The need for new network infrastructure

Addressing constraint management to facilitate the future electricity system

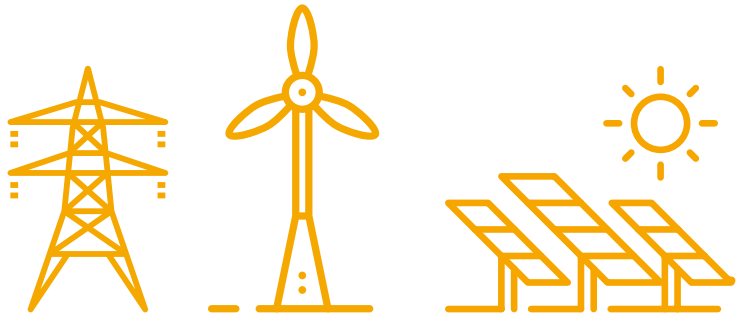
March 2020

The constraint management pathfinder project published by National Grid Electricity System Operator (ESO) highlights an energy industry elephant in the room - unless innovative solutions are identified and brought forward, the current network infrastructure cannot support the expected increase in renewable generation capacity in GB, and significant amounts of this power will be curtailed.

The pathfinder aims to take the first steps towards addressing this issue. Traditionally, long term network constraint issues have been solved through building of new transmission infrastructure. However, this pathfinder aims to introduce a new tendered service that will increase the power transfer capacity of the existing transmission network, without building any major infrastructure.

Growth in renewable generation is critical to decarbonising the power sector as well as the wider economy. However, the nature of renewable technologies means that power generation is highly weather dependant and so installations tends to be built in similar locations, leading to significant challenges in managing the network. In LCP's last piece of analysis on The Need for Flexibility we estimated that as much as 30GW renewable energy would need to be turned down in some periods by 2030 due to energy imbalances alone (where renewable generation produces more power than demand). When combined with system constraints the ability to utilise renewable power could be massively undermined, leading to reduced renewable output, higher CO_2 emissions and increased costs for consumers through balancing costs.

In this analysis, LCP looks at what the future challenges are for network constraints, how further renewable deployment will drive the need for more network development, and where innovative solutions can be used to address system constraints.



What is a balanced system?

In GB, National Grid ESO maintains the electricity system at 50Hz which requires demand and generation to be balanced at all times. Any imbalance will either cause frequency to increase or drop - potentially causing generators and users to disconnect to protect electrical equipment.

There are two reasons why National Grid ESO has to take actions to balance the system:

Energy – The first one is for energy imbalances. Here, supply and demand aren't equal, meaning that National Grid ESO has had to buy or sell power on behalf of the generator or supplier through the Balancing Market.

System – The second, and the focus of this analysis, is for system reasons i.e. the network cannot safely transport the amount of power trying to flow through the cables. This means National Grid ESO have to turn power stations on or off in different locations to address this issue.

The reason this process is expensive is because when National Grid ESO turns a generator down on one side of a network constraint boundary it has to turn another generator up on the other side of the constraint to keep the system in balance. The generator being turned off gets compensated because it can no longer sell the power it promised to the market and the generator on the other side of the constraint boundary gets paid to produce power. This is particularly costly when the generator being turned down/off receives subsidies as National Grid ESO must compensate the generator for its lost subsidy revenue.

In 2018/19, the cost of managing bulk power flow (or "thermal") constraints on the transmission system was approximately £450m. This figure is predicted to rise significantly in the early 2020s prior to new major transmission circuits being completed at the end of the decade. This means that to effectively utilise new generation being brought on to the system, either more network capacity will need to be built or innovative solutions to use or store this power will need to be brought forward.

Analysis of constraint management between 2023 - 2030

We analysed the 2023 – 2030 period, which spans the period from the start of the constraint management service being procured by National Grid ESO until the end of the Network Options Assessment (NOA) period. The primary focus of the analysis was on the B6 boundary (export from Scotland to England) due to this boundary being the focus of the constraints pathfinder. Boundary capabilities were estimated using the recommended NOA 2020 optimal transmission to build paths and the (Electricity Ten Year Statement) ETYS 2019 required transfers.

Cost of managing thermal constraints and % of time constrained over the B6 boundary

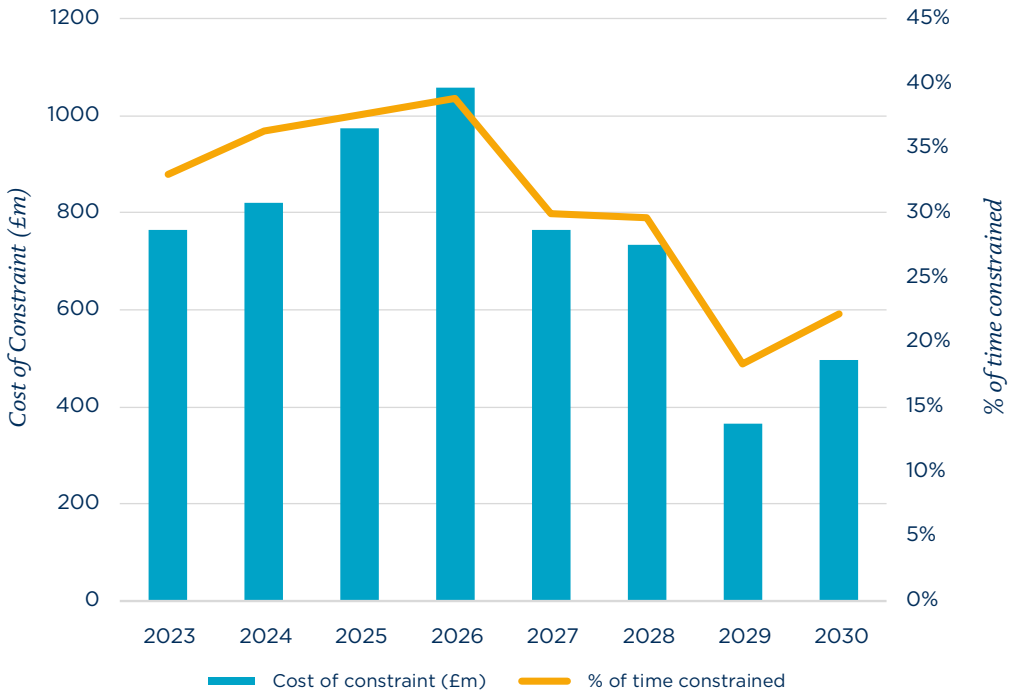
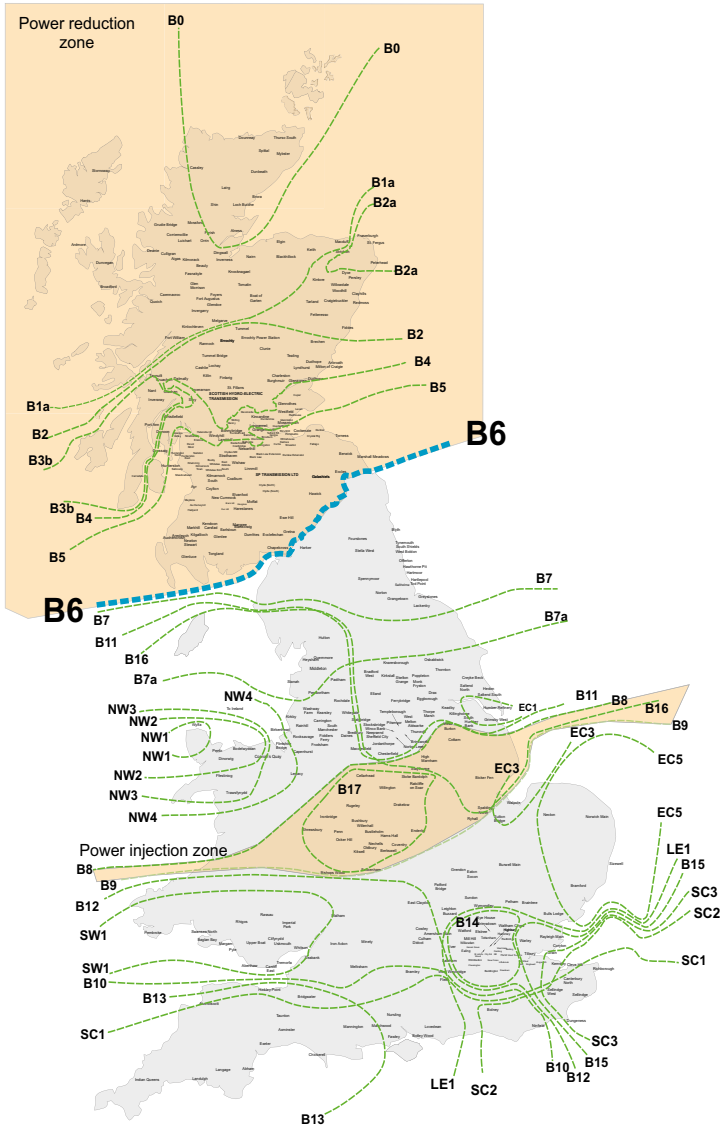


Figure 1: LCP's forecast of thermal export constraint costs on the B6 (Scotland/England) boundary and the percentage of each year in which constraints occur along this boundary.

Constraint Management Pathfinder Transmission System Boundries of Focus



National Grid constraint management pathfinder map

We estimate that by 2026 National Grid will be spending £1bn on resolving Scottish export constraints.

All constraint volumes and costs calculated in this analysis use National Grid ESO's "best case" scenario for the build of new transmission infrastructure. In reality the case is likely to be worsened due to delays in the build of major transmission links between England and Scotland.

Figure 1 shows LCP's constraint forecasts across just the B6 boundary between 2023 and 2030. **Currently the ESO is spending about £450m a year on constraints across all of GB but LCP forecast that by 2025 the ESO will be spending almost £1bn a year across just the B6 transmission boundary.**
As shown, 40% of the time, the power transfer limit of this boundary will be exceeded. **In other words, 40% of the time renewable generation will have to be constrained off and almost certainly replaced with carbon emitting generation sources south of this boundary.** This not only incurs balancing costs but increases the carbon footprint of the energy sector significantly. The rapid deployment of renewables has not been matched by the required build-out of new GB electricity transmission assets to get the renewable energy to end users.

We see significant drops in the cost of managing thermal constraints in 2027 and 2029 this is due to major transmission builds being completed. These are E2DC (a 2GW HVDC cable from Torness to Hawthorne Pit) and E4D3 (a 2GW HVDC cable from Peterhead to Drax). Originally this transmission infrastructure was estimated for delivery in 2023 but despite the ESO recommending the construction of these links, the Transmission Operators (TO's) were not able to proceed with any preliminary work due to Ofgem not guaranteeing funding through the network price controls.

Impact on CO_2 emissions

Until the completion of E4D3 in 2029, Scottish constraints will produce at least an additional 3 million tonnes (Mt) of CO_2 a year, mainly through turning gas plant up/on south of the border to compensate for the turned down/off wind in Scotland. This is the equivalent of having an additional 670,000 cars on the road. Most estimates for carbon emissions from electricity production in the future fail to take constraints into consideration. If these are not taken into consideration we could significantly underestimate emissions and fall short of our emissions targets. For example, under National Grid's 2019 "Two Degrees" future energy scenario, CO_2 emissions from the power sector are projected to total 8.7Mt 2028. **An additional 3Mt due to the B6 network constraint would represent a 34% increase in power sector emissions.**

Tonnes of CO_2 due to constraints (Millions)

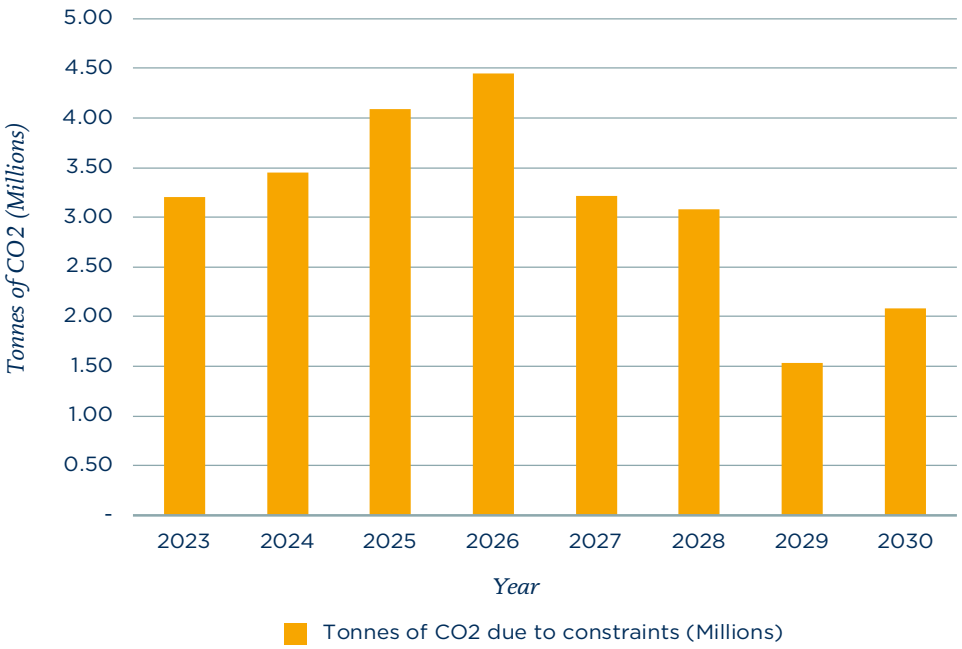


Figure 2: Additional tonnes of CO_2 emissions from Scottish constraints due to the increase in CCGT production required to balance constrained wind generation.

Insufficient network capacity results in an additional 3 million tonnes of CO_2 being emitted annually.

What's National Grid ESO's pathfinder trying to do?

National Grid ESO's pathfinder looks to establish a framework to bring forward new solutions to manage constraints, with the focus being on post fault management. This would allow increased power flow on the network with the 200MW capacity cutting off immediately in the event of unbalanced network flows after a system fault. A system fault in this case is typically the loss of a major transmission asset such as an overhead line or transformer which reduces the overall network capacity available to transfer power. This product effectively acts as a safety net for the transmission system. With our analysis forecasting curtailment levels to increase significantly, we expect the ESO will need to contract significantly more capacity in the future.

If the ESO procures the targeted 200MW in the constraints pathfinder, this could save around £40m a year on average for consumers. However, considering the total size of constraint costs is in the £1bn range, this will have a relatively small impact.

It's also feasible that the Balancing Market could be used to address curtailment by contracting demand in specific areas, with flexible contracts (similar to those being used by Distribution Network Owners) also playing a role in managing network reinforcement.

Participants who are successful in obtaining a constraint management contract would benefit from having a fixed revenue stream based on their available capacity of power reduction or demand turn-up. As storage technologies are able to provide both of these services, these contracts could incentivise additional build of storage technologies in the areas targeted by the constraint management pathfinder. This would have the secondary benefit of placing storage closer to renewable energy sources, effectively allowing more renewable energy to be stored and then released onto the system when it is required.

Summary and looking forward

The ESO constraints pathfinder aims to tackle major thermal constraint issues arising from excess generation in Scotland. Since the construction of new transmission infrastructure has not kept up with the build out of renewable capacity, we are due to see a large rise in constraint costs which will be ultimately passed onto consumers. Not only does this increase the overall cost of energy in GB, it also prevents low carbon energy from reaching end users.

While constraints in Scotland are the focus of this study and the ESO pathfinder, they are not the only issues due to arise from insufficient transmission infrastructure. Major problems are due to arise in North-East England and East Anglia due to a rapid build in offshore wind capacity. These areas are attractive for developers due to relatively shallow sea beds and high potential load factors. However, planned transmission build out will not currently keep pace with the increase in generation capacity in these areas. The additional associated costs of curtailment here will significantly increase the cost of the figures displayed in figure 1.

The pathfinder is a step in the right direction in finding new innovative solutions to reduce constraint costs in the future.

Key messages

- More needs to be done to ensure consumers are not charged for renewable subsidies on generation that doesn't contribute towards decarbonising the energy sector.
- The process of agreeing new network infrastructure needs to be more strategic and align to expected build out of the technologies and capacities to meet our Net Zero targets.
- Without considering the impact of constraints, GB is at risk of underestimating future emissions.
- The ESO constraints pathfinder represents a good first step towards reducing constraint issues, however, further innovation will be required to avoid the escalation of these problems in the future.

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