EXPLORING OPTIONS FOR CONSTRAINT MANAGEMENT IN THE GB ELECTRICITY SYSTEM:

THE POTENTIAL FOR CONSTRAINT MANAGEMENT MARKETS

Executive Summary

A report for Scottish Renewables

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TEL
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Front cover image courtesy of Scottish and Southern Energy Networks

Executive summary

Background

Constraints happen when the electricity network is unable to safely and securely facilitate the outcome of the electricity market. This is particularly important where constraints lead to the curtailment of wind and solar generation and the need to replace that generation with alternatives, often fossil fuel generation, elsewhere in the country.

Constraints add costs to consumer bills and there is uncertainty over future constraints, both their volume and the cost of resolving them, which creates risk for future consumers. Constraint costs are expected to rise over the coming decade, although there is significant uncertainty over the scale of that increase.

Future constraint costs will be affected by the speed at which we deliver renewables, develop batteries, pumped storage, hydrogen electrolysis and other forms of flexibility, and the delivery or delay of new transmission capacity.

Even in a well optimised system, constraint costs will be higher in the future. Reducing the volume of constraints ultimately involves investment in network capacity or flexibility. As the fraction of renewables in our system grows, the level of economically efficient constraints – where the cost of constraints is balanced against the cost of investment to reduce them – is also likely to grow.

In the financial year 2022-23, constraint costs were £1.5 bn, under current arrangements these costs are socialised across demand which equates to around £5.70 / MWh consumed. That adds about £15 / year to a typical domestic consumer's bill[1].

Figure ES1 shows the range of forecasts of constraint costs presented recently by National Grid Electricity System Operator (NGESO) alongside recent historical outturn. It shows that there is the potential for constraint costs to grow further during the late 2020s, potentially reaching as high as £3 bn before dropping back as new transmission capacity is commissioned in the early 2030s.

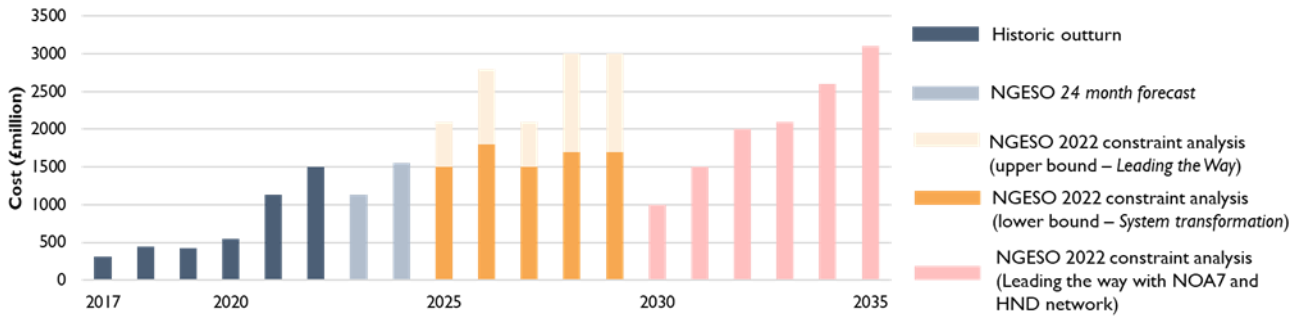

Figure ES1: Constraint costs in GB covering recent historical outturn and available forecasts out to 2035.

Today constraints are largely managed by two mechanisms:

- Firstly, on planning timescales, constraints are reduced through investment in new transmission capacity, with decisions made on timescales of a decade or more.
- Secondly, on operational timescales, constraints are resolved through the use of the Balancing Mechanism (BM) to adjust the electricity market outturn on timescales of an hour or less.

[1] Historic constraint costs available here. https://www.nationalgrideso.com/data-portal/constraint-breakdown. Calculation assumes a typical domestic consumption value of 2,700 kWh / year: https://www.ofgem.gov.uk/information-consumers/energy-advice-households/average-gas-and-electricity-use-explained

Transmission planning has, for the past decade, been carried out through NGESO's annual process: producing credible future market led scenarios in the *The Future Energy Scenarios* (FES), identifying transmission system needs for each scenario in *The Electricity Ten Year Statement* (ETYS), and a cost-benefit analysis of specific transmission investments in *The Network Options Assessment* (NOA). The NOA balances the cost of a particular project against the benefits it is expected to create, the most important of which is the reduction in constraint costs it will facilitate. Those transmission investment decisions have explicitly considered the uncertainty around future constraints through the use of all four of the FES scenarios and a 'least-worst-regrets' approach.

On operational timescales, the majority of constraints are resolved following 'gate closure', one hour ahead of delivery, using the BM. This tends to involve instructing wind and solar power stations to reduce their output behind a constraint, and instructing flexible units in front of a constraint to increase their output.

Over the past few years NGESO has been increasingly using some actions ahead of gate closure. This includes electricity market trading, countertrading over interconnectors, and the use of non-market regulatory frameworks for limiting interconnector flows. However, this remains an ad-hoc approach without a well defined and socialised strategy.

In the intervening period between transmission planning decisions and gate closure there are no formal mechanisms to allow NGESO to react to changes in forecast constraints.

This report recommends that a portfolio approach to constraint management should be explored with tools available to NGESO over all relevant timescales. Transmission planning and the BM would become the bookends to the portfolio. Within those bookends, both long-term and short-term constraint tools should be developed including constraint management markets, competitive tendering, and regulatory approaches.

One design criteria for a constraint management portfolio is that it should be capable of evolved over time. Straightforward reforms can be implemented quickly whilst more complex reforms should built on those initial interventions later.

A it transitions into the Future System Operator (FSO) NGESO needs a clear articulation of the objective of constraint management that goes beyond a high level statement to minimise constraint costs.

This report recommends that the objective of a constraint management portfolio should be to maximise consumer value, including a balance between minimising expected costs under specific scenarios and explicitly managing the risk associated with future uncertainty.

There are a number of pathfinders and exploratory projects which could form the basis of new tools to integrate into a constraint management portfolio. One example is a local constraint management market that has been operating in Scotland since April 2023, procuring day-ahead and intra-day constraint management.

The potential for constraint management markets

This report discusses a number of competitive mechanisms that can be used as part of a constraint management portfolio. These mechanisms are collectively referred to as Constraint Management Markets (CMMs) and are contrasted with non-market regulatory approaches. CMMs can include tendering for long-term contracts and short-term 'spot market' auctions.

The report uses the following working definition for a CMM:

> Any market-based approach operating ahead of gate closure through which the FSO can buy or sell flexibility, or related products such as 'availability' or 'options' in order to relieve constraints on the transmission network. This includes both downward flexibility behind a constraint and upward flexibility in front of a constraint. They can include options for contracting for constraint management over several months or years (long-term CMMs) or running auctions for constraint management days, hours or minutes ahead of delivery (short-term CMMs).

In addition to the definition there are several characteristics that are likely to be present in any CMM design:

- A central buyer market with the FSO defining the quantity and characteristics required.
- Non-mandatory participation by market participants, following the approach used with ancillary service products.
- Open to a wide range of potential providers and not unduly restricted by size and type of provider (e.g. it should not require being a BM participant).

CMMs can provide options to manage both turn down costs incurred in reducing generation or increasing demand behind a constraint, and turn up costs incurred in increasing generation or decreasing demand in front of a constraint. Today, turn up costs paid to schedulable generators represent the vast majority of constraint costs, and increases in turn up costs on a £/MWh basis are the main reason for the increase in constraint costs over the past few years (see box ES1).

Box ES1: Rising constraint costs - volumes and prices in front and behind a constraint

Constraints lead to curtailment of cheap generation, particularly wind and solar, behind an export constraint and more expensive generation, often from fossil fuel power stations, being used to replace the curtailed output.

There are costs associated with turning down renewables which are largely related to lost support mechanism payments. These are called turn down costs. There are also costs associated with turning up the replacement generation. These are called turn up costs.

Total constraint costs have risen significantly over the past few years. This has been driven almost exclusively by increases in turn up prices. Constraint volumes have stayed largely constant and the cost per MWh of curtailing renewables has also remained steady. However, typical turn up costs have increased several times. Overall, the average cost of relieving constraints has risen from £109 / MWh in 2018-19 to £366 / MWh in 2022-23 with almost all that cost increase relating to turn up costs[2].

As gas prices fall from the peak of 2022, unit costs and total costs are expected to fall again in the short term. In the slightly longer term, volumes are expected to rise, leading to a further increase in overall constraint costs.

Figure ES2: The components of constraint costs in recent years. Volume on the left, average cost per MWh of constraint in the middle, and total costs on the right.

[2] https://www.nationalgrideso.com/data-portal/constraint-breakdown

Long-term constraint management markets

There is the potential to develop long-term CMM contracting, using competitive auctions or similar market-based approaches. Such contracts could be offered from a decade or more ahead down to a month ahead and could be used in situations where significant constraint volumes and costs are forecast. They would be particularly useful where, following uncertainty analysis, even the lower bound estimates of constraint costs are significant.

Such contracts could be structured to allow the FSO to procure availability based on a specified number of hours of service provision in a particular year. Close to real time, for example day ahead, the FSO would nominate the specific hours in which availability is required. Finally utilisation costs are only incurred if providers are ultimately dispatched within those availability windows.

This approach allows the FSO to lock in the costs for specific volumes, durations, and depths of constraint management at the time of contracting, whilst only committing to the availability component of the cost up front and if needed.

Short-term constraint management markets

Day-ahead and intra-day CMMs are also likely to be valuable. They would allow the FSO to contract with flexibility ahead of gate closure once there is a degree of certainty over the need for constraint management during particular settlement periods.

There are a number of models which could be used for short-term CMMs. One would involve procuring firm-response day-ahead or intraday, putting an obligation on a provider as soon as the contract is awarded. This would suit providers who need to schedule their activity with several hours notice or those that would be unable to make adjustments to their dispatch on timescales of less than an hour.

A second option is for the FSO to procure availability day-ahead (or intraday) with dispatch at or after gate closure. This would align with the structure of other ancillary services, such as the dynamic frequency response suite and the new balancing reserve service. It would also allow the FSO flexibility in the actions available to it as certainty in the scale and timing of constraints grows between day-ahead stage and delivery.

It is likely that both forms of short-term CMM – firm-response and availability / utilisation – would be of value in enabling the FSO to access provision from a wide range of potential providers, whilst balancing uncertainty, risk and cost.

Areas where greater understanding is needed

Three key challenges need better understanding in order to develop a constraint management portfolio: constraint forecasting; interactions between CMMs and other parts of the electricity market including the BM and wholesale market; and the integration of interconnectors into a constraint management portfolio.

Forecasting constraints

Constraint forecasting is challenging. For example, on planning timescales, in March 2019 NGESO forecasts the constraint element of Balancing System Use of System Charges for the year 2021/22 at £542million whilst the outturn cost was £1,071million[3]. On operational timescales, forecasting constraints during specific settlement periods means bringing together forecasts of wind and solar resources, other weather factors such as the impact of temperature on demand, network availability, interconnector flows, likely dispatch of schedulable generators and the impact of other system operability factors such as the need for voltage support and inertia.

Understanding our ability to forecast constraints and the uncertainty inherent in those forecasts, is central to efficient planning and operation of the power system.

Forecasting of annual volumes and costs with look ahead times of at least a decade is one of the main inputs to the NOA cost-benefit analysis. And forecasting of the volume and cost during specific settlement periods is used today to inform NGESO's existing energy trading and interconnector actions at day-ahead and intraday stage.

However, the process for conducting constraint forecasts and their accuracy is not well understood across the sector. This report recommends that NGESO should publish more information on constraint forecasts, including the volumes and costs used in each year of its NOA calculations (or, in future, similar calculations that will be carried out through the Centralised Strategic Network Plan (CSNP) process).

On operational timescales, there are concerns that publishing constraint forecasts will allow market participants to game opportunities across NGESO trading, wholesale market activities and the BM. However, without more information in the public domain, there is unlikely to be significant progress in improving forecasts or developing consensus across the sector on the most appropriate way to manage constraints.

The design of short-term markets should clearly take account of the level of confidence around constraint forecasts. For example, where there is significant uncertainty around constraint volumes at day-ahead stage, procurement of availability is likely to be a more appropriate method of managing consumer costs and risk than procurement of firm-response.

Market interactions

Interactions between wholesale markets, the BM and CMMs have the potential, if not identified and well managed, to lead to poor outcomes for consumers. The form of these interactions can range from legitimate trading strategies, through 'gaming', to leveraging of market power and illegal market manipulation.

We already see the opportunity for interaction between the wholesale market and BM, and we have developed regulatory tools to mitigate these issues to some degree. For example, the Constraint Management Licence Condition placed on generators provides a route to fine generators who are found to be unduly profiting from a transmission constraint.

We need to learn from this experience and CMM designs need to respond to the potential for each of these forms of interaction.

It is also important to remember that there is no perfect market design for managing constraints and that a 'good' market design will involve balancing the upsides and downsides of different options. Ultimately

[3] Note that these forecasts include a significantly wider range of actions within the definition of constraints than the values quoted in Figure ES1 above which only focus on thermal constraints. Forecast for 2020/21 made in March 2019: https://www.nationalgrideso.com/document/141946/download Outrun for 2020/21: https://www.nationalgrideso.com/document/284216/download

the solution chosen should be one that maximises value. That may mean accepting the potential for some negative interactions between CMMs and other components of the market design if the result is the ability to delivery significant reduction in overall constraint costs.

The preliminary explorations carried out in this report suggest that versions of constraint management markets which procure availability / utilisation rather than firm response are most promising for avoiding negative interactions between markets. It also suggests that markets designed around the explicit encouragement of stacking revenues between CMMs and wholesale markets could avoid some of the pitfalls that previous studies into gaming have identified. And that the use of long-term contracts which fix prices well in advance of delivery provide an additional step to decouple bidding strategies across markets.

This report has not had the scope to investigate market interactions in significant depth, rather these conclusions are presented in order to stimulate further analytical work focused on providing a clearer picture of the value and trade offs associated with using constraint management markets.

Interconnectors

Interconnectors represent a unique challenge. Due to GB's position outside the EU Internal Energy Market, there are a variety of trading arrangements across existing interconnectors including different gate closure times for capacity trading, varying combinations of day-ahead and intraday trading, and a division between interconnectors that are explicitly traded and those that are implicitly traded.

There are clear opportunities to integrate at least some of today's interconnectors into CMMs, this is most obvious for explicitly traded interconnectors with both day-ahead and intraday explicit auctions. At present this would mean the interconnectors between GB and France, Belgium and the Netherlands might be relatively easily integrated into CMMs.

Understanding the market operation of interconnectors, and the options available for developing new trading arrangements including CMMs is a highly specialist area where even many of those with significant GB electricity market experience struggle.

There would be value in the UK Government convening an expert-led working group to carry out a deep dive into the impact of interconnectors on future constraints. This group could be tasked with developing the 'best possible' set of future interconnector arrangements from a GB market perspective, that would support constraint management alongside of a bilateral national wholesale market. This is an important part of an evolutionary approach to market reform and we need a much clearer picture of what is possible.

This group should also consider how such a set of arrangements would align with plans, laid out in the Trade and Cooperation agreement between the UK and the EU, to return to a form of implicit trading known as Multi-Region Loose Volume Coupling.

Recommendations

1 **Forecast and publish estimated annual constraint volumes and costs for future years across a range of scenarios:** estimates made by NGESO of constraint volumes and costs, such as those produced as part of the existing Network Options Assessment, should be published for a range of future scenarios and for timescales out to 2050. This would allow the sector as a whole to develop a clearer understanding and more informed debate about the challenge of managing constraints. Work should also be undertaken to quantify, where possible, the uncertainty in future constraints to ensure an understanding of risk to consumers.

2 **Carry out analysis to understand constraint forecasting on operational timescales:** detailed analysis should be conducted into the accuracy with which constraint volumes and costs can be forecast for specific days, and settlement periods over look-ahead times of weeks, days and hours ahead. This analysis should consider the degree to which different factors drive uncertainty including forecasts of weather, demand, interconnector operation, and the operation of dispatchable power stations.

3 **Develop a constraint management portfolio:** this would form a core component of a market reform option based around evolving the current national bilaterally traded wholesale market. A constraint management portfolio should have a clear objective and overall architecture agreed up front, but it should be capable of being developed in agile and flexible way, for example formalising and integrating existing trading strategies and pathfinder projects first, before adding more complex aspects later.

An example of a fully developed portfolio is shown in Figure ES3.

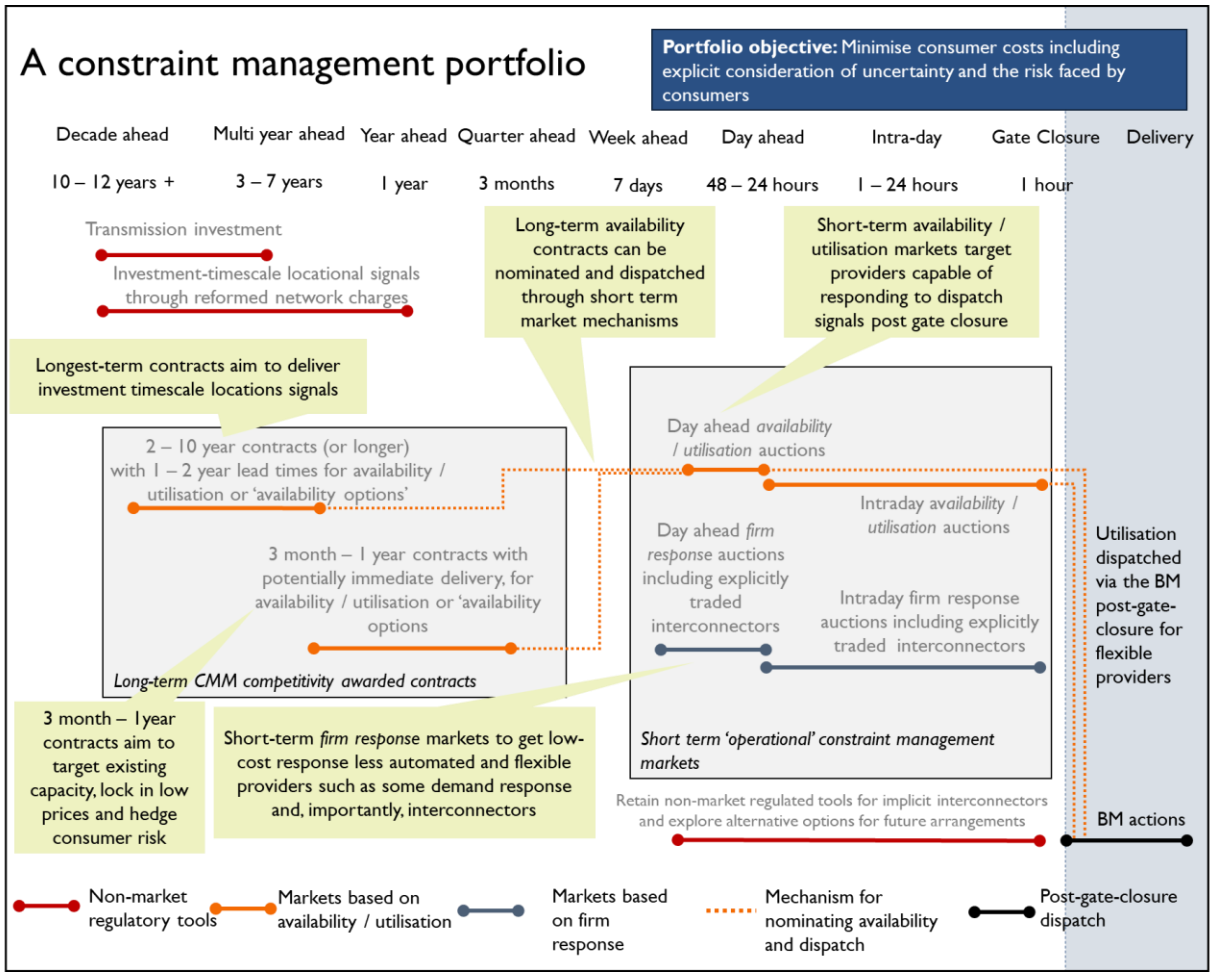

Figure ES3: An illustration of a constraint management portfolio which has the potential to effectively manage constraints, including uncertainty, through a mix of tools applied at different timescales from year ahead to post-gate closure.

4 **Define a clear constraint management objective:** A constraint management portfolio should have a clearly stated objective that is used across all timescales and tools. The objective should be based on maximising value and is likely to include a balance between minimising forecast consumer costs and managing consumer risk.

5 **Types of constraint management actions:** Within the portfolio, include options for both downward constraint management actions behind an export constraint, and upward constraint management actions in front of a constraint.

6 **Timeframes:** Structure the portfolio to include both long-term (e.g. 3 months to 12 years or longer) and short-term (day ahead and intraday) CMMs. There should be the potential for long term CMMs to contract flexibility for any timescale after the option for network investment has passed or for the lifetime of the asset.

7 **Long-term CMMs with competitively awarded contracts:** Explore the value of long-term contracts for availability to provide constraint management actions, awarded through competitive tender or auctions. These contracts could provide investment signals for new investment in flexibility or strategically situated demand. They can support delivery of good outcomes for consumers by acting as 'options' which lock in volumes and prices providing hedges against uncertainty.

8 **Short-term day-ahead and intraday CMMs:** Develop options for a set of short-term constraint management markets which, collectively, are accessible to the full range of potential providers: BM participants, individual domestic and business consumers potentially through aggregators, EV and heat pump fleet operators, non-BM embedded generation and flexibility, and interconnectors.

9 **Markets for availability / utilisation and markets for firm response:** Short-term constraint management market designs should prioritise, where possible, allowing the FSO to procure availability at day-ahead and intraday stage, with utilisation costs incurred closer to real time. However, complementary services, including purchase of 'firm response' ahead of gate closure may be required to allow some providers to offer constraint management who would not be in a position to participate in an availability / utilisation market design.

10 **Integrating explicitly traded interconnectors:** Develop specific options to integrate explicitly traded interconnectors into the short-term CMM designs developed in recommendations 7 and 8.

11 **Interconnector expert group:** Bring together a group of experts in interconnector trading with a mandate to develop the 'best possible' set of arrangements to allow interconnectors to participate in CMMs. This group should take account of the practicalities of trading arrangements including auction timing, explicit vs implicit trading, the impact on the connected markets, the direction of travel laid out in the EU target model and the EU-UK Trade and Cooperation Agreement, along with the pros and cons of diverging from that model in GB.

12 **Understanding market interactions:** Commission work to explore and understand the risks associated with interactions between constraint management markets, the wholesale energy market and the BM. This work should carry out analysis to compare any disbenefits that negative interactions such as gaming might create against the overall benefits that CMMs could deliver.