practice, the specific timing of NESO's decision making related to NTC restrictions is inherently linked to GB's DA and ID energy and IC capacity markets. While NESO can forecast market outcomes and system conditions further ahead of time, the outcomes of these auctions provide NESO with significantly more data to base its calculations and actions on. For example, at the DA stage, NESO receives a 'reference programme' from each IC, which sets out the scheduled operation of the relevant IC based on the nominations submitted by energy traders to date.<sup>45</sup>

---

<sup>41</sup> NESO, GB NTC Calculation Policy, March 2024, page 3 ([link](#)).

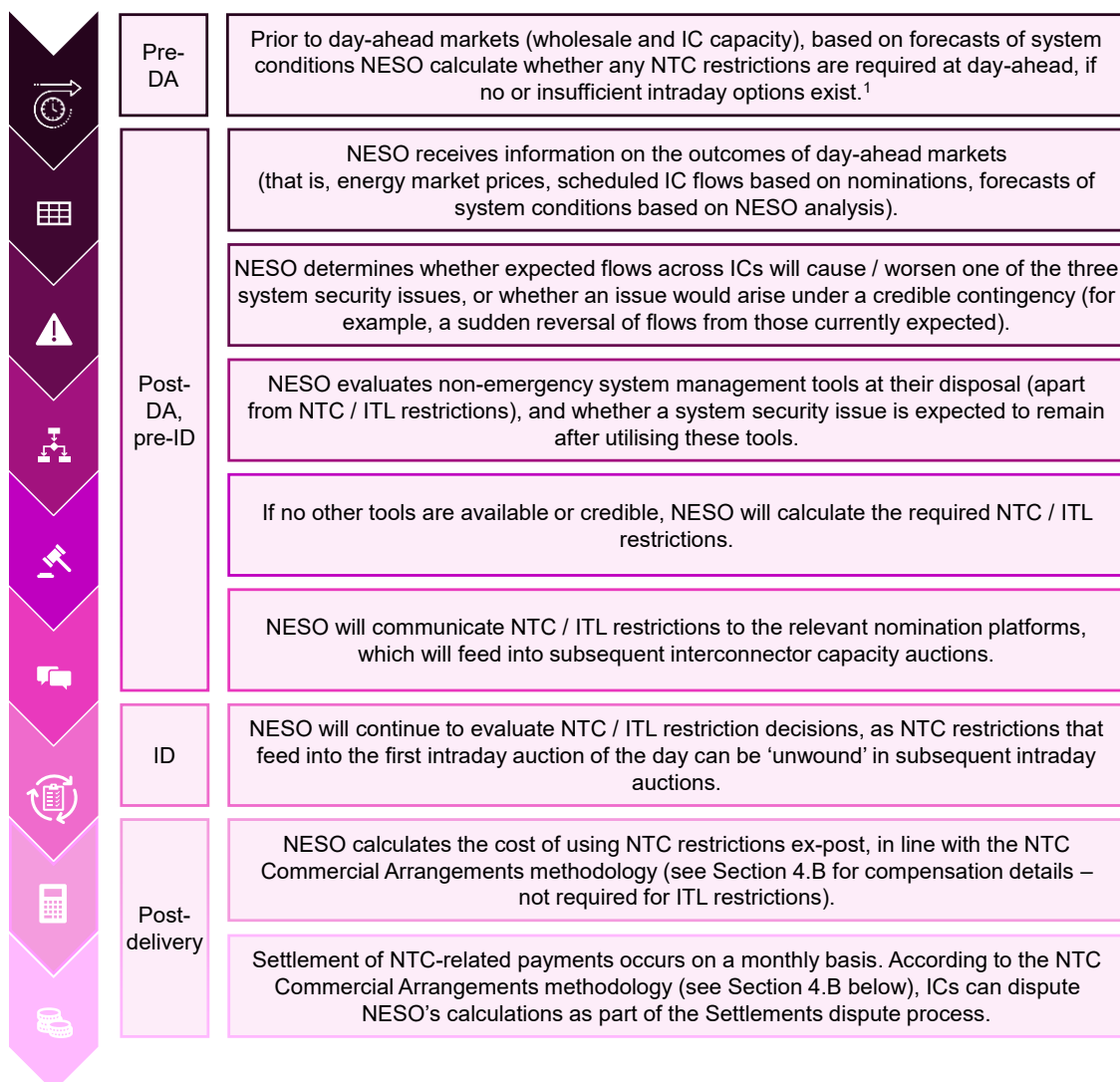
<sup>42</sup> ID options could be either: i) an explicit ID market where energy volumes in the connecting market meets or exceeds that requested by NESO; or ii) some other form of ID service provided by either the IC, connecting SO or another third party with reasonable availability and firmness.

<sup>43</sup> The exception to this principle is where a new ID market or service is formed and confidence in the new market/service is being built up.

<sup>44</sup> It is important to note that, due to variations in the effectiveness of each IC in meeting a particular constraint (and a range of other factors), an equitable allocation may not necessarily result in each contributing IC being restricted by the same amount.

<sup>45</sup> Nomination is the process by which holders of interconnector capacity notify the interconnector owner of their intention (or not) to use their capacity rights. Interconnector owners aggregate the nominations of individual parties to determine how to flow the interconnector.

- 4.9. As a result, NESO typically aims to set NTC restrictions at the ID stage, unless it determines ID options to be insufficient (or non-existent), as set out in paragraph 4.6.
- 4.10. NESO's calculations must take place with reference to the timing of the IC's upcoming capacity auctions (or energy markets, for implicitly traded ICs), such that any restrictions can be reflected in the amount of capacity offered by the IC to energy traders. Each IC may have different deadlines for their ID auctions, which can affect decisions made by NESO. NTC restrictions set for a given auction can also be unwound or increased in subsequent capacity auctions, as system conditions evolve.
- 4.11. Figure 4-1 below summarises the sequence of events in relation to NESO's decision making when setting NTC restrictions.

**FIGURE 4-1: SEQUENCING OF NTC RESTRICTION DECISIONS**

*Note: Currently, NSL capacity is allocated at the DA stage only, meaning NTC restrictions can only be set prior to DA.*



## B. NTC Commercial Arrangements methodology

- 4.12. The NTC Commercial Arrangements methodology outlines the commercial principles for compensating ICs that have been subject to an NTC restriction.<sup>46</sup>
- 4.13. When NESO restricts an IC's capacity, NESO makes payments to the IC owner to compensate them for the loss of the ability to sell cross-border capacity to market participants (or for the loss associated with the IC owner withdrawing capacity it already sold to market participants).<sup>47</sup> As set out in the NTC Commercial Arrangements methodology, these compensation payments are set on a 'make whole' basis to "*ensure cost neutrality*" for IC owners – that is, returning the IC owner to the position that it would have been in without the restriction.<sup>48</sup>
- 4.14. The compensation arrangements for NTC restrictions differ depending on the type of IC capacity restricted. In particular, the specific process of calculating compensation depends on:
- i. whether the IC uses explicit or implicit trading arrangements;
  - ii. the timing of NTC restriction deployment within the market process (that is, whether the restriction feeds into the DA or ID stage); and
  - iii. whether the IC capacity is allocated or unallocated (where allocated capacity is capacity that has been sold by the IC owner and the nomination gate has not closed).<sup>49</sup>
- 4.15. We understand from NESO that unallocated ID capacity is most commonly restricted.

---

<sup>46</sup> The NTC Commercial Arrangements methodology is implemented through the relevant bilateral (NESO and IC owner) and/or trilateral (NESO, IC owner, and connected SO) agreements, such as the IC's Bilateral Ancillary Services Agreement. See Methodology for GB Commercial Arrangements relating to Interconnector Capacity Calculation, September 2023, 3(H) ([link](#)).

<sup>47</sup> In certain circumstances the NTC restriction might result in additional income for the IC owner. For example, it is possible for the price effect of an NTC restriction to outweigh the volume effect. That is, the increase in congestion rent per MW of IC capacity as a result of the restriction (due to the removal of relatively cheap imports from the higher price importing country, and reduced demand in the lower price exporting country) outweighs the loss in revenue from lower IC flows. In these cases the IC owner is, depending on the commercial agreement in place, required to make a payment to NESO. See Methodology for GB Commercial Arrangements relating to Interconnector Capacity Calculation, September 2023, 3(C) ([link](#)).

<sup>48</sup> See Methodology for GB Commercial Arrangements relating to Interconnector Capacity Calculation, September 2023, 3(B) ([link](#)).

<sup>49</sup> For more detail, see Section 5 of the NTC Commercial Arrangements methodology ([link](#)).



- 4.16. Calculation formulae are defined in the ICs' relevant settlement agreements.<sup>50</sup> However, NESO provides examples in the NTC Commercial Arrangements methodology, which we set out in Appendix A2.
- 4.17. The settlement of NTC restriction-related payments occurs monthly. NESO collects the required data to support the settlement – if this data is unavailable to NESO, ICs are requested to provide it. ICs can raise concerns if they believe that a fair value was not achieved due to unaccounted-for additional market activity, and can provide data to be managed as part of the Settlements dispute process. NESO will assess and document these disputes, and can use data provided by ICs to override the relevant the settlement period value, where relevant.<sup>51</sup>
- 4.18. As set out in paragraph 1.11, we understand from NESO that it will conduct a 'call for input' and seek views from key industry stakeholders on the current NTC Commercial Arrangements methodology in the near future. While some IC owners provided feedback regarding the current methodology, we do not focus on examining the details of the current arrangements within this report.

## C. Intraday Trading/Transfer Limits

- 4.19. Prior to the introduction of NTC restrictions in 2021, NESO used a similar tool to manage IC flows – ITLs. ITLs are different to NTC restrictions in that they only limit unallocated capacity, only feed into ID auctions, and there is no associated compensation for the IC owner for being subject to an ITL.
- 4.20. Some interconnectors that were commissioned before the introduction of NTC restrictions remain subject to ITLs. In agreement with NESO, for the purposes of this report, we have assumed that all ICs will become subject to NTC restrictions in future and in our assessment, we have not reflected any consideration of ITLs.

## D. Summary of current NTC restriction and ITL arrangements by IC








- 4.21. Figure 4-2 below presents the ICs that are currently subject to NTC restrictions and ITLs respectively.

---

<sup>50</sup> For more detail, see Appendix 1 of the NTC Commercial Arrangements methodology ([link](#)).

<sup>51</sup> For more detail, see Section 7 and Appendix 1 of the NTC Commercial Arrangements methodology ([link](#)).

**FIGURE 4-2: CURRENT STATUS QUO AGREEMENTS ACROSS EXISTING ICs**

IC	Connecting Region	NTC restrictions / ITLs?	Form of capacity sale	IC capacity auction timings
NSL	Norway 	NTC restrictions	Implicit	Day-ahead <sup>1</sup>
ElecLink	France 	NTC restrictions	Explicit	Day-ahead & Intraday
Viking Link	Denmark 	NTC restrictions	Explicit	Day-ahead & Intraday
NEMO	Belgium 	NTC restrictions	Explicit	Day-ahead & Intraday
BritNed	Netherlands 	ITLs	Explicit	Day-ahead & Intraday
IFA	France 	ITLs	Explicit	Day-ahead & Intraday
IFA2	France 	ITLs	Explicit	Day-ahead & Intraday
GreenLink	I-SEM	Confidential	Implicit	Intraday
EWIC	I-SEM		Implicit	Intraday
Moyle	I-SEM		Implicit	Intraday

Note: (1) NSL is intending to introduce ID capacity auctions (in addition to DA). See Statnett, *Description of the Trading Solution – NSL Consultation*, 20 June 2024, page 2 ([link](#)).

## 5. Benefits and drawbacks of the status quo

- 5.1. In this section, we set out our assessment of the benefits and drawbacks of the current approach to setting NTC restrictions in GB. We first set out a common set of criteria that, if fulfilled, would facilitate good outcomes for both GB consumers and a wider pool of stakeholders (including IC owners and NESO). We then assess whether the features of the current design are consistent with these principles.

### A. Assessment principles

- 5.2. Below, we present the key principles we use to evaluate the merits of NTC restrictions (or alternative IC management tools). These are:
- i. **System security:** As explained in Section 1, NESO is required to ensure compliance with the SQSS and, as such, system security is a dominant criterion within our assessment. IC management tools used by NESO should help ensure that it is able to comply with this standard and maintain system security. For this principle, we focus on security of the GB system only, consistent with NESO's licence.<sup>52, 53</sup>
  - ii. **Cost efficiency:** IC management tools should minimise the total costs of managing the network (which are ultimately recovered from consumers). To do so, tools should be used proportionally to the need (i.e. avoid being too 'heavy handed', for example, it may be preferable to deploy a contingent restriction rather than a binding restriction on an IC flow). NESO's tools should also dispatch resources in ascending order of cost, such that lower cost resources are utilised before higher cost resources.
  - iii. **Efficient investment signals:** The design of IC management tools should incentivise developers to invest in electricity assets (for example, ICs) that deliver the desired level of system reliability and security, in the appropriate locations, in a timely manner. Investment signals are driven by the remuneration that resources can reasonably expect to earn from an investment. Without efficient long-term investment signals, there is a risk of higher than necessary costs of operating the system and the overall grid resilience may be compromised.
  - iv. **Simplicity:** IC management tools that involve less administrative burden in their implementation and operation are preferable over those that require large efforts to develop, implement and monitor.
  - v. **Transparency:** IC management tools that are transparent in how they are applied (to provide clear operational signals), and how they are

<sup>52</sup> Electricity System Operator Licence Conditions, pages 58 and 61 ([link](#)).

<sup>53</sup> System security impacts on connected markets are not considered in this report.

remunerated (to provide clear investment signals) are preferable. Such transparency encourages market participation in the short run and efficient market entry/exit in the longer run.

- vi. **Future-proof:** Tools should be robust to changes in the context that they are used in. For example, IC management tools should be robust to changes in the numbers of ICs, the generation mix and, potentially, energy market design.
- vii. **No undue discrimination:** Effective IC management tools should ensure that different parties are treated equally insofar as technical and price differences permit.<sup>54</sup> An important corollary is that this principle does not imply that all parties should be treated the same in all circumstances, but rather that they should be treated in a way that is proportional to the value that they deliver to the system.<sup>55</sup> In the context of NTC restrictions, undue discrimination could arise if restrictions were concentrated on particular ICs, and not on others, without a valid reason.
- viii. **Compliance with rules, laws and regulations:** Tools should be compliant with relevant laws, EU Regulations, Codes and Guidelines, NESO's Electricity System Operator Licence and industry codes.

## B. Assessment of the status quo

- 5.3. Our initial assessment of the current approach to utilising NTC restrictions is summarised in Figure 5-1 below.

---

<sup>54</sup> Referencing Condition C9.3 of the Electricity System Operator Licence ([link](#)). All further references to 'undue discrimination' in this document are in the context of Balancing Services and this Licence condition.

<sup>55</sup> That is to say that "due" discrimination should be allowed insofar as there are relevant technical or price differences between the services different parties can provide.

**FIGURE 5-1: SUMMARY OF STATUS QUO ASSESSMENT**


Principle	Assessment of NTC restriction status quo	Score
<b>System security</b>	<ul style="list-style-type: none"> <li>NTC restrictions provide an effective, firm mechanism to ensure compliance with SQSS</li> <li>Does not require IC owner or holders of capacity to accept a restriction (that is, tool is unilaterally available to NESO if certain conditions are met)</li> </ul>	
<b>Cost efficiency</b>	<ul style="list-style-type: none"> <li>Under the current design, NESO does not consider the cost to consumers or other stakeholders of using NTC restrictions, risking higher consumer bills than necessary</li> <li>Current non-market-based design leaves no room for competitive pressures to drive down costs</li> <li>However, compensation is typically based on market prices (for example, results of subsequent capacity auction results) and NESO aims to prioritise unscheduled flows (which should represent relatively lower cost restrictions)</li> </ul>	
<b>Efficient investment signals</b>	<ul style="list-style-type: none"> <li>IC owners are compensated on a 'make-whole' basis, resulting in a limited impact on IC investment signals</li> </ul>	
<b>Simplicity</b>	<ul style="list-style-type: none"> <li>NTC restrictions are a relatively simple mechanism, as they allow NESO to manage the system with no requirement to run auctions or another form of more sophisticated market operation</li> <li>Calculations to spread restrictions across equitably ICs can be complex</li> </ul>	
<b>Transparency</b>	<ul style="list-style-type: none"> <li>High level principles of NTC restriction usage are relatively transparent (set out in public NESO documents)</li> <li>Data on NTC restriction usage is available on NESO's data portal, tagged with a high level reason for the restriction</li> <li>However, the specific processes and compensation arrangements for each IC are not completely transparent</li> <li>The exact decision-making process followed by NESO for a particular restriction is not made publicly available (and also is not made available to IC owners)</li> </ul>	
<b>Future-proof</b>	<ul style="list-style-type: none"> <li>Relatively simple mechanism which new ICs can be added to when operational...</li> <li>... however, trilateral agreements between NESO, the IC, and the connected SO can take time to negotiate</li> <li>Performing complex calculations to allocate NTC restrictions across all contributing ICs will become increasingly burdensome for NESO as more ICs connect</li> </ul>	
<b>No undue discrimination</b>	<ul style="list-style-type: none"> <li>ICs are only subjected to NTC restrictions if they are deemed to contribute to a specific issue</li> <li>IC owners should, under the Commercial Arrangements, be compensated on a 'make-whole' basis, so they are in the same position financially (hence no 'discrimination')</li> </ul>	
<b>Compliance with rules, laws and regulations</b>	<ul style="list-style-type: none"> <li>Under NESO's licence, balancing services are required to be procured through market-based procedures; the current NTC restriction design does not comply with this condition and as such NESO has been required to seek derogations from Ofgem</li> </ul>	



- 5.4. In the following subsections, we present each of the elements of Figure 5-1 in more detail.

### System security


**FIGURE 5-2: SUMMARY ASSESSMENT OF STATUS QUO: SYSTEM SECURITY**

Principle	Assessment of NTC restriction status quo	Score
<b>System security</b>	<ul style="list-style-type: none"> <li>• NTC restrictions provide an effective, firm mechanism to ensure compliance with SQSS</li> <li>• Does not require IC owner or holders of capacity to accept a restriction (that is, tool is unilaterally available to NESO if certain conditions are met)</li> </ul>	

- 5.5. Under the current NTC restriction design, NESO has the ability to calculate and set NTC restrictions as required to ensure that system operating limits and constraints are not exceeded. As such, the status quo arrangements are highly effective in supporting NESO to operate the GB electricity system within the conditions stipulated in the SQSS and its licence. As discussed in paragraph 2.8 above, the ability to use NTC restrictions to define a specific envelope for IC flows (which does not necessarily impact the current schedule or planned operating profile of the IC – for example, when setting a non-binding restriction) also provides NESO with an effective tool to plan for and manage contingencies ahead of time. This ability to define a specific operating envelope is not available to NESO via its other IC management tools.
- 5.6. However, one limitation to the effectiveness of NTC restrictions is that they can only set an upper limit on exports and imports. They cannot, for example, be used to change an IC from a position of scheduled to export, to importing (rather, at most, NESO can limit exports to zero). Likewise, NTC restrictions cannot guarantee that an IC that is scheduled to import does not later change to a position of lower or zero imports. Additionally, restrictions can only be fed into IC capacity auctions (or, for ICs trading implicitly, the relevant DA or ID energy markets), meaning NTC restrictions cannot be used to respond to challenges that only arise very close to delivery.

### Cost efficiency

**FIGURE 5-3: SUMMARY ASSESSMENT OF STATUS QUO: COST EFFICIENCY**

Principle	Assessment of NTC restriction status quo	Score
<b>Cost efficiency</b>	<ul style="list-style-type: none"> <li>• Under the current design, NESO does not consider the cost to consumers or other stakeholders of using NTC restrictions, risking higher consumer bills than necessary</li> <li>• Current non-market-based design leaves no room for competitive pressures to drive down costs</li> <li>• However, compensation is typically based on market prices (for example, results of subsequent capacity auction results) and NESO aims to prioritise unscheduled flows (which should represent relatively lower cost restrictions)</li> </ul>	

- 5.7. NESO does not consider costs when setting NTC restrictions, which are calculated ex-post in line with the compensation agreement between the

restricted IC and NESO. Instead, restrictions are spread across all ICs that are deemed to sufficiently contribute to the given system issue.

- 5.8. In practice, however, the cost of making a given IC whole (consistent with the overarching objective of the NTC Commercial Arrangements methodology) will, at times, vary by IC. Broadly, ICs that are connected to markets with smaller differentials between the GB wholesale price and the connected market wholesale price can be made 'whole' at a lower cost, and vice versa. Additionally, the non-market nature of the current tool means there is no potential for competitive pressures between ICs to drive down compensation payable by NESO.
- 5.9. Taken together, these issues mean that the current NTC restriction design risks imposing higher than necessary costs on GB consumers.
- 5.10. However, the risk is, to an extent, mitigated as the compensation paid to ICs is typically based on market prices (for example, the results of subsequent capacity auction results). We also understand from NESO that it prioritises setting restrictions on unscheduled capacity which – assuming the capacity is unallocated because it is against the direction flows implied by the relevant wholesale market prices – will likely be low cost relative to scheduled flows.

### Efficient investment signals

**FIGURE 5–4: SUMMARY ASSESSMENT OF STATUS QUO: EFFICIENT INVESTMENT SIGNALS**

Principle	Assessment of NTC restriction status quo	Score
<b>Efficient investment signals</b>	<ul style="list-style-type: none"> <li>IC owners are compensated on a 'make-whole' basis, resulting in a limited impact on IC investment signals</li> </ul>	

- 5.11. The NTC Commercial Arrangements methodology includes a principle that payments should "*ensure cost neutrality*"<sup>56</sup> for IC owners and that, as summarised by Ofgem, the methodology adopted "*aims to ensure that IC owners are kept whole*".<sup>57</sup> As such, the tool should have a limited or no impact on the incentive to invest in ICs (either encouraging or discouraging).
- 5.12. We note that some ICs have argued that the current NTC Commercial Arrangements methodology does not, in reality, make the restricted IC fully whole.<sup>58</sup> As discussed in 4.18, we understand from NESO that it intends to conduct a separate 'call for input' on the current NTC Commercial

<sup>56</sup> See Methodology for GB Commercial Arrangements relating to Interconnector Capacity Calculation, September 2023, 3(B) ([link](#)).

<sup>57</sup> Ofgem, Decision to grant the Electricity System Operator an extension to derogation from Standard Licence Condition C28.4(h)(i) for Net Transfer Capacity, 28 September 2023, page 2 ([link](#)).

<sup>58</sup> These concerns have remained despite a consultation process on the terms of the NTC Commercial Arrangements methodology relating to NTC restrictions, and subsequent updates to the arrangements in 2023. See NESO, C9 statements and consultations ([link](#)).

Arrangements methodology in the near future. We do not consider the effectiveness of the existing arrangements in detail in our analysis.

## Simplicity

**FIGURE 5–5: SUMMARY ASSESSMENT OF STATUS QUO: SIMPLICITY**

Principle	Assessment of NTC restriction status quo	Score
<b>Simplicity</b>	<ul style="list-style-type: none"> <li>NTC restrictions are a relatively simple mechanism, as they allow NESO to manage the system with no requirement to run auctions or another form of more sophisticated market operation</li> <li>Calculations to spread restrictions across equitably ICs can be complex</li> </ul>	

- 5.13. The nature of the current NTC restriction mechanism results in a relatively simple mechanism to utilise – there is no requirement for NESO to run an auction or other form of market process (and the functionality, such as an auction platform, that this would entail).
- 5.14. However, complexity can arise in other areas. For example, NESO is required to spread NTC restrictions across all ICs that are deemed to sufficiently contribute to a given system issue. Due to the complex nature of power systems, this can be a challenging exercise which is often performed to relative tight timescales (for example, to ensure that any required restrictions are calculated and communicated before IC capacity auctions are held). This may become more challenging as and when the volume of IC capacity increases in the future (and hence the spreading of the NTC restrictions could affect a higher number of individual assets).
- 5.15. In addition, the NTC Commercial Arrangements methodology aims “to ensure that IC owners are kept whole”,<sup>59</sup> however, in practice, this can be a complex exercise due to the various forms of capacity sold by ICs and the dynamic nature of electricity markets.<sup>60</sup>

## Transparency

**FIGURE 5–6: SUMMARY ASSESSMENT OF STATUS QUO: TRANSPARENCY**

Principle	Assessment of NTC restriction status quo	Score
<b>Transparency</b>	<ul style="list-style-type: none"> <li>High level principles of NTC restriction usage are relatively transparent (set out in public NESO documents)</li> <li>Data on NTC restriction usage is available on NESO’s data portal, tagged with a high level reason for the restriction</li> <li>However, the specific processes and compensation arrangements for each IC are not completely transparent</li> <li>The exact decision-making process followed by NESO for a particular restriction is not made publicly available (and also is not made available to IC owners)</li> </ul>	

<sup>59</sup> Ofgem, Decision to grant the Electricity System Operator an extension to derogation from Standard Licence Condition C28.4(h)(i) for Net Transfer Capacity, 28 September 2023, page 2 ([link](#)).


<sup>60</sup> NESO, Methodology for GB Commercial Arrangements relating to Interconnector Capacity Calculation, September 2023, page 8 ([link](#)).



- 5.16. Following the introduction of the NTC Calculation Policy in 2024, adding to the NTC Commercial Arrangements methodology document first published in 2021, the high-level principles that NESO should follow when utilising NTC restrictions appear to be clear. Additionally, NESO publishes hourly data on NTC restriction usage by IC from late 2022 onwards on its data platform and the NTC restriction-related costs incurred by NESO are also published within its Monthly Balancing Services Summary reports (albeit in less granularity than the NTC restriction usage data).
- 5.17. However, while the broad principles are set out in these policies, there are elements that are unclear under the status quo. The specific reasoning, calculations and decision making process made by NESO in calculating required NTC restrictions for a given system issue are not made publicly available (and also are not made available to IC owners) – although a high-level reason for restriction is provided on an hourly basis on NESO’s data portal (for example, ‘network constraints’ or ‘margin extreme’). The specifics of compensation are also set out in the relevant settlement agreements for each IC, reducing transparency to potential new entrants or investors.
- 5.18. We note that despite NESO’s publication of the NTC Commercial Arrangements methodology and NTC Calculation Policy following the consultation process in 2023, discussed in Sections 4.A and 4.B, some ICs have continued to express dissatisfaction with the level of transparency regarding the use of NTC restrictions. In particular, ICs have raised concerns regarding the level of information provided by NESO on the decision making process underlying NTC restrictions, for example how the level (amount of IC capacity) and duration of the restriction is determined, as well as why other viable alternatives were not available to NESO at these time (recognising the last resort nature of the tool).

### Future-proof

**FIGURE 5–7: SUMMARY ASSESSMENT OF STATUS QUO: FUTURE-PROOF**

Principle	Assessment of NTC restriction status quo	Score
<b>Future-proof</b>	<ul style="list-style-type: none"> <li>Relatively simple mechanism which new ICs can be added to when operational...</li> <li>... however, trilateral agreements between NESO, the IC, and the connected SO can take time to negotiate</li> <li>Performing complex calculations to allocate NTC restrictions across all contributing ICs will become increasingly burdensome for NESO as more ICs connect</li> </ul>	


- 5.19. Under the current arrangements, the relatively simple nature of the NTC restriction tool (as discussed under the ‘simplicity’ criterion above) means it is not particularly complex to incorporate additional ICs as and when they connect. There is no need to integrate new ICs into an auction platform, for example.
- 5.20. However, it may in some cases take time to agree on and finalise certain elements of the relevant agreements that are required between NESO, the

connected SO, and the IC. This has been demonstrated by the hesitancy of some existing ICs to transition from ITLs to NTC restrictions.

- 5.21. Separately, as noted in paragraph 5.14 above, the calculations that NESO is required to perform to identify an equitable distribution of restrictions across contributing ICs can be complex. This challenge is likely to grow in future as a greater number of ICs connect to the GB network.

### No undue discrimination


**FIGURE 5–8: SUMMARY ASSESSMENT OF STATUS QUO: NO UNDUE DISCRIMINATION**

Principle	Assessment of NTC restriction status quo	Score
<b>No undue discrimination</b>	<ul style="list-style-type: none"> <li>ICs are only subjected to NTC restrictions if they are deemed to contribute to a specific issue</li> <li>IC owners should, under the NTC Commercial Arrangements methodology, be compensated on a 'make-whole' basis, so they are in the same position financially (hence no 'discrimination')</li> </ul>	

- 5.22. Under the status quo, ICs are only subject to NTC restrictions when they are deemed to sufficiently contribute to a given system issue and the market-based options available to NESO are inadequate. As such, any restrictions set under the status quo should be based on 'due' discrimination (that is, the restricted IC is both contributing to and is the only credible option – perhaps alongside other ICs – available to manage a system issue).
- 5.23. Additionally, the NTC Commercial Arrangements methodology aims “to ensure that IC owners are kept whole”,<sup>61</sup> which should result in the IC owner facing no revenue loss as a result of being subject to NTC restrictions, thereby facing no 'discrimination' (due or otherwise).
- 5.24. However, we note that some ICs have raised concerns that NTC restrictions have been too frequent to truly be a tool of 'last resort' and that this risks undue discrimination against the IC sector.

### Compliance with rules, laws and regulations

**FIGURE 5–9: SUMMARY ASSESSMENT OF STATUS QUO: COMPLIANCE WITH RULES, LAWS AND REGULATIONS**

Principle	Assessment of NTC restriction status quo	Score
<b>Compliance with rules, laws and regulations</b>	<ul style="list-style-type: none"> <li>Under NESO's licence, balancing services are required to be procured through market-based procedures; the current NTC restriction design does not comply with this condition and as such NESO has been required to seek derogations from Ofgem</li> </ul>	

- 5.25. The status quo NTC restriction arrangements are not consistent with NESO's licence requirement to procure balancing services through market-based procedures. As such, NESO has been required to seek multiple derogations from Ofgem to continue using the tool. Indeed, the requirement for such derogations

<sup>61</sup> Ofgem, Decision to grant the Electricity System Operator an extension to derogation from Standard Licence Condition C28.4(h)(i) for Net Transfer Capacity, 28 September 2023, page 2 ([link](#)).

(and associated requested from Ofgem) are at the heart of this report and the exploration of potential alternatives to the existing arrangements. We explore these in the following sections.

## **C. Conclusion on the status quo arrangements**

- 5.26. The current NTC restriction arrangements provide NESO with an effective tool to use ICs to manage a specific set of system issues. The ability to define an operating envelope for IC flows, which is not available through any of NESO's other IC management tools, provides NESO with an effective option to manage contingency risks in particular. The last resort nature of the service (that is, other non-emergency system management options should be considered before using NTC restrictions) and the make whole compensation arrangements should, assuming these principles are consistently followed in practice, result in relatively infrequent use (relative to other options) and a limited impact on ICs' revenues.
- 5.27. However, there are several drawbacks associated with the status quo. As demonstrated by the need for NESO to seek multiple derogations from Ofgem to continue using the service, NTC restrictions are currently not consistent with NESO's licence conditions. There is also a risk that GB consumers bear higher than necessary costs, due to i) the lack of consideration given to the cost of using NTC restrictions, and ii) the lack of competitive or market-based procurement for NTC restrictions.
- 5.28. Stakeholders have also argued that NESO's use of NTC restrictions is not sufficiently transparent, which has also led to concerns that the tool has been used too frequently to represent a true 'last resort' mechanism (noting that NESO consulted on the terms of the NTC Commercial Arrangements methodology in 2023 and developed the NTC Calculation Policy in an attempt to improve transparency, and also intends to call for industry input on the NTC Commercial Arrangements methodology again in the near future).
- 5.29. Additionally, there is a risk that the complexity of allocating NTC restrictions across ICs equitably will increase in future, as the number of GB ICs grows significantly.
- 5.30. Overall, it appears there is a strong case to consider the viability of potential options to reduce reliance on NTC restrictions in the future. In the next two chapters we examine, in turn, the potential for an NTC market in GB and an extension to NESO's current Trades market. These two options seek to make NTC restriction procurement market-based, and to reduce NESO's reliance on NTC restrictions respectively.

## 6. The potential for an NTC market in GB

- 6.1. As part of granting the derogations that have allowed NESO to continue using NTC restrictions, Ofgem has stipulated several requirements and expectations for NESO, including that it should: *“provide evidence to us on where it is developing alternative solutions which reduce reliance on non-market-based balancing options”*.<sup>62</sup>
- 6.2. One option to do this could be to introduce a market for NTC restrictions (we refer to this as an “NTC market”, as discussed in paragraph 1.9). Ofgem and NESO have previously considered the idea of a market-based approach to procuring NTC restrictions. For example, as part of the most recent derogations, Ofgem noted that it expects NESO to continue to review the economic efficiency of an NTC market, especially as more ICs are expected to connect to the GB system in the future.<sup>63</sup> However, Ofgem did not specify the detailed design of such a market. In this report we therefore seek to develop the concept of a potential market further, in order to perform a quantitative assessment of its merits. We do so under the assumption that the existing GB market design will broadly persist in its current form (for example, excluding the possibility of a fundamental evolution in GB-EU cross-border trading relationships such as rejoining the IEM).
- 6.3. In the following section, we examine whether an NTC market could provide an effective alternative to the current status quo arrangements in GB. In particular, we provide an overview of a potential NTC market, focusing on the theoretical benefits that the market could provide from cost savings for consumers (Section 6.A), and set out our quantitative assessment of these potential benefits (Section 6.B). We then discuss design considerations for an NTC market, and consider the potential associated challenges (Section 6.C). Finally, we provide a broader qualitative assessment of the merits of introducing an NTC market (Section 6.D), and conclude on the overall potential for the market in GB (Section 6.E).

### A. Overview of a potential NTC market

- 6.4. An NTC market would allocate NTC restriction adjustments via a competitive process, thereby complying with NESO’s licence requirement. While the specific design of an NTC market could vary and has not previously been defined, we

---

<sup>62</sup> Ofgem, Decision to grant the Electricity System Operator an extension to derogation from Standard Licence Condition C28.4(h)(i) for Net Transfer Capacity, 28 September 2023 ([link](#)), pages 7–8.

<sup>63</sup> Ofgem, Decision to grant the Electricity System Operator an extension to derogation from Standard Licence Condition C28.4(h)(i) for Net Transfer Capacity, 28 September 2023 ([link](#)), page 5.

assume for our analysis that it would take the form of an auction, where each IC owner would compete to satisfy a given NTC restriction requirement identified by NESO.

- 6.5. An NTC market could, in theory, reduce the costs incurred by NESO when setting NTC restrictions which, in turn, may be passed on to consumers. This cost reduction would arise as a result of:
  - i. **Competitive pressure between competing ICs** – different ICs may face varying costs from being subject to an NTC restriction (in turn driven by the opportunity cost of foregone congestion revenues, which are a function of different wholesale prices in different connected countries), and so will bid into the NTC market at different levels.
  - ii. **Price discovery** – the market enables NESO to identify and select the lowest-cost option for NTC restrictions, resulting in lower overall costs for consumers compared to the current status quo.
- 6.6. More specifically, suppose for a given hour, an NTC restriction is required to address a particular constraint. Within a potential NTC market:
  - i. Each participating IC would formulate their own bids, at which they are willing to satisfy NESO's requirements. We expect that ICs would bid with reference to the revenue they would have received from selling capacity had it not been restricted via an NTC restriction (that is, the opportunity cost of having their capacity restricted).<sup>64</sup>
  - ii. NESO would then allocate NTC restrictions to the ICs with the lowest cost bids (unlike the status quo where the restriction is spread across all contributing ICs).
  - iii. Overall, an NTC market allows NESO to identify ICs with the lowest bid prices and prioritise allocating NTC restrictions to those ICs first, thereby reducing the total costs of NTC restrictions for NESO relative to the current status quo.
- 6.7. The potential cost savings of an NTC market over the status quo depend on variation in wholesale price spreads across markets connected to GB. If there is limited variation in wholesale price spreads faced by ICs connected to GB, then the difference in cost between allocating an NTC restriction to one or a few cables, relative to spreading that restriction over all contributing cables, is likely to be low. Conversely, if there is high variation in wholesale price spreads across individual ICs, then that difference in cost is likely to be higher.
- 6.8. To further illustrate this, we set out a stylised example below.

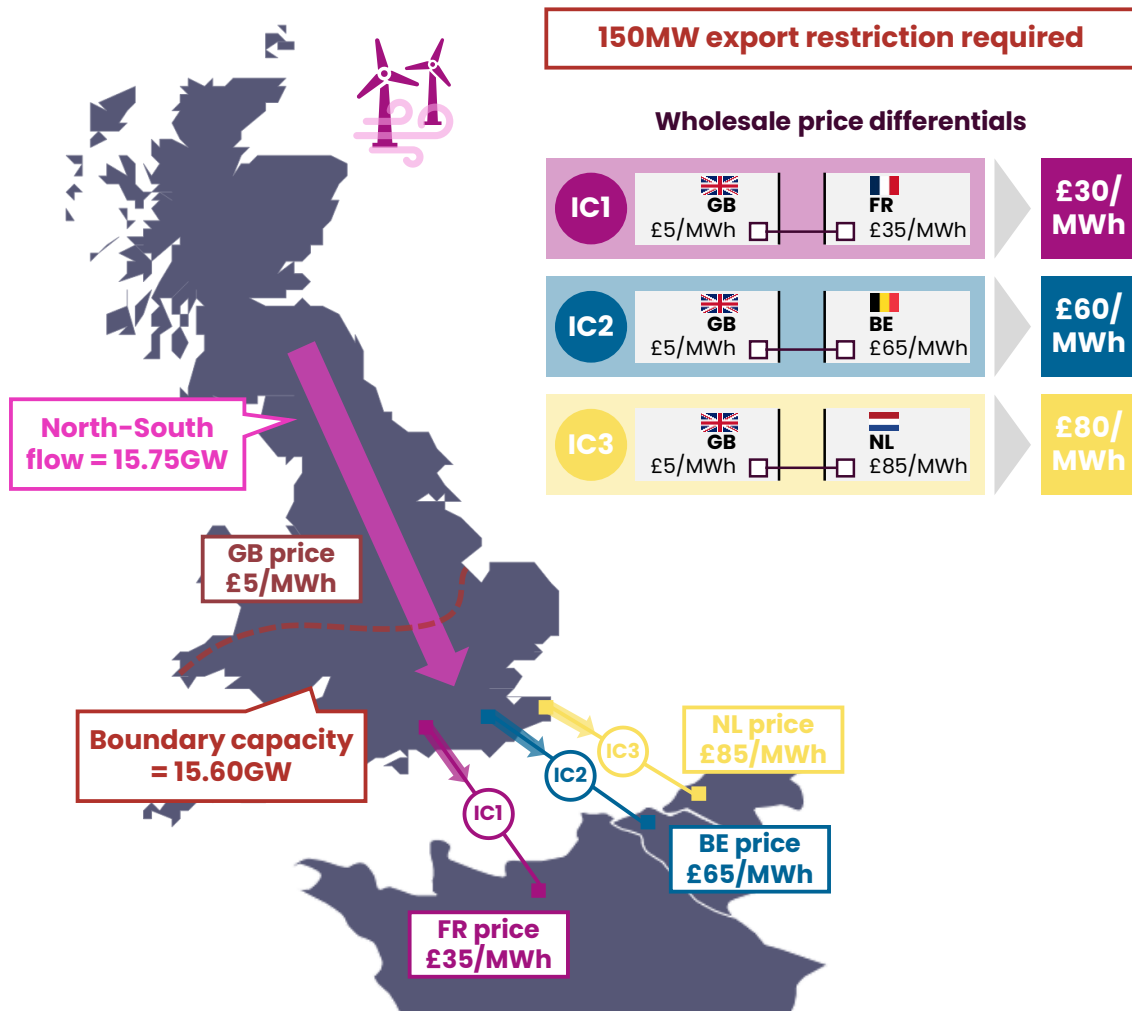
---

<sup>64</sup> In practice, IC bid prices could also include an uplift to reflect factors such as administrative costs associated with having their capacity restricted.

### Theoretical benefits of an NTC market: Stylised example

- 6.9. Figure 6-1 below depicts a stylised example of the GB power system when an NTC restriction is required to address an internal transmission network constraint.<sup>65</sup>

**FIGURE 6-1: STYLISTED DEPICTION OF AN NTC RESTRICTION**



Source: FTI analysis.

- 6.10. Suppose, as shown in the figure above, that it is a windy day in GB:
- there is high wind generation in the North. This low cost renewable generation drives the national GB wholesale price to a low level of £5/MWh; and
  - there are large North-South flows across the GB transmission network, due to high demand in the South East; and
  - there are three ICs located in the South East.

<sup>65</sup> Importantly, for the purposes of the stylised example below, we assume a national wholesale market design for the GB electricity market.

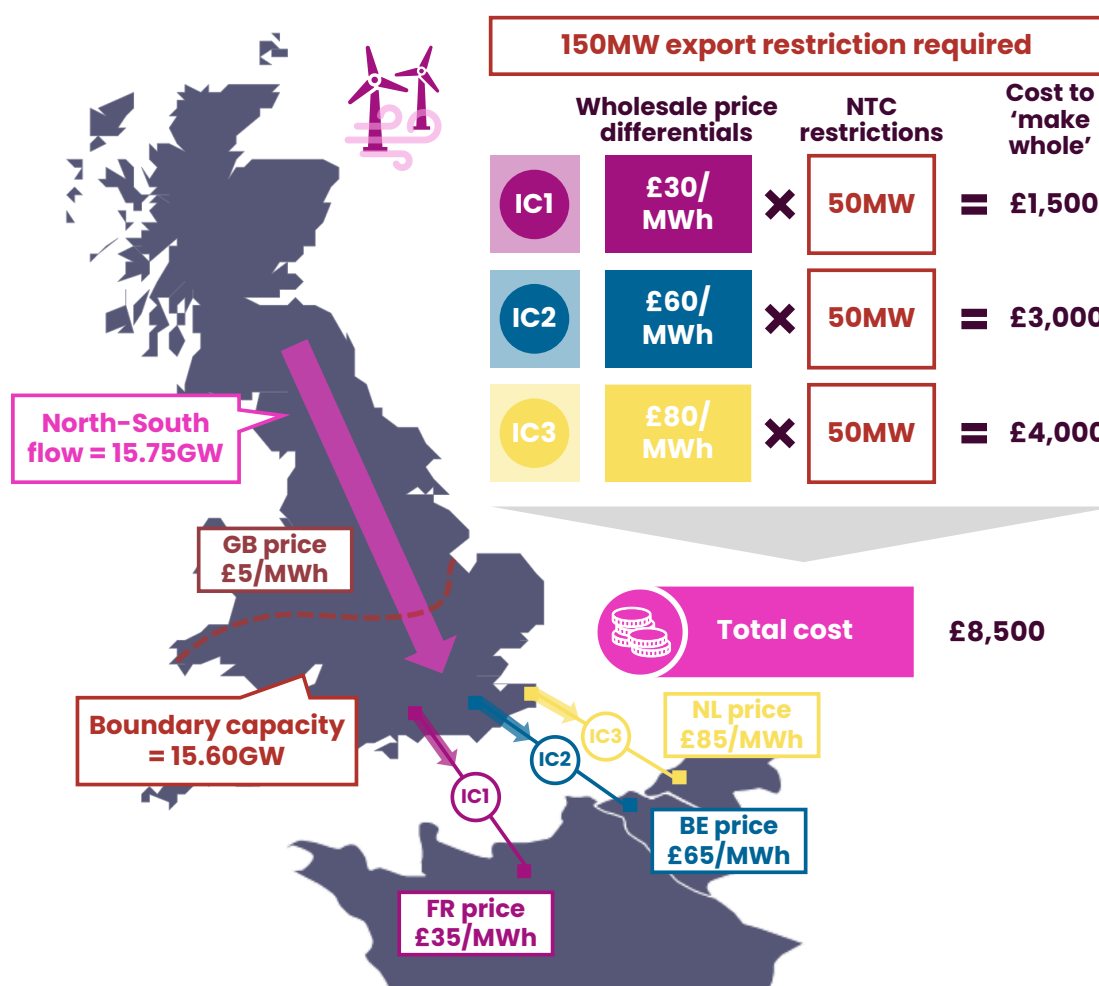
- 6.11. Assume that each IC has the same capacity and is expected to export to different European countries, driven by the low GB wholesale price:
- i. IC1 connects to France and has an expected wholesale price differential of £30/MWh (£35/MWh – £5/MWh).
  - ii. IC2 connects to Belgium and has an expected wholesale price differential of £60/MWh (£65/MWh – £5/MWh).
  - iii. IC3 connects to the Netherlands and has an expected wholesale price differential of £80/MWh (£85/MWh – £5/MWh).
- 6.12. Assume further that at the DA stage, each IC is scheduled to export half of their capacity as per their reference programme.<sup>66</sup> In addition, there is an expectation that, during ID capacity sales, the remainder of each IC's capacity would be sold in the export direction towards Europe.
- 6.13. As a result of the GB system conditions above, a network constraint is expected to arise which requires NESO to apply a 150MW NTC export restriction in the South East area. This is because if further IC export flows are scheduled during the following ID capacity sales, as is expected, such flows will not be feasible as they cannot be supported by the GB transmission system. To avoid this network constraint issue, NESO are therefore required to apply NTC export restrictions on unallocated IC capacity across the ICs after the DA stage as a contingency.<sup>67</sup>
- 6.14. Figure 6-2 below depicts the outcome of applying an NTC restriction under **the current status quo**.

---

<sup>66</sup> As previously set out in paragraph 4.8, the reference programme sets out the scheduled operation of the relevant IC based on nominations submitted by holders of IC capacity.

<sup>67</sup> More specifically, as a result of the large North-South flows (15.75GW) across the GB transmission network, a network constraint issue arises. This is because there is insufficient transmission capacity to facilitate such large flows across the transmission boundary highlighted in Red in Figure 6-1 (capacity of 15.60GW). This causes an intra-GB import constraint of 150MW to arise in the South East (15.75GW – 15.60GW = 150MW). To resolve this issue, NESO must either reduce demand or increase supply in the South East to address the network constraint. In this example, we assume that the three ICs can equally contribute to solving the system management issue in GB, as their landing points in GB are sufficiently close, that is, they can be considered 'substitutable'. We discuss the concept of 'substitutability' further in Section 6.D below.

FIGURE 6-2: STYLISTED DEPICTION OF AN NTC RESTRICTION – CURRENT STATUS QUO



Source: FTI analysis.

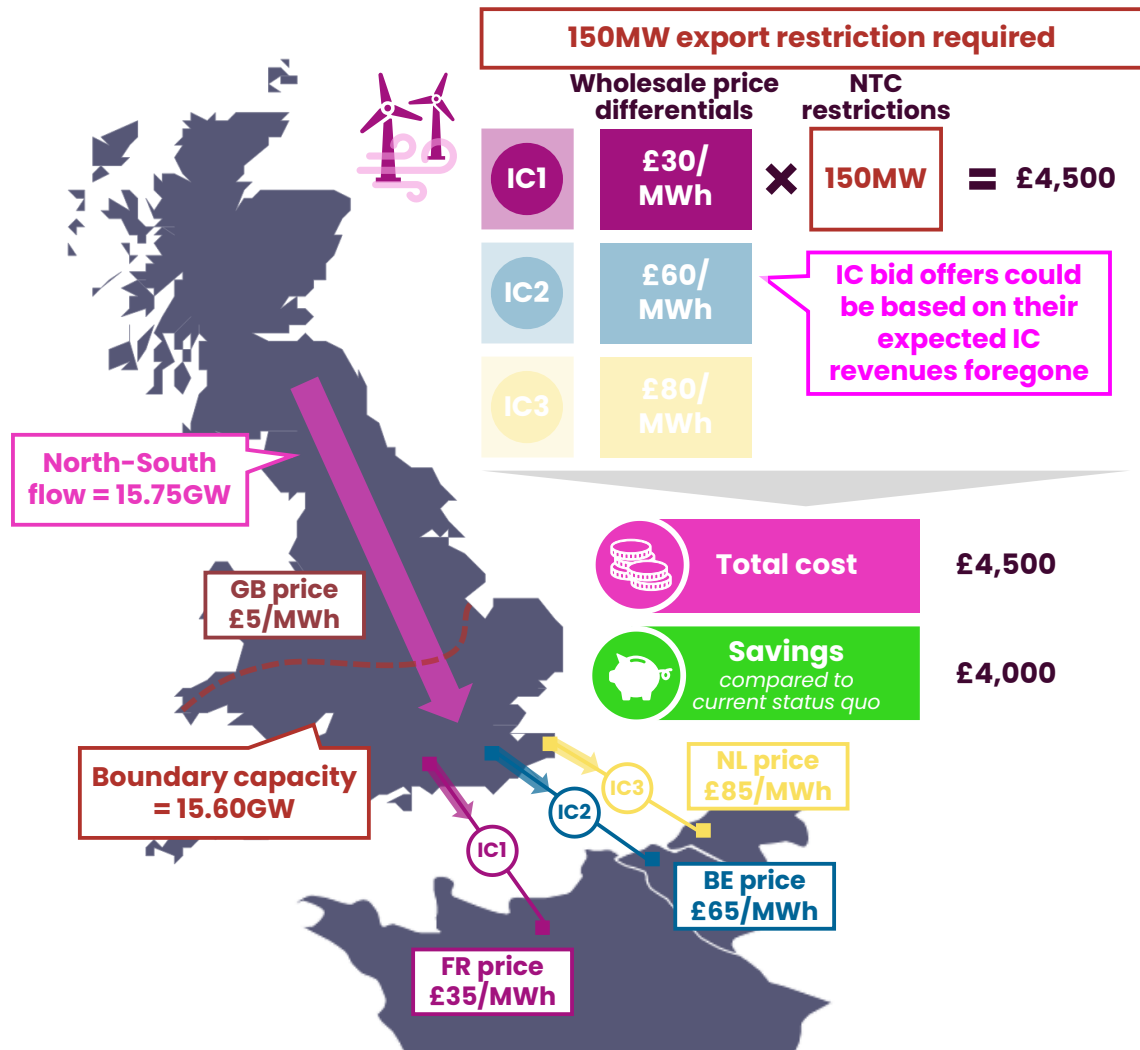
- 6.15. As shown in the figure above, based on the current status quo:
- NESO are required to spread the 150MW restriction across the ICs equitably based on their capacity, that is, a restriction of 50MW on each IC.<sup>68</sup>
  - Each IC's NTC restriction would therefore be adjusted downwards by 50MW for the duration of the NTC restriction.
  - The compensation paid to make each IC whole is equal to their IC revenues foregone (assumed to equal the prevailing wholesale price spread between GB and the connected market), in line with NESO's NTC Commercial Arrangements methodology.
  - The total cost of NTC restrictions across all ICs is £8,500.
- 6.16. Alternatively, Figure 6-3 below depicts the outcome of applying an NTC restriction **assuming an NTC market exists**, and that it operates efficiently (that

<sup>68</sup> As discussed in Section 4.A, NTC restrictions are calculated after the DA stage, and so are only placed on unallocated IC capacity. Therefore, for the purposes of the stylised example above, assume that there is sufficient unallocated capacity on each IC such that an NTC restriction of 50MW is feasible.



is, the participants bid their true opportunity costs), based on the same stylised example in Figure 6-1.

**FIGURE 6-3: STYLISED DEPICTION OF AN NTC RESTRICTION – NTC MARKET**



Source: FTI analysis.

- 6.17. As shown in the figure above, assuming an NTC market exists in which IC1, IC2, and IC3 are all market participants:
- The three ICs would bid into the auction and compete to satisfy NESO's required 150MW NTC restriction.
  - For simplicity, assume that IC bid would be based on the prevailing wholesale price spreads between GB and their connected market.<sup>69</sup>

<sup>69</sup> At this point, the IC is indifferent between the revenue it would receive from the NTC market and from selling its capacity to energy traders (assumed to be its next best alternative to the NTC market, for this example).

Therefore, IC1 would bid £30/MWh, IC2 would bid £60/MWh, and IC3 would bid £80/MWh.<sup>70, 71</sup>

iii. As a result, NESO would allocate the full 150MW restriction to the lowest-cost IC, IC1.<sup>72</sup>

iv. Under an NTC market, the total compensation paid to IC1 would equal £4,500 – this results in a cost saving relative to the current status quo of £4,000 (£8,500 – £4,500).

- 6.18. As illustrated in the stylised example above, the theoretical benefit of an NTC market relative to the current status quo is driven by the variation in bids across the three ICs, and so by the variation in expected price spreads.
- 6.19. It therefore follows that the larger the variation in expected price spreads across ICs, the greater the potential cost savings of an NTC market relative to the status quo.<sup>73</sup> Conversely, this also demonstrates that there is no potential for material benefits from an NTC market only covering ICs that connect to the same market, as there will be no difference in the price spreads across ICs.
- 6.20. Figure 6-4 below further demonstrates this by examining two different illustrative hours for a collection of example connected markets. In both hours, the average of the connected market prices – in this example France, Belgium, the Netherlands, and Germany – is the same (at €51). However, the range of prices is different – the first hour has a relatively smaller range. As a consequence, the benefit per MW of capacity restricted of the NTC market is significantly higher in the second example hour (at €16) than the first example hour (at €4).

---

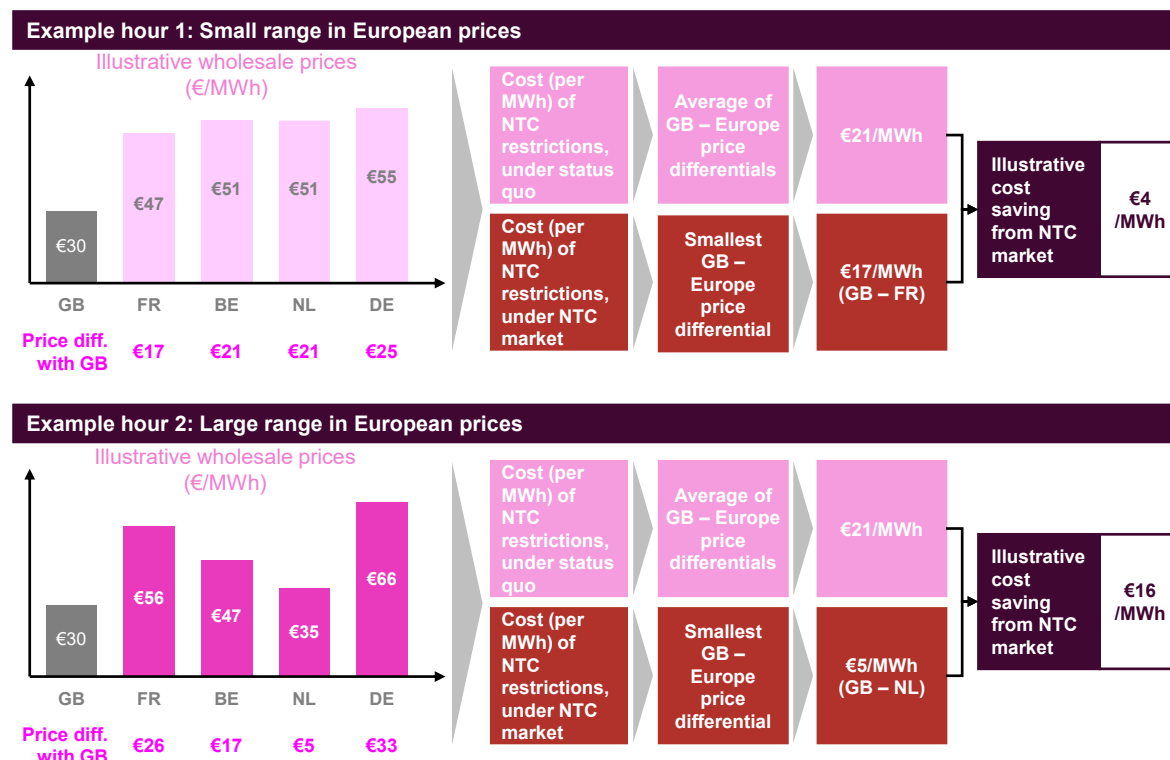
<sup>70</sup> In practice, more sophisticated bidding strategies may emerge, which may increase the compensation earned by ICs. This may erode the cost savings of an NTC market relative to the status quo. We discuss ICs' bidding strategies in more detail below in Section 6.C.

<sup>71</sup> For simplicity, assume that each IC's bid is a fixed volume auction, for 150MW of their capacity. Additional complexity arises if the NTC restrictions on individual ICs are not all equally valuable, for example if a given restriction could be achieved by a 50-50-50 split across three cables, or through, say, 100-40-40 combination (that is, requiring a higher total volume of MWh restrictions, but with a stronger skew towards the lower-cost options). We consider the substitutability of ICs in contributing to a given system issue in more detail in paragraphs 6.93 – 6.95.

<sup>72</sup> For the purposes of the stylised example above, assume that there is sufficient unallocated capacity on IC1 such that an NTC restriction of 150MW is feasible.

<sup>73</sup> This assumes that ICs will bid into the NTC market with reference to their opportunity cost of selling their capacity (which, in turn, will broadly be a function of the expected price spreads across the wholesale markets they connect) as set out in paragraphs 6.6-6.7 above. The gross benefit of the NTC market will be the difference between the compensation paid under the status quo NTC Commercial Arrangements methodology, and the compensation paid under the NTC market.

**FIGURE 6–4: ILLUSTRATION OF THE IMPACT OF THE RANGE CONNECTED MARKET PRICES ON NTC MARKET VALUE**



Note: The figure above assumes: i) there is equal IC capacity for each connected market; and ii) the full NTC restriction could be allocated to the single lowest cost connected country.

Source: FTI analysis.

- 6.21. Based on the illustration above, we can form an indicative view of the potential value of an NTC market by analysing historical price spreads between GB and the markets connected by ICs within the relevant NTC market.

### Geographical scope of an NTC market

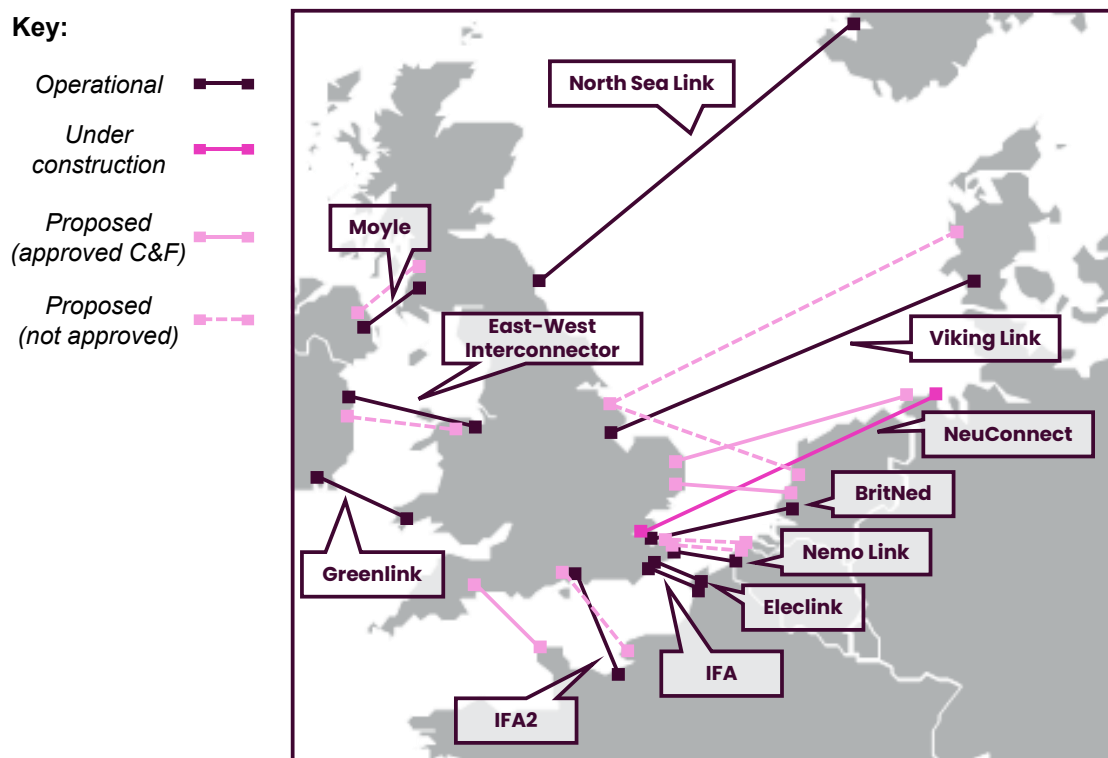
- 6.22. In order to identify the relevant countries to include in our analysis, we must first establish the ICs that could credibly participate in the same NTC market in GB and, in turn, the relevant connected markets.
- 6.23. The intra-GB network constraints managed by NESO are typically highly locational in nature.<sup>74</sup> That is, actions need to be taken relatively close on the network to the constraint being addressed. For NTC restrictions to manage network constraints, this means that to manage any one constraint, not all ICs will be able to contribute, or indeed contribute equally. For example, if an NTC restriction is intended to be used to manage a constraint that arises in Sellindge in the South East, NSL (which connects to Blyth in North East England), may be unable to manage this constraint, but IFA, Nemo Link and ElecLink (which all connect relatively close to Sellindge) may each be able to contribute.

<sup>74</sup> Largest system loss and system margin management are typically less sensitive to asset location.

In an NTC market, therefore, it would not be credible to include NSL in the same auction as IFA, Nemo Link and ElecLink.

- 6.24. Figure 6-5 below illustrates existing and potential future ICs in GB. The clustering of ICs in the South East of England suggests the greatest potential for an NTC market. Clusters of ICs could also exist in East Anglia and the East Midlands in future, although this would likely require additional ICs to be constructed, over and above those set out in the figure below.

**FIGURE 6-5: ILLUSTRATIVE LOCATIONS OF EXISTING AND POTENTIAL FUTURE ICs IN GB**



Sources: (1) FTI Analysis; (2) NESO, *Future Energy Scenarios, NESO Pathways to Net Zero*, July 2024 ([link](#)); (3) Ofgem, *Window 3 IPA Decision*, 12 November 2024, page 10 ([link](#)); and (4) Ofgem, *Decision on the IPA of the FAB Link, IFA2 and Viking Link interconnectors*, 21 July 2015, pages 1 and 2 ([link](#)).

- 6.25. For the purpose of our analysis, we therefore focus on ICs located in the South East of GB, assuming that these ICs would participate in the South East NTC market. We do not include IFA2 in this market, as we understand following discussions with NESO that it cannot consistently be used to effectively manage the same constraints as the South Eastern cluster.<sup>75</sup>

### Analysis of historical wholesale energy prices

- 6.26. As demonstrated in the illustrative examples above, the value of an NTC restriction is market is driven by variation in wholesale market price spreads between European countries connected to GB.

<sup>75</sup> We discuss the challenges associated with the substitutability of ICs in an NTC market further in paragraphs 6.93 – 6.95 below.

- 6.27. Figure 6-6 below shows the annual average wholesale market price across GB and European countries that are connected via ICs to the South East of GB (we include Germany as it is expected to be connected to GB shortly via NeuConnect).

**FIGURE 6-6: GB AND SELECTED EUROPEAN ANNUAL AVERAGE WHOLESALE ELECTRICITY PRICES (2020 TO 2024)**

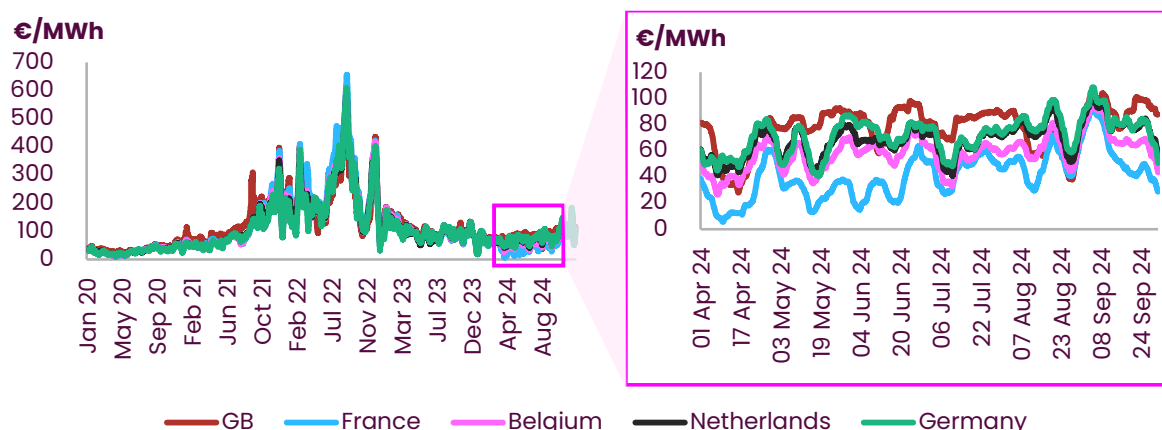
Year	GB	FR	BE	NL	DE	Range of EU prices
2020	38	32	32	32	30	2
2021	134	109	104	103	97	12
2022	233	276	245	242	235	40
2023	107	97	97	96	95	2
2024	84	58	70	77	79	20

Notes: (1) Countries shown in the figure above include: France ("FR"), Belgium ("BE"), Netherlands ("NL"), and Germany ("DE"); (2) GB prices shown above reflect the APX market index price, which is based on prices of wholesale electricity in GB across short term markets; and (3) Prices for France, Belgium, Netherlands and Germany shown above reflect the Single Day-ahead Coupling. 'Range of prices' refers to the difference between the largest and smallest annual average price, across FR, BE, NL and DE.

Source: FTI analysis of Elexon ([link](#)) and European Network of Transmission System Operators for Electricity ("ENTSOE") ([link](#)) data.

- 6.28. Across the year, prices in connected markets do vary on average, which is indicative that there may be the potential for cost savings from an NTC market. The range of prices also fluctuates significantly across the years, implying the value of an NTC market could also change year on year.
- 6.29. Figure 6-7 below further demonstrates this variability. For example, during May to September of 2024, prices in France were volatile but consistently lower than the other countries, while Germany and the Netherlands typically experienced the highest prices. If an NTC market had existed during this period and was able to shift any required NTC restrictions away from GB-France ICs (which often had the greatest price spread) and towards the lower price spread countries, costs to consumers of NTC restrictions may have been lower.

**FIGURE 6–7: GB AND SELECTED EUROPEAN WHOLESALE ELECTRICITY PRICES (2020 TO 2024) – WEEKLY ROLLING AVERAGE**



Notes: (1) GB prices shown above reflect the APX market index price, which is based on prices of wholesale electricity in GB across short term markets; and (2) Prices for France, Belgium, Netherlands and Germany shown above reflect the Single Day-ahead Coupling.

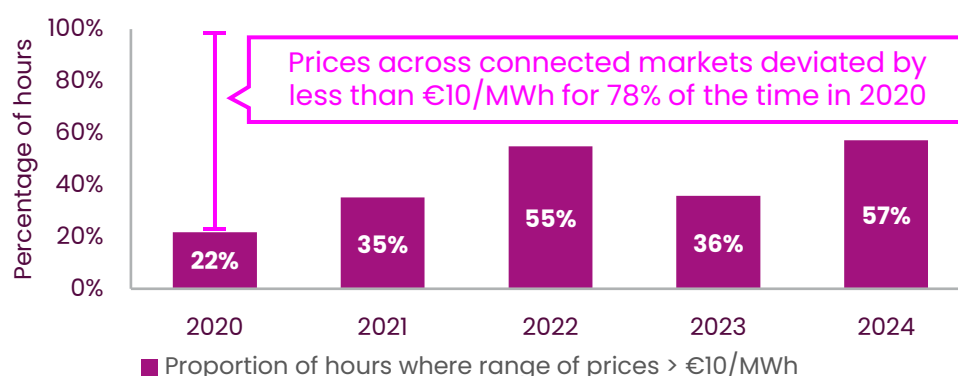
Source: FTI Analysis of Elexon ([link](#)) and ENTSOE data ([link](#)).

- 6.30. While aggregate prices can give an indication of the potential value of an NTC market, it is wholesale prices at the hourly level that will ultimately drive the value of a potential NTC market. In Figure 6–8 below, we present the percentage of hours per year where the range of wholesale price of France, Belgium, Netherlands and Germany was greater than €10/MWh – providing a rough indication of the frequency of periods where a greater potential for NTC market benefits arise.<sup>76, 77</sup>

<sup>76</sup> We note that the threshold divergence of €10/MWh between wholesale prices across connected markets is purely for illustrative purposes and NTC market benefits can also arise below this threshold.

<sup>77</sup> If, in a given hour, the difference between the largest and smallest wholesale price (across EU countries connected to GB) is greater, then there is more likely to be sufficient divergence among the cost of NTC restrictions among interconnectors to make it worthwhile to ‘select’ the lowest cost restriction, via an NTC market.

**FIGURE 6–8: SHARE OF HOURS WHERE THE PRICES OF FRANCE, BELGIUM, NETHERLANDS AND GERMANY DIVERGE BY MORE THAN €10/MWh, BY YEAR**



Source: FTI Analysis of Elexon ([link](#)) and ENTSOE data ([link](#)).

- 6.31. The proportion of hours with a price divergence greater than €10/MWh varies materially over the past 5 years. For example, in 2020 it occurred in only 22% of hours compared to 57% for 2024. This may suggest the potential for a greater value from an NTC market in 2024 than 2022. However, even in 2024, it is likely that an NTC market would not have provided large benefits (in this case, greater than €10/MWh) in nearly half of all hours.<sup>78</sup>
- 6.32. The historical data therefore provides some indication that there might be merit in an NTC market. We examine this potential through forward looking modelling in Section 7.C below.

## B. Quantitative assessment of a possible NTC market

- 6.33. In this section we describe our approach to quantitatively assessing the potential benefits of an NTC market. First, we discuss our overarching approach and aims for the analysis. We then present an overview of our methodology before outlining each of the key stages in detail. Finally, we provide our estimate of the potential gross cost savings of an NTC market, relative to the current status quo arrangements, across 2030, 2035 and 2040.

### Aims of the quantitative analysis

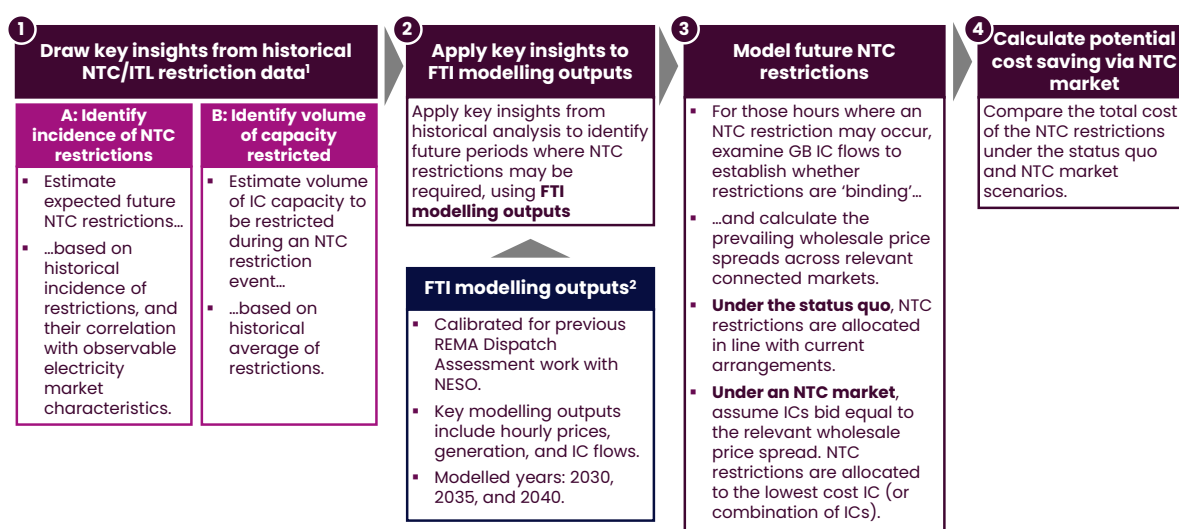
- 6.34. In order to assess the merits of introducing an NTC market in GB, it is important to consider the potential cost savings that could arise from such a market in future (that is, the gross cost savings for consumers that could arise from an NTC market).
- 6.35. However, forecasting the potential need for NTC restrictions in the future is challenging. The GB power system is evolving rapidly, with the nature of both electricity generation and demand changing as GB decarbonises. To accommodate this transition, the GB transmission network is expected to

<sup>78</sup> The specific timing of NTC restriction usage and how this was related to periods of significant price differences would, however, determine the precise value achieved by an NTC market.

significantly expand. As discussed previously in Section 3, this transition will impact NESO's role in managing the system and, within this, the use of NTC restrictions.

- 6.36. Identifying the specific need for an NTC restriction in any given hour is also a complex exercise (as previously discussed in Section 4.A). For example, in the case of network constraints, NESO must forecast the demand and supply for electricity on a locational basis, consider whether this would result in a network constraint (based on the expected network topology, considering factors such as maintenance and outages), then evaluate a sufficient set of alternative actions that could manage the constraint, in order to establish whether an NTC restriction is required.
  - 6.37. It is not possible to forecast, with a high degree of confidence, such system conditions to this level of detail several years, or even decades into the future. Therefore, for our quantitative assessment of the gross benefits of an NTC market, we instead focus initially on examining the existing relationships between the historical usage of NTC restrictions and prevailing GB system conditions. While relatively high-level GB system conditions, such as wholesale market prices or total GB demand, are not directly causal of specific NTC restrictions, this approach provides an indication of the type of periods in which NTC restrictions may be required. That is, we use high-level system conditions as a proxy for the specific and granular factors that drive the need for NTC restrictions in reality.
  - 6.38. We also examine how historical NTC restriction usage has been distributed across the three specific system issues (network constraints, largest system loss, or margin extremes).
  - 6.39. Leveraging these insights, we can then forecast when equivalent system conditions may arise in future, thereby identifying when NTC restrictions could credibly be used, and then examine the costs of applying the status quo arrangements compared to a simplified representation of an NTC market in these time periods.
  - 6.40. While this approach does not attempt to precisely forecast how frequently and when NTC restrictions will be required in future, we view it as a suitable framework to assess the relative cost impact of introducing an NTC market compared to the status quo arrangements.
  - 6.41. In the following subsection, we present an overview of the quantitative methodology we adopt.
- Overview of quantitative assessment methodology**
- 6.42. Figure 6-9 below summarises our approach to quantitatively assessing the potential benefits of an NTC market.



**FIGURE 6–9: SUMMARY OF QUANTITATIVE ASSESSMENT METHODOLOGY**

Notes: (1) NTC restriction/ITL usage data ([link](#)); and (2) See REMA Dispatch Assessment work for NESO ([link](#)).

Source: FTI analysis.

6.43. As shown in the figure above, our quantitative assessment is broadly comprised of four key stages:

- i. **Analysing historical NTC restriction usage data to draw insights for future use.** As explained above, given the complexity of forecasting future NTC restrictions, we focus on leveraging insights from historical data to proxy for the need for NTC restrictions in future. We examine the existing historical relationship between GB demand, and the:
  - a. incidence of NTC restrictions/ITLs,<sup>79</sup> estimated as the probability of an NTC restriction/ITL occurring; and
  - b. volume of IC capacity restricted, estimated as the total amount of IC capacity restricted, given an NTC restriction/ITL has been applied.
- ii. **Applying historical insights to FTI's power market modelling outputs.** We apply the insights of the historical analysis to identify periods in the future where NTC restrictions may be required, based on the outputs of FTI's power market model.<sup>80</sup> We utilise the dispatch modelling outputs from FTI's recent REMA Dispatch Assessment work, commissioned by NESO, which includes modelling of the GB system into 2030, 2035, and 2040.
- iii. **Modelling the allocation and cost of restrictions** under the status quo arrangements and an NTC market.
  - a. We make use of the modelled flows across the relevant ICs and consider whether NTC restrictions are 'binding' – that is whether ICs

<sup>79</sup> As set out in paragraph 4.20, for the purposes of our analysis we assume all ICs currently subject to ITLs will transition to NTC restrictions in future.

<sup>80</sup> See Appendix A6 for further details on the key modelling inputs and assumptions.

are expected to export (thereby incurring a material cost, as discussed in Section 4.B).

- b. We calculate the prevailing wholesale price spreads across the relevant connected markets, as forecasted by our dispatch model.
- c. For the **status quo**, restrictions are allocated in line with NESO's current methodology. The cost of NTC restrictions is calculated as the expected binding volume of NTC restriction across each relevant IC, multiplied by the associated forecast wholesale price spread.
- d. For the **NTC market**, we make the simplifying assumption that ICs will bid equal to their wholesale price spreads and, based on these bids, allocate restrictions to the lowest cost IC (or combination of ICs).

- iv. **Calculating the potential cost savings of an NTC market** – We compare the total cost of the NTC restrictions under the status quo and NTC market scenarios.

- 6.44. We also test a collection of sensitivities to our baseline results, which we discuss in paragraphs 6.83 – 6.89 below.

#### Analysing historical NTC restriction usage data

- 6.45. In this subsection, we describe our approach to selecting future periods (in our dispatch modelling) to apply NTC restrictions to. Importantly, we are not attempting predict the future need for an NTC restriction at any given time. Rather, we are leveraging historical relationships between GB system conditions (specifically, GB electricity demand) and historical NTC restrictions/ITLs, to select future periods to apply NTC restrictions to.<sup>81</sup>

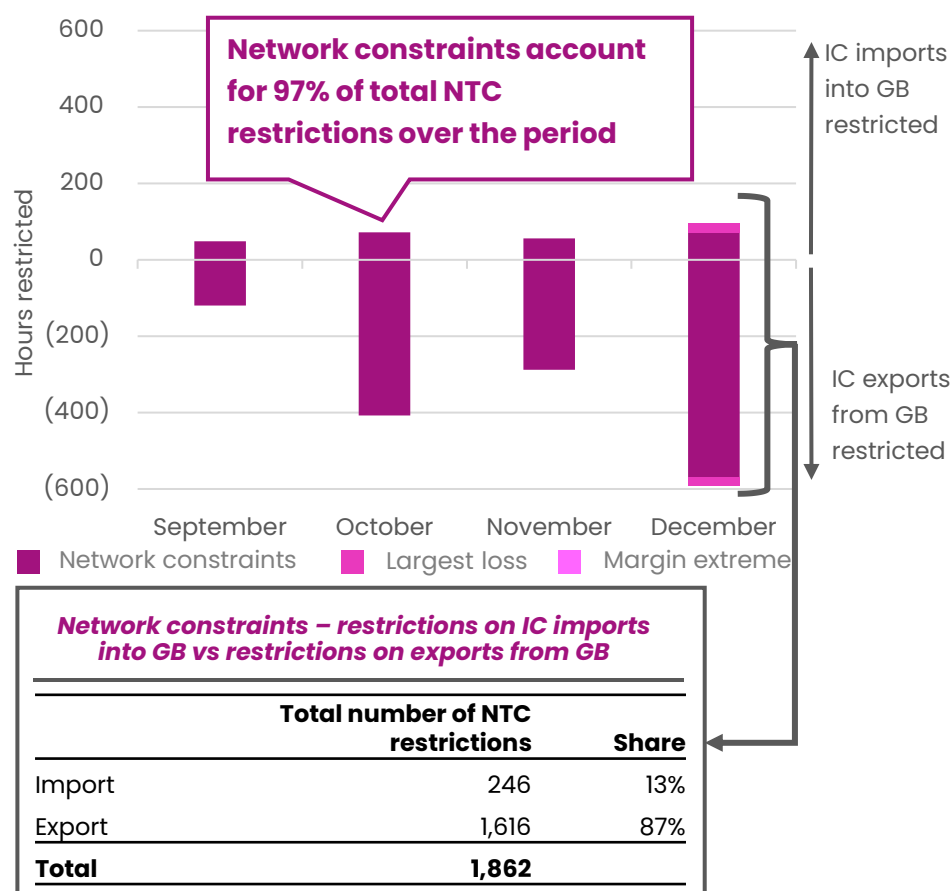
#### Analysis of NTC restrictions by system issue and flow direction

- 6.46. In Figure 6-10 below, we categorise historical NTC restrictions/ITLs by their reason for restriction.

---

<sup>81</sup> See Appendix A5 for a detailed description of the historical NTC restriction/ITL usage data from NESO.

**FIGURE 6–10: OCCURRENCES OF IMPORT AND EXPORT NTC RESTRICTIONS/ITLS ACROSS VARIOUS INTERCONNECTORS BY REASON FOR RESTRICTION**



Notes: (1) Historical NTC restriction/ITL data analysed ranges from late September 2024 to mid-January 2025; (2) Data shown in the figure above includes the following ICs: IFA, IFA2, Nemo Link, NSL, and Viking; (3) ElecLink and BritNed are excluded from the figure above due to various data issues; and (4) Data issues include: missing data for ElecLink due to IC outages which led to the suspension of the cable between 25 September 2024 and 5 February 2025,<sup>82</sup> BritNed data is not disaggregated by direction (that is, NTC restrictions on flows into GB versus flows out of GB), and data for IFA and IFA2 was only available from late December 2024.

Sources: (1) FTI analysis; and (2) NESO NTC restriction/ITL data ([link](#)).

- 6.47. As shown in the figure above:
- The majority (c.97%) of recent NTC restriction/ITL usage has focused on addressing network constraints.
  - For restrictions related to network constraints, the majority (c.87%) of these were applied to IC exports from GB, rather than IC imports into GB.
- 6.48. We have therefore, focused our analysis on NTC export restrictions that have been imposed to address network constraints. At this stage, we will not focus on largest loss and margin issues as drivers of NTC restriction usage.

<sup>82</sup> See Getlink, Gradual return to service of ElecLink operations, 5 February 2025 ([link](#)).

### Identifying incidence of NTC restriction usage and the volume of restrictions

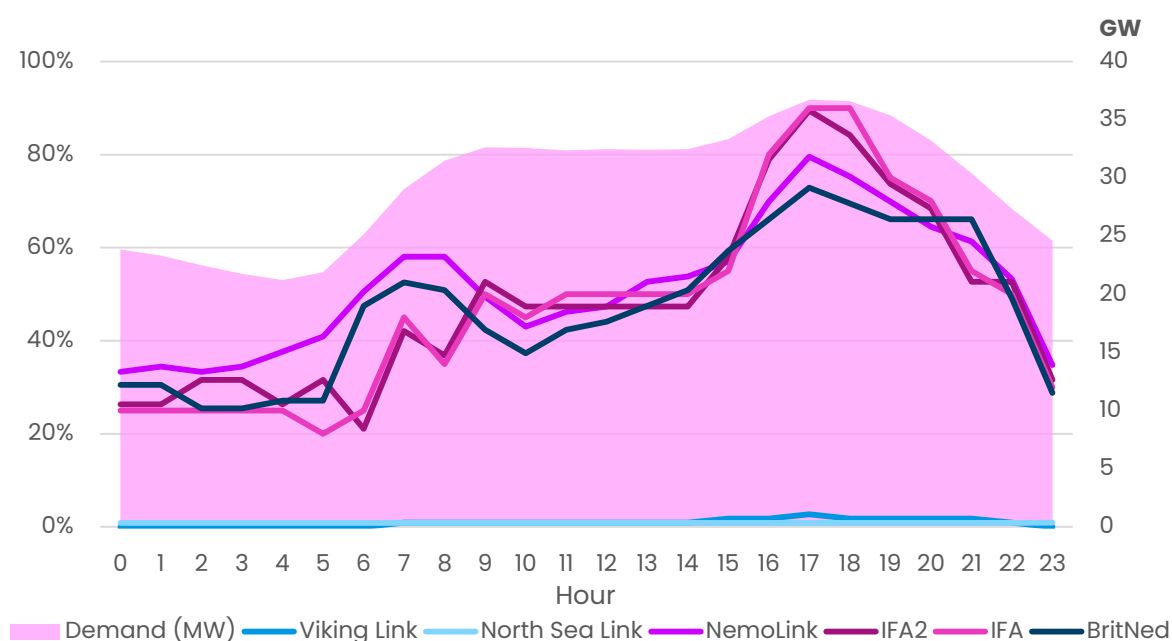
- 6.49. To assess the incidence of NTC restriction usage, our analysis focuses on examining whether there exist relationships between the historical usage of NTC restrictions and the volume of these restrictions, and the prevailing GB system conditions. As discussed above, our analysis uses these potential relationships as simplified predictors of possible future NTC restrictions. We developed and refined this approach through ongoing discussions with NESO, who agreed it was appropriate to use GB system conditions as simplified predictors of future NTC restrictions.
- 6.50. Overall, our analysis of the historical NTC restriction/ITL usage data<sup>83</sup> – both in terms of instances of NTC restriction usage and volume of capacity restricted per instance – suggests that usage is broadly correlated with total GB demand.<sup>84</sup>
- 6.51. Figure 6-11 below shows the correlation between GB Demand and NTC export restrictions/ITLs based on the historical data.

---

<sup>83</sup> See paragraph 4.20 for our discussion of the equivalence between NTC restrictions and ITLs for the purposes of our analysis.

<sup>84</sup> Our analysis also assessed various different high-level GB system conditions, such as wholesale GB market prices, and domestic power generation across different technologies.

**FIGURE 6–11: CORRELATION BETWEEN GB DEMAND AND NTC RESTRICTION/ITL OCCURRENCES: EXPORT RESTRICTIONS ONLY – PROBABILITY OF AN NTC RESTRICTION VS GB DEMAND ACROSS INTERCONNECTORS (HOURLY)**



Notes: (1) Historical NTC restriction/ITL data analysed ranges from late September 2024 to mid-January 2025; (2) ElecLink is excluded from the figure above due to data challenges; and (3) BritNed data is not disaggregated by direction. For the figure above, we assume NTC restrictions on BritNed would have been export restrictions, as per Figure 6–10.

Sources: (1) FTI analysis; and (2) NESO NTC restriction/ITL data ([link](#)).

6.52. As shown in the figure above:

- i. The correlations between average GB Demand and NTC restriction/ITL usage, are strongest for ICs located in the South East (IFA and Nemo Link) and IFA2. In particular, during relatively high demand hours (16 to 19), the probability of an NTC restriction occurring across these ICs reaches 70–90%.<sup>85</sup>
- ii. In contrast, there is no clear correlation across other ICs (NSL and Viking).
- iii. Overall, we consider that the correlation between total GB Demand and NTC restriction/ITL usage applied to South East ICs and IFA2 is consistent with the

<sup>85</sup> Similar correlations between wholesale market prices and NTC restriction/ITL usage, for each hour, are also apparent for ICs located in the South East. We note that this is because prices and GB demand across time of day are both themselves closely related.

fact that NTC restrictions are typically applied to manage network constraints.<sup>86, 87</sup>

- 6.53. Based on our findings above, we use hourly GB electricity demand as a determinant for selecting the incidence of NTC export restrictions for ICs located in the South East. That is, the greater the level of GB demand in a given hour, the more likely it is that network constraint issue will arise in the South East of GB, and so an NTC restriction will be required across the relevant ICs.
- 6.54. Our analysis of the historical data also suggests that the volume of NTC exports restrictions applied is similarly correlated with total GB demand.
- 6.55. Figure 6-12 below summarises the historical data on NTC export restrictions for different levels of GB demand, across South East ICs, from September 2024 to January 2025.<sup>88</sup>

**FIGURE 6-12: SUMMARY OF CORRELATIONS BETWEEN GB DEMAND AND NTC RESTRICTION/ITL USAGE: EXPORT RESTRICTIONS ONLY**

Demand Band	Demand Band range (MW)	Number of hours (total)	Number of hours with at least one NTC restriction (from GB)	Probability of at least one NTC restriction (from GB)	Ave. MW restricted per hr (from GB)
(min) Band 1	16,285 - 22,208	408	221	54%	633
Band 2	22,208 - 28,132	660	354	54%	852
Band 3	28,132 - 34,055	723	433	60%	930
Band 4	34,055 - 39,979	497	320	64%	939
(max) Band 5	39,979 - 45,903	89	68	76%	1,018

Notes: (1) Historical NTC restriction/ITL data analysed ranges from late September 2024 to mid-January 2025; (2) Data shown in the figure above includes the following South East ICs: IFA, ElecLink, Nemo Link, and BritNed; and (3) Data is subject to several data limitations – see Appendix A5.

Sources: (1) FTI analysis; and (2) NESO NTC restriction/ITL data ([link](#)).

<sup>86</sup> In particular, this correlation may suggest NTC restrictions/ITLs are deployed to manage network constraints driven by insufficient generation to meet capacity within a given constraint boundary, which is exacerbated during times of high GB electricity demand.

<sup>87</sup> While the trend in NTC restrictions for IFA2 is similar to the South East ICs, IFA2 cannot credibly be used to effectively manage the same network constraints as the South Eastern cluster (as previously discussed in paragraph 6.25). We therefore do not consider it as part of the South East NTC market in our analysis.

<sup>88</sup> Please see Appendix A5 for an explanation of the data and its limitations.

- 6.56. As shown in the figure above:
- i. The occurrence of an NTC restriction from GB (an export restriction) is positively correlated with total GB demand, as also shown in Figure 6-12 above. For Demand Band 5 (highest demand levels), **76%** of hours included an NTC restriction.
  - ii. The average volume of NTC restriction for GB, that is the average MW restricted per hour across South East ICs that have had their capacity restricted, is also positively correlated with total GB demand. For Demand Band 5, the average MW restricted per hour is **1,018MW**.
- 6.57. In our subsequent analysis, when selecting future periods for NTC restrictions we therefore assume that NTC export restrictions will occur in hours of high GB electricity demand, that is within the top Demand Band. Specifically, when forecasting NTC restrictions into the future using pre-existing FTI modelling outcomes,<sup>89</sup> our analysis assumes for hours within the top Demand Band:
- i. An NTC export restriction across South East ICs occurs with a probability of **76%**; and
  - ii. Given an NTC restriction is required, the total volume of capacity restrictions across South East ICs will be **1,018MW**.

### Applying historical insights to FTI's power market modelling outputs

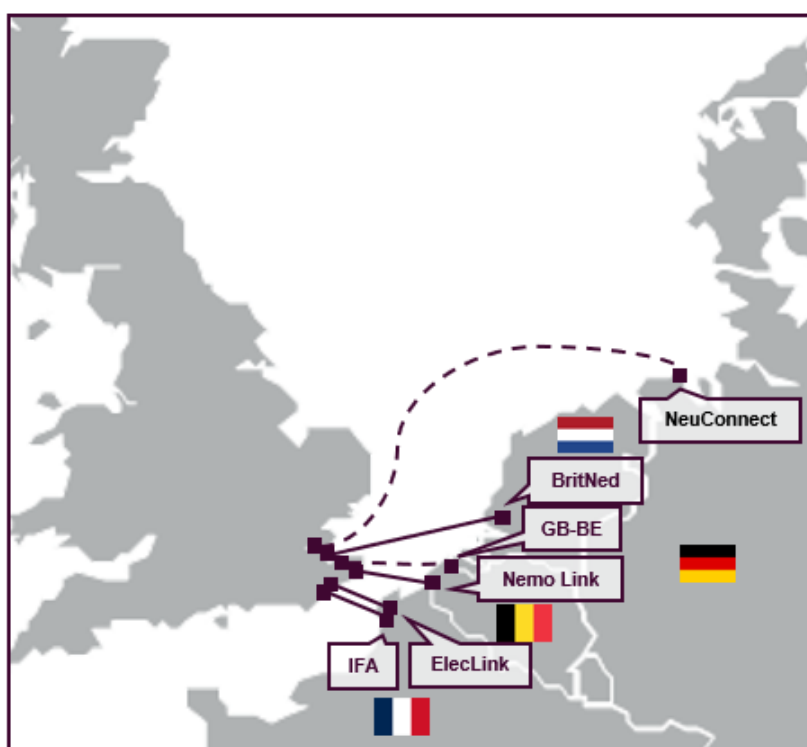
- 6.58. As outlined above, for our quantitative assessment, we utilise the dispatch modelling outputs from FTI's recent REMA Dispatch Assessment work to forecast GB system conditions into 2030, 2035, and 2040.<sup>90</sup> Within FTI's power market model, generation capacities across technologies are taken as given,<sup>91</sup> and the least-cost dispatch profile of generation and storage to meet demand in each hour is determined, subject to technical constraints such as maintenance and outages.
- 6.59. As previously discussed, we focus our assessment of an NTC market on a cluster of ICs connected (or expected to connect) to the South East of GB, reflecting the locational nature of network constraints.
- 6.60. We understand from discussions with NESO that this area represents a South East constraint area which faces import constraints on power flows from the rest of GB (that is, there is insufficient transmission capacity to flow power from the rest of GB to this area). ICs in this area are therefore typically able to address this import constraint, by restricting their export capacity out of this area.
- 6.61. Figure 6-13 below illustrates the ICs that we focus on in our analysis.

---

<sup>89</sup> As discussed in paragraph 6.43, we utilise dispatch modelling outputs from FTI's recent REMA Dispatch Assessment work, commissioned by NESO, across 2030, 2035, and 2040. We have not performed any new power market modelling for this report.

<sup>90</sup> See Appendix A6 for further details on the key modelling inputs and assumptions.

<sup>91</sup> As above, see Appendix A6 for key modelling inputs and assumptions.

**FIGURE 6-13: SOUTH EAST ICs FOCUSED ON IN OUR ANALYSIS**

*Note: The figure above shows European markets that are, or are expected to be, interconnected to GB via a connection to South East GB. Additional ICs beyond those presented above could connect to GB in the future, as shown in Figure 6-5 above.*

*Source: FTI analysis.*

- 6.62. As shown in the figure above, the six ICs included in our analysis:
- i. have landing points in GB that are relatively close geographically; and
  - ii. are interconnected with different European markets, that is, France, Belgium, the Netherlands, and Germany.
- 6.63. For our quantitative assessment of the benefits of an NTC market, we focus on the following hourly outputs across all modelled years:<sup>92</sup>
- i. **GB electricity demand** – We use these outputs to identify high demand periods for electricity across 2030, 2035 and 2040;
  - ii. **Wholesale market prices for GB and across Europe** – We use forecast wholesale market prices to calculate the cost of NTC restrictions, and to identify the most competitive ICs within an NTC market; and
  - iii. **Expected flows across existing and future ICs connected to South East GB** (namely, ElecLink, IFA, Nemo Link, BritNed, NeuConnect and GB-BE) – We use expected flows across ICs to identify the impact of an assumed NTC restriction.<sup>93</sup>

<sup>92</sup> We leverage outputs from our model calibrated to GB's existing national market design.

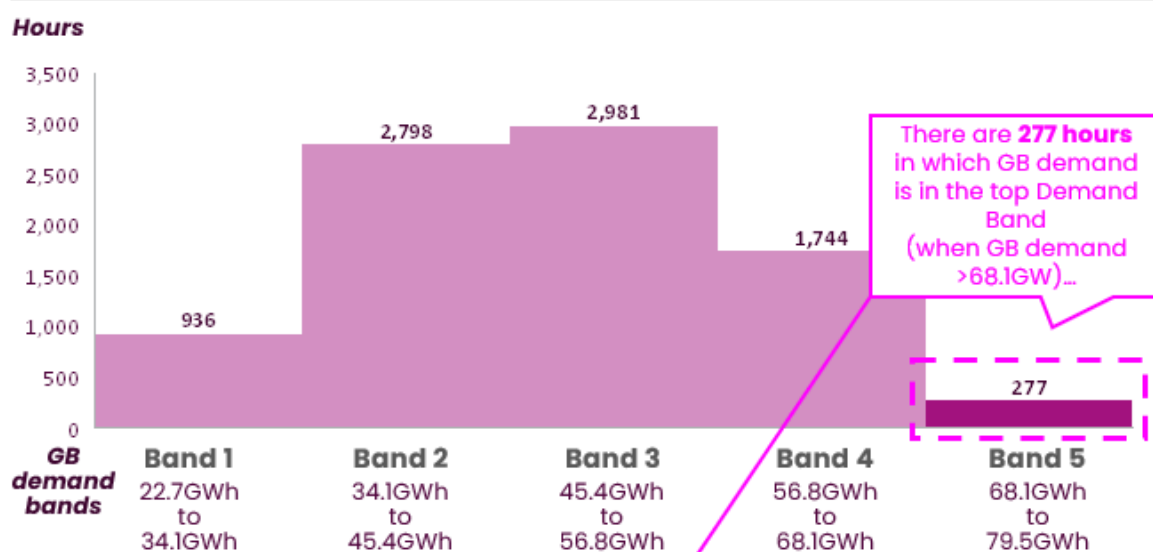
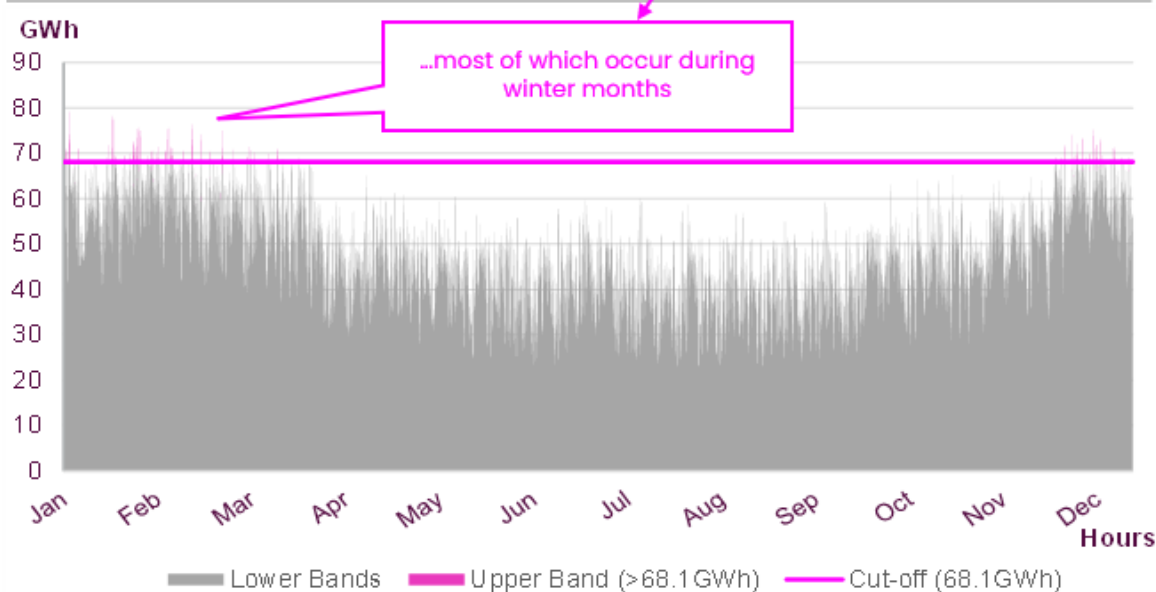
<sup>93</sup> As shown in Figure 6-13, our analysis includes the build of one additional GB-BE IC (connecting GB and Belgium) in the South East.



- 6.64. Importantly, as described above, when selecting future periods for NTC restrictions we assume NTC export restrictions occur in hours of high GB electricity demand, that is, within the **top Demand Band (the top quintile of demand)**.
- 6.65. Figure 6-14 below summarises hourly GB electricity demand categorised into different demand bands,<sup>94</sup> as well as over time, as per FTI's modelling outputs for 2035.

---

<sup>94</sup> Across modelled years, we categorise GB electricity demand into five equidistant 'Demand Bands' based on the minimum and maximum levels of demand in each year. For example, in 2035, the minimum and maximum demand is 22.7GWh and 79.5GWh respectively. Therefore, we categorise the data into five Demand bands with a distance of 11.4GWh between them, that is, 22.7GWh to 34.1GWh, 34.1GWh to 45.4GWh, etc. This is the same approach used for our analysis of the historical NTC restriction/ITL usage data.

**FIGURE 6–14: SUMMARY OF GB ELECTRICITY DEMAND AS PER FTI MODELLING OUTPUTS – 2035****Histogram of total GB demand in our model****Hourly GB demand in our model**

Note: Total GB electricity demand as shown above is based on Customer Load, comprised of Demand from: Native demand at Grid Supply Points ("GSPs"); Electric Vehicles; Heat Pumps; and Electrolysers.

Source: FTI analysis.

- 6.66. As shown in the figure above, based on FTI modelling outputs for 2035:
- There are 277 hours where GB demand is high across the year, that is, in the top Demand Band (between 68.1GWh to 79.5GWh).
  - These high demand hours mostly occur during the winter months. We consider this aligns with expected seasonal trends in electricity demand.
- 6.67. Having identified hours in which GB demand lies within the top Demand Band in the future, we then assume that across these hours, an NTC export restriction occurs with a probability of 76%, in line with the historical NTC restriction/ITL

usage data.<sup>95</sup> To do this, we randomly allocate NTC restrictions with a probability of 76% across hours within the top Demand Band, to ensure an unbiased distribution. For example, for 2035, across the 277 hours within the top Demand Band we randomly allocate NTC restriction events such that overall, we assume there are 211 hours in which an NTC export restriction is required.<sup>96</sup>

- 6.68. For hours where we assume an NTC restriction event occurs, we further assume that in each of these hours the volume of export restrictions required are 1,018MW, in line with the historical NTC restriction/ITL usage data.<sup>97</sup>
- 6.69. An NTC restriction may be 'binding' or 'non-binding', depending on the forecasted price differentials and direction of flow for a given IC during that period. For example, if our modelling outcomes show a particular IC importing during an NTC restriction event, an assumed NTC export restriction on this cable will be 'non-binding', as it is set in the opposite direction to IC's expected flows.<sup>98</sup>
- 6.70. Our modelling outcomes forecast that South East ICs are typically expected to export power from GB across most hours. Therefore, most NTC restrictions are expected be 'binding'. For example, in 2035:
  - i. Across all hours, at least one South East IC is exporting for c.88% of the time.
  - ii. Across hours in which we assume there is an NTC restriction event, at least one South East IC is exporting for c.82% of the time.
- 6.71. In the following paragraphs, we set out how we model the cost and allocation of restrictions under the current status quo arrangements and the NTC market.

### Status quo arrangements

- 6.72. In this section, we describe how our modelled NTC export restrictions are applied to the South East ICs, under the status quo arrangements.
- 6.73. Under the status quo arrangements, across hours identified as NTC restriction events, we assume that across South East ICs:
  - i. NTC export restrictions are prioritised on (that is, first applied to) those ICs that are not expected to export.<sup>99</sup> As explained in paragraphs 4.8 – 4.9, we understand that NESO typically attempts to minimise placing restrictions on scheduled flows. Indeed, NTC export restrictions are often set on ICs scheduled to import, as a contingency against those ICs changing their expected direction of flow. To reflect this, we therefore prioritise placing assumed restrictions on non-exporting ICs. By definition, these assumed restrictions are non-binding and are assumed to be costless.

---

<sup>95</sup> Please see paragraph 6.57.

<sup>96</sup> 277 hours x 76% = 211 hours.

<sup>97</sup> Please see paragraph 6.57.

<sup>98</sup> This is explained in greater detail in Section 2.C.

<sup>99</sup> ICs not expected to export are either ICs that are expected to import, or ICs that are expecting flows in neither direction.

- ii. For any remaining required volumes of NTC export restriction (that is, if less than 1,018MW of NTC restrictions is assumed in across importing ICs), restrictions are then spread across all South East ICs evenly.<sup>100</sup>
- iii. NTC export restrictions are 'binding' for each IC if their NTC is lower than their expected export flows.
- iv. For all binding restrictions, the total compensation required to make each IC whole is set equal to the wholesale price spread between GB and their connected market for that hour, per MW of the restriction.

6.74. The total cost of NTC restrictions under the status quo is therefore given by the sum of all compensation paid out for binding restrictions across the South East ICs.

### NTC market

- 6.75. We compare the total cost of NTC restrictions under the status quo to that calculated under a simplified representation of a competitive market for NTC export restrictions.
- 6.76. We therefore assume that, under this competitive market, each IC bids with reference to the value of their export capacity.<sup>101</sup> The value of this export capacity is taken to be the wholesale price differential in the export direction.<sup>102, 103</sup> The outcomes of this competitive market are such that NTC

---

<sup>100</sup> Specifically, we assume restrictions applied to each IC is weighted by their maximum potential export capacity. As an illustrative example, imagine a situation where an NTC restriction needs to be allocated across two ICs. The first has 1,000MW capacity and the second has 500MW capacity. The required restriction is 300MW. The restriction would be allocated as follows across the two ICs:  $1,000\text{MW} \times (500\text{MW} / 1,500\text{MW}) = 200\text{MW}$  and  $500\text{MW} \times (500\text{MW} / 1,500\text{MW}) = 100\text{MW}$ . We understand that this is in line with NESO's current practice.

<sup>101</sup> That is, a price per MW of capacity that makes the IC indifferent between restricting their export capacity and selling that export capacity to a market participant seeking to flow power between GB and Europe.

<sup>102</sup> That is, the maximum of: i) the price in the connected country less the GB price; and ii) zero. If, under our dispatch modelling outcomes, the interconnector is expected to export (that is, the European price is greater than the GB price), the export capacity is valued at the difference between the European price and the GB price. Conversely, if the interconnector is expected to import (that is, the European price is less than the GB price), the export capacity is valued at zero.

<sup>103</sup> This is a simplification of how market participants, in practice, bid for interconnector capacity under the current explicit trading arrangements. Interconnector capacity is often sold for some margin less than the difference in outturn wholesale prices. This reflects a 'margin' earned by market participants for the price risk they undertake when purchasing transmission capacity separately from power. For the purposes of our assessment of a hypothetical NTC market, however, we consider this a proportionate and reasonable simplification.

export restrictions are applied to ICs in ascending order of the value of their export capacity, in that hour.

- 6.77. A given NTC export restriction, under this NTC market scenario, is therefore allocated as follows:
- i. NTC export restrictions are first applied to those ICs that are not expected to export. Export capacity on IC expected to import is, necessarily, valued at zero. Notably, for non-exporting IC, the outcome is identical to that under the status quo arrangements.
  - ii. Any remaining required volumes of NTC export restriction are then allocated in ascending order of wholesale price differentials (between GB and the connected European market).
- 6.78. The total cost of NTC restrictions under an NTC market is then given by the product of total export restrictions applied, and the value of successful bids. This inherently assumes the competitive NTC market is run as a pay-as-bid auction.<sup>104</sup>

### Other simplifying assumptions

- 6.79. Under both the status quo and the NTC market scenarios, we have made the following simplifying assumptions:
- i. ICs in the South East are perfectly substitutable in respect of NTC restrictions – such that each MW of capacity restriction from each South East IC is able to contribute equally to resolve the assumed system issue.
  - ii. Under the NTC market scenario, ICs bid the value of their export capacity, and do not bid strategically.
  - iii. All ICs in the South East participate in all available NTC restriction auctions, and are willing to restrict the full volume of their capacity (scheduled, or otherwise).

### Calculating cost savings

- 6.80. The gross benefits (which do not account for the cost of implementation) of an NTC market over the status quo arrangements are given by the difference in the compensation paid for NTC restrictions between the two scenarios. This is set out, for each modelled year, in the table below.

---

<sup>104</sup> This assumption is likely to minimise the costs paid by NESO to ICs under an NTC market, and therefore maximise the cost savings of an NTC market. A pay-as-clear auction would instead reduce the cost savings of an NTC market over the status quo.

**TABLE 6-1: TOTAL COST OF NTC RESTRICTIONS, PER YEAR (€M, REAL 2024)**

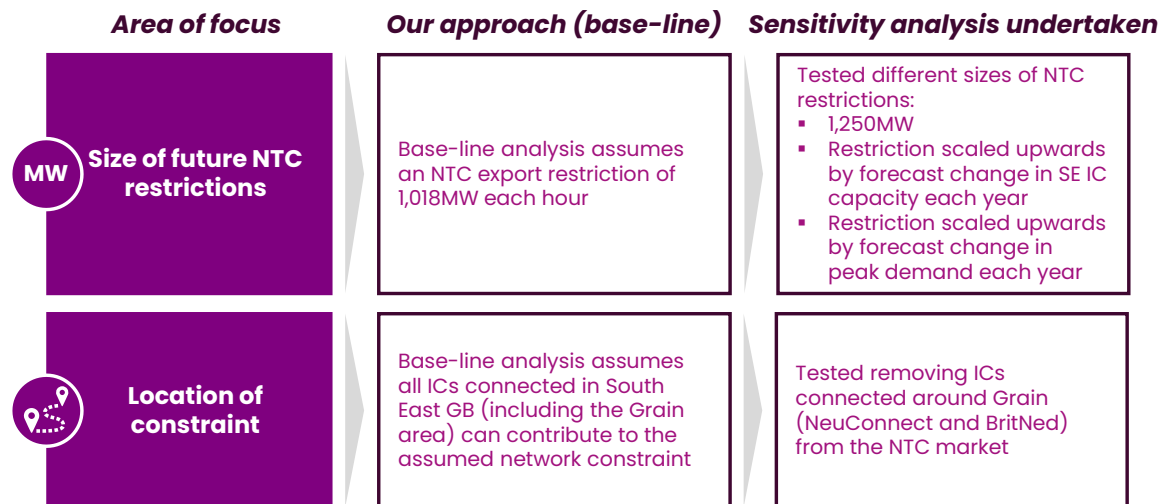
	2030	2035	2040
NTC market	8.8	4.7	5.3
Status quo	10.1	7.6	8.1
<b>Gross benefits of an NTC market</b>	<b>1.3</b>	<b>2.9</b>	<b>2.7</b>

Source: FTI analysis.

- 6.81. An NTC market, operating under ideal conditions, is expected to provide cost savings of between €1.3m and €2.9m per year.
- 6.82. In Appendix A4, we provide an illustrative example of how benefits arise in the NTC market.

### Sensitivity analysis

- 6.83. As discussed in paragraph 6.44, we undertook a number of sensitivities in addition to our baseline analysis to help ensure the robustness of our approach. These sensitivities were developed through discussions with NESO. We use the sensitivities to present a broader envelope of potential NTC market benefits as part of our quantitative assessment.
- 6.84. Figure 6-15 below sets out the key areas of focus for our sensitivities.<sup>105</sup>

**FIGURE 6-15: SUMMARY OF SENSITIVITY ANALYSIS UNDERTAKEN FOR OUR ASSESSMENT**

Source: FTI analysis.

<sup>105</sup> Please see Appendix A7 for a more detailed breakdown of the assumptions underlying our sensitivity analysis.

6.85. Our areas of focus for sensitivity analyses are summarised below:<sup>106</sup>

- i. **Size of future NTC restrictions** – As discussed in Section 3.D, as GB decarbonises, the complexity of managing GB system constraints is expected to grow. For example, regional imbalances between supply and demand, growing IC capacity, and increased intermittency from growing renewables capacity, are all likely to increase the volume of constraints that need to be managed. This is, in turn, likely to change the size of NTC restrictions required in the future. We have therefore tested the benefits of an NTC market, under different sizes of restrictions:
  - a. 1,250MW, reflecting a minor increase from our baseline 1,018MW;
  - b. NTC restriction scaled upwards by forecast change in SE IC capacity (for example, in 2035 this would be a restriction of 1,588MW);<sup>107</sup>
  - c. NTC export restriction scaled upwards by forecast changes in peak demand (for example in 2035 this would be a restriction of 1,795MW).<sup>108</sup>
- ii. **Location of constraint** – As explained in paragraphs 6.22 – 6.25, our analysis focuses on ICs that are, or will be, located in the South East of GB. This includes two ICs, NeuConnect and BritNed, that are connected around Grain, and so may be less able to contribute to an assumed network constraint. We have therefore tested the impact of removing these ICs from the NTC market.

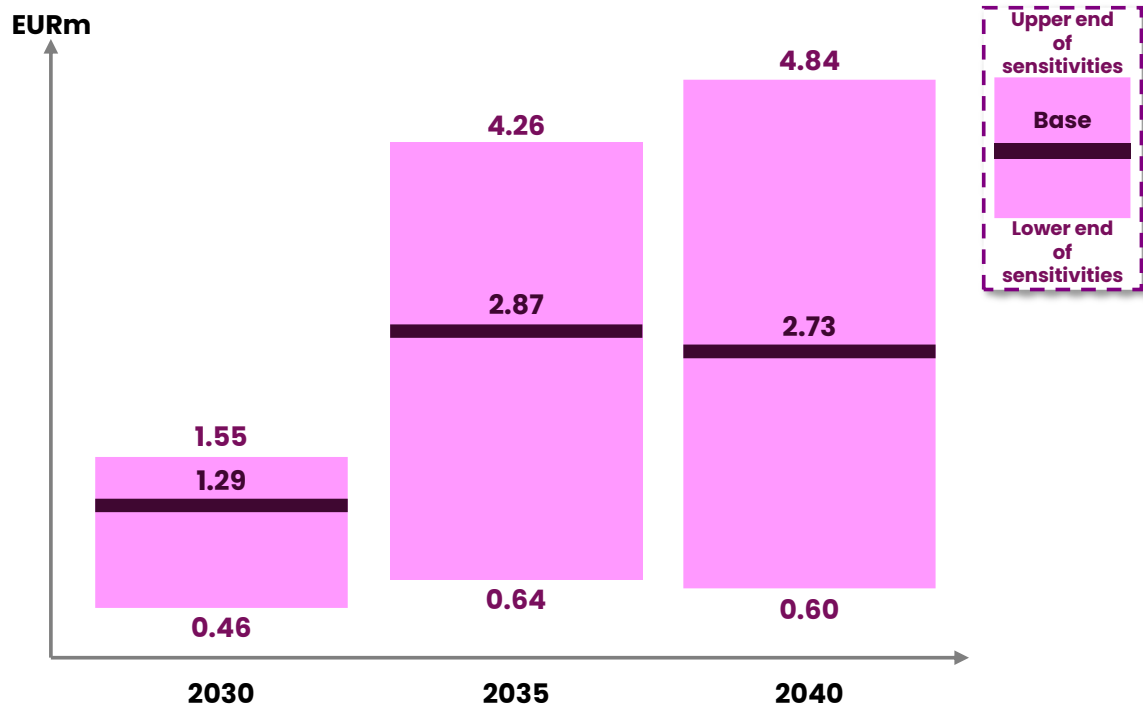
6.86. In Figure 6-16 below, we set out the results of our sensitivity analysis.

---

<sup>106</sup> When testing the sensitivities, we change the parameters of both the status quo and the NTC market in our analysis, which provides a consistent basis for the comparison of savings. For example, the 1,250MW restriction described above would be applied both under the status quo and the NTC market.

<sup>107</sup> SE IC capacity is expected to increase from 5.0GW to 7.8GW between 2024 and 2035 (an increase of c.1.56x).  $1,018\text{MW} \times 1.56 = 1,588\text{MW}$ .

<sup>108</sup> Hourly peak GB demand is expected to increase from c.45.1GW to c.79.5GW between 2024 and 2035 (an increase of c.1.76x).  $1,018\text{MW} \times 1.76 = 1,795\text{MW}$ .

**FIGURE 6–16: ENVELOPE OF BENEFITS FROM A SIMPLIFIED REPRESENTATION OF A COMPETITIVE NTC MARKET (REAL, 2024)**

*Note: We assume the GB-Belgium IC is not available in 2030 but is operational from 2035 onwards, as per our IC modelling assumptions.*

*Source: FTI analysis.*

- 6.87. We find that our gross benefit estimate is sensitive to the different assumptions on IC participation and restriction size, particularly in the later years where the modelled benefit of an NTC market is greater.
- 6.88. The lower bound of the sensitivity range for all years, which is relatively stable at approximately half a million euros per year, is set by the Isle of Grain exclusion sensitivity. This is driven by the high levels of NTC restrictions placed on BritNed in particular under the base case NTC market scenario (that is, BritNed is frequently the lowest cost IC to restrict, driven by a relatively small price differential between GB and the Netherlands). For example, in 2035, the total binding volumes restricted on BritNed increases from 18 GWh over the year under the status quo arrangements to 55 GWh under the NTC market.
- 6.89. All other sensitivities have a positive impact on the benefit of the NTC market. The upper bound in each year is set by the sensitivity where the size of the NTC restriction is scaled up by peak demand. The full sensitivity results are presented in Appendix A7.



## Limitations of our quantitative analysis

- 6.90. Our forward looking quantitative analysis is subject to several limitations, which we summarise below:
- i. We focused solely on the use of NTC restrictions on IC exports from GB to manage network constraints in the South East. It is possible that the NTC market could be, in the future, applied to other use cases.
  - ii. Our estimate of when export NTC restrictions may be required in future is based on a proxy (that is, demand levels), informed by historical analysis. The precise requirements for NTC restrictions will, in practice, vary from those we have modelled and the drivers of NTC restriction use may, in future, become less associated with demand levels.
  - iii. We focus only on the top band of demand. In practice, it is likely that some NTC restrictions will also be required during lower Demand Band periods.
  - iv. We assume that the existing GB market design will broadly persist in its current form (for example, excluding the possibility of a fundamental evolution in GB-EU cross-border trading relationships such as rejoining the IEM).
  - v. We assume that all ICs transition from ITLs to NTC restrictions. See Section 4.C for further discussion of ITLs.
  - vi. We assume that the NTC market operates efficiently (that is, the participants bid their true opportunity costs).
  - vii. We do not incorporate any premium that ICs may incorporate into their bids in practice to reflect administrative issues associated with NTC restrictions or commercial risk (similar to how generators and batteries currently operate in the BM).
  - viii. We do not consider whether other system management tools, such as SO-SO Trades could be used to meet NESO needs instead of NTC restrictions.
  - ix. We utilise modelling outputs from a single scenario as part of our quantitative assessment – that is, the scenario underlying FTI’s recent REMA Dispatch Assessment work, which was developed based on industry-standard forecasts in collaboration with NESO. As such, our analysis is based on a single set of assumptions across a variety of key areas, including:<sup>109</sup> i) capacity outlook across GB and EU; ii) commodity

---

<sup>109</sup> Please see Appendix A6 for a more detailed discussion of the key assumptions underlying FTI’s modelling outputs used in this assessment.

prices; iii) climate years; iv) the GB transmission network; and v) the intra-EU transmission network.<sup>110</sup>

- 6.91. All of these limitations mean that, in practice, the costs associated with NTC restrictions and the potential gross cost savings associated with an NTC market may differ from our estimate.

## C. Design considerations for a potential NTC market in GB

- 6.92. In this section, we explore a selection of the design elements that NESO would need to consider if it were to implement an NTC market and, in the context of the limitations set out above, how the potential benefits of an NTC market may be challenging to achieve in practice. While these considerations are not intended to be exhaustive, they provide an indication of the key concepts and decisions that would need to be made should an NTC market be introduced in GB at some point.

### Substitutability of ICs

- 6.93. As set out in paragraphs 6.23 – 6.25, an NTC market would need to be defined for a specific location, reflecting the locational nature of NESO's system management requirements. However, even within a relatively narrowly defined NTC market, such as the South East of GB the effectiveness of a particular IC to manage a network constraint will vary due to a complex range of factors. For example, despite IFA and Nemo Link being relatively closely located and part of the South East NTC market considered in our analysis, changing the flows across IFA by 100MW will likely have a different impact on a network constraint at Sellindge than a 100MW change in flows across Nemo Link.
- 6.94. Therefore, depending on the relative effectiveness of each participating IC to a given constraint, there would likely be a requirement to apply a form of 'adjustment factor' to the volumes offered by each IC. The offers of less "effective" ICs would be scaled down relative to the offers of more "effective" ICs, with NESO then identifying the lowest cost combination of effectiveness-adjusted offers.

---

<sup>110</sup> Wholesale prices will diverge between connecting countries only if there exist binding transmission constraints between the relevant markets – otherwise participants would arbitrage price differences between the two zones. As such, the extent of transmission network build-out across Europe will influence the value of an NTC market.

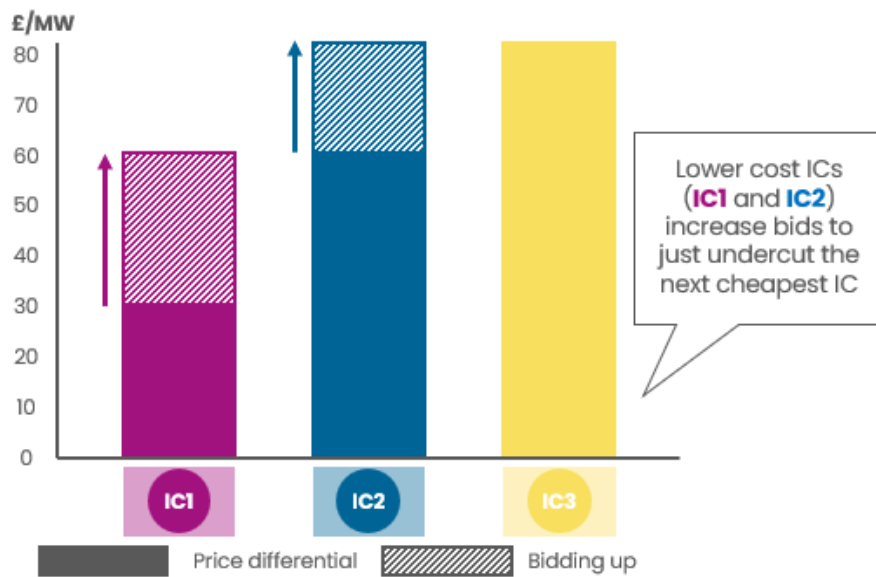
- 6.95. However, in practice, this would likely be highly challenging to implement. The effectiveness of an IC on a given constraint may vary hour by hour,<sup>111</sup> meaning adjustment factors may need to change dynamically. Each specific constraint within a given NTC market area would also be impacted to a different degree by each IC. As such, numerous adjustment factors may be required. Market participants may also reasonably expect the adjustment factors, which could convey detailed information on the GB network, to be publicly available to them, given the material impact they would have on market outcomes. The cost of implementing such an approach would therefore need to be carefully weighed up against the gross benefits.

### Market power risks and IC bidding behaviour

- 6.96. A key challenge for a potential NTC market is the market power of each individual IC over the use of its own capacity. Because only a limited number of ICs are able to resolve a specific system issue, each IC will have a significant degree of influence over the “market for NTC restrictions” within which they operate. In turn, this will influence their bidding strategies.
- 6.97. For example, suppose there are three ICs participating in an NTC market, each connecting to different European countries. If each IC is able to estimate what the other ICs will likely offer as bid prices (based on expected wholesale market price differentials), they can adjust their own bids accordingly. The IC expecting to offer the lowest bid price could increase their bid to just undercut that of the next cheapest, and so on. This is illustrated in Figure 6-17 below, which continues the illustrative example previously set out in Figure 6-1 above:

---

<sup>111</sup> For example, the impact of an IC on a given constraint could depend on factors including, but not limited to: the particular combination of generators operating, the amount and distribution of load across the network, transmission system topology and equipment outages. These factors could result in only one IC being capable of meeting the need for some periods of time and not others.

**FIGURE 6-17: IC BIDS IN AN ILLUSTRATIVE EXAMPLE OF ICs BIDDING UP IN AN NTC MARKET**

Source: FTI analysis.

- 6.98. For example, as shown in the figure above:
- If IC1 is aware of the price differentials in the other connected countries, it could reasonably assume that the other two ICs would not bid in at less than their expected price differential (£60/MW for IC2 and £80/MW for IC3).
  - As a result, IC1 may decide to bid in at marginally less than £60/MW, the expected price differential for the next cheapest IC, making IC1 successful in the NTC restriction auction and allow them to take the entire 150MW restriction at just under £60/MW.
- 6.99. ICs are likely to have an incentive to bid strategically as described above (that is, to increase bids to the next most costly IC) for any number of ICs in a given NTC market. The ability to bid strategically could also increase in circumstances where multiple ICs have a common owner.
- 6.100. Such behaviour may yield an outcome very similar to the current status quo. In some more extreme scenarios, it may erode the theoretical benefits of an NTC market completely (although we note that market monitoring may mitigate this risk to an extent).<sup>112</sup> In the illustrative example above, the cost under an NTC

<sup>112</sup> For example, if there was an NTC restriction that needed to be applied across two cables, under the status quo, the cost of this restriction would be based on the average of the GB-connected country price differentials. With strategic bidding in an NTC market, the cost of this restriction would now be based on the highest GB-connected country price differential (and therefore higher). In this theoretical example, the NTC restriction would cost more under an NTC market than under the status quo.

market would be just under £9,000 – this is nearly £500 more than under the status quo.<sup>113</sup>

- 6.101. For this reason, we expect that an NTC market may not be able – at least in the near future – to function competitively outside of the South East (and even within this relatively deeper market, market power issues may still arise). However, if a different combination of ICs are constructed in future than presented in Figure 6-5, the feasibility of different markets may change.

### IC bid prices

- 6.102. Even in the absence of any significant localised market power, ICs may incorporate a premium into their bids, over and above the opportunity cost associated with being subject to an NTC restriction.
- 6.103. For example, ICs may include additional costs arising from administrative issues associated with capacity restrictions, including developing and maintaining bidding strategies and auction software capabilities. IC owners may also incorporate a premium to reflect commercial risk (actual or perceived). Any such premium would also tend to erode the benefits of an NTC market.

### Operational complexity

- 6.104. Any reform to the status quo would take time to implement and may present operational challenges for NESO and IC owners, as certain processes will be required to facilitate an NTC market in the future.
- 6.105. For example, to facilitate a well-functioning NTC market, NESO must be able to schedule auctions that sufficiently reflect the tight operational timelines required to manage certain system issues, as well as ICs own operating schedules. NESO will likely also be required to implement monitoring arrangements (as with markets for other ancillary services), to ensure participating ICs are complying with the rules of the market. The complexity burden may also increase in future, as innovative IC assets such as Offshore Hybrid Assets are developed, which could necessitate updates to market arrangements due to the connected generation asset.
- 6.106. Beyond NESO, participating ICs will also face greater operational complexity relative to the status quo arrangements. This includes building and maintaining the capability to participate in auctions, as well as developing bidding strategies.

### Timeframes

- 6.107. Under the current status quo, NESO can set NTC restrictions at the DA or ID stages. However, NESO will only set NTC restrictions at DA if a suitable ID option

---

<sup>113</sup> Assuming IC1 bids in to the NTC market at marginally less than £60/MW, and is successful in the auction for the entire 150MW restriction, this would result in a total cost in the market of just under £9,000 (£60/MW x 150MW = £9,000). This is £500 more than the total cost of NTC restrictions under status quo arrangements (£8,500, as shown in Figure 6-2).

does not exist. We understand that this intends to minimise the potential impact of NTC restrictions on the DA wholesale market (where trading volumes are high relative to ID). This also reflects the increased uncertainty that exists regarding system conditions further away from real time.

- 6.108. Furthermore, the greater uncertainty that exists further away from delivery would also present a challenge for ICs to accurately estimate their opportunity cost of being subject to an NTC restriction which, in turn, could affect bidding. ICs could be incentivised to price in an increased element of risk into bids if formulated further away from delivery, which would increase costs of restrictions for NESO and so costs for consumers.
- 6.109. As a result, the NTC market process would need to be calibrated to ensure it completes sufficiently ahead of the relevant ID IC capacity auctions, such that IC owners can adjust the amount of capacity offered in line with NTC restriction auction outcomes (assuming NESO continues its current approach of prioritising unallocated capacity for restrictions).

### Other considerations

- 6.110. In addition to the key design issues set out in the preceding paragraphs, consideration may also need to be given to:
- i. *Fallback arrangements* – Given the importance of the current NTC restriction arrangements in ensuring system security, fallback arrangements for an NTC market would need to be in place. This could cover both the scenario in which auction process fails for technical reasons, or from a lack of sufficient participation (for example, if an NTC market has three IC participants and two are offline for maintenance, it may be reasonable for the NTC market to be suspended). IC owners may also choose not to participate, presenting a further risk to the operation of the NTC market. On the assumption that such periods would be infrequent, NESO could consider retaining the current status quo arrangements as a fallback mechanism.
  - ii. *Participation requirements* – NESO may need to consider mandating the functionality to participate in an NTC market for all ICs,<sup>114</sup> if a market covering the location of their connection point exists. This should, in theory, maximise the potential gross benefits of the market. However, it is important to note that while mandating participation is possible, it is more difficult to guarantee that participants will bid at levels reflecting their marginal cost (as discussed in more detail in the ‘market power’ subsection). NESO may therefore be exposed to the risk that market participants bid in at very high prices and could even result in ICs, in effect, ‘opting out’ of the market through exceptionally high bid prices. A suitable fallback mechanism (for

---

<sup>114</sup> As set out in paragraph 5.5, NESO currently has the ability to unilaterally set NTC restrictions as required to maintain system security.

example, setting a maximum NTC market price above which the status quo arrangements could instead be utilised by NESO) could, however, mitigate this risk.

- iii. *Unwinding NTC restrictions* – Conditions could arise that render previously allocated NTC restrictions redundant or, in the worst case scenario, mean they negatively impact system security. As such, a mechanism to unwind restrictions is likely to be required as part of an NTC market, potentially including compensation for impacted ICs.
- iv. *Cross-border alignment with European SOs* – Any reform to the current NTC restriction arrangements may affect connected SOs which, in turn, could strain existing relationships. For example, if the introduction of an NTC market resulted in a specific IC being restricted very frequently relative to others, this may have implications for system management in the connected market. There could also be knock on impacts on connected wholesale market outcomes by frequently removing IC capacity. Changes to NTC restriction arrangements may also require formal approval from the relevant connected SOs, possibly complicating or even preventing the introduction of an NTC market.<sup>115</sup>

















## D. Assessment of an NTC market

- 6.111. In Figure 6-18 below, we set out a summary of our assessment of the benefits and drawbacks of introducing a potential NTC market in GB against the assessment principles set out in paragraph 5.2 above. In the following subsections, we present our analysis for each principle in more detail.

---

<sup>115</sup> Consideration of any formal approval processes for an NTC market by connected markets, and an assessment of whether such processes are necessary, is outside the scope of this report.

**FIGURE 6-18: SUMMARY OF NTC MARKET ASSESSMENT**

Principle	Assessment of NTC market	Score – NTC market	Score – Status quo
<b>System security</b>	<ul style="list-style-type: none"> <li>Assuming fall back to status quo arrangements if market is unsuccessful, an NTC market should be effective in maintaining compliance with SQSS</li> </ul>		
<b>Cost efficiency</b>	<ul style="list-style-type: none"> <li>An NTC market could in theory lower costs for consumers associated with NTC restriction usage...</li> <li>... by allocating restrictions to ICs that face the lowest price spread (that is, the lowest price differential between GB and the connected market)</li> <li>However, there remains a risk associated with the depth of markets and the potential for exercise of market power</li> <li>Additionally, markets cannot reasonably be applied across all ICs due to their location of nature of the connected market...</li> <li>... and even with a relatively narrow market ICs will not be perfectly substitutable for one another, harming competition</li> </ul>		
<b>Efficient investment signals</b>	<ul style="list-style-type: none"> <li>Any revenues generated from an NTC market (over and above revenues from capacity sales foregone) are likely to be relatively small compared to total interconnector revenues and therefore will have a limited impact on interconnector investment signals</li> </ul>		
<b>Simplicity</b>	<ul style="list-style-type: none"> <li>An NTC market will necessitate the upfront investment in the development of new capabilities from NESO, for example an auction platform</li> <li>Implementation of a market may strain relationships with connected SOs</li> <li>On an enduring basis, operating an NTC market will bring some complexity for NESO and market participants compared to the status quo, and calculating 'adjustment factors' could be highly complex</li> <li>However, the NTC market reduces the need for NESO to calculate an equitable allocation across ICs, instead allocations would be determined by market participants' bids (shifting some complexity from NESO to ICs)</li> </ul>		
<b>Transparency</b>	<ul style="list-style-type: none"> <li>The allocation of NTC restrictions across ICs would be more transparent in an NTC market (that is, they will be allocated to the lowest cost options)...</li> <li>... however, the process followed by NESO for determining when NTC restrictions are needed and the associated volumes restricted would not necessarily be improved through the introduction of an NTC market</li> </ul>		
<b>Future-proof</b>	<ul style="list-style-type: none"> <li>New ICs could be incorporated into NTC markets when they come online</li> <li>The NTC market removes the need for NESO to calculate an equitable allocation of restrictions across ICs, which will likely become increasingly burdensome for NESO as more ICs connect</li> <li>Incorporating new IC asset classes, however, may be challenging</li> <li>Determining asset substitutability may become more complex with more ICs</li> </ul>		
<b>No undue discrimination</b>	<ul style="list-style-type: none"> <li>ICs only can participate in an NTC market if they are deemed to contribute to a specific issue</li> <li>ICs bid into the market at the price of their choosing</li> <li>However, there is a risk that having different mechanisms to allocated NTC restrictions across ICs (that is, those inside or outside of a market) could be perceived as unfair</li> </ul>		
<b>Compliance with rules, laws and regulations</b>	<ul style="list-style-type: none"> <li>Market based mechanism appears more consistent with NESO's licence</li> <li>However, it will not completely remove the need for the status quo NTC restrictions, either in the form of a fallback mechanism if the market fails or for ICs not located within an NTC market</li> </ul>		





## System security

**FIGURE 6–19: SUMMARY OF NTC MARKET ASSESSMENT: SYSTEM SECURITY**

Principle	Assessment of NTC market	Score
<b>System security</b>	<ul style="list-style-type: none"> <li>Assuming fall back to status quo arrangements if market is unsuccessful, an NTC market should be effective in maintaining compliance with SQSS</li> </ul>	

- 6.112. Assuming appropriate fallback mechanisms are in place to allocate restrictions in the event that an auction fails, an NTC market should offer a similar degree of system security as the status quo arrangements (discussed in paragraphs 5.5–5.6 above). For the purpose of our analysis, we assume that this fallback mechanism would, in practice, be an exact continuation of the status quo arrangements, with NESO spreading restrictions across the ICs it deems to contribute to a constraint, with each IC compensated on a make whole basis.

## Cost efficiency

**FIGURE 6–20: SUMMARY OF NTC MARKET ASSESSMENT: COST EFFICIENCY**

Principle	Assessment of NTC market	Score
<b>Cost efficiency</b>	<ul style="list-style-type: none"> <li>An NTC market could in theory lower costs for consumers associated with NTC restriction usage...</li> <li>... by allocating restrictions to ICs that face the lowest price spread (that is, the lowest price differential between GB and the connected market)</li> <li>However, there remains a risk associated with the depth of markets and the potential for exercise of market power</li> <li>Additionally, markets cannot reasonably be applied across all ICs due to their location of nature of the connected market...</li> <li>... and even with a relatively narrow market ICs will not be perfectly substitutable for one another, harming competition</li> </ul>	

- 6.113. As set out in Figure 6–16, our quantitative analysis of an NTC market suggests that the gross benefits of introducing a market in the South East of England could total between €0.5m a year to €4.8m a year, with our base case estimate ranging from €1.3m a year to €2.9m a year. The gross benefit is relatively lower in 2030 (the first year modelled), ranging from €0.5m to €1.6m; for 2035 and 2040, the benefits increase to a range of €0.6m to €4.3m and €0.6m to €4.8m respectively.<sup>116</sup> These gross benefits arise from shifting restrictions towards ICs that face the lowest price spread (that is, the lowest price differential between GB and the connected market).

<sup>116</sup> Our estimate of the gross benefits captures only the potential direct cost saving from NESO payments to ICs. We have not attempted to quantify other monetary costs, such as the cost to NESO of developing NTC market capabilities (such as computer software) or equivalent costs for ICs.

- 6.114. However, this analysis is subject several simplifying assumptions which mean that, in practice, the gross benefits of an NTC market may be lower than modelled. Most significantly, these include:<sup>117</sup>
- i. That each of the ICs will bid into the NTC market at the opportunity cost of their capacity. As discussed in paragraphs 6.96 to 6.101, the relatively limited number of ICs that will be able to participate in any NTC market risks affording each a higher degree of market power and, in turn, the ability to drive up bids above individual opportunity costs. Even absent market power effects, ICs may choose to incorporate a degree of premium into their bids. Both elements will reduce the benefit of an NTC market and may even risk consumers being exposed to higher costs than under the status quo.
  - ii. That ICs within the market are perfectly substitutable for one another. In practice, the effectiveness of a particular IC to manage a network constraint will vary due to a complex range of factors, even within a relatively narrowly defined NTC market. This lack of substitutability will, in effect, increase the cost of using a less-optimally located ICs to manage a given constraint, in turn reducing the potential cost saving associated with an NTC market.
- 6.115. We have also not attempted to quantify the costs that NESO and ICs would incur to develop and implement the capabilities required to operate or participate in an NTC market (although we discuss qualitatively the impact of NESO and ICs' operations in paragraph 6.121 below). As such, we capture only the gross cost benefit of implementing an NTC market, rather than estimating the net benefit which may be significantly lower (or even net negative on a net present value basis).
- 6.116. In this context, we find that the potential cost savings to GB consumers from introducing an NTC market in the South East of England are likely to be relatively limited, particularly in the short term. We also find that consumers could be exposed to the risk of higher costs than under the status quo due to the presence of significant market power and its impact on IC bidding behaviour (although market monitoring may be able to mitigate this risk to an extent).
- 6.117. Outside of the South East, it appears unlikely that there will be a sufficient cluster of ICs to justify the introduction on an NTC market all together, unless there are multiple additional ICs constructed relative to our assumed buildout that are both i) close to existing ICs (for example, in East Anglia); and ii) connected to different European markets. As such, there is limited scope for cost savings outside of the South East.

---

<sup>117</sup> Other assumptions may result in our modelling producing an underestimate of the benefits. Please see paragraphs 6.42–6.44 and Appendix A6 for a detailed discussion of our modelling assumptions.

- 6.118. However, the modelled cost savings in the South East are materially higher in the later years, as the level of IC capacity grows and renewable generation capacity continues to provide a greater share of generation in all modelled countries (in turn, driving greater variability across connect market prices).

### Efficient investment signals

**FIGURE 6–21: SUMMARY OF NTC MARKET ASSESSMENT: EFFICIENT INVESTMENT SIGNALS**

Principle	Assessment of NTC market	Score
<b>Efficient investment signals</b>	<ul style="list-style-type: none"> <li>Any revenues generated from an NTC market (over and above revenues from capacity sales foregone) are likely to be relatively small compared to total interconnector revenues and therefore will have a limited impact on interconnector investment signals</li> </ul>	

- 6.119. Within an NTC market, participating ICs would be free to formulate their own bids. Broadly, we expect that ICs would bid with reference to their opportunity cost (that is, the revenue it would otherwise make from selling the restricted capacity), likely with an additional premium (possibly reflecting a degree of market power and a premium to cover costs of participating in the market). On this basis, ICs would be able to recover their costs associated from participating in the market.
- 6.120. Additionally, ICs may be able to make a degree of profit from the NTC market, depending on the effectiveness of their bidding strategy and in circumstances where a given IC is particularly valuable in meeting a given constraint. However, we expect this would be relatively limited compared to an IC's 'traditional' revenue stream from the sale of capacity. As such, an NTC market is unlikely to materially impact investment signals.

### Simplicity

**FIGURE 6–22: SUMMARY OF NTC MARKET ASSESSMENT: SIMPLICITY**

Principle	Assessment of NTC market	Score
<b>Simplicity</b>	<ul style="list-style-type: none"> <li>An NTC market will necessitate the upfront investment in the development of new capabilities from NESO, for example an auction platform</li> <li>Implementation of a market may strain relationships with connected SOs</li> <li>On an enduring basis, operating an NTC market will bring some complexity for NESO and market participants compared to the status quo, and calculating 'adjustment factors' could be highly complex</li> <li>However, the NTC market reduces the need for NESO to calculate an equitable allocation across ICs, instead allocations would be determined by market participants' bids (shifting some complexity from NESO to ICs)</li> </ul>	

- 6.121. Introducing an NTC market would represent a material increase in operational complexity for NESO and participating ICs, as set out in paragraphs 6.104 to 6.106. This includes both the complexity to initially implement the market (for example, developing an auction platform) and the high ongoing burden to run or participate in auctions, often within relatively short timeframes. Market monitoring processes, implemented by either (or both) NESO or Ofgem, will likely also be required, to ensure market participants are complying with market rules.
- 6.122. The implementation of a market could strain NESO's relationships with connected SOs due to the risk of unintended consequences in connected

markets (for example, if a single IC is consistently being restricted under an NTC market). Reforms may also require approval from the connected SOs.

- 6.123. However, under an NTC market, NESO would no longer be required to calculate an equitable allocation of restrictions across participants (instead, restrictions would be allowed to the lowest bids) or estimate the value of the capacity restricted in line with the existing NTC Commercial Arrangements methodology. In isolation, this would represent a reduction in complexity vs the status quo. However, in practice, the substitutability issues discussed in paragraph 6.95 could result in significant complexity to calculate the appropriate effectiveness-adjusted restriction and subsequent compensation for each IC.
- 6.124. Additionally, complexity is also shifted onto ICs, who are required to develop a bidding strategy and submit bids for each auction.

## Transparency

**FIGURE 6-23: SUMMARY OF NTC MARKET ASSESSMENT: TRANSPARENCY**

Principle	Assessment of NTC market	Score
<b>Transparency</b>	<ul style="list-style-type: none"> <li>The allocation of NTC restrictions across ICs would be more transparent in an NTC market (that is, they will be allocated to the lowest cost options)...</li> <li>... however, the process followed by NESO for determining when NTC restrictions are needed and the associated volumes restricted would not necessarily be improved through the introduction of an NTC market</li> </ul>	

- 6.125. The introduction of an NTC market could improve transparency relative to the status quo, as restrictions would be allocated on the basis of ICs' bids, as opposed to NESO's (non-public) calculation of an equitable allocation.
- 6.126. However, elements of NTC restriction use would likely remain relatively opaque. In particular, the transparency of NESO's calculation regarding what, if any, restrictions are required at any given point in time would unlikely be improved by the introduction of the NTC market. The process for determining the adjustment factor (that is, a metric that captures the effectiveness of an IC in managing a given constraint) may also be a source of uncertainty for market participants (noting that a similar evaluation of IC effectiveness is already required under the status quo).

## Future-proof

**FIGURE 6-24: SUMMARY OF NTC MARKET ASSESSMENT: FUTURE-PROOF**


Principle	Assessment of NTC market	Score
<b>Future-proof</b>	<ul style="list-style-type: none"> <li>New ICs could be incorporated into NTC markets when they come online</li> <li>The NTC market removes the need for NESO to calculate an equitable allocation of restrictions across ICs, which will likely become increasingly burdensome for NESO as more ICs connect</li> <li>Incorporating new IC asset classes, however, may be challenging</li> <li>Determining asset substitutability may become more complex with more ICs</li> </ul>	

- 6.127. Once the operational functionality for an NTC market has been developed by NESO, it should in theory be relatively simple to incorporate new ICs into an existing NTC market (subject to any complexity associated with reaching an agreement between NESO and the IC, and potentially the connected SO). The benefits of an NTC market would, all else assumed equal, likely increase as more ICs join the market also.

- 6.128. Allocating restrictions on the basis of ICs' bids, as opposed to an assessment by NESO of an equitable allocation under the status quo design, is also likely to be more robust to the number of ICs growing in future.
- 6.129. However, it may be challenging to integrate any innovative assets classes such as Offshore Hybrid Assets and could require NTC market reforms, due to the connected generation assets. Calculating appropriate adjustment factors (or a similar mechanism to reflect assets substitutability) may also become increasingly challenging with more ICs.

### No undue discrimination

**FIGURE 6–25: SUMMARY OF NTC MARKET ASSESSMENT: NO UNDUE DISCRIMINATION**


Principle	Assessment of NTC market	Score
<b>No undue discrimination</b>	<ul style="list-style-type: none"> <li>ICs only can participate in an NTC market if they are deemed to contribute to a specific issue</li> <li>ICs bid into the market at the price of their choosing</li> <li>However, there is a risk that having different mechanisms to allocated NTC restrictions across ICs (that is, those inside or outside of a market) could be perceived as unfair</li> </ul>	

- 6.130. ICs will only be able to participate within an NTC market if they are deemed to sufficiently contribute to a given constraint and participating ICs would be free to formulate their own bids. As such, any restrictions set under the NTC market should be based on 'due' discrimination (that is, the restricted IC is both contributing to a given constraint and has bid to be subject to the NTC restriction).
- 6.131. However, there is a risk that the different mechanisms for allocating NTC restrictions for those located within or outside of an NTC market (that is, the status quo arrangements for those not inside a market, and a competitive auction for those within) could be perceived as unequal or unfair by stakeholders.
- 6.132. With an NTC market, it is likely that one or a small number of ICs are subject to restrictions frequently. While this would be on the basis of the bids submitted by the relevant ICs, as driven by the opportunity cost of their transmission capacity, stakeholders may view this negatively. For example, the connected SO may have concerns regarding the frequency of restrictions from a system security perspective, while connected market regulators or policy makers may consider the wholesale energy price impacts of frequent IC exports to be distortive.
- 6.133. While both the perimeter of the NTC market and the application of the NTC restrictions (based on market outcomes) could be defined in a manner that reflects 'due' discrimination (for example, the number of ICs within a given locality; and the relative commercial position of NTC restriction bids), there is a risk that stakeholders, including connecting SOs and/or the IC owners affected could perceive the outcomes as being unfair. We acknowledge this, but overall evaluate the 'No undue discrimination' as being as effective as the status quo.

- 6.134. We also note that the introduction of an NTC market is unlikely to mitigate ICs' concerns on whether the tool is being used only as a last resort, as the process followed by NESO to identify the need for NTC restrictions would be largely unimpacted by the introduction of an NTC market. In other words, the NTC market would be addressing primarily the price of NTC restriction actions being taken, but not their volume.

### Compliance with rules, laws and regulations

**FIGURE 6–26: SUMMARY OF NTC MARKET ASSESSMENT: COMPLIANCE WITH RULES, LAWS AND REGULATIONS**

Principle	Assessment of NTC market	Score
<b>Compliance with rules, laws and regulations</b>	<ul style="list-style-type: none"> <li>Market based mechanism is consistent with NESO's licence</li> <li>However, it will not completely remove the need for the status quo NTC restrictions, either in the form of a fallback mechanism if the market fails or for ICs not located within an NTC market</li> </ul>	

- 6.135. Allocating NTC restrictions via a competitive auction is consistent with NESO's licence requirement to procure balancing services through market-based procedures.
- 6.136. However, both in the event that the auction fails to fully meet NESO's requirements and for ICs where an NTC market is not feasible (for example, due to an insufficient number of ICs located close to one another), the status quo arrangements will still be required. Therefore, while it is possible that an NTC market could reduce NESO's current reliance on non-market mechanisms, it is not currently credible for the status quo NTC restriction arrangements to be removed entirely.
- 6.137. As such, even with a NTC market in place, NESO would still be required to seek derogations from its licence from Ofgem in future.

## E. Conclusions on the NTC market

- 6.138. We find there could, in theory, be gross cost savings for GB consumers from implementing an NTC market in GB, achieved by reallocating restrictions away from relatively high-cost ICs (that is, those that have high price differentials between GB and the connected market) and towards relatively low cost ICs. The market could also help to improve transparency regarding NTC restriction usage to an extent, as restrictions would be allocated across ICs based on their bids.
- 6.139. However, there are several risks that could erode these gross benefits, most critically i) the risk that relatively limited competition within NTC markets would afford individual participants significant market power; and ii) that the lack of substitutability of different ICs to meet a given constraint in practice could significantly limit competition within the market. Implementing an NTC market would also place increased operational burden on both NESO and participating ICs. Furthermore, if an NTC market was implemented, it appears highly unlikely that it could entirely replace the status quo arrangements entirely, most

obviously for ICs that are not located suitably to operate within a market, meaning derogations from NESO's licence would continue to be required.

- 6.140. As previously explained, we have not, in this report, attempted to quantify the expected implementation costs of an NTC market for NESO, IC participants, and Ofgem. We find that the gross benefits (that is, before costs), are between €1.3m and €2.9m per year for our base case. That is, there are expected to be net benefits to GB consumers as long as total annual implementation costs (both operating costs and annualised capital costs) are less than €1.3m per year.
- 6.141. As such, the overall benefits case for an NTC market appears to be currently limited. The case for implementation in the short term in particular appears relatively weaker, as a result of the materially lower gross benefit case found in our quantitative modelling for 2030 compared to later years.
- 6.142. Given the mixed benefits case we have found for an NTC market, in the following section we explore the potential for other options to reduce NESO's reliance on NTC restrictions in their current form.

## 7. Alternative mechanisms to reduce reliance on non-market NTC restrictions

7.1. In this section, we examine the potential for alternative mechanisms to an NTC market, which could reduce NESO's reliance on the status quo NTC restriction arrangements. We first touch on a broad range of options that, in principle, could reduce the need for NTC restrictions. We then consider a shortlist of options in more detail, focusing primarily on an extension of NESO's (existing) trading activities.

### A. Options to reduce reliance on non-market NTC restrictions

7.2. In the previous section, we explored the potential for an NTC market to replace or reduce the use of NTC restrictions in their current form. However, there are a range of other tools or reforms that could be implemented to reduce or manage the same system issues that NESO utilises NTC restrictions for currently.

7.3. Broadly, these alternatives fall into two categories:

- i. GB market design reforms that would reduce the likelihood of system issues arising.
- ii. Tools which can be used to manage and reduce system issues if and when they arise.

#### GB market design reforms

7.4. Under the existing arrangements, NESO use NTC restrictions when a network constraint, margin extreme or largest loss related issue arises that it cannot resolve via other non-emergency tools. As such, reforms to the GB market that reduce the instances or severity of these system issues in future will likely reduce the need for NTC restrictions.

7.5. For example, reforms to the GB market are being actively considered through the REMA process, which recently set out its decision to pursue *"a cohesive package of reforms to improve the effectiveness of our national pricing model."*<sup>118</sup> It is currently unclear what the precise nature of these reforms will be and therefore we do not consider them further within this report (or any other changes to the existing GB market design).<sup>119</sup>

---

<sup>118</sup> DESNZ, REMA Summer Update, July 2025, page 5 ([link](#)).

<sup>119</sup> In this report, we have not considered whether changes to cross-border trading arrangements (for example, MRLVC or price coupling) could impact the need for or use of NTC restrictions.



## Alternative tools

- 7.6. As set out in paragraph 2.4, NESO has a variety of tools at its disposal that it can use to manage system issues. Under the existing NTC restriction arrangements, NESO is already required to consider these alternative tools before it utilises NTC restrictions. However, it is possible that some of these existing tools could evolve or be reformed such that they are better able to meet NESO's requirements and, in turn, avoid the use of NTC restrictions more frequently.
- 7.7. One such option is Trades, which NESO currently uses to alter IC flows and the output of generators. We examine Trades and their potential to reduce NTC restriction usage in more detail in the following section.

## B. Trades

- 7.8. NESO enters into energy Trades with market participants. These Trades are used when a change in an energy position could manage a given system issue at a lower cost than the alternative system management tools available to NESO. For example, if NESO has identified a need to increase generation in a certain location by 50MWh and expects this action to cost £100/MWh in the BM, it may attempt to achieve the same increase in generation via a Trade, if it can do so for less than £100/MWh.
- 7.9. NESO undertakes Trades on an ad hoc basis across a range of different assets, such as ICs, gas generators, batteries and wind farms. In the context of ICs specifically, NESO trades with the holders of IC capacity,<sup>120</sup> with the aim of altering IC flows to manage system needs. This contrasts with NTC restrictions, where NESO places restrictions on the IC owner to impact flows.
- 7.10. In the illustrative example above, an increase in generation of 50MWh could also potentially be met by increasing the imports of a suitably located GB IC. NESO could therefore enter into a Trade with a party that holds the right to import into GB across the relevant IC,<sup>121</sup> or a party that is willing to purchase this right in an upcoming IC capacity auction. However, NESO will only do so if it costs less than the £100/MWh. If a market participant agrees to this Trade with NESO, it will then be required to:
- i. purchase 50MW of capacity rights across the relevant IC for importing into GB for the relevant hour (assuming it does not already own this);
  - ii. nominate these capacity rights; and
  - iii. purchase 50MWh of energy in the connected wholesale energy market, which is then imported into GB.

<sup>120</sup> Or those who intend to purchase capacity in future IC capacity auctions.

<sup>121</sup> Some traders may purchase the right to use IC capacity without necessarily intending to use it. For example, it may be purchased as an option or hedge against further wholesale energy price movements, or possibly with a view to enter Trades with NESO in future.

## Background to trading

- 7.11. NESO's use of trading has evolved over time. In the 2000s,<sup>122</sup> NESO offered and agreed Trades over the phone. In 2018, NESO traded over only two ICs, via email, with a limited number of participants.<sup>123</sup> However, as the number of ICs has increased over recent years, this relatively simple approach became unsuitable. As such, in 2022 NESO initiated a reform process to update its interconnector trading processes.<sup>124</sup>
- 7.12. NESO now leverages a bespoke trading platform to manage its IC trading. Through this platform, for each trading requirement NESO will specify details including:
- i. the ICs that can meet NESO's requirement;
  - ii. the volumes required and in which direction; and
  - iii. the delivery period.
- 7.13. Registered trading participants then submit bids via the platform to meet these requirements, from which NESO chooses the least cost combination that meets its requirements.
- 7.14. For every potential Trade, NESO's trading team identifies a reserve price that must be beaten for a Trade to be executed (that is, it is the maximum price at which a given Trade can be undertaken). This reserve price is based on the trading team's understanding of the cost of alternative actions that NESO could take to manage the given system issue. To inform this reserve price, the trading team liaises closely with the NESO control room (who are responsible for undertaking actions in the BM and utilising ancillary services and, as such, are well placed to estimate the cost of alternative actions).

## Potential reforms to NESO's trading

- 7.15. NESO's reforms to IC trading since 2022 have improved its capability to trade effectively across a growing number of ICs and market participants. However, trading across assets other than ICs does not currently occur via the bespoke trading platform. Instead, we understand from NESO that Trades are still conveyed and agreed over the phone, separate to IC trading.
- 7.16. As such, there may be an opportunity to better integrate non-IC assets into NESO's trading operations. For example, assets could potentially be integrated into the bespoke trading platform currently used for IC trading only (we refer to this as an "Extended Trades market"). This, in turn, could provide easier access to lower cost assets when NESO undertakes Trades and would encourage stronger competition between participants.

---

<sup>122</sup> NESO, Interconnector Trades – Procurement Framework Consultation, 4 April 2022, page 1 ([link](#)).

<sup>123</sup> NESO, Interconnector Trading Procurement Framework Webinar, April 2022, slide 4 ([link](#)).

<sup>124</sup> NESO, Interconnector Trades – Procurement Framework Consultation, 4 April 2022 ([link](#)).

- 7.17. We recognise that a degree of these benefits may already be captured within NESO's existing operations. When NESO undertakes Trades, it considers the options that it expects will likely be available to it via the BM to redispatch resources (for example, generators and storage assets) post gate closure to meet system needs. This informs the reference price set for a given Trade. Traders of IC capacity are therefore already indirectly 'competing' with other parties (or rather, competing against the reference price) to meet system needs when bidding to Trade with NESO; if they are not willing to beat the reference price (that is, NESO's view of the likely cost of alternative actions to meet the given system issue) then the Trade would not occur and NESO would manage the issue using other tools. This places some downward pressure (similar to the effect of competition) on bids for Trades with NESO.
- 7.18. However, the reference price is, by necessity, based on NESO's forecast of future BM bids and offers made by market participants, which may not consistently be accurate. It also does not allow for direct competition between traders of IC capacity, generators and storage assets in the same manner than an Extended Trades market could, at least in theory.
- 7.19. In the following subsection, we examine the benefits of enhancing NESO's trading operations as potential option to reduce its reliance on the status quo NTC restriction arrangements, relative to an NTC market.

### Benefits of Trades

- 7.20. Relative to the status quo NTC restriction arrangements, Trades can offer NESO several benefits (some of which are similar to an NTC market). Importantly, NESO's current trading across ICs is market-based, meaning it is consistent with NESO's licence. The competitive nature of the tool can also, in theory, help to drive down costs to consumers relative to the status quo NTC restriction arrangements.
- 7.21. However, relative to an NTC market, Trades appear to have several additional potential upsides. A key benefit is that NESO enters into Trades with the holders of IC capacity (that is, traders of energy and IC capacity), as opposed to interacting with the IC owner itself. This helps to mitigate the market power issues associated with an NTC market, as at any given point in time multiple parties will be trading over a single IC. In turn, the bids submitted by traders to meet NESO's requirements are more likely to reflect the energy trader's true cost which, like IC owners, will be anchored to wholesale market price spreads.<sup>125</sup>
- 7.22. This larger pool of traders (as opposed to a single IC owner) helps to mitigate the substitutability challenges faced by the NTC market; in instances where a specific single IC may be significantly more effective in managing a constraint

---

<sup>125</sup> The competitive market price should therefore, in theory, be similar for an efficient NTC market and an efficient Trades market that comprised only of ICs.

than others, competition can still arise between the multiple traders of capacity across that IC.

- 7.23. NESO is also able to trade across a broader range of assets than ICs alone. If NESO's trading can be further developed to more systematically incorporate more assets into the auction process, this can promote greater liquidity and further encourage competition to meet NESO's needs, driving down costs for consumers.
- 7.24. For the above reasons, an Extended Trades market (or markets) can be utilised even in areas without a cluster of multiple ICs, unlike an NTC market. Under the existing Trades framework, NESO already runs auctions for single ICs, including for those located outside of the South East of GB.<sup>126</sup> In future this could be extended to areas with a single IC and multiple batteries or other dispatchable generators.
- 7.25. Following the reforms set out in paragraph 7.12 above, NESO already has an bespoke auction platform for undertaking its trading activities, which could also help to reduce the implementation costs relative to implementing an entirely new NTC market (depending on the extent of the changes required to the existing Trades platform to broaden participation to generators).

---

<sup>126</sup> As demonstrated on NESO's data portal. See "Interconnector Requirements and Auction Summary" dataset, which includes auctions for trades across Viking Link ([link](#)).

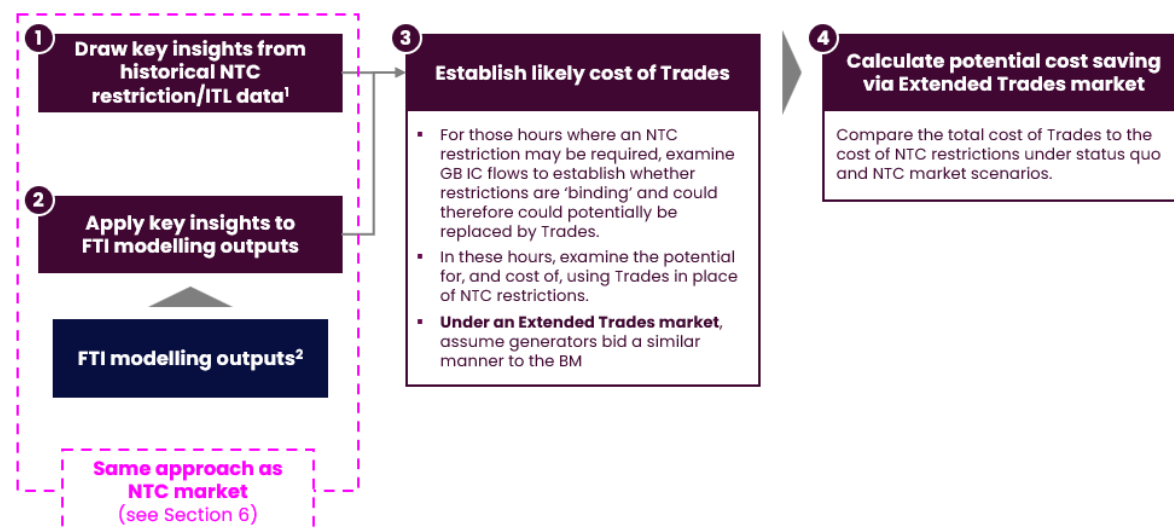
## C. Quantitative analysis of an Extended Trades market

- 7.26. As discussed above, potential reforms to NESO's current trading arrangements may, in some circumstances, provide similar benefits compared to the status quo as an NTC market while mitigating some of the drawbacks.
- 7.27. In this section, we present our quantitative analysis of an Extended Trades market. We start with an overview of our methodology, drawing on our existing quantitative framework for evaluating an NTC market as set out in Section 6. We provide our estimate of the potential gross cost savings of an Extended Trades market relative to the current status quo arrangements across 2030, 2035 and 2040, and also compare these savings to an NTC market.<sup>127</sup>

### Overview of quantitative assessment methodology

- 7.28. Figure 7-1 below summarises our approach to quantitatively assessing the potential benefits of an Extended Trades market.

**FIGURE 7-1: SUMMARY OF QUANTITATIVE ASSESSMENT METHODOLOGY**



Notes: (1) NTC restriction/ITL usage data ([link](#)); and (2) Please see REMA Dispatch Assessment work for NESO ([link](#)).

Source: FTI analysis.

- 7.29. As shown in the figure above, our assessment draws on our existing quantitative framework for assessing an NTC market, as set out in Figure 6-9, but focuses specifically on comparing the status quo to an Extended Trades market. It comprises of four key stages. The first two – covering **'analysing historical NTC restriction usage data'** and **'applying historical insights to modelling outputs'** – are the same as our analysis of the NTC market (as summarised in paragraphs 6.42 – 6.44 above and detailed in the paragraphs

<sup>127</sup> These are estimates of the gross cost savings; they exclude implementation and ongoing costs associated with an extended Trades market.

that follow this). However, for the subsequent stages, we broaden our analysis relative to the NTC market to incorporate a wider range of assets:

- i. **Establishing the likely cost of Trades** – Building on the outputs of the prior two stages, which identify periods in the future that restriction may be required, we calculate the potential for (and cost of) using Trades in place of NTC restrictions in these periods:
  - a. We forecast bids across IC traders, and suitably located generator and storage assets in the context of an Extended Trades market, using pre-existing FTI modelling outputs.
  - b. The cost of Trades is calculated as the change in energy position required across entities trading with NESO, which equates to the expected binding volume of NTC restrictions, multiplied by their bids.
- ii. **Calculating the potential cost savings of an Extended Trades market** – We compare the total cost of Trades to the status quo NTC restriction arrangements and the NTC market (as set out in Table 7-1).

7.30. As for the NTC market, we also test several sensitivities, which we discuss in paragraphs 7.55 – 7.58 below

### Calculating costs under an Extended Trades market

7.31. In this subsection, we describe our approach to estimating the likely cost of replacing binding NTC restriction requirements with equivalent Trades in an Extended Trades market. We first describe the assumed bidding behaviour of generators across technologies and storage assets. We assume this will be similar to existing bidding behaviour in the BM. Then, we discuss whether such assets are likely to be competitive in a future Extended Trades market, on the basis that they are both suitably located in the South East of GB and have competitive bids. Finally, we summarise the key assumptions underlying our analysis of the current status quo arrangements, and an Extended Trades market in the future.

### Bidding behaviour across different traders

- 7.32. As discussed in Section 2.B, participants in the BM make bids and offers into the market that reflect their willingness to change their intended output (or consumption), as determined through the wholesale electricity market. This behaviour is likely to be similar to how market participants will likely engage in Trades with NESO in the future, and so we proxy the bidding behaviour of trading entities in a future Extended Trades market with their assumed bidding behaviour in the BM.
- 7.33. As discussed in Section 6, our analysis focuses on NTC restrictions on exports from GB and, as such, the relevant Trade action is an increase in output from a generator or storage asset only (which are referred to as ‘offers’ in the BM).<sup>128</sup>



---

<sup>128</sup> We note that the bidding behaviour for decreases in output (referred to as ‘bids’ in the BM) may be different between a Trades market and the BM.

Additionally, following discussions with NESO, we focus on assets that are dispatchable (that is, are able to vary their output) only. As such, renewable generators such as wind and solar are not considered in our analysis.

- 7.34. Figure 7-2 summarises our assumptions on bidding behaviour across different generators and storage assets.

**FIGURE 7-2: SUMMARY ASSUMPTIONS RELATED TO BIDDING BEHAVIOUR IN AN EXTENDED TRADES MARKET**

Technology	Assumed bidding behaviour	
Fossil fuel 	Offer uplift	+ Fuel cost + carbon cost
Batteries and other storage 	Offer uplift	+ Price Received <sup>1</sup>

Notes: (1) See below for more detailed discussion on 'Price Received'; and (2) The table above only focuses on bidding behaviour on assets that are suitably located in the context of our assessment, that is, are located in the South East of GB.

Source: FTI analysis.

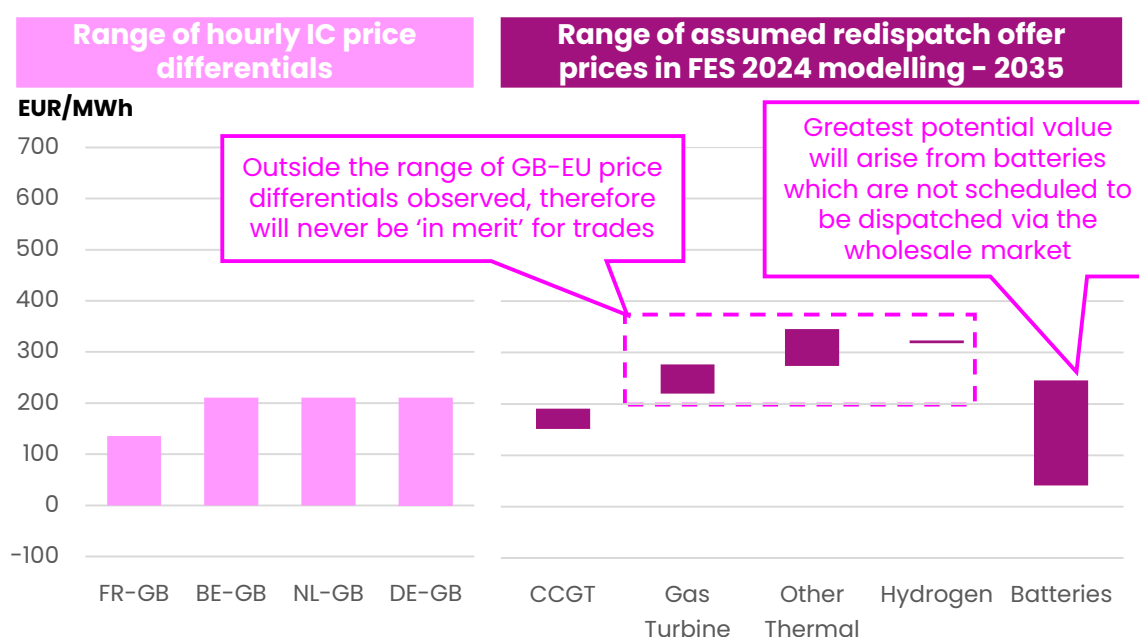
- 7.35. As shown in the figure above, technologies are assumed to engage in the following bidding behaviour:
- Fossil fuels – including Combined Cycle Gas Turbines (“CCGTs”), Oil Turbines, Gas Turbines, Other thermal generators and Hydrogen peakers – are assumed to bid based on their input fuel and carbon costs. Specifically, we assume such generators apply a multiplicative mark up to their costs.
  - Storage assets – including 1-hour batteries, 4-hour batteries, Vehicle to Grid (“V2G”) batteries, and longer duration storage such as Compressed Air Energy Storage (“CAES”) and Liquid Air Energy Storage (“LAES”) – are assumed to bid based on an additive offer uplift, and with reference to a view of future wholesale prices (referred to as their ‘price received’)<sup>129</sup>. We discuss this further in Appendix A8.
- 7.36. We recognise that our assumption regarding the ‘price received’ by storage assets (which was developed in discussion with NESO) involves an element of judgement. To help ensure the robustness of our approach we undertook an additional sensitivity in addition to our baseline analysis, in which the ‘price received’ for batteries is based on average prices across the coming week. We present this sensitivity as part of a broader envelope of potential NTC market benefits for our quantitative assessment, in addition to the sensitivities set out in Section 6.

<sup>129</sup> Specifically, we assume storage assets bid into an extended Trades market with reference to the average of the four highest price hours in the next 24 hours, plus an additive offer uplift. This is discussed further in Appendix A8.



- 7.37. In Figure 7-3 below, we present the forecast range of assumed bids across various technologies in 2035, as per pre-existing FTI modelling outputs.

**FIGURE 7-3: RANGE OF ASSUMED BIDS IN AN EXTENDED TRADES MARKET ACROSS PARTICIPANTS**



*Note: We exclude generation technologies with offer price ranges that are substantially out of merit from the figure above.*

*Source: FTI analysis.*

- 7.38. Based on these forecast bids in the modelled scenario, batteries are likely to provide the greatest potential value to replace restrictions on ICs. CCGTs could also, in theory, provide a lower cost option than some ICs in circumstances where IC price differentials are at the top of the range. Other thermal generators are forecast to be more expensive than the respective IC price differentials in all hours, so cannot provide additional value as part of the Extended Trades market.

#### *Suitably located generators and storage assets*

- 7.39. As previously discussed, NESO's requirements are typically locational. We therefore must limit the pool of generators and storage assets that can participate in the Extended Trades market, based on their proximity to the South Eastern cluster of ICs.
- 7.40. The precise location of each asset is not available in our pre-existing modelling, but each asset is assigned to a specific geographic zone. We therefore utilise this zonal information to provide a high-level proxy for each asset's inclusion in or exclusion from the Extended Trades market. Any asset that is within the same zone as a South East IC is assumed to participate in the market.<sup>130</sup> We recognise that, in practice, this will likely overstate the potential for participation. However,

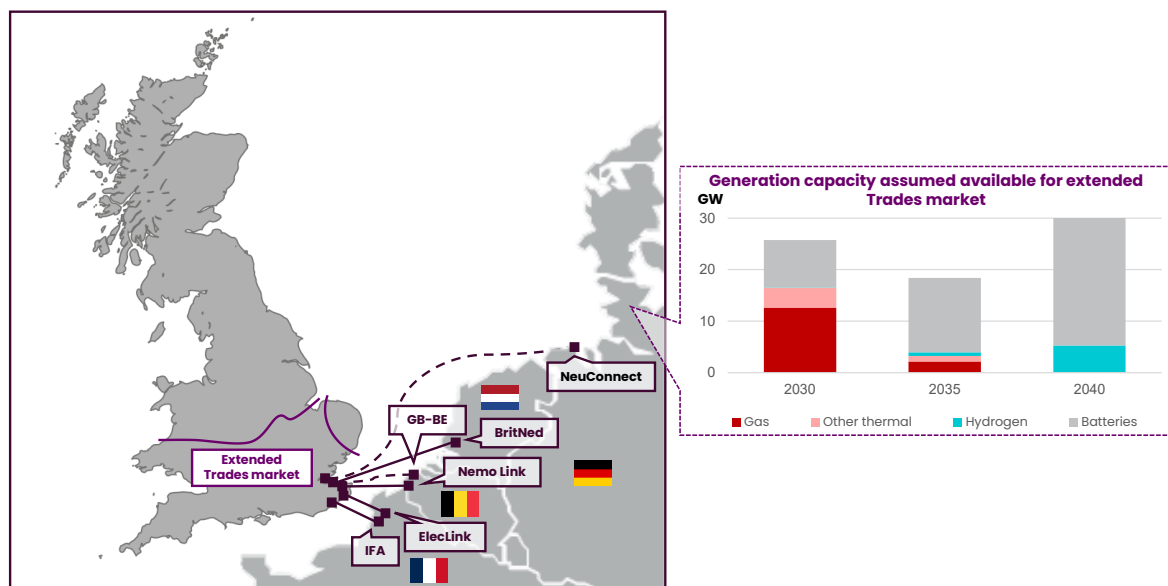
<sup>130</sup> This is a simplification as Trades can take place in other regions, as discussed in paragraph 7.24.



we view it as appropriate for exploring the order of magnitude of possible gross benefits.

- 7.41. Figure 7-4 below shows the total generation capacity assumed to participate in the South East Extended Trades market.

**FIGURE 7-4: ASSUMED GENERATION CAPACITY FOR EXTENDED TRADES MARKET – 2030, 2035 AND 2040**



Notes: (1) FTI modelling outputs are aligned with the GB zonal configuration used by DESNZ throughout wider REMA processes. Please see Appendix A6 for more detail; and (2) Figure only includes technologies that are potentially suitable for an Extended Trades market.

Sources: (1) FTI analysis; and (2) NESO, Future Energy Scenarios: ESO Pathways to Net Zero, July 2024 ([link](#)).

- 7.42. From 2030 to 2040 with the assumed Extended Trades market:
- Total generation capacity assumed available for an Extended Trades market is expected to increase by c.4GW overall, from c.26GW to c.30GW. This reflects a large buildout of storage assets, and phasing out of CCGTs and Thermal generators.
  - Total generation capacity across storage assets specifically increases by c.16GW overall, from c.9GW to c.25GW. This reflects the roll-out of V2G storage capacity, as well as the introduction of new electricity storage technologies.
- 7.43. In the following subsection, we summarise the key assumptions underlying our analysis of a simplified representation of an Extended Trades market, in which the various dispatchable technologies are identified above and IC traders are active participants.

#### *Simplified representation of an Extended Trades market*

- 7.44. We compare the total cost of NTC restrictions under the status quo to the cost of replacing binding NTC restriction requirements with an Extended Trades

market. We assume that, under a simplified Extended Trades market, holders of South East IC capacity,<sup>131</sup> and suitably located dispatchable generation and storage technologies compete to address network constraints (that would otherwise have to be addressed via NTC restrictions on exports from GB).

- 7.45. Trades are only able to impact the actual flows across an IC, by paying traders to nominate IC capacity in line with NESO's specified requirements. This means they can only be used to manage binding constraints (we discuss this limitation further in Section 7.D below). Our quantitative methodology therefore focuses binding constraints only.
- 7.46. Holders of IC capacity, generators, and batteries in the South East compete to address these binding constraints by reducing export flows out of GB (for ICs), or by increasing power output (for generators and batteries).<sup>132</sup>
- 7.47. We assume that IC traders' bids to NESO are equal to the expected wholesale price spread between GB and their connected market for that hour – this is the same assumption used for the status quo and the NTC market scenarios. The bidding behaviour of generators and batteries to NESO is equal to that of the BM, as discussed above.
- 7.48. Overall, the outcome of the Extended Trades market is that the trader(s) with the lowest bid price(s), will participate in Trades with NESO such that there will no longer be any remaining required volumes of NTC export restrictions. In the event that this Trade is not sufficient to address the assumed system issue, we assume NESO will trade with the next most competitive trader, and so on, until there are no remaining required volumes of NTC export restrictions.
- 7.49. Finally, the total compensation of these Trades for NESO will be the bids of each trader for each hour, per MW of traded volumes.

### Calculating cost savings

- 7.50. Based on the assumptions set out in the subsections above, our analysis examines for assumed NTC restriction events what the total cost of managing system constraints in the South would be in the future under both the current status quo via NTC export restrictions, and an Extended Trades market via Trades.
- 7.51. By comparing these total costs, we therefore provide an estimate of the theoretical benefits of an Extended Trades market, for each modelled year. We further compare these estimates to our assessment of an NTC market, as described in Section 6.

---

<sup>131</sup> Note that under an NTC market, we assume that IC owners compete, whereas under the extended Trades market we assume that it is the holders of IC capacity that compete.

<sup>132</sup> Recall that we limit the focus of our analysis to NTC export restrictions used to address import constraints into the South East area from the rest of GB. Thus, addressing these constraints are achieved by either: i) restricting IC export capacity; ii) reducing IC export flows; or iii) increasing power output within the South East area.

- 7.52. The gross benefits of an Extended Trades market over the status quo arrangements are given by the difference in the compensation paid for: i) Trades under the Extended Trades scenario; and ii) NTC restrictions under the status quo. This is set out, for each modelled year, in the table below.

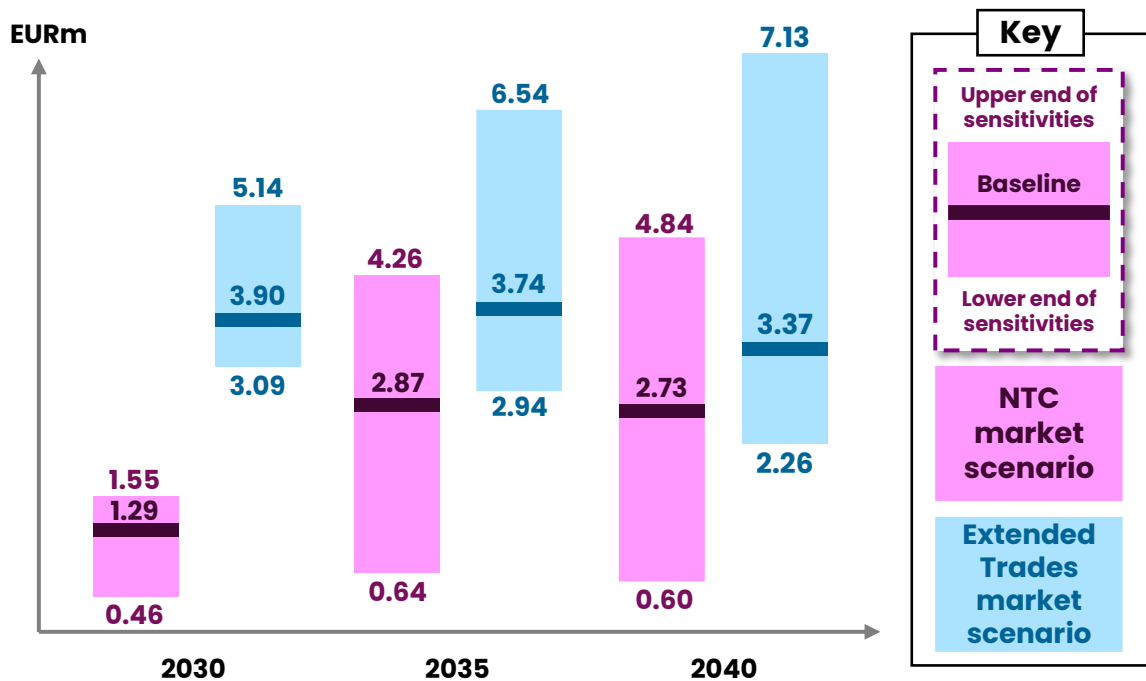
**TABLE 7-1: TOTAL COST OF EXTENDED TRADES MARKET AND STATUS QUO NTC RESTRICTIONS, PER YEAR (€M, REAL 2024)**

	<b>2030</b>	<b>2035</b>	<b>2040</b>
Extended Trades market	6.2	3.8	4.7
Status quo	10.1	7.6	8.1
<b>Gross benefits of an Extended Trades market</b>	<b>3.9</b>	<b>3.7</b>	<b>3.4</b>

*Source: FTI analysis.*

- 7.53. An Extended Trades market, operating under ideal conditions, is expected to provide cost savings of between €3.4m and €3.9m per year.
- 7.54. In Appendix A9, we provide an illustrative example of how benefits arise in the Extended Trades market.
- Sensitivity analysis**
- 7.55. We performed the same sensitivities for the Trades scenario as the NTC market scenario, set out in paragraph 6.85 above. We also tested one additional sensitivity for Trades, by altering our assumption on the battery received price to be based on a forward looking weekly average (see paragraph 7.36).
- 7.56. In Figure 7-5 below, we set out of the results of our sensitivity analysis.

**FIGURE 7-5: ENVELOPE OF BENEFITS FROM SIMPLIFIED REPRESENTATIONS OF BOTH AN NTC MARKET AND AN EXTENDED TRADES MARKET (REAL, 2024)**



*Note: We assume the GB-Belgium IC is not available in 2030 but is operational from 2035 onwards, as per our IC modelling assumptions.*

*Source: FTI analysis.*

- 7.57. As with the NTC market scenario, the Isle of Grain exclusion has a significant negative impact on the gross benefits in all years. We also find that the battery price received sensitivity reduces the benefit in each year, as the longer averaging horizon reduces the instances that batteries bid in at a very low prices (that is, there is less volatility in battery bidding prices, meaning they less frequently represent the lowest cost option for NESO to trade with).
- 7.58. All other sensitivities have a positive impact on the gross benefits. The top end of the sensitivity range is driven by the sensitivity in which the size of NTC restriction is scaled up by peak demand. The full sensitivity results are presented in Appendix A10.

## Limitations

- 7.59. As discussed in paragraphs 7.28 – 7.30, our assessment of an Extended Trades market draws on our existing quantitative framework for assessing an NTC market. Therefore, our forward looking quantitative analysis focusing on Trades is subject to similar limitations to those discussed in paragraph 6.90:
- i. We focused solely on the South East and network constraints arising from IC exports from GB.
  - ii. Our estimate of when intervention by NESO (either via export NTC restrictions or Trades) may be required in future is based on a proxy, informed by historical analysis.
  - iii. We focus only on the top band of demand. In practice, it is likely that some NTC restrictions or Trades will also be required during lower Demand Band periods.
  - iv. We assume that the existing GB market design will broadly persist in its current form.
  - v. We do not consider whether other system management tools, such as SO-SO Trades could be used to meet NESO needs instead of via NTC restrictions or Trades.
  - vi. We utilise modelling outputs from a single scenario as part of our quantitative assessment – that is, the scenario underlying FTI's recent REMA Dispatch Assessment work.
- 7.60. In addition, our analysis focusing on Trades is subject to several further limitations, which we summarise below:
- i. Generators and storage assets may not bid into the Extended Trades market in line with the assumptions set out in Figure 7-2.
  - ii. We assume that traders of IC capacity will not incorporate an offer uplift. In practice, if IC traders did include an offer uplift this would reduce the benefits of an Extended Trades market relative to status quo arrangements for NTC restrictions.
  - iii. We assume any asset located in area set out in Figure 7-4 can participate in the Extended Trades market and is perfectly substitutable with all other assets in the area. This will overstate the potential for participation and the effectiveness of certain assets to meet a particular constraint.
  - iv. While our methodology does consider the initial available state of charge for storage assets when entering a Trade, it may overstate the ability for storage assets to participate in Trades for multiple consecutive hours when, in practice, the asset may be required to recharge.
- 7.61. All of these limitations mean that, in practice, the costs associated with NTC restrictions and the potential gross cost savings associated with an Extended Trades market may differ from our estimate.

## D. Challenges of Trades

- 7.62. While Trades can potentially bring additional gross benefits relative to an NTC market, careful consideration would also need to be given to the associated drawbacks, which we discuss in the following subsections.

### Contingency management

- 7.63. As explained in paragraph 2.8, NTC restrictions are particularly useful for NESO in managing credible contingencies (that is, protecting against unforeseen outcomes such as generator faults) ahead of time. This is facilitated by the ability of NTC restrictions to define the envelope of maximum import and/or export of power into or out of GB, without necessarily impacting flows. NESO can therefore leverage NTC restrictions proactively, managing the risk of credible contingencies before they arise.
- 7.64. A key limitation of Trades relative to NTC restrictions is the inability for Trades to define such an envelope. Instead, Trades are only able to impact the actual flows across an IC, by paying traders to nominate IC capacity in line with NESO's specified requirements. Compared to NTC restrictions, Trades are reactive tool, impacting actual IC flows in response to expected system conditions, as opposed to a proactive tool.
- 7.65. As such, even with enhancements to NESO's existing trading operations that could reduce the reliance on NTC restrictions, a form of NTC restriction mechanism will most likely continue to be required, in order to proactively manage contingencies.

### Operational complexity

- 7.66. While NESO already undertakes Trades across ICs using a bespoke auction platform, extending its trading operations to systematically include a wider pool of assets would likely represent a significant increase in operational complexity for NESO.
- 7.67. A key challenge that NESO would have to overcome is the wide range of different technical characteristics that generators and storage assets have, relative to ICs (which all have broadly similar technical characteristics). For example, each thermal generator has individual operating restrictions (for example, warm up/minimum on and minimum off times), while every battery will at any given point in time have a certain state of charge and capacity limitations. It may therefore be more challenging for NESO to compare bids on a like-for-like basis across asset types, particularly in the relatively short timescales over which Trades would likely need to be undertaken.

### Impact on connected markets and SOs

- 7.68. NESO's existing trading operations across ICs can impact market outcomes in the relevant connected market and, in turn, the connected SOs' management of their system. For example, NESO leveraging Trades to reduce IC exports from GB would likely increase the wholesale price in the connected market (as the IC

would no longer be supplying as much power to the connected market) or could potentially drive system constraints in the connected market.

- 7.69. These impacts are likely to be greatest in smaller connect markets, such as Belgium, relative to larger markets such as France and Germany. We understand that at times NESO's existing IC trading activities have also been limited by a lack of liquidity and market depth in the relevant connected market.
- 7.70. Any reforms to Trades may therefore require a degree of engagement or agreement with the connected SOs. However, we expect that enhancements would have a limited additional impact on connected markets over and above NESO's status quo IC trading activities, as the reforms would be focused solely on improving the integration of GB-based assets into NESO's trading operations, rather than altering how NESO trades with ICs.

#### **Risk that positions are unwound and timeframes**

- 7.71. NTC restrictions are set by NESO and cannot be adjusted by market participants. Trades, however, can in theory be unwound by subsequent actions in the energy and IC capacity markets which, in turn, could present a risk of unnecessary costs being incurred (for example, if a Trade sought to address a system challenge, this was subsequently unwound by the market participant, and NESO would need to incur a cost for the second time to address the underlying system challenge); and potentially even a risk to system security. These risks increase the further ahead of delivery NESO makes a Trade. For this reason, NESO currently aims to trade in ID timescales only. There may also be a risk that with more widespread use, market participants could begin to expect and factor in NESO's use of Trades as part of their operating and bidding strategy, resulting in an element of 'gaming' or deliberate unwinding of NESO Trades.
- 7.72. As a result, the Extended Trades market process would need to be calibrated to ensure it completes sufficiently ahead of the relevant IC capacity nomination windows but doesn't expose NESO to excessive risk of positions being unwound.

#### **Market participation**

- 7.73. An Extended Trades market will only provide additional benefits, over and above NESO's existing trading operations, if a sufficient number of other assets are willing to participate in the extended market. However, assets may in practice be hesitant to participate, or may price in a degree of premium to reflect the commercial risk of participating in a Trade with NESO as opposed to selling into the wholesale market at a later point or participating in the BM. Either will erode the potential gross benefits of an Extended Trades market.

## **E. Assessment of an Extended Trades market**

- 7.74. In Figure 7-6 below, we set out a summary of our assessment of the benefits and drawbacks of an extension to NESO current trading arrangements in GB against the assessment principles set out in paragraph 5.2 above. In the following subsections, we present our analysis for each principle in more detail.



**FIGURE 7–6: SUMMARY OF EXTENDED TRADES MARKET ASSESSMENT**

Principle	Assessment of Extended Trades market	Score – Extended Trades market	Score – NTC market	Score – Status Quo
<b>System security</b>	<ul style="list-style-type: none"> <li>Trades can be an effective tool to alter IC and asset's expected operating profile. However, unlike NTC restrictions, in isolation Trades cannot be used proactively to manage contingencies (by defining an envelope of IC flows), and instead are reactive tool</li> <li>In addition, there remains a risk that Trades will be unwound in subsequent wholesale markets or IC capacity auctions, risking system security</li> <li>Therefore, under an Extended Trades market, NTC restrictions will likely be required to maintain compliance with SQSS, most obviously managing credible contingencies that would arise if expected IC flows change</li> </ul>			
<b>Cost efficiency</b>	<ul style="list-style-type: none"> <li>An Extended Trades market could in theory lower costs for consumers associated with NTC restriction usage in future...</li> <li>... by enabling NESO to trade with a broad range of assets to resolve system issues, rather than allocate restrictions to ICs that may not always be the lowest cost option (for example, during periods where particular ICs have a high price differential between GB and the connected market)</li> <li>There is less risk associated with the depth of markets as NESO can trade with many participants. This can encourage competition, reducing the potential for exercise of market power</li> <li>However, there remains a risk that Trades will be unwound via subsequent IC or wholesale market outcomes, possibly due to deliberate 'gaming' strategies by trading entities, which could result in unforeseen costs for consumers to re-address unwound Trades</li> </ul>			
<b>Efficient investment signals</b>	<ul style="list-style-type: none"> <li>Trading arrangements exist between NESO and IC traders, rather than IC owners. Therefore, IC owners are essentially unimpacted by Trades market activity, and so there is no impact on their investment signals...</li> <li>...for other assets, any revenues generated, or volumes used from Trades are likely to be relatively small compared to revenues they could earn otherwise</li> </ul>			
<b>Simplicity</b>	<ul style="list-style-type: none"> <li>Though NESO can leverage their current trading arrangements, an Extended Trades market will require the development of new trading capabilities from NESO, for example a more sophisticated auction platform and incorporating a broad range of assets into the auction process</li> <li>Operating an Extended Trades market will bring ongoing complexity for NESO, for example comparing bids across a variety of technologies on a like-for-like basis within short timescales (although this may potentially be automated)</li> <li>Implementation of an Extended Trades market may require a degree of engagement with connected SOs regarding IC trading activities</li> </ul>			
<b>Transparency</b>	<ul style="list-style-type: none"> <li>The high level process followed by NESO for current trading arrangements is relatively transparent, with data publicly available on the volumes and costs traded in the market...</li> <li>... however, the process followed by NESO for determining when Trades are required would likely remain less clear and is not systematically publicly available</li> </ul>			
<b>Future-proof</b>	<ul style="list-style-type: none"> <li>Key principles and mechanisms for Trades are already established under the current arrangements...</li> <li>...however, accommodating an increasingly broad range of assets overtime will likely become burdensome for NESO</li> </ul>			
<b>No undue discrimination</b>	<ul style="list-style-type: none"> <li>Traders and assets only can participate in an Extended Trades market if they able to resolve a specific issue via a change in their energy position</li> <li>Participants can bid into the market at the price of their choosing</li> </ul>			
<b>Compliance with rules, laws and regulations</b>	<ul style="list-style-type: none"> <li>Market based mechanism that appears more consistent with NESO's licence</li> <li>However, it will not completely remove the need for the status quo NTC restrictions, either in the form of a fallback if the market fails or if Trades are unable to manage a particular issue (that is, contingencies), or for ICs not located within the Extended Trades market area</li> </ul>			



## System security


**FIGURE 7-7: SUMMARY OF EXTENDED TRADES MARKET ASSESSMENT: SYSTEM SECURITY**

Principle	Assessment of extended Trades market	Score
<b>System security</b>	<ul style="list-style-type: none"> <li>Trades can be an effective tool to alter IC and asset's expected operating profile. However, unlike NTC restrictions, in isolation Trades cannot be used proactively to manage contingencies (by defining an envelope of IC flows), and instead are reactive tool</li> <li>In addition, there remains a risk that Trades will be unwound in subsequent wholesale markets or IC capacity auctions, risking system security</li> <li>Therefore, under an Extended Trades market, NTC restrictions will likely be required to maintain compliance with SQSS, most obviously managing credible contingencies that would arise if expected IC flows change</li> </ul>	

- 7.75. As discussed in paragraph 7.64 above, a key limitation to an Extended Trades market is that, in isolation, Trades as a system management tool cannot be used proactively to manage contingencies relating to system issues in advance. Instead, Trades are a reactive tool that can only be used to impact actual IC flows, as opposed to setting an envelope like NTC restrictions do. There is no mechanism for Trades to proactively protect against the risk of credible contingencies.
- 7.76. In addition, for the purpose of our quantitative analysis, we assume that Trades (for example, taking place at DA or ID stage) would not be unwound through subsequent markets. However, as discussed in paragraph 7.71, in theory Trades could be unwound by subsequent actions in wholesale energy markets or IC capacity auctions. As such, there still remains a risk to system security.
- 7.77. Therefore, under an Extended Trades market scenario, it is likely that NTC restriction will continue to be required to maintain compliance with SQSS.

## Cost efficiency

**FIGURE 7-8: SUMMARY OF EXTENDED TRADES MARKET ASSESSMENT: COST EFFICIENCY**

Principle	Assessment of extended Trades market	Score
<b>Cost efficiency</b>	<ul style="list-style-type: none"> <li>An Extended Trades market could in theory lower costs for consumers associated with NTC restriction usage in future...</li> <li>... by enabling NESO to trade with a broad range of assets to resolve system issues, rather than allocate restrictions to ICs that may not always be the lowest cost option (for example, during periods where particular ICs have a high price differential between GB and the connected market)</li> <li>There is less risk associated with the depth of markets as NESO can trade with many participants. This can encourage competition, reducing the potential for exercise of market power</li> <li>However, there remains a risk that Trades will be unwound via subsequent IC or wholesale market outcomes, possibly due to deliberate 'gaming' strategies by trading entities, which could result in unforeseen costs for consumers to re-address unwound Trades</li> </ul>	

- 7.78. As set out in Figure 7-5, our quantitative analysis of an Extended Trades market suggests that the gross benefits of introducing a market in the South East of England could total between €2.3m a year to €7.1m a year, with our base case estimate ranging from €3.4m to €3.9m. Unlike the NTC market, the base case

benefit is higher in the first year, 2030, than the later years. However, in later years our sensitivity range increases significantly compared to 2030.<sup>133</sup>

- 7.79. These gross benefits are larger than the benefits of an NTC market alone. The incremental benefit of Trades over and above the NTC market arises from shifting 'binding' restrictions towards storage assets when they are most competitive (that is, when storage assets are expecting to face low GB prices relative to IC price spreads in the near future).
- 7.80. However, this analysis is subject to several simplifying assumptions which mean that, in practice, the gross benefits of an Extended Trades market may be lower (and potentially materially lower) than modelled. Most significantly, these include:<sup>134</sup>
- i. That all assets within the market are perfectly substitutable for one another. In practice, the effectiveness of a particular asset to manage a network constraint will vary due to a complex range of factors, even within a relatively narrowly defined area. This lack of substitutability will, in effect, increase the cost of using a less-optimally located asset to manage a given constraint, in turn reducing the potential cost saving associated with Trades.
  - ii. That each trader of IC capacity will bid in at the wholesale price spread across the connected markets. In practice, traders may price in a mark up or premium which would erode the gross benefits (although we view this as a lower risk than in the NTC market, due to the greater number of traders vs IC owners). Other market participants may also bid in at a higher cost than assumed in our analysis also.
  - iii. Trades could potentially be unwound in subsequent wholesale and IC capacity markets. This would expose the risk of GB consumers paying twice to manage a constraint – once for the original Trade and one to re-address the system issue after the Trade is unwound.
- 7.81. We have also not attempted to quantify the costs that NESO would incur to enhance its trading capabilities to operate an Extended Trades market, nor the costs to market participants for developing capabilities to partake (although we discuss qualitatively the impact of NESO and ICs' operations in paragraph 7.85 below). As such, we capture only the gross cost benefit of implementing an

---

<sup>133</sup> Our estimate of the gross benefits captures only the potential direct cost saving from NESO payments to trading assets. We have not attempted to quantify other monetary costs, such as the cost to NESO of developing extended Trading market capabilities, or equivalent costs for those participating in the trader market.


<sup>134</sup> Other assumptions may result in our modelling producing an underestimate of the benefits. Please see paragraphs 6.42–6.44 and Appendix A6 for a detailed discussion of our modelling assumptions.

Extended Trades market, rather than estimating the net benefit which may be significantly lower (or even net negative on a net present value basis).

- 7.82. In this context, we find that an Extended Trades market could provide greater value to GB consumers than an NTC market alone (our gross benefit is also limited to the South East of GB, meaning additional gross benefits could arise in other areas). However, there is a significant range in the gross benefit case, particularly in later years, and the benefits may be lower in practice due to factors including the lack of substitutability of different assets.

### Efficient investment signals

**FIGURE 7–9: SUMMARY OF EXTENDED TRADES MARKET ASSESSMENT: EFFICIENT INVESTMENT SIGNALS**

Principle	Assessment of extended Trades market	Score
<b>Efficient investment signals</b>	<ul style="list-style-type: none"> <li>Trading arrangements exist between NESO and IC traders, rather than IC owners. Therefore, IC owners are essentially unimpacted by Trades market activity, and so there is no impact on their investment signals...</li> <li>...for other assets, any revenues generated, or volumes used from Trades are likely to be relatively small compared to revenues they could earn otherwise</li> </ul>	

- 7.83. As set out in paragraph 7.21, for IC assets, NESO's trading activities take place between NESO and IC traders, rather than the IC owners. Therefore, IC owners will essentially be unimpacted by Extended Trades market activity<sup>135</sup> and so there is no material impact on their investment signals.
- 7.84. For other assets, any revenues generated from Trades agreed with NESO are likely to be relatively small compared to revenues or volumes they would typically earn or generate/consume otherwise. As such, an Extended Trades market is unlikely to materially impact investment signals for market participants overall.

### Simplicity

**FIGURE 7–10: SUMMARY OF EXTENDED TRADES MARKET ASSESSMENT: SIMPLICITY**

Principle	Assessment of extended Trades market	Score
<b>Simplicity</b>	<ul style="list-style-type: none"> <li>Though NESO can leverage their current trading arrangements, an Extended Trades market will require the development of new trading capabilities from NESO, for example a more sophisticated auction platform and incorporating a broad range of assets into the auction process</li> <li>Operating an Extended Trades market will bring ongoing complexity for NESO, for example comparing bids across a variety of technologies on a like-for-like basis within short timescales (although this may potentially be automated)</li> <li>Implementation of an Extended Trades market may require a degree of engagement with connected SOs regarding IC trading activities</li> </ul>	

- 7.85. Though NESO can leverage their current trading arrangements, an Extended Trades market would increase the operational complexity for NESO's trading activities, as set out in paragraphs 7.66 to 7.67. This includes the development of a more sophisticated auction platform to incorporate a broader range of assets into the auction process. There will also be an ongoing operational

<sup>135</sup> There is a possibility that IC owners could be impacted if the trading activity affected the willingness of IC capacity holders to acquire cross-border capacity in the first place. We do not anticipate this to be a significant factor.

burden, as NESO must compare bids across a variety of technologies on a like-for-like basis within short timescales (although this may be possible to automate via the auction platform).

- 7.86. The implementation of an Extended Trades market could also have implications for NESO's alignment with the connected SOs, and so may require a degree of additional cross-border engagement with connected SOs regarding trading activities.

## Transparency

**FIGURE 7-11: SUMMARY OF EXTENDED TRADES MARKET ASSESSMENT: TRANSPARENCY**

Principle	Assessment of extended Trades market	Score
<b>Transparency</b>	<ul style="list-style-type: none"> <li>The high level process followed by NESO for current trading arrangements is relatively transparent, with data publicly available on the volumes and costs traded in the market...</li> <li>... however, the process followed by NESO for determining when Trades are required would likely remain less clear and is not systematically publicly available</li> </ul>	

- 7.87. Under NESO's current trading arrangements, a variety of data is published on NESO's data portal, supporting transparency. In particular, NESO publish trading data and information on:<sup>136</sup>
- Upcoming Trades;
  - Historic Trades;
  - Summaries of each Trade auction held to determine final Trades agreed to; and
  - The Interconnector Trading Procurement Framework – documentation and materials relating to NESO's trading activities.
- 7.88. However, elements of the current trading arrangements are still, and would likely remain, relatively opaque. In particular, as with NTC restrictions, the process followed by NESO for determining when Trades will be required to resolve a given system issue is likely to be less clear and not publicly available.

## Future-proof

**FIGURE 7-12: SUMMARY OF EXTENDED TRADES MARKET ASSESSMENT: FUTURE-PROOF**

Principle	Assessment of extended Trades market	Score
<b>Future-proof</b>	<ul style="list-style-type: none"> <li>Key principles and mechanisms for Trades are already established under the current arrangements...</li> <li>...however, accommodating an increasingly broad range of assets overtime will likely become burdensome for NESO</li> </ul>	

- 7.89. As discussed in paragraph 7.15, reforms to trading in recent years have improved NESO's capability to trade effectively across various IC capacity market participants.
- 7.90. However, there is a risk that extending to incorporate a wider pool of assets (such as innovative storage technologies and Offshore Hybrid Assets) will increase operational complexity for NESO, and over time it may become

<sup>136</sup> See NESO, Balancing services, Trading ([link](#)).

increasingly difficult to manage trading activities as the generation mix continues to evolve.

### No undue discrimination

**FIGURE 7-13: SUMMARY OF EXTENDED TRADES MARKET ASSESSMENT: NO UNDUE DISCRIMINATION**

Principle	Assessment of extended Trades market	Score
<b>No undue discrimination</b>	<ul style="list-style-type: none"> <li>Traders and assets only can participate in an Extended Trades market if they able to resolve a specific issue via a change in their energy position</li> <li>Participants can bid into the market at the price of their choosing</li> </ul>	

- 7.91. Traders across assets will only be able to participate in an Extended Trades market if they able to sufficiently resolve a specific system issue via a change in their energy position and are able to competitively bid into the market in real time subject to various technical constraints. As such, entities engaging in Trades with NESO will be subject to 'due' discrimination (that is, Trades occur between NESO and assets able to resolve a specific constraint, who have bid into the market at a price of their choosing).

### Compliance with rules, laws and regulations

**FIGURE 7-14: SUMMARY OF EXTENDED TRADES MARKET ASSESSMENT: COMPLIANCE WITH RULES, LAWS AND REGULATIONS**

Principle	Assessment of extended Trades market	Score
<b>Compliance with rules, laws and regulations</b>	<ul style="list-style-type: none"> <li>Market based mechanism that appears more consistent with NESO's licence</li> <li>However, it will not completely remove the need for the status quo NTC restrictions, either in the form of a fallback if the market fails or if Trades are unable to manage a particular issue (that is, contingencies), or for ICs not located within the Extended Trades market area</li> </ul>	

- 7.92. Using Trades to resolve system issues (that are currently resolved using NTC restrictions under the status quo) is consistent with NESO's licence requirement to procure balancing services through market-based procedures.
- 7.93. However, similar to an NTC market, if Trades across a broader range of assets are not feasible (or not suitable) for a given requirement, an Extended Trades market will not completely remove the need for status quo NTC restriction arrangements. This applies most obviously in the case of managing contingencies, which Trades as a system management tool are not able to address proactively.
- 7.94. Therefore, while an Extended Trades market could reduce NESO's current reliance on non-market mechanisms, it is likely not credible for the status quo NTC restriction arrangements to be removed entirely. This means that even with an Extended Trades market, NESO would still be required to seek derogations from its licence from Ofgem in future.

## F. Conclusions on Extended Trades

- 7.95. We find there could be gross cost savings for GB consumers from extending NESO's existing trading operations to systematically consider assets other than ICs in its trading auctions. These gross benefits exceed those we find for an NTC

market alone, due to the wider pool of assets that NESO could draw on. Batteries in particular provide the greatest value during periods when GB prices are relatively low compared to connected European markets, as during these periods batteries' opportunity cost of entering a Trade with NESO – which is driven by GB prices – is relatively low compared with the opportunity cost faced by ICs – which is driven by the price spread between GB and connected markets.

- 7.96. The larger pool of traders (as opposed to a single IC owner) helps to mitigate the substitutability and associated market power challenges faced by the NTC market; in instances where a specific single IC may be significantly more effective in managing a constraint than others, competition can still arise between the multiple traders of capacity across that IC, helping drive costs down towards the traders' true cost (which, like IC owners, will be anchored to wholesale market price spreads).<sup>137</sup>
- 7.97. This greater scope for gross benefits is, however, likely to come with greater implementation and operation complexity for NESO relative to the NTC market, in particular due to the varying technological characteristics of different asset.
- 7.98. Trades are also not able to replace NTC restrictions in all circumstances. In particular, they are not able to proactively manage contingencies, as they can only impact actual flows. This compares to NTC restrictions that can define an envelope of possible flows without necessarily impacting an IC's actual operation. An Extended Trades market therefore cannot replace the need for NTC restrictions entirely.
- 7.99. There is a risk that NESO actions could be unwound in through subsequent market actions in the wholesale market or the explicit auctions for IC capacity, exposing consumers to the risk of having the 'pay double' for the same system issue (as set out in paragraph 7.71). Market participants could begin to expect and factor in NESO's use of Trades as part of their operating and bidding strategy. This risks an element of 'gaming' or deliberate unwinding of NESO Trades.
- 7.100. As previously explained, we have not, in this report, attempted to quantify the expected implementation costs of an Extended Trades market for NESO, IC participants, and Ofgem. We find that the gross benefits (that is, before costs), are between €3.4m and €3.9m per year for our base case. That is, there are expected to be net benefits to GB consumers as long as total annual implementation costs (both operating costs and annualised capital costs) are less than €3.4m per year.

---

<sup>137</sup> The competitive market price should therefore, in theory, be similar for an efficient NTC market and an efficient Trades market that comprised only of ICs.

## 8. Conclusions

- 8.1. The GB electricity system is undergoing a rapid and fundamental transition, as the system decarbonises in line with the pursuit of Net Zero ambitions. ICs can play an important role in facilitating this transition, by offering a source of flexibility and managing the volatility that is inherent with wind and solar generation. However, the ability of ICs to act as both a large source of supply and demand means they can have implications for NESO's management of the system.
- 8.2. NTC restrictions currently play an important role in ensuring NESO complies with the SQSS. The tool is particularly effective in proactively managing credible contingencies, as a result of its ability to allow NESO to define an envelope of maximum import and/or export of power into or out of GB – a feature not available to NESO through any other IC management tool.
- 8.3. However, the tool is currently used without any consideration of cost as restrictions are split over each IC that is deemed to contribute to the given constraint (and these costs are material as NESO is committed to keep ICs 'whole' with respect to any NTC restriction actions). This, in turn, exposes GB consumers to the risk that costs incurred from NTC restriction usage are higher than necessary and the non-market nature of the tool means it does not comply with NESO's licence.
- 8.4. The requirement for NESO to identify an equitable allocation for restrictions across ICs also may become increasingly complex as the power system continues to evolve and the number of ICs grows. This, in turn, may exacerbate transparency concerns that also apply to the status quo. In particular, while NESO has recently improved the data it provides on NTC restriction usage, there remains relatively limited information made available on how, in practice, the need for a particular restriction is identified and then allocated across ICs. Feedback from IC owners demonstrates this remains an issue. Some IC owners have also highlighted concerns with the NTC Commercial Arrangements methodology and the ability to dispute NTC restriction outcomes.  
***Key finding 1: NESO's existing NTC restriction tool is effective in supporting system security, providing functionality that is not available to NESO via other options, but risks exposing GB consumers to higher than necessary costs and is not transparent.***
- 8.5. Implementing a form of NTC market (as discussed by Ofgem)<sup>138</sup> could, in theory, mitigate these challenges. The expectation is that encouraging ICs to compete

---

<sup>138</sup> See Ofgem, Decision to grant the Electricity System Operator an extension to derogation from Standard Licence Condition C28.4(h)(i) for Net Transfer Capacity, 28 September 2023, page 5 ([link](#)).



to meet NESO's system management requirements could result in a more efficient allocation of restrictions across ICs. Under an NTC market, restrictions could be allocated to ICs with the lowest price spreads between GB and the relevant connected market; these ICs will face the lowest opportunity cost of being restricted and therefore can be expected to bid at the lowest cost. Restrictions would be shifted away from the more expensive-to-restrict ICs (that is, those facing the highest price spreads). The greatest potential benefit for an NTC market therefore arises in situations where there is high variance across the wholesale prices of the countries that the ICs within the NTC market connect to.

- 8.6. The requirement for NESO to spread restrictions equitably would also be removed and transparency could be improved, as restrictions would be allocated on the basis of the bids received from participating ICs.

***Key finding 2: Implementing an NTC market could, in theory, reduce costs to GB consumers while still maintaining system security by focusing restrictions on the lowest cost ICs to restrict. Potential benefits will increase when the variance across different connected European market prices is high.***

- 8.7. However, the development of a fully-fledged NTC market faces several challenges. Most fundamental is the risk of market power for individual ICs, as a result of the highly locational nature of NESO's requirements and, in turn, the imperfect substitutability of each IC in meeting NESO's needs. This risk means that an NTC market should only be considered in regions with a sufficient number of ICs connecting to different markets.

- 8.8. Based on our assumed buildout of ICs, we expect that such a cluster will likely only exist in the South East of England, meaning an NTC market cannot fully eliminate the need for the status quo NTC restriction arrangements in the rest of GB.

***Key finding 3: An NTC market is likely not suitable for GB ICs outside of the South East due to a lack of competition in those areas. As such, the status quo cannot be – in the short to medium term – fully replaced by an NTC market, necessitating future derogations from Ofgem.***

- 8.9. Our quantitative assessment of an NTC market finds that the gross benefits (that is, the reduction in payments to ICs as a result of using NTC restrictions) could reach between €0.5m and €4.8m per year. The benefits are lower in 2030 (the first year we model) relative to 2035 and 2040.
- 8.10. However, these results are subject to a number of assumptions and limitations that mean in practice the gross benefits are likely to be lower. There is a significant risk that, even within the South Eastern cluster, the relatively limited number of market participants would expose GB consumers to the risk of ICs leveraging their market power to increase bids or engaging in strategic bidding, which is not captured in our modelling. These risks would be further

exacerbated by the common ownership of multiple ICs within a particular market. Additional monitoring functions would need to be put in place in order to manage this risk.

- 8.11. Introducing an NTC market would also bring additional operational complexity for NESO, for example through the requirement to develop an auction platform and then run frequent auctions. Participating ICs would also have to develop bidding strategies and invest in capabilities to be able to participate in the market.
- 8.12. Given the significant challenges facing an NTC market, the overall benefits case for an NTC market appears to be modest (and particularly so in the early years compared to later years).

***Key finding 4: Whether the potential benefits of an NTC market can be realised in practice is uncertain, in part due to the risk of participants having significant market power or engaging in strategic bidding, even within the South East. Given the likely complexity associated with implementing an NTC market, the overall case for doing so therefore appears modest, particularly in the short term.***

- 8.13. We have therefore considered the potential for other mechanisms for NESO to reduce its reliance on the status quo NTC restriction arrangements. We have focused on an enhancement of NESO's existing trading options. NESO currently trades across ICs via a bespoke auction platform. However, this auction is currently not open to generators or storage assets. Therefore, widening its trading operations to systematically include a wider pool of assets could bring benefits, through access to a wider asset pool and greater competition.
- 8.14. For actions across ICs, Trades are less impacted by the risk of market power, as NESO interacts with holders of IC capacity rights, of which there are likely to be many for each individual IC. This contrasts with NTC restrictions (either the status quo or the NTC market) where the interaction is with the IC itself.
- 8.15. However, Trades are not able to replace NTC restrictions in all scenarios. They cannot effectively manage credible contingencies, such as the risk of sudden generator failures, proactively; instead, they can only impact actual IC flows. This compares to NTC restrictions that can define an envelope of possible flows without necessarily impacting the ICs' actual operation – an important and unique element of NESO's suite of IC management tools. An Extended Trades market therefore cannot replace the need for NTC restrictions entirely. Trades also cannot provide the same degree of firmness as NTC restrictions, as there is a risk that NESO actions could be unwound in through subsequent market actions in the wholesale or IC capacity markets.
- 8.16. Incorporating a wider pool of assets into NESO's trading platform would also likely bring significant additional complexity and costs, due to the varying technological characteristics of different assets.

- 8.17. Our quantitative assessment of an Extended Trades market finds that the gross benefits (that is, the reduction in payments to ICs as a result of using NTC restrictions) could reach between €2.3m and €7.1m per year, relative to the status quo. This exceeds the modelled benefit for the NTC market alone, primarily due to the participation of batteries. However, like the NTC market, the benefits are lower in 2030 (the first year we model) relative to 2035 and 2040. These results are subject to a number of assumptions that mean in practice the gross benefits are lower. A key risk appears to be that the inclusion of additional assets in the Extended Trades market could lead to an inefficient outcome where the position of those assets (or other assets in the market participants' portfolio) effectively unwinds NESO's Trades actions, resulting in NESO having to pay a "second time" for resolving the same underlying system issue. Incorporating a wide range of technologies into an Extended Trades market would also likely be complex.
- 8.18. Given the scale of the potential benefits, our overall view is that NESO should continue examining options for incorporating a wider pool of dispatchable assets into its current trading platform in the future, with a particular focus on preventing potential gaming/unwinding of such positions. However, we do not see the Extended Trades market option as a replacement for NTC restrictions as a tool.

***Key finding 5: Enhancing NESO's trading operations would be in keeping with NESO's recent direction of travel and could help to reduce the reliance on non-market NTC restrictions, but would bring significant additional complexity and does not remove the need for NTC restrictions as a tool for managing the system.***

***Key finding 6: In recent years, NESO has improved the transparency of its use of NTC restrictions and the efficiency of its trading operations. However, recognising the concerns raised by ICs, we agree that there is likely scope for further improvements. Our quantitative assessment of i) a formal NTC market; and ii) expanding NESO's existing Trades function identified relatively modest benefits and material risks. As a result, a continuation of incremental reforms to the existing arrangements appears to be – for the time being – a more appropriate way forward compared to a more fundamental re-design of the NTC restriction tool.***

## A1. NTC Calculation Policy by system issue

- A1.1. As explained in paragraph 4.7 above, the specific approach to setting NTC restrictions varies by the type of system issue. In Table A1-1 below, we summarise the factors that NESO considers when setting NTC restrictions to manage each system issue. If more than one of these three issues are present at any one time, the NTC restriction calculation will be based on the issue that results in the tightest restriction (that is, the greatest MW restriction).

**TABLE A1-1: SUMMARY OF NESO NTC CALCULATION POLICY BY SYSTEM ISSUE**

<b>System issue</b>	<b>NTC Calculation Policy</b>
Network constraints	<p>NESO will consider:</p> <ul style="list-style-type: none"> <li>i. whether the IC has an effect on one or more network constraints;</li> <li>ii. for that constraint, whether there are any alternative actions available to manage the constraint (for example network topology changes or additional generation);</li> <li>iii. whether the IC has an explicit ID market that provides sufficient liquidity or certainty. If not, the NTC restriction requires a safety margin in case one of the alternative actions is no longer available in real time; and</li> <li>iv. whether there are multiple ICs between which the NTC restriction should be shared, and the relative shares.</li> </ul>
Largest system loss	<p>NESO will consider:</p> <ul style="list-style-type: none"> <li>i. how much frequency response is required to secure the loss;</li> <li>ii. whether the level of response is achievable and justifiable while still meeting demand and constraint boundaries; and</li> <li>iii. if the level of response is not achievable and justifiable, what is the largest loss that can be achieved with the maximum response level.</li> </ul>
Margin extreme	<p>NESO will consider:</p> <ul style="list-style-type: none"> <li>i. whether, based on up-to-date forecasts, an Electricity Margin Notice ("EMN") and/or a High Risk of Demand Reduction ("HRDR") warning is likely to be issued;</li> <li>ii. the likelihood of ICs re-nominating sufficient volumes to trigger an EMN or HRDR warning.</li> </ul> <p>If there is a risk of these warnings being triggered, NESO can set an NTC restriction to the limit of a warning being triggered.</p>

Source: NESO, GB NTC Calculation Policy, March 2024, pages 4 and 5 ([link](#)).

## A2. Example NTC compensation methodologies

- A2.1. As explained in Section 4.B above, the exact calculation formulae that determine IC NTC restriction compensation is set out in the relevant IC settlement agreements between NESO, the IC owner and the connected SOs. However, NESO provides examples in the NTC Commercial Arrangements methodology, which we set out below for each form of capacity sale.

**FIGURE A2-1: GB COMMERCIAL ARRANGEMENTS MATRIX FOR EXPLICIT DA AND EXPLICIT ID**

	Allocated	Unallocated
Pre DA auction	<p>As per the IC's access rules.</p> <p>For example, ElecLink's compensation is on: i) the price of the initial long term capacity auction; and ii) the volume curtailed.</p>	<p>IC owner no longer sells capacity in the DA market. Therefore, compensation is based on the DA market spread.</p>
Post DA auction, pre ID auction	<p>IC owner is out of balance relative to trader nominations and therefore faces imbalance charges in both connected markets. Compensation is therefore the net of these imbalance charges.</p>	<p>IC owner no longer sells capacity in the ID markets. Therefore, compensation is based on the revenue impact from these ID markets, based on an estimate of the price absent the NTC restriction.</p>

*Note: For example, IFA, BritNed, Nemo Link, IFA2, ElecLink and Viking Link.*

*Source: FTI analysis of NESO, Methodology for GB Commercial Arrangements relating to Interconnector Capacity Calculation, September 2023, page 5 ([link](#)).*

**FIGURE A2-2: GB COMMERCIAL ARRANGEMENTS MATRIX FOR IMPLICIT ID**

	Allocated	Unallocated
Pre DA auction	N/A	N/A
Post DA auction, pre ID auction	IC owner is out of balance relative to trader nominations and therefore faces imbalance charges in both connected markets. Compensation is therefore the net of these imbalance charges.	The IC capacity is no longer available to the ID market. Therefore, compensation is based on the ID market spread or, where possible, the difference in congestion rent from a re-run of the coupling algorithm without restriction.

Note: For example, Moyle, East West Interconnector ("EWIC") and Greenlink.

Source: FTI analysis of NESO, Methodology for GB Commercial Arrangements relating to Interconnector Capacity Calculation, September 2023, page 6 ([link](#)).

**FIGURE A2-3: GB COMMERCIAL ARRANGEMENTS MATRIX FOR IMPLICIT DA**

	Allocated	Unallocated
Pre DA auction	N/A	The IC capacity is no longer available to the DA market. Therefore, compensation is based on the DA market spread or, where possible, the difference in congestion rent from a re-run of the coupling algorithm without restriction.
Post DA auction, pre ID auction	N/A	N/A

Note: For example, NSL.

Source: FTI analysis of NESO, Methodology for GB Commercial Arrangements relating to Interconnector Capacity Calculation, September 2023, page 6 ([link](#)).

## A3. Summary of ICs' views on the current NTC restriction arrangements

A3.1. As discussed in paragraph 4.3, NESO sought responses from several IC owners regarding their views on, and any concerns regarding, the current NTC restriction arrangements,<sup>139</sup> which we summarise by issue raised below.

### Broader regulatory and legal framework

- A3.2. ICs raised several concerns relating to the regulatory and legal frameworks underlying the current NTC restriction arrangements, including:
- i. the broader regulatory framework for NTC restrictions, which in the context of Brexit, may not have sufficient checks and balances and could lead to an asymmetry between the rights of NESO, overseas SOs and IC owners;
  - ii. the lack of a formal framework for regular review of the NTC restriction methodology, and a lack of sufficient dispute resolution mechanisms in place;
  - iii. that new ICs have not been given a choice regarding the current NTC restriction arrangements, and have had to agree to the current methodology;
  - iv. issues related to their specific ownership structure, and the interactions between that structure and the transition to NTC restrictions; and
  - v. concerns regarding NESO's ability to set NTC restrictions unilaterally.

### Keeping ICs whole

- A3.3. Some ICs raised concerns regarding the NTC Commercial Arrangements methodology. In particular, ICs suggested that the current compensation may not be sufficient to 'keep ICs whole' due to:
- i. too much weight being given to the view that NTC restrictions could result in 'scarcity value', that is, when a reduction in available IC capacity due to an NTC restriction increases the value of the remaining capacity;<sup>140</sup>
  - ii. elements of NESO's compensation calculation formulae possibly resulting in lower compensation arbitrarily; and
  - iii. historic issues with the accuracy of NESO's calculations during the monthly settlement process.
- A3.4. As discussed in Section 4.B, we understand from NESO that it intends to conduct a 'call for input' from key industry stakeholders on the current NTC Commercial Arrangements methodology in the near future.

<sup>139</sup> Responses were gathered by NESO on the condition of anonymity. Accordingly, our summary does not attribute the responses to specific IC owners.

<sup>140</sup> See Methodology for GB Commercial Arrangements relating to Interconnector Capacity Calculation, September 2023, 3(C) ([link](#)).



## Transparency

- A3.5. Regarding the transparency of the current arrangements, it was acknowledged that NESO publishes data on NTC restriction usage, allowing for a degree of transparency. However, ICs still raised concerns relating to:
- i. the lack of consistent and regular post-event review processes for NESO's NTC restriction decision making;
  - ii. the lack of information available regarding the processes underlying NTC restriction decisions in general, for example, how NESO determine the size of NTC restrictions and their duration, and explanations as to why alternative actions were not available to NESO at the time (given the last resort nature of the tool);
  - iii. insufficient transparency regarding NESO's post-event evaluation processes for their NTC restriction decisions (that is, whether NESO reviews or publishes information on decisions relating to NTC restrictions); and
  - iv. uncertainty on whether the NTC Commercial Arrangements methodology would apply during unplanned GB transmission system outages.<sup>141</sup>

## Other concerns raised

- A3.6. Some ICs raised concerns related to the potential wider impacts of NTC restrictions. This included the wider impacts on:
- i. *Connected markets* – as NTC restrictions inevitably impact connected markets and overseas SOs, and could potentially impact their system security which may not be considered by NESO when making NTC restriction decisions. This could cause overseas SOs, who may have concerns regarding these potential impacts, to change their policies in response, especially if all GB ICs are expected to transition to NTC restrictions in the future; and
  - ii. *Consumers* – as NTC restrictions potentially limit the IC capacity available for cross-border trade and weaken cost efficiency.
- A3.7. More generally, some ICs argued that it was unclear to what extent the existing policies in place, as per the current arrangements, are actually applied by NESO in practice when making decisions relating to NTC restrictions. For example, the frequency of NTC restrictions may suggest NTC restrictions are not being used only as a measure of last resort.
- A3.8. Finally, some ICs raised concerns regarding the transition from ITLs to NTC restrictions, which has not yet been mandated, expressing their view that any transition should happen on a voluntary basis alone.

---

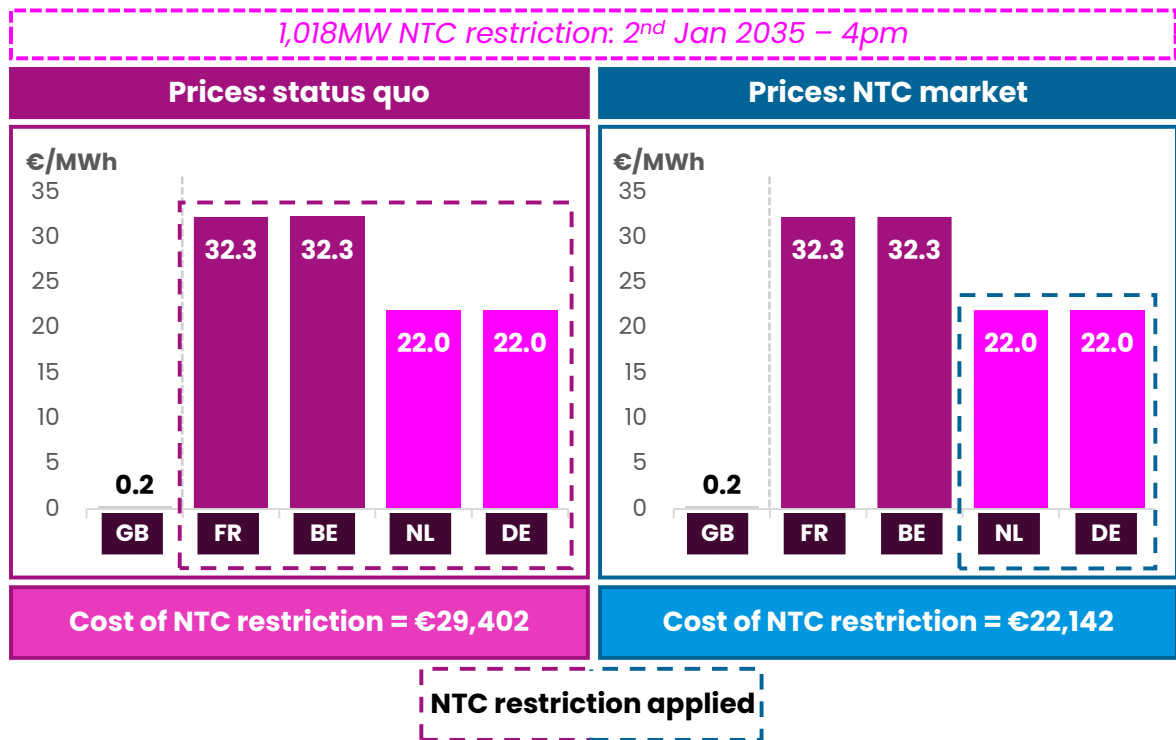
<sup>141</sup> See Section 4.B for a description of the NTC Commercial Arrangements methodology.

## A4. Illustrative examples of savings in an NTC market

A4.1. Figures A4-1 to A4-3 below depict several illustrative examples of NTC restriction events for the modelled year 2035. In particular, the figures depict NTC restriction events for hours in which:

- all South East ICs are expected to export, and there are multiple low cost ICs in the market;
- all South East ICs are expected to export, and there is a single low cost IC in the market; and
- all South East ICs are expected to import.

**FIGURE A4-1: NTC RESTRICTION EVENT IN 2035 (2ND JAN 2035, 4PM) – ALL ICs EXPORTING AND MULTIPLE COMPETITIVE ICs**



Notes: (1) All wholesale market prices shown are in 2024 real prices; and (2) As set out above, the cost of NTC restrictions is equal to volume of binding NTC export restrictions multiplied by the price spread between GB and connected markets for that hour

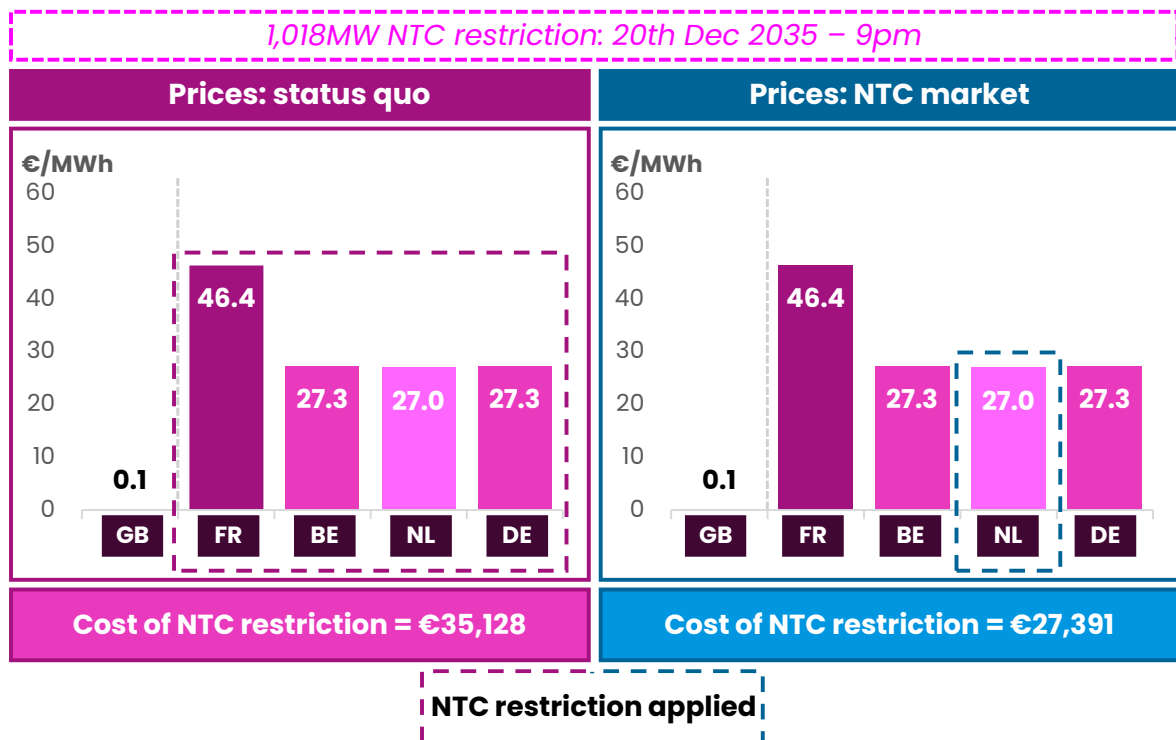
Source: FTI analysis.

A4.2. As shown in the figure above, in this hour:

- European wholesale prices are greater than the GB price, and so all South East ICs are expected to export to their maximum potential. Therefore, all NTC exports restrictions are 'binding'.
- Under the status quo, restrictions are spread equitably (weighted based on IC capacity) across ICs, resulting in a total cost of c. €29,402.<sup>142</sup>
- Under an NTC market, ICs bid in based on their expected price spread, meaning that ICs connecting to the Netherlands (BritNed) and Germany (NeuConnect) are jointly the most competitive. As a result, NTC restrictions are allocated evenly across these ICs, resulting in a total cost of c. €22,142.<sup>143</sup>

A4.3. Comparing the total costs above results in a potential benefit of an NTC market for this hour of €7,259.

**FIGURE A4-2: NTC RESTRICTION EVENT IN 2035 (20TH DEC 2035, 9PM) – ALL ICs EXPORTING AND A SINGLE MOST COMPETITIVE IC**



Notes: (1) All wholesale market prices shown are in 2024 real prices; and (2) As set out above, the cost of NTC restrictions is equal to volume of binding NTC export restrictions multiplied by the price spread between GB and connected markets for that hour.

Source: FTI analysis.

<sup>142</sup> Total IC capacity equals 7,800MW, comprising of: 3,000MW FR, 2,400MW BE, 1,000MW NL, 1,400MW DE. Allocating the 1,018MW restriction in proportion to these capacities results in a total cost of:

$392\text{MWh} \times 32.3\text{€/MWh} + 313\text{MWh} \times 32.3\text{€/MWh} + 131\text{MWh} \times 22.0\text{€/MWh} + 183\text{MWh} \times 22.0\text{€/MWh} = €29,402.$

<sup>143</sup>  $(509\text{MWh} + 509\text{MWh}) \times 22.0\text{€/MWh} = €22,142.$

- A4.4. As shown in the figure above, in this hour:
- i. European wholesale prices are greater than the GB price, and so all South East ICs are expected to export to their maximum potential. Therefore, all NTC exports restrictions are 'binding'.
  - ii. Under the current status quo, restrictions are spread equitably across ICs, resulting in a total cost of c. €35,128.<sup>144</sup>
  - iii. Under an NTC market, ICs connecting to the Netherlands (BritNed) is marginally lower cost than ICs connecting to Belgium and Germany, and so, almost the entire required NTC restriction is allocated to BritNed.<sup>145</sup> This results in a total cost of c. €27,391.<sup>146</sup>
- A4.5. Comparing the total costs above results in a large potential benefit of an NTC market for this hour of €7,737.

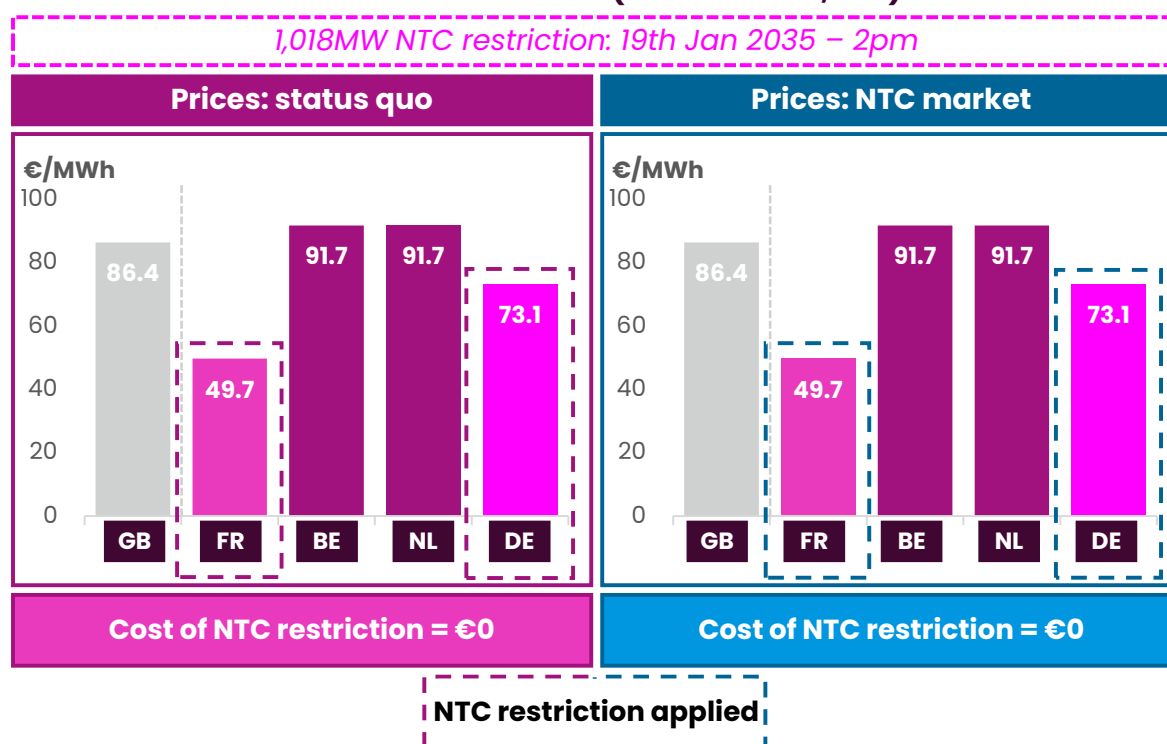
---

<sup>144</sup> Total IC capacity equals 7,800MW, comprising of: 3,000MW FR, 2,400MW BE, 1,000MW NL, 1,400MW DE. Allocating the 1,018MW restriction in proportion to these capacities results in a total cost of:

$392\text{MWh} \times 46.4\text{€/MWh} + 313\text{MWh} \times 27.3\text{€/MWh} + 131\text{MWh} \times 27.0\text{€/MWh} + 183\text{MWh} \times 27.3\text{€/MWh} = \text{€}35,128.$

<sup>145</sup> As explained in paragraph 6.68, we assume for all NTC restriction events that an NTC export restriction of 1,018MW is required. As this is greater than BritNed's maximum export capacity of 1,000MW, small restrictions (<10MW) are also applied to cables connecting to Belgium and Germany, that is, we assume a second auction takes place to allocate the remaining required restriction of 18MW.

<sup>146</sup>  $12\text{MWh} \times 27.3\text{€/MWh} + 1000\text{MWh} \times 27.0\text{€/MWh} + 6\text{MWh} \times 27.3\text{€/MWh} = \text{€}27,391.$

**FIGURE A4-3: NTC RESTRICTION EVENT IN 2035 (19TH JAN 2035, 2PM) – ALL ICs IMPORTING**

Notes: (1) All wholesale market prices shown are in 2024 real prices; and (2) As set out above, the cost of NTC restrictions is equal to volume of binding NTC export restrictions multiplied by the price spread between GB and connected markets for that hour.

Sources: FTI analysis.

A4.6. As shown in the figure above, in this hour:

- i. European wholesale prices in France and Germany are lower than the GB price, and so ICs connected to these countries (IFA, ElecLink, and NeuConnect) are all expected to import to their maximum potential.
- ii. Therefore, all NTC export restrictions are 'non-binding' and so are assumed to be costless.
- iii. Under both the current status quo and an NTC market, we assume export restrictions are first applied to these three IC (that is, non-binding restrictions are prioritised where possible), as explained in paragraph 6.77.

A4.7. Therefore, for this hour there is no potential benefit under an NTC market.

## A5. Historical data on NTC restriction/ITL usage

### A. Historical data used in our analysis

- A5.1. NESO provides data on NTC restriction/ITL usage by IC on an hourly level on its data portal.<sup>147</sup> We extracted the data used our historical analysis (Section 6.B) from the portal on 15 and 16 January 2025.
- A5.2. We have focused our quantitative analysis of historical NTC restriction/ITL usage on the data available following an upgrade to NESO's systems, which we understand occurred in mid-September 2024. This data is more granular than the pre-update data, which facilitates clearer insights. For example, restrictions are now disaggregated into restrictions on flows into GB and flows out of GB.<sup>148</sup>

### B. Historical data limitations

- A5.3. While NESO's historical data on NTC restriction/ITL usage has improved since the upgrade to NESO's systems in mid-September 2024, there are some data limitations that remain. These include:
- i. **BritNed:** NTC restrictions are not disaggregated into restrictions on flows into GB and flows out of GB. Based on the analysis set out in Figure 6-10, we assume all BritNed restrictions are placed on exports from GB.
  - ii. **ElecLink:** ElecLink suffered from an outage during the analysis period.<sup>149</sup> However, there were still NTC restrictions applied to ElecLink during this period on NESO's data portal. We include this data in our analysis, however, this may risk overstating the historical frequency of NTC restriction usage and, by extension, the potential benefits from a future NTC market.
  - iii. **IFA/IFA2:** More granular ITL data, which we use for our analysis, is only available from late December 2024 on the NESO data portal.
  - iv. **Missing data:** In addition to the period of missing ElecLink data, there are further days which contain missing NTC restriction/ITL data for all ICs.
  - v. **Flows below capacity but marked "No Restriction":** Sometimes, there are allowed flows significantly below the maximum capacity of the cable, but the data gives the "Reason for Restriction" as "No Restriction".
  - vi. **NTC restrictions occurring in 24-hour blocks:** At times, NTC restrictions are tagged in the data for 24-hour blocks (or multiples of 24-hour blocks), even if there is no change in allowed flows from a previous period marked "No Restriction" (implying the restriction may not have been in place for the full 24 hour period in practice).

<sup>147</sup> NESO data portal ([link](#)).

<sup>148</sup> Subject to the limitations subsection below.

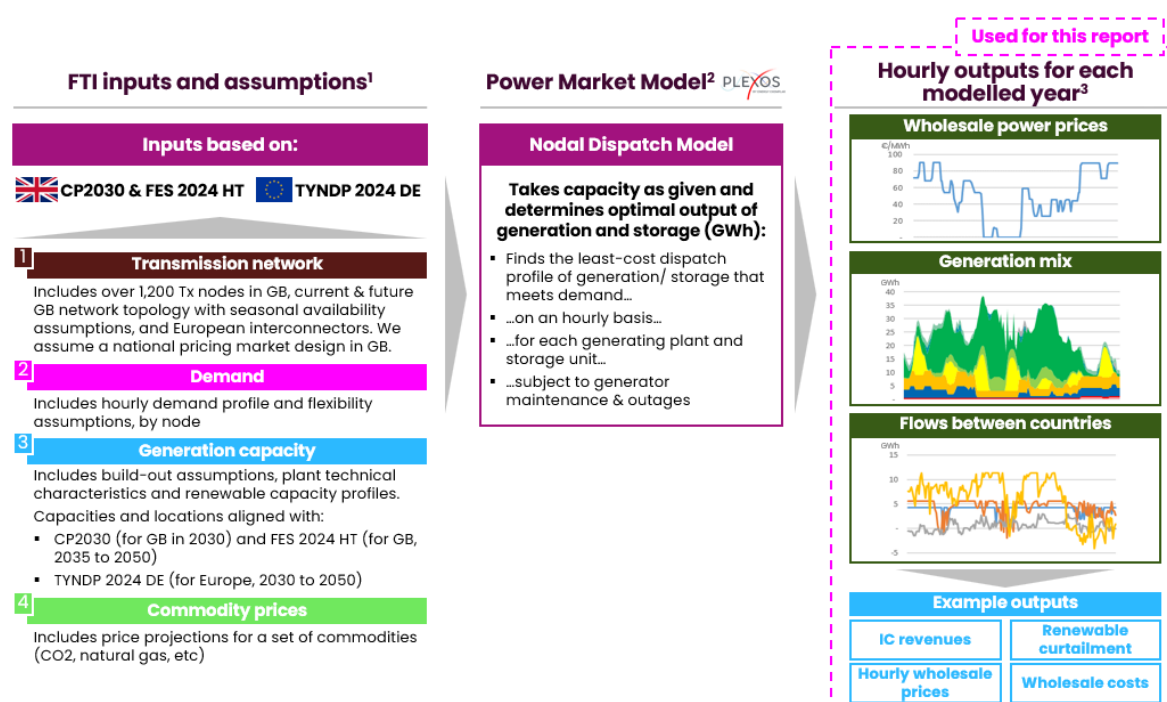
<sup>149</sup> See Getlink, Gradual return to service of ElecLink operations, 5 February 2025 ([link](#)).

## A6. FTI modelling outputs

- A6.1. As explained in Section 6.B, to identify future periods where NTC restrictions may be required as part of our quantitative assessments, we utilise FTI's pre-existing modelling outputs for the GB electricity system. In particular, we use dispatch modelling outputs from FTI's recent REMA Dispatch Assessment work, commissioned by NESO, which includes modelling of the GB system into 2030, 2035, and 2040. We have not performed any new power market dispatch modelling for this report.
- A6.2. Figure A6-1 below provides a brief outline of the key processes underlying our FTI modelling outputs, including: i) calibrating inputs and assumptions to various industry-standard forecasts; ii) FTI's nodal power market dispatch modelling, developed using the PLEXOS software platform;<sup>150</sup> and iii) the hourly outputs focused on as part of this report.

---

<sup>150</sup> This software was developed and licensed by Energy Exemplar. See Energy Exemplar, PLEXOS Energy Modelling Software, ([link](#)).

**FIGURE A6-1: KEY PROCESSES FOR FTI MODELLING OUTPUTS**

Notes: (1) We extensively tested our model set up during our previous REMA Dispatch Assessment work with NESO. Please see REMA Dispatch Assessment work for NESO ([link](#)); (2) Our pan-European model includes 19 countries and clears simultaneously across GB and Europe for each hour modelled. This is critical in assessing IC flows; and (3) The graphs shown for hourly outputs in the figure above are for illustrative purposes.

Sources: FTI analysis of (1) NESO, Clean Power 2030, November 2024 ([link](#)); (2) NESO, Future Energy Scenarios, July 2024 ([link](#)); and (3) ENTSOE, TYNDP 2024 Scenarios Report, January 2025 ([link](#)).







- A6.3. As set out in Figure A6-1 above, the key assumptions underlying our modelling outputs have been developed based on industry-standard forecasts.<sup>151</sup> These were developed through extensive engagement with NESO and DESNZ during our previous REMA Dispatch Assessment work.<sup>152</sup>
- A6.4. Figures A6-2 and A6-3 below describe the key assumptions and scenarios underlying FTI modelling outputs in more detail.

<sup>151</sup> Please see NESO, Future Energy Scenarios, July 2024 ([link](#)) and ENTSOE, TYNDP 2024 Scenarios Report, January 2025 ([link](#)) for more detail on the scenarios selected.

<sup>152</sup> For more detail, please see REMA Dispatch Assessment work for NESO ([link](#)).



**FIGURE A6-2: KEY MODELLING ASSUMPTIONS**

Assumption	Detailed description
<b>Capacity outlook<sup>1</sup></b> 	CP2030 “Further Flex & RES” (2030 GB), FES 2024 HT (“Holistic Transition”) (2035–2050, GB), TYNDP 2024 “Distributed Energy” (Europe)
<b>Interconnectors<sup>2</sup></b> 	Assumed <b>operational ICs</b> aligned with DESNZ REMA IC assumptions
<b>Commodity prices</b> 	<b>Natural gas, hydrogen, oil and coal prices</b> follow DESNZ 2024 projections <b>Biomass price</b> calibrated using FES 2024 forecast capacity factors <b>Carbon price</b> aligned with forward estimates as of Q2 2024
<b>Modelled years</b> 	2030, 2035, 2040, 2045, 2050 (in this report, we focus on 2030, 2035 & 2040)
<b>Climate year (“CY”)<sup>3</sup></b> 	CY2013
<b>Transmission network</b> 	CP2030 and Beyond 2030

Notes: (1) Please see Figure A6-3 below for a detailed breakdown of the future energy scenarios developed as part of CP2030, FES 2024, and TYNDP 2024; and (2) CY2013 is selected in line with NESO’s choice of climate year used for the FES 2024, and represents a typical British weather year, characterised by low temperatures and high winds in winter and a mild summer. See NESO, Future Energy Scenarios: Pathway Assumptions 2024 ([link](#)).

Sources: (1) NESO, Clean Power 2030, November 2024 ([link](#)); (2) NESO, Future Energy Scenarios, July 2024 ([link](#)); and (3) ENTSOE, TYNDP 2024 Scenarios Report, January 2025 ([link](#)).

**FIGURE A6-3: FUTURE ENERGY SCENARIOS MODELLED**

	CP2030		FES 2024				TYNDP 2024	
	Further Flex & RES	New Dispatch	Holistic Transition	Electric Engagement	Hydrogen Evolution	Counter-factual	Global Ambition	Distributed Energy
<b>Net Zero by 2050</b>	N/A	N/A	✓	✓	✓	✗	✓	✓
<b>Electrification</b>	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
<b>Hydrogen</b>	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
<b>Demand flexibility</b>	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
<b>Renewables</b>	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■

**Further Flex & RES** is one of the two scenarios used in the **Clean Power 2030** assessment (it is a variant of the **Holistic Transition** scenario developed for FES 2024).

Net zero targets are met by an **ambitious rollout of renewables** in GB, with significant **demand flexibility**, and a relatively high level of **electrification**.

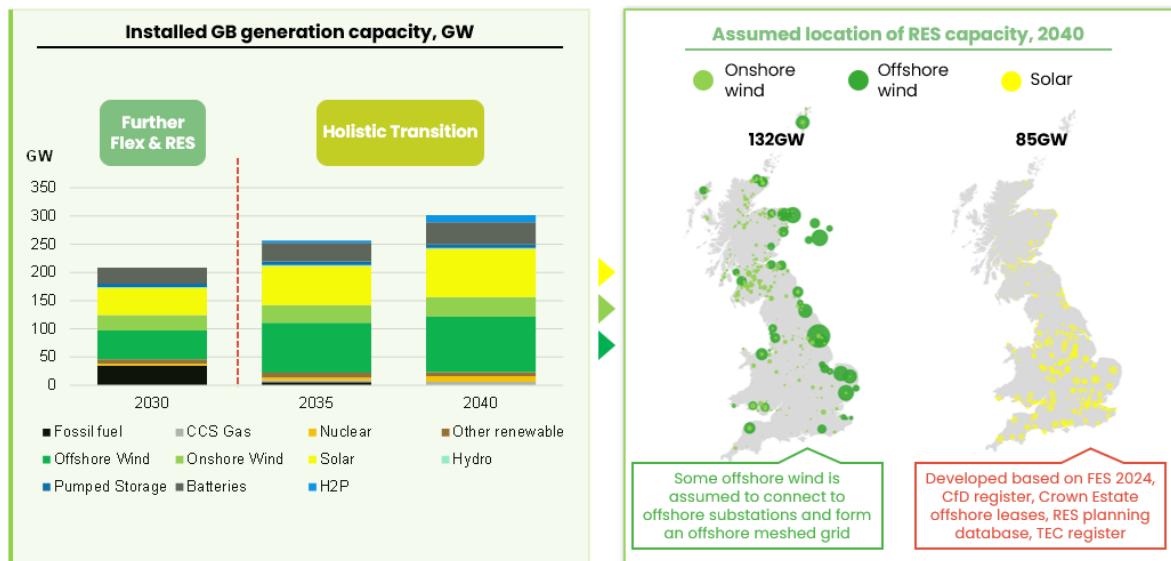
**Distributed Energy** is one of two scenarios used in **TYNDP 2024** and includes ambitious assumptions on RES and flex roll-out, similar to **Holistic Transition** in GB.

Sources: FTI analysis of (1) NESO, Clean Power 2030, November 2024 ([link](#)); (2) NESO, Future Energy Scenarios, July 2024 ([link](#)); and (3) ENTSOE, TYNDP 2024 Scenarios Report, January 2025 ([link](#)).

- A6.5. As described in the figures above, our modelling aligns future power generation capacity in GB to CP2030 “Further Flex & RES” in 2030, and FES 2024 HT (“Holistic Transition”) in 2035 and 2040 – these scenarios assume an ambitious roll-out of renewables in order to meet increased electrification of GB demand, in line with Net Zero. This is illustrated by Figures A6-4 and A6-5 below, which show the

evolution of installed power generation capacity and electricity demand in GB across 2030 to 2040 (and its assumed location as of 2040) respectively.

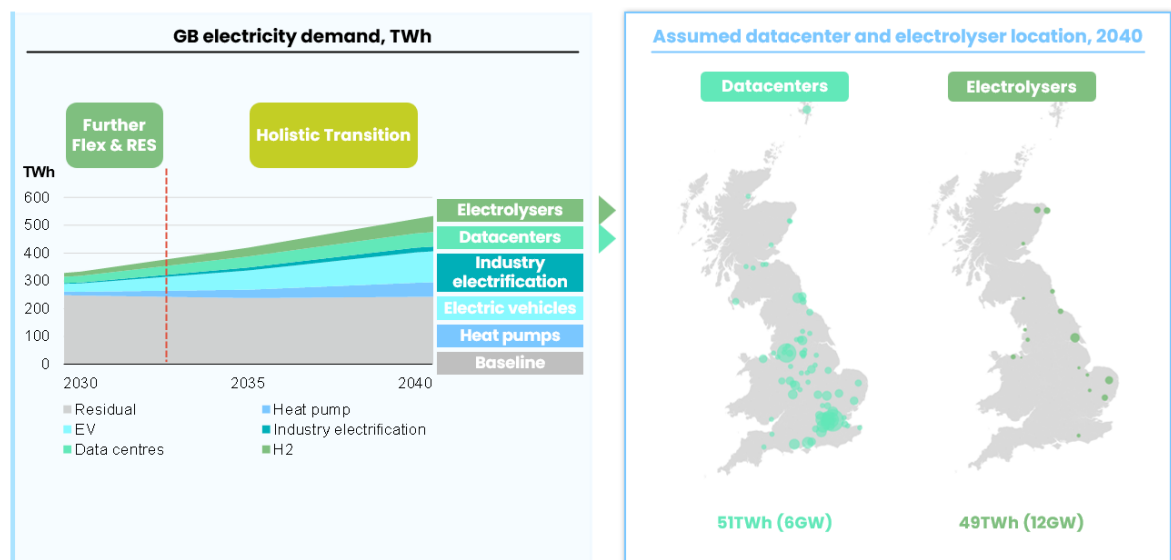
**FIGURE A6-4: GB POWER GENERATION CAPACITY OUTLOOK (2030 TO 2040)**



Note: The size of the discs in the figure above indicates the level of generation capacity in a particular location.

Sources: FTI analysis of (1) NESO, Clean Power 2030, November 2024 ([link](#)) and; (2) NESO, Future Energy Scenarios, July 2024 ([link](#)).

**FIGURE A6-5: GB ELECTRICITY DEMAND (2030 TO 2040)**



Note: The size of the discs in the figure above indicates the level of electricity demand in a particular location.

Sources: FTI analysis of (1) NESO, Clean Power 2030, November 2024 ([link](#)) and; (2) NESO, Future Energy Scenarios, July 2024 ([link](#)).

- A6.6. As shown in Figure A6-6 below, we use DESNZ's REMA IC assumptions in our NTC market analysis, which were provided on a confidential basis.

**FIGURE A6-6: DESNZ IC ASSUMPTIONS USED IN OUR NTC MARKET ANALYSIS**

REDACTED

*Source: FTI analysis of DESNZ IC assumptions.*

- A6.7. We use the following outputs from our recent REMA Dispatch Assessment work at the hourly level, across all modelled years:<sup>153</sup>
- i. GB electricity demand;
  - ii. wholesale market prices for GB (under a national market design), and across Europe for countries connected via South East ICs;
  - iii. flows across South East ICs;
  - iv. generation, available generation capacity, and offer prices across generators located in the South East; and
  - v. generation, available generation capacity, and offer prices across storage assets located in the South East.
- A6.8. The full details of our modelling methodology have been provided to NESO as part of the REMA Dispatch Assessment work referred to above.

---

<sup>153</sup> We leverage outputs from our model calibrated to GB's existing national market design.

## A7. NTC market sensitivity analysis

- A7.1. We calculate expected gross benefits of an NTC market in 2030, 2035 and 2040 across the following sensitivities:
- i. **Isle of Grain exclusion:** This has the same 1,018MW restriction as the base case but removes the two ICs that connect to GB at the Isle of Grain (BritNed and NeuConnect).
  - ii. **1250MW restriction:** This reflects a minor increase from our baseline of 1,018MW.
  - iii. **Restriction scaled up by South East IC capacity growth:** The NTC restriction is scaled upwards by the forecast change in SE IC capacity. In 2030, this would be a restriction of 1,303MW.<sup>154</sup> In 2035 and 2040, this would be a restriction of 1,588MW.<sup>155</sup>
  - iv. **Restriction scaled up by peak demand growth:** The NTC restriction is scaled upwards by forecast changes in peak demand. In 2030, this would be a restriction of 1,356MW.<sup>156</sup> In 2035, this would be a restriction of 1,795MW,<sup>157</sup> and in 2040 this would be a restriction of 2,293MW.<sup>158</sup>

---

<sup>154</sup> SE IC capacity is expected to increase from 5.0GW to 6.4GW between 2024 and 2030 (an increase of c.1.28x).  $1,018\text{MW} \times 1.28 = 1,303\text{MW}$ .

<sup>155</sup> SE IC capacity is expected to increase from 5.0GW to 7.8GW between 2024 and 2035 (an increase of c.1.56x).  $1,018\text{MW} \times 1.56 = 1,588\text{MW}$ . There is not expected to be a further increase between 2035 and 2040.

<sup>156</sup> Hourly peak GB demand is expected to increase from c.45GW to c.60.1GW between 2024 and 2030 (an increase of c.1.33x).  $1,018\text{MW} \times 1.33 = 1,356\text{MW}$ .

<sup>157</sup> Hourly peak GB demand is expected to increase from c.45GW to c.79.5GW between 2024 and 2035 (an increase of c.1.76x).  $1,018\text{MW} \times 1.76 = 1,795\text{MW}$ .

<sup>158</sup> Hourly peak GB demand is expected to increase from c.45GW to c.101.6GW between 2024 and 2040 (an increase of c.2.25x).  $1,018\text{MW} \times 2.25 = 2,293\text{MW}$ .

A7.2. Table A7-1 below sets out our calculations of expected gross benefits of an NTC market in 2030, 2035 and 2040 across all sensitivities.

**TABLE A7-1: TOTAL COST OF NTC RESTRICTIONS IN ALL SENSITIVITIES, PER YEAR (€M, REAL 2024)**

<b>Sensitivity</b>	<b>Scenario</b>	<b>2030</b>	<b>2035</b>	<b>2040</b>
Base	NTC market	8.8	4.7	5.3
	Status quo	10.1	7.6	8.1
	<b>Gross benefits of an NTC market</b>	<b>1.3</b>	<b>2.9</b>	<b>2.7</b>
Isle of Grain exclusion	NTC market	10.4	6.8	7.6
	Status quo	10.8	7.4	8.2
	<b>Gross benefits of an NTC market</b>	<b>0.5</b>	<b>0.6</b>	<b>0.6</b>
1250MW restriction	NTC market	11.1	6.1	6.9
	Status quo	12.5	9.4	9.9
	<b>Gross benefits of an NTC market</b>	<b>1.5</b>	<b>3.3</b>	<b>3.1</b>
Restriction scaled up by South East IC capacity growth	NTC market	11.6	8.1	9.1
	Status quo	13.1	12.0	12.7
	<b>Gross benefits of an NTC market</b>	<b>1.5</b>	<b>3.9</b>	<b>3.6</b>
Restriction scaled up by peak demand growth	NTC market	12.1	9.3	13.7
	Status quo	13.6	13.6	18.5
	<b>Gross benefits of an NTC market</b>	<b>1.5</b>	<b>4.3</b>	<b>4.8</b>

*Note: Figures may not sum due to rounding.*

*Source: FTI analysis.*

## A8. Battery price received assumption

- A8.1. As outlined in Figure 7-2, we assume storage assets will bid into the Extended Trades market with reference to a 'price received'. This assumption reflects that the profitability of storage assets is driven by arbitraging across prices over time – to maximise profits, batteries will typically discharge when prices are high and charge when prices are low.
- A8.2. Any change in the energy position of storage assets, due to trading with NESO, will impact their future profitability. For example, the opportunity cost of an asset discharging in the present, as a result of entering a Trade with NESO, includes:
- i. The cost of future revenues foregone, which is high if future prices are expected to be high, or low conversely; and
  - ii. The cost of having to recharge in the future, which is again high if future prices are expected to be high, or low conversely.
- A8.3. Therefore, in order to capture the opportunity cost of storage assets changing their energy position as a result of a Trade, we assume they bid with reference to a 'price received' based on future wholesale electricity prices, plus an 'offer uplift' which is an additive mark up. We assume the 'price received' is equal to the **average of the four highest priced hours during the forthcoming day**, which broadly approximates a 4-hour battery cycling once a day.<sup>159</sup>
- A8.4. This proxy for the likely behaviour of storage assets in the Extended Trades market, by necessity involves an element of judgement. Therefore, to help ensure the robustness of our analysis, we further tested the impact of batteries bidding with reference to a 'price received' based on the **average price over the forthcoming week** as an additional sensitivity, recognising that longer duration storage assets, such as CAES and LAES, are expected to become more prevalent in future. Table A8-1 below summarises the impact of this sensitivity on our overall quantitative assessment of the potential benefits of an Extended Trades market, as presented in Table 7-1.

---

<sup>159</sup> While 1 and 2 hour batteries are currently most common in GB, FES HT assumes that longer duration batteries will become more prevalent in future.

**TABLE A8-1: TOTAL COST OF EXTENDED TRADES MARKET AND STATUS QUO NTC RESTRICTIONS, PER YEAR (€M, REAL 2024)**

	2030	2035	2040
Extended Trades market – Baseline <sup>1</sup>	6.2	3.8	4.7
Status quo	10.1	7.6	8.1
<b>Gross benefits of an Extended Trades market</b>	<b>3.9</b>	<b>3.7</b>	<b>3.4</b>
Extended Trades market – Sensitivity	7.1	4.2	5.0
Status quo	10.1	7.6	8.1
<b>Gross benefits of an Extended Trades market</b>	<b>3.1</b>	<b>3.4</b>	<b>3.0</b>

Notes: (1) Baseline assumes batteries bid with reference to a 'price received' based on the average of the four highest priced hours during the forthcoming day; and (2) Sensitivity assumes batteries bid with reference to a 'price received' based on the average price over the forthcoming week.

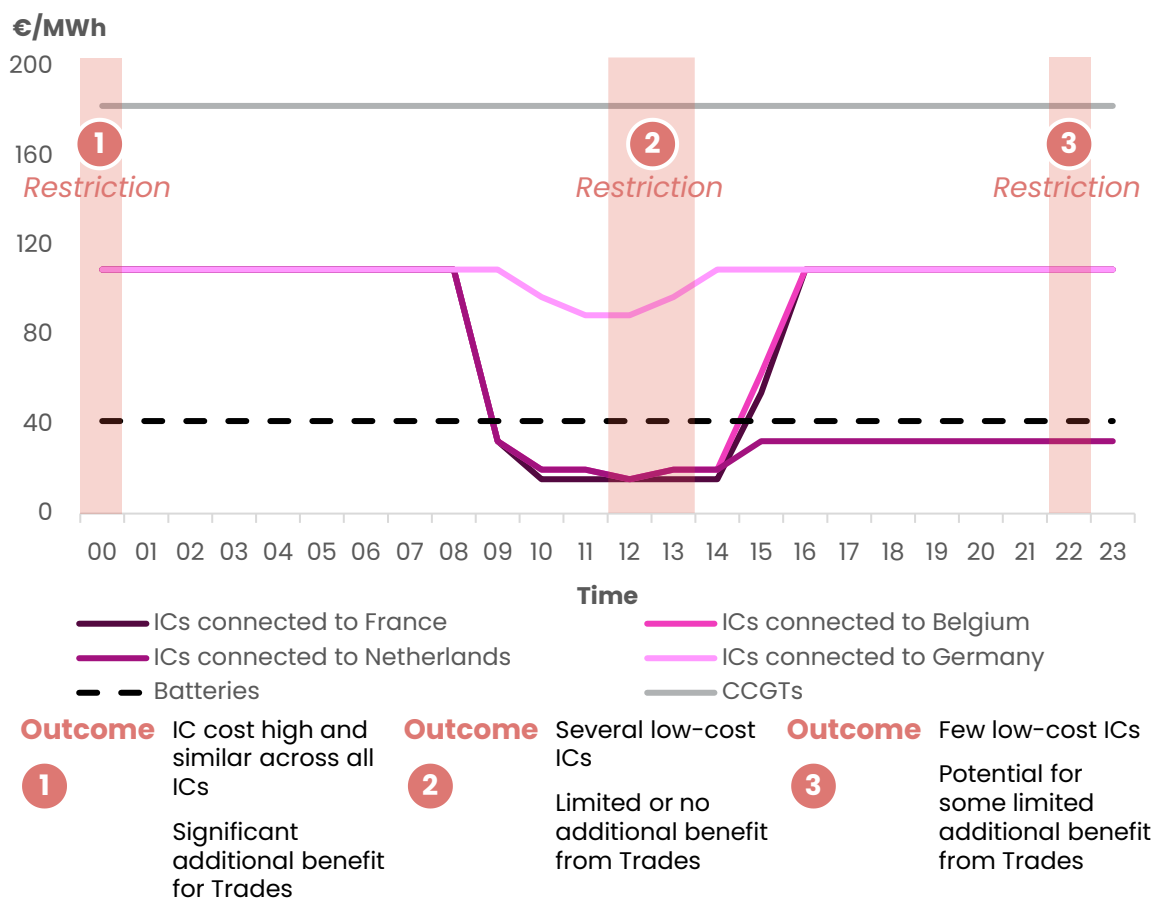
Source: FTI analysis.

- A8.5. As presented in Section 7.C, our baseline approach finds an Extended Trades market is expected to provide cost savings of between €3.4m and €3.9m per year. Based on the sensitivity presented in Table A8-1 above, we find small reduction in the cost savings of an Extended Trades market, to between €3.0m and €3.4m per year. Using the average price over the forthcoming week, relative to the average of the four highest priced hours during the forthcoming day, reduces the chance of very low battery bid prices and, in turn, the likelihood of Trades with batteries providing significant additional value over and above IC traders. This is because it is unlikely for there to be very low GB prices for an entire week compared to within just a single day.

## A9. Illustrative examples of savings in an Extended Trades market

A9.1. In this appendix, we discuss an illustrative example of the Extended Trades market where three periods requiring an NTC restriction or Trade arise across a single day in 2035. Figure A9-1 depicts modelled bids across different technologies participating in the Extended Trades market (that is, IC traders, storage assets and CCGTs in the South East) over the day.

**FIGURE A9-1: NTC RESTRICTION EVENTS IN 2035 (11TH DEC 2035) – TRADING MARKET DYNAMICS ILLUSTRATED THROUGH ASSUMED BID PRICES**



Notes: (1) All wholesale market prices shown are in 2024 real prices; and (2) The bid offers shown above are based on our assumptions as set out in Section 7.C.

Source: FTI analysis.

A9.2. Each period during this day has different outcomes under an Extended Trades market and, as such, different benefits:

- i. **Outcome 1** – IC traders have the same bid price and storage assets are lower cost.
  - a. This outcome occurs because forecast wholesale prices across European countries have converged and are much greater than GB



prices such that trading with IC capacity holders (or imposing a binding NTC export restriction on these ICs) would be expensive.

- b. Therefore, there is significant potential for additional benefit of Trades both compared to the status quo NTC restriction arrangements and under an NTC market, as NESO can trade with low cost storage assets (due to low GB electricity prices).
- ii. **Outcome 2** – Some IC trader bids are low cost relative to storage assets.
  - a. This outcome occurs because wholesale prices across European countries have diverged, resulting in significant variation in the bids of IC traders (some of which are the lowest cost asset within the Extended Trades market).
  - b. This divergence suggests scope for potential savings under an NTC market relative to the status quo (from allowing NTC restrictions onto the lowest cost ICs). The potential for additional benefits via an Extended Trades market is limited, as the bids of storage assets are relatively high compared to IC traders.
- iii. **Outcome 3** – IC traders across a particular cable (that is, BritNed connected to the Netherlands) are low cost relative to storage assets, but other IC traders are not.
  - a. This outcome occurs because the forecast wholesale price of the Netherlands is close to GB, but other European countries have significantly greater prices.
  - b. Similar to outcome 2 above, this divergence in European prices suggests scope for savings under an NTC market relative to the status quo, through allocating restrictions to the lowest cost ICs. There may also be potential for some additional benefits from an Extended Trades market, if IC volumes available to trade across BritNed are not sufficient to meet NESO's requirements for resolving the given system issue. That is, even after trading with IC traders holding BritNed capacity (or who intend to purchase in future), there remains further 'binding' constraints to resolve, which could be met via Trades with storage assets.

## A10. Extended Trades market sensitivity analysis

- A10.1. Table A10-1 below sets out our calculations of expected gross benefits of an Extended Trades market in 2030, 2035 and 2040 across all sensitivities. See paragraph A7.1 for a description of the main sensitivities and Appendix A8 for a description of the battery price received sensitivity.

**TABLE A10-1: TOTAL COST OF EXTENDED TRADES MARKET AND STATUS QUO NTC RESTRICTIONS IN ALL SENSITIVITIES, PER YEAR (€M, REAL 2024)**

<b>Sensitivity</b>	<b>Scenario</b>	<b>2030</b>	<b>2035</b>	<b>2040</b>
Base	NTC market	6.2	3.8	4.7
	Status quo	10.1	7.6	8.1
	<b>Gross benefits of an Extended Trades market</b>	<b>3.9</b>	<b>3.7</b>	<b>3.4</b>
Isle of Grain exclusion	NTC market	7.2	4.5	5.9
	Status quo	10.8	7.4	8.2
	<b>Gross benefits of an Extended Trades market</b>	<b>3.6</b>	<b>2.9</b>	<b>2.3</b>
1250MW restriction	NTC market	7.8	4.8	5.9
	Status quo	12.5	9.4	9.9
	<b>Gross benefits of an Extended Trades market</b>	<b>4.7</b>	<b>4.6</b>	<b>4.0</b>
Restriction scaled up by South East IC capacity growth	NTC market	8.1	6.2	7.7
	Status quo	13.1	12.0	12.7
	<b>Gross benefits of an Extended Trades market</b>	<b>4.9</b>	<b>5.8</b>	<b>5.0</b>
Restriction scaled up by peak demand growth	NTC market	8.5	7.0	11.4
	Status quo	13.6	13.6	18.5
	<b>Gross benefits of an Extended Trades market</b>	<b>5.1</b>	<b>6.5</b>	<b>7.1</b>
Battery price received sensitivity	NTC market	7.1	4.2	5.0
	Status quo	10.1	7.6	8.1
	<b>Gross benefits of an Extended Trades market</b>	<b>3.1</b>	<b>3.4</b>	<b>3.0</b>

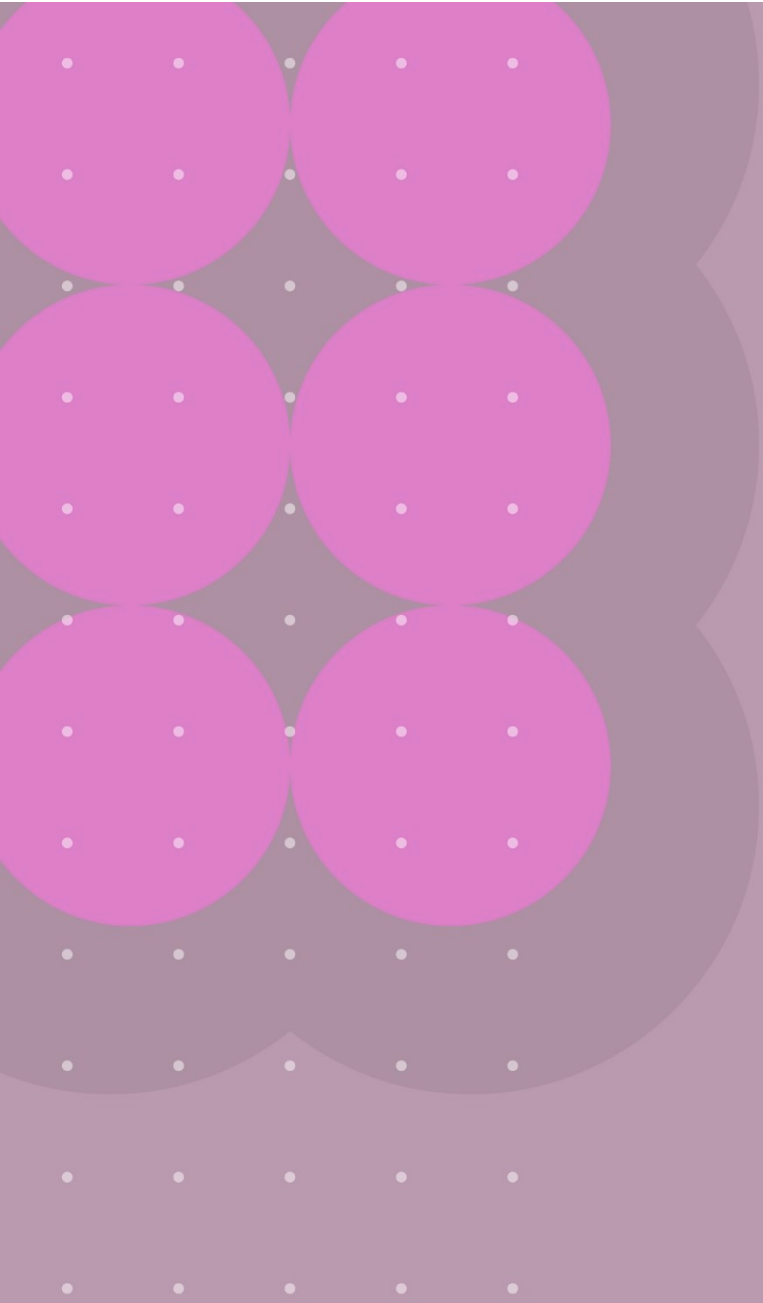
*Note: We assume that batteries bid with reference to a 'price received' based on the average of the four highest priced hours during the forthcoming day, except for in the 'Battery price received sensitivity' where we assume that batteries bid with reference to a 'price received' based on the average price over the forthcoming week.*

*Source: FTI analysis.*

## A11. Glossary

Defined term	Definition
BE	Belgium
BM	Balancing Mechanism
CACM	Capacity Allocation and Congestion Management
CAES	Compressed Air Energy Storage
CCGT	Combined Cycle Gas Turbine
DA	Day-ahead
DE	Germany
DESNZ	Department for Energy Security & Net Zero
EIDAC	EirGrid Interconnector DAC
EMN	Electricity Margin Notice
ENTSOE	European Network of Transmission System Operators for Electricity
EWIC	East West Interconnector
Extended Trades market	Integrating generation assets into the bespoke platform currently used for IC trading only
FR	France
FTI	FTI Consulting
GB	Great Britain
GSP	Grid Supply Point
HRDR	High Risk of Demand Reduction
HT	Holistic Transition
ICs	Interconnectors
ID	Intraday
IEM	Internal Energy Market
ITL	Intraday Trading/Transfer Limit
LAES	Liquid Air Energy Storage
NESO	National Energy System Operator
NL	Netherlands
NSL	North Sea Link
NTC	Net Transfer Capacity
NTC Commercial Arrangements methodology	NESO's methodology for determining how ICs are compensated for being subject to an NTC restriction, dated September 2023.
NTC market	Allocating NTC restrictions via a market-based mechanism

Defined term	Definition
Redispatch	Electricity market participants changing their intended output (or consumption), as determined through the wholesale electricity market, in line with NESO's instructions
REMA	Review of electricity market arrangements
RoCoF	Rate of change of frequency
SO	System Operator
SQSS	Security and Quality of Supply Standard
V2G	Vehicle to Grid



National Energy System Operator  
Faraday House  
Warwick Technology Park  
Gallows Hill  
Warwick  
CV34 6DA  
[www.neso.energy](http://www.neso.energy)