East Anglia ONE North and East Anglia TWO Offshore Windfarms

Applicants' Comments on Suffolk Energy Action Solutions' Deadline 8 Submissions

Applicant: East Anglia TWO and East Anglia ONE North Limited
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Applicable to East Anglia ONE North and East Anglia TWO

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Glossary of Acronyms

AQMA	Air Quality Management Area
CIA	Cumulative Impact Assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
CION	Connection and Infrastructure Options Note
CIWEM	Chartered Institute of Water and Environmental Management
DCO	Development Consent Order
DEFRA	Department for Environment, Food and Rural Affairs
EFT	Emissions Factor Toolkit
ES	Environmental Statement
ESC	East Suffolk Council
GW	Gigawatt
HDD	Horizontal Direction Drill
HGV	Heavy Goods Vehicle
HRA	Habitat Regulations Assessment
IoA	Institute of Acoustics
IEMA	Institute of Environmental Management and Assessment
ISH	Issue Specific Hearing
JNCC	Joint Nature Conservation Committee
NGV	National Grid Ventures
NPPF	National Planning Policy Framework
NO_2	Nitrogen Dioxide
NOx	Nitrous Oxide
NRMM	Non-Road Mobile Machinery
OFGEM	Office of Gas and Electricity Markets
PRoW	Public Right of Way
SCC	Suffolk County Council
SEAS	Suffolk Energy Action Solutions
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
SZC	Sizewell C

Glossary of Terminology

Applicant	East Anglia TWO Limited / East Anglia ONE North Limited
East Anglia ONE North project	The proposed project consisting of up to 67 wind turbines, up to four offshore electrical platforms, up to one construction, operation and maintenance platform, inter-array cables, platform link cables, up to one operational meteorological mast, up to two offshore export cables, fibre optic cables, landfall infrastructure, onshore cables and ducts, onshore substation, and National Grid infrastructure.
East Anglia TWO project	The proposed project consisting of up to 75 wind turbines, up to four offshore electrical platforms, up to one construction, operation and maintenance platform, inter-array cables, platform link cables, up to one operational meteorological mast, up to two offshore export cables, fibre optic cables, landfall infrastructure, onshore cables and ducts, onshore substation, and National Grid infrastructure.
Landfall	The area (from Mean Low Water Springs) where the offshore export cables would make contact with land, and connect to the onshore cables.
National Grid infrastructure	A National Grid substation, cable sealing end compounds, cable sealing end (with circuit breaker) compound, underground cabling and National Grid overhead line realignment works to facilitate connection to the national electricity grid, all of which will be consented as part of the proposed East Anglia TWO / East Anglia ONE North project Development Consent Order but will be National Grid owned assets.
National Grid substation	The substation (including all of the electrical equipment within it) necessary to connect the electricity generated by the proposed East Anglia TWO / East Anglia ONE North project to the national electricity grid which will be owned by National Grid but is being consented as part of the proposed East Anglia TWO / East Anglia ONE North project Development Consent Order.
National Grid substation location	The proposed location of the National Grid substation.
Onshore cable route	This is the construction swathe within the onshore cable corridor which would contain onshore cables as well as temporary ground required for construction which includes cable trenches, haul road and spoil storage areas.
Onshore development area	The area in which the landfall, onshore cable corridor, onshore substation, landscaping and ecological mitigation areas, temporary construction facilities (such as access roads and construction consolidation sites), and the National Grid Infrastructure will be located.
Onshore substation	The East Anglia TWO / East Anglia ONE North substation and all of the electrical equipment within the onshore substation and connecting to the National Grid infrastructure.
Onshore substation location	The proposed location of the onshore substation for the proposed East Anglia TWO / East Anglia ONE North project.

1 Introduction

2. This document provides the comments of East Anglia TWO Limited and East Anglia ONE North Limited (the Applicants) on Written Representations submitted by Suffolk Energy Action Solutions (SEAS) regarding the East Anglia TWO project and the East Anglia ONE North project (the Projects).

3. The Applicants' responses to SEAS' Deadline 8 submissions are provided in ***Section 2*** and cover:

- Oral Presentation to ISH10 Health and Wellbeing by Dr Jane McNeill (REP8-234);
- Comments on the Changing Policy Environment (REP8-235);
- Representation on Roads / Traffic and Tourism (Comments on Applicants' Responses to REP5-113) (REP8-236);
- ISH14 Post Hearing Submissions (REP8-238 to REP8-241);
- Response to the Applicants Comments on Responses to ExA WQ2 (REP8-242);
- Response to the Applicants Comments on Responses to ExA WQ2 (REP8-242);
- SEAS General Report on the DCO Examination Deadline 8 - 25 March 2021 (REP8-243); and
- Air Quality Representation (REP8-244).

4. It should be noted that the Applicants' comments on ***Written Submission for ISH14, Item 1A Negotiations with Affected Persons*** (REP8-237) can be found in ***Applicants Comments on SEAS' Complaint*** (document reference ExA.AS-2.D9.V1).

5. This document is applicable to both the East Anglia TWO and East Anglia ONE North DCO applications, and therefore is endorsed with the yellow and blue icon used to identify materially identical documentation in accordance with the Examining Authority's procedural decisions on document management of 23rd December 2019 (PD-004). Whilst this document has been submitted to both Examinations, if it is read for one project submission there is no need to read it for the other project submission.

2 Applicants' Comments on SEAS' Deadline 8 Submissions

2.1 Oral Presentation to ISH10 Health and Wellbeing by Dr Jane McNeill (REP8-234)

6. The Applicants have no further comments in relation to anxiety and note Dr McNeill's expertise, but would like to highlight a few points made in relation to the Projects during Issue Specific Hearing (ISH) 10 and subsequent submissions.

7. As discussed during Agenda Item 2 of ISH10, the policies under which the Projects are considered are those within National Policy Statements that are relevant to such Nationally Significant Infrastructure Projects (namely EN-1, EN-3 and EN-5). The National Planning Policy Framework (NPPF) is therefore not the primary policy driver; paragraph 5 of the NPPF states that *"The Framework does not contain specific policies for nationally significant infrastructure projects"*. Nonetheless, the Applicants consider that the NPPF can provide useful additional context.

8. REP8-099 states *"This policy framework requires those making planning decisions to engage with local communities with their concerns over their health and wellbeing as a result of the disruption and nuisance the proposed works would cause"*. The Applicants would highlight the pre-application community consultation process, and indeed the engagement fostered by the Examinations themselves to demonstrate how these issues have been taken into account. In addition, the consultation undertaken with the Councils (who represent the affected communities) should also be seen as part of the wider effort to deliver the Projects in a way which reduces disruption to a minimum. The fact that the communities' Council representatives (through their technical experts in the different disciplines such as highways, ecology and air quality) have discussed and agreed assessment approaches and mitigation and management should provide reassurance that issues have been dealt with thoroughly.

9. REP8-099 states that *"Open space, outdoor recreation and public rights of way are all considered of utmost importance in planning decisions. In particular, because these amenities provide such an imperative benefit to their users"*. The Applicants highlight that there has been a lengthy consideration of effects on recreation and open space. No common or open land is affected by the Projects. The onshore substations and National Grid substation are located on farmland and not greenspace per se (based upon Public Health England

definitions[1]). The Public Rights of Way (PRoW) network has been considered throughout the process, with some PRoW avoided completely (e.g. the Suffolk Coast Path) whilst others will be subject to management measures only during active construction and the network maintained (management measures are covered in the ***Outline Public Rights of Way Strategy*** (REP3-024). The only PRoW lost will be at the onshore substation and National Grid substation locations and this will be rerouted so that there is a new route in its place.

2.2 Comments on the Changing Policy Environment (REP8-235)

10. SEAS has been consistent in their opposition to the Applications. A key part of its argument was initially that the Applications should be delayed and the new 'split decision' argument is a refinement of that argument. It is claimed that delay could allow different grid connection options to be identified.

11. There is no policy for support for this position. The Energy White Paper acknowledges that the enduring regime will not be in place until 2030 and National Grid ESO and others have identified that it will be reliant on technology advances and a complete re–write of the legal and regulatory framework. This will require legislation and significant consultation. The Office of Gas and Electricity Markets (OFGEM) has appeared at the Examination and given their opinion on the likely timescales.

12. This all demonstrates the futility of the split decision. It achieves nothing. It would not stimulate the supply chain, the Projects could not bid into auction rounds and there is no feasible grid alternative that is likely to emerge within the lifetime of the consents.

13. The Energy White Paper (HM Government, 2020) policy is to deliver 40 gigawatts (GW) of offshore wind, not consent it. The key passages of the Energy White Paper cannot be ignored. The need and the urgency could not be more clearly stated (pages 38 and 45). There has been an intensification of the need for the delivery of large volumes of offshore wind capacity. Effectively what SEAS are looking for is an embargo on new development until the delivery of a future ring main. This runs counter the Government's energy policy.

14. Further documents have been published. In January 2021 National Grid ESO published an updated Network Options Assessment. A copy is attached as ***Appendix 1*** to this response. This has looked at possible offshore

[1] Any area of vegetated land, urban or rural. This includes both public and private spaces such as parks, gardens, playing fields, children's play areas, woods and other natural areas, grassed areas, cemeteries and allotments, green corridors, disused railway lines, rivers and canals, derelict, vacant and contaminated land which has the potential to be transformed. Public Health England (2020) Improving access to greenspace A new review for 2020 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/904439/Improving_access_to_greenspace_2020_review.pdf

reinforcement options which could be delivered towards the end of the decade (see pages 63 to 70). This included a link to East Anglia. This option evaluation confirmed that this link would not be viable.

15. In addition, in March 2021 the Onshore Transmission Network Review project issued an update (***Appendix 2*** to this response). This confirms on page 3 that the existing industry arrangements are continuing to apply and that there are ongoing workstreams looking at pathfinder opportunities. It is clear that the 'new approach" is aimed at less advanced projects and references Round 4 (currently undergoing Habitat Regulations Assessment (HRA)) and Scotwind which is due have bids submitted later in 2021. These are projects which are likely to be delivered towards the end of the decade.

16. The updated information supports the evidence that has been submitted by the Applicants on this topic. The information is also consistent with the previous evidence provided by OFGEM (***Response to ExA's Further Written Questions 16 December 2020*** (REP4-096)) and National Grid ESO.

2.3 Representation on Roads / Traffic and Tourism (Comments on Applicants' Responses to REP5-113) (REP8-236)

17. In general, the Applicants have no further comments and maintain the positions set out in the various written and oral submissions made throughout the Examinations.

18. The Applicants would reiterate their comments at ID3 of ***Section 2.4*** (REP6–032) that traffic data captured during the global pandemic are not representative of 'normal' travel patterns and behaviours, with notable changes in travel by sector, mode and the quantum of trips. Any conclusions drawn from such data should therefore be viewed with extreme caution and cannot be relied upon to assess 'typical' traffic conditions.

19. The assessments contained in ***Chapter 26 Traffic and Transport*** (APP-074) and ***Appendix 26.2*** of the Environmental Statement (ES) (APP-528), and the subsequent modelling of Friday Street junction (***Deadline 4 Traffic and Transport Clarification Note*** (REP4-027)) have been undertaken in accordance with current Department for Transport (DfT) Transport Assessment Guidance, which directs that assessments should be based on normal conditions.

20. Annual Average Daily Traffic (AADT) is the metric utilised throughout the UK to manage the highway network for normal operating conditions. Both the relevant Highway Authorities (Suffolk County Council (SCC) and Highways England) have been engaged throughout the assessment process and their respective Statement of Common Ground with the Applicants (REP8-114) confirms the

agreement that *"The ES adequately characterises the baseline environment in terms of traffic and transport"*.

21. ***Chapter 26 Traffic and Transport*** of the ES (APP-074), ***Table 26.12*** confirms that the Applicants' traffic data for the A1094 (and other routes) shows a good correlation with traffic counts undertaken for Sizewell C (SZC) and by SCC and therefore has been independently validated.

22. The assessments undertaken adopt the DfT system to classify vehicles by type. The DfT system is a nationally prescribed traffic classification system, adopted by traffic count specialist suppliers. This classification system allows for direct comparison and validation of data across multiple data sources and projects as evidenced within ***Table 26.12*** of the ES.

23. The Applicants would also reiterate their comments at ID5 of ***Section 2.4*** (REP6-032). It can be noted that traditional morning and evening peaks are observed during normal conditions, noting that traffic levels remain fairly constant through the working day. The assessment utilises the morning and evening network peaks as this is when (worst case) the Projects' peak traffic demand will distribute onto the network (e.g. workers arriving and departing from site). This gives the highest 'aggregate' peak conditions on the highway network.

24. The assessments contained in ***Chapter 26 Traffic and Transport*** (APP-074) and ***Appendix 26.2*** of the ES (APP-528), and the subsequent modelling of Friday Street junction (***Deadline 4 Traffic and Transport Clarification Note*** (REP4-027)) conclude that there will not be significant residual impacts as a result of the Projects' traffic demand and therefore it is unlikely that traffic (tourist or otherwise) will re-assign.

25. The Applicants note that REP8-236 also includes some statements regarding the potential economic impacts of traffic generation. The loss of jobs referred to in REP5-113 is based upon the DMO Report figures. The Applicants do not consider that the economic conclusions of the DMO Report are valid (for reasons stated in the ***Tourism Impact Review*** (REP1-102)). Therefore, the Applicants do not consider the projected job losses as valid.

26. In addition, the conclusions of the DMO Report relate to the cumulative case with SZC, not the Projects (either alone or together). SEAS should consider the potential job losses and employment associated with the Projects, and then the potential job losses and employment associated with the Projects cumulatively with SZC. They cannot mix and match negative cumulative impacts with positive project alone impacts.

27. The Applicants note that whilst the employment associated with the Projects would have a low (construction) and medium (operation) magnitude of effect,

with limited employment in the area around the onshore infrastructure, SZC would have a workforce of up to 8,000 during construction and a permanent workforce of 1,000 (increasing by approximately 1,000 every 18 months during outages) (SZC APP-195).

28. Regarding SEAS' claim that the Projects will have significant and long-lasting effect on the communities served by the A1094, by definition, the construction phase and the associated supply chain are time limited and cannot have long-lasting effects. During operation the Projects' vehicle movements would be limited to maintenance activities.

2.4 ISH14 Post Hearing Submissions (REP8-238 to REP8-241)

29. In general, the Applicants have no further comments in relation to the terrestrial ecology items raised by SEAS. The Applicants maintain the positions set out in the various written and oral submissions made throughout the Examinations but would like to reiterate a number of the points made.

2.4.1 The Sandlings Special Protection Area

30. Regarding the suite of ornithological surveys undertaken for the Applications, methodologies, durations and survey areas were agreed during the Expert Topic Group meetings held in 2017 and 2018. In particular, as noted in ***Appendix 23.1 Onshore Ornithology Consultation Responses*** (APP-508), Natural England is content with the approach taken (15/02/2018). The surveys undertaken and the guidance followed are set out within ***section 23.4.2.1*** of ***Chapter 23 Onshore Ornithology*** (APP-071).

31. The Applicants would note that in ***Appendix C7 to the Natural England Deadline 5 Submission*** (REP5-084) Natural England advises that an Adverse Effect on Integrity is unlikely to occur if an open cut trench technique is used to cross the Sandlings Special Protection Area (SPA). The Applicants have sought to resolve any residual concerns Natural England has through updates to outline documents (particularly the ***Outline SPA Crossing Method Statement*** (REP6-036) and ***Outline Landscape and Ecological Management Strategy*** (document reference 8.7)) and sets this out in ***Applicants' Comments on Natural England's Deadline 8 Submissions*** (document reference ExA.AS-4.D9.V1)

2.4.2 Hundred River Crossing

32. Regarding alternatives to the proposed open trench method for crossing the Hundred River, ***Appendix 4*** of the ***Outline Watercourse Crossing Method Statement*** (REP8-084) includes commentary on the unsuitability of a trenchless technique for the Hundred River crossing. The Applicants consider a micro-tunnel operation to be unfeasible due to the disturbance it would impose to the area such as:

- The delivery of the plant, machinery and piping required for this operation as well as the handling and disposal of the material used and removed from the tunnelling operation would involve considerably higher levels of traffic than for an open trench solution;
- It would require the construction and installation of two deep / large caissons / pits (at entry / exit points) for the machine drilling head to be installed / removed. This would increase the area of woodland impacted by the Projects when compared to the proposed open-trench technique;
- It would require the set-up of a large compound at the entry point to cover all aspects of the works including but not limited to set-up of control rooms / offices, laydown area, water, soil and waste management plant areas, among others. This would increase the area of woodland impacted by the Projects when compared to the proposed open-trench technique; and
- The construction programme (including reinstatement of the affected areas) for this technique will extend significantly from that of the open trench crossing technique.

33. The ***Outline Watercourse Crossing Method Statement*** (REP8-084) considers the potential impacts of the Projects on the Hundred River and the features it supports and includes a number of measures developed to ensure the works do not result in unacceptable adverse impacts. These measures can be summarised as follows:

- Pre-construction surveys for eel, fish, otter and water vole will be undertaken;
- The results of pre-construction surveys will inform specific ecological mitigation measures within the final Ecological Management Plan prepared to discharge Requirement 21 of the ***draft DCO*** (document reference 3.1);
- Where pre-construction surveys identify the presence of fish or eels, provision will be made for the upstream / downstream migration;
- Periods of low flow will be chosen to undertake the crossing works wherever practicable;
- Where there is a risk of sediment run-off, sediment interception techniques would be used;
- Any over-pumping at the Hundred River crossing would be undertaken in a manner that ensures the flow rate downstream of the crossing is the same as upstream;
- Following laying of the ducts or onshore cables, subsoil and topsoil will be replaced, and the riverbank reprofiled and replanted. The specification will be set out in the final Watercourse Crossing Method Statement; and

- The construction footprint of the crossing will be reinstated as soon as practicable following completion of the crossing works.

34. The precise working method for crossing the Hundred River will be agreed through the discharge of DCO Requirement 22(2)(k) post-consent and through an application for a Flood Risk Activity Permit from the Environment Agency prior to commencement of the onshore works.

35. Natural England will also be consulted during the preparation of the final Watercourse Crossing Method Statement. Having verified the results of the 2018 extended Phase 1 habitat survey through the site visit undertaken in February 2021, the Applicants are confident that there is sufficient area within the Order limits to replace woodland on a like-for-like basis to that lost as a result of the Projects.

36. The Applicants would note that the Hundred River is considered as a receptor within ***Chapter 20*** of the ES (APP-068) relating to water resources and flood risk and is referred to throughout ***Chapter 22*** of the ES (APP-070) in relation to its ecological function as a waterbody.

37. The ***Outline Landscape and Ecological Management Strategy*** (document reference 8.7) sets out details of the ecological mitigation areas available within the Order limits, those within which woodland planting will be delivered and those within which further woodland planting may be delivered if a need is identified during pre-construction surveys and in consultation with the relevant planning authority. The potential for downstream impacts on the Sandlings SPA and its qualifying features will be managed through the implementation of the identified mitigation measures to minimise sediment generation from construction activities associated with the crossing of the Hundred River.

38. A HRA was included within ***Appendix 5*** of the ***Outline Watercourse Crossing Method Statement*** (REP6-041) submitted at Deadline 6. This focusses on the potential downstream effects of the Hundred River crossing on the Sandlings SPA and also considers habitats within the Leiston – Aldeburgh Site of Special Scientific Interest (SSSI). The HRA concludes that there are unlikely to be adverse effects on the integrity of the SPA and on the notified features of the SSSI. The Applicants would note that in its Deadline 8 submission (REP8-162), Natural England agrees with the conclusions of the HRA assuming adherence to the measures proposed within REP6-041.

2.4.3 Classification of the Woodland at the Hundred River Crossing and Survey Timings

39. The Applicants would note that their classification of the woodland at the Hundred River is based on the species present rather than moisture levels in

the ground (in line with the Joint Nature Conservation Committee's (JNCC) Handbook for Phase 1 Habitat Survey (2016)). The Applicants maintain that the woodland at the Hundred River crossing is semi-natural broadleaf woodland. This conclusion is supported by the independent site visit undertaken by the Councils, as confirmed verbally at ISH7 and subsequently by East Suffolk Council (ESC) in its written submission at Deadline 6 (REP6-075). ESC states *"we agree with the habitat characterisation of area as set out in the ES. We do not consider that the area within the red line boundary is wet woodland as defined by the JNCC"*.

2.4.4 The Rigour and Timing of Ecological Surveys

40. Regarding the independence of surveyors, the Applicants would note that, across the spectrum of consenting regimes, where specialist surveys or assessments are required these are commissioned by developers. This occurs for numerous reasons, not least of all so developers bear the financial costs, but more importantly to ensure they are cognisant of the environmental sensitivities when progressing their proposals. It is very much within the interests of surveyors to discharge their responsibilities in strict accordance with their industry's best practice guidance and to provide impartial advice to developers, indeed it is essential for the retention of the professional qualifications and memberships that enable them to operate.

41. The approach taken to the EIA presented as part of the Applications falls in line with best practice guidelines such as the EIA Guide to Shaping Quality Development prepared by the Institute of Environmental Management and Assessment (IEMA) (the professional body for environment and sustainability specialists). An ES must be prepared by competent experts; the ES submitted as part of the Applications was prepared by specialists accredited by a range of relevant professional organisations, for example IEMA, the Chartered Institute of Ecology and Environmental Management (CIEEM), Chartered Institute of Water and Environmental Management (CIWEM), the Institute of Acoustics (IOA), and the Chartered Institute of Environmental Health.

42. All ecological surveys in support of the Applications were undertaken by suitably qualified ecologists within the optimal surveying windows. All surveys have been undertaken in accordance with industry guidance (such as but not limited to the Handbook for Phase 1 Habitat Survey (JNCC)). Furthermore, industry accepted species-specific guidance and standards have been used when assessing habitats for their suitability to support legally protected and notable species. In line with the aforementioned JNCC guidance, Target Notes have been used at the discretion of field surveyors to highlight points of ecological interest at the time of the survey. Target Notes are not exhaustive and have therefore only been used where deemed necessary; it is not practical to Target Note every feature within a survey area.

43. Regarding the February 2021 survey of the woodland at the Hundred River crossing, this has been the only ecological survey undertaken since submission of the Applications in October 2019 and had the primary aim of verifying the habitat classification assessment of the area already undertaken in April 2018. Across the ecological profession, it is accepted that Phase 1 habitat surveys can be conducted all year round; however, the Applicants acknowledge that the optimum time to have undertaken the February 2021 survey would have been between April and September. The Applicants would note that the information submitted by SEAS to support its conclusion regarding the woodland (REP5-108) was obtained from a visit undertaken in January 2021. With this in mind, SEAS' assertion that the Applicants' survey did not follow best practice in relation to timing should also apply to its own site visit.

44. SEAS' assertions regarding the timing of surveys and key project decisions are incorrect. An extended Phase 1 habitat survey of the full indicative onshore development area (including the location of the Hundred River crossing) was undertaken in April 2018. The final decision to locate the onshore substations and National Grid infrastructure in 'Zone 7' (as identified in APP-443), thus necessitating the Hundred River crossing, was not made until December 2018. From the outset of the Projects, all decisions regarding proposed infrastructure locations have been informed by primary site survey data gathered by appropriately qualified professional ecologists.

2.5 Response to the Applicants Comments on Responses to ExA WQ2 (REP8-242)

45. In general, the Applicants have no further comments and maintain the positions set out in the various written and oral submissions made throughout the Examinations.

46. The Applicants and National Grid are separate entities. The Applicants determined to include the National Grid infrastructure required for the Projects in the Applications to ensure the deliverability of the Projects as a whole. The National Grid infrastructure is the extent of works required for the Projects only. The Planning Act 2008 is designed to provide an integrated consenting process for Nationally Significant Infrastructure Projects and the approach to the Applications is consistent with this. Including the National Grid Infrastructure required for the Projects has enabled the totality of the development proposed to be properly considered through site selection and design. Regarding connection offers for other projects (those not proposed by the Applicants), these are the responsibility of National Grid Electricity System Operator Limited. The Applicants are not party to this information.

47. The Applicants' position regarding the selection of other proposed developments to consider within cumulative impacts assessments (CIAs)

remains as set out within ***Applicant's Comments on Relevant Representations, Volume 3: Technical Stakeholders*** (AS-036). In summary, the Applicants' approach follows Planning Inspectorate Advice Note 17 and identifies other proposed developments for CIA through the use of a three tier system, as follows:

- Tier 1: Projects under construction, permitted or submitted applications;
- Tier 2: Projects on the Planning Inspectorate's Programme of Projects where a scoping report has been submitted; and
- Tier 3: Projects on the Planning Inspectorate's Programme of Projects where a scoping report has not been submitted; projects identified in the relevant Development Plan (and emerging Development Plans); and projects identified in other plans and programmes (as appropriate) which set out the framework for future development consent.

48. Tier 1 and Tier 2 projects are included in all relevant CIAs within the Applications, while in line with Advice Note 17, Tier 3 projects have generally not been included. This is because the information available on Tier 3 projects at the time of the Applications was of inadequate detail to facilitate any meaningful assessment (e.g. no information on the project design or timescales). Tier 3 projects not considered in the CIAs within the Applications include the following:

- Nautilus Interconnector;
- EuroLink Interconnector;
- Greater Gabbard Offshore Windfarm Extension (now known as North Falls); and
- Galloper Offshore Windfarm Extension (now known as Five Estuaries).

49. ExQs2 2.0.14 of ***The Examining Authorities' written questions and requests for information (ExQs2)*** (PD-030) relates to CIA and the potential for other planned energy generation and transmission projects to connect into the National Grid transmission network at the National Grid substation being proposed as part of the Projects. ExQs2 2.0.14 requests that the Applicants reconsider their position that it is not possible to undertake a CIA considering the Projects with the proposed Nautilus, Eurolink, North Falls and Five Estuaries projects.

50. The Applicants can confirm that there have been no major changes with regard to the status of these projects since the submission of the Applications. All the projects are still to undertake Environmental Impact Assessment (EIA) scoping

and the Applicants consider that the Applications as submitted remain current in terms of having assessed projects for which consent is being sought or granted. In addition, it has now been confirmed by both the proposed North Falls (REP7-066) and Five Estuaries (AS-100) projects that they will not connect to the grid near Leiston.

51. In their response to ExQs2 2.0.14 (REP6-059), the Applicants note that although National Grid Ventures' (NGV) initial site appraisal work for Nautilus considers broad areas of search for siting an onshore converter station in the Leiston area, including in the vicinity of the National Grid substation location, it would not be practical to undertake a CIA of this with the Projects due to the lack of information on the proposals, their effects and any proposed mitigation.

52. However, should NGV determine that the connection points for Nautilus and/or Eurolink should be Grove Wood (location 5 in NGV's 'Initial Site Appraisal' map) it is likely that this would be done by extending the proposed National Grid substation. Potential locations for two extensions are in the public domain and the likely infrastructure within them (electrical gantries) will be similar in nature to the design of the National Grid substation. It is a consideration of these potential extensions only that the Applicants have presented in the ***Extension of National Grid Substation Appraisal*** (REP8-074) submitted at Deadline 8.

2.6 SEAS General Report on the DCO Examination Deadline 8 – 25 March 2021 (REP8-243)

ID	SEAS' Comments	Applicants' Comments
1. National Grid is the elusive designer of a master plan		
1	1.1. It is our belief that this DCO Application is not structured correctly. Given our collective knowledge about the true scale of the energy Hub envisaged, it is clear that National Grid is the architect behind the plans for a cluster of substations and inter-connectors and therefore should have at the outset put forward a master plan showing the full scale of what is intended for Friston and the surrounding area, with a separate DCO Application for the National Grid substation prior to any Developer such as ScottishPower coming forward with its own DCO Application. These substations are "associated" but the strategic framework has been designed by National Grid, not by ScottishPower. The Trojan Horse is ScottishPower, but the Leader is actually National Grid. 1.2. National Grid played "Pass the Parcel" (verbatim by Suffolk County Council QC) and Russian Dolls with Interested Parties (IPs). Their DCO was hidden in the SPR DCO. National Grid was never there to answer essential questions relating to the grand scheme, the master plans, when they were invited to attend, yet National Grid went overboard and fielded one of the UK's leading infrastructure planning QCs, [text redacted] , who spent a disproportionate amount of time articulating the detailed plans at more than one CA Hearing, relating to an Affected Person's (AP's) field, which they wish to use on a temporary basis. National Grid's silence for the majority of Hearings was deafening.	The Applicants have no further comments.
2. Inadequate surveys		

ID	SEAS' Comments	Applicants' Comments
2	2.1. The surveys which have been carried out by the Applicant to assess the range of impacts have been wholly inadequate. The ExA is being asked to judge the safety of the plans. SEAS believes that there is insufficient knowledge and evidence due to these incomplete surveys.	The survey effort has been to the level required for DCO applications. All survey methodologies (including durations, timings and geographical coverage) were agreed with the relevant regulatory bodies through the Expert Topic Groups and/or formal EIA scoping.
3. Innumerable outstanding issues		
3	3.1. Adverse impacts relating to environment, communities and economy are not fully understood. These issues are some of the outstanding questions: 3.1.1. The likely level of risk to health and well-being relating to intolerable noise at Friston 3.1.2. The threat to Thorpeness landfall cliff erosion and risk to coralline crag 3.1.3. Aquifer contamination 3.1.4. Habitat severance along the cable route; the threat to AONB and SSSI 3.1.5. PRoW and hedgerow desecration 3.1.6. The quantification of the existential threat to the village of Friston 3.1.7. The quantification of the existential threat to Wardens Trust, the Charity for the physically and mentally disabled 3.1.8. The threat to traffic increases and risk of more accidents on the A12, A1094 and rural lanes; increased dangers to cyclists, drivers and delays for Emergency services	Throughout the Examinations SEAS appears to have overlooked much of the information submitted by the Applicants. The Applicants consider many of the 'outstanding issues' listed to be closed following the numerous written and oral submissions made. In general, the Applicants have no further comments and maintain the positions set out in the various written and oral submissions made throughout the Examinations and within this document.

ID	SEAS' Comments	Applicants' Comments
	3.1.9. The threat to the dynamic tourism sector and to jobs 3.1.10. The threat of air pollution to health	
4. The site selection was flawed		
4	4.1. The site selection was made by National Grid. It was forced to consider Broom Covert as well as its original choice of Friston. But after consultation it rejected Broom Covert giving the reasons that building there would go against national planning laws and for other considerations. This assessment method failed to unearth the reasons why the Friston site selected was so clearly also inappropriate. The only advantages of this site were that it was the largest candidate area, only 9 Kms from the sea and not seemingly expensive to compulsorily purchase. The surveys that were conducted were a post-rationalisation for Friston. If the surveys had been properly carried out by independent, objective surveyors Friston would never have passed the test.	Under Section 9 of the Electricity Act 1989 and the other licence and regulatory requirements, National Grid is required to undertake an appropriate review of grid connection proposals through the Connection and Infrastructure Options Note (CION) process, having regard to the specific statutory and regulatory duties incumbent upon them. In spring 2017, National Grid advised that, due to the changing contracted background and improvements to transmission technology, connection capacity could be available in the Sizewell area. The CION process reviewed all realistic options, and in summer 2017, concluded that the most economic and efficient connections for the Projects, while considering environmental and programme implications, would be into the circuits in the Sizewell and Leiston area (***section 2*** of the ***Development Consent and Planning Statement*** (APP-579)). It was only following the CION process that 'site selection' began. National Grid's role in site selection was to provide the substation parameters that needed to be accommodated by sites under consideration; the Applicants undertook the site selection process. From the outset of the Projects, all decisions regarding proposed infrastructure locations have been informed by site survey data and/or detailed topic specific studies undertaken by appropriately qualified, independent specialists. This work has not been retrospective and is presented in numerous documents submitted as part of the Applications (e.g. ***Appendix 4.5 Summary Note on Landscape and Visual Impact and Mitigation*** (APP-446), ***Appendix 22.3 Extended Phase 1 Habitat Survey*** (APP-503 / 504), ***Appendix 24.3 Archaeology and Cultural Heritage Desk Based Assessment*** (APP-514)).As

ID	SEAS' Comments	Applicants' Comments
		noted in ***section 2.5.4***, all technical specialists that working EIAs on the Projects are independent. It is very much within the interests of these surveyors and technical specialists to discharge their responsibilities in strict accordance with their industry's best practice guidance and to provide impartial advice to developers, indeed it is essential for the retention of the professional qualifications and memberships that enable them to operate.
5. DCO assessment is flawed because surveyors are not independent		
5	5.1. The DCO assessment method is flawed. Independent surveys should be used at all times. The legal and medical sectors have step changed to using objective assessors some years ago. The infrastructure planning sector is behind the times and is still reliant on surveys carried out by the Applicants' chosen surveyors, who are not objective because they were chosen by the Applicant. This is a nonsense. The so-called independent surveys are suspect and many of them have still not been presented for interrogation. The recent scoping survey for the Hundred River "wet" woodland has not been shared with the ExA and IPs. It is not a comprehensive survey.	The Applicants would note that, across the spectrum of consenting regimes, where specialist surveys are required these are commissioned by developers. This occurs for numerous reasons, not least of all so developers bear the financial costs, more importantly to ensure they are cognisant of the environmental sensitivities when progressing their proposals. It is very much within the interests of surveyors to discharge their responsibilities in strict accordance with their industry's best practice guidance and to provide impartial advice to developers, indeed it is essential for the retention of the professional qualifications and memberships that enable them to operate. The approach taken to the EIA presented as part of the Applications falls in line with best practice guidelines such as the EIA Guide to Shaping Quality Development prepared by the IEMA (the professional body for environment and sustainability specialists). An ES must be prepared by competent experts; the ES submitted as part of the Applications was prepared by specialists accredited by a range of relevant professional organisations, for example IEMA, the CIEEM, CIWEM, the IOA, and the Chartered Institute of Environmental Health. Regarding the *"scoping survey for the Hundred River "wet" woodland"*, the Applicants assume SEAS is referring to ***Ecology Survey Results February 2021*** (REP6-035) submitted at Deadline 6.

ID	SEAS' Comments	Applicants' Comments
6. Surveys are conducted at the wrong time of year		
6	6.1. Many of these surveys were carried out retrospectively and some of the ecology surveys were carried out at the wrong time of year (see Deadline 8 Submission by SEAS relating to Biodiversity).	All ecological surveys in support of the Applications were undertaken within the optimal surveying windows; SEAS' assertion that 'many' surveys have been retrospective and undertaken at the wrong time of year is untrue. The only ecological survey undertaken following submission of the Applications has been the extended Phase 1 habitat survey of the woodland at the Hundred River crossing, which had the primary aim of verifying the habitat classification assessment of the area already undertaken in April 2018. Across the ecological profession it is accepted that Phase 1 habitat surveys can be conducted all year round. The Applicants acknowledge that the optimum time to have undertaken the February 2021 survey would have been between April and September, however they would note that the information submitted by SEAS to support its conclusion regarding the woodland at the Hundred River crossing (REP5-108) was obtained from a visit undertaken in January 2021. With this in mind, SEAS' assertion that the Applicants' survey did not follow best practice in relation to timing applies to its own site visit also.
7. Superficial mapping		
7	7.1. The fact that the Wardens Trust was only identified as an issue when [text redacted] presented his concerns on behalf of the Trustees at a Hearing in January 2021, is revealing. It shows us how superficial the studies were and how little information was gathered in relation to the adverse impacts for the local communities. Not to have been aware of the existence of the Wardens Trust is astonishing.	The Applicants would note that community engagement is a two way process. The Applicants have been in discussions with Agents instructed by one of the Trustees at the Wardens Trust since 2018.
8	7.2. The aquifers running below ground at Ness House were not identified as an issue at the outset. These aquifers are a laced	Aquifers are considered within the Applications (notably ***Chapter 18*** (APP-066) ***Chapter 20*** (APP-068)). Regarding horizontal directional drilling works at the

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	network running along these cliffs and shoreline. They risk being contaminated or destroyed by the drilling works for the cable corridor.	landfall, the ***Landfall Hydrogeological Risk Assessment*** (REP6-021) provided at Deadline 6 shows that such works are regular occurrences on construction projects and through the application of well-established mitigation measures there will be no degradation of water supplies as a result of the Projects.
8. Thorpeness cliffs landfall is unsafe (source: [text redacted], Chairman – Alde & Ore Association):		
9	8.1. In the absence of any surveys in the field, the plans for which are only in the future, and despite the statement that the cliffs are fragile, there appears to be limited understanding that the Thorpeness Cliffs are, at best, a hardened sand dune in consistency. The cliffs are essentially formed from the geological strata called the Norfolk Crag Formation: this is not a hard rock that will withstand drilling, it consists of sand and some gravels and, as is very evident from the cliff face on the shoreline, it is highly susceptible to collapse caused by thundering waves. The Applicant's document 'Landfall Hydrogeological Risk Assessment', REP6-021, mentions in paragraph 44 that if the layers forming the cliff land are of reasonably medium or dense consistency HDD would work but, if they were loose granular sediments, they may not form a stable bore. Observation of the cliff face in the southern part of the landfall area shows a very loosely formed stratum.	Regarding details on the proposed horizontal directional drill (HDD) works and the properties of the Coralline Crag, the Applicants would point to the ***HDD Verification Clarification Note*** (REP6-024) submitted at Deadline 6 and prepared by Riggall & Associates to provide a review of the feasibility of using HDD at the landfall; this is the report upon which the ***Landfall Hydrogeological Risk Assessment*** (REP6-021) is based. To note, Riggall & Associates is an independent firm providing technical advice on HDD solutions. The company has worked on over 200 HDD projects and specialises in feasibility studies, hydrofracture modelling, drill force modelling, detailed design and planning. The Applicants would also point to ***Appendix 2*** within REP6-022, which presents the Outline Landfall Monitoring Plan. The objectives of this plan are to quantify the beach profile and cliff top changes along, or in the close vicinity of, the alignment of the HDD bores following construction of the landfall and during the operational life of the Projects. This will enable both landward cliff recession and beach profile lowering to be monitored, should these processes occur.
10	8.2. The Applicant's 'Outline Landfall Construction Methods Statement', REP6-022, is helpful in explaining the HDD process and the monitoring plan and adjustments that can be made but is silent on what can be done if a stable bore proves not possible. There are to be 2 to 4 bores for cables for each EA project which increases the extent of even minimal vibration, were that achievable, and it would occur throughout the entire length from	

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	entry from the sea upwards to the land fall HDD entry pit through the sandy ground. Direct drilling will be necessary over 24-hour periods and a period of days. The impact may be more if other companies' projects come in this way too.	
11	8.3. There appears to be no plan should the surveys, which will be done later this year, show the Crag formation forming the whole cliff area back to the 85-metre emerging point is not of the necessary medium density. While Doc REP6-022 explains the type of HDD to be used will be rotary not percussive and so vibration will be minimal and describes the plan to halt drilling and adjust the process to work more gently, it is not clear how, if they are found, loosely granular sediments can be dealt with so that the friable cliff will not be caused to disintegrate more rapidly.	
12	8.4. Further, the cables coming on shore will start below sea level and involve going through the Coralline Crag. This rock is only partly indurated and very friable, witness the many small thin chunks of it thrown up on the beach after storms. While it is recognized that the Applicant plans to seek to minimise the impact on the Coralline Crag, if that proves not possible any changes to the Coralline Crag would potentially affect the coastal flows which the current Crag bank dominates.	
9. IPs were limited in their chance to contest		
13	9.1. Unlike a Court hearing, there is no cross-examination. The ExA can ask questions, particularly towards the end of the Examination, relating to the more technical aspects, but there is no chance of any in-depth probing by the IPs. This means that at every Hearing, there was a sense of frustration that a particular issue for the IPs	The Applicants would note that the DCO process is a predominantly written process. Examination hearings are intended to be inquisitorial rather than adversarial; SEAS' comparison to Court hearings is inappropriate. The Applicants would add that the ExA held an additional week of hearings for the Projects' Examinations (16th – 19th March) and that the hearings held from

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	had been skirted over and rarely with any real scrutiny or opportunity for a further question. 9.2. At times, there were feelings that IPs were not given enough time to make their points. IPs felt pressured to rush through their evidence.	9th -19th March, allowed full days for individual topics with round table discussions being held between the parties that were present.
10. SPR is belatedly presenting a mini-CIA on Nautilus		
14	10.1. The fact that on 24 March 2021, six months after the beginning of the Hearings, there is still no official recognition of the impact caused by multiple projects, including Nautilus, makes a disturbing and discordant note in the overview. SPR presents itself as a disingenuous player, gaming the system at will. SPR decided at the last hour to present its surveys relating to Nautilus at Deadline 8 on 25 March 2021. We await this report but we are not holding our breath. We doubt that it will explore the true impacts on the environment, economy and communities. However, thanks to the Easter holidays, there are likely to be no more than three (3) or four (4) working days before the final Deadline 9 on 6 April 2021. 7 Not enough time or opportunity to contest the cumulative impact with any depth of analysis (see Deadline 8 Submission by SEAS relating to "Cumulative Impact").	Please see ***section 2.7*** of this document.
11. SPR has used compulsory purchase statutory powers to gag landowners		
15	11.1. Opposing voices have been silenced. The NDA Clauses in the suite of agreements have understandably created a climate of fear amongst the majority of APs. We know this for a fact having approached landowners who are APs. They have made it clear that they would like to engage but that they feel silenced. Dr Gimson was uniquely prepared to stick his neck above the parapet and	The Applicants do not consider that this is an accurate summary of the position and it is largely based on unsubstantiated assertions. The Applicants have negotiated in good faith with the affected persons and this engagement has been professional and collaborative. The affected persons have been

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	openly challenge SPR's behaviour and method of dealing with APs. SEAS has only recently discovered how evidence has been suppressed. This is procedurally unfair and undermines the whole Examination (see Deadline 8 Submission by SEAS relating to "Negotiations with Affected Persons").	represented by agents and solicitors throughout. We refer to ***Applicants Comments on SEAS' Complaint*** (ExA.AS-2.D9.V1)
12. SPR is promoting outdated, irresponsible solutions		
16	12.1. SPR has not appeared to notice the changing policy environment, except in the context of using the White Paper's statement about 40GW objectives, for its own ends. In terms of the brave new world, SPR only defines that world within its own parameters of so-called energy efficiency and bottom line. It does not grasp the new environmental goals and as these projects will be constructed in the future, not in the past, SPR is falling behind the curve, promoting outdated and irresponsible solutions. SPR has shown zero interest in embracing new technology for these plans and yet is exploring new technology for other projects.	The Applicants have based their Policy submissions on the clear wording of the policies within the White Paper. The comments from SEAS relate to one aspect of the White Paper on grid. Again, the Applicants have set out their position on these aspects and the position that they have presented has been supported by OFGEM. The timelines for change have been articulated in the White Paper and they lie well beyond the delivery times for these projects. Please see ***section 2.2*** for further details.
13. No real community engagement		
17	13.1. An issue specific Hearing took place for Health including Mental Health. However, no serious consultations ever took place at a local level. At the Health Hearing, [text redacted] spoke on behalf of the Applicant presenting a case of local community engagement. In fact, her work is more akin to PR with "roadshows" (per [text redacted]). For future projects there should be community liaison representatives (chosen by the community) overseeing the	The Applicants note their response at ***section 2.1*** of this document and would also point to the extensive community consultation undertaken for the Projects as set out in the ***Consultation Report*** (APP-029). The Applicants undertook several phases of consultation from 2016 to 2019 using several methods of engagement, including Public Information Days; meetings; newsletters; direct

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	"consultations" held by developers in order to ensure that the true concerns are "ventilated" at the earliest possible opportunity.	discussion with landowners; and dedicated projects websites with e-mail addresses for queries.
14. SPR's tourism forecasts have been flawed from the outset		
18	14.1. The interdependence between the road system and the tourism sector has never been fully recognised by the Applicant. Nor has the Applicant acknowledged that Aldeburgh is an iconic tourism destination, a magnet for Nature and Music lovers. Aldeburgh is less than three miles from Friston. It is clear to us, that the Applicant would like to think that Aldeburgh is 100 miles away. The A1094 is the main arterial road for tourists to Thorpeness and Aldeburgh and neighbouring villages.	Please see ***section 2.3*** of this document.
19	14.2. The Applicant has tried to isolate the cable route and Friston artificially from its geographical context. It has failed to acknowledge the implications of the Estuaries and the principal arterial road to the coast. It is almost as if these valued tourists do not exist. They are a figment of our imagination.	Please see ***section 2.3*** of this document.
20	14.3. No original quantitative targeted research was conducted by SPR. Simon Cleary has sought to undermine the DMO report suggesting that the methodology is flawed. Cleary suggests that the research moderators should not have asked the respondents questions relating to their own attitudes and expected behaviour, but should have asked respondents to imagine attitudes amongst others. In fact, from a market research perspective both approaches have validity. If we took the most optimistic outcomes from the DMO report, the loss to tourism business is still significant. If we take the £25m loss per annum forecast instead of the £40m loss per annum,	SEAS' initial point is a misreading of what Mr Cleary said. In the Written Summary of Oral Case (ISH5) (REP5-029) the point is stated: *"The perception-based study approach taken in the DMO report does not provide robust evidence of changes to future behaviour. The approach was based on the respondents predicting changes in their behaviour at a future date. Studies have found that individuals are generally poor predictors of their future behaviour and are better at predicting the behaviour of others. People are unlikely to consider all the factors that will influence their behaviour in the future but will instead focus on their current situation and intentions at the point of being asked the question. What this means for the DMO report is that the individuals' predictions of their behaviour are likely to be less accurate than if*

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	given the cumulative impact of new additional projects not factored in by the DMO, such as Nautilus and other substation projects, we can estimate at minimum a loss of around £300m over a ten-year period.	*individuals had been asked to predict how other people would react to the Energy Coast developments. The respondents are likely to have overstated how they would react to any potential negative impacts because at the time of questioning the focus was on perceived deterrents, rather than the reasons why they would choose to visit”.* The document goes on to highlight other methodological issues which undermine the conclusions of the DMO Report.
21	14.4. Current mitigation proposals agreed between East Suffolk Council and the applicant are an insult to the hospitality service businesses such as the hotels in Aldeburgh, the B&Bs in Snape, the restaurants dotted across the region and the Festival operators. A £150,000 offer for marketing materials is the proposed mitigation. The vast discrepancy between the losses forecast and the paltry mitigation leads us to the conclusion that East Suffolk Council is indifferent to the future outcomes and jobs for communities along the Suffolk Heritage Coast, holding scant regard for the real value of unspoilt nature and tranquillity to this particular region.	The Applicants note that the proposed tourism fund is related to the Projects alone. The losses envisaged by SEAS (based upon the DMO Report) relate to SZC and the Projects cumulatively. Sizewell C has its own provisions for mitigating its effects, which due to the much longer duration and larger workforce (predicted to be approximately 8,000 at peak) are greater both in scale and scope.
15. Whither this DCO?		
22	To conclude, the DCO is in our terms, not fit for purpose. It is flawed and has been from the outset. SEAS recommends a “split decision” as we have proposed in our WR, reference REP5-114 at Deadline 6. We urge the ExA to refuse consent for the onshore infrastructure as proposed in these ill-conceived plans. The Examination process has conventionally looked through a single prism based on current planning law; we now have a duty and obligation to future generations to look first through through the prism of emerging environmental policy and new value systems for	The Applicants have no further comments.

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	a sustainable economy and planet. Unless a renewable energy project is green from end-to-end, it fails any sensible green test. Harnessing wind energy through a substation at Friston means the whole process is tainted. Onshore delivery at a brownfield or pre-industrialised site is the only way to ensure that we are delivering the benefits of clean, green energy for our people, our precious habitats and our priceless planet.	

2.7 Air Quality Representation (REP8-244)

ID	SEAS' Comments	Applicants' Comments
2.0 AREAS OF CONCERN		
1	2.1 **Issue 1 – Air Quality Impacts Associated with Vessel Emissions** 2.1.1 Air quality impacts associated with vessel emissions have not been assessed. It is stated in the Royal HaskoningDHV response that: *"The scoping reports produced for the Projects considered that the impacts of vessel emissions operating offshore would be unlikely to significantly impact air quality at onshore human and ecological receptors and were therefore scoped out"*. 2.1.2 It is accepted that offshore vessel emissions are unlikely to affect onshore receptors. However, movements in and around the ports have the potential to increase pollutant levels in the vicinity of mooring locations and transport routes. These have not been considered in any part of the application. As such, we would maintain our position that it is not possible to determine whether the effects are likely to be significant in accordance with the requirements of the Town and Country Planning (Environmental Impact Assessment) Regulations (2017) until an assessment has been undertaken.	The Applicants would not that the scoping reports produced for the Projects considered that the impacts of vessel emissions operating offshore would be unlikely to significantly impact air quality at onshore human and ecological receptors and were therefore scoped out. This was agreed by the Planning Inspectorate in its Scoping Opinion (APP-573). The final selection of the port facilities required to construct and operate the Projects has not yet been determined. The offshore construction phase would occur for a duration of 27 months, and that there would be a total of 3,672 vessel trips across this period. This equates to an increase in vessel trips of approximately 5 per day. In the context of existing vessel movements within ports, this is not considered to be a significant increase which would materially affect local air quality in the context of daily port movements. During the operation phase, it is expected that approximately 687 roundtrips would be required per year for both scheduled and unscheduled maintenance. This equates to approximately 2 vessels per day and is again not expected to give rise to significant impacts on local air quality. Small crew vessels would sail from shore to the wind farm sites on a daily basis if the onshore operation option is selected; if the offshore option is preferred, the majority of vessels would visit the wind farms from the offshore accommodation vessel or platform, minimising the interaction with any landside receptors. Larger jack-up vessels may be required if any large components require replacement, although this is expected to be a very rare occurrence during operation of the Projects.

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		In addition, it is considered unlikely that any vessels utilised during the construction or operation phases of the Projects would be moored in the immediate vicinity of sensitive receptors. Whilst port activities can, overall, have a significant impact on local air quality in their vicinity, the number of vessels utilised for the Projects is expected to have an insignificant contribution to total emissions in comparison to emissions from ports as a whole, particularly in regard to the size of the vessels to be used and frequency of vessel calls in comparison to larger cargo or container vessels. To note, vessels operating within the North Sea area are required to meet emission standards set by the International Maritime Organisation's Marine Pollution convention as the North Sea is a designated Emission Control Area. Emissions from vessels would therefore be regulated. The Projects may also utilise ports to supply materials used during construction. It is expected that this import of materials would be undertaken under the ports' existing permissions and operators would simply be serving a different customer, rather than the Projects generating any additional vessel movements.
2	2.2 **Issue 2 – Ammonia Emissions from Road Traffic and Non-Road Mobile Machinery** 2.2.1 Air quality impacts associated with NH_3 emissions from road traffic and NRMM have not been quantified. Increased levels can lead to direct impacts on foliage, as well as changes in ground flora. This also affects the amount of nitrogen and acid deposition with similar adverse effects. The Sandlings Special Protection Area (SPA) has been designated for the protection of European nightjar and Wood lark. Information available from the UK Air Pollution Information System (APIS) website, which is a joint venture between the Joint Nature Conservation Committee, the	**Road Traffic** SEAS notes that ammonia emission factors for road traffic have been provided by Air Quality Consultants Ltd, and used in the planning system in the assessment of impacts of traffic generated by the Epping Forest District Council Local Plan. The Applicants would note that the cited assessment was carried out to consider long-term impacts across the local plan period, whereas the impacts of the Projects would be experienced across a shorter duration (construction phase only). Nevertheless, further consideration is given to ammonia emissions below.

ID	SEAS' Comments	Applicants' Comments
	Environment Agency, the Northern Ireland Environment Agency, Scottish Natural Heritage, Sniffer, Natural England, Natural Resources Wales, the Scottish Environmental Protection Agency and the UK Centre for Ecology and Hydrology, indicates that there is the potential for negative impacts on both species due to impacts on the species' broad habitat as a result of increased NH_3 concentrations and nitrogen deposition. Without detailed consideration of these issues the conclusions of the EIA and Appropriate Assessment under the Habitats Regulations may therefore be flawed. 2.2.2 Royal HaskoningDHV indicate that the UK Government has not provided relevant NH_3 emission factors. However, they have been derived by Air Quality Consultants Ltd and subsequently used in the planning system, such as during the recent examination of the Epping Forest District Council Local Plan and associated impacts on the Epping Forest Special Area of Conservation (SAC). This data source is therefore considered appropriate for an assessment of this nature and justification of modelling of these emissions has not been provided. 2.2.3 Royal HaskoningDHV also state that the Euro VI emission standard for NH_3 will 'significantly reduce or eliminate ammonia emissions from the majority of vehicles used by the Projects'. If the applicant is confident that this level of emission will not cause exceedences of the relevant critical level for NH_3 at the Leiston-Aldeburgh Site of Special Scientific Interest (SSSI) and Sandlings SPA then this should be proven through dispersion modelling. This would also show the extent of any impact and identify whether any habitat deemed of high quality would be affected. Without this data it is not possible to fully understand the additional pollutant loading within the designations. This may affect both the conclusions of	The ammonia emissions calculator provided by Air Quality Consultants Ltd[2] shows that the ammonia emission rate from a single Heavy Goods Vehicle (HGV) is approximately one-fifth of the Nitrogen Oxide (NOx) emissions using the same input parameters in the Department for Environment, Food and Rural Affairs' (DEFRA) Emission Factor Toolkit (EFT)[3]. As such, ammonia emissions from road vehicles are smaller than those of NOx. However, the deposition velocity of ammonia to grassland (0.02 m/s) is higher than that of Nitrogen Dioxide (NO_2) (0.0015 m/s) and therefore ammonia can contribute a greater proportion to nutrient nitrogen and acid deposition. With regard to Project-related vehicles travelling on the local road network, the assessment carried out for the ES considers effects at the Sandlings SPA / Leiston Aldeburgh SSSI and Sizewell Marshes SSSI. Impacts are considered across a transect at 50m intervals from the road edge, up to 200m. In-combination nutrient nitrogen deposition is predicted to be 0.8% and 0.3% of the relevant Critical Loads at the Sandlings SPA / Leiston Aldeburgh SSSI and Sizewell Marshes SSSI respectively, at the transect locations directly adjacent to the roadside. For acid deposition, in-combination impacts are 0.8% and 0% of the relevant Critical Loads at the Sandlings SPA / Leiston Aldeburgh SSSI and Sizewell Marshes SSSI respectively. At all other locations at 50m+ from the road, impacts reduced to either 0.1% of the Critical Load or 0% for nitrogen and acid at both sites. Increases in nitrogen and acid deposition as a result of ammonia would therefore have negligible effect at 50m from the road edge and beyond. At the road edge, it is unlikely that ammonia would give rise to significant increases in nutrient nitrogen or acid deposition at either of the designated sites based on the impacts predicted without the effects

2 https://www.aqconsultants.co.uk/resources/calculator-for-road-emissions-of-ammonia
3 https://laqm.defra.gov.uk/documents/EFT2019_v9.0.xlsb

ID	SEAS' Comments	Applicants' Comments
	the EIA and Appropriate Assessment. As such, without this information, it is not possible to determine whether the effects are likely to be significant.	of ammonia. Furthermore, impacts would be experienced during the temporary construction phase only. As detailed in the ***Deadline 3 Air Quality Clarification Note*** (REP3-061), increases in HGV and Large Goods Vehicle movements travelling along the haul road within Sections 1 and 2 of the onshore cable route, which are in the vicinity of ecological receptors, are predicted to be 106 and 152 per day respectively, as peak flows, and therefore average movements over the construction period would be lower. The Design Manual for Roads and Bridges guidance provides screening criteria to assess whether increases in traffic can be considered to be insignificant. These criteria are changes in total flow of 1,000 vehicles per day or 200 HGVs per day and are considered by Natural England to equate to a 1% change in the Critical Load or Level[4], which is regarded as a threshold of insignificance. Traffic flows along the haul road are well below the screening criteria and would therefore be considered to have an insignificant impact on air quality, and consequently would not require assessment in their own right. However, emissions from these vehicles are included in the assessment of Non-Road Mobile Machinery (NRMM) emissions to provide a robust consideration of all emission sources. With the exception of the SPA crossing (if trenched techniques are utilised) there are no locations where the haul road would be immediately adjacent to ecological receptors. As noted in the Air Quality Consultants Ltd report[5], concentrations of ammonia decrease exponentially with distance from the road, particularly within the first 10m. As such, the movement of vehicles along the haul road is unlikely to have a significant impact on ecological receptors with

[4] http://publications.naturalengland.org.uk/publication/4720542048845824
[5] https://www.aqconsultants.co.uk/resources/ammonia-emissions-from-roads-for-assessing-impacts

ID	SEAS' Comments	Applicants' Comments
		regard to increased emissions from ammonia. The preferred option for crossing the SPA is using an open trench technique; the duration of works undertaken in this manner would be restricted by the breeding bird season and therefore would only occur for 5.5 months per year. The consequent annual mean impact of additional emissions of ammonia would therefore be reduced, and impacts are unlikely to be significant. **NRMM** With regard to emissions of ammonia from NRMM, the rate of ammonia 'slip' from catalytic reduction methods used on NRMM is uncertain. The EMEP Guidebook[6] provides an emission factor for ammonia of 0.002 g/kWh; however, this does not vary based upon the plant's age (and emission stage) or engine size and is therefore unlikely to be representative. However, this is very low in comparison to the NOx emission rate for Stage IV plant (0.4 g/kWh). As acknowledged in the ***Applicants' Comments on Suffolk Energy Action Solutions' (SEAS) Deadline 5 Submissions*** (REP6-032), the use of NRMM may lead to increases in ammonia emissions and consequential nutrient nitrogen and acid deposition. However, the intensive construction activities, primarily associated with construction of the landfall, will be short-term in nature. As shown in REP3-061, impacts on ecological sites following completion of the HDD works were greatly reduced. **Habitat Condition** Further ecological assessment, as presented in the ***Deadline 6 Onshore Ecology Clarification Note*** (REP6-025), has been undertaken to consider the condition of the habitat at receptors. Within the Sandlings SPA, the habitat is considered to be in moderate to poor condition, and

[6] https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-4-non-road-1/view

ID	SEAS' Comments	Applicants' Comments
		the habitats and species recorded at the receptor locations were not representative when compared to the wider SPA. As such, the habitats in the receptor locations are not considered to contribute to the overall function or integrity of the SPA and/or its qualifying features. For the Leiston-Aldeburgh SSSI, the habitat is also considered to be of moderate to poor condition with a lack of species diversity. Temporary impacts in these areas are not considered to prevent their long-term recovery, and the habitats are not considered to contribute towards the overall function and integrity of the SSSI. Given the above, whilst increases in ammonia concentrations, and subsequent nitrogen and acid deposition, would occur, it is unlikely that this would alter the conclusions of the assessment. The receptor locations are not in areas of high-quality habitat which are essential to the function or integrity of the designated sites, and the areas are expected to be able to recover from short-term impacts experienced during construction.
3	2.3 **Issue 3 – Generator Exhaust Positioning** 2.3.1 Optimistic assumptions have been adopted in regards generator exhaust positioning within the assessment of NRMM and haul road emissions. Horizontal sources and point sources with rain caps have little or no initial vertical velocity. Royal HaskoningDHV state: *"The ADMS 5 modelling software does not allow the user to specify horizontal emissions from point sources"*. 2.3.2 This statement is factually correct. However, horizontal emissions can be represented within ADMS 5 using jet sources. Alternatively, the United States Environmental Protection Agency has proposed that the stack exit velocity should be reduced to 0.001m/s and an equivalent stack diameter calculated such that the buoyant plume is properly calculated. Experience of using this method has indicated significantly greater air	The Applicants note that if horizontal exhausts were to be used, they would reduce the vertical exhaust gas plume velocity and result in an increase in predicted pollutant concentrations and deposition at ground level. However, this is not expected to result in a change to the assessment conclusions as presented in relation to ammonia emissions, based on the condition of the habitats assessed and that emissions from temporary works would be unlikely to prevent long-term recovery of the habitats.

ID	SEAS' Comments	Applicants' Comments
	quality impacts than if standard point sources are modelled. Given that the actual plant to be used on site is unknown at this stage of the project, worst-case assumptions should be adopted to ensure a robust assessment. As this was not the case, and coupled with the non-inclusion of NH_3 emissions, effects on the Leiston-Aldeburgh SSSI and Sandlings SPA may be significantly underestimated.	
4	2.4 **Issue 4 – Sensitivity Analysis of Exhaust Emission Reduction** 2.4.1 The results of the sensitivity analysis of exhaust emission reduction and how these affect predicted pollutant concentrations have not been given any weight. As stated in the original representation, it is understood that previous research has shown better correlation between vehicle emission performance and the DEFRA Emissions Factor Toolkit (EFT) in recent years. However, there is always uncertainty when predicting future conditions and a precautionary approach should be adopted when undertaking environmental assessment. This position is supported by Appeal Decisions APP/V2255/W/15/3067553 & APP/V2255/W/16/3148140 which indicate that although it is accepted that emissions will reduce in the future, the rate of improvement is difficult to predict and should therefore be viewed with caution. No comment has been provided by Royal HaskoningDHV to justify their approach in the context of these planning appeal decisions. Additionally, consideration to any lesser improvement in air quality conditions than currently predicted by DEFRA has not ben provided. Clarification on how the effects of COVID-19 on vehicle purchasing habits and associated impact on fleet mix may affect predicted air quality impacts, as requested in the original representation, has also been omitted. 2.4.2 Although it appears that agreement with East Suffolk Council (ESC) has generally been reached in regards mitigation of impacts within the	As stated in the ***Applicants' Comments on Suffolk Energy Action Solutions' (SEAS) Deadline 5 Submissions*** (REP6-032), it is not considered appropriate to draw conclusions as to the significance of impacts based on no reduction in pollutant concentrations between 2018 and 2023, as monitoring data collected within the Stratford St Andrew Air Quality Management Area (AQMA) has shown a reduction in concentrations in recent years. The cited appeal decisions are dated 2016 and are based on an air quality assessment carried out utilising an older version of the EFT which was known to be overly optimistic with respect to future vehicle emissions and fleet composition. As stated in REP6-032, and acknowledged by SEAS, this has been improved in recent years and is now considered to be sufficiently robust. The effects of Covid-19 on vehicle purchasing habits and fleet mix cannot be predicted at this stage. However, irrespective of a change in future fleet predictions, the Applicants have committed to 70% of its fleet being of Euro VI standard in the event of an overlap of the Projects' construction with that off Sizewell C. This commitment was made following numerous discussions with ESC and SCC with regard to cumulative impacts within the Stratford St Andrew AQMA with Sizewell C (as set out in the ***Outline Construction Traffic Management Plan*** (8.9)).

ID	SEAS' Comments	Applicants' Comments
	Stratford St Andrew Air Quality Management Area (AQMA), it is concerning that the above factors have not been considered fully and future year predictions have been accepted without question. This may have led to effects on human receptors and ecological designations being underestimated and the current response to the previously provided comments are not considered satisfactory.	It is ESC's statutory responsibility to improve air quality within AQMAs. As such, ESC and SCC commissioned its consultants to undertake a cumulative assessment of the impacts of both the Applicants' Projects and Sizewell C to determine a level of mitigation which all projects would be required to commit to, to ensure significant impacts would not be experienced. Given that pollutant concentrations are reducing within the AQMA and that the Applicants have committed to implementing sufficient mitigation measures to minimise emissions, it is not considered that there is any potential for significant impacts to arise.
5	2.5 **Issue 5 – Cumulative Road Traffic** 2.5.1 Traffic associated with the proposals, as well as Sizewell C and any other relevant committed developments not considered within the Air Quality Assessment, will travel through the AQMA located along the A12 in Stratford St Andrew. This has been declared by ESC due to exceedences of the statutory AQO for annual mean NO_2 concentrations. The Royal HaskoningDHV clarification note indicates that: *"A qualitative assessment was undertaken in the absence of finalised data from Sizewell C, as explained in the Sizewell Projects Cumulative Impact Assessment (Traffic and Transport) Clarification Note submitted at Deadline 2 (REP2-009)"*. 2.5.2 Within the Sizewell Projects Cumulative Impact Assessment (Traffic and Transport) Clarification Note it is made clear that Sizewell C data is now available. However, this has not been utilised to further quantify air quality impacts within the AQMA. Justification for not updating the modelling has not been provided. Without this data we would maintain our position outlined in the original representation that when considered in the context of the potentially overly optimistic representation of future emissions and the sensitivity of human receptors within the Stratford St Andrew AQMA, the current assessment may have led to a significant underestimation of cumulative air quality impacts within the vicinity of the access route.	

3 References

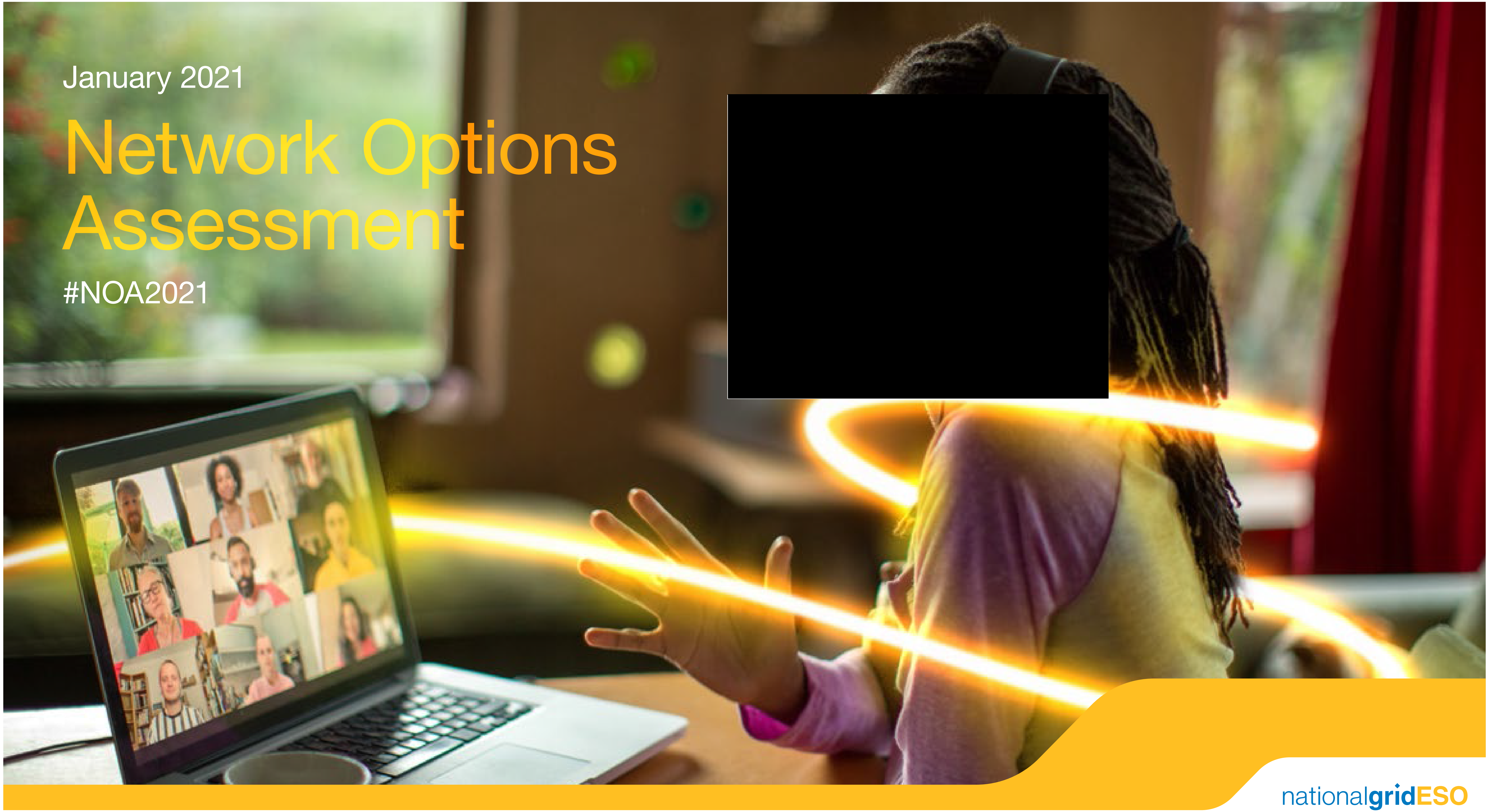
HM Government (2020) Energy White Paper: Powering our Net Zero Future. December 2020. CP 337.

Appendix 1 – Network Options Assessment (January, 2021)

January 2021

Network Options Assessment

#NOA2021



nationalgridESO

Navigation

To help you find the information you need quickly and easily we have published the report as an interactive document.

Pop-ups & Rollovers

Click or Roll over highlighted text or the ⊕ symbol to reveal extra content or take you to a different section

Page navigation explained

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From here you can navigate to any part of this publication - for example, this will allow you to find your place quickly and easily after you have followed an internal link

www

Click on orange text to go to the appropriate webpage.

Download a pdf

To download a full copy of this report go to nationalgrideso.com/noa-2020

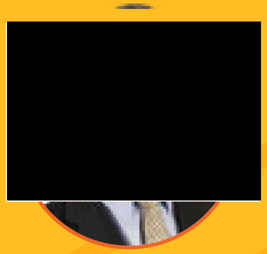
Contents

Welcome

Foreword

Last year saw further development of the Government's energy ambitions to reach net-zero with the Prime Minister's Ten Point Plan for a Green Revolution and the publication of the Energy White Paper. Both of these documents set out significant targets for the connection of new generation over the next decade as well as up to 2050 and will require careful consideration of network plans to support these targets.

This year's *Network Options Assessment (NOA)* is a key publication in recommending the major projects that are needed to deliver a transmission system that is fit for purpose to meet GB's net zero and green ambitions, whilst balancing the costs to the end consumers. Building on the work of the *Future Energy Scenarios 2020 (FES)* and the *Electricity Ten Year Statement 2020 (ETYS),* the *NOA* is a key part of the Electricity System Operator's (ESO) role.



Julian Leslie
Head of Networks,
Electricity System Operator
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The ESO fully supports the Government's net-zero targets and will continue to work with stakeholders across industry and government to develop the future network to support these ambitions, to ensure that collectively we can achieve a secure, sustainable and affordable energy future.

We are pleased to present the 6th *NOA* report, with the aim of generating consumer value by avoiding over or under investment in the transmission network. To make sure our processes are transparent, we follow the *NOA methodology*, in full consultation with our stakeholders and which is approved by Ofgem on an annual basis. This methodology sets out how we base recommendations on the data and analysis of the latest *FES* and *ETYS*.

The *NOA* represents a balance between asset investment and network management to achieve the best use of consumers' money. The future energy landscape is uncertain, and the ESO's recommendations make sure the GB transmission network is fit for the future. These recommendations are imperative for us all to address the 'energy trilemma' of secure, sustainable and affordable energy. They are the key stepping stones for us to meet our 2025 target to operate a carbon-free network and accomplish the wider 2050 ambition of a net zero carbon emission society.

As the ESO we published a report in December concluding the first phase of our *Offshore Coordination Project (OCP)*, setting out the benefits of a more integrated approach to offshore connections. This report has been submitted to the Government as part of their wider network review, whose ultimate conclusions will dictate the future direction of the *NOA.*

This year's *NOA* has, for the first time, explored offshore wider works in detail. We have learnt from the outputs of the ESO's *OCP* which identified significant consumer and environmental benefit from the coordination of offshore infrastructure. The *NOA* analysis is restricted solely to constraint savings, and as such does not evaluate the same range of factors as the *OCP.*

In producing this year's *NOA* we have listened to and acted on your feedback. We are making more changes and enhancements to the process. I would welcome your thoughts as to how we can push the *NOA* even further to drive value for consumers whilst continuing to operate a safe and secure GB transmission system.

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Executive summary

Executive summary

The *NOA* recommends which reinforcement projects should receive investment during the year. We reach our conclusions using the *FES 2020* scenarios, *ETYS 2020* options, and the latest *NOA methodology report*. The diagram below summarises the key messages in this publication.

171 assessed options

Proceed	45
Delay	2
Hold	66
Do not start or Stop	58
NOA I/C	16.9 to 27.7 GW

£13.9bn
Total Cost

£183m
Investing in 2020/21

4
Number of ESO-led commercial solutions Saving consumers up to £2.1bn

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Executive summary

This year's *NOA* analysis signals the need to invest more than £16 billion[1] to manage heavily constrained system boundaries through asset build options into the mid-2030s. This investment will pave the way and help enable the ambitions of a net zero future. The key driver is the large increase in renewable generation, particularly in the North and East of Great Britain, described in the *Future Energy Scenarios* 2020, as we strive to meet net zero climate targets by 2050.

We have identified a need for four Anglo-Scottish subsea reinforcements along the east coast as well as several large onshore reinforcements which combine to facilitate north-to-south power transfer. These options will be refined through the TOs regulatory investment processes.

In the south and east of England, we continue to forecast a growing volume of interconnection capacity over the next decade. Last year we recommended a new offshore transmission route between Suffolk and Kent and a new circuit from Bramford to Twinstead. This year, our analysis shows the need for these links and three further new onshore transmission route circuits across the south east coast from Norfolk to Kent to alleviate increased network constraints.

We also see significant value in pursuing 4 ESO-led commercial solutions across the north of England and Scottish border region and the south east coast region, providing up to £2.1 billion in consumer savings.

Even with the *NOA's* substantial investment recommendations, constraint costs are still forecast to rise significantly over the next decade. We are engaging with BEIS, Ofgem and the industry for alternative ways to manage these constraint costs in the short to medium term.

Our recommendations can be found in Chapter 4 - 'Investment recommendations'; detailed data and a comparison to last year can be found in Appendix A – 'Economic analysis results'.

1 This figure is the total cost of all reinforcements required in the System Transformation scenario up to the mid-2030s. This scenario represents the lowest total spend of the three net zero scenarios.

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Executive summary

This year's interconnector analysis suggests a total interconnection capacity range of between 16.9 to 27.7 GW between GB and European markets would provide optimal consumer benefit. These recommendations represent the best view at a snapshot in time. Investment decisions taken by any business should always consider these recommendations in the light of subsequent events and developments in the energy sector. You can find these results in Chapter 6 - 'Interconnector analysis'.

This year, some of the options we've recommended to proceed with are likely to meet Ofgem's criteria for onshore competition. We've expanded this assessment to include any new or modified contracted connection projects for generator and demand connections. The competition assessment is in accordance with Ofgem's agreed methodology. The outcomes are described in Chapter 4 - 'Investment recommendations'.

For the first time, we have demonstrated the economic benefits of offshore integration within our *NOA* analysis. We have proposed a number of conceptual offshore options and tested their benefit solely against constraint reductions, the analysis undertaken by the separate *Offshore Coordination Project (OCP)* has considered other factors beyond the remit of *NOA*. In the future, it is possible that the *NOA* will evolve to account for these factors as well. Our analysis has found that three conceptual options are economically viable in at least one scenario and warrant further investigation. We will continue in conjunction with the *OCP* to engage with the industry in 2021 to seek your views on the *NOA's* offshore wider works results. We've published these results in a new dedicated Chapter 5 - 'Offshore Wider Works'.

This year's *NOA* provides a clear set of recommendations for investment in the transmission network, that are necessary if the UK is to achieve net-zero by 2050. The shift to a decarbonised electricity system requires unprecedented investment over the coming years. We are working together across the industry to deliver the decarbonised, sustainable electricity system of the future.

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Have your say

Your views are important in helping us continue to develop and improve the *NOA*. Chapter 7 - 'Stakeholder engagement' describes how you can contact us.

Future energy publications

National Grid ESO has an important role in leading the energy debate across our industry and working with you to make sure that together we secure our shared energy future. As the ESO, we are perfectly placed as an enabler, informer and facilitator. The ESO publications we produce every year are intended to be a catalyst for debate, decision-making and, ultimately, change.

The starting point for our flagship publications is the *FES*. This is published every year and involves input from stakeholders from across the energy industry.

These scenarios create a range of credible futures which allow us to provide credible supply and demand projections out to 2050. They inform the energy industry about network analysis and planned investment to benefit our customers.

We set out our long-term view of the electricity transmission capability in our *FES*, *ETYS*, and *NOA* publications. Your input can help shape these publications and inform the energy debate.

NOA / Executive summary 09

Chapter 1

Introduction

Navigating this document

We've structured the *NOA* document to help you understand how we've reached our recommendations and conclusions.

Chapter 2

Methodology

Describes the *NOA* process and the economic theory behind it. This is useful if you are unfamiliar with the *NOA*, or if you would like to understand more about how we carry out the economic analysis of options.

Chapter 3

Proposed options

Describes the reinforcement options that can increase the NETS' capability. It provides an overview of the options being proposed by TOs and ESO.

Chapter 4

Investment recommendations

Shows our investment recommendations for 2020/21. It also summarises the eligibility assessment for competition in onshore electricity transmission.

Chapter 5

Offshore Wider Works

Presents our methodology, options and results for the assessment of conceptual Offshore Wider Works options within the *NOA*.

Chapter 6

Interconnector analysis

Presents our interconnection analysis results. We describe the optimum levels of interconnection between GB and European markets and explain the economic theory behind the benefit of interconnectors to the consumer.

Chapter 7

Stakeholder engagement

Let's you know how to get involved with the *NOA* process and how to use data in the document.

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How the *NOA* fits in with the *FES* and the *ETYS*

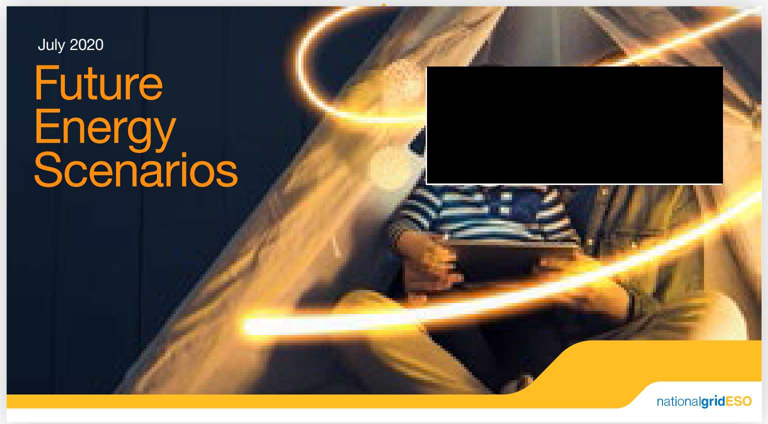
The ESO produces a suite of publications on the future of energy for Great Britain, which inform the whole energy debate by addressing specific network planning issues. The *FES*, *ETYS* and *NOA* provide an evolving and consistent voice in the development of GB's electricity network.

We use the *FES* to assess network requirements for power transfers across the GB NETS. The TO responds with options for reinforcing the network and the requirements are published in the *ETYS*. The *NOA* is based on our economic analysis of these options. More information about this can be can be found in Chapter 2 - 'Methodology'.

We summarise our economic analysis of reinforcement options by region. Based on the economic analysis, we give our recommended options for each of the regions. Where appropriate, we've included a summary of those options which meet Ofgem's criteria for further assessment, including Large Onshore Transmission Investments (LOTI).

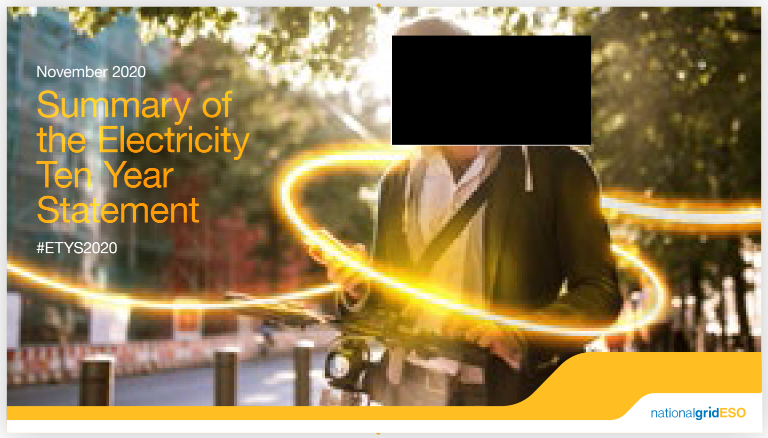
It is important to note that while we recommend options to meet system needs, the TOs or other relevant parties will ultimately decide on what, where and when to invest.

Some alternative options we've evaluated are reduced-build or operational options as explained in Chapter 3 - 'Proposed options'. The *NOA* emphasises the need to reinforce the network, and we are keen to embrace innovative ways to do so.



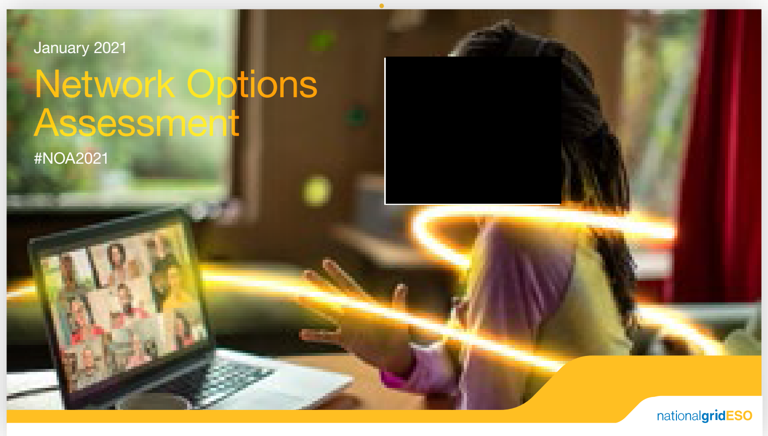
FES July 2020

A range of plausible and credible pathways for the future of energy from today out to 2050



ETYS November 2020

The future transmission requirements on the electricity system



NOA January 2021

The recommended options to meet reinforcement requirements on the electricity system

Figure 1.1 *NOA* and *ESO* publications

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What the *NOA* can and cannot do

The *NOA* can…

- **recommend** the most economic reinforcements, whether build or alternative options, for investment over the coming years, to meet bulk power transfer requirements as outlined by the *ETYS*.
- **recommend** when investments should be made under the different scenarios set out in the *FES* to deliver an efficient, coordinated and economic future transmission system.
- **recommend** whether the TOs should start, continue, delay, hold or stop reinforcement projects to make sure they are completed at a time that will deliver the most benefit to consumers.
- **indicate** the optimum level of interconnection to other European electricity networks and necessary reinforcements.

The *NOA* cannot…

- **provide** recommendations for customer connections. The *NOA* only recommends the most economic reinforcement to resolve wider network issues.
- **insist** that reinforcement options are pursued. We can only recommend options based on our analysis. The TOs or other relevant parties are ultimately responsible for what, where and when they invest.
- **comment** on the details of any specific option, such as how it could be planned or delivered. The TOs or other relevant parties decide how they implement their options.
- **evaluate** the specific designs of any option, such as the choice of equipment, route or environmental impacts. These types of decisions can only be made by the TOs or other relevant parties when the options are at a more advanced stage.
- **assess** network asset replacement projects which don't increase network capability or individual customer connections.
- **procure** products or services. The *NOA* may highlight a need to explore options further, either through the *NOA* Pathfinder projects or further engagement.
- **provide** a recommendation on options that provide no boundary benefit or where the costs for the expected benefit would be prohibitive.
- **forecast** or recommend future interconnection levels. It indicates the optimum level of interconnection.

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What's new this year?

- ***NOA* Interested Persons' process** - this year we introduced a new submission process, available on our website, allowing options from non-TO parties to be submitted and potentially assess in the annual process. We are gathering lessons learnt from this process and will continue to engage with our stakeholders on how this process will be progressed in future.

- **Offshore Wider Works chapter (OWW)** - We have continued developing conceptual OWW reinforcements for the NOA and this year we have increased the number of reinforcements and the detail of the studies. This year we have included a dedicated chapter to further explain our progress.

- **Handover process** - We continue to improve our processes based on stakeholder feedback. After publishing the *NOA* 2019/20 report, we continued to refine our system requirements form (SRF) and developed a platform for submission to provide a smoother experience in the handover process. Every year we look to improve these tools, to improve the TO's experience of submitting their options as well as adding extra levels of quality assurance to the *NOA* process.

- **The *NOA* Pathfinder projects** - Since we published our Network Development Roadmap, committing to conducting pathfinding projects to explore ways of including other system needs, we have made significant progress. Currently there are three *NOA* Pathfinders: voltage, stability and constraint management. Voltage aims to find a solution to resolve regional high voltage issues. Stability aims to address our immediate needs of national inertia and deliver local short circuit level needs in Scotland. Constraint Management aims to resolve network constraint issues and lower balancing costs. For the most up-to-date information on their progress and to get involved please visit our website.

- **Least Worst Weighted Regret (LWWR)** - this year, academics at the University of Melbourne independently validated the robustness of our *NOA* process and described it as "state of the art planning under uncertainty". In collaboration, we developed a new tool called Least Worst Weighted Regret (LWWR). It provides a sensitivity study of varying the probability of each future energy scenario occurring. We used this tool for the first time this year at the *NOA* Committee, to help improve the robustness of the marginal options presented. You can find out more about LWWR by downloading the report on our website.

- **Contract for Difference (CfDs)** - In this year's *NOA* analysis, we have improved our modelling of forecast constraint costs, to account for wind generators having a Contract for Difference (CfDs). CfDs are the mechanism for subsidising wind, replacing Renewable Obligation Certificates (ROC). This change in subsidy affects the prices wind will bid into the balancing mechanism, and hence affects constraint costs. We have improved our understanding of the effects that large scale adoption of CfDs may have through: stakeholder engagement with industry and academia; and detailed analysis of historical bid price data. We have modelled all future wind generators in our economic tool to respond as we'd expect from a generator with a CfD. This improves how reflective our modelled cost of constraints are in the medium and longer term, which increases our confidence in the *NOA* 2020/21 results. We are committed to continuously improving our modelling of the constraint cost impacts from subsidy changes in future *NOA* iterations. Therefore, we will review our assumptions as more data becomes available.

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Chapter 2

Methodology

Introduction and the *NOA* process

This chapter highlights the methodology we use for the *NOA*, and explains the process and economic theory behind our analysis.

The *NOA* methodology describes how we assess major NETS reinforcements to meet the requirements identified from our analysis of the FES. The latest methodology is published on our website, it also includes the methodologies for interconnection analysis included in Chapter 6 – 'Interconnector analysis'. In accordance with our licence condition, major NETS reinforcements are defined in paragraph 1.31 of the *NOA methodology report* as: "a project or projects in development to deliver additional boundary capacity or alternative system benefits, as identified in the *Electricity Ten Year Statement* or equivalent document".

Some customer connection agreements have major reinforcements as their required enabling works for connection.

If the *NOA* recommends a change to the delivery of these works, we will work with these customers to identify if any updates are required to their agreement. Their connections will not be delayed.

In December 2020 Ofgem published their final determinations for the new RIIO-2 framework which starts in April 2021. The new framework changes how TOs are funded for future projects. For RIIO-2, projects will be funded by two uncertainty mechanisms:

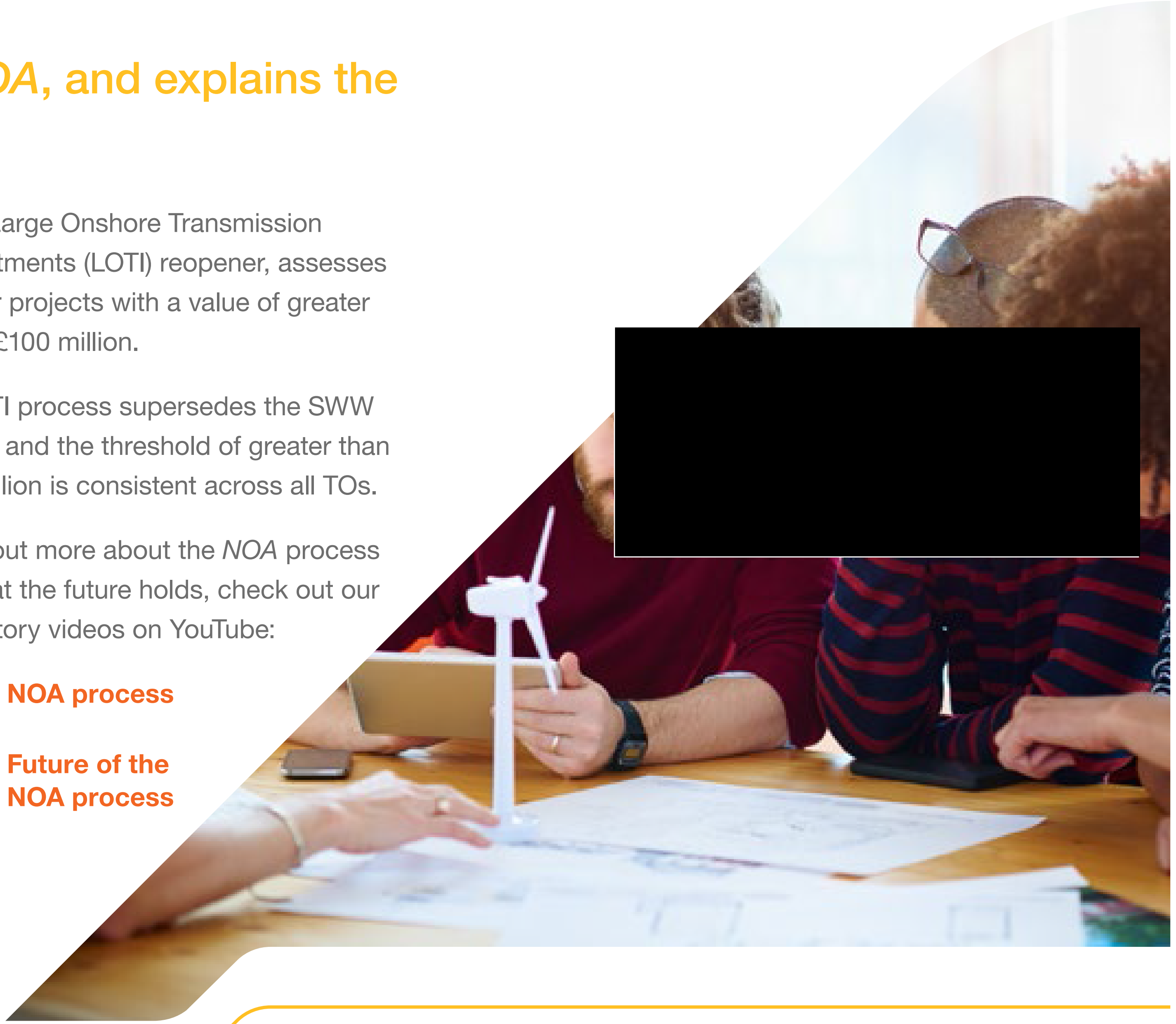
- The Medium Sized Investment Projects (MSIP) re-opener, provides TOs with an annual opportunity to request funding for projects valued at less than £100 million.
- The Large Onshore Transmission Investments (LOTI) reopener, assesses larger projects with a value of greater than £100 million.

The LOTI process supersedes the SWW process and the threshold of greater than £100 million is consistent across all TOs.

To find out more about the *NOA* process and what the future holds, check out our explanatory videos on YouTube:

NOA process

Future of the NOA process



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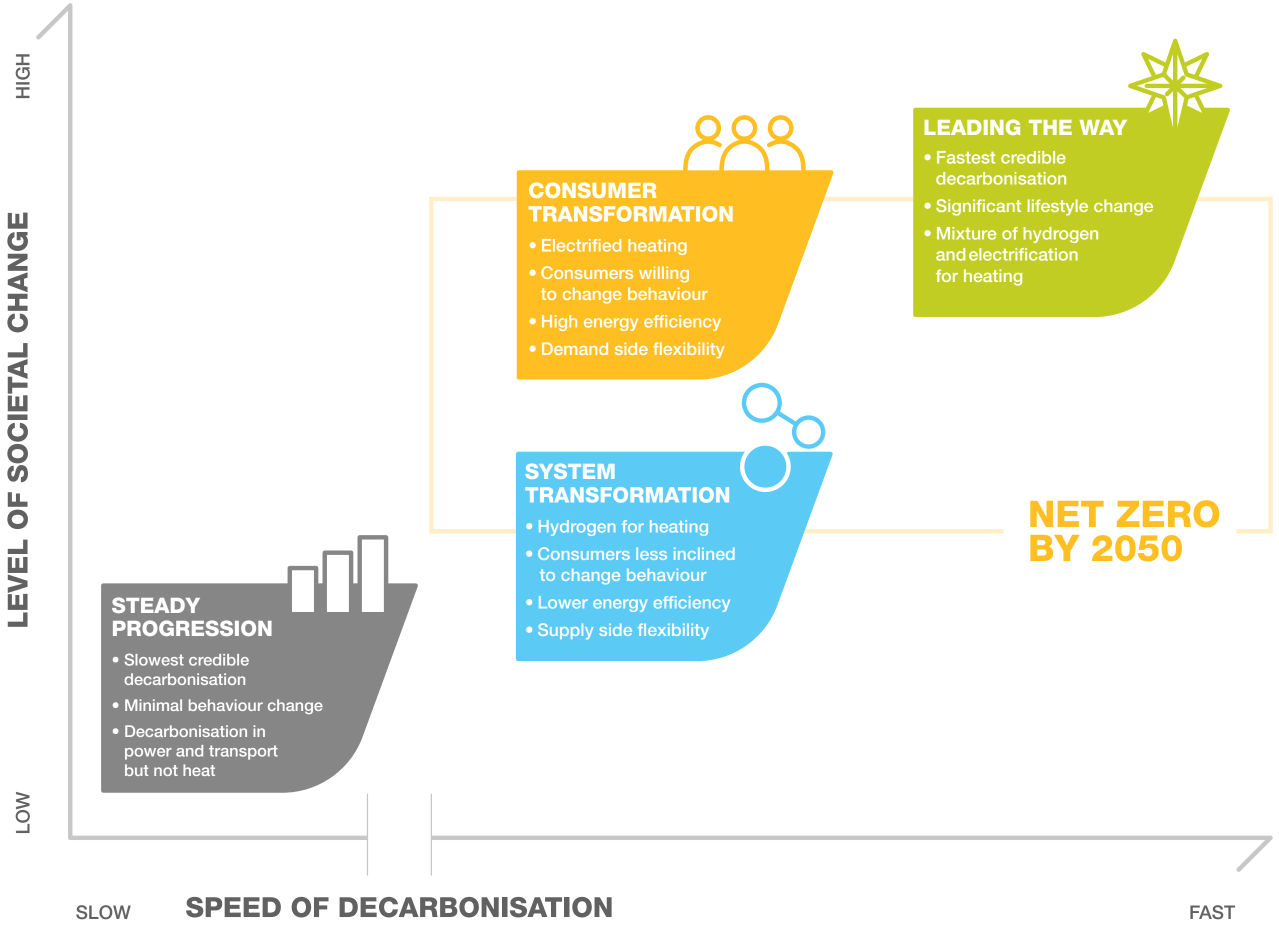
Introduction and the *NOA* process

Future Energy Scenarios

The first stage of the *NOA* process starts with the *FES*. These are a credible range of future scenarios across the whole energy system and the electricity components form the foundation for our studies and economic analysis. The four scenarios published in 2020 are:



This year, a new set of scenarios were developed through extensive industry collaboration. These have net zero at their core and explore how the level of societal change and speed of decarbonisation could lead to a range of possible future pathways.

COVID-19 impact

COVID-19 will impact many aspects of the future of energy. This year's *NOA* uses the latest *FES* 2020 scenarios which, due to the uncertainty and lack of evidence of the pandemic's impact at the time has not been included in the latest *FES*. With further impacts to be discussed with stakeholders this will form part of the *FES* 2021 which will affect *NOA* 2021/22.

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Economic analysis theory

It is important to understand why we recommend investment in the transmission network.

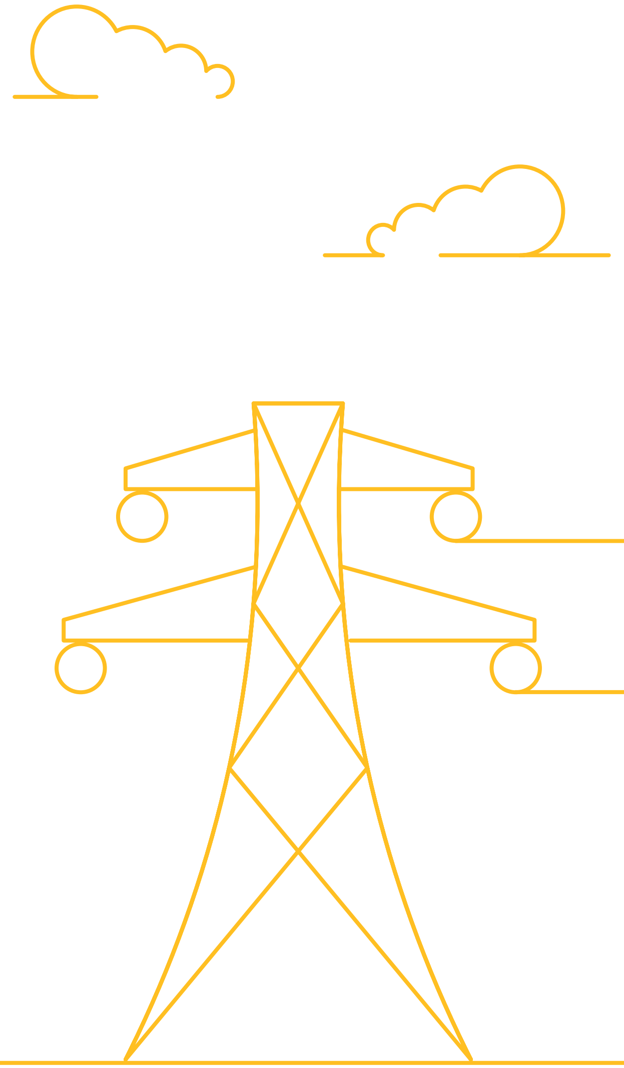
The transfer of energy across our network boundaries occurs because generation and demand are usually in different locations. When the power transfer across a transmission system boundary is above that boundary's capability, our control room must reduce the transfer to avoid overloading the transmission assets. This is called 'constraining' the network.

When this happens, we ask generators on the exporting side of the stressed boundaries to limit their output. To maintain an energy balance, we replace this energy with generation on the importing side. Balancing the network by switching generation on and off costs money, and if we are regularly constraining the network by large amounts, costs begin to accumulate.

Assessment of future constraint costs is an important factor in our decision-making process. It enables us to evaluate and recommend investments such as adding new overhead lines and underground cables to the network. We call these potential investments 'options' and, although they cost money, they also increase the capability of the network, meaning that more power can be transferred across boundaries without the need to constrain.

We work with the TOs to upgrade the transmission networks at the right time in the right places to give the best balance between investing in the network and constraining it.

You can find out more information about the economic analysis in our full *NOA methodology report* (paragraphs 2.79 to 2.88). This includes a detailed explanation of the cost-benefit analysis, the single year least worst regret selection process and our economic modelling tool.



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Chapter 3

Proposed options

Introduction

This chapter summarises the reinforcement options that could increase the NETS boundary capability. It also provides an overview of the transmission system boundaries we've studied.

For a more detailed boundary description, please read our *ETYS* report. A summary of options that have started the SWW process are included in Appendix B – 'LOTI projects'. A more detailed description of the options, as well as the boundaries can be found in Appendix C – 'List of options'.

Most of the options we've analysed are large asset-based solutions but we've also explored small scale, low-cost solutions. These can include overhead line conductor re-profiling to increase operating temperature limits, or additional cooling. Operational options usually provide additional transfer capabilities without physically uprating the network. This is normally by operational measures (such as special running arrangements), sometimes with commercial arrangements. We give more details of alternative options in Table 2.2 in the *NOA methodology report*. Our role also includes early development of offshore options in accordance with Part D of licence condition C27. This is so that we can carry out *NOA* analysis of these options. You can find out more about this in 'The options' section of this chapter.

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The system boundaries

We use boundaries to represent pinch points on the electricity transmission network. How constrained the boundaries are varies from hour to hour throughout the year. Power flows across the system can be significantly impacted by changing demand and generation patterns.

Over the next 10 years, wind generation is forecast to increase to 40GW across Great Britain with a high concentrationed in Scotland and East Anglia. Demand is predominantly located in the south of the country leading to high north-south power flows with high variability. Interconnectors to other European electricity markets help to manage the electricity network, and increasing volumes of intermittent renewable generation, as well as better security and competition, but may also drive boundary reinforcement.

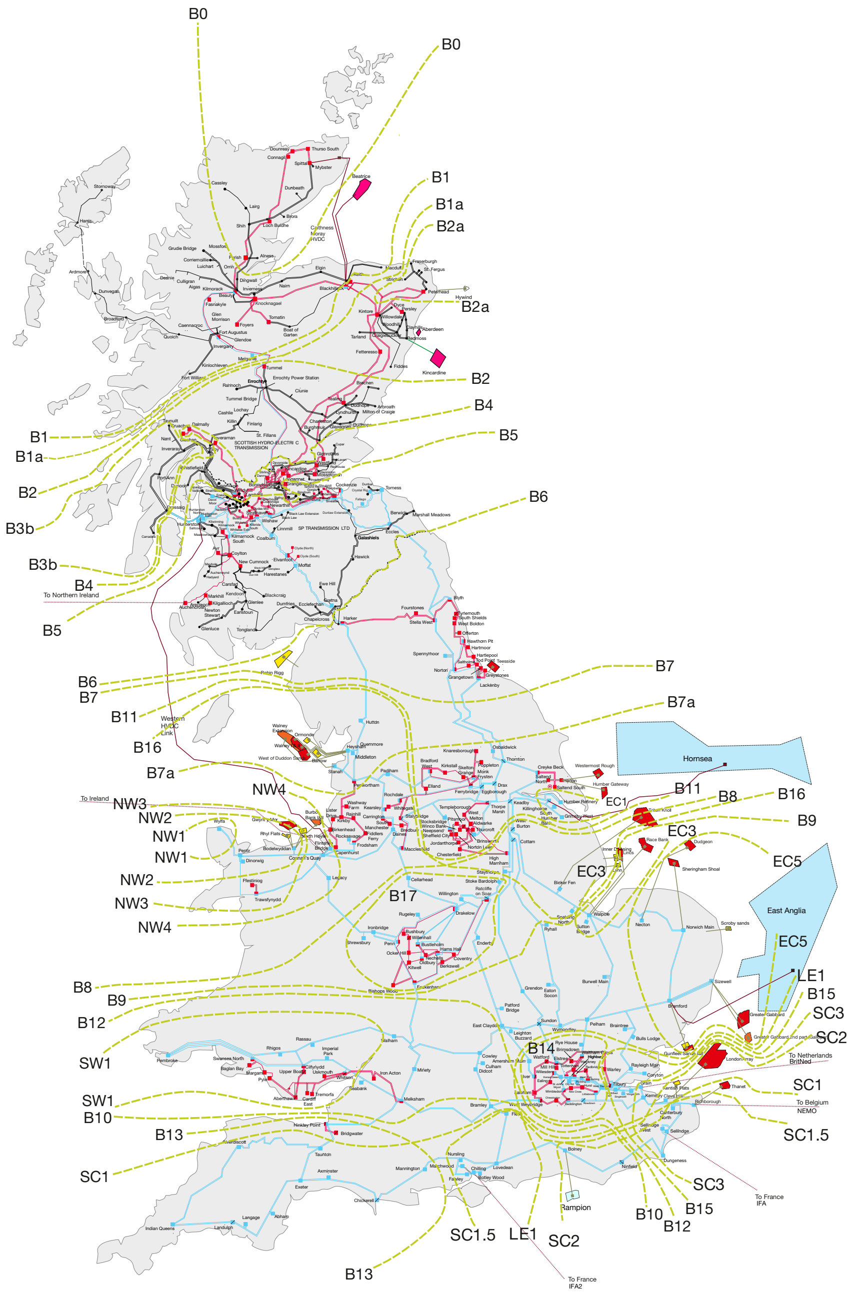
In the move to net zero over the next decade, the GB Transmission System will face growing needs in several regions by 2030:

- Increasing quantities of wind generation connected across the Scottish networks will more than double the north-to-south transfer.

- A potential growth of over 6GW in low-carbon generation and interconnectors in the North of England combined with high Scottish generation, will increase transfer requirements in the Midlands.

- A 10GW increase expected in generation coming from offshore wind on the east coast connecting to East Anglia, will increase the need for reinforcement.

- New Interconnectors connecting in the south of the country will also increase the transfer requirements on the network.



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The options

We provide an overview of the options in this chapter, with more detail in Appendix C – 'List of options' which is listed according to the option codes we use.

Options fall into two groups: asset-based options; and ESO proposed options. Some seek to use existing assets more intensively, though the costs of doing this can vary widely.

Thermal constraints

Thermal constraints are the most common constraints. The constraint 'bites' when a fault overloads the weakest component on the boundary. As the generation mix changes, even in the course of a single day, the overload can move from one area to another. The size of the overload and how much it moves influences the choice of investment. The cost of the proposed reinforcements, how much benefit they'll provide, and their delivery date also influence the choice. Options that could reduce thermal constraints include, but aren't limited to:

Upgrade existing circuits

Examples include replacing overhead line conductors, replacing sections of cable, or increasing the operating voltage, often from 275kV to 400kV. A cheaper approach where possible is to make the most of the clearance distance between overhead lines and nearby structures, trees and other objects. Adjusting the conductor profile, for instance, by re-tensioning the conductors can maintain the clearance distance while carrying higher flows.

Develop new circuits

This might be offshore High Voltage Direct Current (HVDC) links or new onshore circuits, which often re-use existing assets.

Build a new substation or reconfigure an existing substation

The aim is usually to optimise the flows on a pair of overhead line circuits. When the loading isn't balanced, one side will tend to overload before the other. This is often a result of how the network has been configured to meet previous needs; for instance, the location of generation. Options improve the balance of flows by making the ends of two circuits as connected as possible. New substations and redirecting circuits into existing substations can achieve this. Sometimes fault (or short circuit) levels or other characteristics of the network prevent us from electrically connecting substations at the end of heavily-loaded circuits. Some options replace switchgear and other substation infrastructure to change how we operate the substation and ease the constraint.

NOA / Proposed options / The options 22

The options

Control power flow

If we want to alter the flow on a circuit, in some cases, it's worth investing in suitable equipment. We can use quad boosters (QBs) and series compensation, usually reactors, and we expect new technology to become an option that uses solid-state electronics to control the flows.

Alternative options

These include two categories: operational options and reduced-build options. Where possible, we use low-cost means to control thermal loadings while meeting NETS SQSS requirements. One approach is to reduce the loading on an overloaded circuit after a fault, for example, by quickly reducing generation.

This can be by special arrangement with one or more generators for fast de-load services or an intertrip. Payment for the service is subject to the scale and competitiveness of the market. Another approach is to use dynamic ratings where we monitor a circuit's temperature or its immediate environment. This might allow us to increase the rating slightly and relieve the constraint.

Voltage and stability constraints

Some of the approaches detailed above affect the transmission system's voltage performance and we need to take this into account when designing the system. We do have means to manage the system voltages using asset- based solutions such as shunt reactors, shunt capacitors, synchronous compensators and static reactive compensators ('STATCOMs', 'SVCs'). We also use commercial solutions by contracting with customers to produce or consume reactive power but this involves an ongoing cost. We can experience stability constraints on weaker parts of the network, particularly when flows are high. Strengthening the network is often necessary but we are exploring other approaches, such as fast intertrips and series capacitors, to improve the boundary capability.

ESO-led commercial solutions

Commercial solutions formed an integral part of our *NOA* analysis. In this assessment, they are included in the same way as asset-based reinforcements and form part of the final 'optimal' paths, depending on where the analysis indicates they are needed.

Commercial solutions can be contracted flexibly and don't have a fixed 'asset life' or duration so we've assessed when to discontinue them. We factor the availability and arming fee into the operational costs based on our historical data.

Commercial solutions aren't free of capital costs, but only need a relatively small initial investment (mostly on communication and control systems). This, together with the flexibility of their contracts, makes commercial solutions a reasonable alternative option.

Figure 3.1 groups the options for this year's *NOA* and gives the total number for each category. Each option has an associated icon which will be used throughout the report.

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The options

Figure 3.1 The reinforcement options in their categories.

	Total
Develop new circuits	48
Control power flow	27
Build a new substation or reconfigure an existing substation	7
Upgrade existing circuits	50
Voltage and stability constraints	27
Alternative options	4
ESO-led commercial solutions	8

171 options submitted for economic analysis.

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Excluded options

While this report looks at options that could help meet major NETS reinforcement needs, it doesn't include:

- projects which do not increase the transfer of power across critical system boundaries.
- options that provide benefits, such as voltage control during low demand periods in the summer, but no boundary capability improvement. These will be published separately as part of our *NOA* Pathfinder projects.
- analysis of options where the costs would be prohibitive for the expected benefits.
- long-term conceptual options submitted by the TOs to support the analysis; this is explained in more detail next.

Long-term conceptual options

We recommend options for the upcoming investment year, and optimum delivery dates over the next few decades. This long-term strategy allows the TOs to evolve and develop their electricity transmission networks to deliver the best value for consumers.

We receive a wide range of options from the TOs for analysis and comparison, which we then assess for cost and benefit. However, development of reinforcement in the network will be a continuous process where the costs for some options in the distant future are unknown. To represent these long-term eventual reinforcements in our economic analysis, the TOs may also provide more conceptualised reinforcements to support the long-term future network.

These options are in the very early stages of development and are included in the *NOA* process as an indicator for additional long-term reinforcement. Due to the conceptual nature of these reinforcements, it is highly likely that their costs are not reflective of the final design. Whilst the *NOA* will make recommendations on asset-based options, it does not include long-term conceptual options and so their costs are not counted in the overall total CAPEX of the *NOA* report has recommended reinforcement profile.

Offshore Wider Works

For *NOA* 2020/21, our approach has been to create conceptual OWW reinforcements that we can test to connect major offshore wind developments while taking account of the commissioning dates of those developments. We have developed a dedicated chapter to discuss our progress and more information can be found in Chapter 5 - 'Offshore Wider Works'.

There is now a greater drive towards integration due to the expansion of offshore wind, such as round 4. There is also a need to avoid several parties trying to gain consents in the same land corridors to bring their connections to the onshore transmission system. We recently published our final Phase 1 report on the costs and benefits of a more coordinated approach to connecting offshore electricity infrastructure. It includes a report on holistic planning of the offshore transmission network and proposals for changes to the offshore connections regime.

Chapter 4

Investment recommendations

Introduction

Here we present our investment recommendations from our analysis, which gives the most economic investment strategy for each scenario and enables us to identify our preferred options and the recommended next steps for works in each region.

£183m

Investing £183m this year

41

Through 41 asset-based options

£13.9bn

Total cost of £13.9bn

4

Develop 4 ESO-led commercial solutions

£2.1bn

Additional consumer benefit of up to £2.1bn

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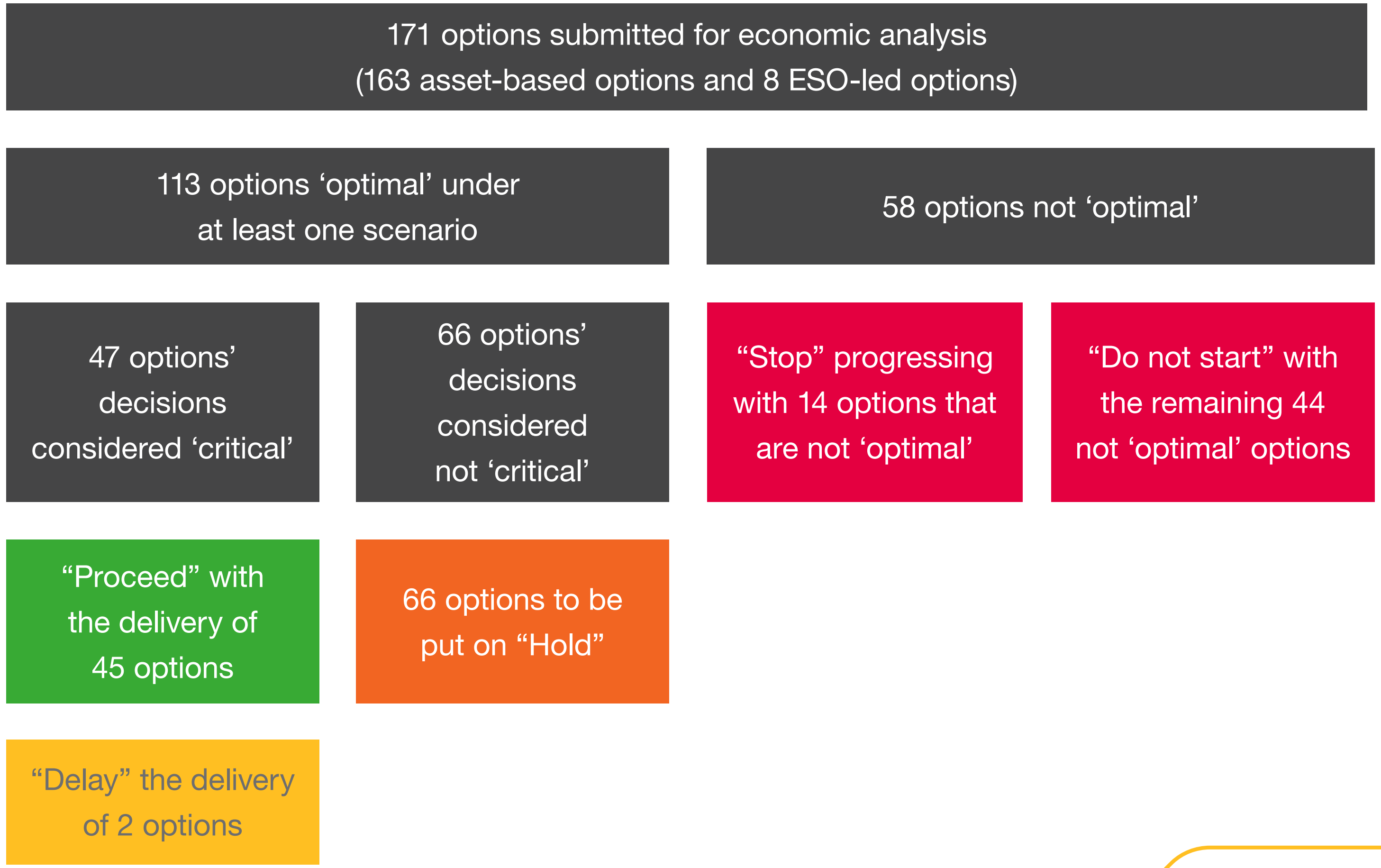
Introduction

Figure 4.1 Shows an overview of how the options went through the *NOA* process and obtained their recommendations

Figure 4.1 How the options went through the process



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Interpretation of the *NOA*

This section explains how to interpret the *NOA* outcomes, including the economic analysis results and our investment recommendations.

'Optimal' path and optimum delivery date

Our cost-benefit analysis investigates the economic benefits of different combinations of reinforcement options across four *Future Energy Scenarios*. We identify the single combination that provides the most value for the consumer, which we call the 'optimal' path. A reinforcement on this path is considered 'optimal' if it is in the 'optimal' path on any year in at least one scenario. An option is considered not 'optimal' if it does not appear in any of the 'optimal' paths. The 'optimal' path not only shows the most economic options but also their optimum completion years. If an option's optimum delivery date is its current earliest in service date (EISD) in at least one scenario, it is considered a 'critical' option, as an investment decision must be made by the TOs and/or relevant parties this year to meet the optimum delivery date. If under all scenarios, the optimum delivery date(s) of an option are later than its EISD, the option is not 'critical' and a decision can be put on hold until there is greater certainty.

'Critical' options' single year least regret analysis

A decision on each 'critical' option must be made this year by the TOs and/or relevant parties, so it is further assessed in our single year least regret analysis. This measures and compares the regret of delivering each 'critical' option against the regret of not delivering it. If a region has multiple 'critical' options, we compare the regret of delivering different combinations.

We always recommend the option, or combination of options, that minimises the levels of regret across all scenarios. If an option is driven by a single scenario, we will further investigate the drivers to ensure we make the right recommendation.

Economic regret

In economic analysis, the regret of an investment strategy is the net benefit difference between that strategy and the best strategy for that scenario. So, under each scenario, the best strategy will have a regret of zero, and the other strategies will have different levels of regret depending on how they compare to the best strategy. We always choose the strategy with the least regret across all scenarios. For more information, see Chapter 2 - 'Methodology'.

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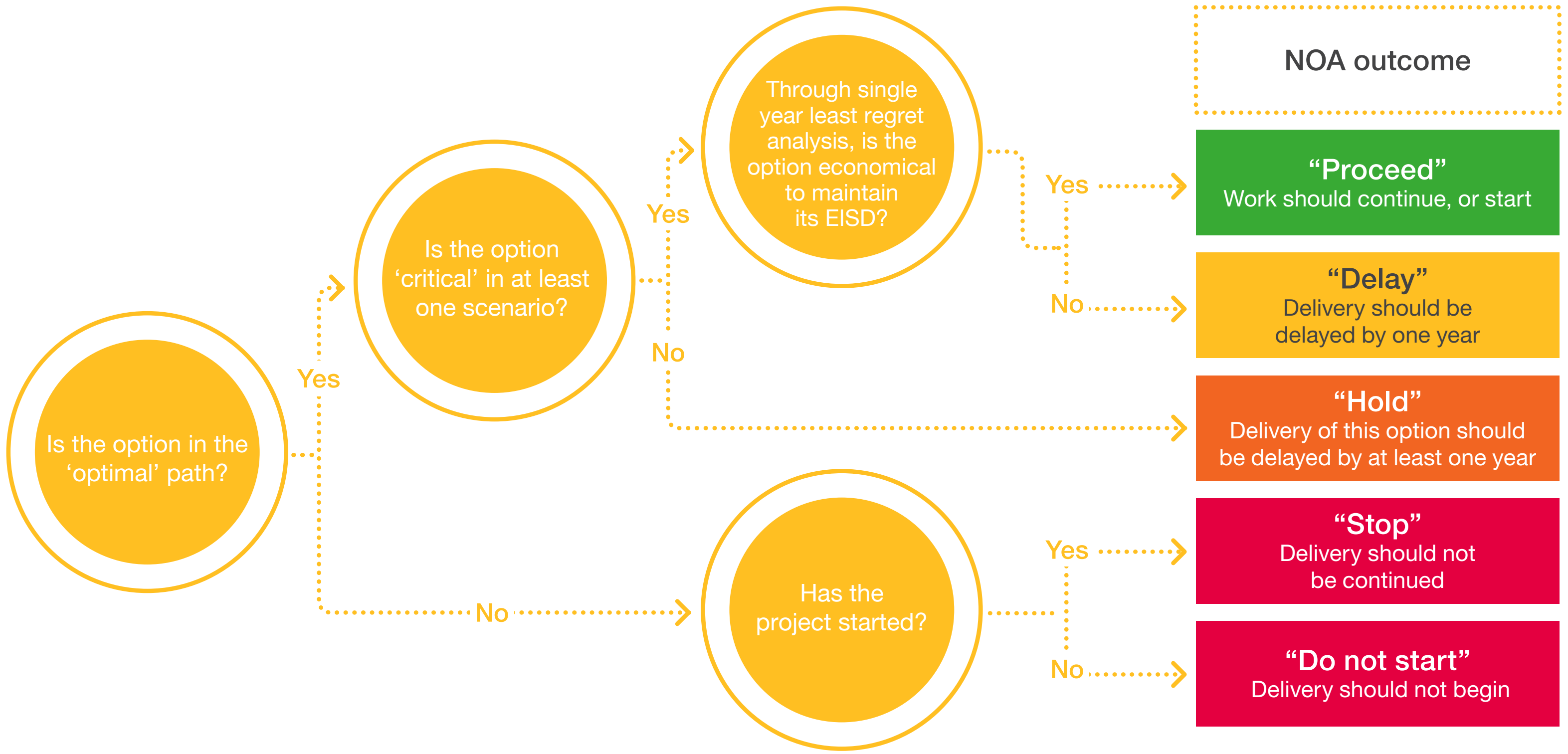
Interpretation of the *NOA*

Investment recommendations

Following the cost-benefit analysis and single year least regret analysis, we present the results to the *NOA* Committee for additional scrutiny. It focuses on marginal options where recommendations are driven by a single scenario or factor, or are considered sensitive in terms of stakeholder engagement.

The *NOA* Committee brings expertise from across the ESO, including knowledge on operability challenges, network capability development, commercial operations and insight into future energy landscapes. All options will be allocated to one of the outcomes outlined in the diagram below:



An option we don't recommend to "Proceed" can still be considered in any relevant LOTI assessment.

As our energy landscape is changing, our recommendations for an option may alter accordingly. This means an option we recommended to "Proceed" last year may be recommended for "Delay" this year, and vice versa. The benefit of the single year least regret analysis is that an ongoing project is revaluated each year to ensure its planned completion date remains best for the consumer.

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Interpretation of the *NOA*

Eligibility for onshore competition

We assess projects recommended for further development in the *NOA* for their eligibility for competition, and undertake the same assessments on future generator and demand connections to the transmission system.

This includes options we recommend to "Proceed" this year, SWW or LOTI projects with a Needs Case, and contracted connections.

In the competition assessment, we use three criteria: 'new', 'separable' and 'high value', proposed by Ofgem in their latest guidance, as indicators that an option is eligible for onshore competition. The option must fulfil all criteria to be considered.

- To assess if the option meets the 'new' criterion, we test whether it involves completely new assets or the complete replacement of an existing transmission asset.
- To assess if the option meets the 'separable' criterion, we test whether new assets can be clearly delineated from other (existing) assets.
- To assess if the option meets the 'high value' criterion, we assess whether the capital expenditure for the assets which meet the new and separable criteria is £100 million or more. We check costs provided by the TOs as part of our *NOA* process.

The ESO is currently developing the Early Competition Plan, which will set out how competitions could be run to design, build and own transmission assets. If Ofgem decides to introduce the early competition regime, it is proposed that *NOA* will identify projects that meet the early competition criteria alongside those that meet the late competition criteria. Projects that meet the early competition criteria would begin the competitive process prior to the preliminary works stage of project development. Further information on the early competition plan can be found on our website.

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The *NOA* outcomes

This section presents the results of our economic analysis, investment recommendations, and eligibility for onshore competition.

For each region, we focus on the following aspects to identify our final investment recommendations:

- The 'optimal' paths by scenario, which highlight 'optimal' options and their delivery dates.
- 'Critical' options from the 'optimal' paths and single year least regret analysis, which produce the "Proceed" and "Delay" recommendations.
- Drivers such as system needs or changes to the energy landscape and network.

The main outputs of the economic analysis, including 'optimal' paths and initial investment recommendations, are shown in Table 4.1, Table 4.5 and Table 4.9 for the three regions. The 'optimal' options are listed in four-letter codes (as detailed in Appendix C – 'List of options') with the optimum delivery dates highlighted in different colours for different scenarios. If an option is not in the optimal path of a scenario, no optimum delivery year will be highlighted.

The initial recommendations are indicated by different shadings in Table 4.1, Table 4.5 and Table 4.9. 58 options were not currently 'optimal' under any of the scenarios and are not included. The initial recommendation for those is either "Do not start" or "Stop" if work is already in progress.

The economic analysis and initial recommendations were then further scrutinised by the *NOA* Committee and the final recommendation for each option is shown on the interactive map in the Recommendations for each option. There may be differences between initial and final recommendations for some options. In the interests of transparency, we publish the minutes from the *NOA* Committee meetings on our website. A full list of 'optimal' options for each region with descriptions and optimum delivery dates can be found in Recommendations for each option of the report. Some options are marked as 'N/A' as they are not optimal under that particular scenario.

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Scotland and north of England region

Background setting and context

- Scotland and the north of England is typically an 'exporting' region where installed generation capacity is more than enough to supply the local demand. Larger demand areas lie in central and south of England and so the energy flows across the Scottish and northern English boundaries are predominantly north-to-south, which is the main driver for reinforcements.
- All four scenarios suggest different levels of growth in low-carbon and renewable generation, in addition to new storage and interconnector developments. The similarity is that wind energy is the main contributor. With Leading the Way, System Transformation and Consumer Transformation hitting the net-zero CO_2 target by 2050, these three scenarios will see a much faster build-up of wind and a much higher total installed capacity in Scotland and the north of England. As a result, we need more reinforcements delivered on their EISDs to meet the transfer requirement in those three scenarios. On the other hand, the Steady Progression scenario which fails to meet the 2050 target is less demanding on transfer capability and therefore fewer reinforcements are required. We include our recommendation and detailed narratives for each of the reinforcements in the 'optimal' path tables. Here are some highlights of our recommendations:

This year several new options were submitted for analysis. These include an additional 2GW eastern HVDC Subsea link from south east Scotland to south Humber region, and several new onshore reinforcements from the south east of Scotland to the north of England and into the midlands facilitating high north to south power flows. For more information about these new options, see TGDC, CMNC, and EDNC on the 'optimal' path tables.

This *NOA* included 10 eastern subsea HVDC link options between England and Scotland. These fall into four different categories based on their connection locations. From the analysis, we confirmed the need for four subsea links to accommodate the increasing north-to-south flows. These are from:

- South east Scotland to northern England (E2DC)
- North east Scotland to northern England (E4D3)
- North east Scotland to south Humber (E4L5)
- South east Scotland to south Humber (TGDC)

The analysis recommends proceeding with the Torness to Hawthorn Pit option as the first eastern link (E2DC), the Peterhead to Drax option as the second Eastern HVDC link (E4D3) and the north east Scotland to south Humber (E4L5) option as the third link. In addition, due to the high transfer requirement in the north region this year, we see a strong need for a fourth link from south east of Scotland to the South Humber area (TGDC) as well. These options are needed across all scenarios consistently.

We continued to explore how commercial solutions may help further reduce constraint costs. In this *NOA*, our improved methodology means commercial solutions can be decommissioned to reflect a flexible service life. For this year's analysis, the commercial solutions are also split into two stages to allow for a more granular investigation of the benefit required. We found two-stage commercial solutions are beneficial in this region and recommend developing them further. For more information, see the hover over text for CS05 & CS06 on Table 4.1

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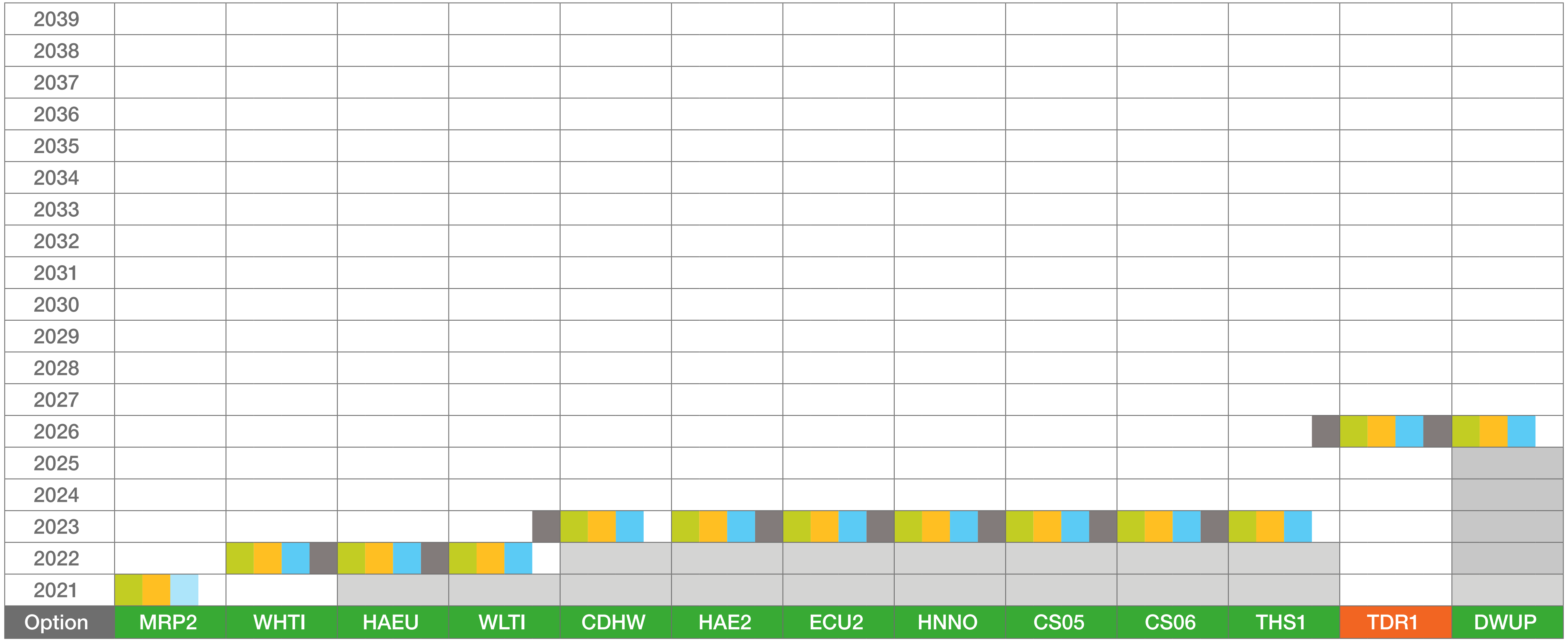
Scotland and north of England region (continued)

Table 4.1 Scotland and the north of England region

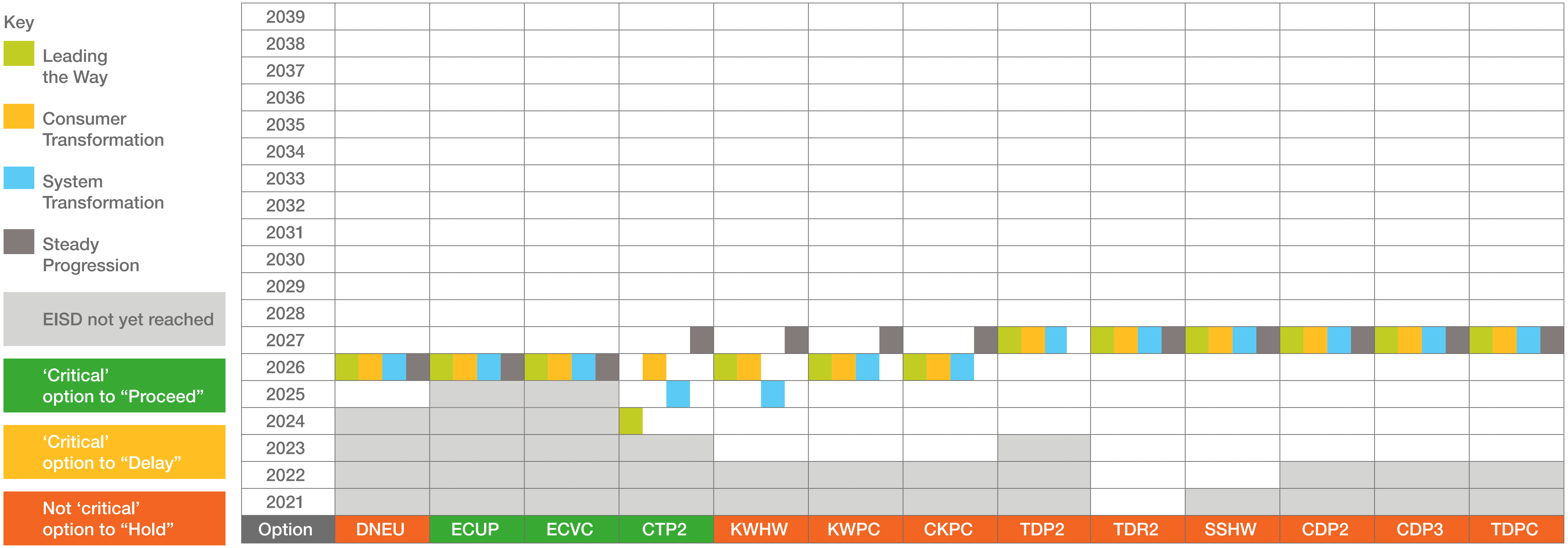
Key

- Leading the Way
- Consumer Transformation
- System Transformation
- Steady Progression
- EISD not yet reached
- 'Critical' option to "Proceed"
- 'Critical' option to "Delay"
- Not 'critical' option to "Hold"



Hover over the option codes, at the bottom of the table for further information

Scotland and north of England region (continued)



Hover over the option codes, at the bottom of the table for further information

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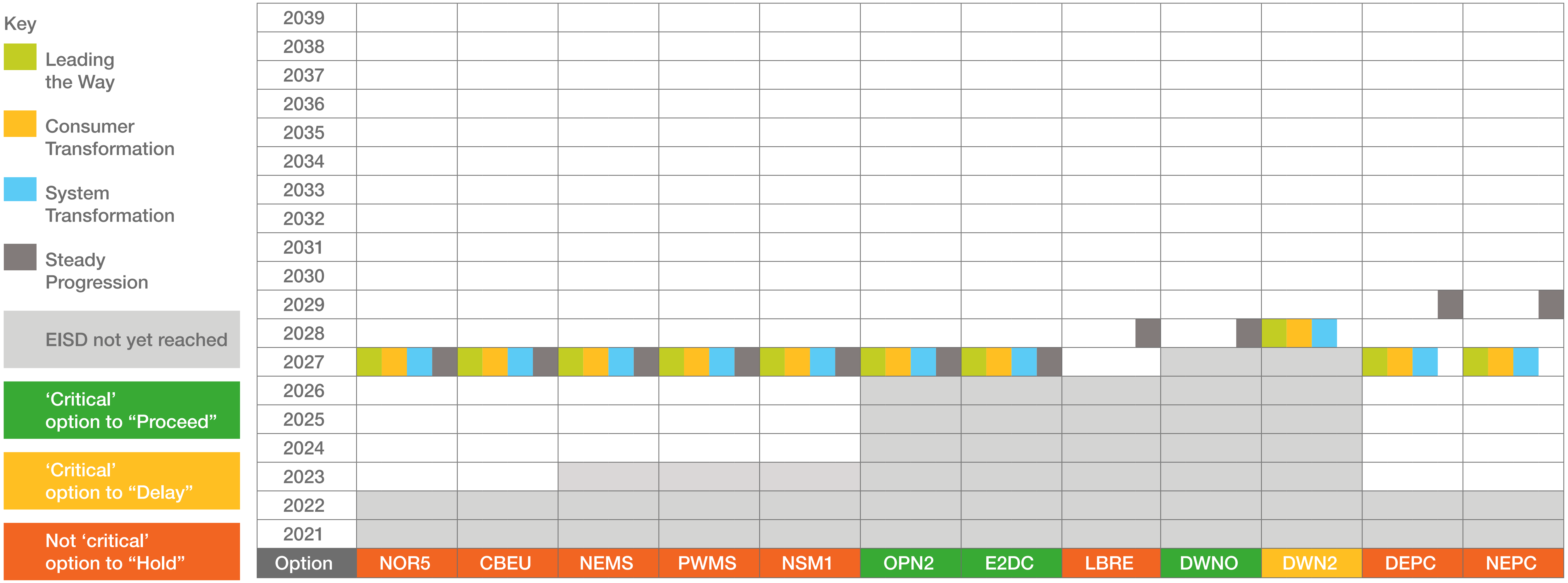
Scotland and north of England region (continued)



Hover over the option codes, at the bottom of the table for further information

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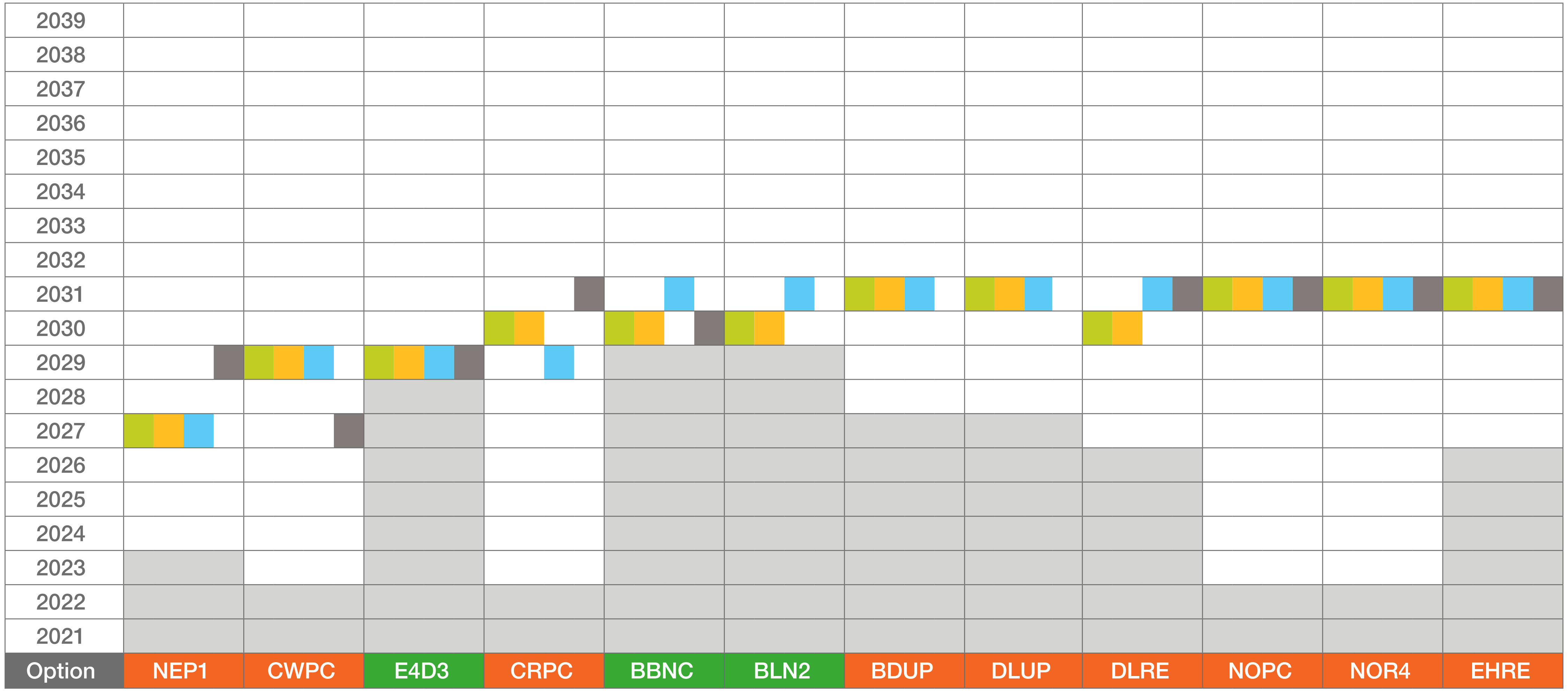
Scotland and north of England region (continued)

Key

- Leading the Way
- Consumer Transformation
- System Transformation
- Steady Progression
- EISD not yet reached
- 'Critical' option to "Proceed"
- 'Critical' option to "Delay"
- Not 'critical' option to "Hold"



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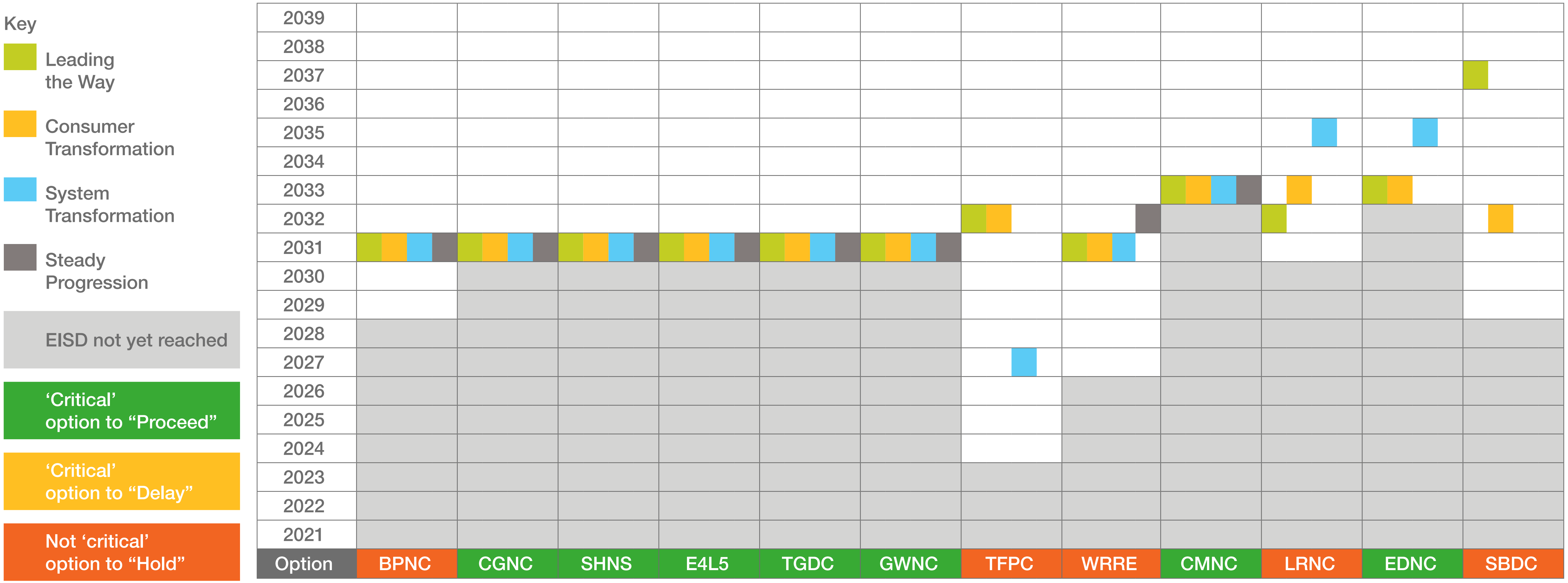
Scotland and north of England region (continued)



Hover over the option codes, at the bottom of the table for further information

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Scotland and north of England region (continued)

For Scotland and the north of England region, we identified 62 'optimal' options as shown in Table 4.1. Their optimum delivery dates are highlighted in different colours for different scenarios.

Of the 62 'optimal' options, 28 are 'critical' in at least one scenario, and can receive "Proceed" or "Delay" recommendations.

The optimum delivery years of the following options are the same as their EISDs across all four scenarios. These 17 options, as seen in Table 4.2, don't need to be assessed in the single year least regret analysis, as progressing them to maintain their EISDs is the optimum course of action under all scenarios.

Table 4.2 'Critical' options in all scenarios in Scotland and north England region

Code	Option description
CGNC	A new 400kV double circuit between Creyke Beck and south Humber
CMNC	South east Scotland to north west England AC onshore reinforcement
CS05	Commercial solution for Scotland and the north of England - stage 1
CS06	Commercial solution for Scotland and the north of England - stage 2
E2DC	Eastern subsea HVDC link from Torness to Hawthorn Pit
E4D3	Eastern Scotland to England link: Peterhead to Drax offshore HVDC
E4L5	Eastern Scotland to England 3rd link: Peterhead to south Humber offshore HVDC
ECU2	East Coast onshore 275kV upgrade
ECUP	East Coast onshore 400kV incremental reinforcement
ECVC	Eccles hybrid synchronous compensators and real-time rating system
GWNC	A new 400kV double circuit between south Humber and south Lincolnshire
HAE2	Harker supergrid transformer 6 replacement
HAEU	Harker supergrid transformer 5 and supergrid transformer 9A banking arrangement
HNNO	Hunterston East–Neilston 400kV reinforcement
OPN2	A new 400kV double circuit between the existing Norton to Osbaldwick circuit Poppleton and relevant 275kV upgrades
SHNS	Upgrade substation in south Humber area
TGDC	Eastern subsea HVDC link from south east Scotland to south Humber

Scotland and north of England region (continued)

This leaves 11 options which are 'critical' in some, but not all, scenarios, as seen in Table 4.3, and just over 2048 different possible combinations of the following reinforcements on which we performed the single year least regret analysis. The least regret strategy is to "Proceed" with all critical options except DWN2 - Denny to Wishaw 400kV reinforcement.

Table 4.3 'Critical' options in at least one scenario in Scotland and north England region

Code	Option description
BBNC	Beauly to Blackhillock 400kV double circuit addition
BLN2	Beauly to Loch Buidhe 275kV reinforcement
CDHW	Cellarhead to Drakelow circuits thermal uprating
CTP2	Alternative power control device along Creyke Beck to Thornton
DWN2	Denny to Wishaw 400kV reinforcement
DWNO	Denny to Wishaw 400kV reinforcement
DWUP	Establish Denny North-Clydesmill-Wishaw single 400kV circuit from existing 275kV circuits
EDNC	Uprate Brinsworth and Chesterfield to double circuit to 400kV and a new 400kV double circuit between Ratcliffe and Chesterfield
MRP2	Additional power control devices at both Harker and Penwortham
THS1	Installation of a single series reactor at Thornton substation
WLTI	Windyhill–Lambhill–Longannet 275kV circuit turn-in to Denny North 275kV substation

NOA / Investment recommendations / Scotland and north of England region 40

Scotland and north of England region (continued)

In summary, we recommend progressing with the following reinforcements in Scotland and the north of England region:

Table 4.4 Options to progress in Scotland and north of England region

Code	Option description	To meet its EISD of:
MRP2	Additional power control devices at both Harker and Penwortham	2021
WHTI	Tee-in of the West Boldon to Hartlepool circuit at Hawthorn Pit	2021
CDHW	Cellarhead to Drakelow circuits thermal uprating	2023
HAEU	Harker supergrid transformer 5 and supergrid transformer 9A banking arrangement	2022
WLTI	Windyhill–Lambhill–Longannet 275kV circuit turn-in to Denny North 275kV substation	2022
CS05	Commercial solution for Scotland and the north of England - stage 1	2023
CS06	Commercial solution for Scotland and the north of England - stage 2	2023
ECU2	East Coast onshore 275kV upgrade	2023
HAE2	Harker supergrid transformer 6 replacement	2023
HNNO	Hunterston East–Neilston 400kV reinforcement	2023
THS1	Installation of a single series reactor at Thornton substation	2023
CTP2	Alternative power control device along Creyke Beck to Thornton	2024
DWUP	Establish Denny North-Clydesmill-Wishaw single 400kV circuit from existing 275kV circuits	2026
ECUP	East Coast onshore 400kV incremental reinforcement	2026
ECVC	Eccles hybrid synchronous compensators and real-time rating system	2026
E2DC	Eastern subsea HVDC link from Torness to Hawthorn Pit	2027
OPN2	A new 400kV double circuit between the existing Norton to Osbaldwick circuit and Poppleton and relevant 275kV upgrades	2027
DWNO	Denny to Wishaw 400kV reinforcement	2028
E4D3	Eastern Scotland to England link: Peterhead to Drax offshore HVDC	2029
BBNC	Beauly to Blackhillock 400kV double circuit addition	2030
BLN2	Beauly to Loch Buidhe 275kV reinforcement	2030
CGNC	A new 400kV double circuit between Creyke Beck and south Humber	2031
E4L5	Eastern Scotland to England 3rd link: Peterhead to the south Humber offshore HVDC	2031
GWNC	A new 400kV double circuit between south Humber and south Lincolnshire	2031
SHNS	Upgrade substation in the south Humber area	2031
TGDC	Eastern subsea HVDC link from south East Scotland to south Humber	2031
CMNC	South east Scotland to north west England AC onshore reinforcement	2033
EDNC	Uprate Brinsworth and Chesterfield to double circuit to 400kV and a new 400kV double circuit between Ratcliffe and Chesterfield	2033

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Eligibility assessment for onshore competition

Following this, we conducted eligibility assessments for onshore competition for all reinforcements recommended to proceed this year in Scotland and the north of England. The following options meet the competition criteria proposed by Ofgem:

- Beauly to Loch Buidhe 275kV reinforcement (BLN2)
- Beauly to Blackhillock 400kV double circuit addition (BBNC)
- Eastern Scotland to England link: Peterhead to Drax offshore HVDC (E4D3)
- Eastern Scotland to England 3rd link: Peterhead to the south Humber offshore HVDC (E4L5)
- Eastern subsea HVDC link from Torness to Hawthorn Pit (E2DC)
- Eastern subsea HVDC link from south east Scotland to south Humber area (TGDC)
- South east Scotland to north west England AC onshore reinforcement (CMNC)
- A new 400kV double circuit between the existing Norton to Osbaldwick circuit and Poppleton and relevant 275kV upgrades (OPN2)
- A new 400kV double circuit between Creyke Beck and the south Humber region (CGNC)
- A new 400kV double circuit between the south Humber area and South Lincolnshire (GWNC)
- Uprate Brinsworth and Chesterfield to double circuit to 400kV and a new 400kV double circuit between Ratcliffe and Chesterfield (EDNC)

The options OPN2 and EDNC would have to be split to meet the competition criterion for separability. We also assessed all new or modified contracted connection projects in this region. We identified the following projects which meet the competition criteria proposed by Ofgem:

- 2nd Shetland HVDC link Kergord - Rothienorman
- Dounreay - Orkney 220kV Subsea HVAC Cable link 1
- Dounreay - Orkney 220kV Subsea HVAC Cable link 2
- Western Isles - Beauly HVDC link
- Skye 2nd Circuit reinforcement
- North Argyll substation
- North Argyll - Craig Murrail 275kV Operation
- Glenmuckloch to ZV Route reinforcements

The Orkney and Western Isles links are current SWW projects led by SHE Transmission. Please see Ofgem's website for more information and updates on these projects. The second Shetland link and second Orkney link are not at present live projects and have yet to progress to their LOTI stage. The Argyll and Skye projects are proposed for connections with the latter having non-load asset replacement aspects and each at varying stages of development.

NOA / Investment recommendations / Scotland and north of England region 42

The south and east England region

Background setting and context

The south and east region includes East Anglia and London, touches the Midlands and stretches along the south coast to Devon and Cornwall. The region has a high concentration of power demand and generation, with high demands in London and increased generation capacity in East Anglia and the Thames Estuary. The south coast has several interconnectors that influence power flows in the region through the import and export of power with Europe.

Offshore renewable generation is expected to grow in East Anglia and more interconnectors will be commissioned in the south coast and East Anglia. Combined with the increase in renewable generation in other parts of the country, we expect that the main driver of constraints in the long term will be the north-to-south flows through the region, as well as the flows through and across the East Anglia area.

We have included our recommendation and detailed narratives for each of the reinforcements in Table 4.5. Highlights of our recommendations include:

- BTNO, a new double circuit in East Anglia, supports the export of power out of the area and reinforces the south east area. BTNO continues to be 'critical' in all scenarios due to high exports from East Anglia.
- SCD1 that builds an offshore HVDC link between Suffolk and Kent and bypasses the most constrained areas. As the HVDC link can be configured to transfer power in both directions, it can benefit multiple areas in the south and east region. SCD1 continues to be 'critical' in two scenarios and 'optimal' in all.
- HWUP that upgrades one of the transmission routes that feeds power into London and onwards to the south coast interconnectors.
- A set of three new transmission routes (options AENC, ATNC and TENC) that facilitate power flows from East Anglia to the south coast.

Furthermore, we found that CS07 and CS08, two ESO-led commercial solutions for the East Anglia area, provide economic benefit in our assessment. Commercial solutions use operational measures from commercial providers to increase the volume of power that can be securely transferred through an area. CS07 was required in the 'optimal' paths in three of the scenarios while the CS08 was required in only two of them. These options are at an early stage of development.

Due to the proximity of many options and the large number of new generation connection works in the region, the necessary access to the network in order to deliver our recommendations is expected to be challenging. Recognising this, we have identified several options whose delivery plans should be co-optimised to facilitate the recommendations and the 'optimal' years outlined by *NOA* 2020/21. A detailed delivery plan for these options should be developed and submitted for the *NOA* 2021/22 assessment for the recommendations to be upheld. This is a necessary step to ensure the efficient, economic and coordinated planning of the future electricity transmission system.

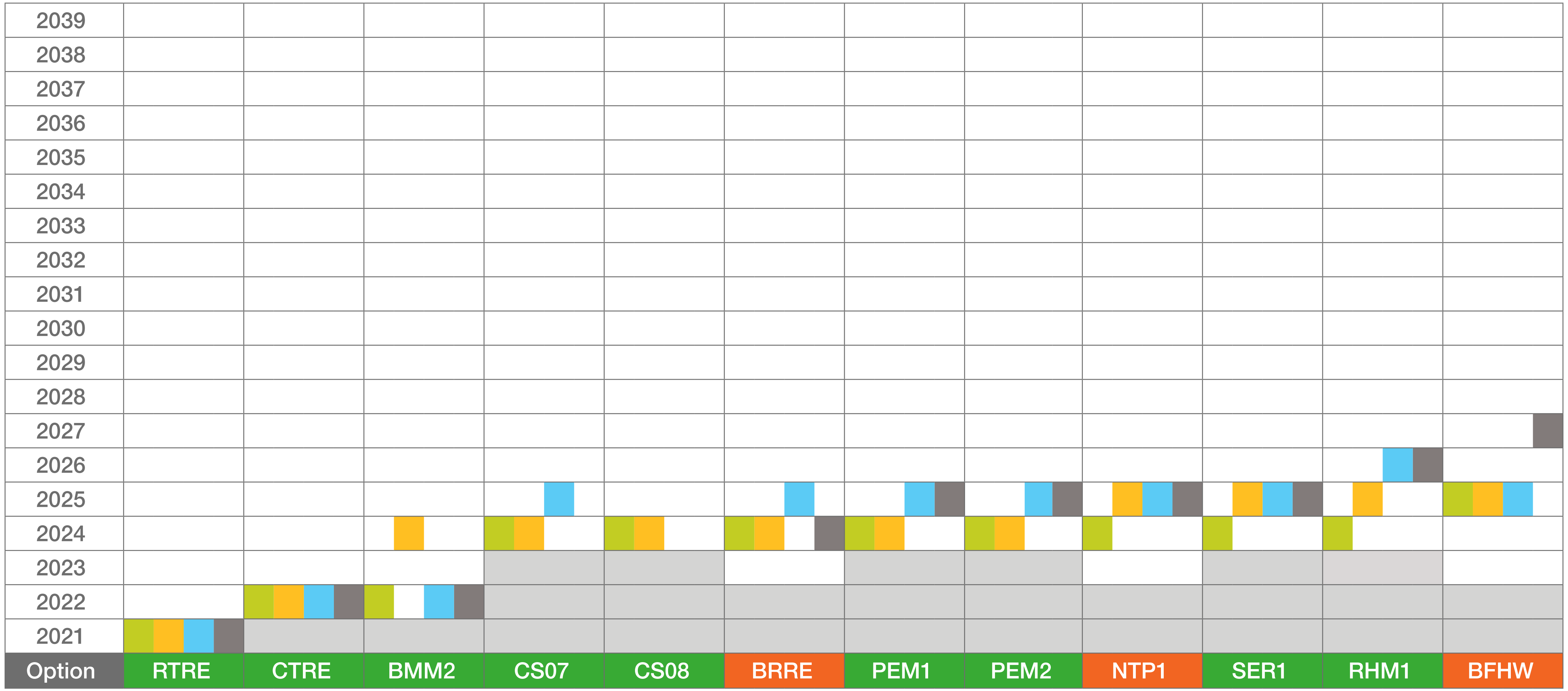
NOA / Investment recommendations / The south and east England region 43

The south and east England region (continued)

Key

- Leading the Way
- Consumer Transformation
- System Transformation
- Steady Progression
- EISD not yet reached
- 'Critical' option to "Proceed"
- 'Critical' option to "Delay"
- Not 'critical' option to "Hold"

Table 4.5 The south and east England region



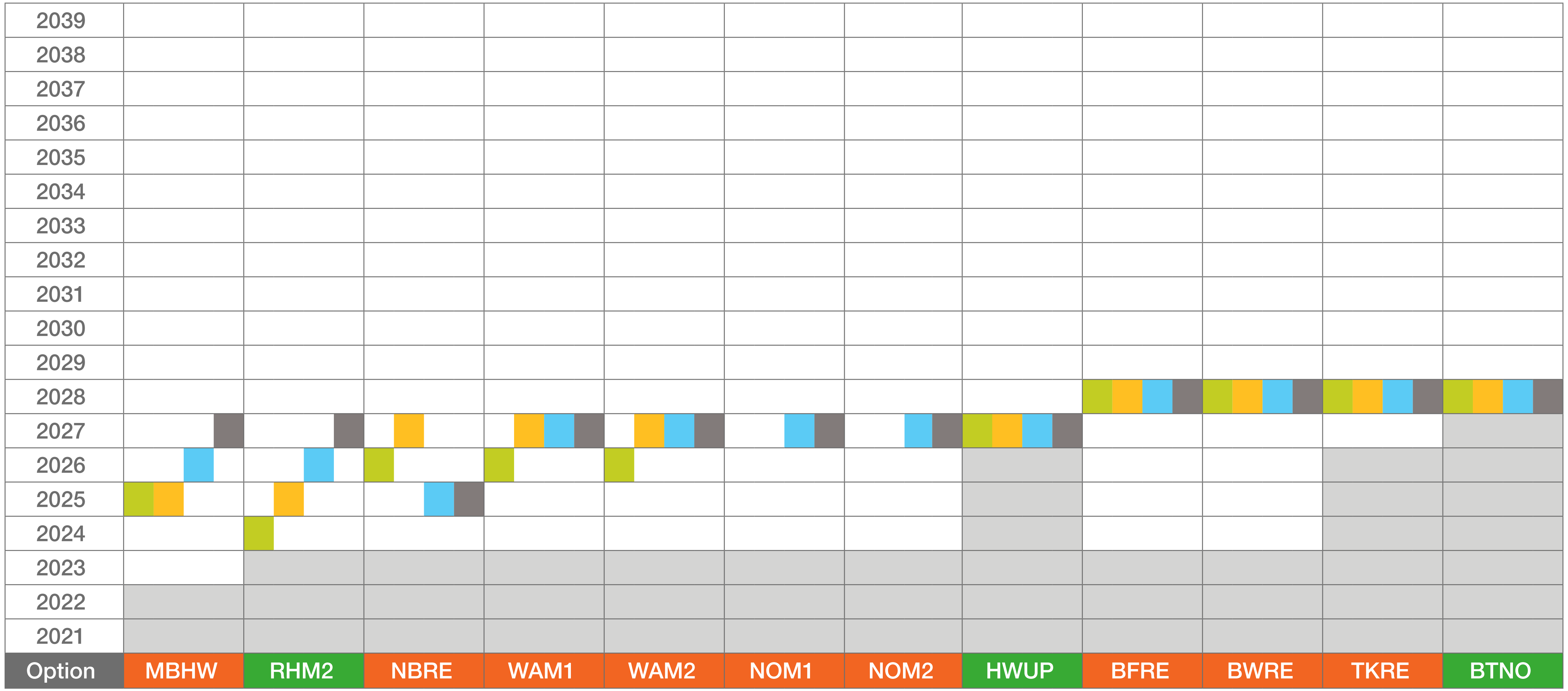
Hover over the option codes, at the bottom of the table for further information

NOA / Investment recommendations / The south and east England region 44

The south and east England region (continued)

Key

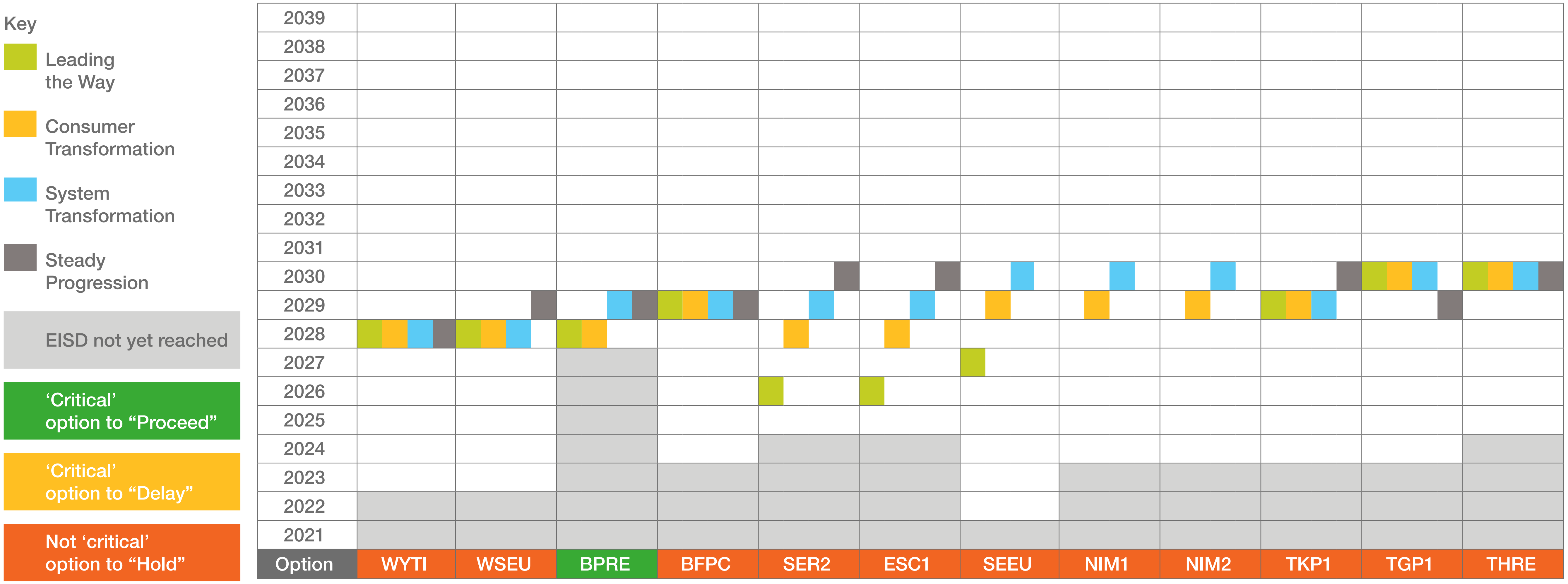
- Leading the Way
- Consumer Transformation
- System Transformation
- Steady Progression
- EISD not yet reached
- ‘Critical’ option to “Proceed”
- ‘Critical’ option to “Delay”
- Not ‘critical’ option to “Hold”



Hover over the option codes, at the bottom of the table for further information

NOA / Investment recommendations / The south and east England region 45

The south and east England region (continued)



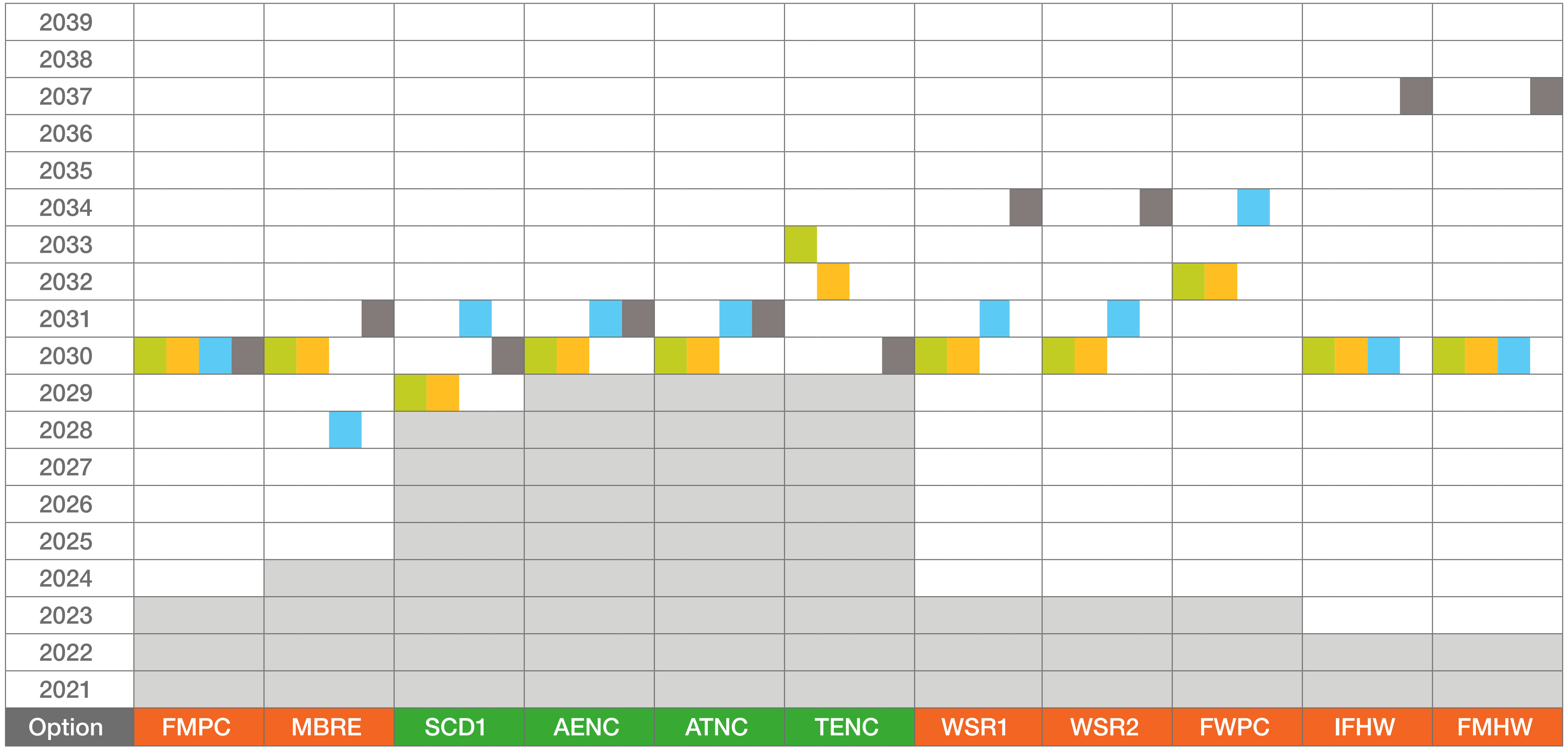
Hover over the option codes, at the bottom of the table for further information

NOA / Investment recommendations / The south and east England region 46

The south and east England region (continued)

Key

- Leading the Way
- Consumer Transformation
- System Transformation
- Steady Progression
- EISD not yet reached
- 'Critical' option to "Proceed"
- 'Critical' option to "Delay"
- Not 'critical' option to "Hold"



Hover over the option codes, at the bottom of the table for further information

NOA / Investment recommendations / The south and east England region 47

The south and east England region (continued)

For the south and east England region, we identified 47 'optimal' options as shown in Table 4.5. Their optimum delivery dates are highlighted in different colours for different scenarios.

Of the 47 'optimal' options, 13 are 'critical' in at least one scenario but they have optimum delivery years later than their EISD in some of the scenarios. The 11 asset based options from these could offer 2048 different combinations of "Proceed" or "Delay". The optimum delivery years for 4 options are the same as their EISDs across all four scenarios.

These 4 options, as seen in Table 4.6, don't need to be assessed in the single year least regret analysis, as progressing them to maintain their EISDs is the optimum course of action under all scenarios.

Table 4.6 'Critical' options in all scenarios in the south and east England region

Code	Option description
RTRE	Reconductor remainder of Rayleigh to Tilbury circuit
CTRE	Reconductor remainder of Coryton South to Tilbury circuit
HWUP	Uprate Hackney, Tottenham and Waltham Cross 275kV to 400kV
BTNO	A new 400kV double circuit between Bramford and Twinstead

This leaves 13 'critical' options, as seen in Table 4.7, where the least regret strategy is "Proceed" with all options.

Table 4.7 'Critical' options in at least one scenario in the south and east England region

Code	Option description
BMM2	225MVAr MSCs at Burwell Main
PEM1	225MVAr MSCs at Pelham
PEM2	225MVAr MSCs at Pelham
RHM1	225MVAr MSCs at Rye House
RHM2	225MVAr MSCs at Rye House
SER1	Elstree to Sundon reconductoring
BPRE	Reconductor the newly formed second Bramford to Braintree to Rayleigh Main circuit
SCD1	New offshore HVDC link between Suffolk and Kent option 1
AENC	A new 400kV double circuit in north East Anglia
ATNC	A new 400kV double circuit in south East Anglia
TENC	Thames Estuary reinforcement
CS07	Commercial solution for East Anglia - stage 1
CS08	Commercial solution for East Anglia - stage 2

NOA / Investment recommendations / The south and east England region 48

The south and east England region (continued)

In summary, we recommend progressing with the following reinforcements in the south and east England region:

Table 4.8 Options to progress in south and east England region

Code	Option description	To meet its EISD of:
RTRE	Reconductor remainder of Rayleigh to Tilbury circuit	2021
BMM2	225MVAr MSCs at Burwell Main	2022
CTRE	Reconductor remainder of Coryton South to Tilbury circuit	2022
CS07	Commercial solution for East Anglia - stage 1	2024
CS08	Commercial solution for East Anglia - stage 2	2024
PEM1	225MVAr MSCs at Pelham	2024
PEM2	225MVAr MSCs at Pelham	2024
RHM1	225MVAr MSCs at Rye House	2024
RHM2	225MVAr MSCs at Rye House	2024
SER1	Elstree to Sundon reconductoring	2024
HWUP	Uprate Hackney, Tottenham and Waltham Cross 275kV to 400kV	2027
BPRE	Reconductor the newly formed second Bramford to Braintree to Rayleigh Main circuit	2028
BTNO	A new 400kV double circuit between Bramford and Twinstead	2028
SCD1	New offshore HVDC link between Suffolk and Kent option 1	2029
AENC	A new 400kV double circuit in north East Anglia	2030
ATNC	A new 400kV double circuit in south East Anglia	2030
TENC	Thames Estuary reinforcement	2030

NOA / Investment recommendations / The south and east England region 49

The south and east England region (continued)

Eligibility assessment for onshore competition

Following this, we conducted an eligibility assessment for onshore competition for all reinforcements recommended to “Proceed” this year in the south and east of England region. We identified the following options that meet the competition criteria proposed by Ofgem:

- A new 400kV double circuit between Bramford and Twinstead (BTNO)
- A new 400kV double circuit in north East Anglia (AENC)
- A new 400kV double circuit in south East Anglia (ATNC)
- Thames Estuary reinforcement (TENC)
- New offshore HVDC link between Suffolk and Kent option 1 (SCD1)

NOA / Investment recommendations / The south and east England region 50

Wales

Background setting and context

The west region includes north Wales and south Wales. Both the volume and timing of the constraints in this region are heavily dependent on the local generation profile that is forecast across the four scenarios.

In early years, north Wales experiences similar levels of flow both into and out of the region. A large volume of offshore wind capacity is forecasted to connect in the region in all four scenarios throughout the late 2020s and early 2030s. A mixture of biomass, solar and nuclear capacity is also expected to connect into the region which results in predominantly high flows out of the north Wales region, towards demand centres in the Midlands. This rise in export flows results in the requirement for reinforcements on the North Wales boundary in all four scenarios.

South Wales is typically an exporting region although there are some larger demand centres, such as Cardiff, Swansea and surrounding industry. Generation types in south Wales include wind, solar and gas plant. Some plants are due to close in the region, but new generation capacity is expected to connect in the future. The Consumer Transformation scenario experiences the highest growth in capacity in the region, which mainly consists of tidal generation capacity.

Here are some highlights of our recommendations:

- There was a total of 4 options studied in Wales in *NOA* 2020/21, all of which are 'optimal' in at least one scenario.
- There is a requirement to reinforce the North Wales boundary in all four scenarios. This requirement is driven by the build-up in generation capacity behind the boundary.
- The South Wales boundary requires reinforcing in one scenario, Consumer Transformation, which has the highest generation - including the earlier connection of tidal generation.

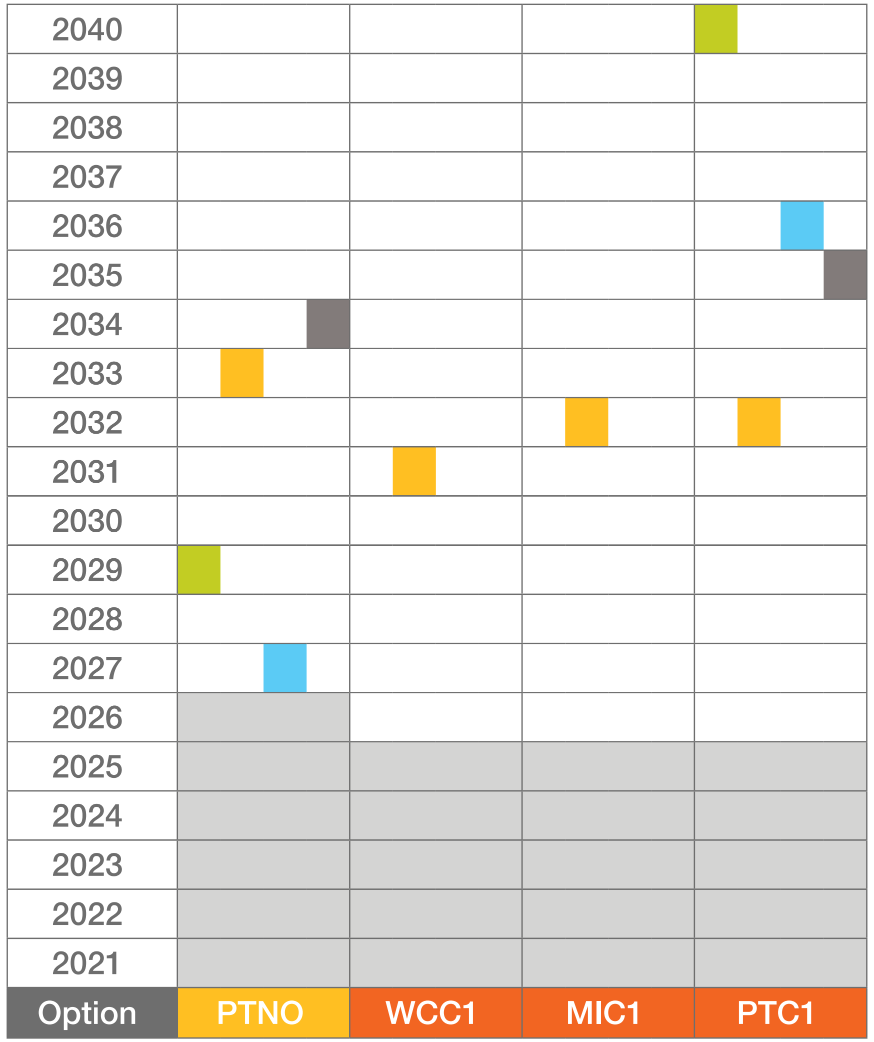
NOA / Investment recommendations / Wales 51

Wales (continued)

Key

- Leading the Way
- Consumer Transformation
- System Transformation
- Steady Progression
- EISD not yet reached
- 'Critical' option to "Proceed"
- 'Critical' option to "Delay"
- Not 'critical' option to "Hold"

Table 4.9 Wales



Hover over the option codes, at the bottom of the table for further information

In Wales, we identified 4 optimal options as shown in Table 4.9. Their optimum delivery dates are highlighted in different colours for different scenarios.

Of the 4 'optimal' options, one option, PTNO, was identified as 'critical'. No options in Wales had optimum delivery years the same as their EISDs across all four scenarios.

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Clean Energy Package

Regulation (EU) 2019/943 on the internal market for electricity (recast) as retained in UK law, also known as the Clean Energy Package, places requirements in Article 13 on planners and operators of networks.

The requirement, as part of the network planning process, is to limit the redispatch of generation from renewable sources to 5%, unless there is more than 50% of total energy being produced from renewable and high-efficiency cogeneration.

From the analysis as part of *NOA* 2020/21, in all scenarios we reach the 50% threshold in renewables and high-efficiency cogeneration this decade (Leading the Way 2024, Consumer Transformation and System Transformation 2025, and Steady Progression 2028). In terms of the quantity of redispatch, the figure is below or just above the threshold, but within the tolerance of the future energy scenarios and our modelling approach. The *NOA* itself provides recommendations for transmission investment to reduce redispatch but is limited by the options brought forward by the TOs and when these options can be delivered on to the network. In addition, in this year's analysis only two options received a "Delay" recommendation and neither of these options have EISDs which would have affected the results of the Clean Energy Package analysis. The two options are:

- Denny to Wishaw 400kV reinforcement (DWN2)
- North Wales reinforcement (PTNO)

The "Proceed" options help to reduce the energy to be redispatched from renewable sources.

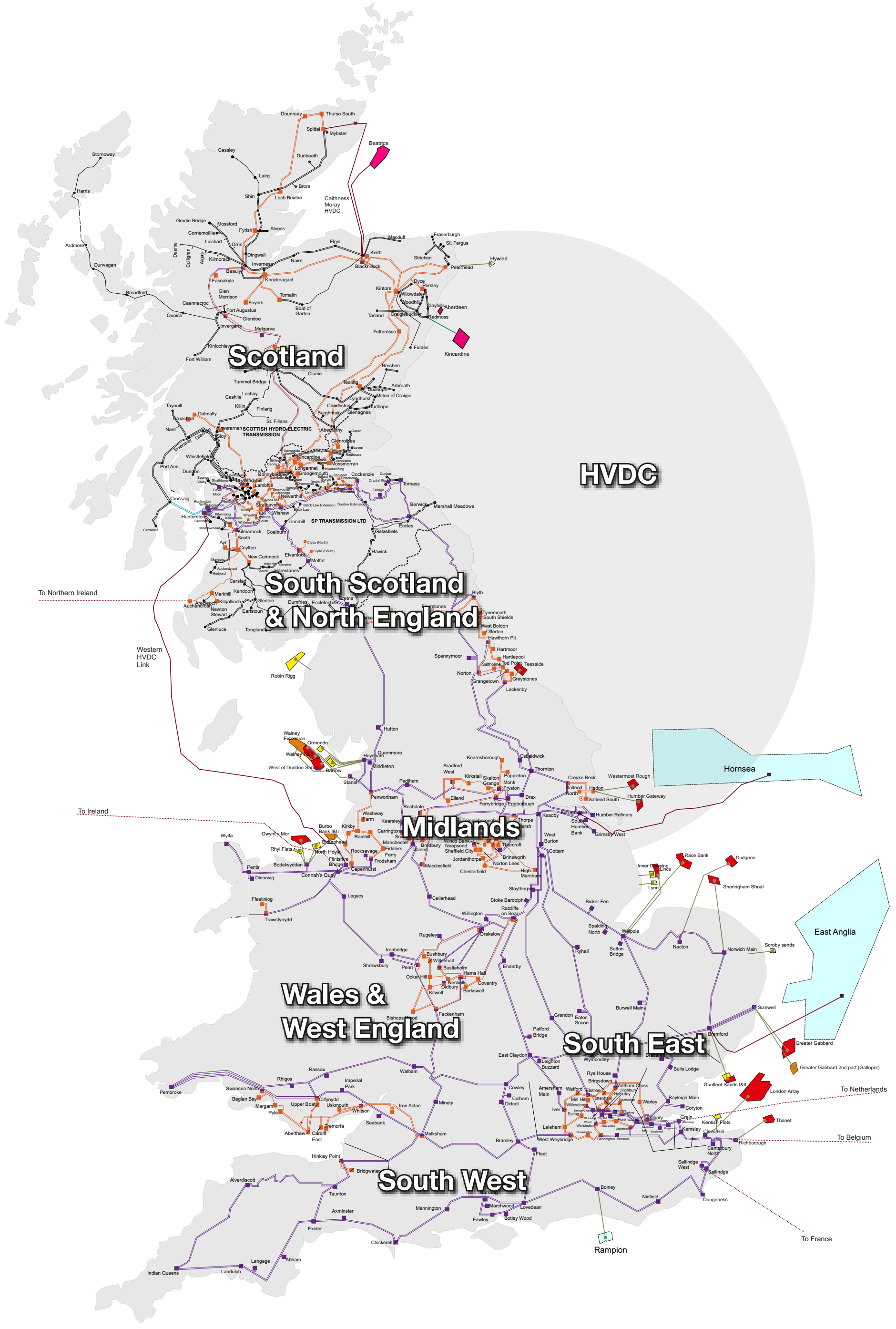
NOA / Investment recommendations / Clean Energy Package 53

Recommendations for each option

This section presents the recommendation for each option assessed in *NOA* 2020/21.

Here we highlight the options and their optimum delivery dates across the different scenarios. For a better understanding of how we make our *NOA* recommendations please refer to the flow diagram on page 30.

The following section provides a visual representation of the options and their recommendations. Options that have received a recommendation of "Do not start" are not shown in the visualisation as we currently do not see a future need for these reinforcements. To view these, and the full list of all the options and their recommendations, navigate to Table A.1, Table A.2 and Table A.3 in Appendix A – 'Economic analysis results'.



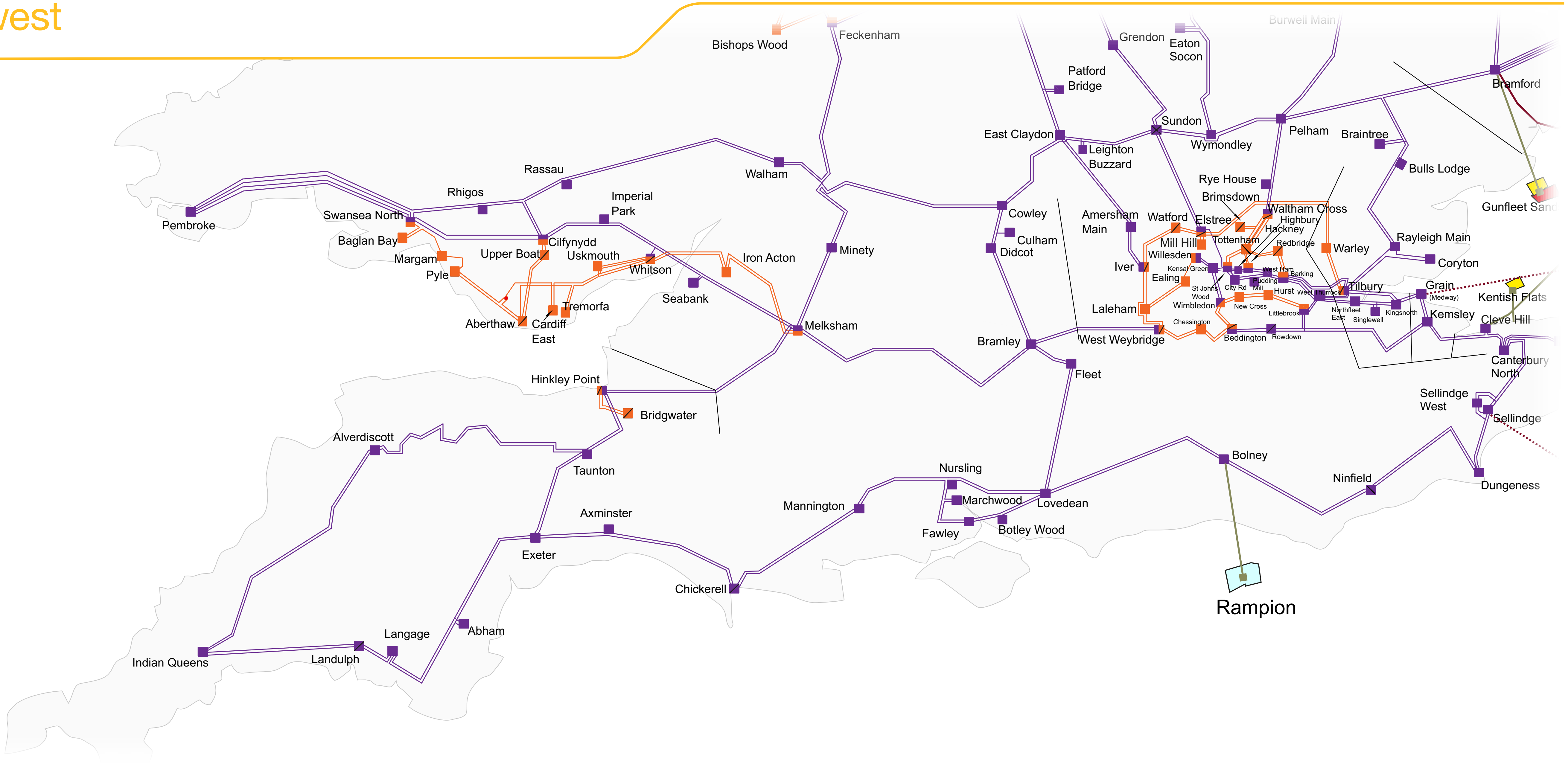
⊕ Boundaries

Disclaimer

All option routes and locations are for illustrative purposes only and are not intended to be an accurate representation of the planned route, locations and/or development of the National Electricity Transmission System, which are yet to be finalised. More details are included in the Disclaimer at the end of the publication.

NOA / Investment recommendations / Recommendations for each option 54

South west



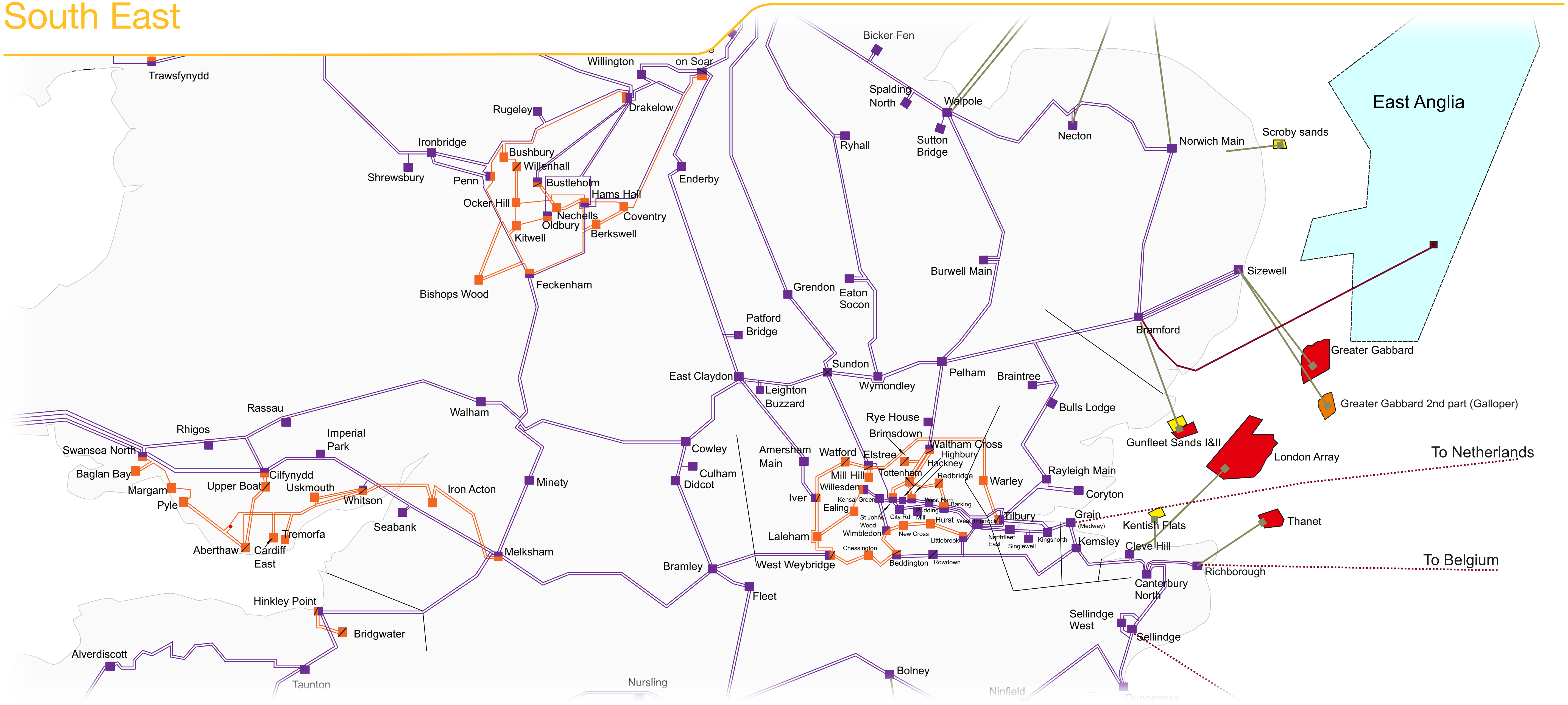
NOA 2020/21 recommendations

Stop Hold

Click here to view details on the options

NOA / Investment recommendations / Recommendations for each option 55

South East

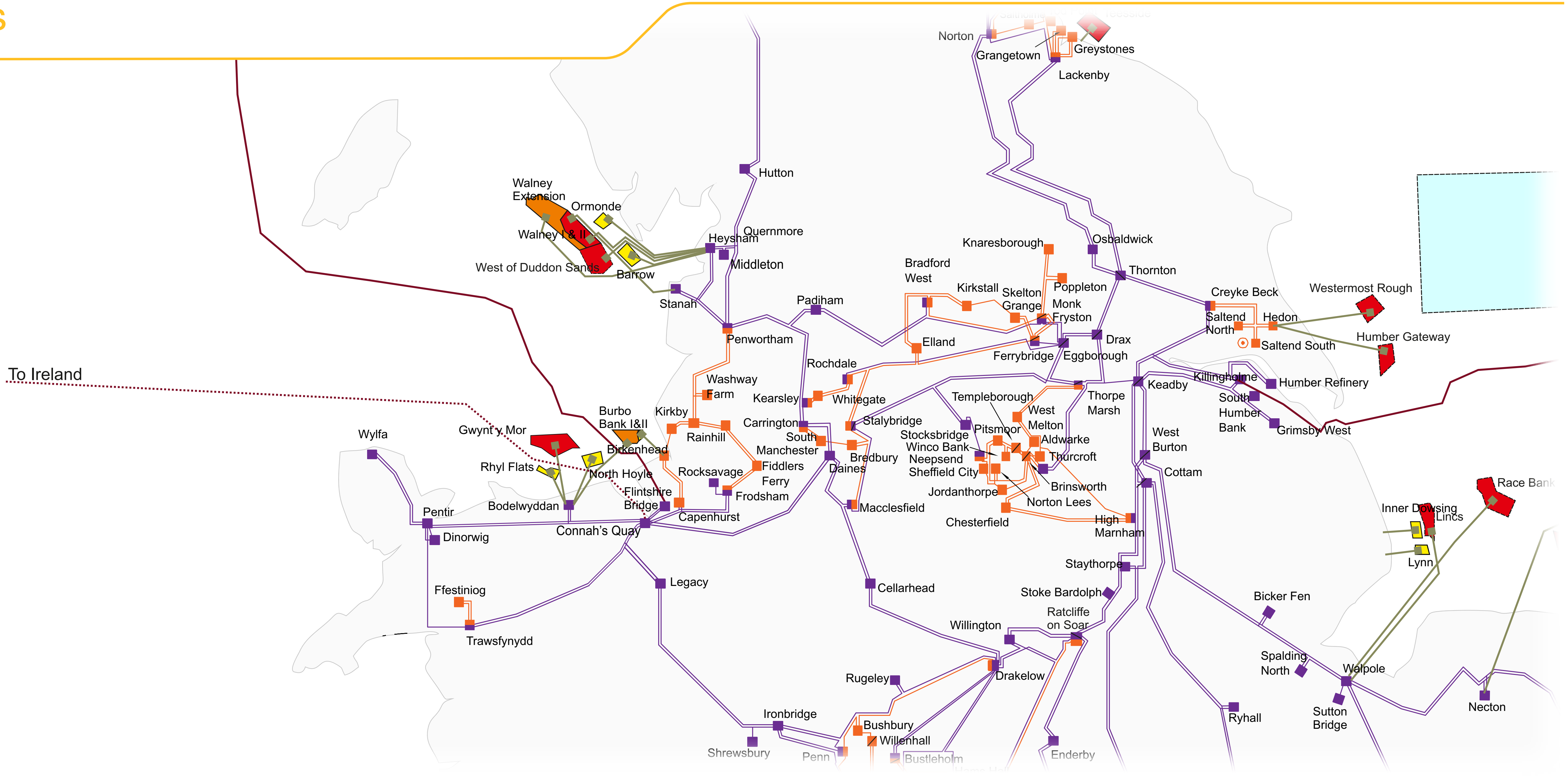


NOA 2020/21 recommendations

Stop Hold Proceed

Click here to view details on the options

Midlands



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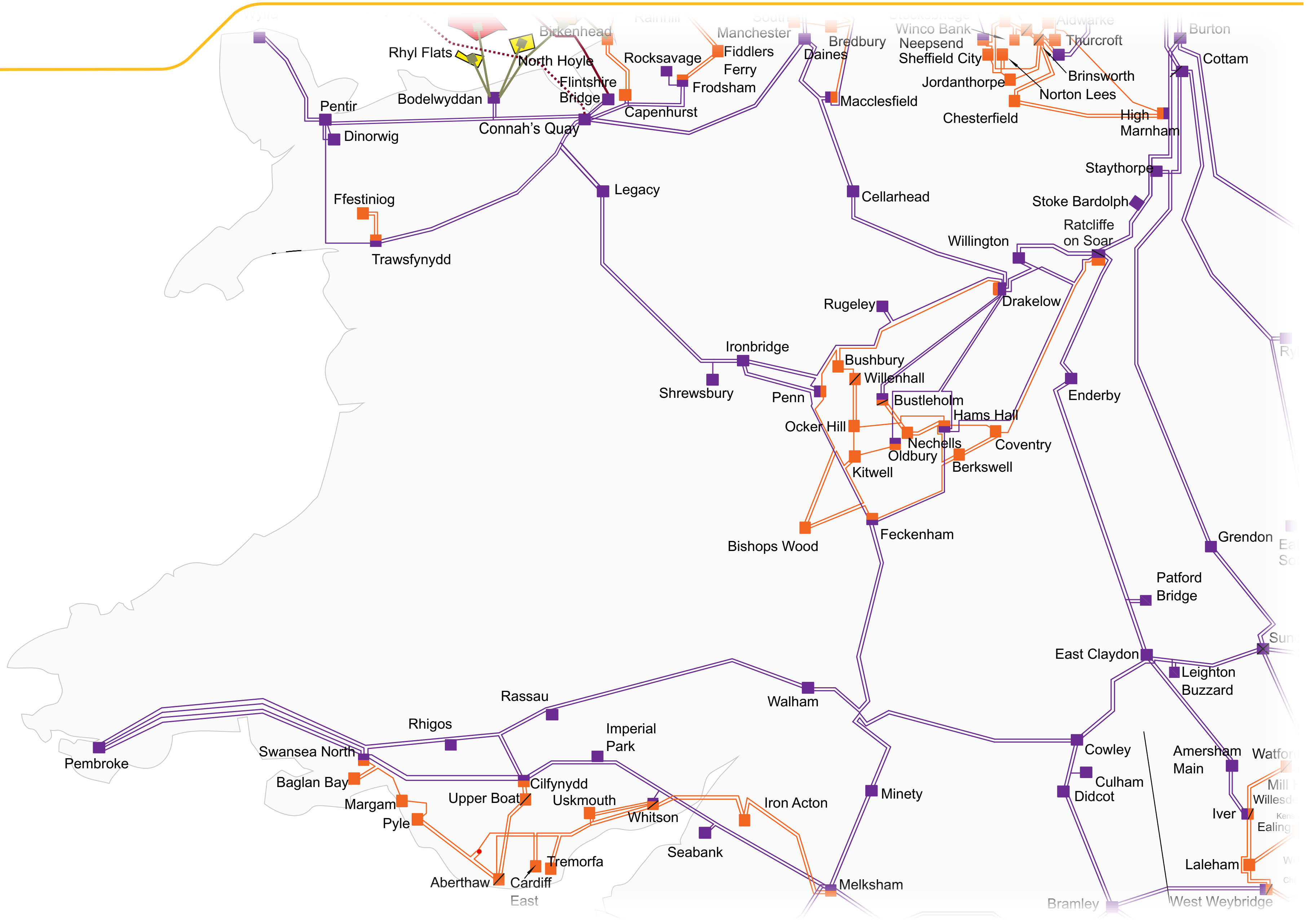
***NOA* 2020/21 recommendations**

Stop Hold Proceed

NOA / Investment recommendations / Recommendations for each option 57

Wales & West England



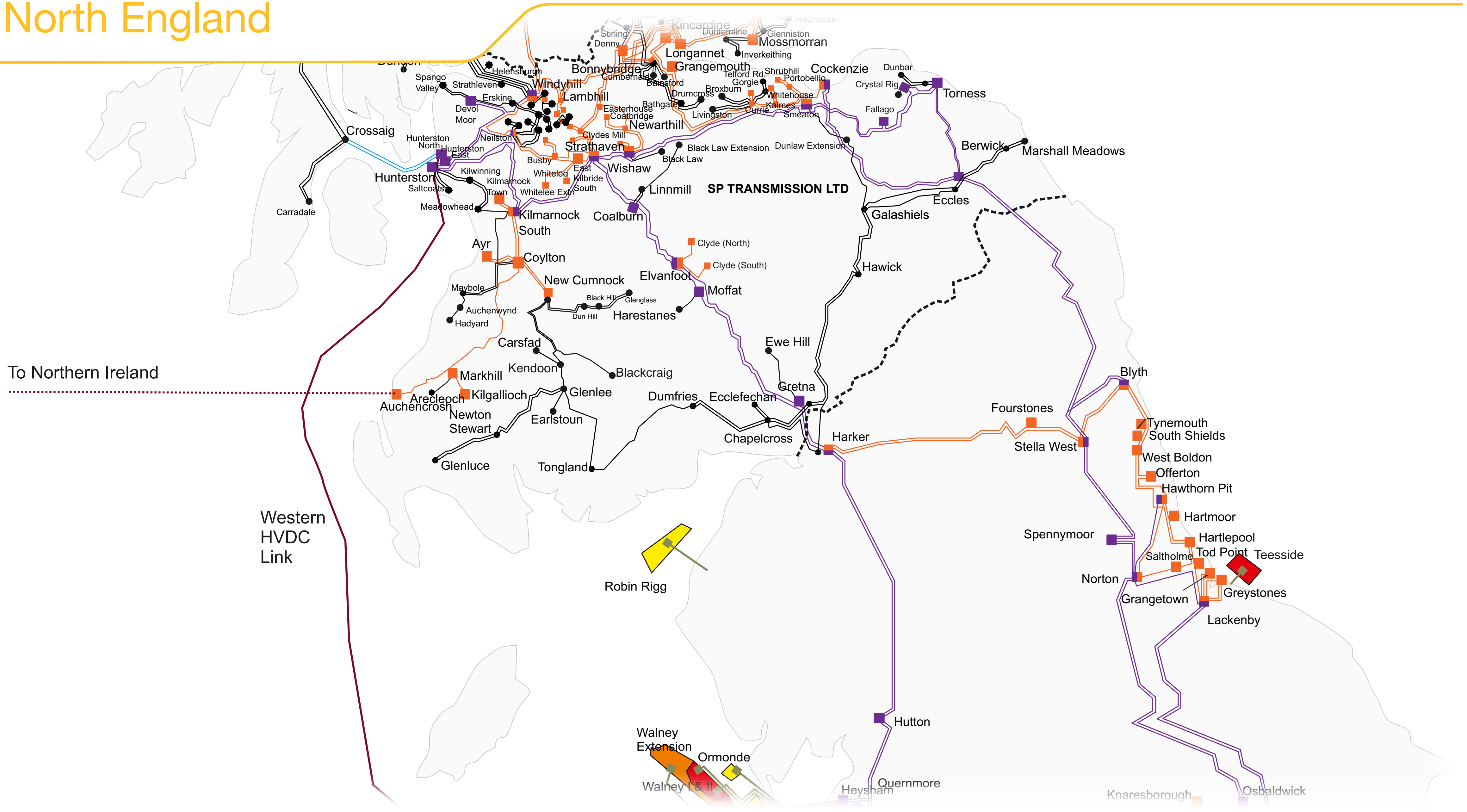
Click here to view details on the options

***NOA* 2020/21 recommendations**

Hold Delay

NOA / Investment recommendations / Recommendations for each option 58

South Scotland & North England



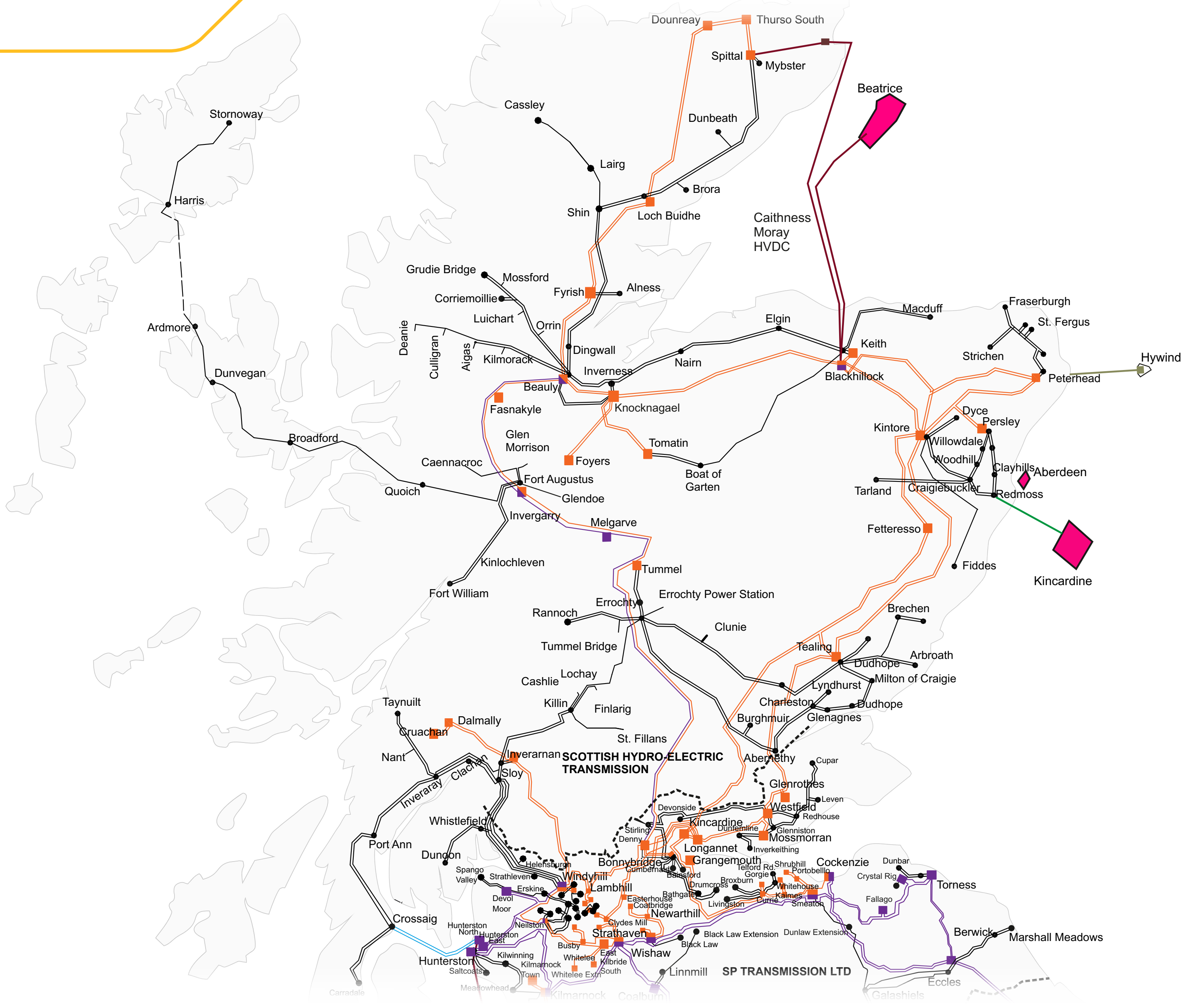
Click here to view details on the options

***NOA* 2020/21 recommendations**

Stop Hold Proceed

Legend | Main map | South West | South East | Midlands | Wales & West England | South Scotland & North England | Scotland | HVDC

Scotland



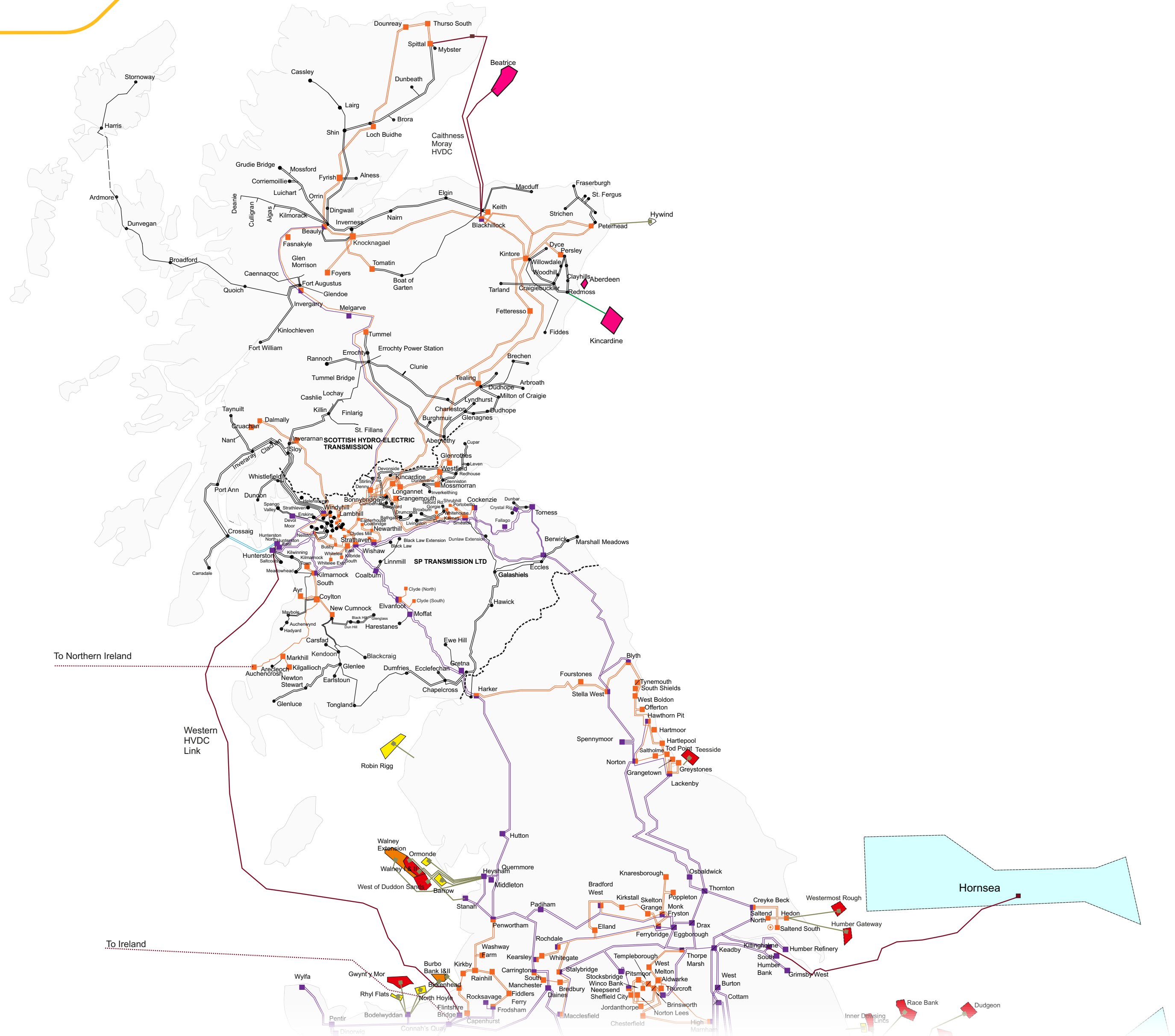
Click here to view details on the options

***NOA* 2020/21 recommendations**

Stop Hold Delay Proceed

NOA / Investment recommendations / Recommendations for each option 60

HVDC



Click here to view details on the options

***NOA* 2020/21 recommendations**

Stop   Proceed

Legend | Main map | South West | South East | Midlands | Wales & West England | South Scotland & North England | Scotland | HVDC

NOA / Investment recommendations / Recommendations for each option 61

Chapter 5

Offshore Wider Works

Introduction

For the first time, the ESO has demonstrated the economic benefits of offshore integration within our *NOA* analysis. We have proposed a number of conceptual offshore options and tested their benefit solely against constraint reductions, the analysis undertaken by the separate *Offshore Coordination Project* (*OCP*) has considered other factors beyond the remit of *NOA*.

Like the long-term conceptual options that we describe in Chapter 3 - 'Proposed options', the conceptual OWW reinforcements are used as an indicator of potential reinforcement needs. This meets our licence condition C27 as well as supporting competition for providing transmission assets and services to the national electricity transmission system (NETS). It should also facilitate economy of scale for integration with the rapidly growing offshore wind industry.

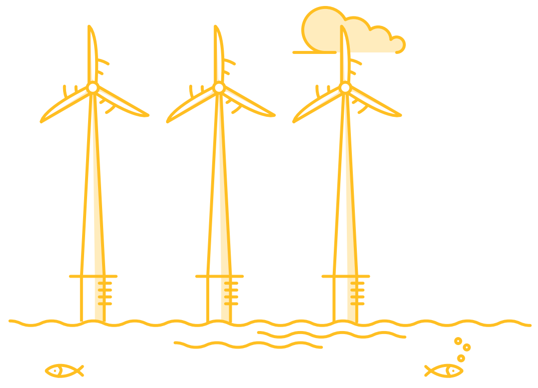
The reinforcements have been developed together with the *Offshore Coordination Project* (*OCP*). This project was set up by the ESO with support from Ofgem and the Department for Business, Energy & Industrial Strategy (BEIS) and forms part of the *Offshore Transmission Network Review*. The *OCP* Phase 1 report concluded that an integrated network in which assets are shared between connected parties offers consumer, environmental, and community benefits, including significant cost reductions.

The *OCP's* work moves to its next phase in January 2021. This will consider how we can facilitate a coordinated network through changes to industry codes, standards and processes as well as further technical analysis and planning. The output of this is likely to shape our future *NOA* analysis.

Our approach for *NOA* 2020/21 has been to create conceptual OWW reinforcements that we can test to connect major offshore wind developments while taking account of their commissioning dates. We then used these reinforcements in the *NOA* economic assessment process by analysing their costs against benefits. We calculated some estimated costs, capability benefits and timings for the reinforcements. This chapter gives a summary of those OWW reinforcements and how they performed in our analysis, allowing us to understand the impact they may have on our onshore planning process and the *NOA*.

The analysis also showed what changes may be needed to work with *OCP* outcomes and engage with stakeholders about the next steps. We hope this will also give an idea of the opportunities for OWW development.

Our analysis has found that three conceptual options are economically viable in reducing constraints in at least one scenario and warrant further investigation.



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Methodology

In our *NOA* economic process, we analyse the change to constraint costs that an OWW *NOA* reinforcement causes and then assess that benefit against the cost.

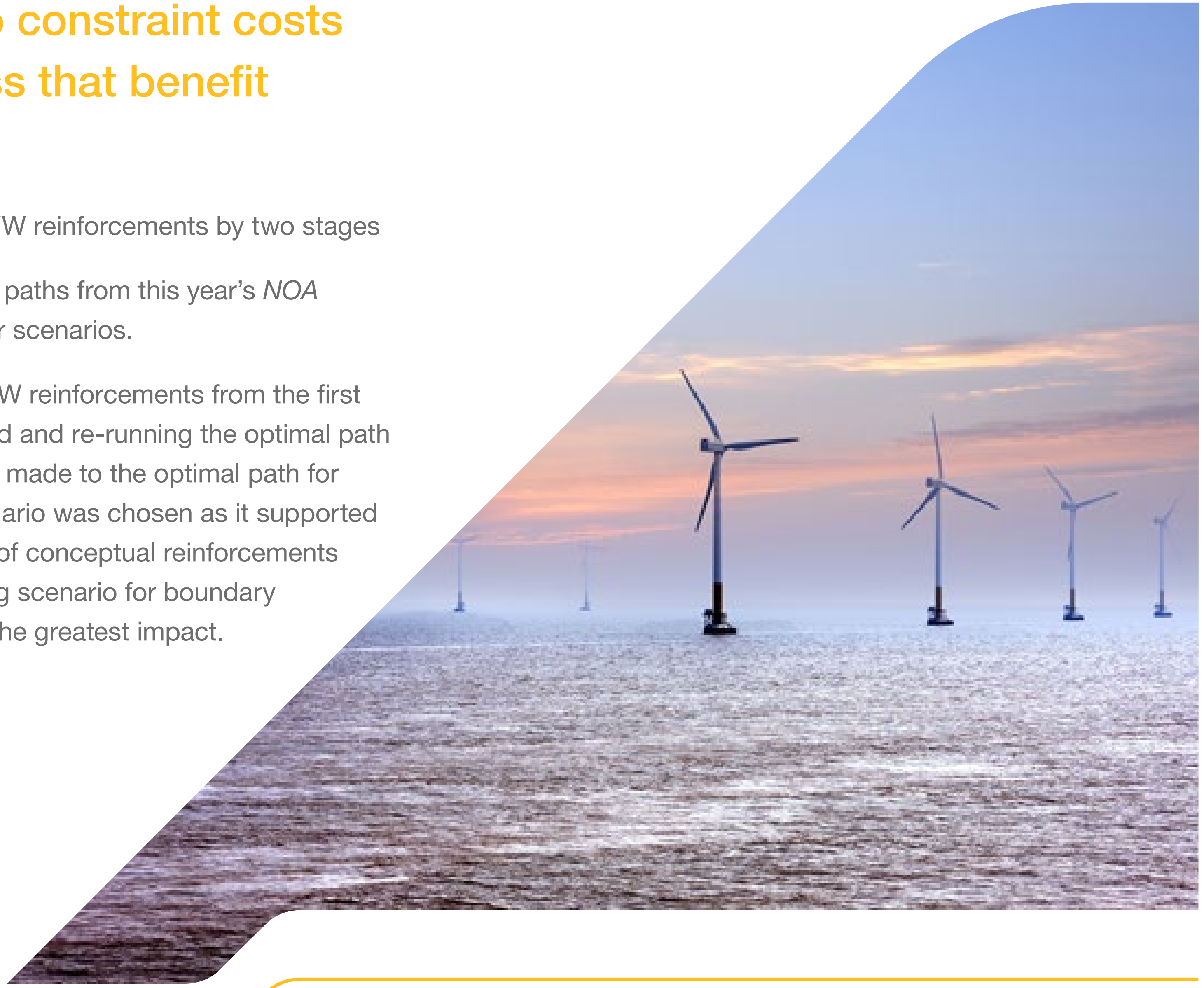
We considered the OWW *NOA* reinforcements in the same way and our *NOA methodology* goes into greater detail about the core *NOA* process. To consider the OWW reinforcements in *NOA* we adapted our modelling tool to accommodate offshore nodes that would have no demand.

The system boundaries of interest for the conceptual OWW study were onshore boundaries B7a in northern England, B8 and B9 in the Midlands, and EC5 in East Anglia.

We analysed the OWW reinforcements after we found the optimal paths based on the standard TO-led and commercial solution options. This means we have a separate set of recommendations for the OWW reinforcements and can compare them against the optimal path. A positive outcome for an OWW reinforcement this year is viable which contrasts with "Proceed" for the standard *NOA* options.

We tested the conceptual OWW reinforcements by two stages

- adding them to the optimal paths from this year's *NOA* analysis for each of the four scenarios.
- putting the conceptual OWW reinforcements from the first approach in the background and re-running the optimal path to see what difference they made to the optimal path for Leading the Way. This scenario was chosen as it supported the highest number (three) of conceptual reinforcements and as the most demanding scenario for boundary requirements would show the greatest impact.



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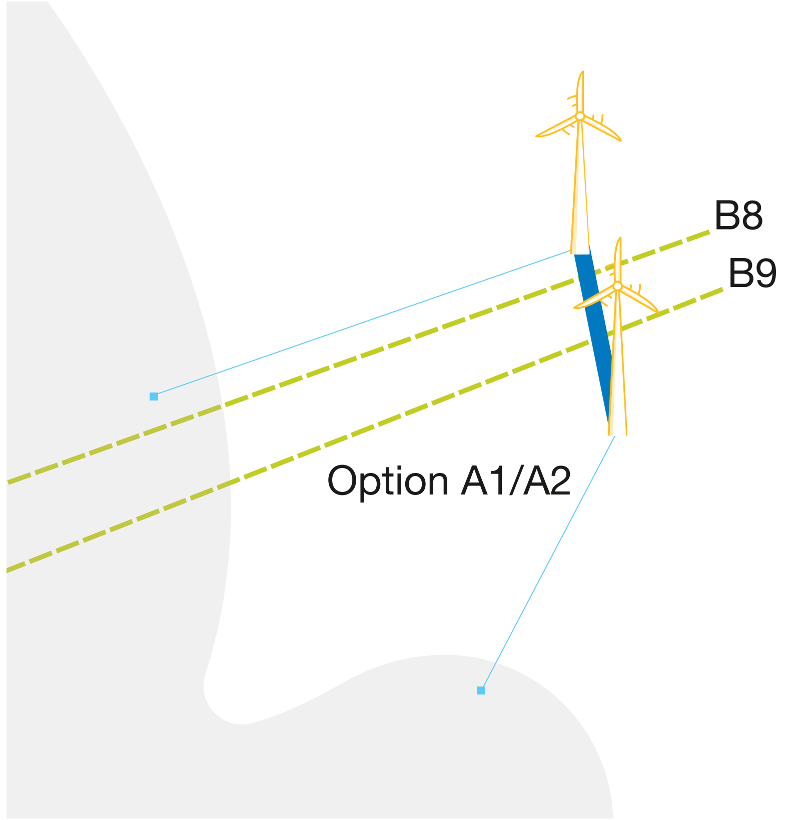
The conceptual options

We devised and developed six conceptual OWW reinforcements for the *NOA* to test their performance in relieving onshore boundaries. This complements the *OCP* work that was focused on zones around GB with drivers of reducing landing points and reducing network constraints. The main factors selecting the reinforcements for the *NOA* analysis were the size and commissioning dates of the proposed windfarms. This determined the order of the reinforcements, limiting the number of combinations to be analysed. Other factors include the technology availability, its rate of development, development timing, minimisation of routing distance and cost. In this assessment the counterfactual is deemed to be the onshore reinforcements as described in the *NOA* 2020/21 optimal paths. Our conceptual OWW *NOA* reinforcements are as follows.

Option A1 1000 MW connection from Dogger Bank area to Hornsea area provides additional transmission capacity across onshore boundaries B8 and B9. As the link would be around 150km, we expect HVDC technology would have to be used and need a converter station at each end and AC connection to the offshore wind farm. The proposed rating of this link would be 1000 MW.

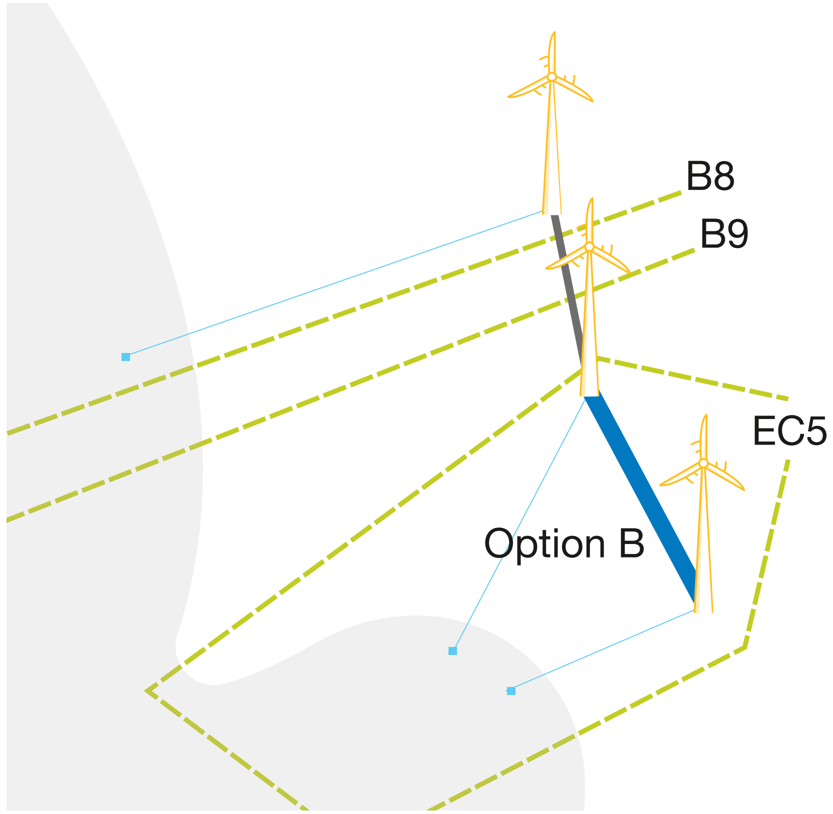
Option A2 1500 MW connection from Dogger Bank area to Hornsea area is the same as A1 but rated at 1500 MW. A2 would be an alternative to A1 so 'mutually exclusive'. The different ratings of options A1 and A2 allow us to test the performance of their reinforcement capacities and whether the benefit from higher capacity cables would justify the additional build costs.



NOA / Offshore Wider Works / The conceptual options 65

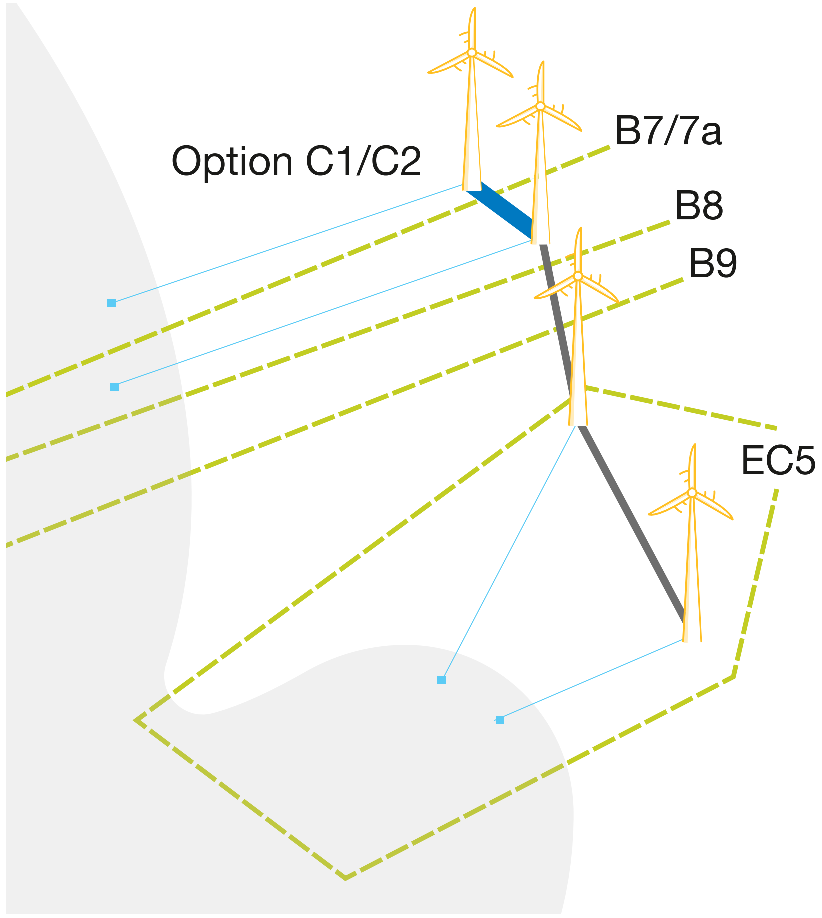
The conceptual options

Option B 1000 MW connection from Hornsea area to East Anglia area would add to A1 or A2 with an HVDC converter platform at East Anglia to create a three ended HVDC link (Dogger Bank – Hornsea – East Anglia). This could provide additional transmission capacity out of East Anglia and to the B8 and B9 boundaries. The East Anglia leg would be about 90km rated at 1000 MW and join to the East Anglia wind farms. This also makes A1 or A2 a pre-requisite to B.



Option C1 400 MW internal connection within Dogger Bank area would connect between wind farms within the Dogger Bank seabed area. Its key assumption is that wind farms within Dogger Bank will connect to the onshore network at Lackenby and Creyke Beck so interconnecting offshore will provide a power flow path, bridging the onshore network across boundaries B7 and B7a. The offshore interconnection distance is assumed to be around 40km by good positioning of the wind farm collector platforms; this would allow AC cables to be used and at a voltage that matches the turbine cable connections, avoiding further transformers. The number of cables could be determined by the optimal capacity needed. For C1 the rating would be 400 MVA taking into account the capacity of the HVDC links to shore already mentioned and the generation load factor. So, C1 would cross and ease boundaries B7 and B7a which are relatively highly constrained.

Option C2 700 MW internal connection within Dogger Bank area is the same as C1 but increases the number of connecting cables to provide a 700 MVA capability. This allows us to test its economic benefit compared to C1.



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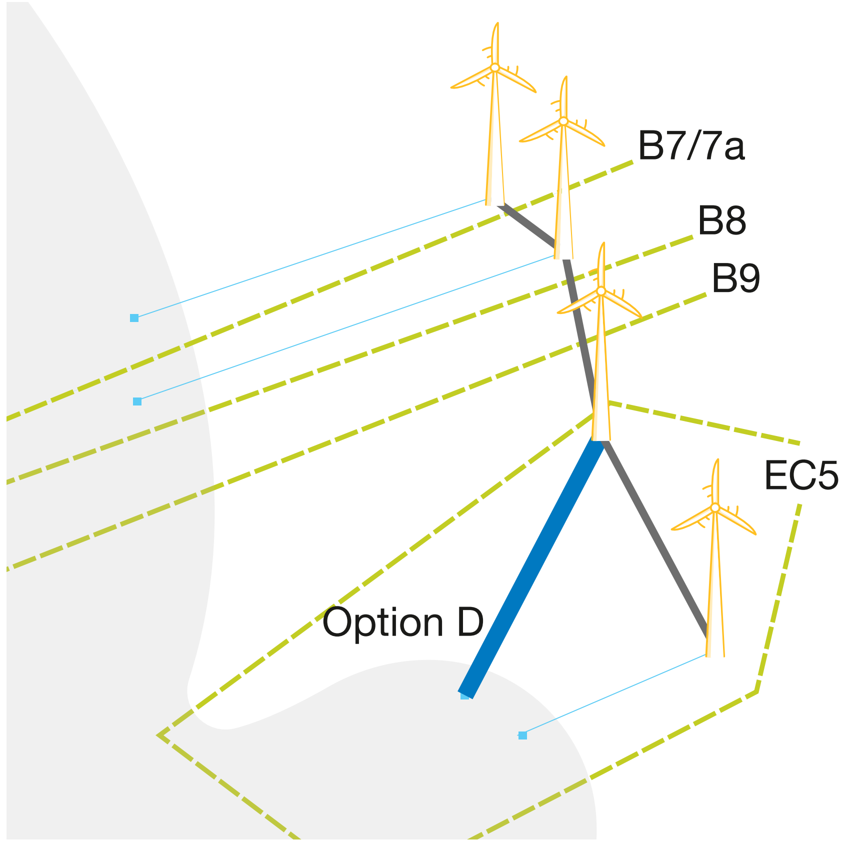
The conceptual options

Option D Increased rating to 2500 MW of proposed connection from Hornsea area to shore (Norfolk) would increase the capability of a proposed Hornsea wind farm connection to the onshore network from 1500 MW to 2500 MW. This would reduce potential conflict between local wind farm output and interconnection power flow. It would be an HVDC link of about 180km. It would work with reinforcement A1 or A2 and to some extent with B to bring ashore generation output and also cross boundaries B8 and B9. It would however sit behind congested boundary EC5 that we use for westward exports from East Anglia.



We have assumed all the reinforcements, apart from options C1 and C2, would use HVDC technology as they cover distances for which this tends to be more economic. Following conclusions in our *OCP* work, HVDC circuit breakers were not used in our conceptual OWW reinforcements as they did not extend to Scotland, which is where they were used in the *OCP* designs.

When devising the conceptual OWW reinforcements for the *NOA* analysis, the aim is to be able to test them giving boundary capability to the onshore network where it is needed. The designs must take account of the location and timing of offshore generation. The transmission distances between areas affect the choice of AC or HVDC technology. The anticipated offshore wind farm connections and their ratings are a factor in calculating the opportunities for joining up or 'integrating'. Those ratings and any headroom are determined by the wind farms' size. A fundamental point is where wind farms connect to the onshore network and their positions with respect to constraint boundaries. When we perform the economic modelling, we consider the capacity and within-year generation profiles for each targeted wind farm. This has an impact on the offshore reinforcements' loadings so we can compare how different reinforcement ratings perform.

NOA / Offshore Wider Works / The conceptual options 67

Results

The six conceptual OWW reinforcement options were analysed using the methodology outlined above.

Table 5.1 shows how each option performed against each *future energy scenario.* A viable result indicated that the option provided greater economic benefit in terms of constraints savings compared to the indicative cost of the option. A viable result is not a signal to proceed and build infrastructure but an indication to the industry that from our analysis, the proposed options will help relieve onshore constraints.

Table 5.1 Conceptual OWW reinforcement performance for each scenario. We describe a reinforcement as viable where it has a positive net present value

Option code	Description	Assumed Delivery Year	Leading the Way	Consumer Transformation	System Transformation	Steady Progression
A1	1000 MW connection from Dogger Bank area to Hornsea area	2027	Viable but larger link (A2) performed better	Not viable		
A2	1500 MW connection from Dogger Bank area to Hornsea area	2027	Viable	Not viable		
B	1000 MW connection from Hornsea area to East Anglia area	2028	Not viable			
C1	400 MW internal connection within Dogger Bank area	2033	Viable but larger link (C2) performed better			Not viable
C2	700 MW internal connection within Dogger Bank area	2033	Viable			Not viable
D	Increased rating to 2500 MW of proposed connection from Hornsea area to shore (Norfolk)	2029	Viable	Not viable		

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Results

Our analysis concludes that three conceptual options form a viable set of options that may provide economic benefit under the Leading the Way scenario. The options deemed viable are A2, C2 and D.

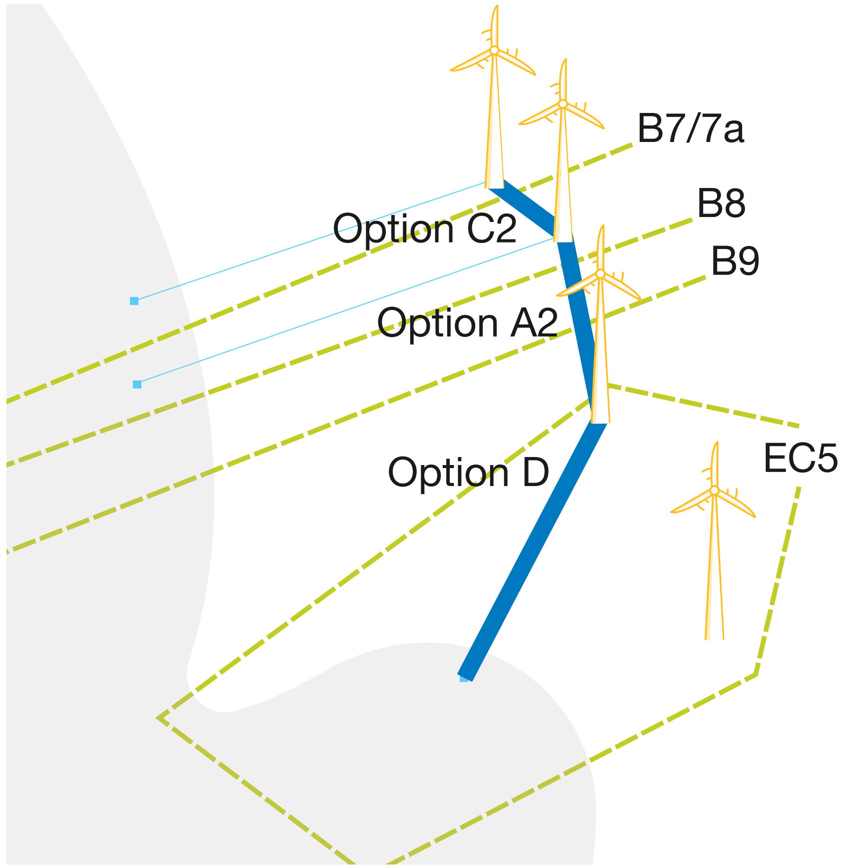
This would create a 700 MW AC link between the Dogger Bank platforms, then a 1500 MW HVDC link to Hornsea, and an increased capacity connection of 2500 MW to shore from Hornsea.

The offshore link between the Dogger Bank platforms (C2) is shown to be viable in all three net zero scenarios as it provides additional boundary capability on B7 and B7a. The other viable options (A2 and D) also provide benefit in the other net zero scenarios (Consumer Transformation and System Transformation), but not enough on their own to make the investment worthwhile.

The link from Hornsea to East Anglia was found to be not viable in our analysis, as it does not provide additional boundary capacity on its own and does not provide enough boundary capacity in conjunction with other options to justify the investment.

In all cases where both a smaller and larger capacity link were tested, when a small link (A1 and C1) was found to be viable, the large link provided additional economic benefit and is preferred.

Our analysis has also found that the viable offshore options under the Leading the Way scenario do not displace any existing onshore *NOA* recommendations. There were slight changes to optimal delivery dates for some reinforcements, but these did not impact any recommendations.



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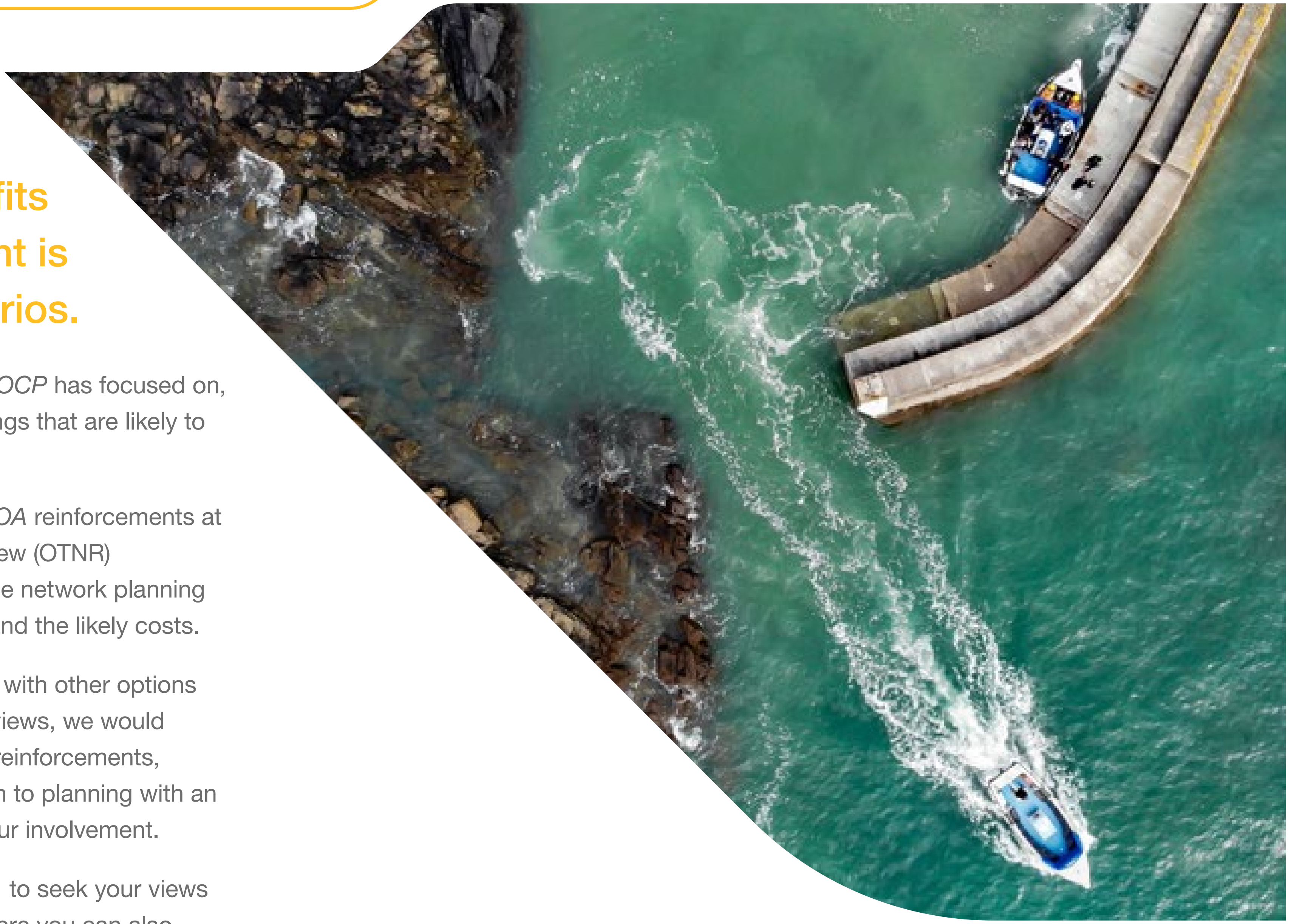
Next steps



We have found that three conceptual OWW reinforcements give economic boundary benefits in at least one scenario while one reinforcement is also considered viable all three net zero scenarios.

However, these studies do not consider all of the benefits of integration that the *OCP* has focused on, namely fewer cable landings, less environmental impact, asset expenditure savings that are likely to strengthen the case for reinforcements in an integrated network.

We recognise that the high-level design assumptions of the conceptual OWW *NOA* reinforcements at this stage could affect cost outcomes. The Offshore Transmission Network Review (OTNR) is currently considering the approach to offshore connections, which may change network planning beyond this development but we'd still like your input on what may be possible and the likely costs.

In the future, using the *NOA* to assess OWW reinforcements on an equal footing with other options could be one approach but there may be better ways to do it. If you have other views, we would like to hear about them. We want to improve how we devise and develop OWW reinforcements, particularly the technical design and costing, and also inform the approach taken to planning with an integrated offshore network. These are areas where we are also keen to have your involvement.

We will continue in conjunction with the *OCP* to engage with the industry in 2021 to seek your views on the *NOA's* OWW results. Please keep up to date using our *NOA* webpage where you can also subscribe to updates.

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Chapter 6

Interconnector analysis

Introduction

NOA for Interconnectors (*NOA* IC) assesses how much interconnection would provide the most benefit to consumers and other interested parties. It also highlights the potential benefits of efficient levels of interconnection capacity between GB and other markets. For this analysis we have assumed that following the signing of the EU-UK Trade and Cooperation Agreement on 30 December 2020, longer term energy trading arrangements will be agreed so that markets are not affected.

The purpose of this analysis

This analysis outlines the socio-economic benefits of interconnection for consumers, generators and interconnector developers under a range of scenarios.

What *NOA* IC can do:

Provide a market and network assessment of the optimal level of interconnection capacity to GB.

Evaluate the social economic welfare, that is the overall benefit to society of a particular option, as well as constraint costs and capital expenditure costs of both the interconnection capacity and network reinforcements.

What *NOA* IC can't do:

Assess the viability of current or future projects: the final insights are largely independent of specific projects.

Provide any project-specific information.

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Introduction

NOA and *NOA* IC

The *NOA*'s purpose is to recommend to Britain's Transmission Owners which projects to proceed with to meet the future network requirements as defined within the *Electricity Ten Year Statement*. *NOA* IC uses the output from *NOA* as the baseline network reinforcement assumptions: this maximises consistency between the *NOA* and *NOA* IC.

Value

There are many opportunities for additional GB interconnection to provide economic and environmental benefit for GB and Europe. They are essential to achieving net zero by 2050.

Benefits

Increased levels of interconnection bring benefits to GB and European consumers, both in terms of lower wholesale prices and increased use of renewable power. They are a key source of additional electricity system flexibility, reducing renewable energy supply curtailment, exporting excess intermittent renewable electricity and reducing the need for electricity storage by importing electricity when intermittent renewable electricity levels are too low to meet demand.

16.9 to 27.7 GW

Our analysis shows that interconnection capacity in the range of 16.9 GW to 27.7 GW between GB and European markets by 2040 would provide the maximum benefit to GB and European consumers.

Renewable energy

All four *FES* 2020 scenarios see an increase in renewable generation. Consumer Transformation and Leading the Way see higher levels of renewable generation than previous years, driven by increased government support for some renewable technologies which will be necessary to meet net zero greenhouse gas emissions by 2050. The more established technologies of solar and wind which dominate the mix are intermittent sources, meaning there could be times where there is not enough supply and times where there is an excess.

GB consumer

Analysis shows that the GB consumer can benefit from more interconnection projects than those included within Cap and Floor Window 2. For three of the scenarios, the levels of interconnection are significantly above these levels.

Interconnector options

While the analysis results in four optimal interconnector paths based on *FES* 2020, there may be other combinations of interconnectors that will also add value.

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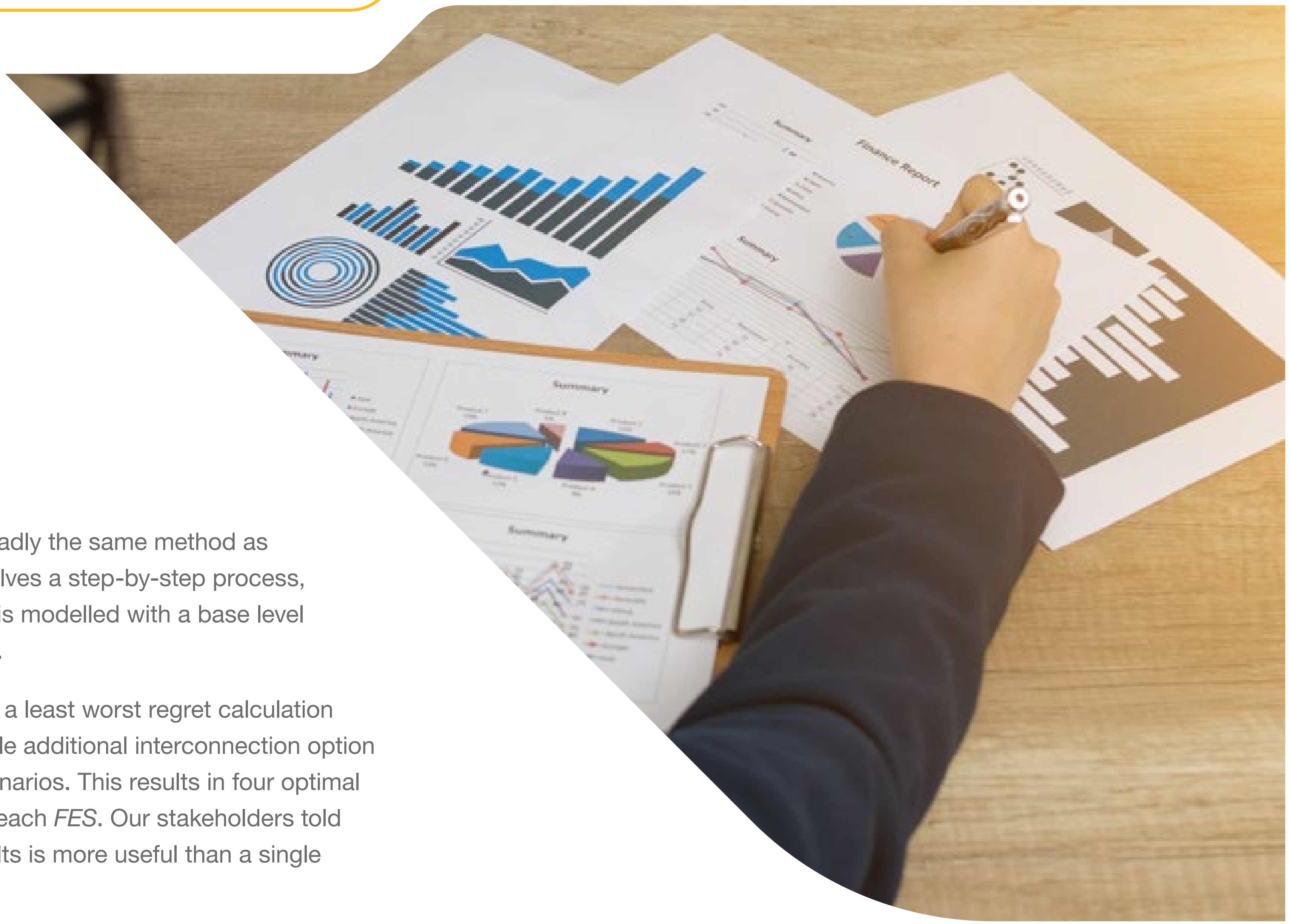
Introduction



Improvement to this year's analysis

This year, we have continued to develop the methodology approved by Ofgem.

- We have continued to use the output from this year's *NOA* as the baseline network reinforcement assumptions for the *NOA* IC analysis: this provides greater consistency between the *NOA* and *NOA* IC analysis.
- We have focused on identifying the optimum level of interconnection by examining social economic welfare, capital costs and reinforcement costs.
- Based on stakeholder feedback, we have not analysed the impact interconnectors may have on other operational costs, specifically ancillary services.
- We have used broadly the same method as last year. This involves a step-by-step process, where the market is modelled with a base level of interconnection.
- We do not include a least worst regret calculation to assign one single additional interconnection option across all four scenarios. This results in four optimal solutions, one for each *FES*. Our stakeholders told us a range of results is more useful than a single optimal solution.

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Interconnection theory

Electricity interconnectors allow the transfer of energy between countries.

With the commissioning of the IFA2 interconnector to France at the end of 2020, GB has roughly 6GW of interconnection with other European markets. However, our 2020 *future energy scenarios* (*FES*) see an increase to between 16 GW in Steady Progression and 22 GW in Leading the Way by 2030.

Increases in interconnection can deliver benefits to both industry and consumers.

Social Economic Welfare (SEW) is a common cost-benefit indicator when analysing projects of public interest. It captures the overall benefit, in monetary terms, to society from a given course of action. It is an aggregate of multiple parties' benefits – so some groups in society may lose money because of the option taken. In this analysis, SEW captures the financial benefits and detriments to market participants due to increased interconnection. Figure 6.2 shows how SEW is reached.

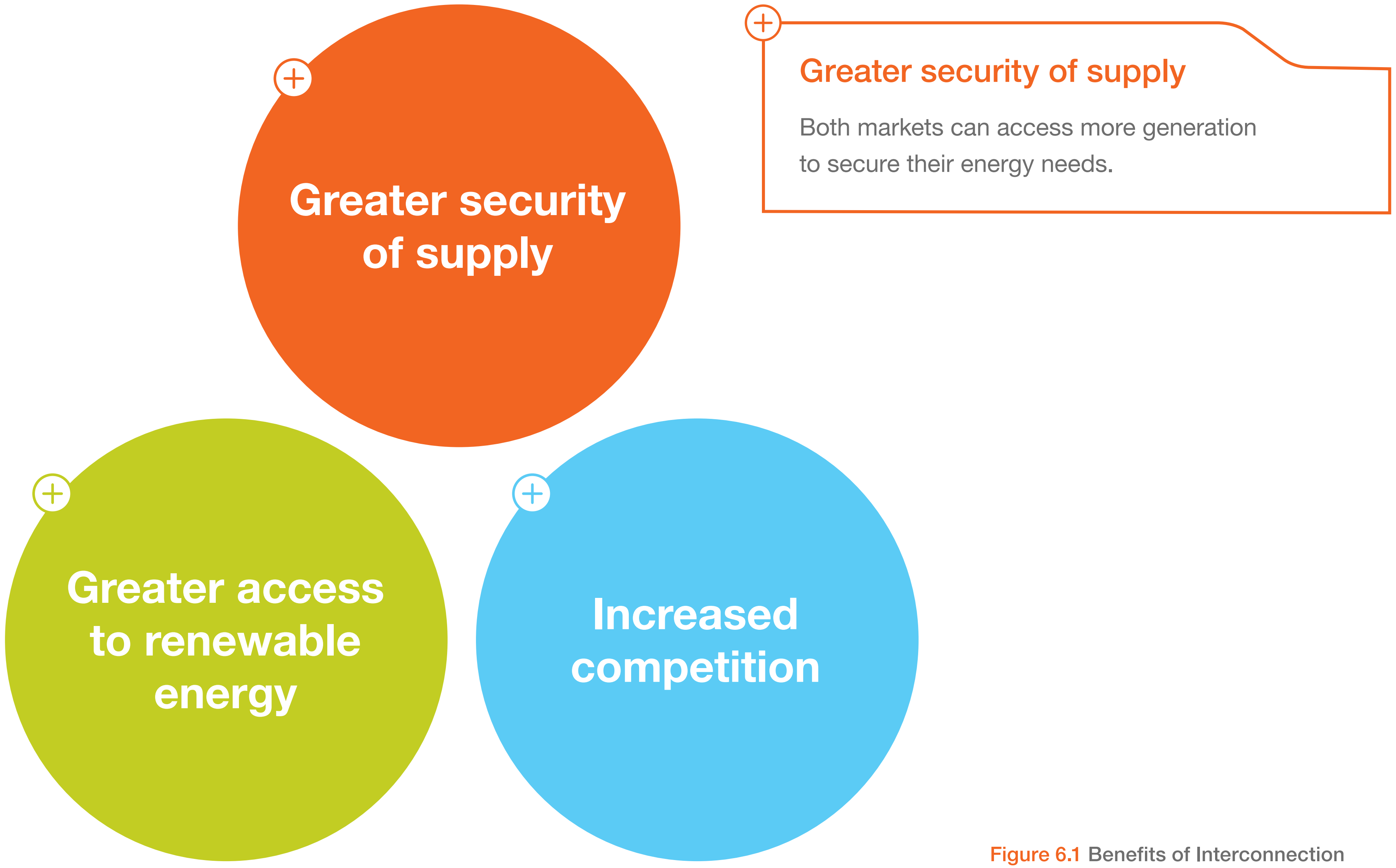

Figure 6.1 Benefits of Interconnection

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Interconnection theory

The increase in SEW must also be balanced against the capital costs of delivering the increased interconnection capacity and any associated reinforcement costs. As capacity is increased between two markets and SEW delivered, prices begin to converge until further interconnection brings no benefit. The interconnection capacity is optimised, having delivered maximum benefits.

Consumer welfare

Increased consumer welfare due to reduced prices in the higher priced market, as suppliers have increased access to cheap renewable generation.

Reduced consumer welfare due to increased prices in the cheaper market, as access to cheaper generation is shared with more consumers.

Figure 6.2 Social economic welfare

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Methodology

This section provides an overview of the methodology used for the *NOA* IC analysis, updated using feedback from stakeholders.

Developments to methodology

This year we have continued to focus our analysis on the optimal level of interconnection capacity for GB. The key highlights are:

- The process continues to quantify SEW, capital costs and reinforcement costs of additional interconnection.
- The optimal paths are based on SEW for Europe, not just GB and connecting country. This was necessary to achieve credible results.
- For consistency, we use recommendations from this year's *NOA* as the baseline network reinforcement assumptions for the analysis.
- We have identified four optimal interconnection development paths: one for each future energy scenario. Stakeholders continue to tell us that a range of results was more beneficial, due to the high levels of uncertainty in the European energy market.

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Current and potential interconnection

As stated within the *FES* 2020, interconnection capacity increases beyond current levels in all four scenarios. Table 6.1 shows the current and planned interconnection levels which form the basis for this study's base interconnection capacity.

The first step is setting an initial baseline level of interconnection. In previous versions of *NOA* IC this has been set lower than within the *FES* to allow us to investigate different combinations of interconnection to those within *FES*. This year we cannot do this because the levels of *FES* interconnection are required to achieve a supply demand balance within the *NOA* IC modelling.

This year's scenarios explore three pathways that meet the UK's legally binding net zero target. Two meet the net zero target at a similar speed of decarbonising, but with varying levels of societal change, and one exceeds these. The levels of interconnection with *FES* 2020 are significantly higher than in previous *FES*, and two of the scenarios have interconnection capacity higher than the levels seen in last year's *NOA* IC. Capacities are higher in the scenarios with greater levels of societal change, as high levels of intermittent generation favour more flexible sources such as interconnectors, which play an increasingly important role in providing flexibility.

In the net zero scenarios flows become more variable due to the high levels of renewable generation capacity, with increased interconnector capacities transporting large volumes of electricity in both directions. As renewable generation capacities increase across GB and Europe, interconnectors help balance supply and demand with flows responding to price differences between countries increasingly driven by variable renewable generation output.

The levels of interconnection in the *FES* are essential to achieving an hourly supply demand balance; it is not possible to run the *FES* 2020 scenarios with a lower level of interconnection than that originally set within the scenarios. So this year's baseline has been set at the *FES* 2020 level.

Using the original *FES* levels of interconnection does have the benefit of keeping the scenarios 'whole', as the *NOA* IC process does not alter a key element of the underlying scenario framework.

For this year's analysis, we have continued to treat any Icelandic interconnection in the *FES* as a generator. The unique properties of the Icelandic market, specifically the levels of renewable generation, result in a very low wholesale electricity price. Further Icelandic interconnection was excluded from the process.

Table 6.1 shows the current and planned interconnection levels of base interconnection capacity. 2028 represents the first year modelled. The baseline levels of interconnection continue to rise in the *FES* as additional interconnectors are added; for example Leading the Way has 27.2 GW of interconnection by 2040.

	Interconnection capacity (GW)
2020 capacity	6
2028 Consumer Transformation	17.9
2028 Leading the Way	18.7
2028 Steady Progression	14.5
2028 System Transformation	15.9

Table 6.1 Interconnection capacity and 2028 base case

Recommendation for capacity development is an optimisation for each future energy scenario to maximise the present value, equal to SEW less CAPEX less constraint costs. Figure 6.3 provides a high-level overview of the process. Further details are available in the *NOA methodology report*.

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Methodology

1 Set base level interconnection

2 Create study cases

3 Simulate European markets for all four *FES*

4 Calculate net benefit of each option

5 Identify optimal interconnector solution for each *FES*

6 Update base level of interconnection in each *FES*

1. Set base level interconnection

The base level of interconnection is the total capacity GB has with each of the seven studied markets at the start of the iteration. This year, the original level of *FES* interconnection within each scenario formed the baseline.

Figure 6.3 Iterative process for interconnection optimisation

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Connecting country	Connection Zone	Reinforcement on boundary
Base	Base	None
Belgium	5	EC5
Belgium	5	None
Belgium	7	None
Denmark	2	B7a
Denmark	2	None
Denmark	5	EC5
Denmark	5	None
Denmark	8	None
France	6	None
France	6	SC1
France	7	None
France	7	SC1
Germany	5	EC5
Germany	5	None
Germany	7	LE1
Germany	7	None
Germany	8	None
Ireland	1	None
Ireland	2	None
Ireland	3	None
Ireland	4	None
Netherlands	5	EC5
Netherlands	5	None
Netherlands	7	LE1
Netherlands	7	None
Norway	1	B6
Norway	1	None
Norway	2	B7a
Norway	2	None

Table 6.2 Study cases, showing interconnector connecting country, GB zone and reinforcement options. The connection zones and reinforcements are shown on the map in Figure 6.4

Estimation of interconnection construction costs

The cost of building interconnection capacity varies significantly between different projects, with key drivers including converter technology, cable length and capacity. The capital costs were derived from a publicly-available ACER (Agency for the Cooperation of Energy Regulators) document, based on surveys carried out on European projects, and approximations of median possible cable lengths. Costs were converted to 2020 prices and benchmarked against a range of interconnector cost data in the public domain.

Whilst there was considerable variation across projects, the ACER costs provide a reasonable average.

We also considered including interconnector operational costs (OPEX) but initial investigations showed this is a complex area and operating costs are project-specific. As *NOA* IC is not project specific, we have not attempted to model OPEX but will continue to review this topic with stakeholders.

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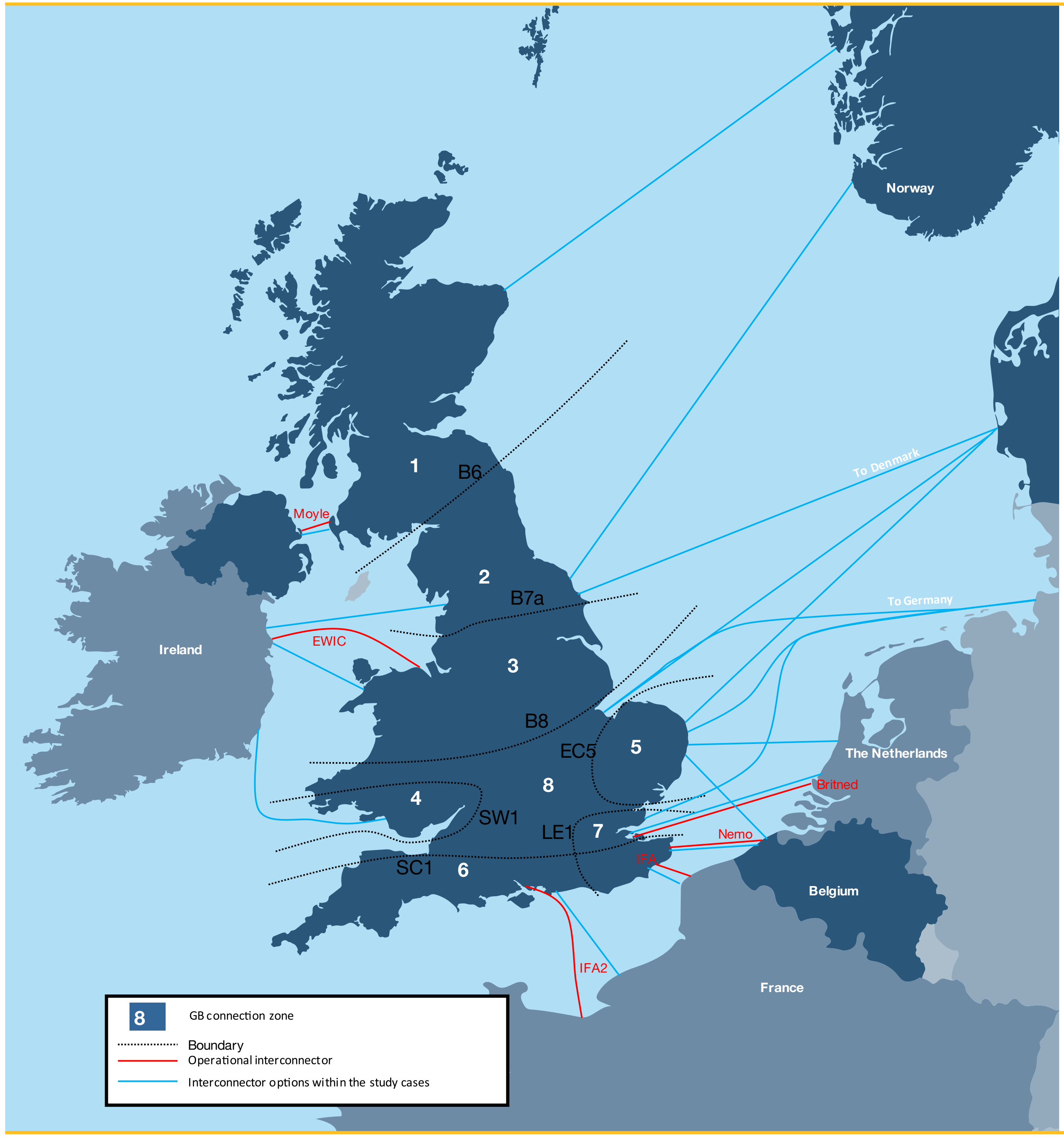

Estimation of network reinforcement costs

Based on the output from this year's *NOA*, we have updated the boundaries to divide the network into high-level zones. The eight zones represent areas of significant constraints on the network or areas of high interconnection.

Figure 6.4 highlights the GB connection zones, boundaries and interconnectors currently operational and the study cases.

Figure 6.4 GB network high level zones, boundaries and interconnector options

Outcome

The market studies identified the interconnector options that resulted in the highest Net Present Value. These options provide the most benefit to GB and Europe.

The output is presented in four parts:

1. **Optimal interconnection range.**
2. **GB consumer benefit.**
3. **Interaction of interconnectors and constraints.**
4. **Environmental implications.**

Optimal interconnection range

For each *Future Energy Scenario (FES)*, the results show the markets to connect to, whether reinforcement of the GB network was necessary and in which years to connect to maximise Social Economic Welfare (SEW). The results should be considered in the context of the methodology:

- Interconnector projects which connect to markets not in the optimal paths may well be beneficial, but not the most beneficial based on the assumptions in this study.
- The attractiveness of different markets varies across the scenarios. There is uncertainty as to where the best opportunities lie, due to the uncertainty of future market conditions.
- The results are not a forecast: many other factors will influence the outcome for interconnection over the next decade and beyond.
- Variations in network constraint and construction costs will have a major impact on the attractiveness of projects.

The results of the modelling are very different from previous years. The optimal paths, i.e. the additional interconnection added to the baseline level of interconnection are much lower than in last year's analysis because of the higher baseline level used. For System Transformation, there was no additional interconnection, i.e. the optimal level of interconnection is the baseline level in the original *FES* scenario.

As the baselines are much higher than last year's, and as the interconnectors that form the base case diminish the level of additional SEW further interconnection can bring, the SEW generated by additional interconnection is reduced.

The number of iterations varied across the scenarios. The optimal level of interconnection between GB and European markets for each *FES* in 2040, including the baseline levels of interconnection, is shown in Figure 6.5.

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Outcome

Scenario	Optimal interconnection
Consumer Transformation	27.1 GW
Leading the way	27.7 GW
Steady Progression	16.9 GW
System Transformation	21.5 GW

Figure 6.5 Optimal interconnection for each FES including the base case level

The four optimal levels of interconnection shown in Figure 6.5 give a range of between 16.9 GW and 27.7 GW of interconnection capacity across the four *FES*. All four are very similar to the interconnection capacity in the *FES* 2020 scenarios, which have a range of between 15.9 GW and 27.2 GW in 2040. They have up to 2 GW additional capacity over the *FES* 2020 scenarios, driven by the potential for creating additional value.

The optimal interconnection range is between roughly 3 to 5 times the current interconnector capacity of 6 GW.

A direct comparison to last year's results is not possible as the *FES* scenario framework is different. For *FES* 2020, the levels of interconnection are nearly optimal. This is partly explained by the levels of interconnection in *FES* 2020 being partially driven by the results of *NOA* IC 2019/20, which showed substantially higher levels of interconnection than that within *FES* 2019. This results in short paths for *NOA* IC 2020/21, i.e. there is little additional value in adding interconnection over and above the levels in *FES* 2020.

Our attempts at modelling *NOA* IC 2020/21 with a baseline level of interconnection lower than that set within *FES* 2020 were unsuccessful. This highlights how important the levels of interconnection set within *FES* 2020 are to achieving a supply and demand match for every hour for each year from 2028 to 2040.

Additional interconnection is essential to achieving net zero. As levels of intermittent renewable generation increase in the scenarios, interconnectors play an increasingly important role providing flexibility in the net zero scenarios.

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Outcome

The optimal level of interconnection varies considerably across the different *FES*. Consumer Transformation, Leading the Way and System Transformation, which achieve the net zero target by 2050, have the highest levels of societal change, with high levels of intermittent generation requiring greater system flexibility. This may be provided by increased electricity storage, demand side response, electrolysis or interconnection. Interconnection not only provides additional system flexibility but also opportunities for creating additional value driven by the significant differences in wholesale prices between markets. In these scenarios the new sources of flexibility beyond generation become more important to meet peak demand. When renewable generation exceeds demand such as on windy, sunny summer days, the excess supply is balanced by flexible demand side response (DSR) or electrolysis to produce hydrogen, used to charge electricity storage, or for exporting via interconnectors.

As levels of intermittent renewable generation increase, interconnectors play an increasingly important role providing flexibility in the net zero scenarios.

In System Transformation the levels of interconnection are slightly lower as there is less need for demand side flexibility. This is due to higher levels of dispatchable thermal generation powered by hydrogen providing additional system flexibility and lower levels of electrification.

Steady Progression has the lowest levels of interconnection capacity. It still has over 40 GW of natural gas fired thermal generation throughout the modelling period of 2028 to 2040, providing high levels of supply side flexibility.

Levels of electricity flexibility increase slowly up to 2030 in all scenarios, as increases in interconnection, electricity storage and demand side response are offset by reduced dispatchable thermal generation capacity. As renewable generation dominates between 2030 and 2040, further flexibility is needed to balance a net-negative carbon emission electricity system in the net zero scenarios.

Interconnection is just one of a range of technologies that will be essential to achieving the levels of electricity system flexibility necessary to achieve the net zero target by 2050. Other technologies such as dispatchable thermal generation, large scale energy storage and demand side response will be needed too.

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Outcome

Last year's *NOA* IC gave a range of between 18.1 GW and 23.1 GW. The higher levels of interconnection in this year's analysis for the Consumer Transformation and Leading the Way scenarios are the result of higher levels of welfare due to more intermittent renewable generation and the requirement for increased system flexibility. Consumer Transformation, Leading the Way and System Transformation all achieve net zero greenhouse gas emissions by 2050 and a key element in achieving this is significant investment in low carbon electricity generation, with increased levels of low carbon and renewable generation compared to the *FES* 2019 scenarios. Consumer Transformation, Leading the Way and System Transformation also include greater volumes of intermittent renewable generation across Europe, providing additional welfare opportunities for balancing renewable generation volumes.

The results show there is value for additional interconnection capacity over and above that included in Ofgem's Cap and Floor Window 2, especially for the three scenarios that meet the net zero target.

Figure 6.6 shows the results in graphical format for each option, including the number of iterations, the cumulative level of interconnection capacity, the connecting country, whether any additional reinforcement was needed, the connecting zone and the connecting year.

Figure 6.6 Optimal interconnection paths for each FES

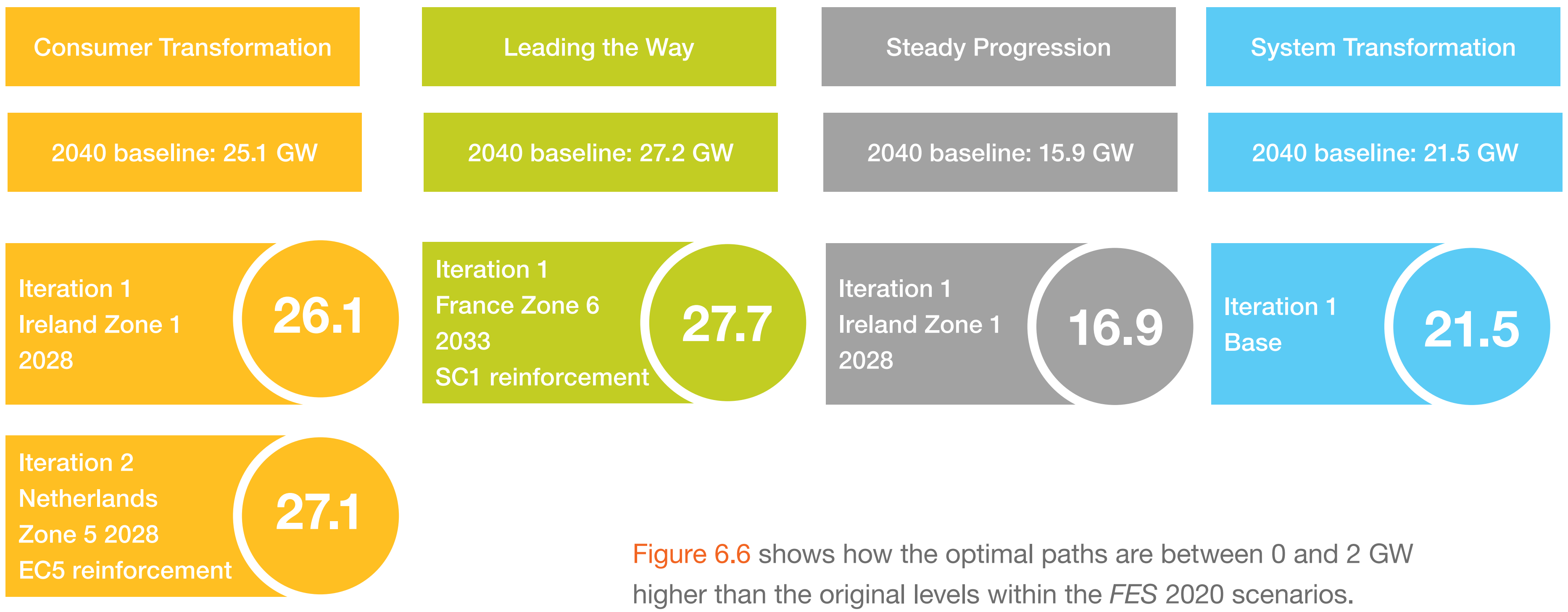

Figure 6.6 shows how the optimal paths are between 0 and 2 GW higher than the original levels within the *FES* 2020 scenarios.

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Outcome

Figure 6.7 shows the level of interconnection to each European market for the four optimal paths. Two of the optimal paths result in additional interconnection to Ireland. The average Irish wholesale price is modelled as generally higher than GB, resulting in welfare generation opportunities. Also generating welfare is Ireland's synchronous generation constraint which imposes a limit on the level of demand that can be met by wind. These two factors mean British exports to Ireland exploit arbitrage and Irish exports to Britain avoid wind curtailment.

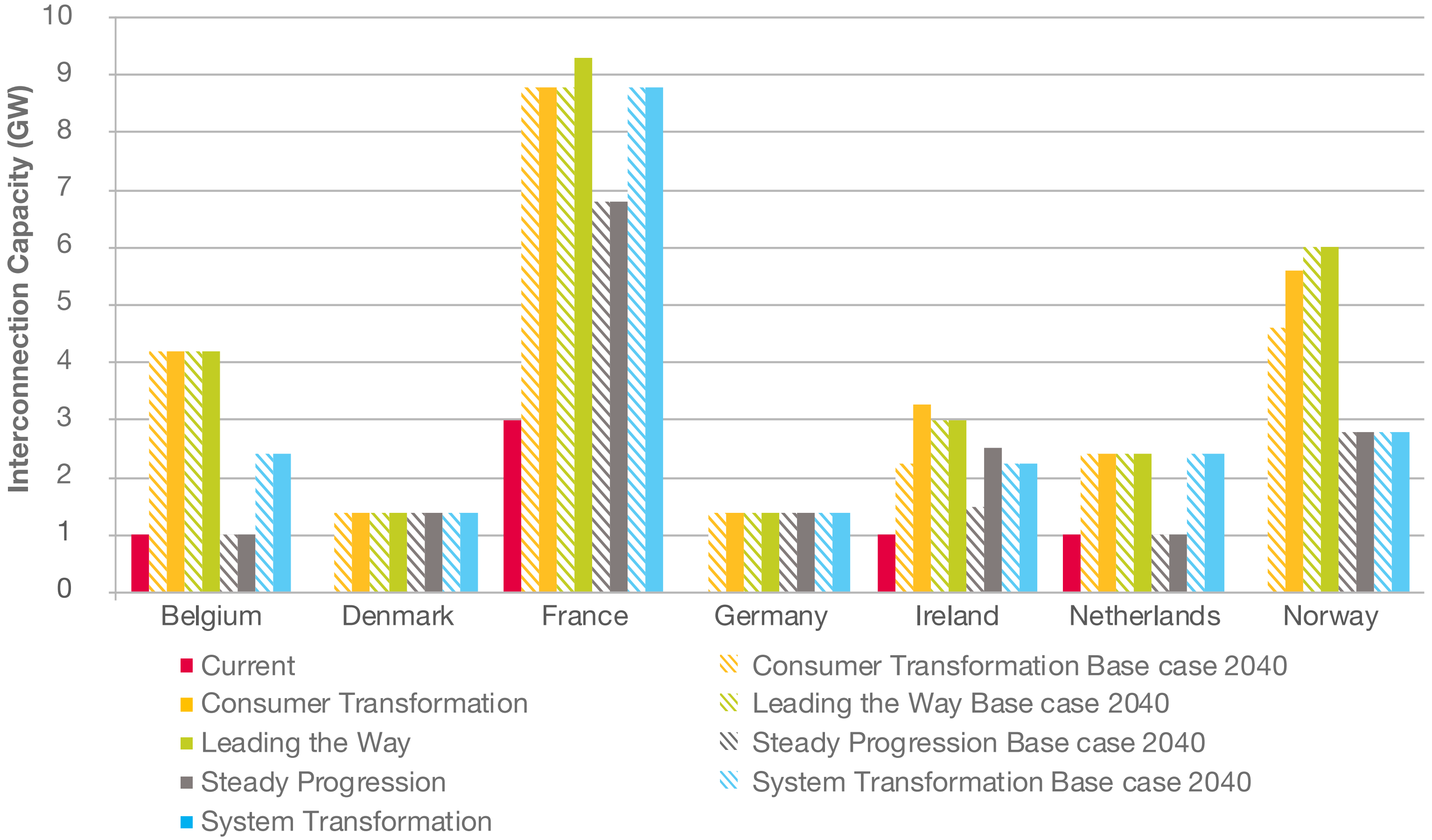

Figure 6.7 Optimal level of interconnection to each European market in 2040, for each scenario

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Outcome

Figure 6.8 shows the variation in length of optimal paths across the four scenarios and the variations in net present value (NPV) relative to the base case for each iteration. It also shows the composition of each NPV broken down by welfare, CAPEX and constraints. Not surprisingly, CAPEX is always negative relative to the base case. Constraints can result in both savings and additional costs, although in Figure 6.8 all constraints are savings.

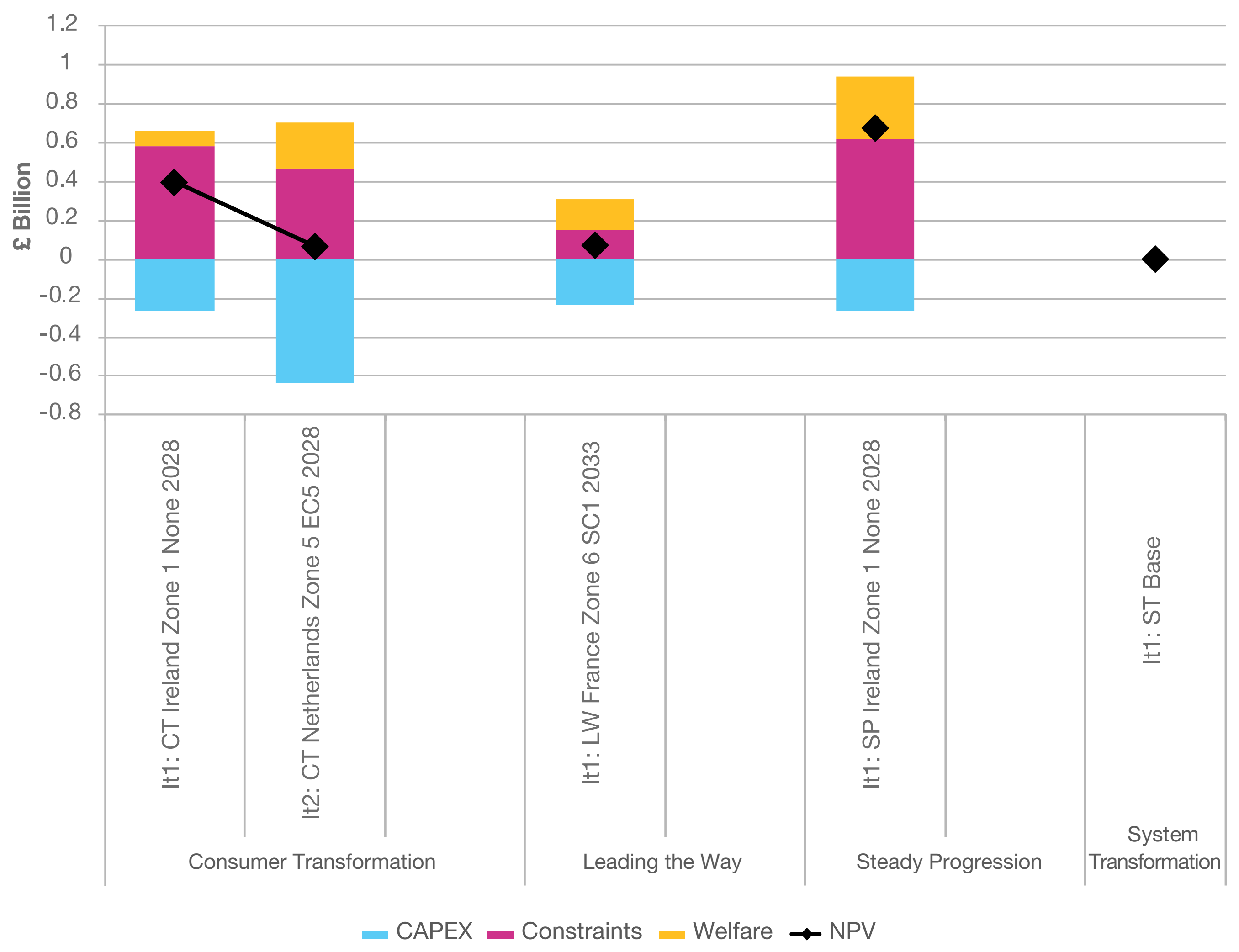
Only Consumer Transformation had an optimal path of more than one iteration, and for System Transformation, the winning study case from the first iteration was the base case, implying that no additional interconnection provided incremental value.

Figure 6.8 shows the low levels of additional welfare relative to the base case. This is because the baseline level of interconnection for each scenario was set at levels in the *FES* 2020 scenarios and as these have much higher levels than previous additions, there was very little additional SEW value created by adding more interconnection.

The additional interconnection to Ireland for Consumer Transformation iteration 1 and Steady Progression is primarily driven by the constraint savings from the interconnector and not by any additional SEW relative to the base case. Such constraint savings may well reduce in subsequent iterations of the *NOA* process as new network options are developed. Similarly, Consumer Transformation iteration 2 includes additional boundary capability for EC5 (East Anglia region) and Leading the Way includes additional boundary capability for SC1 (south coast region): the value obtained from these reinforcements may be negated in the next *NOA*.

Unlike previous years' *NOA* IC, where there were often many beneficial projects not in the optimal paths, that is they provided additional benefit relative to the base case, this year's study showed very few other projects producing positive net present value. This was again a result of using the *FES* 2020 levels of interconnection as the baseline level.

Figure 6.8 Net Present Value of each winning study case for the optimal path for each *FES*



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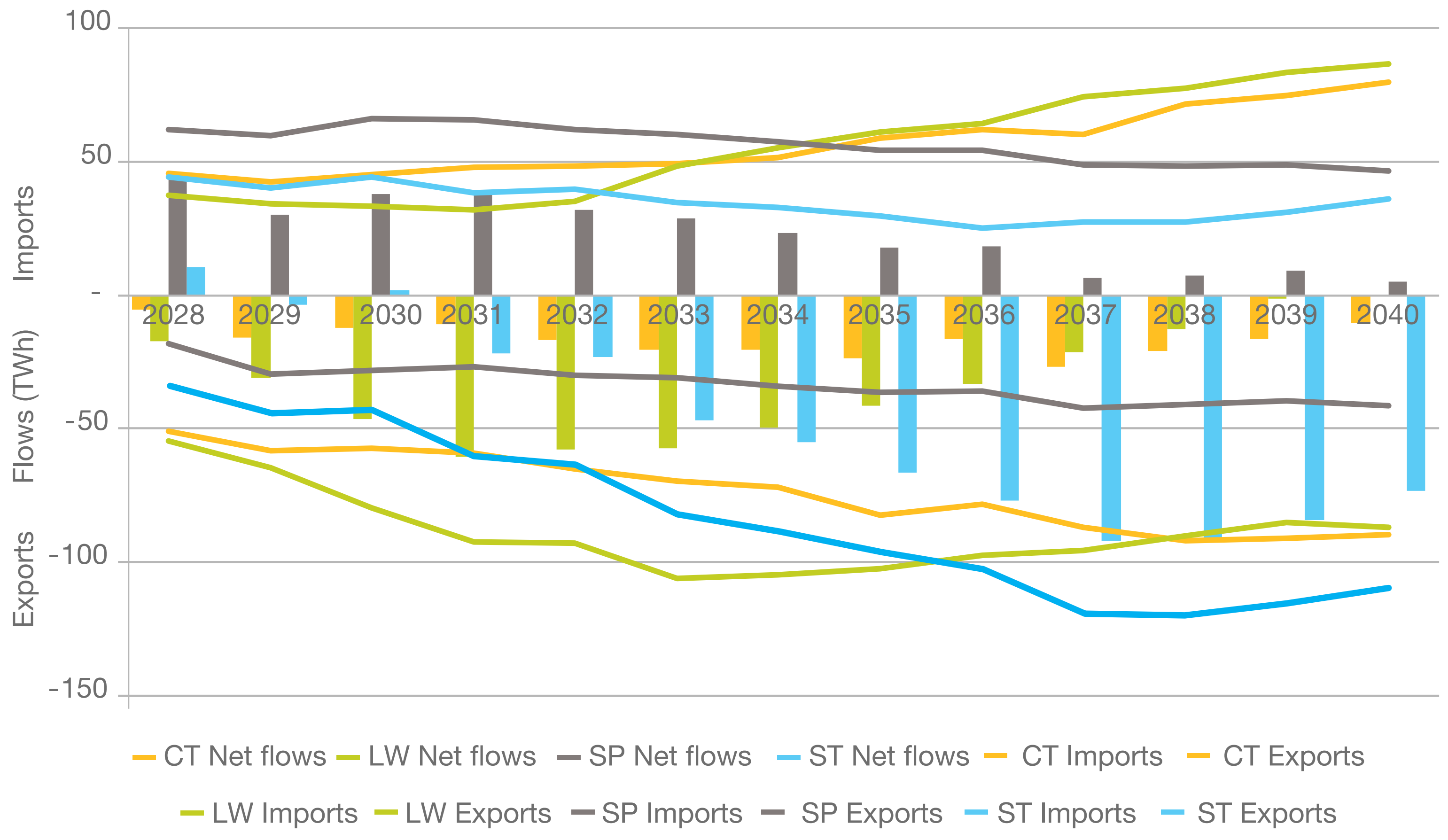
GB consumer benefit

The GB consumer gains from interconnection to cheaper wholesale electricity markets. Figure 6.9 shows annual imports and exports for each of the optimal interconnection paths.

Steady Progression maintains net annual import flows across the study period, whereas Consumer Transformation shows marginal net annual export flows, and Leading the Way and System Transformation show significant annual net export flows, but with different profiles across the years.

Figure 6.9 Annual import and export flows



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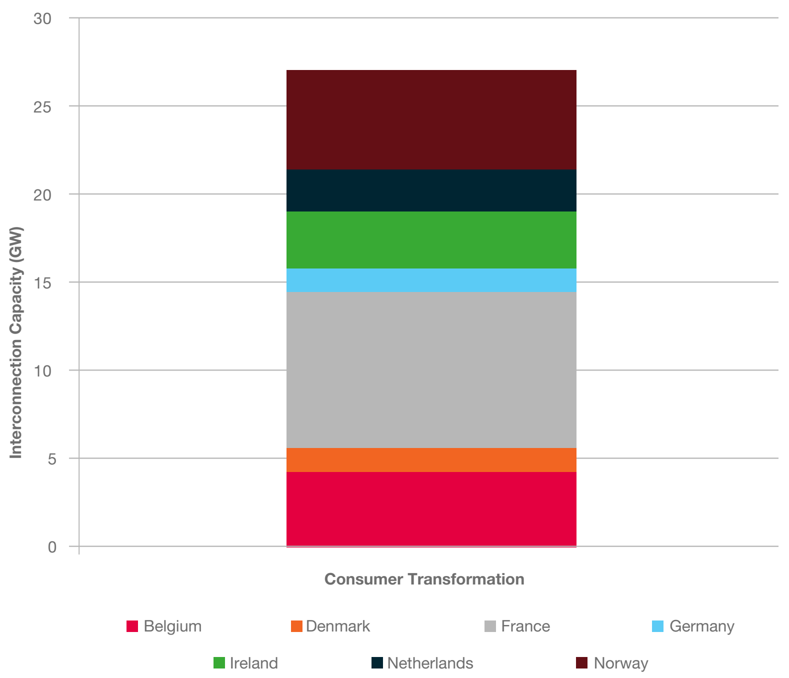
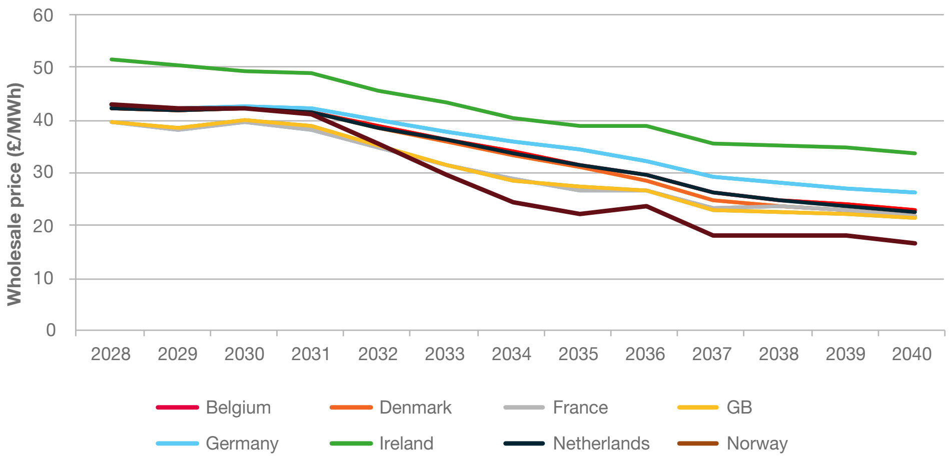
Outcome

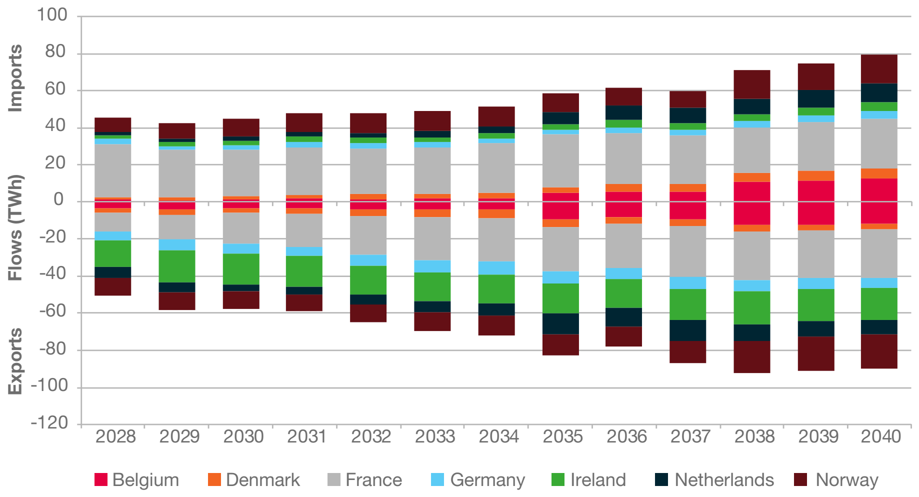
[Figures 6.10 to 6.13] explore average annual wholesale prices for GB and the seven European markets for the four *FES*. The prices are not demand weighted. They also show the level of interconnection capacity as well as the annual import and export flows broken down by country.

Consumer Transformation shows a marked decrease in wholesale electricity prices across Europe, with only Norway showing lower prices than GB. This drives high export flows across the interconnectors, particularly to France, Ireland and Norway. The wholesale price differences allow arbitrage opportunities for imports to GB. Consumer Transformation shows lower levels of interconnection export than Leading the Way or System Transformation, although exports still reach over 80 TWh by 2037.

Figure 6.10 Interconnection capacity, wholesale electricity prices and import and export flows for the optimal path for Consumer Transformation







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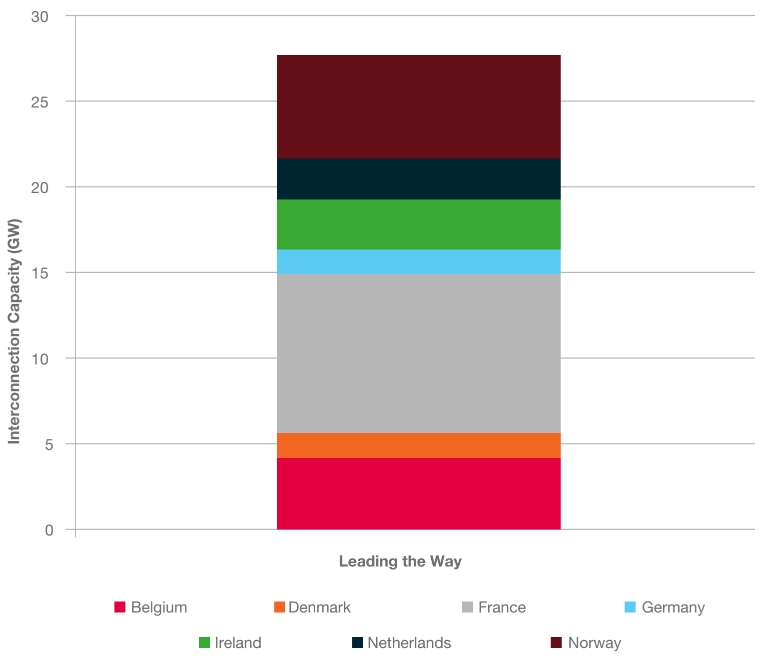
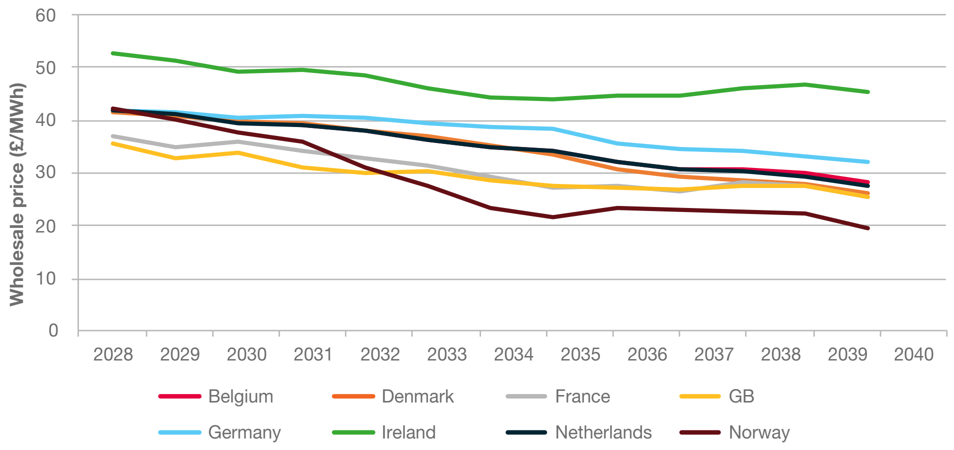
Outcome

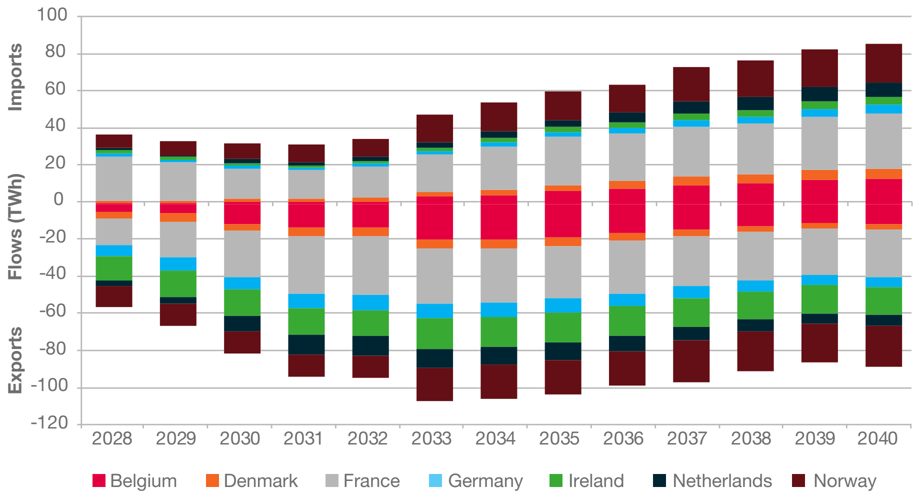
Leading the Way shows a decline in GB and other European wholesale prices, driven by increasing levels of renewable generation. At an annual average price level, GB has some of the lowest prices in Europe, only beaten by Norway. From 2028 to the early 2030s there is a sustained ramping up of exports to the continent as increasing volumes of intermittent renewable generation are commissioned in GB, driving down prices and allowing arbitrage opportunities for renewable energy export. Exports peak in 2033 at over 100 TWh. Leading the Way shows the highest levels of exports of all the scenarios for the first half of the 2030s, but these decline slightly in the second half of the decade.

There are significant imports from both France and Norway, when prices in these two countries are lower than in GB. Throughout the 2030s there is a sustained growth in imports to GB, with Leading the Way seeing the highest levels in 2040.

Figure 6.11 Interconnection capacity, wholesale electricity prices and import and export flows for the optimal path for Leading the Way







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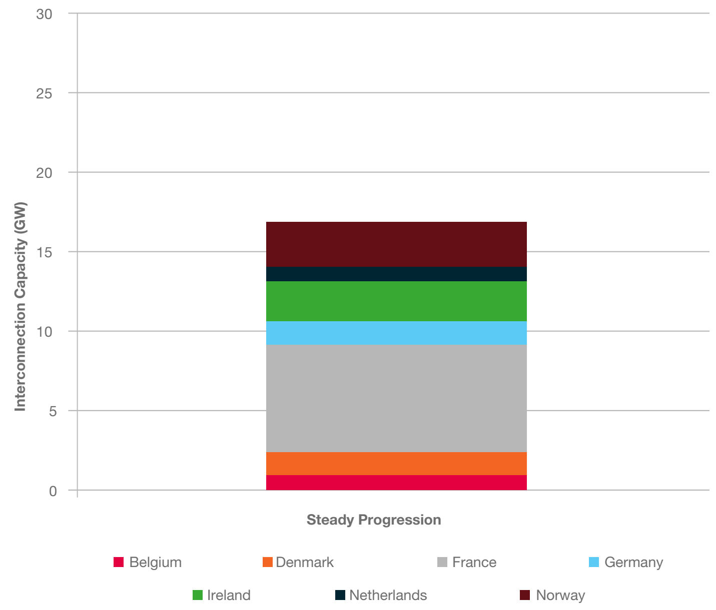
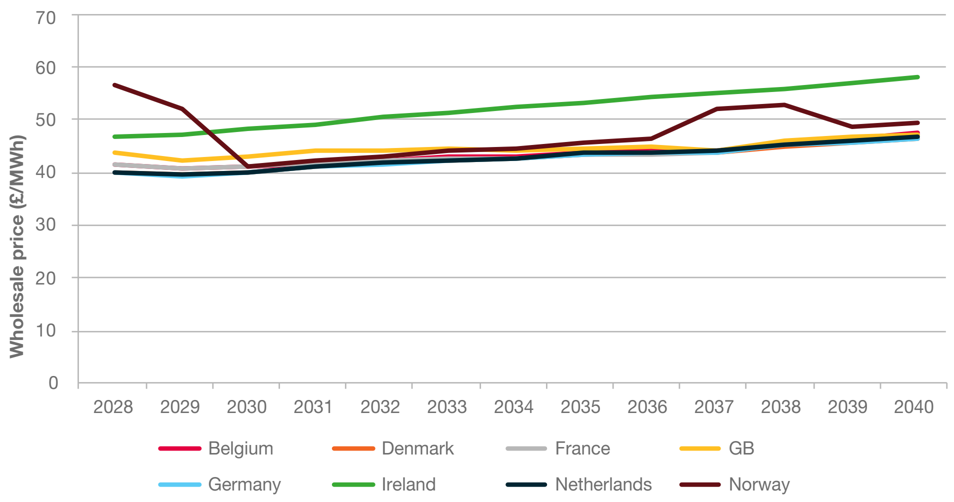
Outcome

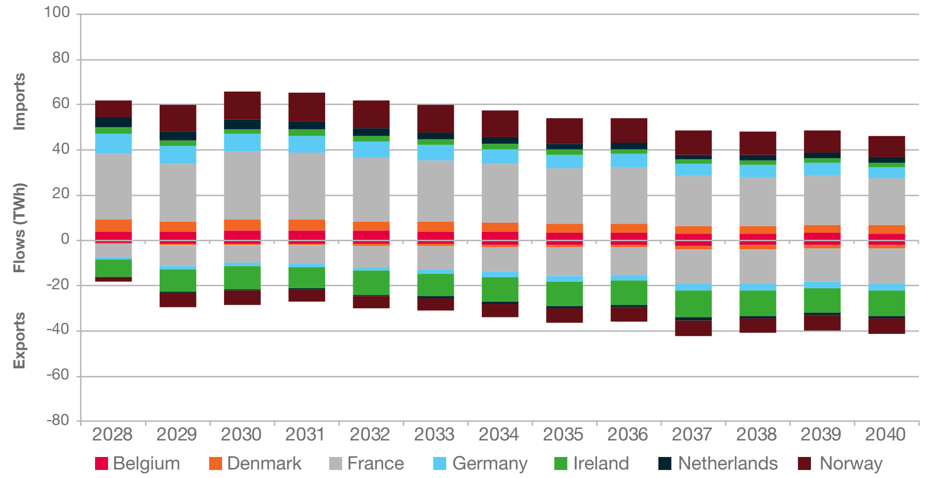
In general, Steady Progression shows GB wholesale prices to be higher than other countries, apart from Ireland. It has the highest levels of electricity prices of the four scenarios, as they are not reduced by the significant levels of renewable generation in the other three scenarios.

This leads to high import flows across the interconnectors, particularly from France, Norway and Germany. Steady Progression shows by far the lowest levels of exports of the four scenarios, as it has the lowest levels of intermittent renewable generation to drive down prices. The relatively high wholesale prices in Ireland lead to GB export arbitrage opportunities.

Figure 6.12 Interconnection capacity, wholesale electricity prices and import and export flows for the optimal path for Steady Progression







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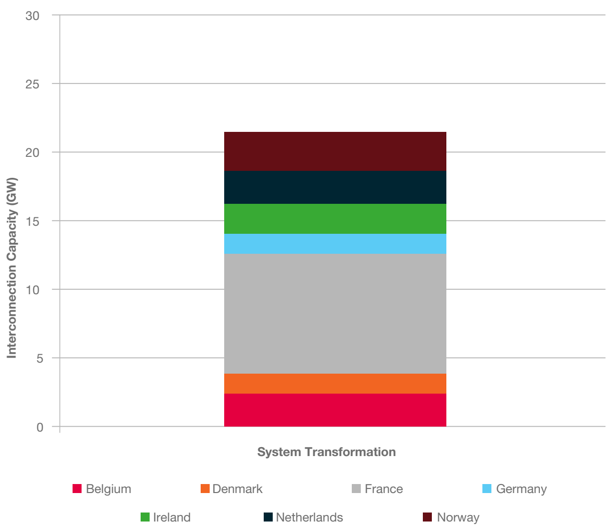
Outcome

System Transformation has some of the lowest GB and other European wholesale prices driven by increasing levels of renewable generation. Of the three scenarios that achieve net zero by 2050, System Transformation sees the lowest level of imports, as it has the highest levels of dispatchable thermal generation using hydrogen as a fuel, transported through the repurposed gas transmission and distribution networks. Throughout the 2030s exports steadily increase, and peak at roughly 120 TWh in 2038, the highest level seen across the four scenarios.

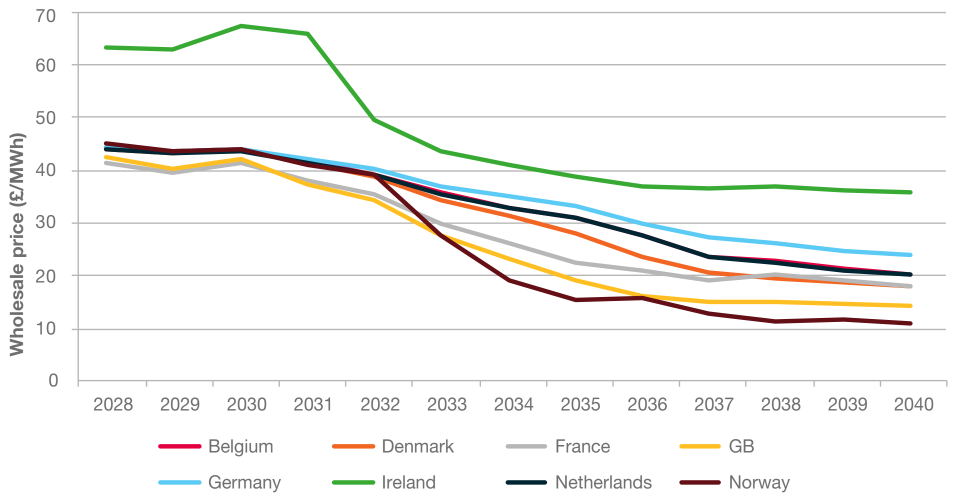
Electricity exports are highest in System Transformation because interconnectors are a source of flexibility to help balance the high levels of variable renewable generation and it has lower levels of electricity demand for electrolysis than the other net zero scenarios.

Also, the ambition to decarbonise with more centralised technologies leads to a focus on large-scale nuclear generation.

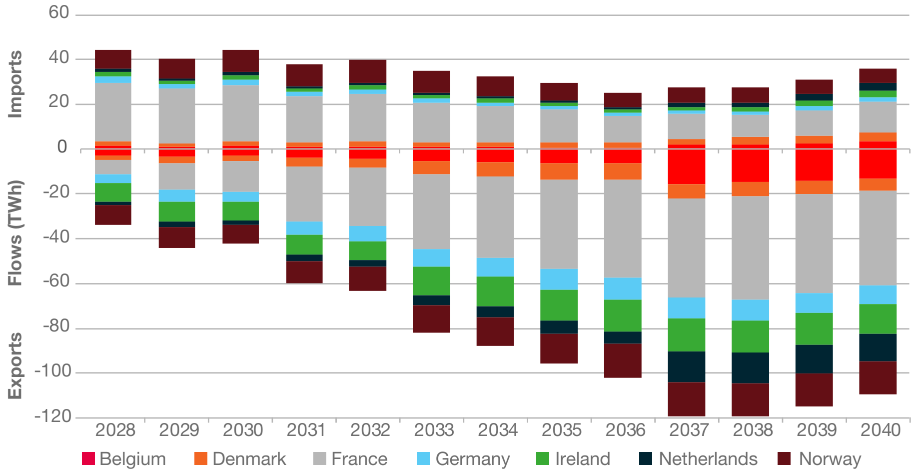
Figure 6.13 Interconnection capacity, wholesale electricity prices and import and export flows for the optimal path for System Transformation



Click to jump to enlarged diagram



Click to jump to enlarged diagram



Click to jump to enlarged diagram

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Outcome

Interaction of interconnectors and constraints

The impact of interconnectors on GB constraints costs is dependent on the location of the interconnector and the level of onshore reinforcement built to accommodate it.

Constraint costs are incurred when power in the merit order is limited by network restrictions. In this event, the System Operator will incur balancing mechanism costs from generation not able to output and offer generation elsewhere on the system to alleviate the constraint. Interconnection to different markets provides the System Operator with another balancing option. Additional interconnection to GB may either help or hinder system balancing, as balancing mechanism costs increase or decrease as network boundaries are further strained or relieved.

Flows across the GB network are from high levels of generation in the north to high levels of demand in the south. Interconnectors in the north may help alleviate constraints when exporting from GB and increase constraints when importing. Conversely, interconnectors in the south of England may reduce network constraints when importing and vice-versa.

This year, the optimal interconnection paths are short, indicating there is little opportunity for SEW value creation or constraint savings from additional interconnection. The former is due to the high level of interconnection already in the baseline for each scenario, and the latter indicates that further interconnection options do not provide significant additional constraint savings beyond that already seen in this year's *NOA*.

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Environmental implications

Increased levels of interconnection bring significant benefits to GB and European consumers, through lower wholesale energy prices, greater use of renewable power and increased environmental benefits.

Reduction in CO_2 emissions

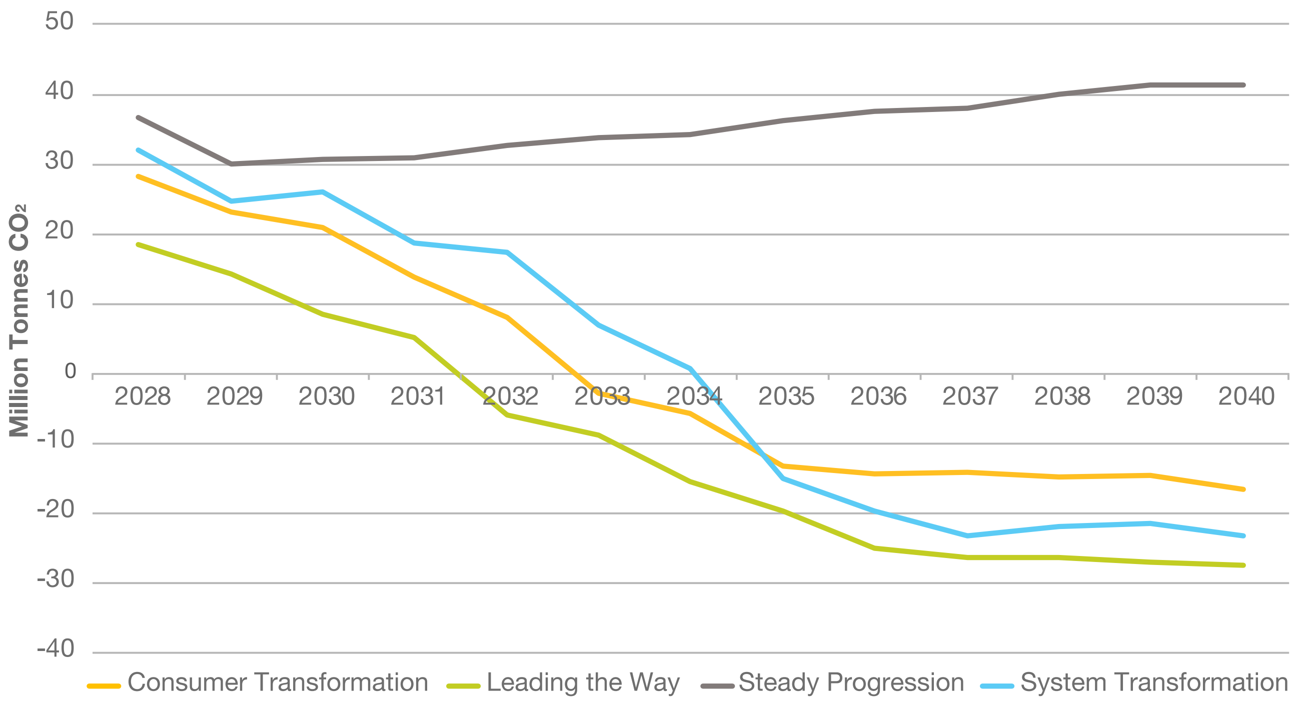
Interconnectors can increase access to renewable power, leading to reductions in CO_2. Interconnection allows surplus power from renewable generation to be exported, rather than curtailed. Figure 6.14 shows the annual CO_2 emissions from generation for each scenario for the final iteration optimal path.

In last year's *NOA* IC we compared the levels of CO_2 emissions for each scenario between the base case and the optimal path. This year, the optimal paths are so short that is of little value, so we have compared the levels of CO_2 emissions across the scenarios. The three scenarios that achieve net zero energy system emissions by 2050 all show significant decreases in CO_2 emissions in the power sector from 2028, achieving net negative emissions in the power sector by the early 2030s. Leading the Way achieves this first. Steady Progression never achieves net negative emissions in the power sector due to the significant levels of fossil fuel generation and lack of Carbon, Capture, Usage and Storage (CCUS). For Leading the Way to achieve the goal of energy system net zero by 2048, power sector emissions need to be negative by 2032.

The difference in emissions between Steady Progression and Leading the Way is roughly 70 million tonnes of CO_2 by 2040.

There is considerable uncertainty in quantifying the cost of greenhouse gas emissions, but using BEIS valuation of greenhouse gas emissions which sets a central price of carbon at £156/tonneCO_2 by 2040, this equates to over £10 bn (undiscounted) for that year.

Figure 6.14 Annual CO_2 emissions from generation for each scenario for the optimal paths



Outcome

Reduction in Renewable Energy Supply (RES) curtailment

Interconnection allows surplus power from renewable generation to be exported, rather than curtailed. This may also replace more expensive fossil fuel generation, resulting in a reduction in prices and reduced curtailment of RES.

Figure 6.15 shows the annual levels of RES curtailment for Consumer Transformation and Steady Progression for the iteration one base case and for the final iteration optimal path.

Figure 6.15 shows that for Consumer Transformation, which has 106 GW of low carbon and renewable capacity by 2030, levels of RES curtailment are considerably higher than in Steady Progression, which has 82 GW of low carbon and renewable capacity by 2030. For both scenarios, in the paths with the optimal levels of additional GB interconnection, the levels of RES curtailment are lower, with Consumer Transformation roughly 24 TWh less and Steady Progression 14 TWh from 2028 to 2040. This equates to approximately 210 MW and 120 MW less RES curtailment for every hour over the thirteen-year period for Consumer Transformation and Steady Progression, respectively.

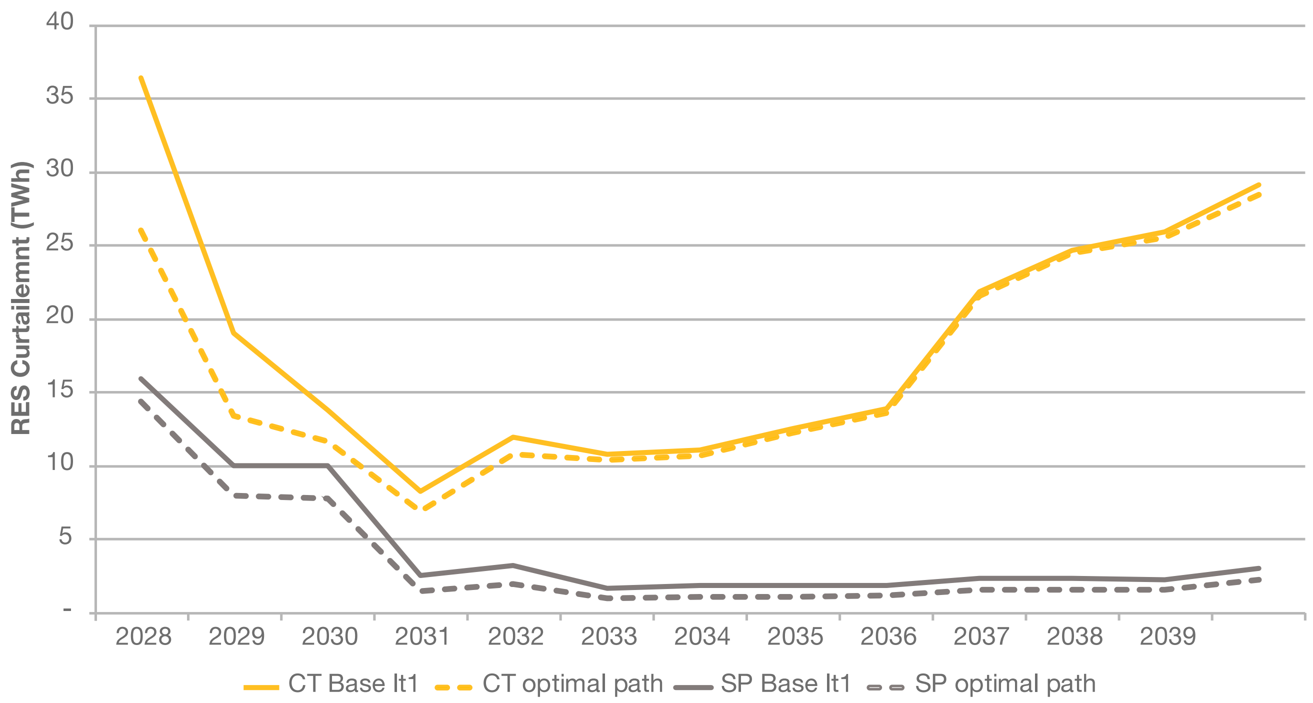


Figure 6.15 Annual levels of RES curtailment for Consumer Transformation for the base case and optimal paths

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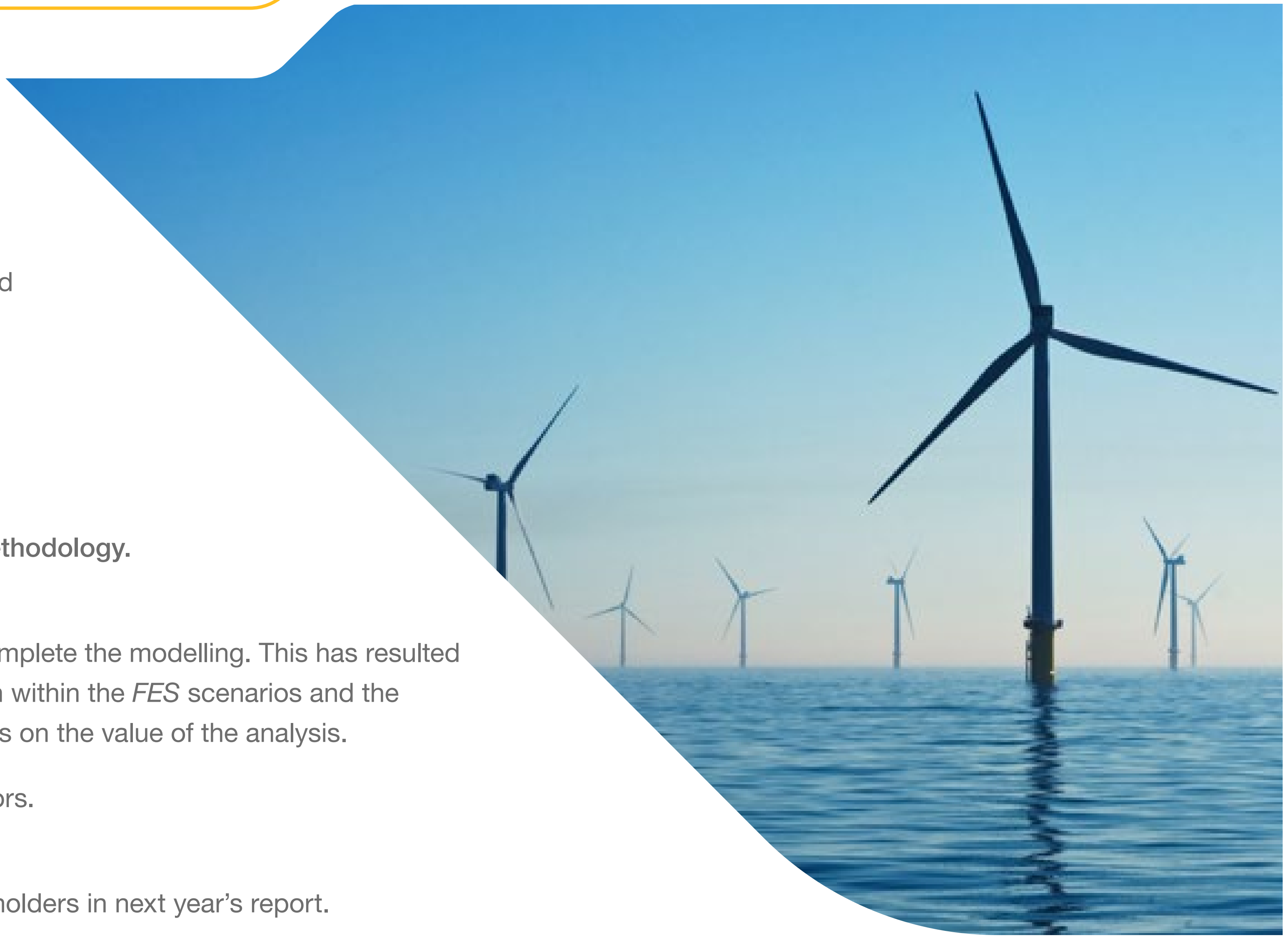
Outcome

System Operability Analysis

We have not included in this year's *NOA* IC analysis a detailed exploration of the impact of interconnectors on the ESO's requirements for system operability. Interconnector system operability analysis will feature within our National Trends and Insights report to be published in February 2021, which forms part of our System Operability Framework.



Stakeholder feedback

Have your say

We continue to rely on stakeholder feedback to develop the *NOA* for Interconnectors methodology. We want to hear your views on this year's analysis and how we can improve next year's.

This year we used the *FES* 2020 levels of interconnection as our baseline to successfully complete the modelling. This has resulted in the baseline levels and optimal paths being similar. Over time the levels of interconnection within the *FES* scenarios and the optimal paths have tended to converge. We are keen to hear your views on the impact of this on the value of the analysis.

Next year we will begin to explore the potential impacts and benefits of hybrid interconnectors. We would value your views on how we should take this work forward.

We are keen to continue to develop our *NOA* IC analysis to provide more value to our stakeholders in next year's report. What additional improvements would you like to see?

We need your help to shape next year's methodology and look forward to your involvement in 2021.

You can send us your thoughts at noa@nationalgrideso.com

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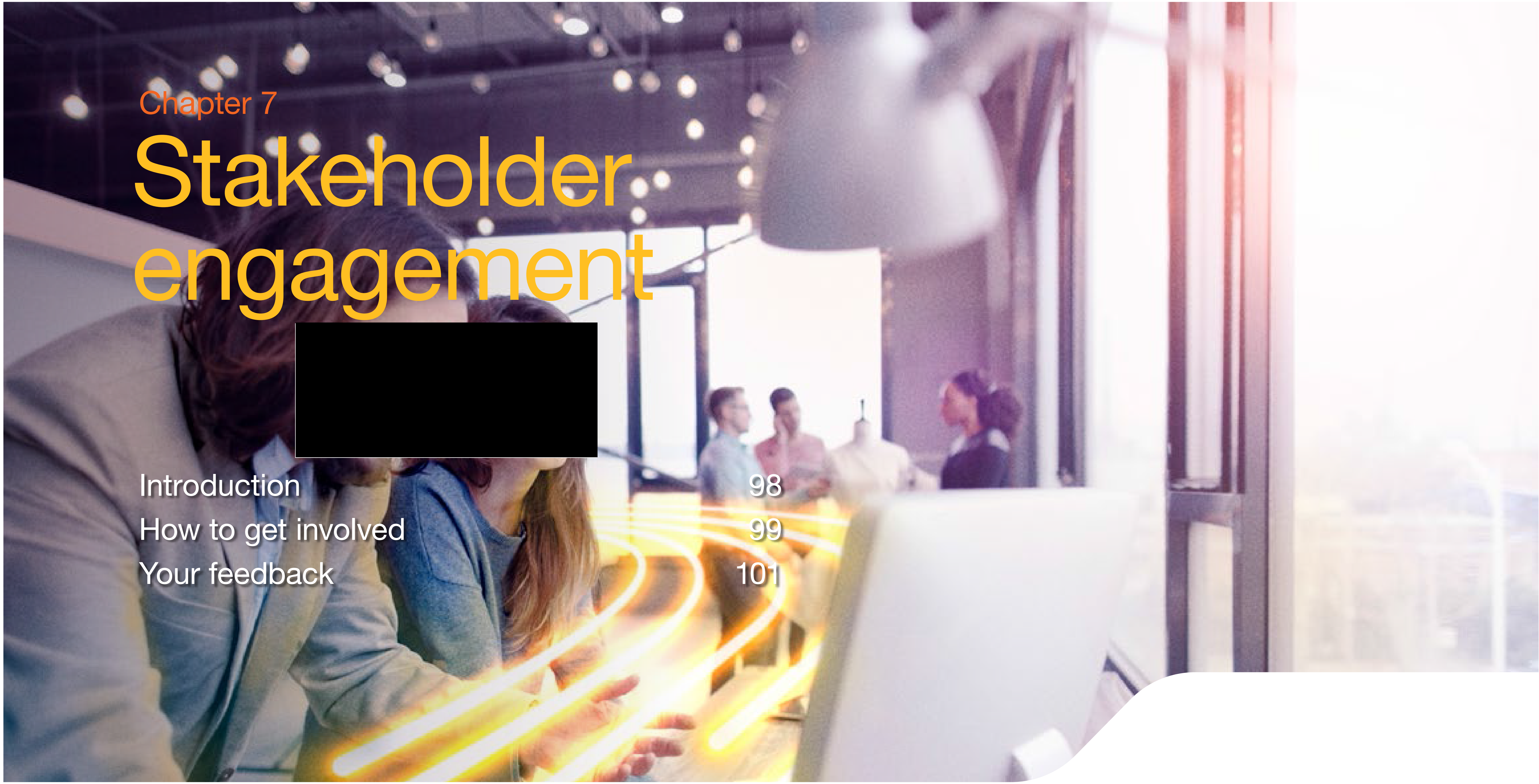

Chapter 7

Stakeholder engagement

Introduction

Your feedback on the *NOA* publication helps us improve year-on-year. Our 2021 stakeholder engagement programme, which runs from when the *NOA* is published until May, is a great opportunity for you to give your views.

Your feedback is important for us to continue developing and improving the *NOA* and the *ETYS*. And because the two documents are closely related, we'll make sure the way we communicate and consult with you reflects this. We'll make sure that the *NOA* publication continues to add value by:

- collating and understanding your views and opinions
- providing opportunities for constructive debate throughout the process
- creating open and two-way communication to discuss assumptions, drivers and outputs; and
- telling you how your views have been used and reporting back on the engagement process.

The annual *NOA* review process will help us develop the publication and we encourage all parties to get involved to help us improve the publication every year.

We've redesigned our *NOA* website to provide a more intuitive and interactive experience, helping you access the results quicker and easier than before.

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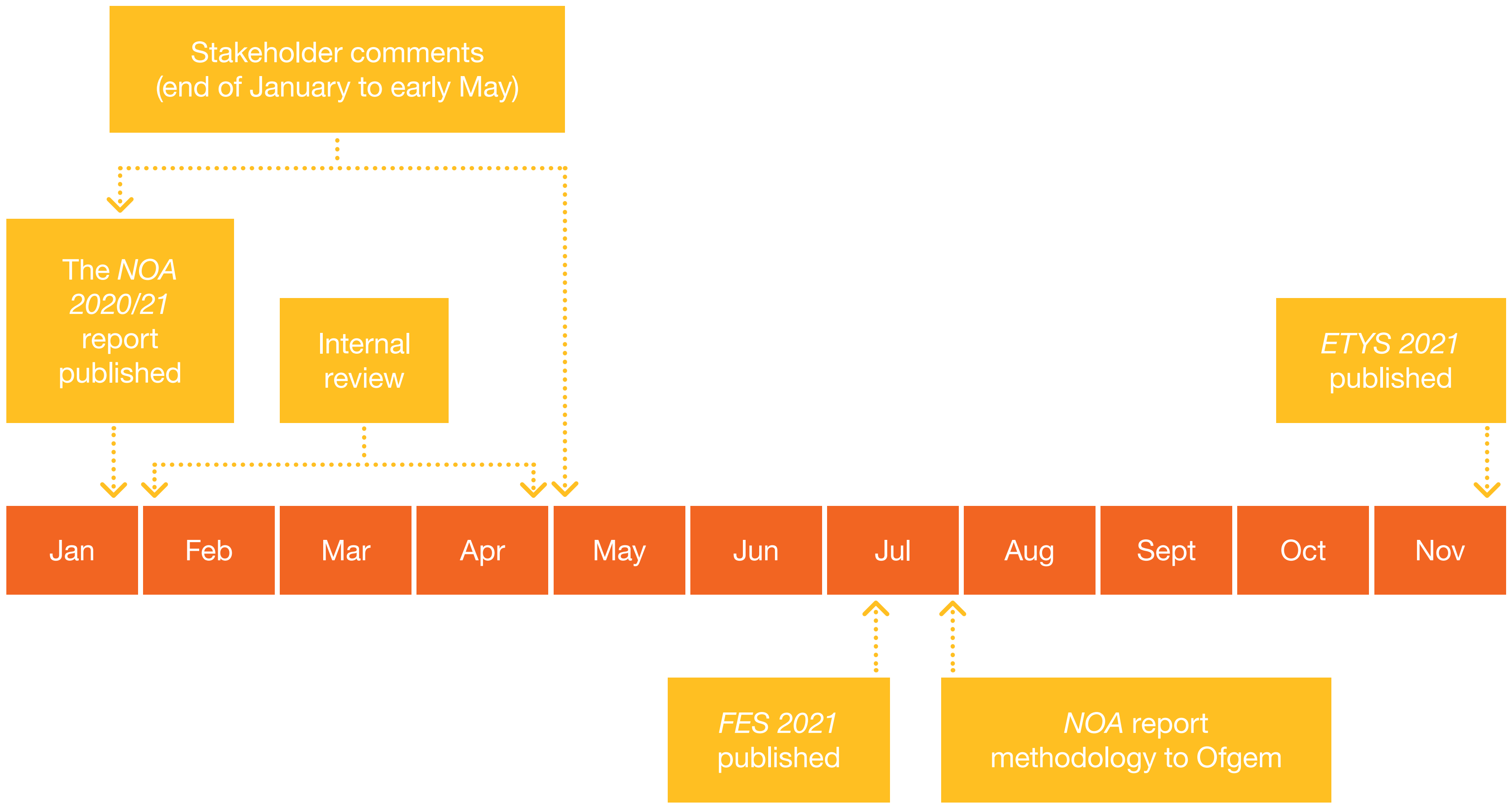
NOA methodology

Now the *NOA* is published, we'll start the review process and we look forward to having conversations with you between now and June 2021. This consultation will cover the *NOA* methodology and the look of the publication, as well as its contents. Because some parts of the *NOA* process start in May, we have already started on some of the methodology's higher-level aspirations.

Figure 7.1 shows our stakeholder activities programme and outlines our licence obligation dates.

Your feedback is important to us, and we urge you to get involved. With your early engagement, we can make sure your views are captured even before the formal consultation process begins.

Figure 7.1 *ETYS/NOA* stakeholder activities programme



How to get involved

Help shape the *NOA* Pathfinder projects

NOA Pathfinder projects look to resolve additional challenges on the electricity network including thermal, high voltage and stability constraints. There are three *NOA* pathfinder projects. They are:

Voltage Pathfinder	Stability Pathfinder	Constraint Management Pathfinder
Aims to find solutions to resolve regional high voltage issues.	Aims to address our immediate needs of national inertia and deliver local short circuit level needs in Scotland.	Aims to resolve network constraint issues and lower balancing costs.

- Help shape the direction of the pathfinder projects. You can do this by emailing: box.networkdevelopment.roadmap@nationalgrideso.com
- You can sign up to our mailing list to receive regular updates on progress of the *NOA* pathfinders.

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Your feedback

We are always happy to listen to your views:

- at consultation events, such as our customer seminars
- through responses to noa@nationalgrideso.com
- at bilateral stakeholder meetings; and
- through any other means convenient for you
- you can also connect with us through social media.

We're continuing to ask readers to let us know what parts of the *NOA* are useful for them to help meet their business goals so we can continue to streamline the document. Please take the time to complete this short survey to help us understand how you use the *NOA*.

@ng_eso

National Grid ESO

National Grid ESO

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Appendix A

Economic analysis results

Economic analysis results

Tables A.1–3 present the results from our cost–benefit analysis. The results present the recommendations from last year's *NOA* for comparison and indicate whether an option meets the criteria as a LOTI project. We also include cost bands for options with a "Proceed" recommendation that satisfy the competition criteria. These options and their cost bands have been highlighted.

Table A.1 Scotland and the north of England region

Code	Option description	Potential LOTI?	*NOA 2019/20* recommendation	*NOA 2020/21* recommendation	Commentary
BBNC	Beauly to Blackhillock 400kV double circuit addition (cost band: £100 million - £500 million)	Y	Do not start	Proceed	This reinforcement becomes 'critical' under three scenarios
BDUP	Uprate the Beauly to Denny 275kV circuit to 400kV		Not featured	Hold	
BLN2	Beauly to Loch Buidhe 275kV reinforcement (cost band: £100 million - £500 million)	Y	Do not start	Proceed	This reinforcement becomes 'critical' under two scenarios
BPNC[1]	A new 400kV double circuit between Blackhillock and Peterhead		Not featured	Hold	
BYRE	Reconductor Blyth to Tynemouth 275kV circuit		Not featured	Do not start	
CBEU	Creyke Beck to Keadby advance rating		Hold	Hold	
CDHW	Cellarhead to Drakelow circuits thermal uprating		Hold	Proceed	This reinforcement becomes 'critical' under three scenarios
CDP1	Power control device along Cellarhead to Drakelow		Delay	Stop	This reinforcement is no longer 'critical' under any scenario
CDP2	Power control device along Cellarhead to Drakelow		Hold	Hold	
CDP3	Additional alternative power control devices along Cellarhead to Drakelow		Do not start	Hold	
CDP4	Additional alternative power control devices along Cellarhead to Drakelow		Hold	Stop	This reinforcement is no longer 'critical' under any scenario
CDRE	Cellarhead to Drakelow reconductoring		Stop	Stop	
CENC	South east Scotland to north east England AC onshore reinforcement		Not featured	Do not start	
CGNC	A new 400kV double circuit between Creyke Beck and the south Humber region (cost band: £100 million - £500 million)	Y	Proceed	Proceed	No change
CKPC	Power control device along Creyke Beck to Keadby to Killingholme		Hold	Hold	
CLNC	New north west England to Lancashire reinforcement		Not featured	Do not start	
CMNC	South east Scotland to north west England AC onshore reinforcement (cost band: £100 million - £500 million)	Y	Not featured	Proceed	This reinforcement is new for *NOA* 2020/21
CRPC	Power control device along Cottam to West Burton		Hold	Hold	
CS03	Commercial solution for the north of Scotland - stage 1		Not featured	Do not start	
CS04	Commercial solution for the north of Scotland - stage 2		Not featured	Do not start	
CS05	Commercial solution for Scotland and the north of England - stage 1		Not featured	Proceed	This reinforcement is new for *NOA* 2020/21
CS06	Commercial solution for Scotland and the north of England - stage 2		Not featured	Proceed	This reinforcement is new for *NOA* 2020/21

1 In order to align with E4L5 delivery.

Economic analysis results

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Table A.1 Scotland and the north of England region (continued)

Code	Option description	Potential LOTI?	*NOA 2019/20* recommendation	*NOA 2020/21* recommendation	Commentary
CTP2	Alternative power control device along Creyke Beck to Thornton		Proceed	Proceed	No change
CTP3	Additional power control devices along the Creyke Beck - Thornton 1 400kV circuit		Not featured	Do not start	
CVUP	Uprating the Clydesmill to Strathaven 275kV circuits to 400kV single circuit		Not featured	Do not start	
CWPC	Power control device along Cottam to West Burton		Hold	Hold	
DEP1	Additional power control devices along the Drax - Eggborough 1 400kV circuit		Not featured	Do not start	
DEPC	Power control device along Drax to Eggborough		Hold	Hold	
DLRE	Loch Buidhe to Dounreay 275kV double circuit reconductoring		Not featured	Hold	
DLUP	Uprate the Windyhill-Lambhill-Denny North 275kV circuit to 400kV		Do not start	Hold	
DNEU	Denny North 400/275kV second supergrid transformer		Hold	Hold	
DREU	Generator circuit breaker replacement to allow Thornton to run a two-way split		Do not start	Do not start	
DWN2	Denny to Wishaw 400kV reinforcement		Do not start	Delay	A decision to invest was not deemed economical this year
DWNO	Denny to Wishaw 400kV reinforcement		Proceed	Proceed	No change
DWUP	Establish Denny North-Clydesmill-Wishaw single 400kV circuit from existing 275kV circuits		Do not start	Proceed	This reinforcement becomes 'critical' under three scenarios
E2D2	Eastern Scotland to England link: Torness to Cottam offshore HVDC		Proceed	Stop	This reinforcement is no longer 'critical' in any scenario
E2D3	Eastern Scotland to England link: Torness to Drax offshore HVDC		Do not start	Do not start	
E2DC	Eastern subsea HVDC link from Torness to Hawthorn Pit (cost band: £1000 million - £1500 million)	Y	Proceed	Proceed	No change
E4D2	Eastern Scotland to England link: Peterhead to Cottam offshore HVDC		Do not start	Do not start	
E4D3	Eastern Scotland to England link: Peterhead to Drax offshore HVDC (cost band: £2000 million - £2500 million)	Y	Proceed	Proceed	No change
E4DC	Eastern Scotland to England link: Peterhead to Hawthorn Pit offshore HVDC		Stop	Stop	
E4L5	Eastern Scotland to England 3rd link: Peterhead to the south Humber offshore HVDC (cost band: £2000 million - £2500 million)	Y	Proceed	Proceed	No change

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Economic analysis results

Tables A.1–3 present the results from our cost–benefit analysis. The results present the recommendations from last year's *NOA* for comparison and indicate whether an option meets the criteria as a LOTI project. We also include cost bands for options with a "Proceed" recommendation that satisfy the competition criteria. These options and their cost bands have been highlighted.

Table A.1 Scotland and the north of England region (continued)

Code	Option description	Potential LOTI?	*NOA 2019/20* recommendation	*NOA 2020/21* recommendation	Commentary
E5L5	Eastern Scotland to England 3rd link: Blackhillock to the south Humber offshore HVDC		Do not start	Do not start	
ECU2	East coast onshore 275kV upgrade		Proceed	Proceed	No change
ECUP	East coast onshore 400kV incremental reinforcement		Proceed	Proceed	No change
ECVC	Eccles hybrid synchronous compensators and real-time rating system		Proceed	Proceed	No change
EDNC	Uprate Brinsworth and Chesterfield double circuit to 400kV and a new 400kV double circuit between Ratcliffe and Chesterfield (cost band: £100 million - £500 million)	Y	Not featured	Proceed	This reinforcement is new for *NOA* 2020/21
EHRE	Elvanfoot to Harker reconductoring		Stop	Hold	
FBRE	Beauly to Fyrish 275kV double circuit reconductoring		Do not start	Do not start	
FINS	East coast 132kV upgrade		Do not start	Do not start	
GWNC	A new 400kV double circuit between the south Humber area and south Lincolnshire (cost band: £500 million - £1000 million)	Y	Proceed	Proceed	No change
HAE2	Harker supergrid transformer 6 replacement		Proceed	Proceed	No change
HAEU	Harker supergrid transformer 5 and supergrid transformer 9A banking arrangement		Proceed	Proceed	No change
HFRE	Reconductor Harker to Fourstones double circuit		Do not start	Do not start	
HNNO	Hunterston East–Neilston 400kV reinforcement		Proceed	Proceed	No change
HSP3	Additional power control device along Harker to Stella West		Not featured	Do not start	
HSR1	Reconductor Harker to Stella West		Hold	Stop	
KBRE	Knocknagael to Blackhillock 275kV double circuit reconductoring		Stop	Stop	
KWHW	Keadby to West Burton circuits thermal uprating		Hold	Hold	
KWPC	Power control device along Keadby to West Burton		Hold	Hold	
LBRE	Beauly to Loch Buidhe 275kV double circuit OHL reconductoring		Hold	Hold	
LCU2	Eastern 400kV reinforcement		Not featured	Do not start	
LRNC	South Lincolnshire to Rutland reinforcement	Y	Not featured	Hold	
LWUP	Longannet 400kV reinforcement		Not featured	Do not start	

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Economic analysis results

Tables A.1–3 present the results from our cost–benefit analysis. The results present the recommendations from last year's *NOA* for comparison and indicate whether an option meets the criteria as a LOTI project. We also include cost bands for options with a "Proceed" recommendation that satisfy the competition criteria. These options and their cost bands have been highlighted.

Table A.1 Scotland and the north of England region (continued)

Code	Option description	Potential LOTI?	*NOA 2019/20* recommendation	*NOA 2020/21* recommendation	Commentary
MRP1	Power control device along Penwortham to Washway Farm to Kirkby		Do not start	Do not start	
MRP2	Additional power control devices at both Harker and Penwortham		Not featured	Proceed	This reinforcement is new for *NOA* 2020/21
NEMS	225MVAr MSCs within the north east region		Hold	Hold	
NEP1	Power control device along Blyth to Tynemouth and Blyth to South Shields		Proceed	Hold	This reinforcement is no longer 'critical' in any scenario
NEPC	Power control device along Blyth to Tynemouth and Blyth to South Shields		Hold	Hold	
NOPC	Power control device along Norton to Osbaldwick		Hold	Hold	
NOR1	Reconductor 13.75km of Norton to Osbaldwick 400kV double circuit		Stop	Stop	
NOR2	Reconductor 13.75km of Norton to Osbaldwick number 1 400kV circuit		Proceed	Stop	This reinforcement has been superceded by new reinforcement NOR5
NOR4	Reconductor 13.75km of Norton to Osbaldwick number 2 400kV circuit		Hold	Hold	
NOR5	Reconductor 13.75km of Norton to Osbaldwick number 1 400kV circuit to a higher rated conductor		Not featured	Hold	
NSM1	225MVAr MSCs within the north east region		Not featured	Hold	
NSM2	225MVAr MSCs within the north east region		Not featured	Do not start	
NSM3	225MVAr MSCs within the north east region		Not featured	Do not start	
OENO	A new 400kV double circuit within Yorkshire between Eggborough and Osbaldwick		Stop	Stop	
OPN1	A new 400kV double circuit between the existing Norton to Osbaldwick circuit and Poppleton and relevant 400kV upgrades		Do not start	Do not start	
OPN2	A new 400kV double circuit between the existing Norton to Osbaldwick circuit and Poppleton and relevant 275kV upgrades (cost band: £100 million - £500 million)	Y	Proceed	Proceed	No change
OPN4	A new alternative 400kV double circuit between the existing Norton to Osbaldwick and Poppleton and relevant 275kV upgrades		Do not start	Do not start	
OPN5	A new 400kV double circuit between the existing Norton to Osbaldwick and Poppleton and relevant 275kV and 400kV upgrades		Not featured	Do not start	
PFRE	Reconductor Penwortham to Washway Farm 275kV double circuit		Not featured	Do not start	

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Economic analysis results

Tables A.1–3 present the results from our cost–benefit analysis. The results present the recommendations from last year's *NOA* for comparison and indicate whether an option meets the criteria as a LOTI project. We also include cost bands for options with a "Proceed" recommendation that satisfy the competition criteria. These options and their cost bands have been highlighted.

Table A.1 Scotland and the north of England region (continued)

Code	Option description	Potential LOTI?	*NOA 2019/20* recommendation	*NOA 2020/21* recommendation	Commentary
PMU1	Yorkshire reinforcement upgrade 1		Not featured	Do not start	
PMU2	Yorkshire reinforcement upgrade 2		Not featured	Do not start	
PSDC	Spittal to Peterhead HVDC reinforcement		Not featured	Do not start	
PWMS	Two 225MVAr MSCs at Penwortham		Hold	Hold	
SBDC	Spittal to Blackhillock HVDC reinforcement		Not featured	Hold	
SBRE	Reconductor South Shields to West Boldon 275kV circuit		Not featured	Do not start	
SHNS	Upgrade substation in the south Humber area		Proceed	Proceed	No change
SLU2	Loch Buidhe to Spittal 275kV reinforcement		Not featured	Do not start	
SNHW	Spennymoor to Norton circuit thermal uprating		Not featured	Do not start	
SSHW	Stella West to Spennymoor circuit thermal uprating		Not featured	Hold	
TBRE	Reconductor Tynemouth to West Boldon 275kV circuit		Not featured	Do not start	
TDP2	Additional power control device along Drax to Thornton		Hold	Hold	
TDPC	Power control device along Drax to Eggborough		Hold	Hold	
TDR1	Reconductor Drax to Thornton 2 circuit		Not featured	Hold	
TDR2	Reconductor Drax to Thornton 1 circuit		Not featured	Hold	
TFPC	Power control device on Tealing to Westfield circuit		Not featured	Hold	
TGDC	Eastern subsea HVDC Link from south east Scotland to south Humber area (cost band: £1500 million - £2000 million)	Y	Not featured	Proceed	This reinforcement is new for *NOA* 2020/21
THDC	Alternative staged eastern subsea HVDC link from Torness to Hawthorn Pit		Not featured	Do not start	
THS1	Installation of a single series reactor at Thornton substation		Proceed	Proceed	No change
TKU2	Alternative east coast onshore phase 2 reinforcement		Not featured	Do not start	
TKUP	East coast onshore 400kV phase 2 reinforcement		Do not start	Do not start	
TLNO	Torness to north east England AC onshore reinforcement		Proceed	Stop	This reinforcement has been superceded by new reinforcement CMNC

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Economic analysis results

Tables A.1–3 present the results from our cost–benefit analysis. The results present the recommendations from last year's *NOA* for comparison and indicate whether an option meets the criteria as a LOTI project. We also include cost bands for options with a "Proceed" recommendation that satisfy the competition criteria. These options and their cost bands have been highlighted.

Table A.1 Scotland and the north of England region (continued)

Code	Option description	Potential LOTI?	*NOA* 2019/20 recommendation	*NOA* 2020/21 recommendation	Commentary
TTNC	New north east England to north Yorkshire reinforcement		Not featured	Do not start	
TUEU	Tummel reconfiguration		Do not start	Do not start	
WHTI	Tee-in of the West Boldon to Hartlepool circuit at Hawthorn Pit		Proceed	Proceed	No change
WLTI	Windyhill–Lambhill–Longannet 275kV circuit turn-in to Denny North 275kV substation		Delay	Proceed	This reinforcement becomes 'critical' under three scenarios
WORE	Reconductor West Boldon to Offerton 275kV circuit		Not featured	Do not start	
WRRE	Reconductor West Burton to Ratcliffe-on-Soar circuit		Do not start	Hold	

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Economic analysis results

Tables A.1–3 present the results from our cost–benefit analysis. The results present the recommendations from last year's *NOA* for comparison and indicate whether an option meets the criteria as a LOTI project. We also include cost bands for options with a "Proceed" recommendation that satisfy the competition criteria. These options and their cost bands have been highlighted.

Table A.2 South and east of England region

Code	Option description	Potential LOTI?	*NOA 2019/20* recommendation	*NOA 2020/21* recommendation	Commentary
AENC	A new 400kV double circuit in north East Anglia (Cost band: £100 million - £500 million)	Y	Not featured	Proceed	This reinforcement is new for *NOA* 2020/21
ATNC	A new 400kV double circuit in south East Anglia (Cost band: £100 million - £500 million)	Y	Not featured	Proceed	This reinforcement is new for *NOA* 2020/21
BFHW	Bramley to Fleet circuits thermal uprating		Hold	Hold	
BFPC	Power control device along Bramley to Fleet		Not featured	Hold	
BFRE	Bramley to Fleet reconductoring		Hold	Hold	
BMM2	225MVAr MSCs at Burwell Main		Proceed	Proceed	No change
BPRE	Reconductor the newly formed second Bramford to Braintree to Rayleigh main circuit		Proceed	Proceed	EISD submitted for *NOA* 2020/21 is one year earlier
BRRE	Reconductor remainder of Bramford to Braintree to Rayleigh route		Proceed	Hold	This reinforcement is no longer 'critical' under any scenario
BTNO	A new 400kV double circuit between Bramford and Twinstead (Cost band: £100 million - £500 million)		Proceed	Proceed	No change
BWRE	Reconductor Barking to West Ham double circuit		Do not start	Hold	
CS07	Commercial solution for East Anglia - stage 1		Not featured	Proceed	This reinforcement is new for *NOA* 2020/21
CS08	Commercial solution for East Anglia - stage 2		Not featured	Proceed	This reinforcement is new for *NOA* 2020/21
CS09	Commercial solution for the south coast - stage 1		Not featured	Do not start	
CS10	Commercial solution for the south coast - stage 2		Not featured	Do not start	
CTRE	Reconductor remainder of Coryton South to Tilbury circuit		Hold	Proceed	This reinforcement becomes 'critical' under all scenarios
ESC1	Second Elstree to St John's Wood 400kV circuit		Hold	Hold	
FMHW	Feckenham to Minety circuit thermal uprating		Not featured	Hold	
FMPC	Power control device along Feckenham to Minety		Not featured	Hold	
FMRE	Feckenham to Minety circuit reconductoring		Not featured	Do not start	
FWPC	Power control device along Feckenham to Walham		Not featured	Hold	

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Economic analysis results

Tables A.1–3 present the results from our cost–benefit analysis. The results present the recommendations from last year's *NOA* for comparison and indicate whether an option meets the criteria as a LOTI project. We also include cost bands for options with a "Proceed" recommendation that satisfy the competition criteria. These options and their cost bands have been highlighted.

Table A.2 South and east of England region (continued)

Code	Option description	Potential LOTI?	*NOA* 2019/20 recommendation	*NOA* 2020/21 recommendation	Commentary
HBUP	Uprate Bridgewater to 400kV and reconductor the route to Hinkley		Hold	Stop	
HENC	Hertfordshire reinforcement		Not featured	Do not start	
HWUP	Uprate Hackney, Tottenham and Waltham Cross 275kV to 400kV	Y	Stop	Proceed	This reinforcement becomes 'critical' under all scenarios. Change is due to updated technical data provided for *NOA* 2020/21
IFHW	Feckenham to Ironbridge circuit thermal uprating		Not featured	Hold	
IFR1	Feckenham to Ironbridge circuit reconductoring		Not featured	Do not start	
MBHW	Bramley to Melksham circuits thermal uprating		Proceed	Hold	This reinforcement is no longer 'critical' under any scenario
MBRE	Bramley to Melksham reconductoring		Hold	Hold	
NBRE	Reconductor Bramford to Norwich double circuit		Hold	Hold	
NIM1	225MVAr MSCs at Ninfield		Not featured	Hold	
NIM2	225MVAr MSCs at Ninfield		Not featured	Hold	
NOM1	225MVAr MSCs at Norwich		Hold	Hold	
NOM2	225MVAr MSCs at Norwich		Hold	Hold	
NTP1	Power control device along North Tilbury		Proceed	Hold	This reinforcement is no longer 'critical' under any scenario
PEM1	225MVAr MSCs at Pelham		Hold	Proceed	This reinforcement becomes 'critical' under two scenarios
PEM2	225MVAr MSCs at Pelham		Hold	Proceed	This reinforcement becomes 'critical' under two scenarios
RHM1	225MVAr MSCs at Rye House		Hold	Proceed	This reinforcement becomes 'critical' under one scenario
RHM2	225MVAr MSCs at Rye House		Hold	Proceed	This reinforcement becomes 'critical' under one scenario
RTRE	Reconductor remainder of Rayleigh to Tilbury circuit		Proceed	Proceed	No change
SCD1	New offshore HVDC link between Suffolk and Kent option 1 (Cost band: £1000 million - £1500 million)	Y	Proceed	Proceed	No change
SCD2	New offshore HVDC link between Suffolk and Kent option 2		Hold	Stop	
SCN1	New 400kV transmission route between south London and the south coast		Stop	Stop	

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Economic analysis results

Tables A.1–3 present the results from our cost–benefit analysis. The results present the recommendations from last year's *NOA* for comparison and indicate whether an option meets the criteria as a LOTI project. We also include cost bands for options with a "Proceed" recommendation that satisfy the competition criteria. These options and their cost bands have been highlighted.

Table A.2 South and east of England region (continued)

Code	Option description	Potential LOTI?	*NOA* 2019/20 recommendation	*NOA* 2020/21 recommendation	Commentary
SEEU	Reactive series compensation protective switching scheme		Proceed	Hold	This reinforcement is no longer 'critical' under any scenario
SER1	Elstree to Sundon reconductoring		Proceed	Proceed	No change
SER2	Elstree–Sundon 2 circuit turn-in and reconductoring		Hold	Hold	
TENC	Thames Estuary reinforcement (Cost band: £100 million - £500 million)	Y	Not featured	Proceed	This reinforcement is new for *NOA* 2020/21
TGP1	Power control device along Tilbury to Grain		Not featured	Hold	
THRE	Reconductor Hinkley Point to Taunton double circuit		Hold	Hold	
TKP1	Power control device along Tilbury to Kingsnorth		Not featured	Hold	
TKRE	Tilbury to Grain and Tilbury to Kingsnorth upgrade	Y	Proceed	Hold	This reinforcement is no longer 'critical' under any scenario
WAM1	225MVAr MSCs at Walpole		Hold	Hold	
WAM2	225MVAr MSCs at Walpole		Hold	Hold	
WSEU	Thermal upgrade for Sundon and Wymondley 400kV substation		Not featured	Hold	
WSR1	Sundon-Wymondley circuit 1 reconductoring		Not featured	Hold	
WSR2	Sundon-Wymondley circuit 2 reconductoring		Not featured	Hold	
WTUP	Uprate Tilbury to Waltham Cross route from 275kV to 400kV		Not featured	Do not start	
WYTI	Wymondley turn-in		Hold	Hold	

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Economic analysis results

Tables A.1–3 present the results from our cost–benefit analysis. The results present the recommendations from last year's *NOA* for comparison and indicate whether an option meets the criteria as a LOTI project. We also include cost bands for options with a "Proceed" recommendation that satisfy the competition criteria. These options and their cost bands have been highlighted.

Table A.3 Wales

Code	Option description	Potential LOTI?	*NOA* 2019/20 recommendation	*NOA* 2020/21 recommendation	Commentary
MIC1	Cable replacement at Severn Tunnel	Y	Not featured	Hold	
PTC1	Pentir to Trawsfynydd cable replacement	Y	Not featured	Hold	
PTNO	North Wales reinforcement	Y	Not featured	Delay	A decision to invest was not deemed economical this year
WCC1	Cable replacement at Hinksey		Not featured	Hold	

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Appendix B

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B.1 Eastern network reinforcement

1. Background

The scope of reinforcements included for the eastern network in the northern region includes offshore HVDC links as well as onshore reinforcement. These projects increase capability on one or more of the MITS boundaries, B1a, B2, B4, B5, B6, B7, B7a and B8. The objective is to increase the north-to-south transfer capability on the east coast of the Scottish and northern England transmission system between boundaries B1a in the Scottish Hydro Electric Transmission (SHE Transmission) area and B8 in the National Grid Electricity Transmission (NGET) area. This will safely enable greater volumes of north-to-south power flows arising from predominantly new renewable generation in Scotland. This includes key boundaries between SHE Transmission and SP Transmission (B4) and between SP Transmission (SPT) and NGET (B6). Several reinforcements are proposed in accordance with the NETS SQSS[1] and under the Transmission Owners' obligations in their transmission licences.

We have assessed six permutations of the early subsea HVDC link options for potential landing points within the north of England:

- E4DC – Eastern Scotland to England link: Peterhead to Hawthorn Pit offshore HVDC
- E4D2 – Eastern Scotland to England link: Peterhead to Cottam offshore HVDC
- E4D3 – Eastern Scotland to England link: Peterhead to Drax offshore HVDC
- E2DC – Eastern subsea HVDC link from Torness to Hawthorn Pit
- E2D2 – Eastern Scotland to England link: Torness to Cottam offshore HVDC
- E2D3 – Eastern Scotland to England link: Torness to Drax offshore HVDC

We also added a further option this year to test optimal capacity of the E2DC link, where a staged approach to delivering a 2.8GW link as an alternative to the assumed 2GW of the above, in the form of THDC option. This is due in part to the increasing levels of generation expected local to the Torness area in SPT's area.

The links from Peterhead along with associated onshore works, can increase transfer capability on boundaries B1a down to B8[2]. The links from Torness increase transfer capability on boundaries B6 down to B8[3].

The scope of the eastern onshore reinforcements involves increasing the capacity of the existing eastern onshore circuits between Blackhillock and Kincardine that cross B1a, B2 and B4, by initially augmenting their capability at 275kV. Further uplift in capacity will be delivered by uprating these circuits to operate at 400kV. Both projects have consistently been identified as 'critical' and are included within the RIIO-T2 base allowance. Additionally, onshore network reinforcement is included to develop the network in the central belt of Scotland and increase the capability of the B5 boundary by establishing a new 400kV corridor between Denny and Wishaw in the SPT network.

To reflect the significant increase in system transfer requirements driven by the new Net Zero *Future Energy Scenarios*, several additional options were included. These include additional onshore reinforcements, as well as further offshore HVDC links between the north east of Scotland (Peterhead) and England and between the south east of Scotland (in the Torness area) and England:

- E4L5 – Eastern Scotland to England 3rd link: Peterhead to the south Humber offshore HVDC
- E5L5 – Eastern Scotland to England 3rd link: Blackhillock to the south Humber offshore HVDC
- TGDC - Eastern subsea HVDC link from south east Scotland to south Humber area
- TLNO – Torness to north east England AC onshore reinforcement

1 The NETS SQSS is the National Electricity Transmission System Security and Quality of Supply Standard. GB Transmission Owners have licence obligations to develop their transmission systems in accordance with the NETS SQSS.
2 Depending on onshore location in the north of England.
3 Depending on onshore location in the north of England.

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- CMNC – South east Scotland to north west England AC onshore reinforcement
- CENC – South east Scotland to north east England AC onshore reinforcement
- CLNC – New north west England to Lancashire reinforcement
- TTNC – New north east England to north Yorkshire reinforcement

The additional HVDC links from Peterhead and Blackhillock can increase transfer capability on boundaries B1a down to B8[4]. The additional HVDC link from Torness increases transfer capability on boundaries B6 down to B8[5].

The recommendation from the 2020/21 *NOA* process is to progress the following reinforcements for the eastern network in the northern region this year to maintain the earliest in-service date (EISD):

- ECU2 - East coast onshore 275kV upgrade
- ECUP - East coast onshore 400kV incremental reinforcement
- E2DC – Eastern subsea HVDC link: Torness to Hawthorn Pit
- E4D3 – Eastern Scotland to England link: Peterhead to Drax offshore HVDC
- DWNO - Denny to Wishaw 400kV reinforcement
- E4L5 – Eastern Scotland to England 3rd link: Peterhead to the south Humber Offshore HVDC
- TGDC – Eastern subsea HVDC link from south east Scotland to south Humber area
- CMNC – South east Scotland to north west England AC onshore reinforcement

The need to reinforce the transmission network is driven by the growth of mainly renewable generation and interconnectors in the SHE Transmission, SPT and NGET (north England) areas, including offshore windfarms and interconnectors situated in the Moray Firth, in the Firth of Forth and off the north east coast of England. Required transfers for boundaries B4, B6, B7, B7a and B8 for the four 2020 *Future Energy Scenarios* can be found in sections 3.1 and 3.2 (in chapter 3) of the *ETYS* 2020. The figures also show current network capabilities across the boundaries, as well as the annual power flow for each scenario. Expected future power flows are greatly above current network capability. Further information on how to interpret these boundary graphs is included in this year's *ETYS*. The difference between the required transfers and the network capability shows a need for further network reinforcement, which is assessed economically against cost of constraints via the *NOA* process.

2. Option development

Reinforcement options have been developed in the eastern network in the northern region to improve boundary capability across boundaries B1a to B8. These consider onshore and offshore solutions and are at varying levels of development. To reflect the significant increase in system transfer requirements for this year, we have proposed additional options which include additional onshore reinforcements and further offshore HVDC links between the North of Scotland and England and between the South East of Scotland and England.

2.1 Notable Options

(a) East coast onshore 275kV upgrade (ECU2)

Establish a new 275kV substation at Alyth, including shunt reactive compensation, extend Tealing 275kV substation and install two phase shifting transformers; re-profile the 275kV circuits between Kintore, Alyth and Kincardine, and Tealing, Westfield and Longannet, and uprate the cable sections at Kincardine and Longannet. This option provides additional transmission capacity across boundaries B1a, B2 and B4 and is included within the RIIO-T2 base allowance.

(b) East coast onshore 400kV incremental reinforcement (ECUP)

Following ECU2, establish a new 400kV substation at Kintore, uprate Alyth substation for 400kV operation, re-insulate the 275kV circuits between Blackhillock, Peterhead,

4 Depending on onshore location in the north of England.
5 Depending on onshore location in the north of England.

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Rothienorman, Kintore, Fetteresso, Alyth and Kincardine for 400kV operation and install phase shifting transformers at Blackhillock. This provides additional transmission capacity across boundaries B1a, B2 and B4 and is included within the RIIO-T2 base allowance.

(c) Denny to Wishaw 400kV reinforcement (DWNO)

Construct a new 400kV double circuit from Bonnybridge to Newarthill and reconfigure associated sites to establish a fourth north-to-south double circuit supergrid route through the Scottish central belt.

One side of the new overhead line will be operated at 400kV, the other at 275kV. This will establish Denny– Bonnybridge, Bonnybridge–Wishaw, Wishaw– Strathaven No.2 and Wishaw–Torness 400kV circuits, and a Denny–Newarthill–Easterhouse 275kV circuit. This provides additional transmission capacity across boundary B5.

Ahead of the completion of DWNO, there may be benefit in completing option DWUP, using existing 275kV overhead line circuits ahead of the construction of a new double circuit, reconfigured to establish a 400kV single circuit between Denny North, Clydesmill and Wishaw. If completed in combination with DWNO the result is two new additional 400kV circuits over B5, establishing a total of three 400kV circuits over B5.

(d) Eastern Scotland to England link: Peterhead to Hawthorn Pit offshore HVDC (E4DC)

Construct a new offshore 2GW HVDC subsea link from Peterhead to Hawthorn Pit (north of England), including AC/DC converter stations and associated AC onshore works at both ends of the link. At Hawthorn Pit, works include a new 400kV Hawthorn Pit substation, uprating of the Hawthorn Pit–Norton circuit and associated circuit reconfiguration works in the area. This provides additional transmission capacity across boundaries, B1a, B2, B4, B5, B6, B7, and B7a.

(e) Eastern Scotland to England link: Peterhead to Cottam offshore HVDC (E4D2)

Construct a new offshore 2GW HVDC subsea link from Peterhead to Cottam (north Nottinghamshire), including AC/DC converter stations and associated AC onshore works at both ends of the link. The works at Cottam connect into a spare bay at Cottam 400kV substation. This provides additional transmission capacity across boundaries B1a, B2, B4, B5, B6, B7, B7a and B8.

(f) Eastern Scotland to England link: Peterhead to Drax offshore HVDC (E4D3)

Construct a new offshore 2GW HVDC subsea link from Peterhead to Drax (Yorkshire), including AC/DC converter stations and associated AC onshore works at both ends of the link. At Peterhead, work includes the upgrade of the 275kV circuits along the Blackhillock–Rothienorman–Peterhead route to 400kV operation. Work at Drax involves connecting into a new bay at the 400kV substation and may also include associated fault level mitigation. This gives additional transmission capacity across boundaries B1a, B2, B4, B5, B6, B7, B7a and B8.

(g) Eastern subsea HVDC link from Torness to Hawthorn Pit

Construct a new offshore 2GW HVDC subsea link from the Torness area to Hawthorn Pit, including AC/DC converter stations and associated AC works. The AC onshore works in the Torness area include extension of the pre-existing ‘Branxton 400kV substation’ by two 400kV GIS bays to provide connection to the ‘Branxton Converter Station’. At Hawthorn Pit a new 400kV Hawthorn Pit substation will be needed, along with uprating the Hawthorn Pit–Norton circuit and associated circuit reconfiguration works. This provides additional transmission capacity across boundaries B6, B7 and B7a.

(h) Eastern Scotland to England link: Torness to Cottam offshore HVDC (E2D2)

Construct a new offshore 2GW HVDC subsea link from the Torness area to Cottam, including

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AC/DC converter stations and associated AC works at Torness and Cottam. The AC onshore works around Torness include extension of the pre-existing 'Branxton 400kV substation' by two 400kV GIS bays to connect to the 'Branxton Converter Station'. The AC onshore works at Cottam connect into a spare bay at the 400kV substation. This provides additional transmission capacity across boundaries B6, B7, B7a and B8.

(i) Eastern Scotland to England link: Torness to Drax offshore HVDC (E2D3)

Construct a new offshore 2GW HVDC subsea link from the Torness area to Drax, including AC/DC converter stations and associated AC works at Torness and Drax. AC onshore works around Torness include extension of the pre-existing 'Branxton 400kV substation' by two 400kV GIS bays connecting to the 'Branxton Converter Station'. Work at Drax includes connecting into a new bay at the 400kV substation and may also include associated fault level mitigation. This provides additional transmission capacity across boundaries B6, B7, B7a and B8.

(j) Alternative staged eastern subsea HVDC link from Torness to Hawthorn Pit (THDC)

Construct a two-stage 2.8GW HVDC subsea link from Torness to Hawthorn Pit, in two 1.4GW stages. The AC onshore works around Torness include extension of the pre-existing 'Branxton 400kV substation' by two 400kV GIS bays to connect to the 'Branxton Converter Station'. At Hawthorn Pit work includes a new 400kV substation, uprating of the Hawthorn Pit–Norton circuit and associated circuit reconfiguration works. This provides additional transmission capacity across boundaries B6, B7 and B7a.

(k) Eastern Scotland to England 3rd link: Peterhead to the south Humber offshore HVDC (E4L5)

Following completion of both the first (E2DC) and second (E4D3) eastern HVDC links from Scotland to the north east of England construct a second offshore 2GW HVDC subsea link from Peterhead terminating at a substation in the south Humber area. Works to include AC/DC converter stations and associated AC onshore works at both ends of the link. The required works at the Peterhead end include a new 400kV double circuit between Blackhillock and Peterhead via New Deer (BPNC). In south Humber works include substation equipment and circuit upgrades once the best location has been identified. This provides additional transmission capacity across boundaries B1a, B2, B4, B5, B6, B7, B7a and B8.

(l) Eastern Scotland to England 3rd link: Blackhillock to the south Humber offshore HVDC (E5L5)

Following completion of both the first (E2DC) and second (E4D3) Eastern HVDC Links from Scotland to the north east of England construct a 2GW HVDC subsea link from Blackhillock terminating at a substation in the south Humber area. Works to include AC/DC converter stations and associated AC onshore works at both ends of the link. Work in south Humber includes substation equipment and circuit upgrades once the best location has been identified. This provides additional transmission capacity across boundaries B1a, B2, B4, B5, B6, B7, B7a and B8.

(m) Eastern subsea HVDC link from south east Scotland to south Humber area (TGDC)

Following completion of both the first (E2DC) and second (E4D3) Eastern HVDC Links from Scotland to the north east of England construct a 2GW HVDC subsea link from the Torness area terminating at a substation in the south Humber area. Works to include AC/DC converter stations and AC onshore works at both ends of the link. This provides additional transmission capacity across boundaries B6, B7, B7a and B8.

(n) South east Scotland to north west England AC onshore reinforcement (CMNC)

Install a new 400kV double circuit from a substation in the south-east of the SPT area to a substation in NGET's north west area, and install new substation equipment. This forms a new east-west circuit crossing the B6 boundary and is also required to facilitate large renewable connection applications in the Scottish borders, which cannot be supported without major new built transmission assets.

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(o) South east Scotland to north east England AC onshore reinforcement (CENC)

Install a new 400kV double circuit from a substation in the south-east of the SPT area to a substation in NGET's north east area, and new substation equipment. This forms a new circuit crossing the B6 boundary and is also required to facilitate large renewable connection applications in the Scottish borders, which cannot be supported without major new built transmission assets.

(p) Torness to north east England AC onshore reinforcement (TLNO)

Install a new double circuit from a new 400kV substation in the Torness area to the transmission system in north east England. Construct a new 400kV double circuit from the Torness area to a suitable connection point in north east England, including additional substation equipment. This provides additional thermal capacity across boundaries B6, B7 and B7a.

2.2 Lead options

In the 2020/21 *NOA*, ECU2, ECUP, E2DC, DWNO (or the alternative staged approach). E4D3, E4L5, TGDC and CMNC have been identified as the most efficient and beneficial reinforcements.

(a) East coast onshore 275kV upgrade (ECU2)

ECU2 has a "Proceed" recommendation in *NOA* 2020/21. It is justified in all four 2020 *FES* and has been identified as 'critical' for four consecutive years. It reinforces boundary B1a to B4 and is the earliest reinforcement option to release B4 boundary constraints with its EISD of 2023. ECU2 is included in the RIIO-T2 base allowance.

(b) East coast onshore 400kV incremental reinforcement (ECUP)

ECUP is in the 'optimal' path and 'critical' in all four scenarios. As a further onshore network upgrade to ECU2 on the east coast, it unlocks system constraints from B2 to B4, especially boundary B4. It has a "Proceed" recommendation and is also included in the RIIO-T2 base allowance.

(c) Eastern subsea HVDC link from Torness to Hawthorn Pit (E2DC)

E2DC is in the 'optimal' path and 'critical' in all four *FES* 2020. It unlocks transmission constraints across boundary B5 to B7a from 2027 onwards. With help of B7a and B8 reinforcements transporting Scottish energy further south, E2DC is required as early as possible to maximise its value.

(d) Eastern Scotland to England link: Peterhead to Cottam offshore HVDC (E4D3)

E4D3 is identified in the 'optimal' path and 'critical' in all four 2020 *FES*. An eastern Link from Peterhead has been 'critical' for five years, with E4D3 being the recommended option for the last three years. It provides additional boundary capability between B1a and B8.

(e) Eastern Scotland to England 3rd link: Peterhead to the south Humber offshore HVDC (E4L5)

E4L5 is identified in the 'optimal' reinforcement path and 'critical' across all four of the 2020 *FES*. It has been Identified as 'critical' for the last two years. Following completion of both the first (E2DC) and second (E4D3) eastern HVDC Links E4L5 together with associated onshore reinforcement works satisfies the additional system transfer requirements, providing further boundary capability between B1a and B8.

(f) Eastern subsea HVDC link from south east Scotland to south Humber area (TGDC)

TGDC was included for the first time this year and is identified in the 'optimal' reinforcement path and 'critical' across all four of the 2020 *FES*. Following completion of both the first (E2DC) and second (E4D3) eastern HVDC Links, it provides further boundary capability between B6 and B8, as well as facilitating new generation connections in the local area at the north end of the link.

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(g) South east Scotland to north west England AC onshore reinforcement (CMNC)

CMNC has been developed this year for the first time as NOA5 indicated the need for further onshore options over the B6 boundary. It has been identified as 'optimal' and 'critical' in all four *FES*, replacing TLNO from NOA5, and provides capability over B6.

3. Status

3.1 Initial Onshore reinforcement

The East coast onshore projects in the SHE Transmission and SPT areas are scheduled for delivery in 2023 for the 275kV works and 2026 for the 400kV uprate. These projects are both included within the RIIO-T2 base allowance, and are being developed on that basis.

3.2 First and Second Eastern HVDC Links from Scotland to north east of England

A joint team from the three onshore TOs has continued to assess the *NOA* options in more detail as part of an SWW initial needs case submitted to the regulator in October 2020. This team is working towards submission of the final SWW needs case in late 2021. This will consider system requirements, project development and delivery, and technologies. The TOs are working with the ESO who provide a detailed cost benefit analysis of the reinforcement options to help identify optimum delivery dates.

Subsea survey work has started for the link from Torness. A similar survey for the link from Peterhead is scheduled to start in Q1/early Q2 2021. Planning permission for the 400kV substation at Peterhead has been granted and a preferred location identified. The connection point at Torness in SPT's area has been assessed and a preferred convertor station site selected for further development. The southern landing points of the links and associated AC onshore works continue to be progressed with the Torness link connecting into Hawthorn Pit via a converter station. The Peterhead route will terminate in the Drax area with the converter located nearby. It is expected that the construction of the HVDC projects will take place between 2024 and 2029.

3.3 Further Eastern HVDC Links and associated Onshore reinforcement

For a second year the *NOA* has indicated that a second link from the north east of Scotland (Peterhead) and a new onshore circuit over B6 is needed. A further HVDC link from the Torness area has also been recommended. This provides the TOs and the ESO with a clear indication of significant reinforcement requirements following the delivery of the first two eastern HVDC links. The development of all links will continue to be coordinated with the development of the offshore network, to ensure the overall best solution for the consumer.

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B.2 Beauly to Blackhillock reinforcement

1. Background

Significant volumes of new, mainly renewable generation are expected to connect to the SHE Transmission network, resulting in much greater bulk power transfer requirements on all major SHE Transmission boundaries.

Generation volumes are forecast to increase across most fuel types, but particularly offshore wind towards the end of this decade and into the 2030s. Much of this offshore wind is likely to connect to the far north of the SHE Transmission network and contributes to the increased transfer requirement of the B1a boundary which separates the north and north west of Scotland from the southern and eastern regions.

In addition, under periods of high north-to-south power transfer a double circuit loss of the main western corridor of the SHE Transmission network, specifically the Beauly to Denny 400/275kV OHL, significantly stresses the circuits between Beauly and Blackhillock.

Under this contingency, power must flow through these circuits and across the B1a boundary to reach the eastern corridor of the network. Under these network conditions a Beauly to Blackhillock reinforcement works well with the future reinforced eastern network.

2. Options development

We assessed two options to increase transmission capacity between Beauly and Blackhillock and across B1a. They considered new build 400kV infrastructure and reconductoring the existing 275kV circuit with a High Temperature Low Sag conductor.

2.1 Leading option

The *NOA* 2020/21 recommends BBNC as the leading option for reinforcing the transmission network that connects the Eastern and Western corridors. It establishes a new 400kV double circuit between Beauly and Blackhillock substations and extension of the 400kV busbar arrangement at both sites to allow additional circuit breaker bays.

3. Economic assessment

In *NOA* 2019/20 BBNC was given a “Stop” recommendation. It was not ‘optimal’ in any scenario due to lower constraints across Scottish boundaries. The energy flow across Scottish boundaries under *FES* 2020 has been increased significantly. BBNC provides additional boundary B1 to B4 capability from 2030s, which makes it ‘optimal’ in all scenarios and ‘critical’ in all four *FES* scenarios except System Transformation. It has received a “Proceed” recommendation following least worst regret analysis.

4. Status

The option ultimately taken forward to a LOTI Initial Needs Case submission will be subject to further optioneering and stakeholder consultation as well as being informed by the LOTI cost-benefit analysis to ensure the solution is ‘optimal’.

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B.3 North of Beauly reinforcement

1. Background

Significant volumes of new, mainly renewable generation are expected to connect to the SHE Transmission network, leading to major increases to the bulk power transfer requirements of all major SHE Transmission boundaries.

Generation volumes are expected to increase across most fuel types but specifically offshore wind towards the end of the decade and into the 2030s. Most of this is likely to connect to the far north of the SHE Transmission network and leads to an increased transfer requirement of the B0 boundary which separates the network north of Beauly from the remaining Main Interconnected Transmission System (MITS) in the SHE Transmission area. North of Beauly encompasses the north of the Highlands, Caithness, Sutherland and Orkney.

2. Options development

We assessed several options to increase transmission capacity across B0. These included replacing 132kV circuits with higher capacity 275kV circuits, reconductoring existing 275kV circuit routes with High Temperature Low Sag conductors and new offshore HVDC circuits between Spittal in the far North and landing points in both Morayshire and the North East.

2.1 Leading option

The *NOA* 2020/21 recommends BLN2 as the leading option. This involves replacing the Beauly to Shin to Loch Buidhe 132kV double circuit overhead line with a higher capacity 275 kV double circuit overhead line, including new transformers at Shin and substation extensions at Beauly and Loch Buidhe.

3. Economic assessment

BLN2 provides incremental boundary capability from B0 to B4 (SHE-T area). It is required on its EISD of 2030 in Leading the Way and Consumer Transformation scenarios, and one year later in System Transformation. It is not required in Steady Progression due to the lower generation in this region under that scenario. Based on the single year Least Worst regret analysis, it is recommended to “Proceed”.

4. Status

The current scope of the leading option BLN2 is as per SHE Transmission reinforcement scheme (SHE-RI-058) as described in the Transmission Works Report published by the ESO.

The complete scope of the option taken forward to a LOTI Initial Needs Case submission will be subject to further optioneering and stakeholder consultation as well as being informed by the LOTI cost-benefit analysis to ensure the solution is ‘optimal’.

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B.4 London and south east network reinforcement

1. Background

The London and south east region have a high concentration of both power demand and generation, with much of the demand in London and growing generation capacity in the Thames Estuary and East Anglia. Interconnectors to Europe also operate along the south coast of England and East Anglia and heavily influence power flows in the region by importing and exporting to continental Europe. The coastline and waters around East Anglia are attractive for offshore wind projects and nuclear generation is also expected in the region.

The future growth of renewable generation capacity in East Anglia is expected to give rise to a high volume of constraints if the East Anglia boundary (EC5) is not reinforced. Furthermore, the increase of interconnection capacity on the south coast, combined with the build-up of renewable generation in East Anglia and the north, is expected to drive more consistent north-to-south flows through the region to meet demand in London and export power to Europe through interconnectors on the south coast.

If they are not reinforced, these flows are expected to give rise to constraints on the London Export (LE1) and south coast export (SC1rev) boundaries in the long term. At times when the south coast interconnectors are importing, however, the south coast import boundaries (SC1, SC2 and SC3) could also give rise to some constraints.

2. Options Development

Several reinforcement options have been developed to improve transmission capacity across the south coast, London and East Anglia. These options include uprating transmission routes, constructing new routes, new substations and installing reactive power compensation at key locations.

2.1 Leading options

Similar to *NOA* 2019/20 last year, the *NOA* 2020/21 recommends SCD1 as the leading option. This was submitted by NGET for analysis for the first time in 2019. It consists of constructing a 2 GW offshore HVDC link and associated substation works between Suffolk and Kent. This will significantly increase the transmission capacity on system boundaries SC1, SC1rev, SC2, LE1 and EC5.

2.2 Other options

Other recommendations from this year's *NOA* process to “Proceed” the following reinforcements for the south east region:

- Upgrade Hackney, Tottenham and Waltham Cross 275kV to 400kV (HWUP)
- Tilbury to Grain and Tilbury to Kingsnorth upgrade (TKRE)
- A new 400kV double circuit between Bramford and Twinstead (BTNO)
- New offshore HVDC link between Suffolk and Kent option 1 (SCD1)
- A new 400kV double circuit in south East Anglia (ATNC)
- Thames Estuary reinforcement (TENC)
- A new 400kV double circuit in north East Anglia (AENC)

3. Economic Assessment

The *NOA* 2020/21 analysis suggests SCD1 provides significant economic benefit. It is ‘critical’ in Customer Transformation and Leading the Way, being required on its EISD of 2029. However, Steady Progression doesn't need it until 2030, and System Transformation until 2031. As it was not ‘critical’ in all scenarios, a single year least worst regret (LWR) was performed and it was given a “Proceed” recommendation.

The economic benefit comes largely from the capability it provides to LE1 and EC5 which are the two most constrained boundaries in the south. It also contributes to reducing the constraints on SC1Rev in later years when the interconnectors are exporting.

One alternative option, SCD2, has the drawbacks compared to SCD1, of an EISD that's one year later (2030 for SCD2), and being mutually exclusive with another new route for *NOA* 2020/21, ATNC. ATNC is a new onshore circuit in south East Anglia, is a lower-cost reinforcement and provides significant capability, which is essential for improving the capability for EC5 and LE1. This means SCD2 is not on the 'optimal' path for *NOA* 2020/21, as was the case for *NOA* 2019/20.

The other alternative, SCN1, also considered in *NOA* 2019/20, is cheaper than both SCD1 and SCD2, but only provides capability for the south coast boundaries and doesn't help EC5 and LE1 north of London, and so was not in the 'optimal' path in *NOA* 2020/21.

4. Status

NGET has reviewed several design variations of SCD1 since the "Proceed" recommendation was given by *NOA*. This encompasses other reinforcements around London and East Anglia to attain the full benefit of the leading option on other system boundaries. Preliminary work to identify the optimal substations at both ends and other accompanying reinforcements with "Proceed" signal *NOA* this year is ongoing. System access for several ongoing projects around London and East Anglia is challenging due to the high connection works contracted around this area. NGET will continue working with stakeholders to address these challenges. The SWW Initial Needs Case submission is due early next year.

B.5 York, Humber and Lincolnshire reinforcements

1. Background

The reinforcements included for the network across northern and central England provide capability on one or more of the MITS boundaries B7, B7a, B8 and B9.

The objective is to increase the north-to-south transfer capability to safely enable greater volumes of predominantly new renewable generation to flow from Scotland and northern England down to central England.

2. Options development

Several reinforcement options have been developed to improve boundary capability in both northern and central England. To reflect the significant increase in system transfer requirements driven by the new Net Zero *Future Energy Scenarios*, additional options have been included for assessment.

2.1 Notable options

a) A new 400kV double circuit between the existing Norton to Osbaldwick circuit and Poppleton and relevant 400kV upgrades (OPN1)

Construct a new 400kV double circuit in Yorkshire to facilitate power transfer across boundaries. This new circuit connects near Poppleton and ties in to the Norton to Osbaldwick 400kV circuit. The scope includes 400kV circuit upgrades and substation works to increase power transfers. This option provides additional transmission capacity across boundaries B7, B7a and B8.

b) A new 400kV double circuit between the existing Norton to Osbaldwick circuit and Poppleton and relevant 275kV upgrades (OPN2)

Construct a new 400kV double circuit in Yorkshire to allow power transfer across the

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relevant boundaries. This new circuit connects near Poppleton and ties in to the Norton to Osbaldwick 400kV circuit. The scope covers 275kV upgrades and substation works to increase power transfers. This option provides additional transmission capacity across boundaries B7, B7a and B8.

c) A new 400kV double circuit between the existing Norton to Osbaldwick and Poppleton and relevant 275kV upgrades (OPN4)

Construct a new 400kV double circuit in Yorkshire to enable power transfer across the relevant boundaries. This connects near Poppleton and ties in to the Norton to Osbaldwick 400kV circuit. The scope includes 275kV upgrades and substation works to increase power transfers. This option provides additional transmission capacity across boundaries B7, B7a and B8.

d) A new 400kV double circuit between the existing Norton to Osbaldwick and Poppleton and relevant 275kV and 400kV upgrades (OPN5)

Construct a new 400kV double circuit in Yorkshire to facilitate power transfer requirements across the relevant boundaries. This new circuit connects near Poppleton and ties in to the Norton to Osbaldwick 400kV circuit. Upgrades to the 275kV upgrades and substation works are included to increase power transfers. This reinforcement option provides additional transmission capacity across boundaries B7, B7a and B8.

e) A new 400kV double circuit within Yorkshire between Eggborough and Osbaldwick (OENO)

Construction of a new 400kV route and substation works for power transfer across the relevant boundaries.. This reinforcement provides additional transmission capacity across boundaries B7, B7a and B8.

f) A new 400kV double circuit between Creyke Beck and the south Humber (CGNC)

Construct a new 400kV double circuit in Yorkshire with substation works to facilitate power transfer requirements across the relevant boundaries. This option provides additional transmission capacity across boundaries B7, B7a and B8.

g) A new 400kV double circuit between the south Humber and South Lincolnshire (GWNC)

Construct a new 400kV double circuit with substation works in Lincolnshire to facilitate power transfer across the relevant boundaries. This provides additional transmission capacity across boundaries B7, B7a, B8 and B9.

h) South Lincolnshire to Rutland reinforcement (LRNC)

Construct a new 400kV double circuit together with substation works from South Lincolnshire to Rutland to allow power transfer across the relevant boundaries. This provides additional transmission capacity across boundaries B8 and B9.

i) Uprate the Brinsworth and Chesterfield to double circuit 400kV and a new 400kV double circuit between Ratcliffe and Chesterfield (EDNC)

This is to alleviate high power flows in and around East Anglia and the Humber area and provide additional transmission capacity across boundaries B8 and B9.

2.2 Lead options

In *NOA* 2020/21, OPN2, CGNC, GWNC, LRNC and EDNC are the most efficient options giving the greatest benefits.

a) A new 400kV double circuit between the existing Norton to Osbaldwick circuit and Poppleton and relevant 275kV upgrades (OPN2)

OPN2 has a “Proceed” recommendation in *NOA* 2020/21 and is ‘critical’ in all four *FES* scenarios. It has been recommended in the last two *NOA*s and provides boundary capability across B7, B7a and B8. It is critical to deliver alongside an eastern link to Hawthorn Pit (E2DC) as it unlocks transmission constraints from Scotland through the north of England.

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b) A new 400kV double circuit between Creyke Beck and the south Humber (CGNC)

CGNC has a "Proceed" recommendation in *NOA* 2020/21 and is 'critical' in all four *Future Energy Scenarios* (*FES*). It has been recommended in the last two *NOA*s and provides boundary capability across B7, B7a and B8, while supporting the connection of renewable generation in Yorkshire and delivering transmission capacity to the east side of the network.

c) A new 400kV double circuit between the south Humber area and South Lincolnshire (GWNC)

GWNC has a "Proceed" recommendation in *NOA* 2020/21 and is 'critical' in all four *FES* scenarios. It has been recommended in the last two *NOA*s and provides boundary capability across B7, B7a, B8 and B9. It supports the connection of renewable generation in Yorkshire and Lincolnshire, delivering transmission capacity to the east side of the network.

d) South Lincolnshire to Rutland reinforcement (LRNC)

LRNC has a "Hold" recommendation in *NOA* 2020/21 and is 'optimal' in three of the four *FES* scenarios. It has been assessed for the first time in *NOA* and provides boundary capability across B8 and B9. It supports the connection of renewable generation in Lincolnshire and ensures transmission capacity in East Anglia is not reduced.

e) Uprate Brinsworth and Chesterfield to double circuit to 400kV and a new 400kV double circuit between Ratcliffe and Chesterfield

EDNC has a "Proceed" recommendation in *NOA* 2020/21 and is 'optimal' in three of the four *FES* scenarios. It has been assessed for the first time in *NOA* and provides boundary capability across B8 and B9. It supports the increasing north-to-south requirements of the transmission network driven by the net zero targets.

3. Status

A new 400kV double circuit between the existing Norton to Osbaldwick circuit and Poppleton and relevant 275kV upgrades (OPN2)

NGET has completed strategic optioneering for this project to identify the optimal options, which have been included in *NOA* to determine the most economical option. Work is currently being undertaken to support a planning application later next year, which will enable construction to begin in 2025 and the project to meet its EISD of 2027. An initial needs case is planned to be submitted to the regulator early this year.

Humber and Lincolnshire (CGNC, GWNC, LRNC, EDNC)

These projects form a wider Humber strategy which both reinforce the system and support offshore generation connections. These projects are currently in scoping, with preliminary work to identify the optimal reinforcement combinations, as well as other accompanying reinforcements required. The design of these options is being coordinated and assessed in conjunction with one another.

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Appendix C

List of options

List of options

This table shows the options assessed in this *NOA* publication, together with their four-letter codes. The four-letter codes appear throughout the report in tables and charts.

We have added a unique icon which represents the category. You can find out more about the various options in Chapter 3 - 'Proposed options'.

Please click here to navigate back to the interactive map in the Chapter 4 - 'Recommendations for each option' section of the report.

	AENC **A new 400kV double circuit in north East Anglia** Status: Scoping Boundaries affected: LE1; EC5I; EC5E Region: South	Construct a new 400kV double circuit in north East Anglia to facilitate power transfer requirements across the relevant boundaries. Substation works is required to accommodate the new circuits.
	ATNC **A new 400kV double circuit in south East Anglia** Status: Scoping Boundaries affected: SC1Rev; LE1; EC5E Region: South	Construct a new 400kV double circuit in south East Anglia to facilitate power transfer requirements across the relevant boundaries. Substation works is required to accommodate the new circuits.
	BBNC **Beauly to Blackhillock 400kV double circuit addition** Status: Project not started Boundaries affected: B1aE; B1aF; B1al; B2E; B2F; B2I; B4E; B4F; B4I Region: North	Construct a new 400kV double circuit between Beauly and Blackhillock. At both sites extend the 400kV busbar arrangements to allow for the connection of two additional bays.
	BDUP **Uprate the Beauly to Denny 275kV circuit to 400kV** Status: Scoping Boundaries affected: B1al; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F; B5 Region: North	Uprating of the 275kV side of the existing Beauly-Denny circuit to 400kV operation between SHE Transmission and SPT. Substation works will be required at Beauly, Fasnakyle, Fort Augustus, Kinardochy, Braco West and Denny North. The Errochty I/T scheme (implemented under ECU2) shall be amended to trip the 400/132kV supergrid transformer(SGTs) at Kinardochy under loss of the 400kV double circuit south of Kinardochy.
	BFHW **Bramley to Fleet circuits thermal uprating** Status: Project not started Boundaries affected: SC1Rev; SC1.5Rev; SC2Rev Region: South	Thermal upgrade of the Bramley to Fleet circuits to allow them to operate at higher temperatures, and increase their thermal rating.

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BFPC

Power control device along Bramley to Fleet
Status: Project not started
Boundaries affected: SC1Rev; SC1.5Rev; SC2Rev
Region: South

Install a power control device along the Bramley to Fleet 400kV overhead line route. This would improve the capability to control the power flows across the South Coast area of the transmission network.

BFRE

Bramley to Fleet reconductoring
Status: Project not started
Boundaries affected: SC1Rev; SC1.5Rev; SC2Rev
Region: South

Replace the conductors in the Bramley to Fleet circuits with higher-rated conductors to increase their thermal ratings.

BLN2

Beauly to Loch Buidhe 275kV reinforcement
Status: Scoping
Boundaries affected: B0; B1aI; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F
Region: North

Replace the Beauly to Shin to Loch Buidhe 132kV double circuit overhead line with a higher capacity 275kV double circuit overhead line, including new transformers at Shin and substation extensions at Beauly and Loch Buidhe.

BMM2

225MVAr MSCs at Burwell Main
Status: Design/development and consenting
Boundaries affected: SC1Rev; LE1; EC5I; EC5E
Region: South

Two new 225 MVAr switched capacitors (MSCs) at Burwell Main would provide voltage support to the East Anglia area as system flows increase in future.

BPNC

A new 400kV double circuit between Blackhillock and Peterhead
Status: Project not started
Boundaries affected: B1aI; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F
Region: North

Establish a new 400kV double circuit overhead line from Peterhead to Blackhillock via New Deer. Peterhead and Blackhillock substations will require extension to accomodate termination of the new double circuit. This reinforcement is required as onshore works to facilitate the 2nd eastern HVDC link from Peterhead (*NOA* option reference E4L5).

BPRE

Reconductor the newly formed second Bramford to Braintree to Rayleigh Main circuit
Status: Project not started
Boundaries affected: SC1Rev; EC5I; EC5E
Region: South

Replace the conductors of the newly formed second Bramford to Braintree to Rayleigh Main circuit that has not already been reconductored with higher-rated conductors. This would increase the circuit's thermal rating following the new 400kV double circuit between Bramford and Twinstead.

BRRE

Reconductor remainder of Bramford to Braintree to Rayleigh route
Status: Project not started
Boundaries affected: SC1Rev; LE1; EC5I; EC5E
Region: South

Replace the conductors in the limiting sections of the existing Bramford to Braintree to Rayleigh overhead line that have not already been reconductored with higher-rated conductors, to increase the circuits overall thermal rating.

BTNO

A new 400kV double circuit between Bramford and Twinstead
Status: Scoping
Boundaries affected: SC1Rev; LE1; EC5I; EC5E
Region: South

Construct a new 400kV double circuit between Bramford substation and Twinstead tee point to create double circuits that run between Bramford to Pelham and Bramford to Braintree to Rayleigh Main. It would increase power export capability from East Anglia into the rest of the transmission system.

BWRE

Reconductor Barking to West Ham double circuit
Status: Project not started
Boundaries affected: SC1Rev; LE1
Region: South

Replace the conductors in the Barking to West Ham single circuit with higher-rated conductors.

BYRE

Reconductor Blyth to Tynemouth 275kV circuit
Status: Project not started
Boundaries affected: B7aI
Region: North

Replace the conductor in the Blyth to Tynemouth circuit with higher-rated conductors to increase the circuit's thermal rating.

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	CBEU **Creyke Beck to Keadby advance rating** Status: Project not started Boundaries affected: B7al; B8 Region: North	Using weather data, enhance the rating of the Creyke Beck to Keadby 400kV overhead line to enable higher average power flows.
	CDHW **Cellarhead to Drakelow circuits thermal uprating** Status: Project not started Boundaries affected: B8 Region: North	Thermal upgrade of both Cellarhead to Drakelow 400kV circuits to allow them to operate at higher temperature and rating.
	CDP1 **Power control device along Cellarhead to Drakelow** Status: Project not started Boundaries affected: B8 Region: North	Install a power control device along the Cellarhead to Drakelow 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.
	CDP2 **Power control device along Cellarhead to Drakelow** Status: Project not started Boundaries affected: B8 Region: North	Install a power control device along the Cellarhead to Drakelow 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.
	CDP3 **Additional alternative power control devices along Cellarhead to Drakelow** Status: Project not started Boundaries affected: B8 Region: North	Install an additional alternative power control devices along the Cellarhead to Drakelow 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.
	CDP4 **Additional alternative power control devices along Cellarhead to Drakelow** Status: Project not started Boundaries affected: B8 Region: North	Install an additional alternative power control device along the Cellarhead to Drakelow 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.
	CDRE **Cellarhead to Drakelow reconductoring** Status: Scoping Boundaries affected: B8 Region: North	Replace the conductors on the existing double circuit from Cellarhead to Drakelow with higher-rated conductors to increase their thermal rating.
	CENC **South east Scotland to north east England AC onshore reinforcement** Status: Project not started Boundaries affected: B6SPT; B6I Region: North	Construct a new 400kV double circuit from in south east Scotland to north east England, to facilitate power transfer requirements across the relevant boundaries. Suitable connection points at each end will be identified, as well as relevant substation works required to accommodate the new circuit.
	CGNC **A new 400kV double circuit between Creyke Beck and the south Humber region** Status: Project not started Boundaries affected: B7al; B8 Region: North	Construct a new 400kV double circuit in Yorkshire to facilitate power transfer requirements across the relevant boundaries. Substation works is required to accommodate the new circuits.
	CKPC **Power control device along Creyke Beck to Keadby to Killingholme** Status: Project not started Boundaries affected: B7al; B8; B9 Region: North	Install a power control device along the Creyke Beck to Keadby to Killingholme 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

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CLNC

New north west England to Lancashire reinforcement
Status: Project not started
Boundaries affected: B6l
Region: North

Construct a new 400kV double circuit from north west England to Lancashire, to facilitate power transfer requirements across the relevant boundaries. Suitable connection points at each end will be identified, as well as relevant substation works required to accommodate the new circuit.

CMNC

South east Scotland to north west England AC onshore reinforcement
Status: Project not started
Boundaries affected: B6SPT; B6l
Region: North

Construct a new 400kV double circuit from in south east Scotland to north west England, to facilitate power transfer requirements across the relevant boundaries. Suitable connection points at each end will be identified, as well as relevant substation works required to accommodate the new circuit.

CRPC

Power control device along Cottam to West Burton
Status: Project not started
Boundaries affected: B8
Region: North

Install a power control device along the Cottom to Ryhall 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

CS03

Commercial solution for the north of Scotland - stage 1
Status: Project not started
Boundaries affected: B2; B4
Region: North

This ESO-led commercial solution provides benefit across several boundaries in the north of Scotland.

CS04

Commercial solution for the north of Scotland - stage 2
Status: Project not started
Boundaries affected: B2; B4
Region: North

This ESO-led commercial solution provides benefit across several boundaries in the north of Scotland.

CS05

Commercial solution for Scotland and the north of England - stage 1
Status: Project not started
Boundaries affected: B6; B7a
Region: North

This ESO-led commercial solution provides benefit across several boundaries in the north of England.

CS06

Commercial solution for Scotland and the north of England - stage 2
Status: Project not started
Boundaries affected: B6; B7a
Region: North

This ESO-led commercial solution provides benefit across several boundaries in the north of England.

CS07

Commercial solution for East Anglia - stage 1
Status: Project not started
Boundaries affected: EC5
Region: South

This ESO-led commercial solution provides boundary benefit across the East Anglia region.

CS08

Commercial solution for East Anglia - stage 2
Status: Project not started
Boundaries affected: EC5
Region: South

This ESO-led commercial solution provides boundary benefit across the East Anglia region.

CS09

Commercial solution for the south coast - stage 1
Status: Project not started
Boundaries affected: SC1; SC3
Region: South

This ESO-led commercial solution provides boundary benefit in the south coast.

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CS10

Commercial solution for the south coast - stage 2
Status: Project not started
Boundaries affected: SC1; SC3
Region: South

This ESO-led commercial solution provides boundary benefit in the south coast.

CTP2

Alternative power control device along Creyke Beck to Thornton
Status: Project not started
Boundaries affected: B7aI; B8
Region: North

Install an alternative power control device along the Creyke Beck to Thornton 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

CTP3

Additional power control devices along the Creyke Beck - Thornton 1 400kV circuit
Status: Project not started
Boundaries affected: B8
Region: North

Install additional power control devices along the Creyke Beck to Thornton 1 400kV circuit. This is to help alleviate high power flows in the Humber area.

CTRE

Reconductor remainder of Coryton South to Tilbury circuit
Status: Scoping
Boundaries affected: SC1Rev; LE1
Region: South

Replace the conductors on the remaining sections of the Coryton South to Tilbury circuit, which have not recently been reconductored with higher-rated conductors. These would increase the circuit's thermal rating.

CVUP

Uprating the Clydesmill to Strathaven 275kV circuits to 400kV single circuit
Status: Project not started
Boundaries affected: B5
Region: North

Following LWUP or DWUP, reconfigure and reconductor the 275kV circuits between Clydesmill and Strathaven to establish a 400kV single circuit, including substation works at Clydesmill and Strathaven. The new circuit connects the new 400kV circuit into Clydesmill into the existing 400kV east-west corridor improving power flows.

CWPC

Power control device along Cottam to West Burton
Status: Project not started
Boundaries affected: B8; B9
Region: North

Install a power control device along the Cottam to West Burton 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

DEP1

Additional power control devices along the Drax - Eggborough 1 400kV circuit
Status: Project not started
Boundaries affected: B7aI; B8
Region: North

Install additional power control devices along the Drax to Eggborough 1 400kV circuit. This is to help balance the flows and alleviate overloading of circuit due to system faults.

DEPC

Power control device along Drax to Eggborough
Status: Project not started
Boundaries affected: B7aI; B8
Region: North

Install a power control device along the Drax to Eggborough 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

DLRE

Loch Buidhe to Dounreay 275kV double circuit reconductoring
Status: Project not started
Boundaries affected: B0; B1aI; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F
Region: North

Reconductor the Loch Buidhe to Dounreay 275kV double circuit overhead line with a high temperature low sag conductor. This option is conditional on SHE Transmission business approval for the use of a high temperature conductor on the 275kV network and suitability of the conductor for use on the existing L3 tower structures.

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DLUP

Uprate the Windyhill-Lambhill-Denny North 275kV circuit to 400kV
Status: Project not started
Boundaries affected: B1al; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F; B5
Region: North

Following WLTI and DNEU, increase the operating voltage of the Windyhill to Lambhill to Denny 275kV circuit by the establishment of a new 400kV gas insulated substation at Windyhill, the installation of a new 400/275kV transformer at Windyhill 400kV substation, a new 400/275kV transformer at Lambhill substation and transferring existing 275kV circuit onto the existing Denny 400kV substation.

DNEU

Denny North 400/275kV second supergrid transformer
Status: Scoping
Boundaries affected: B1al; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F; B5
Region: North

Installation of a new 400/275kV 1000MVA supergrid transformer (SGT2) at Denny North 400kV substation.

DREU

Generator circuit breaker replacement to allow Thornton to run a two-way split
Status: Project not started
Boundaries affected: B7al; B7aE; B8
Region: North

This reinforcement is to replace generator owned circuit breakers with higher-rated equivalents including substation equipment. This would allow higher fault levels, which in turn improves load sharing on circuits connecting to the substation.

DWN2

Denny to Wishaw 400kV reinforcement
Status: Design/development and consenting
Boundaries affected: B1al; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F; B5
Region: North

Following DWUP or LWUP, construct a new 400kV double circuit from Bonnybridge to north of Newarthill. One side of the new double circuit will operate at 400kV, the other at 275kV. This reinforcement will establish Denny to Bonnybridge, Bonnybridge to Wishaw, and a Denny to Newarthill to Easterhouse 275kV circuit in addition to new 400kV route establish in preceding scheme. Resulting in two new 400kV corridors in Scotland, providing additional north-to-south capability.

DWNO

Denny to Wishaw 400kV reinforcement
Status: Design/development and consenting
Boundaries affected: B1al; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F; B5
Region: North

Construct a new 400kV double circuit from Bonnybridge to Newarthill, and reconfigure associated sites to establish a fourth north-to-south double circuit supergrid route through the Scottish central belt. One side of the new double circuit will operate at 400kV, the other at 275kV. This reinforcement will establish Denny to Bonnybridge, Bonnybridge to Wishaw, Wishaw to Strathaven No.2 and Wishaw to Torness 400kV circuits, and a Denny to Newarthill to Easterhouse 275kV circuit.

DWUP

Establish Denny North-Clydesmill-Wishaw single 400kV circuit from existing 275kV circuits
Status: Project not started
Boundaries affected: B1al; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F; B5
Region: North

Establish a new 400kV single circuit between Denny North, Clydesmill and Wishaw by reconfiguration of the existing Longannet to Easterhouse/Clydesmill 275kV circuits and existing de-energised circuit between Easterhouse and Newarthill and the existing Newarthill to Wishaw circuit. Provides additional capability in Scotland via a new 400kV corridor.

E2D2

Eastern Scotland to England link: Torness to Cottam offshore HVDC
Status: Scoping
Boundaries affected: B6I; B6SPT; B7al; B8
Region: North

Construction of a new offshore 2 GW HVDC subsea link from Torness area to Cottam to provide additional transmission capacity. The onshore works involve the construction of AC/DC converter stations and the associated AC works at Torness and Cottam.

E2D3

Eastern Scotland to England link: Torness to Drax offshore HVDC
Status: Scoping
Boundaries affected: B6SPT; B6I; B7al; B8
Region: North

Construction of a new offshore 2 GW HVDC subsea link from Torness area to Drax to provide additional transmission capacity. The onshore works involve the construction of AC/DC converter stations and the associated AC works at Torness and Drax.

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E2DC

Eastern subsea HVDC link from Torness to Hawthorn Pit
Status: Scoping
Boundaries affected: B6SPT; B6I; B7aI; B8
Region: North

Construct a new offshore 2 GW HVDC subsea link from the Torness area to Hawthorn Pit to provide additional transmission capacity. The onshore works involve the construction of AC/DC converter stations and the associated AC works at Torness and Hawthorn Pit.

E4D2

Eastern Scotland to England link: Peterhead to Cottam offshore HVDC
Status: Design/development and consenting
Boundaries affected: B1aE; B1aF; B1aI; B2E; B2F; B2I; B4E; B4F; B4I; B5; B6I; B6SPT; B7aI; B8
Region: North

Construct a new offshore 2GW bipole HVDC subsea link from Peterhead in the north east of Scotland to Cottam along the east side of England. The onshore works involve the construction of AC/DC converter stations and the associated AC works at Peterhead and Cottam.

E4D3

Eastern Scotland to England link: Peterhead to Drax offshore HVDC
Status: Design/development and consenting
Boundaries affected: B1aE; B1aF; B1aI; B2E; B2F; B2I; B4E; B4F; B4I; B5; B6I; B6SPT; B7aI; B8
Region: North

Construct a new offshore 2 GW bipole HVDC subsea link from Peterhead in the north east of Scotland to Drax in the Yorkshire area of England. The onshore works involve the construction of AC/DC converter stations and the associated AC works at Peterhead and Drax.

E4DC

Eastern Scotland to England link: Peterhead to Hawthorn Pit offshore HVDC
Status: Design/development and consenting
Boundaries affected: B1aE; B1aF; B1aI; B2E; B2F; B2I; B4E; B4F; B4I; B5; B6I; B6SPT; B7aI; B8
Region: North

Construct a new offshore 2GW bipole HVDC subsea link from Peterhead in the north east of Scotland to Hawthorn Pit in the north of England. The onshore works involve the construction of AC/DC converter stations and the associated AC works at Peterhead and Hawthorn Pit.

E4L5

Eastern Scotland to England 3rd link: Peterhead to the south Humber offshore HVDC
Status: Optioneering
Boundaries affected: B1aE; B1aF; B1aI; B2E; B2F; B2I; B4E; B4F; B4I; B5; B6I; B6SPT; B7aI; B8
Region: North

Following a first HVDC link from Peterhead to England, construct an additional offshore 2GW bipole HVDC link from Peterhead to a location in the south Humber area. The link will involve substation works and HVDC converter stations at both Peterhead and south Humber. Circuit upgrades will also be required in the south Humber area.

E5L5

Eastern Scotland to England 3rd link: Blackhillock to the south Humber offshore HVDC
Status: Optioneering
Boundaries affected: B1aI; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F; B5; B6SPT; B6I; B7aI; B8
Region: North

Following a first HVDC link from Peterhead to England, construct an additional offshore 2GW bipole HVDC link from Blackhillock to a location in the south Humber area. The link will involve substation works and HVDC converter stations at both Blackhillock and south Humber. Circuit upgrades will also be required in the south Humber area.

ECU2

East coast onshore 275kV upgrade
Status: Planning / consenting
Boundaries affected: B1aI; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F; B5
Region: North

Establish a new 275kV substation at Alyth; re-profile the 275kV circuits between Kintore, Fetteresso, Alyth and Kincardine; and Tealing, Westfield and Longannet; and uprate the cable sections at Kincardine and reconfigure at Longannet to match the enhanced rating. Extend Tealing 275kV substation and install two phase shifting transformers. Install shunt reactive series compensation at the new Alyth substation.

ECUP

East coast onshore 400kV incremental reinforcement
Status: Planning / consenting
Boundaries affected: B1aI; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F; B5
Region: North

The option builds on the east coast onshore 275kV upgrade (ECU2) and upgrades 275kV infrastructure on the east coast for 400kV operation. Complete the construction of the new 400kV substation at Kintore (substation part developed under the north east 400kV reinforcement) and uprate Alyth substation (constructed under ECU2) for 400kV operation. Re-insulate the 275kV circuits between Kintore, Fetteresso, Alyth and Kincardine for 400kV operation. Install phase-shifting transformers at Blackhillock on the 275kV circuits from Knocknagael. Install 400/275kV transformers at Kincardine and Alyth and 400/132kV transformers at Fetteresso.

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ECVC

Eccles hybrid synchronous compensators and real-time rating system
Status: Scoping
Boundaries affected: B6SPT; B6l; B6E; B6F; B7al; B7aE
Region: North

Installation of two hybrid synchronous compensators at Eccles 400kV substation, and a real-time ratings system on the 400kV overhead line circuits between Moffat and Harker and Gretna and Harker and 400kV cable circuits between Crystal Rig and Torness.

EDNC

Uprate Brinsworth and Chesterfield to double circuit 400kV and a new 400kV double circuit between Ratcliffe and Chesterfield
Status: Project not started
Boundaries affected: B9; B8
Region: North

Upgrade the Brinsworth to Chesterfield 400kV double circuit and a new 400kV double circuit between Ratcliffe and Chesterfield. This is to help alleviate high power flows in and around East Anglia and the Humber area.

EHRE

Elvanfoot to Harker reconductoring
Status: Scoping
Boundaries affected: B6SPT; B6l; B7al; B7aE
Region: North

Replace the double circuit conductors in the Elvanfoot to Harker circuits with a higher-rated conductor to increase their thermal ratings.

ESC1

Second Elstree to St John's Wood 400kV circuit
Status: Project not started
Boundaries affected: SC1Rev; LE1; EC5E
Region: South

New second 400kV cable transmission circuit from Elstree to St. Johns Wood in the existing tunnel, and carry out associated work, including modifying Elstree 400kV and St. John's Wood 400kV substations. This will improve the power flow into London.

FBRE

Beauly to Fyrish 275kV double circuit reconductoring
Status: Project not started
Boundaries affected: B0
Region: North

Reconductor the Beauly to Fyrish 275kV double circuit overhead line with a high temperature low sag conductor. This option is conditional on SHE Transmission business approval for the use of a high temperature conductor on the 275kV network and suitability of the conductor for use on the existing L3 tower structures.

FINS

East coast 132kV upgrade
Status: Scoping
Boundaries affected: B2l; B2E; B2F; B4l; B4E; B4F
Region: North

Create a new grid supply point near Fiddes connected to the 275kV double circuit overhead line between Kintore and Tealing. Construct a new 132kV double circut from Tealing to Brechin and rationalise the present Fiddes, Brechin, Tarland and Craigiebuckler network configuration.

FMHW

Feckenham to Minety circuit thermal uprating
Status: Project not started
Boundaries affected: SC1Rev
Region: South

Thermal upgrade of the Feckenham to Minety to allow them to operate at higher temperatures, and increase their thermal rating.

FMPC

Power control device along Feckenham to Minety
Status: Project not started
Boundaries affected: B9; SC1Rev
Region: South

Install a power control device along the Feckenham to Minety 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

FMRE

Feckenham to Minety circuit reconductoring
Status: Project not started
Boundaries affected: SC1Rev
Region: South

Replace the conductors in the Feckenham to Minety circuit with higher-rated conductors.

FWPC

Power control device along Feckenham to Walham
Status: Project not started
Boundaries affected: B9; SC1Rev
Region: South

Install a power control device along the Feckenham to Walham 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

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GWNC

A new 400kV double circuit between the south Humber area and south Lincolnshire
Status: Project not started
Boundaries affected: B7al; B8; B9
Region: North

Construct a new 400kV double circuit in Lincolnshire to facilitate power transfer requirements across the relevant boundaries. Substation works is required to accommodate the new circuits.

HAE2

Harker supergrid transformer 6 replacement
Status: Design/development and consenting
Boundaries affected: B6l; B6E; B7al; B7aE
Region: North

Replacing an existing transformer at Harker substation with a new one of higher rating to prevent overloading following transmission system faults.

HAEU

Harker supergrid transformer 5 and supergrid transformer 9A banking arrangement
Status: Design/development and consenting
Boundaries affected: B6l; B6E; B6F; B7al; B7aE
Region: North

Banking of existing transformers supergrid transformer 5 and supergrid transformer 9A at Harker substation and connecting directly to the Fourstones – Harker 275kV circuit to help alleviate overloading of supergrid transformers following transmission system faults.

HBUP

Uprate Bridgewater to 400kV and reconductor the route to Hinkley
Status: Design/development and consenting
Boundaries affected: B13
Region: South

Upgrade the Hinkley Point to Bridgewater 275kV circuits to 400kV including insulator and conductor replacement. Connect the circuits to the new Hinkley Point 400kV substation.

HENC

Hertfordshire reinforcement
Status: Project not started
Boundaries affected: LE1
Region: South

Construct new 400kV double circuit from Hertfordshire from Waltham Cross 400kV substation. These works would further provide additional transmission capacity between London and the south coast.

HFRE

Reconductor Harker to Fourstones double circuit
Status: Project not started
Boundaries affected: B7al
Region: North

Replace the conductors in the Harker to Fourstone single circuit with higher-rated conductors.

HNNO

Hunterston East–Neilston 400kV reinforcement
Status: Optioneering
Boundaries affected: B6SPT
Region: North

Modification of the Hunterston East to Devol Moor 400kV circuit to establish a second Hunterston East to Neilston 400kV circuit, and development of a new 400/275kV supergrid transformer 4 at Neilston 400kV substation, increasing the fault level in the Hunterston area.

HSP3

Additional power control device along Harker to Stella West
Status: Project not started
Boundaries affected: B6E; B6F
Region: North

Install additional power control devices along the Harker to Stella West route. This would improve the capability to control the power flow from east-to-west of the transmission network.

HSR1

Reconductor Harker to Stella West
Status: Project not started
Boundaries affected: B7al; B7aE
Region: North

Replace the conductors in the Harker to Stella West single circuit with higher-rated conductors.

HWUP

Uprate Hackney, Tottenham and Waltham Cross 275kV to 400kV
Status: Design/development and consenting
Boundaries affected: SC1Rev; LE1; EC5l; EC5E
Region: South

Hackney, Tottenham and Waltham Cross substation uprate from 275kV to 400kV, and the double circuit route connecting them. This will strengthen the power flow into London, via Rye House, down to Hackney.

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IFHW

Feckenham to Ironbridge circuit thermal uprating
Status: Project not started
Boundaries affected: SC1Rev
Region: South

Thermal upgrade of the Feckenham to Ironbridge circuit to allow them to operate at higher temperatures, increasing its thermal rating.

IFR1

Feckenham to Ironbridge circuit reconductoring
Status: Project not started
Boundaries affected: SC1Rev
Region: South

Replace the conductors in the Feckenham to Ironbridge circuit with higher-rated conductors.

KBRE

Knocknagael to Blackhillock 275kV double circuit reconductoring
Status: Project not started
Boundaries affected: B1aI; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F
Region: North

Reconductor the Knocknagael to Blackhillock 275kV double circuit overhead line with a high temperature low sag conductor. This option is conditional on SHE Transmission business approval for the use of a high temperature conductor on the 275kV network and suitability of the conductor for use on the existing L3 tower structures.

KWHW

Keadby to West Burton circuits thermal uprating
Status: Project not started
Boundaries affected: B8
Region: North

Thermal upgrade of the Keadby to West Burton circuits to allow them to operate at higher temperatures, and increase their thermal rating.

KWPC

Power control device along Keadby to West Burton
Status: Project not started
Boundaries affected: B7aI; B8; B9
Region: North

Install a power control device along the Keadby to West Burton 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

LBRE

Beauly to Loch Buidhe 275kV double circuit OHL reconductoring
Status: Project not started
Boundaries affected: B0; B1aI; B1aE; B1aF; B2I; B2E; B2F; B4I; B4E; B4F
Region: North

Reconductor the Beauly to Loch Buidhe 275kV double circuit overhead line with a high temperature low sag conductor. This option is conditional on SHE Transmission business approval for the use of a high temperature conductor on the 275kV network and suitability of the conductor for use on the existing L3 tower structures.

LCU2

Eastern B5 400kV reinforcement
Status: Project not started
Boundaries affected: B5
Region: North

Reconfiguration of existing 275kV circuits between Longannet and Currie via Kincardine, and Currie and Cockenzie via Smeaton and Kaimes, reprofiling one side of the existing overhead line double circuit to 400kV operation. Establishes a new 400kV corridor north-to-south, tying into existing east-west 400kV circuits.

LRNC

South Lincolnshire to Rutland reinforcement
Status: Project not started
Boundaries affected: B9
Region: North

Construct a new 400kV double circuit from South Lincolnshire to Rutland to facilitate power transfer requirements across the relevant boundaries. Substation works are required to accommodate the new circuits.

LWUP

Longannet 400kV reinforcement
Status: Project not started
Boundaries affected: B2I; B2E; B2F; B4I; B4E; B4F; B5
Region: North

Establishment of 400kV GIS substation at the existing Longannet substation site. Installation of two 400/275kV 1000MVA supergrid transformers to connect into 275kV substation. Reconfiguration and uprating of existing 275kV network circuits to establish 400kV connections between Longannet, Alyth, Denny North and Wishaw 400kV substations.

MBHW

Bramley to Melksham circuits thermal uprating
Status: Project not started
Boundaries affected: B12a; B13; SC1Rev; SC1.5Rev
Region: South

Thermal Upgrade of both Bramley to Melksham 400kV circuits to allow them to operate at higher temperature and rating.

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MBRE

Bramley to Melksham reconductoring
Status: Project not started
Boundaries affected: B12a; B13; SC1Rev; SC1.5Rev
Region: South

Replace the conductors in the Bramley to Melksham circuits with higher-rated conductors to increase their thermal ratings.

MIC1

Cable replacement at Severn Tunnel
Status: Project not started
Boundaries affected: SW1
Region: West

Upgrade the cable in the Imperial Park to Melksham circuit passing through the Severn Tunnel with a larger cable section. This will give higher circuit rating.

MRP1

Power control device along Penwortham to Washway Farm to Kirkby
Status: Project not started
Boundaries affected: B7al
Region: North

Install an additional power control device along the Penwortham to Washway Farm to Kirkby 275kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

MRP2

Additional power control devices at both Harker and Penwortham
Status: Project not started
Boundaries affected: B6E; B6F; B7aE; B7aF
Region: North

Install additional power control devices at both Harker and Penwortham. This would improve the capability to control the power flow in both these areas of the transmission network.

NBRE

Reconductor Bramford to Norwich double circuit
Status: Project not started
Boundaries affected: SC1Rev; LE1; EC5I; EC5E
Region: South

The double circuit that runs from Norwich to Bramford would be reconductored with a higher-rated conductor.

NEMS

225MVAr MSCs within the north east region
Status: Scoping
Boundaries affected: B6I; B7aI; B7aE
Region: North

Three new 225 MVAr switched capacitors (MSCs) at Norton, Osbaldwick and Stella West 400kV substations would provide voltage support to the east side of the transmission network as system flows increase in future.

NEP1

Power control device along Blyth to Tynemouth and Blyth to South Shields
Status: Project not started
Boundaries affected: B7aI
Region: North

Install an additional power control device along the Blyth to Tynemouth and Blyth to South Shields 275kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

NEPC

Power control device along Blyth to Tynemouth and Blyth to South Shields
Status: Project not started
Boundaries affected: B7aI
Region: North

Install a power control device along the Blyth to Tynemouth and Blyth to South Shields 275kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

NIM1

225MVAr MSCs at Ninfield
Status: Scoping
Boundaries affected: SC1; SC2
Region: South

One new 225 MVAr switched capacitor (MSC) at Norwich would provide voltage support East Anglia area as system flows increase in the future.

NIM2

225MVAr MSCs at Ninfield
Status: Scoping
Boundaries affected: SC2
Region: South

One new 225 MVAr switched capacitor (MSC) at Norwich would provide voltage support East Anglia area as system flows increase in the future.

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NOM1

225MVAr MSCs at Norwich
Status: Project not started
Boundaries affected: EC5I
Region: South

One new 225 MVAr switched capacitor (MSC) at Norwich would provide voltage support East Anglia area as system flows increase in the future.

NOM2

225MVAr MSCs at Norwich
Status: Project not started
Boundaries affected: EC5I
Region: South

One new 225 MVAr switched capacitor (MSC) at Norwich would provide voltage support East Anglia area as system flows increase in future.

NOPC

Power control device along Norton to Osbaldwick
Status: Project not started
Boundaries affected: B7aI
Region: North

Install a power control device along the Norton to Osbaldwick 400kV circuit overhead line route. This would improve the capability to control the power flows across the east and west of the transmission network.

NOR1

Reconductor 13.75km of Norton to Osbaldwick 400kV double circuit
Status: Scoping
Boundaries affected: B7aI; B7aE
Region: North

Replace some of the conductors in the Norton to Osbaldwick double circuit with higher-rated conductors to increase the circuits' thermal ratings.

NOR2

Reconductor 13.75km of Norton to Osbaldwick number 1 400kV circuit
Status: Project not started
Boundaries affected: B7aI; B7aE
Region: North

Replace some of the conductors in Norton to Osbaldwick 1 circuit with higher-rated conductors to increase the circuit's thermal rating.

NOR4

Reconductor 13.75km of Norton to Osbaldwick number 2 400kV circuit
Status: Project not started
Boundaries affected: B7aI
Region: North

Replace some of the conductors in Norton to Osbaldwick 2 circuit with higher-rated conductors to increase the circuit's thermal rating.

NOR5

Reconductor 13.75km of Norton to Osbaldwick number 1 400kV circuit to a higher rated conductor
Status: Project not started
Boundaries affected: B7aI
Region: North

Replace some of the conductors in Norton to Osbaldwick 1 circuit with an even higher-rated conductor to increase the circuit's thermal rating.

NSM1

225MVAr MSCs within the north east region
Status: Project not started
Boundaries affected: B7aI; B7aE
Region: North

Three new 225 MVAr switched capacitors (MSCs) at Norton and Spennymoor 400kV substations would provide voltage support to the east side of the transmission network as system flows increase in future.

NSM2

225MVAr MSCs within the north east region
Status: Project not started
Boundaries affected: B7aI; B7aE
Region: North

Two new 225 MVAr switched capacitors (MSCs) at Norton and Spennymoor 400kV substations would provide voltage support to the east side of the transmission network as system flows increase in future.

NSM3

225MVAr MSCs within the north east region
Status: Project not started
Boundaries affected: B7aI
Region: North

A new 225 MVAr switched capacitor (MSC) at Norton 400kV substation would provide voltage support to the east side of the transmission network as system flows increase in future.

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NTP1

Power control device along North Tilbury
Status: Project not started
Boundaries affected: SC1Rev; LE1
Region: South

Install a power control device along the North Tilbury 400kV overhead line route. This would improve the capability to control the power flows east of the transmission network.

OENO

A new 400kV double circuit within Yorkshire between Eggborough and Osbaldwick
Status: Scoping
Boundaries affected: B7al; B8
Region: North

Construct a new 400kV double circuit in Yorkshire to facilitate power transfer requirements across the relevant boundaries. Substation works may be required to accommodate the new circuits.

OPN1

A new 400kV double circuit between the existing Norton to Osbaldwick circuit and Poppleton and relevant 400kV upgrades
Status: Project not started
Boundaries affected: B7al; B8
Region: North

Construct a new 400kV double circuit in Yorkshire to facilitate power transfer requirements across the relevant boundaries. This new circuit connects near Poppleton and tee-in to the existing Norton to Osbaldwick 400kV circuit. 400kV circuit upgrades are delivered as part of the scope to increase power transfers. Substation works are also required.

OPN2

A new 400kV double circuit between the existing Norton to Osbaldwick circuit and Poppleton and relevant 275kV upgrades
Status: Project not started
Boundaries affected: B7al; B8
Region: North

Construct a new 400kV double circuit in Yorkshire to facilitate power transfer requirements across the relevant boundaries. This new circuit connects near Poppleton and tee-in to the existing Norton to Osbaldwick 400kV circuit. 275kV upgrades are delivered as part of the scope to increase power transfers. Substation works are also required.

OPN4

A new alternative 400kV double circuit between the existing Norton to Osbaldwick and Poppleton and relevant 275kV upgrades
Status: Project not started
Boundaries affected: B7al; B8
Region: North

Construct a new alternative 400kV double circuit in Yorkshire to facilitate power transfer requirements across the relevant boundaries. This new circuit connects near Poppleton and tee-in to the existing Norton to Osbaldwick 400kV circuit. 275kV upgrades are delivered as part of the scope to increase power transfers. Substation works are also required.

OPN5

A new 400kV double circuit between the existing Norton to Osbaldwick and Poppleton and relevant 275kV and 400kV upgrades
Status: Project not started
Boundaries affected: B7al; B8
Region: North

Construct a new 400kV double circuit in Yorkshire to facilitate power transfer requirements across the relevant boundaries. This new circuit connects near Poppleton and tee-in to the existing Norton to Osbaldwick 400kV circuit. 275kV upgrades are delivered to facilitate a new 400kV substation as part of the scope to increase power transfers. Substation works are also required.

PEM1

225MVAr MSCs at Pelham
Status: Project not started
Boundaries affected: LE1; EC5I; EC5E
Region: South

One new 225 MVAr switched capacitor (MSC) at Pelham would provide voltage support through East Anglia and north London as system flows increase in the future.

PEM2

225MVAr MSCs at Pelham
Status: Project not started
Boundaries affected: LE1; EC5I; EC5E
Region: South

One new 225 MVAr switched capacitor (MSC) at Pelham would provide voltage support through East Anglia and north London as system flows increase in the future.

PFRE

Reconductor Penwortham to Washway Farm 275kV double circuit
Status: Project not started
Boundaries affected: B7aE
Region: North

Replace the conductor in the Penwortham to Washway Farm double circuit with higher-rated conductors to increase the circuit's thermal rating.

PMU1

Yorkshire reinforcement upgrade 1
Status: Project not started
Boundaries affected: B7al
Region: North

Upgrade the existing 275kV route and associated upgrades, completed under OPN2, to 400kV.

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	PMU2 **Yorkshire reinforcement upgrade 2** Status: Project not started Boundaries affected: B7al Region: North	Upgrade the existing 275kV route and associated upgrades, completed under OPN5, to 400kV.
	PSDC **Spittal to Peterhead HVDC reinforcement** Status: Project not started Boundaries affected: B0; B1aE; B1aF; B1al Region: North	Construct a 2GW HVDC subsea link from a new 400kV substation at Spittal to the existing 400kV substation at Peterhead. The onshore works involve construction of 400kV substations at Dounreay, Thurso and Spittal and rebuilding of the existing Dounreay to Thurso to Spittal 275kV double circuit overhead line to 400kV.
	PTC1 **Pentir to Trawsfynydd cable replacement** Status: Scoping Boundaries affected: NW2 Region: West	Upgrade the cable section on the existing Pentir to Trawsfynydd circuit to allow this to operate at higher temperatures and increase the circuits thermal rating.
	PTNO **North Wales reinforcement** Status: Project not started Boundaries affected: NW2 Region: West	Construct a second circuit in north Wales, making use of the existing transmission infrastructure to facilitate power transfer requirements across the relevant boundaries. Associated substation works are required at each end.
	PWMS **Two 225MVAr MSCs at Penwortham** Status: Project not started Boundaries affected: B7al Region: North	Two new 225 MVAr switched capacitors (MSCs) at Penwortham substations would provide voltage support in the Mersey area as system flows increase in the future.
	RHM1 **225MVAr MSCs at Rye House** Status: Scoping Boundaries affected: LE1; EC5E Region: South	One new 225 MVAr switched capacitors (MSCs) at Rye House would provide voltage support through East Anglia and north London as system flows increase in the future.
	RHM2 **225MVAr MSCs at Rye House** Status: Project not started Boundaries affected: LE1; EC5E Region: South	One new 225 MVAr switched capacitors (MSCs) at Rye House would provide voltage support through East Anglia and north London as system flows increase in the future.
	RTRE **Reconductor remainder of Rayleigh to Tilbury circuit** Status: Scoping Boundaries affected: SC1Rev; LE1 Region: South	Replace the conductors on the remaining sections of the Rayleigh to Tilbury circuit, which have not recently been reconductored with higher-rated conductors. These would increase the circuit's thermal rating.
	SBDC **Spittal to Blackhillock HVDC reinforcement** Status: Project not started Boundaries affected: B0; B1aE; B1aF; B1al Region: North	Construct a 2GW HVDC subsea link from a new 400kV substation at Spittal to the existing 400kV substation at Blackhillock. The onshore works involve construction of 400kV substations at Dounreay, Thurso and Spittal and rebuilding of the existing Dounreay to Thurso to Spittal 275kV double circuit overhead line to 400kV.
	SBRE **Reconductor South Shields to West Boldon 275kV circuit** Status: Project not started Boundaries affected: B7al Region: North	Replace the conductor in the South Shields to West Boldon circuit with higher-rated conductors to increase the circuit's thermal rating.
	SCD1 **New offshore HVDC link between Suffolk and Kent option 1** Status: Project not started Boundaries affected: B8; B9; SC1Rev; SC1.5Rev; SC2Rev; SC3; LE1; EC5I; EC5E Region: South	Construct a new offshore 2GW HVDC circuit between Suffolk and Kent.

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SCD2

New offshore HVDC link between Suffolk and Kent option 2
Status: Project not started
Boundaries affected: SC1Rev; LE1; EC5E
Region: South

Construct a second new offshore 2GW HVDC circuit between Suffolk and Kent, parallel with SDC1.

SCN1

New 400kV transmission route between south London and the south coast
Status: Scoping
Boundaries affected: SC1Rev; SC1.5Rev; SC2Rev
Region: South

Construct a new transmission route from the south coast to south London, and carry out associated work. These works would provide additional transmission capacity between the south of London and the south coast.

SEEU

Reactive series compensation protective switching scheme
Status: Scoping
Boundaries affected: SC2
Region: South

Provide a new communications system, and other equipment, to allow existing reactive equipment to be switched in or out of service very quickly following transmission system faults. This would allow better control of system voltages following faults.

SER1

Elstree to Sundon reconductoring
Status: Project not started
Boundaries affected: SC1Rev; LE1
Region: South

Replace the conductors from Elstree to Sundon circuit 1 with higher-rated conductors to increase their thermal rating.

SER2

Elstree–Sundon 2 circuit turn-in and reconductoring
Status: Project not started
Boundaries affected: SC1Rev; LE1; EC5E
Region: South

Turn-in the Elstree to Sundon circuit 2, which currently passes the Elstree 400kV substation, to connect to it and replace the conductor with a higher-rated conductor. This would ensure better load flow sharing and increase the thermal rating.

SHNS

Upgrade substation in the south Humber area
Status: Project not started
Boundaries affected: B7al; B8
Region: North

Substation upgrade of the 400kV South Humber substation equipment.

SLU2

Loch Buidhe to Spittal 275kV reinforcement
Status: Project not started
Boundaries affected: B0; B1al; B1aE; B1aF; B2l; B2E; B2F; B4l; B4E; B4F
Region: North

Replace the existing Loch Buidhe to Spittal 132kV double circuit overhead line via Brora and Dunbeath with a higher capacity 275kV double circuit overhead line. Extension/reconfiguration works will be required at both Loch Buidhe and Spittal substations to accommodate the 275kV double circuit. At Brora and Dunbeath grid supply points (GSPs) replace the existing 132/33kV grid transformers (GTs) with 275/33kV GTs to connect the new 275kV overhead line to the existing 33kV network.

SNHW

Spennymoor to Norton circuit thermal uprating
Status: Project not started
Boundaries affected: B7al
Region: North

Thermal upgrade of the Spennymoor to Norton circuits to allow them to operate at higher temperatures and increase their thermal rating.

SSHW

Stella West to Spennymoor circuit thermal uprating
Status: Project not started
Boundaries affected: B7al
Region: North

Thermal upgrade of the Stella West to Spennymoor circuits to allow them to operate at higher temperatures and increase their thermal rating.

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TBRE

Reconductor Tynemouth to West Boldon 275kV circuit
Status: Project not started
Boundaries affected: B7al
Region: North

Replace the conductor in the Tynemouth to West Boldon circuit with higher-rated conductors to increase the circuit's thermal rating.

TDP2

Additional power control device along Drax to Thornton
Status: Project not started
Boundaries affected: B8
Region: North

Install an additional power control device along the Drax to Thornton 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

TDPC

Power control device along Drax to Eggborough
Status: Project not started
Boundaries affected: B8
Region: North

Install a power control device along the Drax to Thornton 400kV overhead line route. This would improve the capability to control the power flows from north-to-south of the transmission network.

TDR1

Reconductor Drax to Thornton 2 circuit
Status: Project not started
Boundaries affected: B7al; B7aE; B8
Region: North

Replace the conductor in the Drax – Thornton 2 circuit with higher-rated conductors to increase the circuit's thermal rating. This will increase the power flow across the boundary.

TDR2

Reconductor Drax to Thornton 1 circuit
Status: Project not started
Boundaries affected: B7al; B7aE; B8
Region: North

Replace the conductor in the Drax – Thornton 1 circuit with higher-rated conductors to increase the circuit's thermal rating. This will increase the power flow across the boundary.

TENC

Thames Estuary reinforcement
Status: Project not started
Boundaries affected: SC1Rev; SC3; LE1; EC5E
Region: South

Construct a new 400kV double circuit bridging the Thames Estuary to facilitate power transfer requirements across the relevant boundaries. Substation works are required to accommodate the new circuits.

TFPC

Power control device on Tealing to Westfield circuit
Status: Project not started
Boundaries affected: B4l; B4F; B4E
Region: North

Install a power flow control device on the Tealing to Westfield 275kV circuit 1 at Tealing substation to optimise the power flow across the Tealing to Westfield 275kV double circuits 1 and 2, under a double circuit loss of the Alyth to Kincardine 400kV double circuit.

TGDC

Eastern subsea HVDC Link from south east Scotland to south Humber area
Status: Project not started
Boundaries affected: B6l; B6SPT; B7al
Region: North

Construct a new offshore 2GW HVDC subsea link from south east Scotland to the south Humber area in England to provide additional transmission capacity. Suitable connection points at each end will be identified, with the onshore works involving the construction of AC/DC converter stations and the associated AC works in both Scotland and England. This is in addition to a first HVDC link from the Torness area.

TGP1

Power control device along Tilbury to Grain
Status: Project not started
Boundaries affected: SC1Rev; SC1.5Rev; SC2Rev; SC3Rev
Region: South

Install a power control device along the Tilbury to Grain 400kV overhead line route. This would improve the capability to control the power flows in the south east region of the transmission network.

THDC

Alternative staged eastern subsea HVDC link from Torness to Hawthorn Pit
Status: Scoping
Boundaries affected: B6SPT; B6l; B7al; B8
Region: North

Construct a staged a 2.8GW new offshore HVDC subsea link from the Torness area to Hawthorn Pit to provide additional transmission capacity. The onshore works involve the construction of AC/DC converter stations and the associated AC works at Torness and Hawthorn Pit. Intention to deliver project over in two 1.4GW stages, with the first 1.4GW link available for service ahead of completion of 2nd.

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THRE

Reconductor Hinkley Point to Taunton double circuit
Status: Scoping
Boundaries affected: SC1Rev; SC1.5Rev; SC2Rev
Region: South

Replace the conductors in the Hinkley Point to Taunton circuits with higher-rated conductors to increase the circuits' thermal ratings.

THS1

Installation of a single series reactor at Thornton substation
Status: Optioneering
Boundaries affected: B7aI; B7aE; B8
Region: North

Installation of a single 2400MVA series reactor at Thornton substation. These would connect the parts of the site at present operated disconnected from one another to limit fault levels. The reactors would allow some flow sharing between the different parts of the site and reduce thermal overloads on connected circuits.

TKP1

Power control device along Tilbury to Kingsnorth
Status: Project not started
Boundaries affected: SC1Rev; SC1.5Rev; SC2Rev; SC3Rev
Region: South

Install a power control device along the Tilbury to Kingsnorth 400kV overhead line route. This would improve the capability to control the power flows in the south east region of the transmission network.

TKRE

Tilbury to Grain and Tilbury to Kingsnorth upgrade
Status: Scoping
Boundaries affected: SC1Rev; SC1.5Rev; SC2Rev; SC3; SC3Rev; LE1; EC5E
Region: South

Replace the conductors in the Tilbury to Grain and Tilbury to Kingsnorth circuits with higher-rated conductors, and replace the associated cables with larger cables of a higher rating, including Tilbury, Grain and Kingsnorth substation equipment. This will increase the circuits' thermal ratings.

TKU2

Alternative east coast onshore phase 2 reinforcement
Status: Project not started
Boundaries affected: B4E; B4F; B4I; B5; B2E; B2F; B2I
Region: North

Establish further 400kV infrastructure on the east coast following ECUP. Re-profile the existing Kintore to Tealing 275kV double circuit to enable a higher operating temperature. Establish a new 400kV substation at Tealing, including new 400/275kV transformers. Re-insulate the existing Alyth to Tealing 275kV double circuit OHL for 400kV operation. Reinsulate a single side of the existing 275kV double circuit between Tealing and Longannet via Westfield to 400kV operation, installing a new 400/275kV transformer at Westfield.

TKUP

East coast onshore 400kV phase 2 reinforcement
Status: Project not started
Boundaries affected: B2I; B2E; B2F; B4I; B4E; B4F; B5
Region: North

Establish further 400kV infrastructure on the east coast following ECUP. Rebuild the Kintore to Tealing 275kV double circuit for 400kV operation and establish a new 400kV substation at Tealing, including new 400/275kV transformers. Re-insulate the existing Alyth to Tealing 275kV double circuit OHL for 400kV operation. Re-insulate the existing Tealing to Longannet 275kV route through Glenrothes, Westfield and Mossmorran for 400kV operation. Install 400/275kV transformers at Glenrothes and new 400/132kV transformers at Westfield and Mossmorran.

TLNO

Torness to north east England AC onshore reinforcement
Status: Scoping
Boundaries affected: B6SPT; B6I
Region: North

This option provides additional transmission capacity by installing a new 400kV double circuit from a 400kV substation in the Torness area to a suitable connection point in north east England, including required additional substation equipment at both ends.

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TTNC

New north east England to north Yorkshire reinforcement
Status: Project not started
Boundaries affected: B6l
Region: North

Construct a new 400kV double circuit from north east England to north Yorkshire, to facilitate power transfer requirements across the relevant boundaries. Suitable connection points at each end will be identified, as well as relevant substation works required to accommodate the new circuit.

TUEU

Tummel reconfiguration
Status: Scoping
Boundaries affected: B4l; B4E; B4F
Region: North

Relocate the existing Tummel 275/132kV supergrid transformers to the new Kinardochy 275KV substation and remove the existing Tummel substation. Connect to the existing Errochty circuits with new 132kV cables.

WAM1

225MVAr MSCs at Walpole
Status: Project not started
Boundaries affected: EC5l; EC5E
Region: South

One new 225 MVAr switched capacitor (MSC) at Walpole would provide voltage support the north London area as system flows increase in the future.

WAM2

225MVAr MSCs at Walpole
Status: Project not started
Boundaries affected: EC5l; EC5E
Region: South

One new 225 MVAr switched capacitor (MSC) at Walpole would provide voltage support the north London area as system flows increase in the future.

WCC1

Cable replacement at Hinksey
Status: Project not started
Boundaries affected: SC1Rev; SW1
Region: West

Upgrade the cable section in the Cowley to Walham 400kV circuit at Hinksey to increasing the circuits' thermal ratings.

WHTI

Tee-in of the West Boldon to Hartlepool circuit at Hawthorn Pit
Status: Design/development and consenting
Boundaries affected: B6l; B7al; B7aE
Region: North

Tee-in of the West Boldon to Hartlepool circuit, which currently passes the Hawthorn Pit site to connect to it. This would create a new 3 ended circuit, Hartlepool to Hawthorn Pit to West Boldon 275kV circuit. This would ensure better load flow sharing and increased connectivity in the north east 275kV ring.

WLTI

Windyhill–Lambhill–Longannet 275kV circuit turn-in to Denny North 275kV substation
Status: Design/development and consenting
Boundaries affected: B5
Region: North

Turn the Windyhill to Lambhill to Longannet 275kV circuit into Denny North 275kV Substation to create a 275kV Windyhill to Lambhill to Denny North circuit and a Denny North to Longannet No.2 275kV circuit.

WORE

Reconductor West Boldon to Offerton 275kV circuit
Status: Project not started
Boundaries affected: B7al
Region: North

Replace the conductor in the West Boldon to Offerton circuit with higher-rated conductors to increase the circuit's thermal rating.

WRRE

Reconductor West Burton to Ratcliffe-on-Soar circuit
Status: Project not started
Boundaries affected: B8
Region: North

Replace the conductors in the West Burton to Ratcliffe-on-Soar circuit with higher-rated conductors to increase the circuit's thermal ratings.

WSEU

Thermal upgrade for Sundon and Wymondley 400kV substation
Status: Project not started
Boundaries affected: LE1; EC5E
Region: South

Upgrade the 400kV Sundon and Wymondley substation equipment to increase its thermal capacity, supporting future load flow within the area.

WSR1

Sundon-Wymondley circuit 1 reconductoring
Status: Project not started
Boundaries affected: EC5E
Region: South

Replace the conductors in the Sundon to Wymondley circuit 1 with higher-rated conductors.

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	WSR2 **Sundon-Wymondley circuit 2 reconductoring** Status: Project not started Boundaries affected: EC5E Region: South	Replace the conductors in the Sundon to Wymondley circuit 2 with higher-rated conductors.
	WTUP **Uprate Tilbury to Waltham Cross route from 275kV to 400kV** Status: Project not started Boundaries affected: LE1 Region: South	Upgrade Waltham Cross, Tilbury and Warley 400kV substation, turn-in Elstree to Warley circuit into Waltham Cross 400kV substation and uprate Warley to Tilbury circuit to 400kV from 275kV. These works would further provide additional transmission capacity between London and the south coast.
	WYTI **Wymondley turn-in** Status: Design/development and consenting Boundaries affected: LE1; EC5E Region: South	Modify the existing circuit that runs from Pelham to Sundon. Turn-in the circuit at Wymondley to create two separate circuits that run from Pelham to Wymondley and from Wymondley to Sundon to improve the balance of flows.

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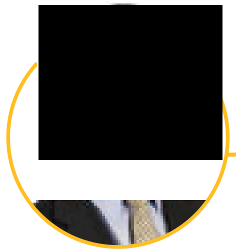
Appendix D

Meet the *NOA* team

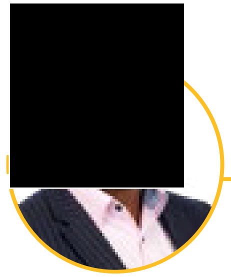
Meet the *NOA* team



Julian Leslie

Head of Networks,
Electricity System Operator
[redacted]@nationalgrideso.com

The Networks team addresses the engineering challenges of operating the electricity network by studying from the investment options stage in a changing energy landscape through to network access just a day ahead of real-time.



Nicholas Harvey

Network Development Manager
[redacted]@nationalgrideso.com

The Network Development team delivers an efficient GB and offshore electricity transmission system by understanding present capabilities and working out the best options to meet the requirements of possible *Future Energy Scenarios*.

Network Development

We develop a holistic strategy for the NETS. This includes the following key activities:

- Testing the *FES* against models of the GB NETS to identify potential transmission requirements and publishing in the *ETYS*.
- Supporting Needs Case studies of reinforcement options as part of the SWW process.
- Supporting cost-benefit studies of different connections designs.
- Developing long-term strategies for a secure and efficient GB transmission network against the changing industry needs.

You can contact us to discuss about:

The *Network Options Assessment*

Jason Hicks
Technical Economic Assessment Manager
[redacted]@nationalgrideso.com

Cost-benefit analysis and the *Network Options Assessment*

Paul Wakeley
Economic Assessment Manager
[redacted]@nationalgrideso.com

The *Electricity Ten Year Statement*

James Whiteford
GB System Capability Manager
[redacted]@nationalgrideso.com

Supporting parties

Strategic network planning and production of the *NOA* requires support and input from many people.
These include:

- National Grid Electricity Transmission
- SHE Transmission
- SP Transmission
- our customers.

Don't forget you can also email us with your views on the *NOA* at:
noa@nationalgrideso.com

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Appendix E

Glossary

Average cold spell (ACS)
Average cold spell is defined as a particular combination of weather elements which gives rise to a level of winter peak demand which has a 50% chance of being exceeded as a result of weather variation alone. There are different definitions of ACS peak demand for different purposes.

BID3
BID3 is an economic dispatch optimisation model supplied by AFRY Management Consulting. It can simulate all European power markets simultaneously including the impact of interconnection between markets. BID3 has been specifically developed for National Grid to model the impact of electricity networks in GB, allowing the System Operator to calculate constraint costs it would incur to balance the system, post-gate closure.

Boundary allowance
An allowance in MW to be added in whole or in part to transfers arising out of the NETS SQSS economy planned transfer condition, to take some account of year-round variations in levels of generation and demand. This allowance is calculated by an empirical method described in Appendix F of the security and quality of supply standards (SQSS).

Boundary transfer capacity
The maximum pre-fault power that the transmission system can carry from the region on one side of a boundary to the region on the other side of the boundary while ensuring acceptable transmission system operating conditions will exist following one of a range of different faults.

Cost-benefit analysis (CBA)
A method of assessing the benefits of a given project in comparison to the costs. This tool can help to provide a comparative base for all projects to be considered.

Contracted generation
A term used to reference any generator who has entered into a contract to connect with the National Electricity Transmission System (NETS) on a given date while having a transmission entry capacity (TEC) figure as a requirement of said contract.

Critical
The option is optimal on its earliest in-service date (EISD) in at least one scenario.

Department of Business, Energy & Industrial Strategy (BEIS)
A UK government department. The Department of Business, Energy & Industrial Strategy (BEIS) works to make sure the UK has secure, clean, affordable energy supplies and promote international action to mitigate climate change.

Distribution Network Operator (DNO)
Distribution network operators own and operate electricity distribution networks.

Double circuit overhead line
In the case of the onshore transmission system, this is a transmission line which consists of two circuits sharing the same towers for at least one span in SHE Transmission's system or NGET's transmission system or for at least two miles in SP Transmission system. In the case of an offshore transmission system, this is a transmission line which consists of two circuits sharing the same towers for at least one span.

Earliest In Service Date (ESID)
The earliest date when the project could be delivered and put into service, if investment in the project was started immediately.

Embedded generation
Power generating stations/units that don't have a contractual agreement with the National Electricity Transmission System Operator (NETSO). They reduce electricity demand on the National Electricity Transmission System.

Future Energy Scenarios (FES)
The *FES* is a range of credible futures which has been developed in conjunction with the energy industry. They are a set of scenarios covering the period from now to 2050, and are used to frame discussions and perform stress tests. They form the starting point for all transmission network and investment planning, and are used to identify future operability challenges and potential solutions.

Gigawatt (GW)
1,000,000,000 watts, a measure of power.

Gigawatt hour (GWh)
1,000,000,000 watt hours, a unit of energy.

Great Britain (GB)
A geographical, social and economic grouping of countries that contains England, Scotland and Wales.

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High voltage alternating current (HVAC)

Electric power transmission in which the voltage varies in a sinusoidal fashion, resulting in a current flow that periodically reverses direction. HVAC is presently the most common form of electricity transmission and distribution, since it allows the voltage level to be raised or lowered using a transformer.

High voltage direct current (HVDC)

The transmission of power using continuous voltage and current as opposed to alternating current. HVDC is commonly used for point to point long-distance and/or subsea connections. HVDC offers various advantages over HVAC transmission, but requires the use of costly power electronic converters at each end to change the voltage level and convert it to/from AC.

Interconnector

Electricity interconnectors are transmission assets that connect the GB market to Europe and allow suppliers to trade electricity between markets.

Large Onshore Transmission Investment (LOTI)

This is a funding mechanism for the TOs as part of the RIIO-2 price control that allows TOs to bring forward investment projects worth more than £100m that have not been funded in the price control settlement.

Load factor

The average power output divided by the peak power output over a period of time.

Marine technologies

Tidal streams, tidal lagoons and energy from wave technologies (see www.emec.org.uk)

Megawatt (MW)

1,000,000 watts, a measure of power.

Megawatt hour (MWh)

1,000,000 watt hours, a measure of power usage or consumption in 1 hour.

Merit order

An ordered list of generators, sorted by the marginal cost of generation.

Main Interconnected Transmission System (MITS)

This comprises all the 400kV and 275kV elements of the onshore transmission system and, in Scotland, the132kV elements of the onshore transmission system operated in parallel with the supergrid, and any elements of an offshore transmission system operated in parallel with the supergrid, but excludes generation circuits, transformer connections to lower voltage systems, external interconnections between the onshore transmission system and external systems, and any offshore transmission systems radially connected to the onshore transmission system via single interface points.

National Electricity Transmission System (NETS)

The National Electricity Transmission System comprises the onshore and offshore transmission systems of England, Wales and Scotland. It transmits high-voltage electricity from where it is produced to where it is needed throughout the country. The system is made up of high-voltage electricity wires that extend across Britain and nearby offshore waters. It is owned and maintained by regional transmission companies, while the system as a whole is operated by a single system operator (SO).

National Electricity Transmission System Operator (NETSO)

National Grid acts as the NETSO for the whole of Great Britain while owning the transmission assets in England and Wales. In Scotland, transmission assets are owned by Scottish Hydro Electricity Transmission Ltd (SHE Transmission) in the north of the country and Scottish Power Transmission SP Transmission in the south.

National Electricity Transmission System Security and Quality of Supply Standards (NETS SQSS)

A set of standards used in the planning and operation of the National Electricity Transmission System of Great Britain. For the avoidance of doubt the National Electricity Transmission System is made up of both the onshore transmission system and the offshore transmission systems.

National Grid Electricity Transmission plc (NGET)

National Grid Electricity Transmission plc (No. 2366977) whose registered office is 1-3 Strand, London, WC2N 5EH.

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Network access
Maintenance and system access is typically undertaken during the spring, summer and autumn seasons when the system is less heavily loaded and access is favourable. With circuits and equipment unavailable the integrity of the system is reduced. The planning of the system access is carefully controlled to ensure system security is maintained.

Network Options Assessment (NOA)
The *NOA* is the process for assessing options for reinforcing the National Electricity Transmission System (NETS) to meet the requirements that the system operator (SO) finds from its analysis of the *Future Energy Scenarios (FES)*.

Office of Gas and Electricity Markets (OFGEM)
The UK's independent National Regulatory Authority, a non-ministerial government department. Their principal objective is to protect the interests of existing and future electricity and gas consumers.

Offshore
This term means wholly or partly in offshore waters.

Offshore transmission circuit
Part of an offshore transmission system between two or more circuit breakers which includes, for example, transformers, reactors, cables, overhead lines and DC converters but excludes busbars and onshore transmission circuits.

Onshore
This term refers to assets that are wholly on land.

Onshore transmission circuit
Part of the onshore transmission system between two or more circuit-breakers which includes, for example, transformers, reactors, cables and overhead lines but excludes busbars, generation circuits and offshore transmission circuits.

Optimal
The option is economically justified in at least one scenario.

Peak demand
The maximum power demand in any one fiscal year: Peak demand typically occurs at around 5:30pm on a week-day between December and February. Different definitions of peak demand are used for different purposes.

Photovoltaic (PV)
A method of converting solar energy into direct current electricity using semi-conducting materials.

Planned transfer
A term to describe a point at which demand is set to the National Peak when analysing boundary capability.

Power supply background (aka generation background)
The sources of generation across Great Britain to meet the power demand.

Ranking order
A list of generators sorted in order of likelihood of operation at time of winter peak and used by the NETS SQSS.

Reactive power
Reactive power is a concept used by engineers to describe the background energy movement in an alternating current (AC) system arising from the production of electric and magnetic fields. These fields store energy which changes through each AC cycle. Devices which store energy by virtue of a magnetic field produced by a flow of current are said to absorb reactive power; those which store energy by virtue of electric fields are said to generate reactive power.

Real power
This term (sometimes referred to as 'active Power') provides the useful energy to a load. In an AC system, real power is accompanied by reactive power for any power factor other than 1.

Seasonal circuit ratings
The current carrying capability of circuits. Typically, this reduces during the warmer seasons as the circuit's capability to dissipate heat is reduced. The rating of a typical 400kV overhead line may be 20% less in the summer than in winter.

SHE Transmission
Scottish Hydro-Electric Transmission (No.SC213461) whose registered office is situated at Inveralmond HS, 200 Dunkeld Road, Perth, Perthshire PH1 3AQ.

Social Economic Welfare (SEW)
Social Economic Welfare (SEW) is a common cost-benefit indicator when analysing projects of public interest. It captures the overall benefit, in monetary terms, to society from a given course of action.

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SP Transmission
Scottish Power Transmission Limited (No. SC189126) whose registered office is situated at 1 Atlantic Quay, Robertson Street, Glasgow G2 8SP.

System requirements form (SRF)
Set of templates that are completed by the TOs and submitted to NGESO which contain details on the options to be assessed in the *NOA*. To find out more, please read the *NOA* Methodology report.

Summer minimum
The minimum power demand off the transmission network in any one fiscal year: Minimum demand typically occurs at around 06:00am on a Sunday between May and September.

Supergrid
That part of the National Electricity Transmission System operated at a nominal voltage of 275kV and above.

Supergrid transformer (SGT)
A term used to describe transformers on the NETS that operate in the 275–400kV range.

Switchgear
The term used to describe components of a substation that can be used to carry out switching activities. This can include, but is not limited to, isolators/disconnectors and circuit breakers.

System Operability
The ability to maintain system stability and all of the asset ratings and operational parameters within pre-defined limits safely, economically and sustainably.

System Operability Framework (SOF)
The SOF identifies the challenges and opportunities which exist in the operation of future electricity networks and identifies measures to ensure the future operability.

Electricity System Operator (ESO)
An entity entrusted with transporting electric energy on a regional or national level, using fixed infrastructure. Unlike a TO, the ESO may not necessarily own the assets concerned. For example, National Grid ESO operates the electricity transmission system in Scotland, which is owned by Scottish Hydro Electricity Transmission and Scottish Power.

System stability
With reduced power demand and a tendency for higher system voltages during the summer months, fewer generators will operate and those that do run could be at reduced power factor output. This condition has a tendency to reduce the dynamic stability of the NETS. Therefore network stability analysis is usually performed for summer minimum demand conditions as this represents the limiting period.

Strategic Wider Works (SWW)
This is a funding mechanism as part of the RIIO-T1 price control that allows TOs to bring forward large investment projects that have not been funded in the price control settlement.

Transmission circuit
This is either an onshore transmission circuit or an offshore transmission circuit.

Transmission entry capacity (TEC)
The maximum amount of active power deliverable by a power station at its grid entry point (which can be either onshore or offshore). This will be the maximum power deliverable by all of the generating units within the power station, minus any auxiliary loads.

Transmission losses
Power losses that are caused by the electrical resistance of the transmission system.

Transmission Owners (TO)
A collective term used to describe the three transmission asset owners within Great Britain, namely National Grid Electricity Transmission, Scottish Hydro-Electric Transmission Limited and SP Transmission Limited.

Transmission System Operators (TSO)
An entity entrusted with transporting energy in the form of natural gas or power on a regional or national level, using fixed infrastructure.

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nationalgridESO

Appendix 2 – Offshore Transmissions Network Review Update (March, 2021)

OTNR UPDATE

REGULAR UPDATE NEWSLETTER FOR THE OFFSHORE TRANSMISSION NETWORK REVIEW PROJECT

FOREWORD

ANNE-MARIE TREVELYAN, MINISTER FOR BUSINESS, ENERGY & CLEAN GROWTH

The offshore wind sector has been a major British success story to date. The UK is home to the world's largest wind farms, supplying 10% of current UK electricity demand. We are committed to building on this by delivering 40GW of offshore wind by 2030, which forms a pivotal aspect of helping the UK to meet our 2050 Net Zero target.

This is of course a great opportunity for the UK in terms of the jobs and investment created; however, it poses a significant challenge to ensure that these large volumes of future offshore wind are connected to the transmission network in the most appropriate and efficient way. To achieve this, BEIS launched the Offshore Transmission Network Review (OTNR) last summer.

The Review has brought together key government departments, devolved administrations, and organisations to work collaboratively to realise the benefits of coordination, whilst maintaining the pace of offshore wind delivery.

IN THIS ISSUE

We are aiming for a much greater level of coordination and shared infrastructure, to create a regime which works for our future requirements.

Coordination can reduce consumer costs, as well as reduce the impacts on the environment and local communities. This infrastructure programme can bring a great boost to the UK economy, bringing new jobs and growth to coastal regions, encouraging around £20bn private investment to the UK, and increasing the competitiveness of the UK offshore wind sector.

Since our last update in December, we have been advancing our policy thinking across the four core OTNR workstreams. We are hoping to launch consultations on key areas of change later this year, with the aim of implementing changes to primary legislation as part of any Energy Bill that comes forward.

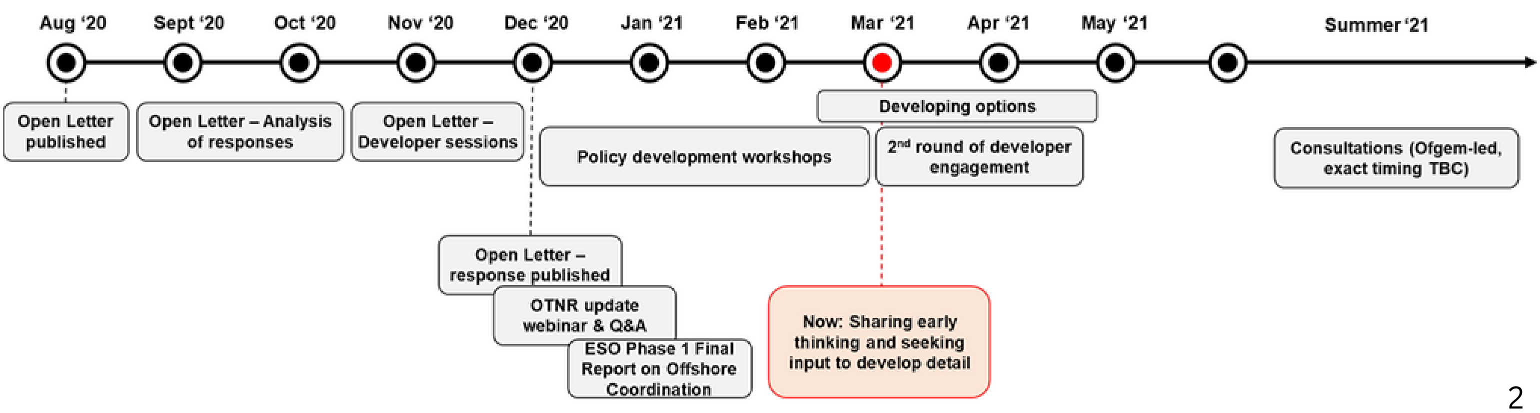
I very much look forward to the outcomes of the Review, and want to thank our OTNR partners, the industry, and the communities and organisations which have been helping us to shape the future offshore network regime.

We will be updating you regularly on our progress and are looking forward to engaging with you further.

The Rt Hon Anne-Marie Trevelyan MP
Minister for Business, Energy and Clean Growth
Department of Business, Energy and Industrial Strategy

Early Opportunities: considering options for change to address pathfinder barriers

Timeline



BEIS & Ofgem

The Early Opportunities workstream aims to facilitate coordination for in-flight projects by making changes within the current overall regulatory framework.

In August 2020, BEIS and Ofgem published a joint Open Letter which invited stakeholders to propose potential pathfinder projects and identify perceived barriers to coordination. We received responses from a wide range of stakeholders and published a response and summary of feedback received on the OTNR webpage in December 2020. The Electricity System Operator (ESO) also published their final Phase 1 report on Offshore Coordination in December, which highlighted the benefits of a more coordinated approach to offshore transmission.

Throughout this quarter we have held sessions with a variety of project partners and developers. We are working on identifying and supporting pathfinder projects, and developing regulatory changes to enable these projects.

The ESO is reviewing the technical feasibility and other potential challenges of possible pathfinder projects proposed by developers. We are also proactively identifying additional opportunities for coordination between live projects, focusing on the projects with clear opportunity for coordination. BEIS and Ofgem encourage all developers of inflight projects at an appropriate stage, who have yet to explore options for coordination with us, to get in touch to ensure we capitalise on as many early opportunities for coordination as possible.

We would like to remind all stakeholders that while discussions are ongoing regarding addressing the barrier to potential pathfinders, existing industry processes will still apply and therefore developments would not be negatively impacted by participating in these discussions.

Ofgem intend to consult on potential regulatory changes later this year. The ESO are also analysing requirements for change within codes and standards, as well as the current connections process.

On the Pathway to 2030: progressing coordination options to support the 40 GW target

The Pathway to 2030 workstream broadly covers projects that are aiming to be operational by around 2030 and are not already covered under the Early Opportunities workstream. We are committed to delivering increased coordination as soon as possible, whilst maintaining the pace of offshore wind delivery required to support the government's target of 40 GW of offshore wind by 2030. Achieving this target will require more infrastructure than we have today. Our aim is to find effective solutions to ensure that both the onshore and offshore network is planned and built in a more coordinated way.

We have started work with Ofgem, the ESO and Onshore Transmission Owners on developing an improved plan-led approach to connecting offshore wind and delivering the associated onshore infrastructure. This new approach seeks to bring together onshore and offshore network planning in a more holistic way, facilitate more anticipatory investment, better consider cumulative impacts and overcome the potential limitations of bottom-up project-led coordination.

Our intention is that this new approach will speed up the connection of less advanced projects, including potentially those coming through The Crown Estate's Leasing Round 4 and Crown Estate Scotland's ScotWind leasing round.

We will be further developing proposals on this during Q2 2021 with the support of the Expert Advisory Group and wider stakeholders with the aim of launching a public consultation on the proposals later this year.

Developing options for the enduring regime

For the enduring regime, we are working on the assumption that we will be able to completely re-shape the end-to-end process for the connection of an offshore windfarm. We could, if appropriate, make changes to: the roles and responsibilities of the key organisations involved; the sequencing of key development stages; the design of the transmission connection; the planning processes; the development and construction of the transmission connection and how this fits in with the commercial incentives such as the Contracts for Difference scheme and transmission charging.

We have been working with our Expert Advisory Group to develop a range of potential models, from a centralised and strategic approach involving significant changes, down to more incremental changes. We are currently in the process of refining these models, by defining the changes which would be needed to each of the constituent processes, and to understand the benefits, disadvantages, and risks of each. This process involves a range of relevant project partners and brings in specific sectoral expertise, through focussed sessions with the Expert Advisory Group. As the scope of these changes could be significant, there is likely to be a requirement for changes to primary legislation. We are preparing to consult with stakeholders later this year, in order to implement any changes to primary legislation in any energy bill that comes forward.

MPIs - Facilitating International Coordination

BEIS & Ofgem

Multi-Purpose Interconnectors (MPI) combine connections of offshore wind with links to neighbouring countries. The MPI workstream aims to facilitate these novel assets, both through exploiting flexibilities for near-term projects, as well as ensuring the enduring regime works for MPIs. We are seeking to ensure there is an appropriate legal and regulatory framework, and considering how MPIs are treated in the planning regime, the Contracts for Difference process and future trading arrangement models.

Ofgem have started gathering evidence as part of the Multi-Purpose Interconnectors workstream in order to review whether the conclusions of their Integrated Transmission Planning and Regulation (ITPR) project on MPIs remain fit for purpose; and to consider options for the regulation of MPIs and how this might interact with our regulatory approaches to point-to-point interconnectors.

Building on the Trade and Cooperation Agreement, BEIS (in conjunction with the Foreign, Commonwealth and Development Office) has engaged extensively with our North Seas neighbours on MPIs, fostering international momentum. This has included well-attended industry roundtables and bilateral meetings with counterpart ministries, as well as the UK Hybrid Project Forum, featuring Minister Trevelyan alongside Belgian Minister Tinne van der Straeten.

Over the coming months, we will be further developing our view on changes required to facilitate MPIs and will be refining this through engagement with developers and our North Seas neighbours.

Working Effectively Across Government

The regulatory framework for developing and connecting offshore wind is complex and involves multiple government departments, regulators, statutory bodies, devolved administrations, and industry parties. The OTNR has established a governance structure which includes a Project Board, a Working Group, an Engagement Working Group and an Expert Advisory Group. The project reports into a wider cross-Whitehall Ministerial Delivery Group, which brings together relevant government departments to oversee the expansion of renewable power in the UK.

The following updates from some of our OTNR Project Partners seek to highlight this cross-governmental working. If there are any questions about the coordination between different departments, please get in touch via the contact details at the end of this newsletter.

Marine Planning & Strategic Renewables Unit

Marine Management Organisation

Work continues on the North East, North West, South East and South West Marine Plans. Amendments to the plans have been completed to reflect comments received to the public consultation last year. A Consultation Summary has been produced and published. The revised plans have now been submitted to the Department for Environment, Food and Rural Affairs (Defra) Secretary of State for consideration.

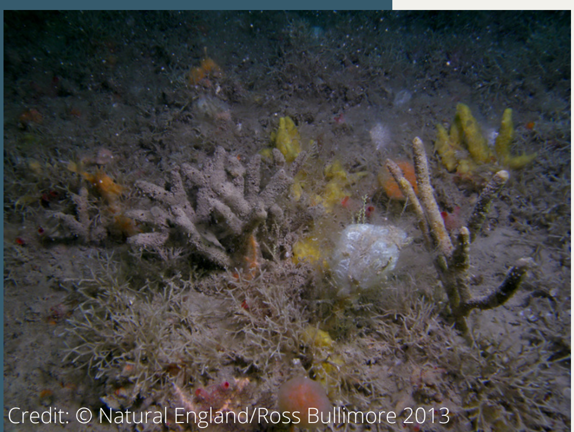
We are also currently producing the first Three-year Report on the South Marine Plan. This is due to be published in July this year, following which we will make a recommendation to keep, amend or replace the South Marine Plan based on the monitoring findings.

In response to a range of challenges and the need for more capacity to service the increasing and at times fast developing projects and initiatives in support of offshore wind, the MMO has also established a new 'Strategic Renewables Unit' (SRU). The SRU will work across, and be a shared resource between, the MMO Planning and Licensing teams. It will promote join-up and facilitate links to wider planning and licensing work and engage with a range of government and other initiatives and projects, such as the OTNR.

If you would like to receive further updates about marine planning, you can sign up to the MMO Marine Planning newsletter here.

The Importance of Considering Environmental Impacts

Defra



Credit: © Natural England/Ross Bullimore 2013

The OTNR provides a vital and very timely opportunity to make changes which can substantially reduce the environmental impacts of future offshore wind cabling infrastructure. To meet the UK's 2050 Net Zero target, thousands of kilometres of additional cabling will be required. The impacts of cabling can result in changes to and loss of sensitive marine and terrestrial habitats. This risks impacts to sensitive, and often rare, habitats and species at a time when Government is also focussed on responding to a growing biodiversity crisis (as evidenced by the recent Dasgupta Review). It also increases the consenting risk for developers, since any potential adverse environmental effects of developments must be fully considered and addressed before consent can be granted as part of the consenting process.

By improving future coordination, the OTNR project can play a major role in helping to prevent this. Early indications are that coordinated designs have the potential to significantly reduce the total amount of cabling infrastructure. Environmental experts from government policy teams, Statutory Nature Conservation Bodies and The Wildlife Trusts are working with the OTNR to provide guidance on environmental considerations.


Credit: © Natural England/Tom Daguerre 2015

Consultations & Events

Previous

On 17th December 2020, BEIS held an OTNR Update Webinar, alongside Ofgem, NG ESO and the Crown Estate. If you were unable to attend, you can access the slides and recording on the OTNR webpage.

On 10th March 2021, BEIS chaired the UK Hybrid Project Forum, considering the role of Multi-Purpose Interconnectors in meeting our Net Zero goals. If you were unable to attend, you can find the slides shared on the OTNR webpage.

Upcoming

BEIS and Ofgem will be holding consultations later this year, to gather the views of stakeholders on ongoing policy work. We will provide further updates in due course.

Contact

Webpages

https://www.gov.uk/government/groups/offshore-transmission-network-review

https://www.ofgem.gov.uk/electricity/transmission-networks/offshore-transmission/offshore-transmission-policy-design/coordination-policy

https://www.nationalgrideso.com/future-energy/projects/offshore-coordination-project

Contact via email

BEIS: offshore.transmission@beis.gov.uk
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NG ESO: box.OffshoreCoord@nationalgridESO.com
The Crown Estate: OffshoreStakeHolder@thecrownestate.co.uk
Crown Estate Scotland: marine@crownestatescotland.com
Marine Management Organisation: planning@marinemanagement.org.uk

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