Funded Incremental Obligated Capacity

Need Case Submission

Western Gas Network Project

June 2021

nationalgrid

Executive Summary

Project Snapshot

Having received a customer request for additional entry capacity at the Milford Haven Entry Point, National Grid Gas Transmission has followed its approved capacity methodologies and framework obligations to develop the Western Gas Network Project proposal.

The request for 163 GWh/d, which represents a ~17% increase on the existing obligated baseline, cannot be met by the existing network in any scenario and is therefore to be treated as Funded Incremental Obligated Entry Capacity.

Our preferred strategic option requires the least new infrastructure, therefore minimising the impact of the project on communities and the environment. This option has the lowest capital cost with the greatest consumer benefit and represents the most economic and efficient solution for UK consumers. It is a modular solution, meeting the immediate requirements of the customer request, whilst being flexible for future development as the energy landscape evolves.

This document represents the Need Case submission of the RIIO-T2 Funded Incremental Obligated Capacity process. It details the project need and optioneering process that led to the preferred strategic option, meeting the requirements of the guidance documentation, for Ofgem assessment.

This project aligns with our RIIO-T2 stakeholder priorities, '*I want to connect to the transmission system'* and *'I want to take gas on and off the transmission system where and when I want'.*

1. National Grid Gas Transmission (referred to in this regulatory submission as 'National Grid') are submitting this Need Case under the RIIO-T2 Funded Incremental Obligated Capacity (FIOC) Re-Opener Price Control Deliverable Uncertainty Mechanism, in accordance with Licence Special Condition 3.13 Part C and as per the FIOC Guidance and Submissions Requirements Document. The purpose of this stage of the process is to seek Ofgem approval of the project need and options analysis, providing a detailed view of the project and its associated timings, setting out the different options considered and the preferred strategic option.

2. As the owner and operator of the Gas National Transmission System (NTS), National Grid has a statutory obligation under the Gas Act 1986 to develop and maintain an efficient and economical pipeline system for the conveyance of gas.

3. Requests to reserve firm NTS capacity are through the Planning and Advanced Reservation of Capacity Agreement (PARCA) process. The PARCA is a bilateral contract that allows long-term NTS entry and/or exit capacity to be reserved for a customer while they develop their own project, before they buy that reserved capacity. The release of funded incremental obligated entry capacity is only possible through a PARCA.

4. South Hook Gas Company Limited (SHGCL) submitted a PARCA application for 163 GWh/d in excess of the prevailing level of Firm Entry Capacity at the Milford Haven Aggregate System Entry Point (ASEP), with a capacity Registration Date of 1st January 2023. Milford Haven ASEP is an LNG entry terminal in South Wales, comprising two sub-terminals.

5. During the Phase 1 PARCA works, the application was considered in the context of the Future Energy Scenarios (FES), National Grid's legal duties, obligations and the capacity of the existing NTS. The application was considered to be compliant with requirements and an offer was therefore made to the applicant for the entry capacity they had applied for, to be treated as Funded Incremental Obligated Entry Capacity, with an indicative registration date of 1st January 2026. The project has progressed to PARCA Phase 2.

6. As well as the PARCA framework, we are following our internal Gas Network Development Process (GNDP or ND500). The project has passed through the relevant stages to date and is on track to reach the T3/F3 stage gates in mid-2022. National Grid keeps all projects under review and revisits earlier stages if key assumptions, such as supply and demand forecasts, change. This submission reflects the analysis performed from initial options selection, through to a recent refresh based on the FES 2020 that include three pathways to net zero by 2050.

7. The preferred strategic option includes modifications to the existing network and requires the least new infrastructure, therefore minimising the impact of the project on communities and the environment. This option has the lowest capital cost with the greatest consumer benefit and therefore represents the most economic and efficient solution for UK consumers. The option has continued to be refined in order to provide the optimum solution to meet the needs of the PARCA and has the potential to bring forward the capacity release date for the customer, to 1st January 2025.

8. National Grid has undertaken engagement on the proposed option with a wide variety of stakeholders including relevant statutory bodies, the PARCA customer, political representatives, potentially affected landowners and the general public through a variety of approaches. Feedback from engagement will continue as design work matures and is being taken into account ahead of planning submissions later in 2021. This supports the acquisition of necessary rights for the construction and operation of the infrastructure through voluntary agreements or compulsory purchase where necessary.

9. This preferred strategic option contains the following main elements:

   - Pressure uprating of part of the existing Feeder 28 pipeline between Felindre and Three Cocks and the section from Felindre to Cilfrew;
   - 9km of new pipeline between Wormington and Honeybourne and 2km of new pipeline between Churchover Compressor and Churchover Multijunction; and
   - Related works at several existing Above Ground Installations (AGIs) and compressor stations to facilitate the higher flows, pressure uprating, connection of new pipelines and effective compression at existing stations.

10. The forecast spend profile for this option is represented in Table 1:

£m	RIIO-T1	RIIO-T2					RIIO-T3	Total
	Prior years	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	
2018/19 Prices	[redacted]							
Outturn Prices								

Table 1: Western Gas Network Project forecast spend profile ([redacted])

11. National Grid does not consider that the Western Gas Network project meets the criteria for late competition. The project has developed sufficiently for a need case assessment and consultation to be carried out by Ofgem. As further progress is made and costs become more certain, we will continue to engage with the authority leading up to the FIOC Project Direction Submission.

12. The Western Gas Network project is designed to accommodate the immediate requirements triggered by a customer request for incremental capacity without over-investing in infrastructure which may not be required. As such it does not resolve the potential wider network constraints that may appear in some scenarios in the longer term. It is however, a scalable, modular option that would support any future investment that is needed, which would be highlighted through our Annual Network Capability Analysis Report (ANCAR) and requested as part of a future regulatory period and business plan.

13. Ofgem are invited to assess and approve the project need and options analysis and publish those views as per the FIOC Guidance and Submission Requirements Document. In order to maintain programme to deliver the capacity as per the PARCA framework, we request the appropriate priority is given to this assessment. A decision before the end of 2021 would enable National Grid to progress efficiently and meet our PARCA obligations. We welcome engagement with Ofgem throughout the needs case assessment process, plus intend to keep engaging with the regulator at relevant project development stages, so they remain informed throughout and ensure we successfully deliver the capacity for the customer and value for consumers.

1. Table of Contents

2. Summary Table

The costs in this summary table and throughout the document are in outturn prices unless otherwise stated

Name of Project	Western Gas Network (Milford Haven ASEP PARCA)		
Scheme Reference	[redacted]		
Primary Investment Driver	Customer PARCA Application		
Project Initiation Year	2018		
Project Close Out Year	2026		
Total Installed Cost Estimate (£)	[redacted]		
Cost Estimate Accuracy	[redacted]		
Project Spend to date (£)	[redacted]		
Current Project Stage Gate	4.2 – Select Option		
Reporting Table Ref	4.2 - LR Uncertainty Mechanism, Entry, Incremental		
Outputs included in RIIO-T1 Business Plan	No		
Outputs included in RIIO-T2 Business Plan	No. PARCA and UM flagged in BP.		
Spend apportionment	**RIIO-T1** [redacted]	**RIIO-T2** [redacted]	**RIIO-T3** [redacted]

Table 2: Engineering Justification Paper Summary Table

14. The FIOC Guidance and Submissions Requirements document details the information that should be included within this Need Case and specifies it should use the RIIO-GT2 Engineering Justification Paper (EJP) format. Table 3 provides a summary mapping the guidance requirements to this EJP document.

15. As referenced in paragraph 3.10 of the submission document, a proportionate approach should be taken to the level of detail submitted with a needs case submission. Where appropriate, justifications can and have been provided where some information cannot be included.

FIOC Guidance and Submissions Requirements Document	Need Case/EJP Format Location
3.11. Updated project summary, including identifying where any changes have been made to the information provided to Ofgem previously pursuant to the requirements in Part B of Special Condition 9.13.	This is the first submission, due to the implementation of the FIOC process mid-way through the PARCA project, therefore no changes need to be identified.
3.12. Evidence that NGGT has applied the capacity release methodologies in the statements maintained by NGGT pursuant to Special Condition 9.18 (Methodology to determine the release of Entry Capacity and Exit Capacity volumes).	Information included in 3. Project Status and Request Overview. Further detail in Appendix I. PARCA Phase I Output Report.
3.13. Evidence that any volumes proposed as Non-Incremental Obligated Entry Capacity or Non-Incremental Exit Capacity were determined in accordance with Special Condition 9.17 (Entry Capacity and Exit Capacity Obligations and Methodology Statements).	Information included in 3. Project Status and Request Overview. Further detail in Appendix I. PARCA Phase I Output Report.
3.14. Information on any areas of its needs case submission NGGT expects may need to be updated in a subsequent application for a FIOC Project Direction.	Elements of the Need Case that will be updated between now and the Project Direction submission are included in the Project Plan in Chapter 8.
3.15. Latest project information, dependencies and estimated milestones.	Information included in 3. Project Status and Request Overview.
3.16. Technical summary demonstrating the validity of the technical requirements of the project.	Summaries and capability analysis include in chapters 6 and 7, with further detailed information in Appendix VI.
3.17. Statement of preferred option for the project.	Information included in the Project Scope Summary in chapter 5.
3.18. Evidence of the selection process for preferred option, and estimated costs.	Selection process and costs covered in chapters 6 and 7, with supporting detailed costs in Appendix V.
3.19. Evidence on the expected long-term value of the proposed project for consumers.	Provided in chapters 6 and 7, through CBA sections and summary.
3.20. Information relating to the proposed procurement strategy and scope of works.	Information included in Chapter 8.
3.21. Information on engagement with stakeholders.	Information included in Chapter 8.

Table 3: FIOC Guidance to EJP location table

3. Project Status and Request Overview

Introduction

16. This document, produced by National Grid Gas Transmission (referred to in this report as 'National Grid') has been prepared as the submission required to seek Need Case approval for the Funded Incremental Obligated Entry Capacity (FIOC) Re-opener for the Western Gas Network (WGN) Project, driven by the Milford Haven ASEP Planning and Advanced Reservation of Capacity Agreement (PARCA).

17. National Grid are submitting this under the FIOC Re-opener Price Control Deliverable Uncertainty Mechanism, which allows application for the funding required to release Incremental Obligated Entry Capacity or Incremental Obligated Exit Capacity that cannot be released by Entry Capacity Substitution or Exit Capacity Substitution.

18. This Need Case submission is in accordance with Special Condition 3.13 and 9.13 of the NTS Transmission Licence, the RIIO-T2 FIOC Guidance and Submissions Requirements Document and the RIIO-T2 Final Determinations for National Grid Gas. Its purpose at this stage of the FIOC Re-opener, is to provide Ofgem with a detailed view of the project, its associated timings, setting out the different options considered and the preferred strategic option.

19. Ofgem approval of this Need Case is required to enable National Grid to submit an application for a FIOC Project Direction at a later date, to request an output, delivery date and associated allowances to be included in NGGT's licence.

20. The WGN project will span multiple regulatory periods. All applicable processes and notifications have been published in accordance with RIIO-T1 obligations and methodologies, this need case marks the first applicable step relevant to this stage of the project under the RIIO-T2 Licence.

Project Overview

21. National Grid has duties under the Gas Act 1986 to develop and maintain an efficient and economical pipe-line system (the NTS) for the conveyance of gas and to comply, so far as it is economical to do so, with any reasonable request to connect to that system.

22. Typical lead times for the delivery of new pipeline infrastructure to create additional capacity in the NTS, and the lead time for the construction of connected facilities, are dependent on many variables including planning processes. It is important therefore that Shipper Users and Reservation Parties are able to commit early to the provision of additional capacity to avoid misalignment of projects. Delay in commencement of work to deliver additional capacity in the NTS could lead to that capacity not being available to the timeframes originally required by the connecting party.

23. In order to facilitate the timely delivery of capacity, a Shipper User or Reservation Party can apply for a PARCA that allows the reservation of capacity, ahead of it being allocated and registered to that party and hence before they are financially committed to the capacity itself. Capacity requests are considered against the provisions of National Grid's statutory licence obligations and in accordance with our published methodologies.

24. The South Hook Gas Company Ltd submitted a PARCA with the intention of increasing the baseline entry obligation by 163 GWh/d (15 mscm/d). This would increase the baseline obligation at the Milford Haven ASEP to 1,113 GWh/d (102.7 mscm/d).

25. If such an increase in flows was accommodated on the existing NTS then unacceptably high levels of entry constraint costs would be anticipated from 2023 onwards (see section on capacity release methodology later in this chapter). National Grid has therefore considered options that would enable it to offset network constraint costs through physical network changes, review of commercial contracting strategy and regulatory rules.

26. The development of the WGN project, as well as following the PARCA framework, also uses the National Grid Network Development Process (GNDP or ND500) as outlined in Figure 1 below.

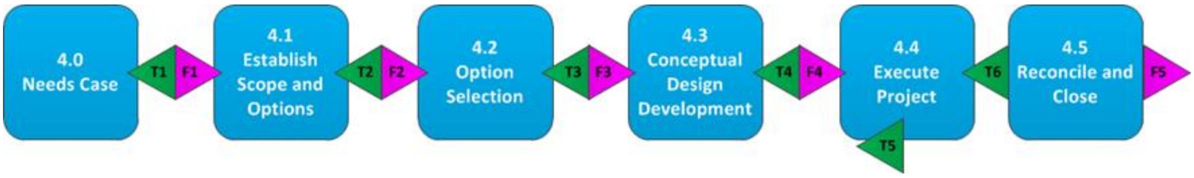

Figure 1: Network Development Process

27. The project is currently in 4.2 Option Selection and is on track to reach the T3/F3 stage gates in mid-2022. National Grid keeps all projects under review and revisits earlier stages if key assumptions, such as supply and demand forecasts, change.

<u>PARCA</u>

28. The PARCA application requested Firm NTS Entry Capacity of up to 163,000,000 kWh/d above the prevailing Obligated Entry Capacity at Milford Haven ASEP. This was received on 24 April 2018 and was validated as a Competent PARCA Application[1] on 4 May 2018.

29. This triggered Phase 1 of the PARCA process and the invitation for PARCA applications from other customers through the opening of a PARCA window. No such applications were received.

30. The Phase 1 Outputs Report identified options for how National Grid could deliver the capacity through a desktop study. This study assessed if this capacity could be delivered

[1] Uniform Network Code, Transportation Principal Document, Section B1.15.4

through (or by a combination of) existing network capability, substitution of capacity, a contractual solution or physical investment in the NTS. The completion of this exercise led to the publication of a PARCA Notice[2] on 18th January 2019, confirming the following details:

- The quantity of capacity requested at the NTS Entry Point in excess of the prevailing level of Firm Entry Capacity to be treated as Incremental Obligated Entry Capacity is 163,000,000 kWh/d.
- The quantity of Firm Entry Capacity to be treated as;
  - Funded Incremental Obligated Entry Capacity is 163,000,000 kWh/d
  - Non-incremental Obligated Entry Capacity provided by Capacity Substitution is 0 kWh/d
- The indicative Registration Date is 1st January 2026

31. The report also provided the customer with relevant information in order to proceed to the next Phase, triggered by the signing of the PARCA Phase 2 Contract, which occurred and was notified to the industry on 15th March 2019[3].

32. Phase 2 includes the production of a Strategic Options Report (SOR), building on the work completed in Phase 1 and initiating the relevant statutory planning activities. The evolution of the SOR has been discussed with the Customer as part of regular engagement. The SOR is included in Appendix IV, and formed the basis of public engagement, resulting in the proposal to proceed to Front End Engineering Design (FEED) with the preferred option. The preferred option identified in the SOR is summarised as follows, noting however that, as described later in this document, the scope of the WGN project has been further optimised since:

- Pressure uprating (with maximum operating pressure below equipment class limit) of the existing Feeder 28 pipeline between Milford Haven and Three Cocks;

- 9km of new pipeline between Wormington and Honeybourne and 2km of new pipeline between Churchover Compressor and Churchover Multijunction; and

- Related works at several existing AGI sites to facilitate the increased flow, pressure uprating, connection of new pipelines and effective compression at existing stations.

33. Through the process of creating the SOR, we considered the widest range of options which could meet our operational requirements and accommodate the customer application for increased capacity, irrespective of an initial view of their viability. Following an early filtering process, a shortlist of options was then costed from an asset investment perspective. Our recommended solution is supported by a Cost Benefit Analysis (CBA) which has considered investment costs, constraints and contracts costs, and operational costs.

34. Further technical studies have been undertaken (with some ongoing) to input into FEED to support our CBA and to feed into the decision-making process. More specifically this

[2] https://www.nationalgrid.com/uk/gas-transmission/document/125146/download
[3] https://www.nationalgrid.com/uk/gas-transmission/document/126451/download

includes modelling of site level requirements to support the overall effectiveness of the project, route corridor investigations for new pipeline, and progression of the pressure uprating process as defined in IGEM/TD/1 (Institute of Gas Engineers and Managers specification for steel pipelines and associated installations for high pressure gas transmission).

35. Since the production of the SOR, as part of our regular processes, a re-validation exercise of the continued preference for the strategic option was also undertaken in early 2021, to take account of the release of FES 2020 data (the SOR analysis having been based on FES 2019). In parallel, a number of sensitivity reviews were used to optimise the detailed composition and scope of the strategic option.

36. This work has led to the refinement of the preferred option. In summary this refinement comprised reducing the extent of pressure uprating by removing pressure uprating between Milford Haven and Felindre, specification changes to some of the new pipeline required (reducing from 1200mm to 900mm diameter) and some other improved designs reducing the extent and scope of some works. Full details of this are included in chapters 6 and 7.

Capacity Release Methodology

37. Both the Entry Capacity Substitution and Entry Capacity Release Methodology Statements were applied during Phase 1 of the PARCA process. The results form part of the Phase 1 Works Output Report and informed the PARCA Phase 2 Contract, with the relevant Publications/Notices published on the NG website. Capacity Methodology statements will have been applied using the approved versions at the time and may have been subsequently updated.

38. As part of the Phase 1 Need Case Analysis, the entry capacity levels specified in the application form were assessed to understand the impact on the “constraint volume” and the current risk levels for entry at Milford Haven. This initial capability assessment, illustrated in Figure 2 below, highlighted that the existing NTS is not capable of accommodating the entry capacity being requested at any demand level.

39. To minimise the need for Funded Incremental investment (FIOC) we consider the substitution of unsold[4] Entry Capacity from existing sites (Donor Sites). The objective of the Entry Capacity Substitution Methodology is to avoid the incremental increase in network risk. With the existing NTS being constrained at all lower demand levels, any proposal to increase the Entry Capacity at the Milford Haven ASEP via substitution would result in an increase in network risk. Therefore, in line with paragraph 72 of the Entry

[4] Any available unsold Non-incremental Obligated Entry Capacity that is not allocated, or reserved, or subject to a retainer, will be deemed available for substitution.

Capacity Substitution Methodology[5], substitution has been discounted and FIOC proposed.

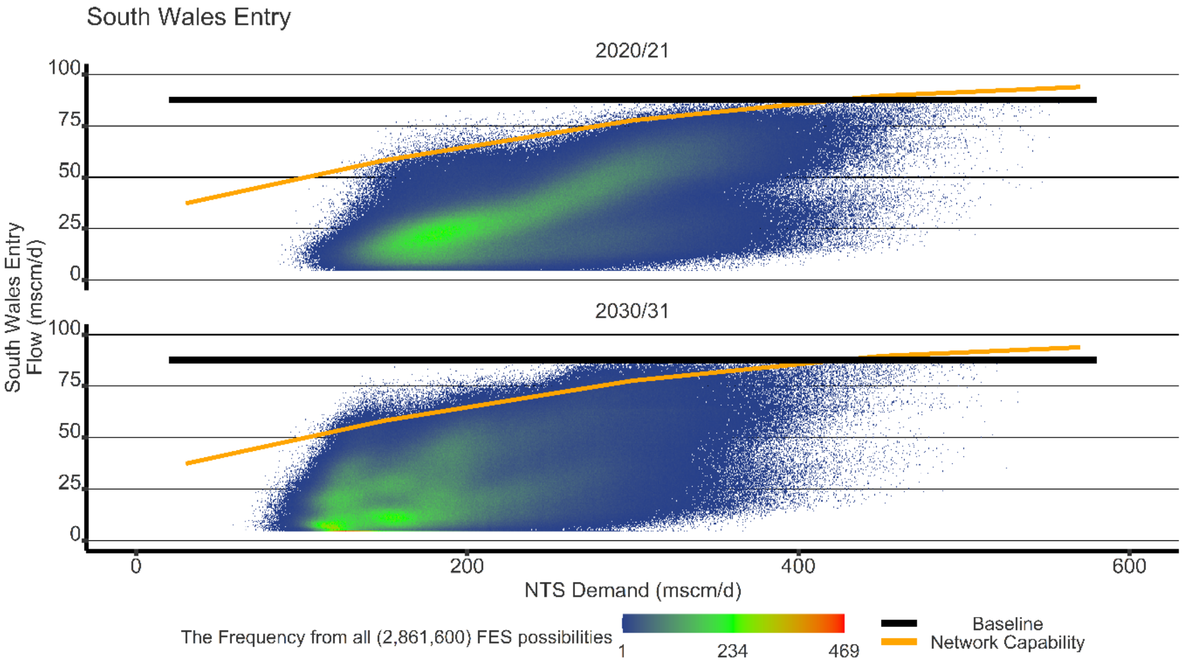

Figure 2 – Flame Chart illustration of existing NTS capability against entry capacity at Milford Haven ASEP

Funding Mechanism

40. The initial Phase 1 works are funded through the PARCA application fee, which was reconciled to actual costs at the end of this phase.

41. The FIOC Re-opener, as defined in Special Condition 3.13, allows for the application for funding required to release Incremental Obligated Entry Capacity that cannot be released by Entry Capacity Substitution.

42. The FIOC Project Direction stage of the reopener, subject to an approved need case submission and National Grid obtaining any material planning consents, is where National Grid will submit project costs for assessment. This will cover all expenditure related to Phases 2 and 3 of the PARCA process.

43. The current estimated cost for delivery of this network reinforcement project is [redacted].

[5] Entry Capacity Substitution Methodology https://www.nationalgrid.com/uk/gas-transmission/document/135026/download

44. Should the FIOC Need Case or Project Direction be rejected by Ofgem, or the PARCA be cancelled or terminated, pass-through of a PARCA Termination Value will be carried out in accordance with Special Condition 6.1.

45. National Grid does not consider that the WGN project, in whole or in part, meets the criteria for late competition as detailed in the RIIO-2 Sector Specific Methodology Decision Core Document. As such, it should not be delivered through a late competition model, identified in Chapter 9 of RIIO-2 Final Determinations Core Document.

Request Summary

46. Ofgem are invited to assess and approve the project need and options analysis, and publish those views as per the FIOC Guidance and Submission Requirements Document. In order to maintain programme to deliver the capacity as per the PARCA framework, we request the appropriate priority is given to this assessment. A decision before the end of 2021 would enable National Grid to progress efficiently and meet our PARCA obligations.

4. Problem/Opportunity Statement

47. Milford Haven is an LNG entry terminal in South Wales. There are two sub-terminals, South Hook and Dragon. The South Hook Gas Company Ltd has submitted a PARCA with the intention of increasing the baseline entry obligation by 163 GWh/d (approximately 15 mscm/d) from January 2023. This increases the physical capability and baseline obligation at Milford Haven to 1,113 GWh/d (102.7 mscm/d). South Hook Gas Company intend to increase their maximum deliverability to 813 GWh/d (75 mscm/d).

48. Table 4 shows the current and future maximum (obligated and deliverable) sustainable entry flows for each sub-terminal:

Name	Current maximum (GWh/d)	New maximum (GWh/d)	Current maximum (mscm/d)	New maximum (mscm/d)
South Hook	650	813	60.0	75.0
Dragon	300	300	27.7	27.7
Total	950	1,113	87.7	102.7

Table 4: Milford Haven maximum sustainable flows

49. Feeder 28 connects Milford Haven to the rest of the NTS. Figure 3 shows the location of Milford Haven and the key compressors used to move gas away from the terminal:

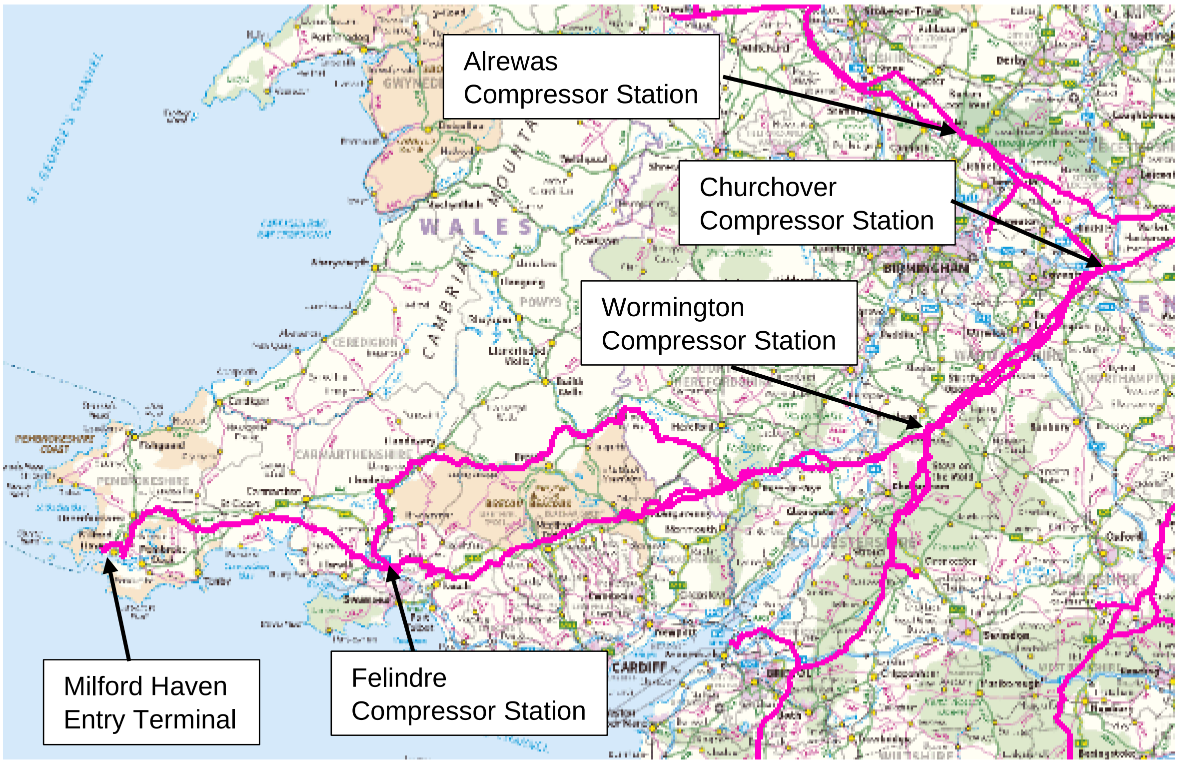

Figure 3 – Milford Haven and key compressor sites on the NTS.

50. To provide the maximum entry capability on the existing NTS, compression at Felindre, Wormington, Churchover and Alrewas are all required. The ability of the NTS to receive gas from Milford Haven is linked to the availability and capabilities of these sites. For example, any of the gas entering the system at Milford Haven not used to support demands between the terminal and Wormington, will need to flow through the compressor station at Wormington. For Wormington to meet the current baseline entry capacity of 87.7 mscm/d, two units would need to operate in parallel, giving a maximum flow capability of 80 mscm/d. Therefore, there would need to be a demand of 7.7 mscm/d between the terminal and the compressor station for it to be possible to accept the baseline level on to the NTS.

51. A similar principle applies at the other sites. Tables 5 to 8 summarise the units and flow capabilities of each site as of June 2021:

Unit	Manufacturer / Type	Fuel Type	Power Base (MW)	Installation Date	Nominal Capacity (mscm/d)	Maximum discharge pressure (barg)
A	Siemens Electric Variable Speed Drive (VSD)	Electric	35	2008	90	94
B	Solar Titan	Gas	14.5	2008	39 (78 parallel)	94
C	Solar Titan	Gas	14.5	2008	39 (78 parallel)	94

Table 5: Felindre Compressor Station[6]

Unit	Manufacturer / Type	Fuel Type	Power Base (MW)	Installation Date	Nominal Capacity (mscm/d)	Maximum discharge pressure (barg)
A	RR/Avon	Gas	12.34	1989	40(80 parallel)	75
B	RR/Avon	Gas	12.34	1990	40(80 parallel)	75
C	Siemens Electric Variable Speed Drive (VSD)	Electric	15	2009	50	75

Table 6: Wormington Compressor Station

[6] Nominal Capacity and Power Base data for Felindre units are working assumptions used for Network Modelling purposes. This data may be revised following unit commissioning and testing, which is currently in progress.

Unit	Manufacturer / Type	Fuel Type	Power Base (MW)	Installation Date	Nominal Capacity (mscm/d)	Maximum discharge pressure (barg)
D	Solar Titan	Gas	14.5	2001	50	75 (West) 70 (East)
E	Siemens Electric Variable Speed Drive (VSD)	Electric	15	2010	60	75 (West) 70 (East)

Table 7: Churchover Compressor Station

Unit	Manufacturer / Type	Fuel Type	Power Base (MW)	Installation Date	Nominal Capacity (mscm/d)	Maximum discharge pressure (barg)
A	RR/Avon	Gas	12.34	1971	30 (50 parallel)	70
B	RR/Avon	Gas	12.34	1971	30 (50 parallel)	70
C	Solar Titan	Gas	14.5	2001	50	70

Table 8: Alrewas Compressor Station

52. Before the requested increase in baseline capacity at Milford Haven could be accepted, an assessment of the capability of the existing network was required. This capability was determined using approved network modelling software containing a model of the NTS which had been validated against real life operation. Modelled flows were based on supply and demand patterns consistent with the FES.

53. To minimise the need for FIOC investment, we consider the substitution of unsold Entry Capacity from existing sites (Donor Sites). The objective of the Entry Capacity Substitution Methodology is to avoid the incremental increase in network risk. With the existing NTS being constrained at all lower demand levels any proposal to increase the Entry Capacity at the Milford Haven ASEP via substitution would result in an increase in network risk. Therefore, in line with paragraph 72 of the Entry Capacity Substitution Methodology, substitution has been discounted and FIOC proposed.

54. During Phase 1 of the PARCA there was a parallel consideration of the range of physical and commercial changes to the network and its operation, that might enhance National Grid's ability to accept an increase in baseline capacity at Milford Haven ASEP. At this initial stage it became clear that physical network reinforcements would be required to support the requested increase.

55. Several possible physical options were explored, using the network modelling approach to identify the "bottlenecks" or relative flow and pressure restrictions along the corridor between Milford Haven and Wormington, and also along the onward flow paths towards Churchover and towards the southwest. Network reinforcements, including new compressor stations, new feeders, control valves and changes to operating pressures were combined in the most logical sequences, to increase capability where it was most needed as the modelled flow was incrementally increased. As a parallel approach, opportunities were explored to bypass restricted areas altogether to provide larger

increments in capability. These options would be most effective when connecting directly into other locations on the NTS, that have high levels of connectivity or demand.

56. The PARCA Phase 1 modelling approach is detailed in the PARCA Phase 1 technical options report. Figure 4 is taken from this report and visually represents, at a high level, the themes explored. The aim in Phase 1 was to provide an initial view to the customer of the range of options that would be considered and the likely timescales to complete the related works. This would allow the customer to decide whether to progress to a full strategic options phase.

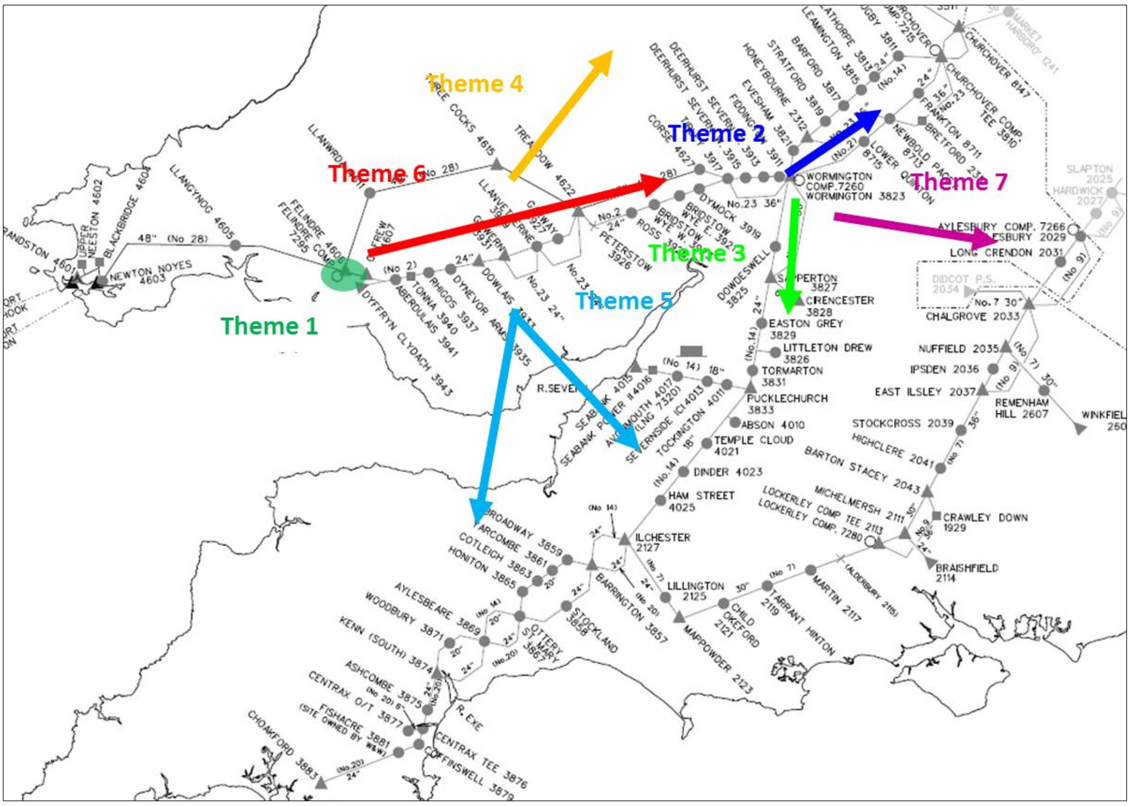

Figure 4: Phase 1 Reinforcement Themes

Uncertainties affecting the Problem / Opportunity Statement

57. There are a number of potential uncertainties that could influence the problem/opportunity statement. These are summarised below under four main themes, with some examples of how they may occur:

- Changes in UK supply and demand patterns beyond the FES modelled;
    - Investment or new discoveries in UK gas production (UKCS, Shale and green gas) reducing LNG import dependency with possible consequence of the

closure of storage sites in the South West if they are no longer economic, requiring additional compression to support demand.

  - UK moving towards a hydrogen market sooner than 2030 and/or to a bigger scale. This may reduce LNG import demand if there was a greater emphasis on electrolysis (with energy from renewables) as the technology for production or conversely increase LNG imports if there was an emphasis on technology based on the use of natural gas as feedstock.

  - Changes in geographical demand relative to today due to areas adopting different technologies for heating. This could reduce compression requirements if areas in the South adopt cleaner fuels for heating or increase it if they have access to Carbon Capture Utilisation and Storage (CCUS) schemes, that are based on converting natural gas to hydrogen.

- Changes in European markets and thus flows to UK through interconnectors;

  - Conversion of European power stations to gas which could reduce imports through the interconnectors and increase UK dependency on LNG, or changes in the interconnectors' operating models or services that either increase or decrease supplies from Europe.

  - Europe and Norway move to a hydrogen based market (predominantly from natural gas) at different timescales to the UK. This reduces the flows through the interconnectors and may increase the UK requirement for LNG to meet demand.

- Changes in global LNG markets;

  - Changes in world markets could either reduce or increase the amount of LNG coming to the UK. Historically the Asian markets have influenced how much LNG comes to the UK e.g. the Japanese tsunami in 2011.

  - An increase in supplies of LNG to the UK may also occur if new pipeline supplies of natural gas become available from Russia to other parts of the world that reduce those countries LNG requirements and result in a shift in commercial viability that lead to additional cargoes to the UK.

- Technical challenges to deliver the proposed scheme of a scale beyond that currently anticipated.

  - Pressure uprating on Feeder 28 and associated assets could be found to cause significantly more building proximity distance infringements, environmental effects and/or technical challenges than currently anticipated with the potential for another strategic option to become more favourable.

  - The capability of existing compression units at Felindre, Wormington, Churchover and/or Alrewas may be found to present a significant risk in supporting all future flow scenarios meaning that another strategic option may become preferable.

- It may become technically unfeasible to provide efficient control of the pressure boundaries at Tirley and Three Cocks with increased flows, whilst continuing to meet local planning requirements.
- If the Wormington MCPD project delivers a substantially different solution to that assumed for the purposes of WGN modelling (two new 17.5MW gas turbines).

58. The WGN project responds to these potential external factors and uncertainties through a range of measures:

- Deployment of both National Grid and external provider expertise to confirm the viability of technical solutions based at appropriate stages on a combination of professional judgement, desk-based assessment, modelling and direct investigations.
- Backcheck reviews – such as when new FES releases occur and relevant data becomes available.
- Refinement of the CBA timeframes to understand when uncertainties may begin to impact the assessment outcomes.
- Consideration of a staged approach, with a modular option that means the capacity can be released, but avoids over-investment before long term uncertainties are better understood.
- Frequent liaison with dependant projects.

Related projects

59. As previously described, the WGN solution is reliant on effective compression at Felindre, Wormington, Churchover and Alrewas compressors. Several separate projects are being progressed by National Grid at some of these sites. The two primary projects relevant to WGN are related to the following stations:

I. <u>Commissioning of the Variable Speed Drive at Felindre Compressor Station</u> – This project, currently ongoing, will provide accurate performance data for the electric motor driven compressor at Felindre. This data will inform our system modelling and may drive a requirement to re-wheel the compressor, implement a different control system, and/or increase its shaft power. DNV, our appointed Uprating Contractor, will assess compressor train performance and suitability for the uprated duty as soon as this information is available.

II. <u>Medium Combustion Plant Directive (MCPD) works at Wormington compressor</u> – The preferred option for Wormington MCPD at the point of RIIO-T2 business plan submission was two new gas turbine driven compressor units. Following RIIO-T2 final determinations, this is funded for Project Development costs only, considering this option alongside retro-fit compressor emissions technology, Control System Restricted Performance (CSRP) and any other feasible options. Further works will be funded through an Uncertainty Mechanism within the RIIO-T2 period. The stated WGN strategic option and final solution capabilities in this document assume that two new 17.5 MW units are installed and commissioned at Wormington, to remain consistent with our RIIO-T2 business plan. Therefore, if MCP Project Development identifies that a different solution is most economic and efficient, it may prompt a back check of work done so far on WGN. To fully inform decision making on this, the Wormington MCP FEED Feasibility will consider a central case with sensitivities as follows:

- Central case - Milford Haven PARCA duty required, Western Gas Network reinforcements commissioned in Jan 2025.
- Sensitivity 1 - Milford Haven PARCA duty not required (contract terminated), Western Gas Network reinforcements not commissioned
- Sensitivity 2 - Milford Haven PARCA duty required, Western Gas Network reinforcements commissioned in Jan 2025, subsequent system reinforcement (most notably 26km of pipeline Tirley to Wormington) commissioned at a later date.

60. The second sensitivity is included due to the possibility that PARCA Process Duty Specification points (the central case) may demand more powerful compressor units (than sensitivity 1). For example, if the preferred solution for central case was two new 17.5 MW units, and the preferred solution for sensitivities 1 and 2 were retrofit or CSRP, then a comparison between central case and sensitivity 2 would be required to determine the most economic and efficient solution, considering the relative costs and capabilities of pipeline vs. more powerful compressors. In these circumstances, the additional compression power requirement would be demonstrably as a result of the PARCA, but the MCP FEED Feasibility study will validate this and inform investment decision making for both projects.

61. The WGN scope is deliberately modular and facilitates expansion at a later date. Depending on how supply and demand patterns progress towards net zero by 2050, there may be a requirement to consider additional uprating (from Milford Haven terminals to Felindre compressor) and/or additional new pipeline from Tirley to Wormington and/or other system reinforcements for which a need is identified at a later date. These projects would not necessarily have a PARCA driver but could have economic and efficient capital investment needs cases if future entry constraint cost risk is significant.

62. There are also a number of other projects which are related to WGN as listed below. Whilst none are considered to affect the WGN project requirements, they are being monitored to keep this under review and to ensure any construction programme implications are understood and factored in:

- Tirley Tactical Access Valves

- Boundary Control System replacement/removal
- Decommissioning of Upper Neeston Minimum Offtake Connection from Feeder 28
- The portfolio of RIIO-T2 works to be delivered in the region between Milford Haven and Churchover including:
    - Minor site remedial works such as painting and refurbishment
    - Compressor refurbishments (unit overhauls, air intakes, cabs, exhausts, ventilation, fire suppression, structural, HV motors and exciters, transformers, frequency converters)
    - Corrosion and Cathodic Protection defects resolution
    - Replacement of failed Insulation Joints (IJs)
    - Replacement of failed valves, overhauls of non-return valves and/or vent and sealant lines repairs
    - Cyber and Telemetry works
    - PSSR Filters, PSSR PIG Traps, ILI and OLI/4 inspections including subsequent repairs as required
    - Integrated Security Solutions (ISS) Technical Refreshes

Project Boundaries

63. The Western Gas Network project is designed to accommodate the immediate requirements triggered by a customer request for incremental capacity through the PARCA process.

64. It does not resolve the potential wider network constraints that may appear in some scenarios in the longer term. It is however, a scalable modular option that would support any future investment that is needed, which would be highlighted through the ANCAR and requested as part of a future regulatory period and business plan.

5. Project Definition

Supply and Demand Scenario Discussion and Selection

65. To fully assess the project, a network assessment and a risk and constraint assessment have been carried out at numerous steps of the process. The network assessment was done to define the capability boundaries. The boundaries feed into the constraint and risk assessment to define the associated costs.

66. For PARCA Phase 1, the Two Degrees (TD) scenario from the FES 2018 was used as the base scenario for this proposal. The reason for selecting the TD scenario, was that the demand in this scenario was the lowest of the four FES 2018 scenarios making it the most challenging in terms of the additional flows onto the system from Milford Haven as a result of the PARCA.

67. The SOR showed the Net Present Value (NPV) rankings based on FES 2019, which was the latest available at the time. When available, these options were tested against FES 2020, which did not result in a change to the Strategic Option selected, with the need for investment confirmed under all scenarios. The CBA for both the Strategic Option selection and Strategic Option refinement were based on FES 2020 and are detailed in the following ‘Future Requirements’ section in this document.

68. All four scenarios are defined in FES as having equal probability and there was no clear mid-case to be used as the basis for additional gas inputs at the Milford Haven ASEP. Given the significant differences between the scenarios, the CBA assessments were carried out against all four scenarios to ensure the selected option would benefit consumers against all scenarios.

Future Requirements

69. As detailed previously, SHGCL submitted a PARCA which requests an increase in entry baseline capacity of 163 GWh/d (equating to approximately 15 mscm/d) from 1st January 2023. We have assessed the requested increase in capacity and it has been determined that this cannot be met without capital investment to facilitate the baseline capacity increase. This is the main driver for the investment. Without investment, we estimate that constraint costs will increase significantly from 2023 onwards, rising to unacceptable levels.

70. Imported LNG entering at the Milford Haven terminal is routed through South Wales along Feeder 28, proceeding into the Midlands, North and the South West. Entry capability is facilitated by compression at Felindre, Wormington, Churchover and Alrewas, and is also impacted by the demand in South Wales. When demand in South Wales is low, there is a greater need for LNG entering at Milford Haven to be transported away from South

Wales, increasing the requirement for compression at Felindre, Wormington, Churchover and Alrewas.

71. The gas landscape has changed considerably in the last 20 years. With the continued decline of UK Continental Shelf (UKCS) supplies and the need to decarbonise, National Grid expects gas supply and demand patterns to continue to change going forwards. As highlighted in our uncertainties to the problem/opportunity statement, various factors create uncertainty on the extent and speed of change. Given this uncertainty, it is impossible to forecast a single energy future over the long term. Each year in July the FES are published. These scenarios are created by drawing on National Grid's own analysis and input from stakeholders across the energy industry.

72. This project has progressed through multiple iterations of the FES, with a process of backcheck undertaken to ensure that the latest iteration still supports the WGN project. The WGN project was originated when FES 2018 was the relevant basis and has been revalidated against both FES 2019 and 2020 scenarios. FES 2020 has seen an updated scenario framework published (see Figure 5 below) and net zero targets included.

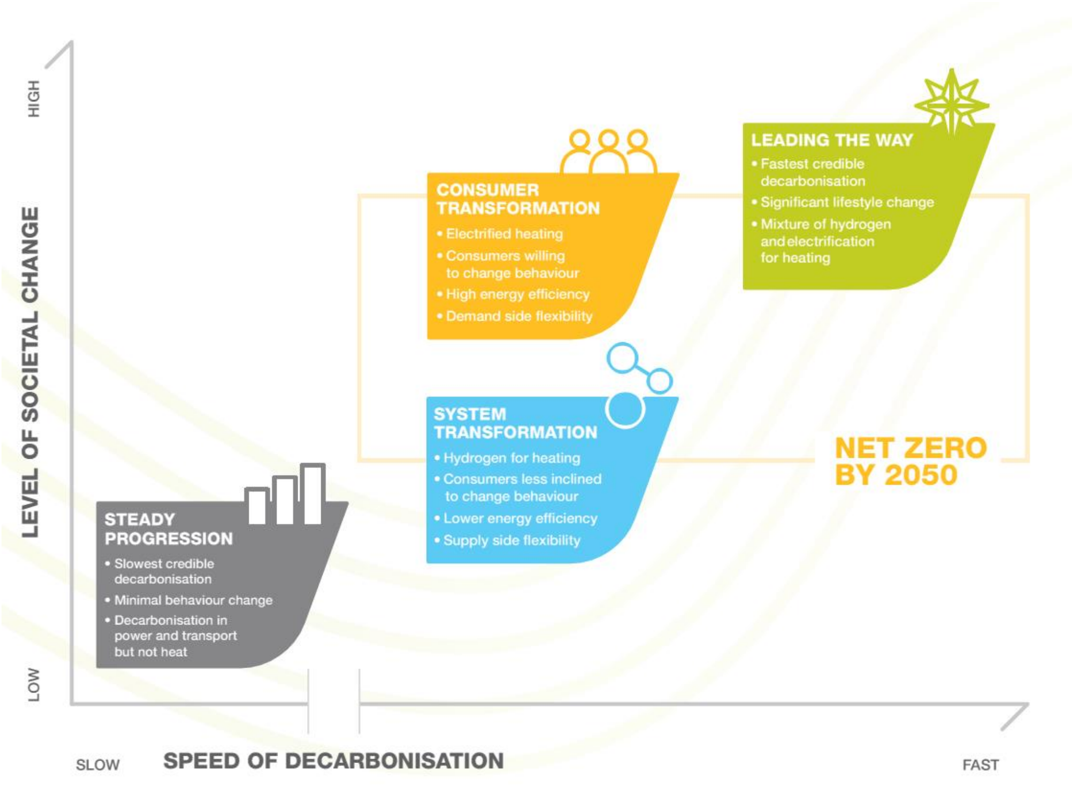

Figure 5: FES 2020 framework

73. Our assessment of the required capital investment is based on the requirements arising from the PARCA, but it is also informed by changes in supply and demand (Figure 6 below) expected over time as described in the FES 2020 document.

74. FES considers a number of plausible supply and demand scenarios looking out to the net zero 2050 deadline. These scenarios cover a wide range of potential flows which will depend on the actual pathway the UK takes to achieve net zero. Although the range of demand is wide, all of these scenarios have a decrease in overall demand out to 2050 in common.

75. The Consumer Transformation (CT) and Leading the Way (LTW) scenarios use of electrification and of green hydrogen from hydrolysis, results in very low demand for natural gas. Conversely, natural gas demand remains high in both the System Transformation (ST) and Steady Progression (SP) scenarios. In ST, heating demand is met using hydrogen produced mainly from natural gas, and in SP heating demand is still provided largely from natural gas.

76. Over the next 20 years, UKCS supplies will continue to decline. In the CT and LTW scenarios this is offset by a corresponding reduction in demand for natural gas. However, in the ST and SP scenarios the use of natural gas continues at elevated levels which will then be met by a corresponding increase in imports (Figure 7). These imports could be from continental Europe or as LNG (Figure 8).

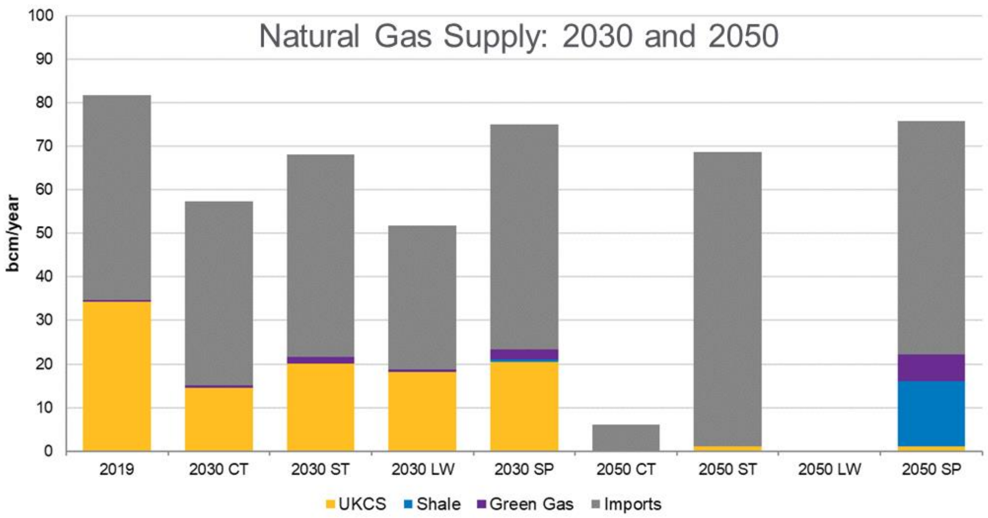

Figure 6: Natural gas supply by scenario, 2030 and 2050

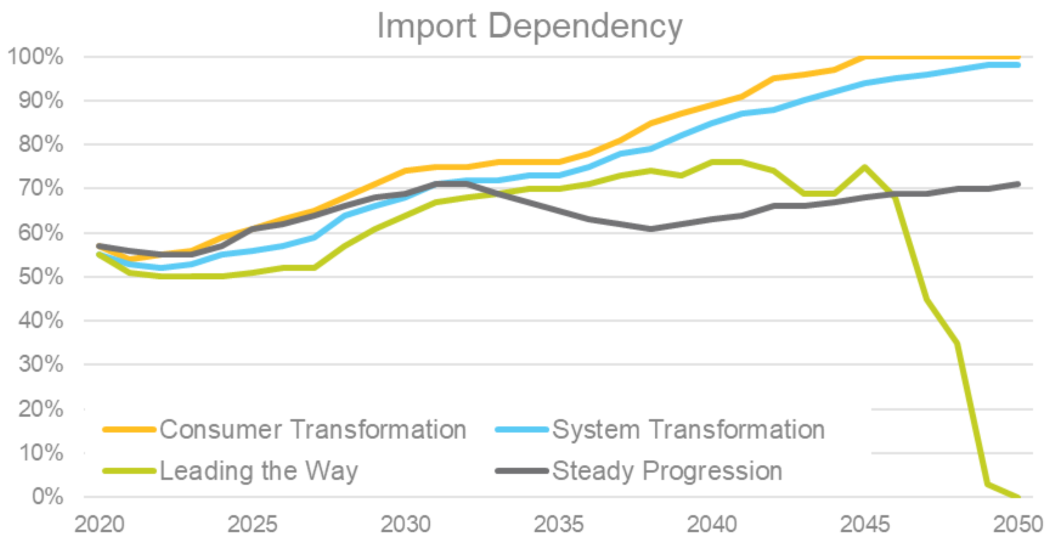

Figure 7: Gas import dependency (%)

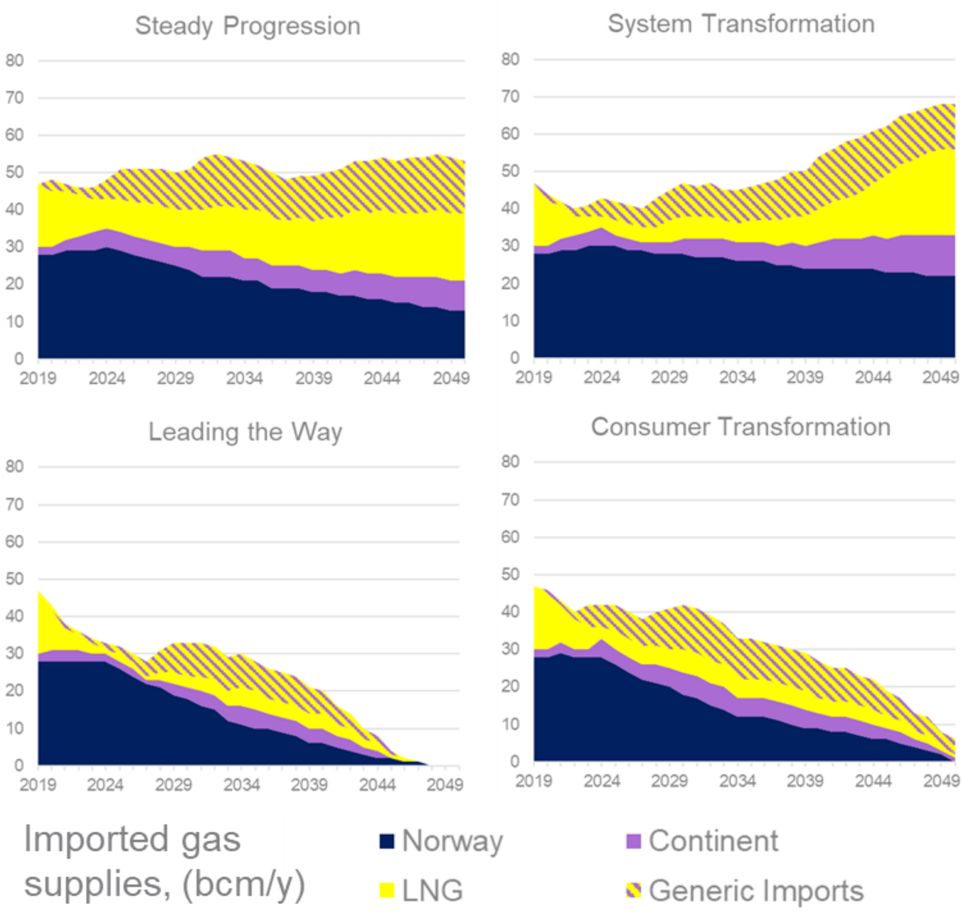

Figure 8: Gas Import Mix by scenario

77. Figure 9 shows the average daily LNG supply range across the four scenarios under both a high LNG or high Continental Europe supply scenario.

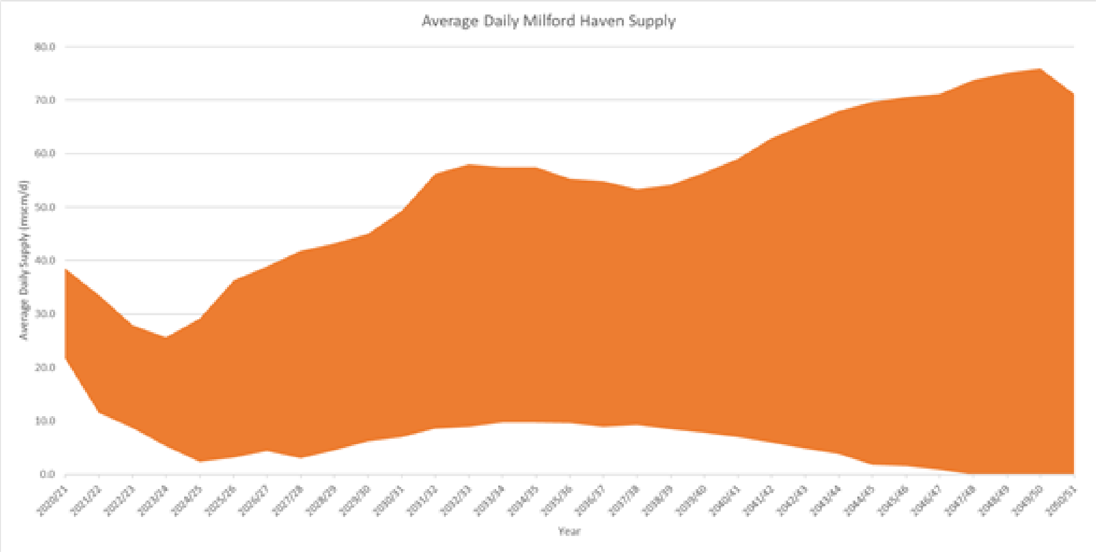

Figure 9: FES 2020 Milford Haven flow range

78. Network analysis has been carried out to assess the risk of constraint costs arising over a wide range of plausible demand scenarios for the current intact network. The network analysis has been carried out using our capability analysis process which has been developed to assist in defining the capability of the NTS. The results are shown in the form of 'Flame Charts' in Figure 10 to Figure 13 below. Further details of the capability analysis process and the creation of the Flame Charts are given in our annual publication "GTYS 2020 Network Capability Annex"[7], with a brief summary of the creation of the Flame Charts also given below.

79. The Flame Charts contain dots plotted onto the chart where one dot is associated with one day in that year, and for every day there are 980 alternative supply and demand patterns. The different coloured dots are for different years showing how we expect supply and demand patterns to change over time up to 2040. The table at the top of the chart shows how the number of dots above a line translates into constraint days. For instance, in Figure 10 for the Steady Progression scenario, the orange row of the table "Intact" shows we would expect an average of [redacted] days of constraints in 2030/31.

80. The charts show the supply/demand at the South Wales Entry boundary. This is the point where gas flows leave South Wales and enters the rest of the NTS. This "boundary" is used for the purposes of defining capability across a range of Milford Haven supplies and South Wales demands. The assessment of the flows is done on a net flow basis, i.e. Milford Haven supply less South Wales demand. As the level of flows which can be accepted from Milford Haven is impacted by the level of demand in South Wales it is important to understand how changing demand patterns impact this capability going forward. This is covered in more detail in the Capability Analysis section.

[7] https://www.nationalgrid.com/uk/gas-transmission/insight-and-innovation/gas-ten-year-statement-gtys

81. Figures 10 and 11 compare the network entry capability with our forecasts of entry supplies through the Milford Haven terminals under our high entry flow scenarios. Both System Transformation and Steady Progression scenarios continue to have high demands up to 2040 and beyond, although there will still be a reduction in demand compared to the present day. In 2040 the number of constraint days is estimated to be significant with [redacted] for SP and [redacted] for ST. Without investment, it is expected that substantial constraint costs will be incurred over time out to 2040 and beyond.

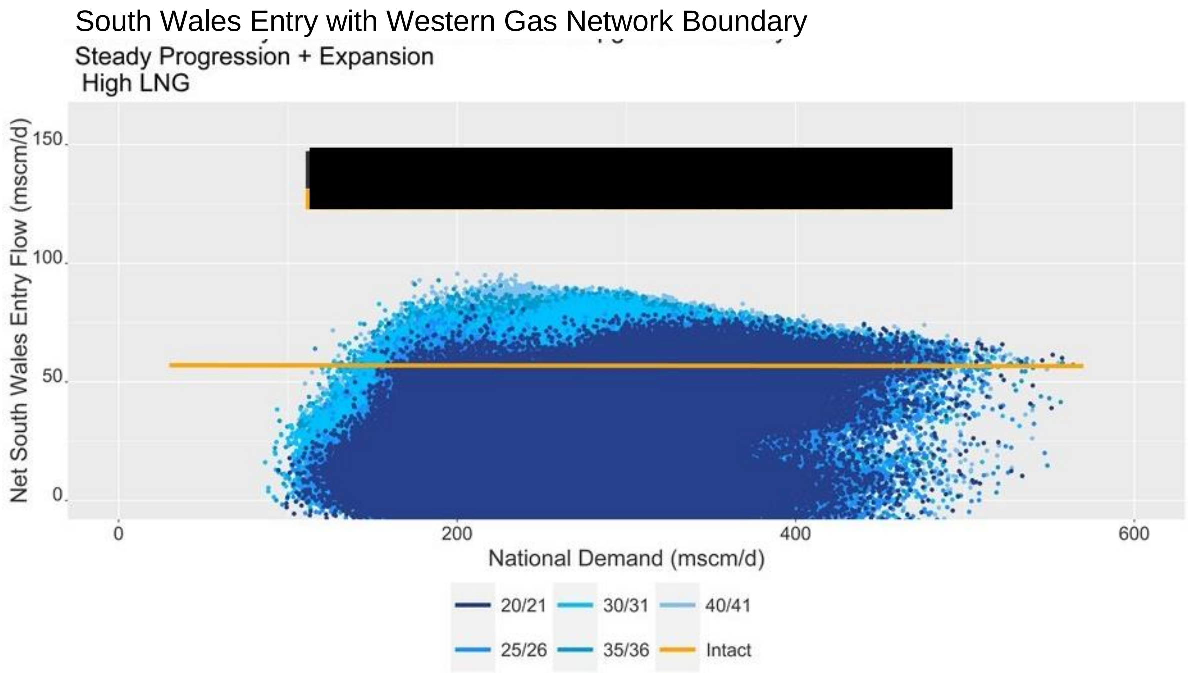

Figure 10: Network entry capability at Milford Haven (Steady Progression 2020 plus expansion)

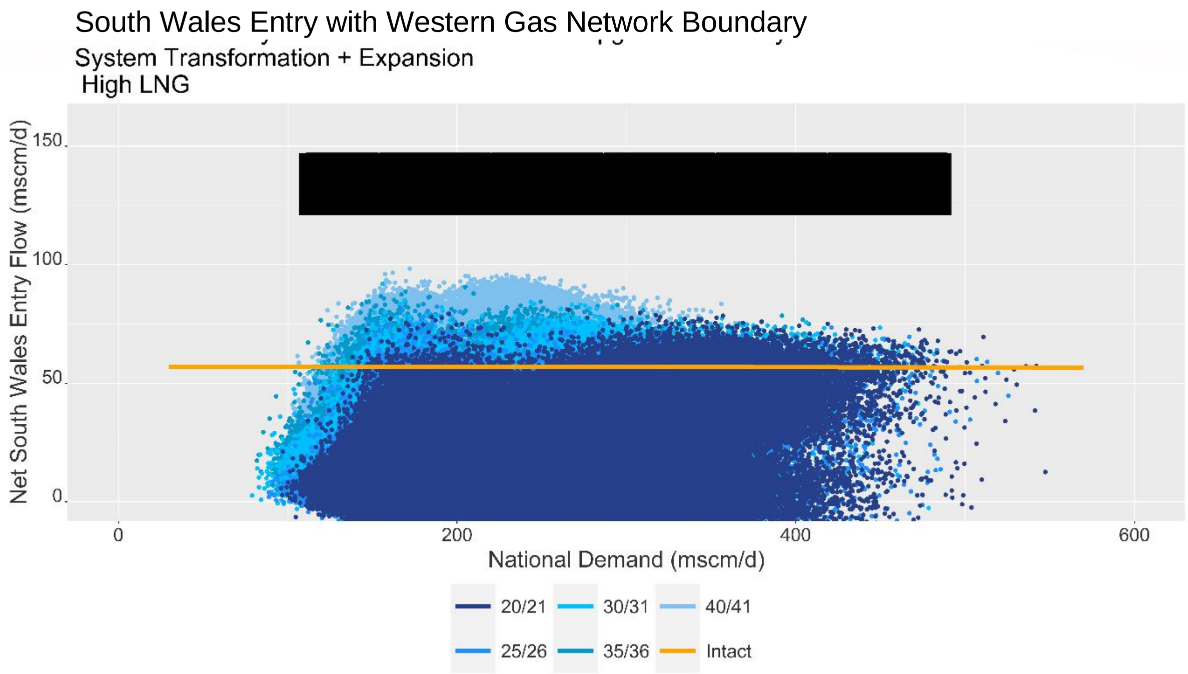

Figure 11: Network entry capability at Milford Haven (System Transformation 2020 plus expansion)

82. Figures 12 and 13 illustrate the two scenarios where a large reduction in gas demand is expected by 2050. Demand is still significant in 2040, but due to the reduced demand compared to the present day, the expected number of constraint days per year is reduced to [redacted] for CT and [redacted] for LTW. In these scenarios there is not the same imperative to make additional asset investments to avoid constraint costs.

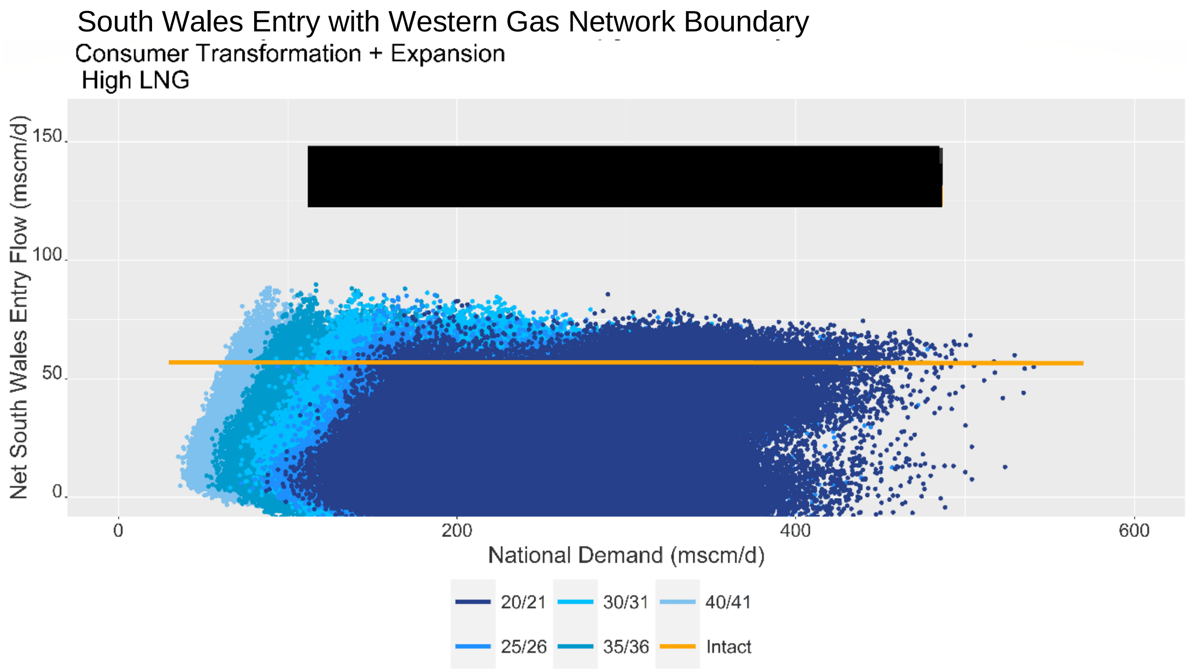

Figure 12: Network entry capability at Milford Haven (Consumer Transformation 2020 plus expansion)

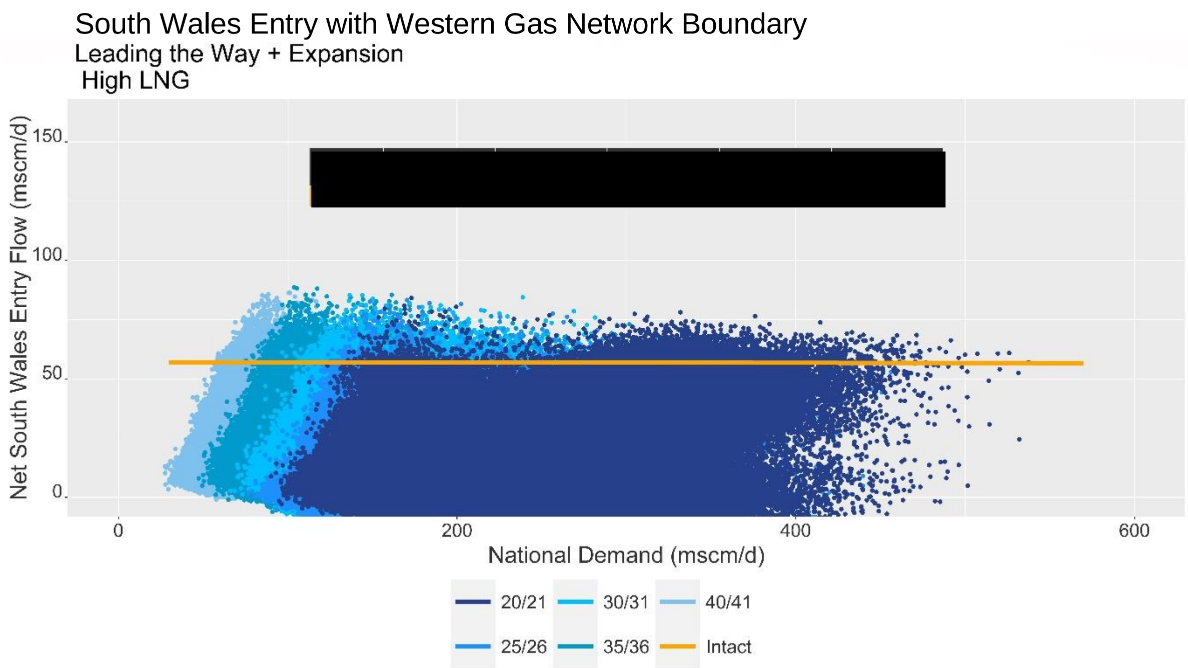

Figure 13: Network entry capability at Milford Haven (Leading The Way 2020 plus expansion)

83. Since it is uncertain exactly which scenario pathway will materialise, consideration needs to be given to the investment strategy. Investing to avoid excessive constraint costs in some scenarios may mean that investment exceeds that which may actually be required, if the scenario that transpires sees a much lower level of constraint. Where there is uncertainty, alternative strategies can be used, only investing to the minimum requirement and selecting options that facilitate additional investment in the future when necessary.

WGN Future Requirements Summary

84. There are Future Requirements both in the short and long term, which are subject to uncertainty, and the uncertainty increases over time out to the 2050 net zero target.

85. In the short to medium term National Grid are required to provide for the capacity increase reserved by the PARCA for SHGCL. LNG supplies to the UK have increased in recent years, with 19.4 bcm and 16 bcm delivered during 2019/20 and 2020/21 respectively, up from an average of ~12 bcm/y since 2009. There is a high degree of certainty in the short to medium term that LNG imports via Milford Haven will continue to increase, both in terms of frequency of LNG deliveries and in the instantaneous LNG flows delivered onto the NTS. Based on this, there is a requirement for investment to increase the LNG import capability at Milford Haven.

86. In the longer term, out to 2050, there is uncertainty arising from the actual pathway followed by the UK in pursuit of the 2050 net zero target. Therefore, there is a need to invest to meet the short-term requirement whist allowing for long term uncertainty. There is advantage in terms of consumer value, to be gained from making minimum investment in the short term to facilitate increased entry capability and the avoidance of excessive constraint costs, but to ensure this investment is both kept to a minimum and will allow (or not preclude or lead to adverse efficiency of any) future investment, where the case arises that high LNG importation scenarios continue towards 2050.

Project Scope Summary

87. The project being progressed has been identified following a comprehensive evaluation process of options capable of meeting the PARCA. The option identified as F6.6e is the optimum solution to meet the needs of the PARCA in an economic and efficient manner at least cost to UK consumers, and consists of the following with further detail set out in Table 9:

I. Pressure uprating of part of the existing Feeder 28 pipeline between Felindre and Three Cocks which also includes the section Felindre to Cilfrew;

II. 9km of new pipeline between Wormington and Honeybourne and 2km of new pipeline between Churchover Compressor and Churchover Multijunction; and

III. Related works at several existing Above Ground Installations (AGIs) and compressor stations to facilitate the pressure uprating, connection of new pipelines and effective compression at existing stations.

New Pipeline – Wormington to Honeybourne	
Start Point	Wormington Multijunction
End Point	Honeybourne Multijunction
Design Pressure	75 Barg
Design Capacity	45 Million Standard Cubic Metres/Day
Expected materials of construction	API 5L X65 / ISO 3183 L450 Steel

New Pipeline – Churchover Compressor to Churchover Multijunction	
Start Point	Churchover Compressor Station/ Compressor Tee
End Point	Churchover Multijunction
Design Pressure	70 Barg
Design Capacity	42 Million Standard Cubic Metres/Day
Expected materials of construction	API 5L X65 / ISO 3183 L450 Steel

Pressure Uprating (Feeder 28) and other Associated Works	
Start Point	Felindre Compressor Station and Multijunction
End Point	Three Cocks Above Ground Installation and Cilfrew Pressure Reduction Station
Design Pressure	102 Barg
Associated Works	Modifications to Wormington and Felindre Compressor Stations, Churchover Tee and Multijunction, Honeybourne AGI, Felindre Multijunction, Cilfrew Pressure Reduction Station, Alltwern Compressor Recycle Facility, Llanwrda Block Valve, Three Cocks Above Ground Installation and Tirley Pressure Reduction Station

Table 9: Project Scope Summary Tables

88. The spreadsheet provided in Appendix VI summarises the physical and operational changes we are making to the NTS under this project, with a focus on explaining why and how we are addressing the specific challenges presented by the sites and areas of the network relevant to the project. The appendix also includes the evidence base for changes and why they are preferable to the alternatives.

6. Options Considered & 7. Business Case Outline and Discussion

Introduction

89. As highlighted throughout the report, the WGN project has passed through a number of stages of the PARCA process, aligned to our internal project governance, as well as multiple publications of the FES.

90. As a result, we are presenting chapters 6 and 7 (Options Considered, Business Case Outline and Discussion) as a consolidated section, that takes a chronological approach to the strategic optioneering and analysis undertaken since the project entered Phase 2 of the PARCA.

91. The key stages of the process leading up to this FIOC Need Case Submission to be covered in this section are categorised as:

I. Option identification

- Application of technical and benefit filters that leads to the shortlist

II. Shortlist Options Analysis

- Leading to the preferred option for the SOR (SOR based on FES 2019 data, has since been updated to reflect FES 2020)
- Descriptions and rationale
- Capability Analysis
- Assessment and CBA

III. Preferred option refinement with FES 2020 data

- Variations of preferred option
- Capability Analysis
- Assessment and CBA

Cost Estimate Ranges

92. Several cost estimates have been developed to inform different stages of decision making on the WGN project, each responding to additional detail in terms of scope, technical insight or route siting. These are summarised in Table 10 as follows:

Estimate Purpose	Expected accuracy	Description
Strategic Option Selection	+/-50%	High level cost estimate derived from broad unit costs on a like for like basis
Strategic Option Refinement	+30/-20%	eHub estimate derived from unit costs, early engagement with suppliers and cost/time/resource estimates
Total installed cost for the preferred (refined) option	+30/-20%	eHub estimate derived from unit costs, early engagement with suppliers and cost/time/resource estimates – for purpose of this document

Table 10: Project cost estimate development

93. As the project has developed, the accuracy of the scope of works and the estimate itself is gradually improving. The current level of cost confidence (+30%/-20%) is consistent with other projects at similar stage and reflect the inherent uncertainties ahead of, for example: further engineering work to finalise the scope of works; detailed design; and the completion of construction contract tendering processes. These costs, which are consistent between options and sub-options, are appropriate to inform the tools for the decision-making processes undertaken. As detailed in the FIOC guidance document, the project direction submission will be based on a finalised scope of works, Detailed Design and Build Main Works Contractor (MWC) tendered prices and order values for long lead items.

94. Appendix V contains detailed breakdowns of option costs at the relevant stages, this has been designed in a format to be used as a reference document alongside the analysis below.

95. Due to the number of different solutions considered, along with variations within similar solutions, options titles have had to be assigned a combination of letters and numbers, rather than scope descriptions.

Strategic Optioneering

96. Initial strategic optioneering was undertaken to support the PARCA Phase 1 process and is summarised within the Project Status and Request Overview. This was designed to identify, after a high-level assessment, the likely viability and means of response to the PARCA.

97. Subsequent to this the PARCA Phase 2 process requires a Strategic Options Report to be completed and was a key focus for the first 12 months of this phase of the project. This process is also important to support the acquiring of relevant planning consents and approvals as it provides a robust evidence base to justify the general form of the option being progressed, including potentially through compulsory acquisition of rights to land for construction and operation.

98. Options Appraisal is a robust and transparent process used by National Grid to compare options and to assess the positive and negative effects the options may have across a wide range of criteria including environmental, socio-economic, technical and cost factors. The detail of the approach adopted varies on a case by case basis, to respond efficiently to the specific scale and nature of individual projects, but comprise a staged process of options appraisal.

99. The SOR reports the findings of the first stage of options appraisal and documents the process of investigation, analysis and review that has been undertaken to identify the strategic proposal. The strategic proposal provides the most economic and efficient solution to safely provide the reserved capacity, requested in the competent PARCA from SHGCL, in line with National Grid's various duties, obligations and guiding principles. The guiding principles were developed to provide a consistent basis for defining viable options and to aid their comparison.

100. Figure 14 provides a flow diagram of the strategic optioneering process that has been followed in relation to this project

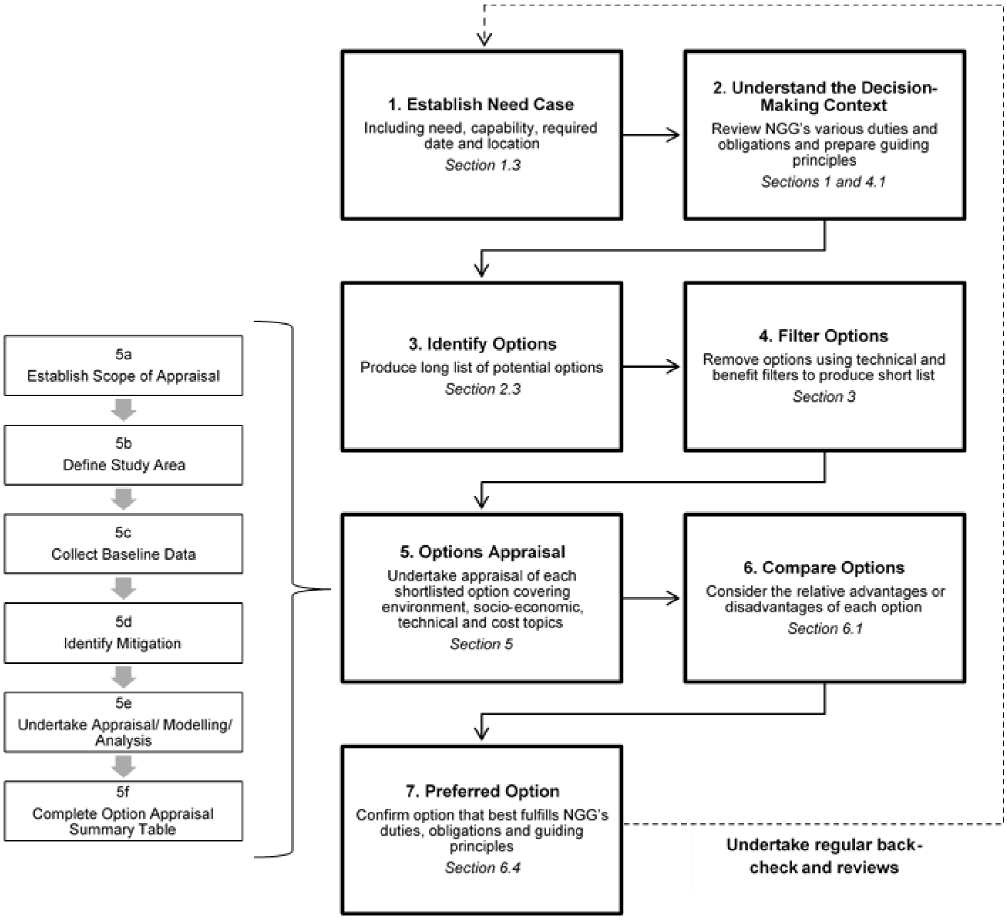

Figure 14: Flow chart outlining Strategic Optioneering Process

101. The SOR was produced which contains the Options Appraisal Summary Tables (OAST), see Appendix IV, and the customer was provided with a non-technical version. Since that time, a new FES has been produced which included scenarios that meet net zero emissions by 2050, leading to a review of the preferred option using the latest scenario, route and cost data.

I. Option Identification

102. The strategic options considered (over 70 were identified) cover a range of commercial, regulatory and physical options aimed at enabling National Grid to accept the requested increase in entry capacity at Milford Haven ASEP. These options are laid out within the SOR (and illustrated in figure 15) and include; different connection points in the UK and elsewhere, on and offshore pipelines alone or in various combinations, short-term storage, alternative transport modes for LNG and various others. The counterfactual option is defined as a management of constraints on the existing network with no network reinforcements and no changes to commercial contracts or regulatory frameworks.

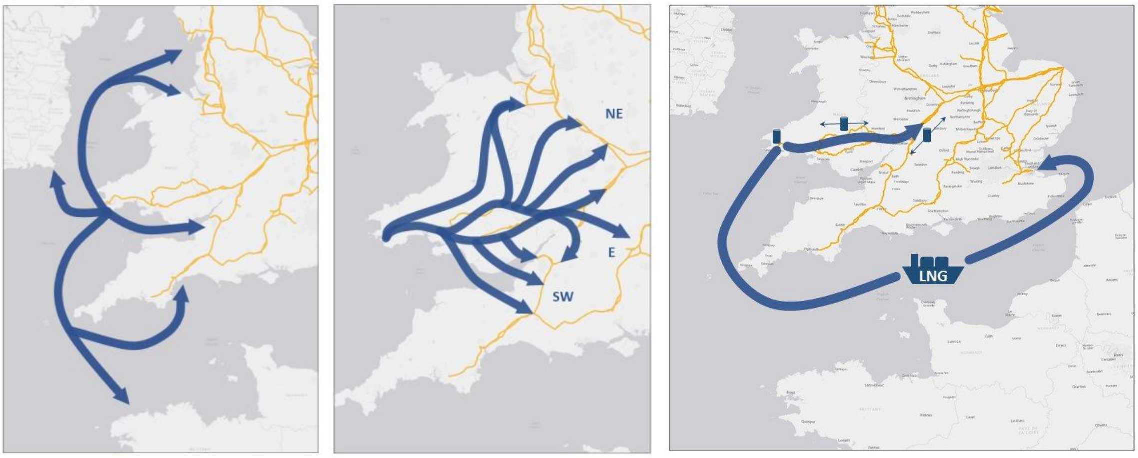

Figure 15: Long list options covered many possibilities, beyond traditional reinforcement options

103. All options were initially passed through Benefit and Technical Filters in order to discount any options which did not merit progression to the Options Appraisal stage. Options were discounted through the technical filter if they did not provide (or did not come close to providing) the required physical network capability or were not technically achievable. Options were discounted through the benefit filter where it was clear that they performed poorly against other options in one or more area (e.g. cost, environmental, or socio-economic effects) without showing any clear benefits in other areas. This process and detail of options discounted is contained within the SOR and accompanying tables.

104. In general terms, the physical reinforcement routes that were discounted involved creating extensive new pipeline routes to bypass the existing bottlenecked routes and connect directly to areas of demand or high connectivity; or substantial duplication of existing pipelines to the south of Wormington. The length of the routes versus additional capability they would provide was not found to be comparable with the shortlisted options. The cost and other challenges associated with long pipeline routes, in some cases crossing large bodies of water and AONBs were amongst reasons for ruling out these routes.

II. Shortlist Options Summary

105. A shortlist of 11 options remained after the benefit and technical filters were applied. Figure 16 shows a visual representation of the network reinforcements which the shortlisted options comprise. Each option contains a subset of these common elements as detailed in the next section.

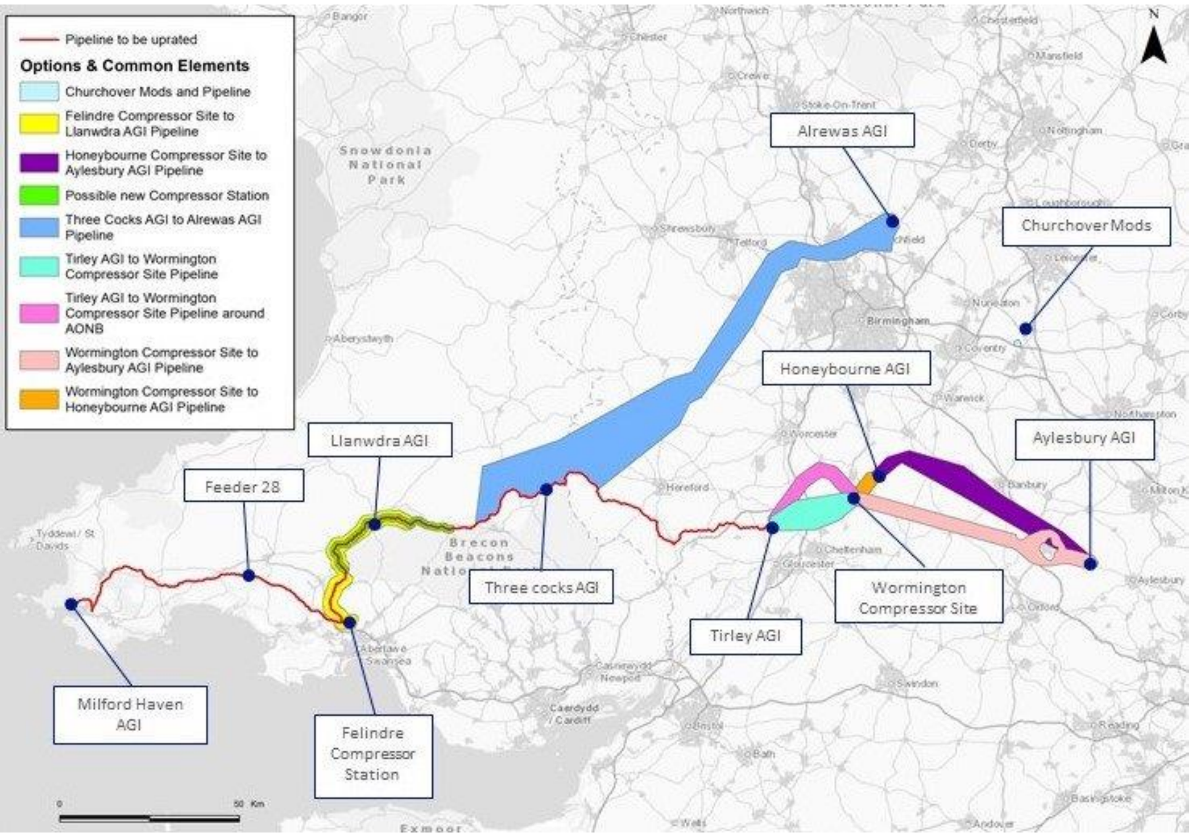

Figure 16: Common Elements Contained within Shortlisted Options

106. The shortlist options contain a range of reinforcements including new compression, new pipeline and pressure uprating. The potential value of pressure uprating has been explored in relation to all feeders along the existing routes from Milford Haven, through Wormington and onward to Churchover, Peterborough and Alrewas, and to the southwest. Technical limitation and comparison with other possible reinforcements yielded the outcome that only in the case of Feeder 28 would uprating the Maximum Operating Pressure (MOP) provide significant benefit at relatively low cost, compared with the alternative of new pipeline or compressor builds.

107. A high-level summary of all options progressed to Options Appraisal is shown in Table 11. The counterfactual option was discounted for reasons discussed in the earlier Future Requirements section of this document. All other options discounted prior to Options Appraisal are listed in the supporting documentation for the SOR.

Table 11: List of Options Progressed to Options Appraisal

Option Ref	Option short name	New pipeline (km)	Pressure uprating	New compressor site	Modifications to existing compression	Extension to existing AGI	New AGI	Total Installed Cost (£m)	Notes
F3.1	New compression between Felindre and Llanwdra AGI with ~37km of new pipeline	37	N	Y	Y	Y	Y	[redacted]	Pipeline from Tirley to Wormington compressor site (of which ~3km is within the Cotswolds AONB), Wormington compressor site to Honeybourne AGI and between Churchover multijunction and compressor sites
F3.2	New compression between Felindre and Llanwdra AGI with ~44km of new pipeline	44	N	Y	Y	Y	Y	[redacted]	Pipeline as F3.1 but with a route between Tirley and Wormington outside the Cotswolds AONB
F3.3	New compression in the vicinity of Three Cocks AGI with ~11km of new pipeline	11	N	Y	Y	Y	N	[redacted]	Pipeline from Wormington compressor site to Honeybourne AGI and between Churchover multijunction and compressor sites
F4.1	New pipeline of ~92km	92	N	N	Y	Y	Y	[redacted]	Pipeline as F3.1 plus ~55km from Felindre towards Llanwdra
F4.2	New pipeline of ~99km	99	N	N	Y	Y	Y	[redacted]	Pipeline as F3.2 (a route outside the Cotswolds AONB) plus ~55km from Felindre towards Llanwdra
F6.1	Uprating below MOP limit from Milford Haven to Three Cocks with ~37km new pipeline	37	Y	N	Y	Y	Y	[redacted]	Pipeline as F3.1
F6.2	Uprating below MOP limit from Milford Haven to Three Cocks with ~44km new pipeline	44	Y	N	Y	Y	Y	[redacted]	Pipeline as F3.2
F6.6	Uprating below MOP limit from Milford Haven to Three Cocks with ~11km new pipeline	11	Y	N	Y	Y	N	[redacted]	Pipeline as F3.3
F7.1	New ~125km pipeline from Three Cocks area to Alrewas	125	N	N	Y	Y	Y	[redacted]	Pipeline from the Three Cocks area to Alrewas routeing to the west of Birmingham
G1.1	New pipeline of ~95km from Tirley to Aylesbury via Wormington	95	N	N	Y	Y	Y	[redacted]	Pipeline from Tirley to Wormington compressor site and on to Aylesbury AGI with a minimum of ~16km through the Cotswolds AONB
G1.3	New pipeline of ~104km from Tirley to Aylesbury via Honeybourne	104	N	N	Y	Y	Y	[redacted]	Pipeline from Tirley to Honeybourne AGI and on to Aylesbury AGI with a minimum of ~5km in the Cotswolds AONB

Shortlisted Option Descriptions and Rationale

108. Eleven strategic options were shortlisted for Options Appraisal, as summarised in Table 11. Of these, the following options are all based on an initial reinforcement of the existing network between Wormington and Churchover by means of a new 9km pipeline between Wormington and Honeybourne and a 2km new pipeline in the Churchover area, to address the primary bottlenecks restricting flows between Wales and the West Midlands. For all of these options these reinforcements must first be in place in order realise the value of any further investments.

Option F3.1

New compression (Llanwrda area) with 37km of new pipeline

109. This option addresses the limitation in flow capability between Milford Haven and Wormington by increasing the compression available in Wales. This is achieved via the installation of a new compressor station near the existing installation at Llanwrda, and by removing the bottleneck caused by smaller diameter downstream pipework between Tirley and Wormington, by means of installing an additional 26km pipeline along this route plus the 11km of new pipelines between Wormington and Honeybourne and at Churchover.

Option F3.2

New compression with 44km of new pipeline avoiding the Cotswolds Area of Outstanding Natural Beauty (AONB)

110. This is a variation on Option F3.1, involving a 7km longer pipeline between Tirley and Wormington, to avoid the AONB

Option F3.3

New compression (at or within 20km to the west of Three Cocks AGI) with 11km of new pipeline

111. This option is similar to F3.3 but there is no pipe reinforcement west of Wormington, so the new compressor station is sited further east (than in F3.1) in order to offset the effect of the main remaining bottleneck between Tirley and Wormington.

Option F4.1

A total of around 92km of new pipeline

112. The strategy with this option is to directly resolve flow constraints by means of new pipeline build, following the existing network paths. Along with the 11km of new pipelines between Wormington and Honeybourne and at Churchover, this includes 26km of new pipeline between Tirley and Wormington to address the most concentrated area of constraint and adds to this a pipeline running from Felindre for a distance of 55km to help reduce pressure loss on the long (~200km) route to Tirley. The reinforcement is most effective at the Felindre end as it allows the compressor to work more effectively.

Option F4.2

A total of 99km of new pipeline of which 55km is in addition to Feeder 28 from Felindre with other new pipeline avoiding the Cotswolds AONB

113. This is a variation on Option F4.1, involving a 7km longer pipeline between Tirley and Wormington, to avoid the AONB

Option F6.1

Uprating with MOP below equipment classification limits of Feeder 28 with 37km of new pipeline

114. This option relies on new pipeline build (set out for F3.1) to address the flow constraint between Tirley and Wormington, but in place of the new compression used in F3.1, it enables higher flows and downstream pressure by means of uprating the maximum operating pressure of the existing Feeder 28 pipeline from Milford Haven to Three Cocks (around 300km). This means when necessary gas is pushed through the network at a higher initial pressure at Milford Haven and at Felindre, enabling higher flow and offsetting downstream losses

Option F6.2

Uprating with MOP below equipment classification limits of Feeder 28 with 44km of new pipeline avoiding the Cotswolds AONB

115. This is a variation on Option F6.1, involving a 7Km longer pipeline between Tirley and Wormington, to avoid the AONB

Option F6.6

Uprating with MOP below equipment classification limits of Feeder 28 with 11km of new pipeline

116. This option comprises a reduction to the scope of F6.1, involving the same uprating of the maximum operating pressure of Feeder 28 pipeline and AGIs, but without the 26km of new pipeline build between Tirley and Wormington.

117. The following options omit reinforcement between Wormington and Churchover, instead bypassing this area of constraint by creating new routes to centres of demand and connectivity on the NTS:

Option F7.1

New 125km pipeline to Alrewas

118. Focussed on bypassing both of the principle areas of existing constraint, west and east of Wormington, this option creates a major new flowpath into the Midlands by means of a 125km new pipeline to Alrewas, which is a major junction point on the NTS with existing compression capability. This strategy relieves existing constraints in the West Midlands by dividing the high flows between two major routes. From Alrewas the gas can take any of four onward routes. The new pipeline connects to Feeder 28 at Three Cocks to create the shortest straight-line route.

Option G1.1

New 95km pipeline Wormington to Aylesbury

119. This option is based around a new pipeline route that takes a substantial proportion of Milford Haven flow directly into centres of demand in the south east of England, thereby greatly alleviating bottlenecks in the West Midlands and providing an efficient means of moving gas towards the areas of highest demand. To address flow constraints west of Wormington, 26km new pipeline from Tirley is included as for a number of other options. For this option the connection to Aylesbury AGI is made from Wormington which, whilst providing for a shorter connection route includes a substantial length through an area designated as an AONB.

Option G1.3

New 106km pipeline Honeybourne to Aylesbury

120. The option follows a similar strategy to G1.1, but the new pipeline from Wormington also provides interconnection with other feeders at Honeybourne from where the connection to Aylesbury is made. This facilitates an onward connection to Aylesbury that requires a shorter section of pipeline through areas designated as AONB albeit by a longer overall route than Option G1.1.

Rationale for the Options

121. Most of the shortlisted options are shown to be effective at resolving or offsetting the effect of areas of lower flow capacity on the NTS (bottlenecks). The primary bottleneck is found where capacity is limited to two 600mm connections along relatively short sections of the route between Wormington and Churchover. Once this is resolved, a further bottleneck between Tirley and Wormington becomes most significant, and then the overall limitation of capacity between Milford Haven and Tirley requires reinforcement. The bottlenecks are removed with additional pipeline build, or their effect on system pressure is offset by either increasing operating pressures (MOP) or installing additional compression. Site modifications are also used to facilitate higher flow and optimise existing compression.

122. The most viable option for bypassing both the primary area of existing bottleneck (east of Wormington) and the secondary bottleneck immediately to the west of Wormington is also shortlisted (F7.1). This option was largely retained due to the high potential the route offers for additional capability in the event of a continued increase in Milford Haven flows with declining national demand, notably beyond 2035, as shown in some scenarios. The route connects directly into a junction with high connectivity at Alrewas.

123. In principle, pressure uprating along Feeder 28 aims to offset losses in pressure further downstream (notably between Tirley and Wormington where capacity is lower than on Feeder 28), and thus has the effect of replacing the need for duplication of part of this route with additional pipeline or using compression to boost pressure at this point.

Capability Analysis

124. Network modelling was completed in principle for 11 shortlisted options in order to determine the network capability provided by each, using the same supply and demand scenarios, based on 2018 FES TD as were used to assess the existing network capability.

125. In general, the capability of the NTS to accommodate entry flow at Milford Haven depends upon the restrictions to flow through the corridor from Milford Haven, through South Wales and into the Midlands through Wormington and onto Churchover. This means that the capability is highly sensitive to levels of regional demand along the route. For example in higher demand cases, although greater flow can be accommodated at Milford Haven, a substantial proportion of this supply will be absorbed along the route so that onward flows beyond Churchover may be lower than in a low demand scenario. Demand varies seasonally (in line with National Demand), but also across the various FES.

126. For the purposes of comparing the option capability in a CBA, it is necessary to normalise the entry capability in each scenario used, to compare the capability of each option to bring gas into the centre of the network. The most appropriate point at which to define the South Wales Entry boundary is Churchover compressor, since this is the point at which the main flows diverge to other regions. Churchover boundary was assessed for each option, across three supply and demand scenarios.

127. It should be noted that where there are variants of options routeing pipeline through or around AONBs (which require slightly longer lengths of new pipeline) one set of modelling results was assumed, as from modelling experience the difference in capability would be negligible. This case applies to variations between F4.1/F4.2, F6.1/ F6.2, and G1.1/G1.3.

128. The modelled boundary capability of each option is represented on Figure 17 below.

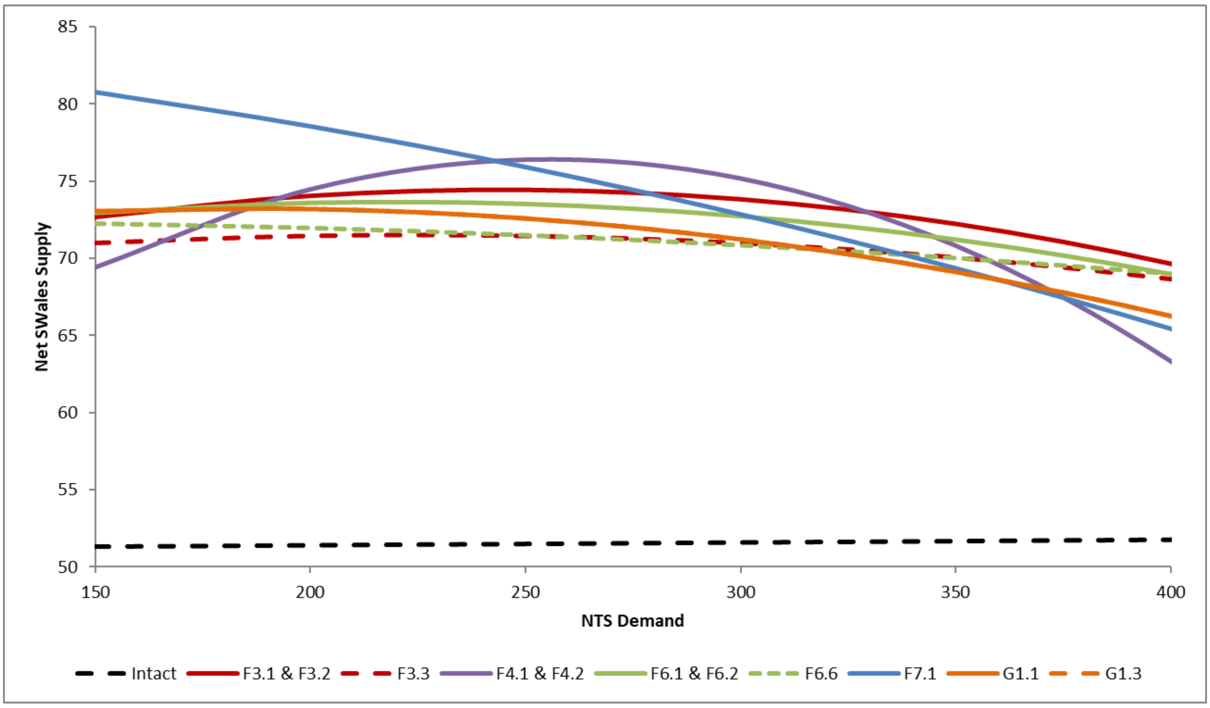

Figure 17: Strategic Option Boundary Capability

Discussion of Option Capability

Options containing Wormington to Churchover Reinforcements

129. All options based upon reinforcing parts of the route between Wormington and Churchover show a substantial increase in capability by virtue of effectively resolving an inconsistency in pipe capacity along this route. The current network relies on two 600mm diameter feeders in both Wormington and Honeybourne areas, whereas the 900mm Feeder 23 between Honeybourne and Churchover Tee creates much greater flow capability across this section of the route. The primary reinforcements contained in these options address this by means of adding extensions to Feeder 23 as follows:

- 9km section between Wormington and Honeybourne
- 2km section between Churchover Compressor Tee and Churchover Multijunction

130. The modelling has shown that these reinforcements are very effective in increasing capability across all supply and demand scenarios. The strategy is particularly effective in low demand scenarios typical of the summer period. In these scenarios, a high proportion of Milford Haven entry flow makes its way from Wormington to Churchover and hence relieving the bottleneck here is especially advantageous, with in excess of [redacted] mscm/d additional capability possible.

131. As stated previously, these reinforcements are primary to other elements within these options. The further reinforcements, differing between options, are shown to be ineffective until the Wormington to Churchover route has been reinforced, since Wormington compressor is achieving the maximum rated pressure of the downstream pipework, effectively pushing against the bottleneck. Once this is resolved the limitation to further flows shifts to the west of Wormington, where feeder capacity is initially lower, and to the challenge of flowing large volumes through the very long Feeder 28 route.

132. For all options except **Option F7.1,** reinforcements are made to the existing route between Milford Haven and Wormington. In general, these reinforcements are effective across the demand range, but particularly so at higher demands, since in this case the flows are initially higher to the west, feeding large demands into South Wales in particular.

133. As shown on the chart (Figure 17), of the options involving major new infrastructure in this area, **Options F3.1 / F3.2** achieve the least capability. The limitation of the existing maximum operating pressure of the Feeder 28 (94 Barg), and then the reduction to 75 Barg at Tirley prevents full value being realised from additional compression alone along the route to Wormington. The compression must be quite close to the existing station at Felindre as otherwise the effect tends to be limited by an opposing requirement for pressure reduction at Tirley.

134. The addition of a new pipeline from Tirley to Wormington (**Option F3.3)** substantially enhances capability across the range. This effectively removes the large pressure drop from Tirley onwards and allows new compression to work more effectively and more equidistantly between the existing stations.

135. **Option F4.1 / F4.2,** using 55km of new pipeline from Felindre, in addition to the Tirley to Wormington reinforcement, is more effective than the new compression options at most demands. It has the advantage that it directly eases the network restriction in Wales rather than requiring the energy input of additional compression to overcome loss of pressure. This solution also avoids conflict with the downstream pressure boundary at Tirley.

136. **Option F6.6** provides a level of capability similar to that of compression option F3.1, but without requiring major new infrastructure west of Wormington. This achieves the benefit instead by allowing the initial entry pressure at Milford Haven and the discharge pressure at Felindre to be raised above the existing MOP limitation to offset pressure losses downstream. Since the pressure is raised at these points on the NTS there is no conflict with the pressure boundary at Tirley. Protection measures may be required to ensure that a new 102 Barg to 94 Barg pressure boundary at Three Cocks is maintained but these are unlikely to require major investment.

137. **Options F6.1 / F6.2** achieve a significant increase over F6.6 at most demand levels as would be expected with the additional pipe reinforcement. At the highest demands the incremental benefit is reduced as lower net flows into England tend to mean the bottleneck effect between Tirley and Wormington is less pronounced.

Options Creating new Routes (bypassing Wormington or Churchover)

138. **Option G1.1 /G1.3** resolves the bottleneck east of Wormington by creating a new route into a centre of high demand (the south east via Steppingley junction). Together with a pipeline reinforcement west of Wormington, this facilitates a capability increase at low demands which is comparable with other options. However, the results show that the potential for increasing capability through maximising reinforcements to the east is limited, this option requiring additional reinforcements in Wales in order to match the higher demand capability of other options. In capability terms, it is an option with overinvestment in England and underinvestment in Wales.

139. **Option F7.1** provides much greater capability than other options in low demand scenarios, as shown on the chart, by creating a completely new route into the centre of the network at Alrewas. However, despite being the most extensive option on the shortlist, this strategy would require further additional reinforcements to achieve a similar benefit at higher demands, since the option leaves the flow capacity along the 200km route from Milford Haven to Three Cocks unchanged. There may also be substantial routeing challenges with this option on the approach to Alrewas, as a result of various environmental designations and urban areas constraining routeing opportunities.

Cost Benefit analysis of shortlist options

140. Cost benefit analysis was completed to inform decision making, to ensure consideration of the different benefits that each option provides to UK consumers, reflecting that different options reduce likely future constraint costs by different amounts. The constraints were calculated based on supply and demand from FES 2020 (whilst initial CBA was completed on earlier FES data a backcheck was undertaken using the most up to date FES 2020 data). The options were assessed against all four scenarios, Steady Progression, Consumer Transformation, Leading the Way and System Transformation. Given the large degree of uncertainty in the UK's future energy landscape it was critical to understand how the options performed against each of these scenarios.

141. Capital cost estimates were derived from estimated route lengths (with costs adjusted in line with paragraph 3.3.2 of the SOR), equipment quantities and generic unit costs. Capital costs were refined as part of the iterative refinement of options to ensure comparison is made on a fair basis. Operational costs are incorporated within the CBA.

142. Figure 18 shows the breakdown of the costs included in the CBA. These are detailed further in Appendix V: Optioneering Cost Breakdowns. Appendix V has been designed to be used as a reference document for the detailed costs that have informed the analysis throughout this section, rather than break up the assessment narrative. As would be expected the lowest cost option is the counterfactual, as this does not involve any investment. The highest cost option is F7.1 new pipeline from Three Cocks to Alrewas.

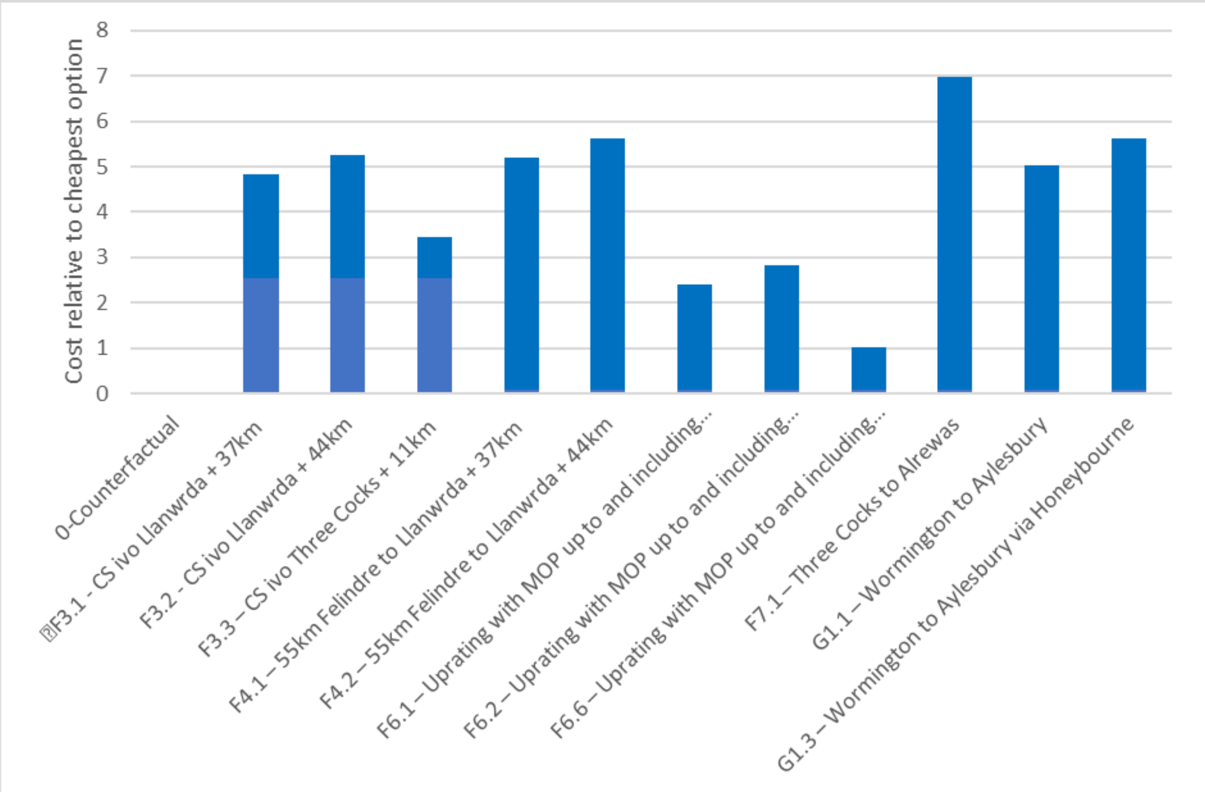

Figure 18: Costs included in the CBA

143. The CBA assessed the benefits which may accrue over the first 25 years of the asset's lifetime from the capability provided by an option. This calculates the benefits from 2025 – 2050. Whilst capability would still be provided after this date, this is beyond the range of the FES, so estimating supply and demand patterns would carry a very large range of uncertainty.

144. As can be seen in Figure 19 there is a wide range of constraints across the options. This is driven by increasing LNG flows combined with falling demands in South Wales, especially during the later years, these flow patterns are covered in more detail in the Future Requirements section.

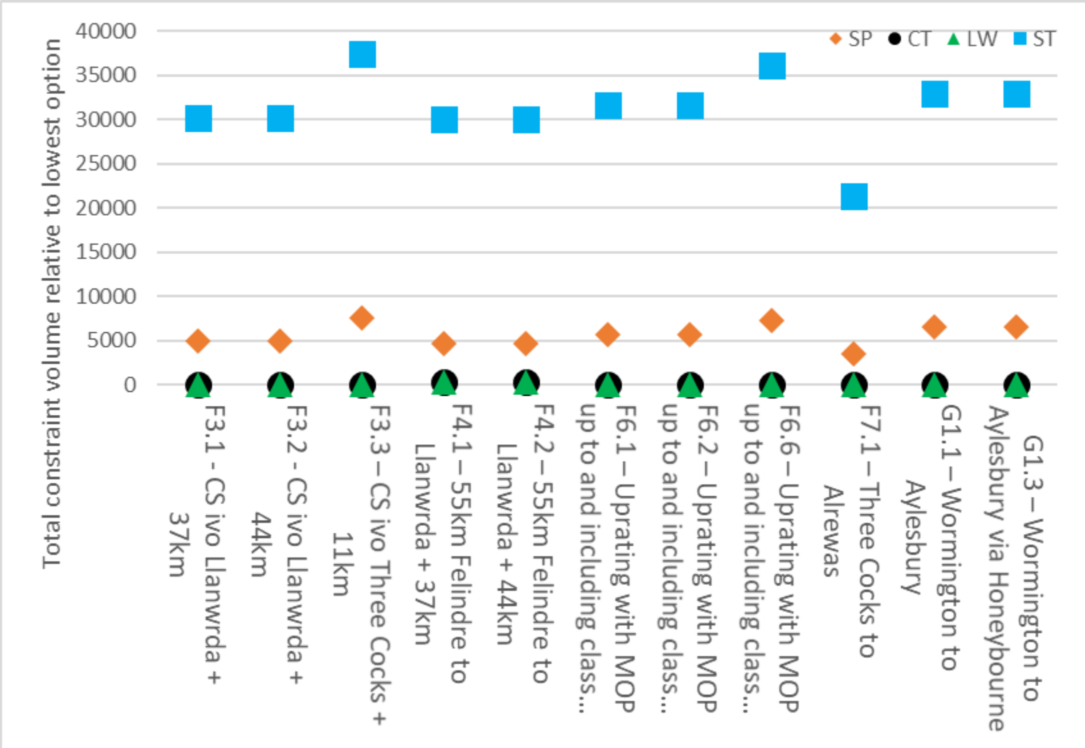

Figure 19: Total range of constraints to 2050

145. The constraints vary significantly across the scenarios and increase significantly towards the end of the period in both Steady Progression and System Transformation scenarios. This is illustrated below in Figure 20, which shows the total constraints for option 0 (no investment), this is indicative of when the constraints occur in the scenarios but will vary in each option dependant on the capability.

[redacted]

Figure 20: Annual Constraints by Year and Scenario (Option 0)

CBA Sensitivities and Key Assumptions

146. All of the options have been tested against all four scenarios from FES 2020. In addition, the probabilistic modelling considers High LNG and High Continent supply cases, which is achieved by an assumption that all of the 'generic imports' defined in the FES come from either LNG or the Interconnectors. Each case is given a 50% weighting in the scenarios.

147. To ensure these constraints in the later years, which are subject to considerable uncertainty, do not unduly influence the option selection, we carried out a sensitivity test where constraints which occur after 2035 were not included in the assessment. This allows us to evaluate how the options perform in the first ten years of operation, during which time it may be possible to expand the selected option to increase the capability if required. This approach avoids the risk of overinvestment whilst retaining flexibility to respond as uncertainty reduces.

148. The key assumptions are detailed in Table 12 below. We have applied sensitivities to the assumptions which could have an impact on the investment decision to test what would need to change for another decision to be favoured.

	Assumption	Base Assumption	Rationale	Sensitivities Considered	Sensitivity Outcome
CBA parameters	WACC	2.81%	Defined in RIIO-2	N/A	
	Social Time Preference Rate	3.5% (Years 0 – 30) / 3.0 % (30+)	Defined in Green Book	N/A	
	Regulated Asset Life	45 years	Defined in RIIO-2	N/A	
	Assessment Period	25 years from installation.	Consistent with RIIO-2 investments / Duration of FES scenarios	Until 2035, tests investment performance over first 10 years	F6.6 favoured in all scenarios
	Depreciation	SOYD	Defined in RIIO-2	N/A	
	Capitalisation	75%	Defined in RIIO-2	N/A	
Investment Costs	Investment Costs	Detailed in Appendix V: Optioneering Cost Breakdowns	Detailed in Appendix V: Optioneering Cost Breakdowns	+200%/-50%	Lead option does not change when constraints stop in 2035
Operating Costs	Supply/Demand Scenario	FES2020 – All Scenarios	Wide range of uncertainty, all scenarios given equal weight	N/A	
	Constraint management method	50% buy backs / 50% locational actions	Reflective of tools available to manage constraints.	N/A	
	Constraint Costs	BEIS Reference scenario	As defined by Commercial Constraint Price Methodology	+200%/-50%	Lead option does not change when constraints stop in 2035

Table 12: CBA Key Assumptions

149. The absolute and relative NPVs against all four scenarios can be seen in Tables 13 and 14 below. When the options are compared against all four scenarios several options appear to be favourable. In both Consumer Transformation and Leading the Way option *F6.6 – Uprating with MOP up to class limits + 11km* is the lead option. In System Transformation *F7.1 – Three Cocks to Alrewas* becomes the lead option. In Steady Progression *F6.1 - Uprating with MOP up to class limits + 37km* is the lead option. It is pertinent to note that the entirety of the works within option F6.6 form part of the requirement for works in option F6.1.

Option	Steady Progression	Consumer Transformation	Leading the Way	System Transformation
0-Counterfactual	[redacted]	[redacted]	[redacted]	[redacted]
F3.1 - CS near Llanwrda + 37km	[redacted]	[redacted]	[redacted]	[redacted]
F3.2 - CS near Llanwrda + 44km	[redacted]	[redacted]	[redacted]	[redacted]
F3.3 – CS near Three Cocks + 11km	[redacted]	[redacted]	[redacted]	[redacted]
F4.1 – 55km Felindre to Llanwrda + 37km	[redacted]	[redacted]	[redacted]	[redacted]
F4.2 – 55km Felindre to Llanwrda + 44km	[redacted]	[redacted]	[redacted]	[redacted]
F6.1 – Uprating with MOP up to and including class limit + 37km	[redacted]	[redacted]	[redacted]	[redacted]
F6.2 – Uprating with MOP up to and including class limit + 44km	[redacted]	[redacted]	[redacted]	[redacted]
F6.6 – Uprating with MOP up to and including class limit + 11km	[redacted]	[redacted]	[redacted]	[redacted]
F7.1 – Three Cocks to Alrewas	[redacted]	[redacted]	[redacted]	[redacted]
G1.1 – Wormington to Aylesbury	[redacted]	[redacted]	[redacted]	[redacted]
G1.3 – Wormington to Aylesbury via Honeybourne	[redacted]	[redacted]	[redacted]	[redacted]

Table 13: Absolute NPV against four FES 2020 scenarios

Option	Steady Progression	Consumer Transformation	Leading the Way	System Transformation
0-Counterfactual	£0 m	£0 m	£0 m	£0 m
F3.1 - CS near Llanwrda + 37km	£4945 m	£376 m	£31 m	£6138 m
F3.2 - CS near Llanwrda + 44km	£4919 m	£350 m	£5 m	£6112 m
F3.3 – CS near Three Cocks + 11km	£4820 m	£462 m	£118 m	£5740 m
F4.1 – 55km Felindre to Llanwrda + 37km	£4939 m	£301 m	-£51 m	£6088 m
F4.2 – 55km Felindre to Llanwrda + 44km	£4912 m	£275 m	-£77 m	£6062 m
F6.1 – Uprating with MOP up to and including class limit + 37km	£5040 m	£529 m	£184 m	£6203 m
F6.2 – Uprating with MOP up to and including class limit + 44km	£5013 m	£502 m	£157 m	£6176 m
F6.6 – Uprating with MOP up to and including class limit + 11km	£4988 m	£616 m	£272 m	£5990 m
F7.1 – Three Cocks to Alrewas	£4884 m	£244 m	-£103 m	£6578 m
G1.1 – Wormington to Aylesbury	£4796 m	£363 m	£18 m	£5955 m
G1.3 – Wormington to Aylesbury via Honeybourne	£4758 m	£326 m	-£19 m	£5917 m

Table 14: Relative NPV against four FES2020 scenarios

150. To test the nearer term impact of the options, CBA was run with no constraints after 2035. This shows how the options perform over the first ten years, at this stage it may then be possible to expand an option if this is required by the level of flows. The absolute and relative NPVs without these post 2035 constraints can be seen in Tables 15 and 16 below. When only constraints up to 2035 are considered, the lead option in all four scenarios is *F6.6 – Uprating with MOP up to class limit + 11km*.

Option	Steady Progression	Consumer Transformation	Leading the Way	System Transformation
0-Counterfactual	[redacted]	[redacted]	[redacted]	[redacted]
F3.1 - CS near Llanwrda + 37km	[redacted]	[redacted]	[redacted]	[redacted]
F3.2 - CS near Llanwrda + 44km	[redacted]	[redacted]	[redacted]	[redacted]
F3.3 – CS near Three Cocks + 11km	[redacted]	[redacted]	[redacted]	[redacted]
F4.1 – 55km Felindre to Llanwrda + 37km	[redacted]	[redacted]	[redacted]	[redacted]
F4.2 – 55km Felindre to Llanwrda + 44km	[redacted]	[redacted]	[redacted]	[redacted]
F6.1 – Uprating with MOP up to and including class limit + 37km	[redacted]	[redacted]	[redacted]	[redacted]
F6.2 – Uprating with MOP up to and including class limit + 44km	[redacted]	[redacted]	[redacted]	[redacted]
F6.6 – Uprating with MOP up to and including class limit + 11km	[redacted]	[redacted]	[redacted]	[redacted]
F7.1 – Three Cocks to Alrewas	[redacted]	[redacted]	[redacted]	[redacted]
G1.1 – Wormington to Aylesbury	[redacted]	[redacted]	[redacted]	[redacted]
G1.3 – Wormington to Aylesbury via Honeybourne	[redacted]	[redacted]	[redacted]	[redacted]

Table 15: Absolute NPV, no constraints post 2035

Option	Steady Progression	Consumer Transformation	Leading the Way	System Transformation
0-Counterfactual	£0 m	£0 m	£0 m	£0 m
F3.1 - CS near Llanwrda + 37km	£1036 m	£191 m	-£111 m	£67 m
F3.2 - CS near Llanwrda + 44km	£1009 m	£164 m	-£138 m	£40 m
F3.3 – CS near Three Cocks + 11km	£1099 m	£276 m	-£24 m	£153 m
F4.1 – 55km Felindre to Llanwrda + 37km	£1005 m	£154 m	-£146 m	£38 m
F4.2 – 55km Felindre to Llanwrda + 44km	£978 m	£127 m	-£173 m	£11 m
F6.1 – Uprating with MOP up to and including class limit + 37km	£1178 m	£340 m	£38 m	£215 m
F6.2 – Uprating with MOP up to and including class limit + 44km	£1151 m	£313 m	£11 m	£189 m
F6.6 – Uprating with MOP up to and including class limit + 11km	£1248 m	£426 m	£125 m	£302 m
F7.1 – Three Cocks to Alrewas	£891 m	£53 m	-£250 m	-£73 m
G1.1 – Wormington to Aylesbury	£999 m	£174 m	-£127 m	£49 m
G1.3 – Wormington to Aylesbury via Honeybourne	£962 m	£136 m	-£165 m	£12 m

Table 16: Relative NPV, no constraints post 2035

151. To test how the results could be impacted by increases or decreases in the investment costs we ran a sensitivity where costs were increased by 200% for all options, and a sensitivity where costs decreased by 50% for all options. Neither sensitivity resulted in a significant change in the order of the options with option *F6.6 – Uprating with MOP up to class limit + 11km* remaining the lead option across all scenarios.

152. To test how the results could be impacted by increases or decreases in the constraint costs we ran a sensitivity where constraint costs were increased by 200% for all options, and a sensitivity where costs decreased by 50% for all options. Neither sensitivity resulted in a significant change in the order of the options with option *F6.6 – Uprating with MOP up to class limit + 11km* remaining the lead option across all scenarios.

153. An example of the results for both sensitivities can be seen in Table 17 below. This illustrates the relative NPVs for the Steady Progression scenario only, comparison with Table 16 shows how the sensitivity impacted each of the options.

Option	SP - Investment Costs @ 200%	SP - Investment Costs @ 50%	SP - Constraint Costs @ 200%	SP - Constraint Costs @ 50%
0-Counterfactual	[redacted]	[redacted]	[redacted]	[redacted]
F3.1 - CS near Llanwrda + 37km	[redacted]	[redacted]	[redacted]	[redacted]
F3.2 - CS near Llanwrda + 44km	[redacted]	[redacted]	[redacted]	[redacted]
F3.3 – CS near Three Cocks + 11km	[redacted]	[redacted]	[redacted]	[redacted]
F4.1 – 55km Felindre to Llanwrda + 37km	[redacted]	[redacted]	[redacted]	[redacted]
F4.2 – 55km Felindre to Llanwrda + 44km	[redacted]	[redacted]	[redacted]	[redacted]
F6.1 – Uprating with MOP up to and including class limit + 37km	[redacted]	[redacted]	[redacted]	[redacted]
F6.2 – Uprating with MOP up to and including class limit + 44km	[redacted]	[redacted]	[redacted]	[redacted]
F6.6 – Uprating with MOP up to and including class limit + 11km	[redacted]	[redacted]	[redacted]	[redacted]
F7.1 – Three Cocks to Alrewas	[redacted]	[redacted]	[redacted]	[redacted]
G1.1 – Wormington to Aylesbury	[redacted]	[redacted]	[redacted]	[redacted]
G1.3 – Wormington to Aylesbury via Honeybourne	[redacted]	[redacted]	[redacted]	[redacted]

Table 17: Additional sensitivities for Steady Progression, constraints up to 2035

CBA Summary

154. Due to the large differences between the scenarios, and particularly as a consequence of the constraints costs increasing exponentially in the later years, the use of the full time horizon as the basis for selecting the strategic option, risks significant over investment. In effect, the level of uncertainty about the level of constraint seems to disproportionately skew the analysis to those options where constraints in the future (where they are very uncertain) are predicted to be highest. As Option F6.1 contains all the elements of F6.6, this creates the opportunity to pursue a modular approach to the investment. By

proceeding with option *F6.6 – Uprating with MOP up to class limit + 11km*, which is the lead option when we consider constraints up to 2035, we retain the option to expand to option F6.1 later if required. By taking this approach we deliver the additional capability required in the short term and retain the option to expand this if required whilst avoiding the risk of over-investment

155. Based on the current scenario projections we would proceed with F6.6 to deliver the additional capability by 2025. In Steady Progression and System Transformation, we would expand this to F6.1 by constructing the additional 26km of pipeline. In Consumer Transformation and Leading the Way, we would not expand the option to F6.1, because the reduction in gas requirements does not trigger the need for the investment in additional pipeline infrastructure (as such the cells have been greyed out in Table 18).

156. The value of this flexibility is demonstrated in Table 18 below, taking this modular approach outperforms the other options in three out of the four scenarios. Selecting option *F7.1 – Three Cocks to Alrewas* would be the best option in the System Transformation scenario, however this would result in a significant over investment in the other three scenarios.

Option	Steady Progression	Consumer Transformation	Leading the Way	System Transformation
F6.6 Uprating + 11km	[redacted]	[redacted]	[redacted]	[redacted]
F6.6 Uprating + 11km / Additional 26 km by 2035	[redacted]			[redacted]
F6.1 Uprating + 37 km	[redacted]	[redacted]	[redacted]	[redacted]
F7.1 – Three Cocks to Alrewas	[redacted]	[redacted]	[redacted]	[redacted]

Table 18: NPV of selected options, relative to F6.6

Overall Appraisal of shortlisted options

157. The options appraisal of the shortlisted options considered a breadth of topics to ensure that decision-making is based on a broad understanding of the implications of National Grid’s projects. It considered:

- environmental (National and regional level biodiversity, landscape and historic constraints and physical aspects such as flooding);
- socio-economic (related to existing property assets);
- technical (complexity, delivery and construction issues, sustainability and network capability);
- capital cost and cost benefit analysis (weighing capital and lifetime costs against reduced system constraint costs).
- Programme and the ability to release capacity on or before the agreed PARCA date

158. Following the options appraisal, the balanced decision is that the preferred strategic option is F6.6, which is comprised of the following elements:

- Pressure uprating (with maximum operating pressure below equipment class limit) of the existing Feeder 28 pipeline between Milford Haven and Three Cocks;
- 9km of new duplicate pipeline between Wormington and Honeybourne and 2km between Churchover Compressor and Churchover Multijunction; and
- Related works at several existing AGI sites to facilitate the pressure uprating, connection of new pipelines and effective compression at existing stations.

III. Preferred Option Refinement

159. The options considered in the options appraisal summarised above, comprised certain distinct combinations of network reinforcements where some standard assumptions had been made about key parameters, such as pipe diameters and compressor station configuration. Once a clear preference (F6.6) had emerged from this process, it was then necessary to consider in more detail any potential for variation in the design of each specific reinforcement element, as such a variation might affect the investment cost, timeline, outage requirements and network capability. A number of sensitivity reviews were undertaken to investigate whether the detailed composition and scope of the preferred strategic option could be optimised. Key elements of the optimisation were:

- Whether all sections of uprating should be taken forward
- Whether the assumed 1200mm new pipeline for Wormington to Honeybourne could be reduced to 900mm or 600mm
- If more extensive or more localised arrangements were most appropriate at Three Cocks and Tirley PRS to address pressure boundary / flow issues
- The project interface with the Medium Combustion Plant Directive upgrades scheduled to be undertaken at Wormington

160. Different outcomes from the above reviews had the potential to provide beneficial changes in:

- Programme to submission, construction and for capacity release
- Outage requirements for construction
- Construction and operational costs as well as constraints costs in context of network capability to further guide the selection of the most economical and efficient solution to the PARCA
- The required modifications to equipment and activities of SHGCL (shipper), SHLNG (terminal operator) and Dragon LNG, an adjacent terminal operator
- The extent of the activities associated with public engagement, environmental surveys and applications

Strategic Option F6.6 Variations ("Sub-Options")

161. The sensitivities were considered by creating a number of sub-options of option F6.6. A summary of the "sub options" or variations are presented in Table 19.

Sub Option	Sub Option Name	Sub Option Description	Included in CBA / Reason omitted
a	Counterfactual	No Reinforcements	Yes
b	F6.6 1200 Max	1200mm pipe Wormington to Honeybourne; full uprating; new 1200mm Tirley bypass, Churchover re-wheel and complex pipeline connection	Not included as the option leads to additional costs relative to F6.6c with little increase in capability. In addition, conceptual design studies indicated significant constructability challenges which could further increase costs for little benefit.
c	F6.6 1200 Base	1200 WORM to HNBN, all uprating and biggest Tirley bypass, Churchover Partial Bypass	Yes
d	F6.6 1200 Light	1200mm pipe Wormington to Honeybourne; uprating only downstream of Felindre, existing bypass at Tirley, Churchover partial bypass	Yes
e	F6.6 900 Light	900 Wormington to Honeybourne, uprating only downstream of Felindre, existing bypass at Tirley, Churchover partial bypass	Yes
f	F6.6 900 Min	900mm pipe Wormington to Honeybourne; no uprating, existing bypass at Tirley, Churchover partial bypass.	Yes
g	F6.6 600 Light	600mm pipe Wormington to Honeybourne; uprating from Felindre, existing bypass at Tirley, Churchover re-wheels.	Not included primarily due to significantly lower capability on [redacted] scenario. 600mm pipeline connections are also more complex than 900 (900 is effectively an extension of existing FM23 Honeybourne to Churchover)

Table 19: Summary of Variations of Strategic Option F6.6

Sub Option Effects on Capability

162. All of the defined sub options were modelled to determine the network capability they would provide. However it became clear that the value of the CBA process would be found in differentiating between options b, c, d and e as referenced in Table 19; i.e. to determine the relative value of the Churchover compression / configuration variations, the 900mm versus 1200mm options for the Wormington to Honeybourne pipe, and the value of pressure uprating between Milford Haven and Felindre. For this reason, more detailed modelling was applied only to these options with results illustrated by Figure 21.

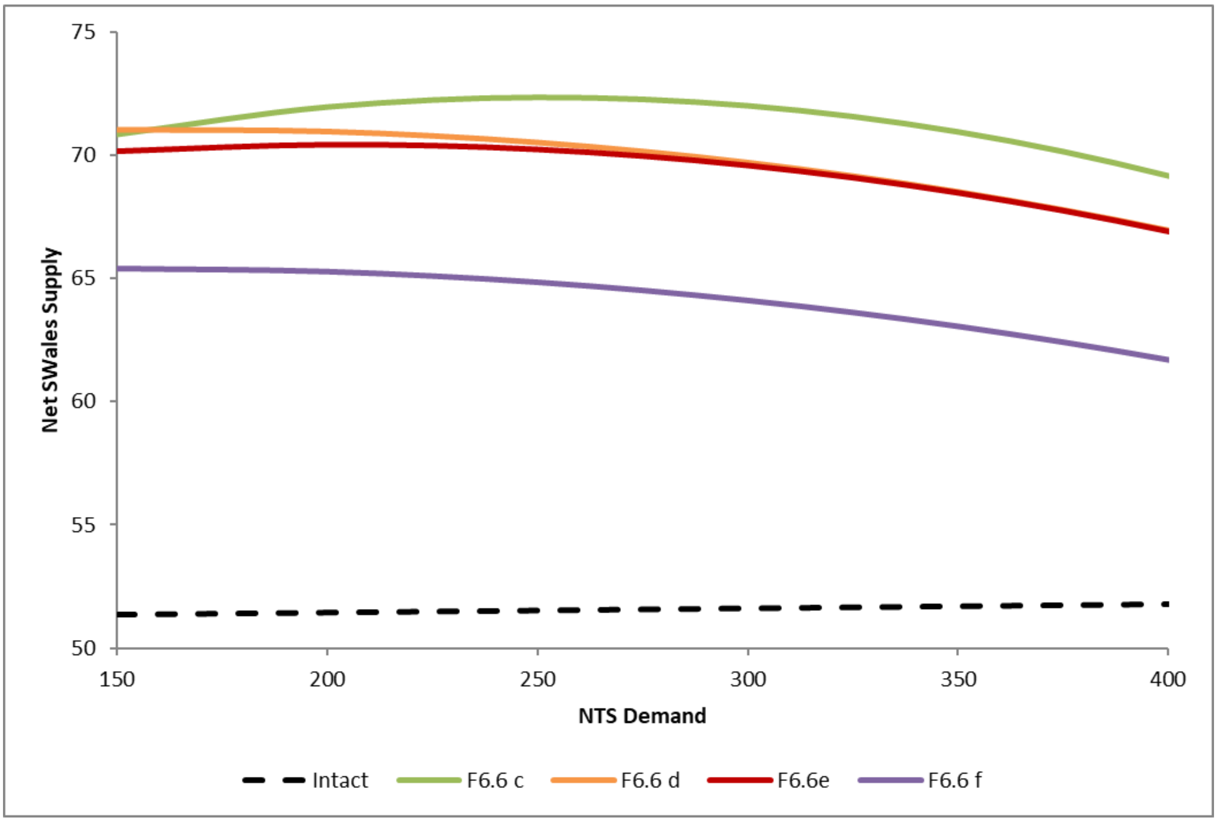

Figure 21: Boundary Capability Strategic Option Refinement

163. The results from modelling of the sub-options demonstrate the considerable increment in capability provided by pressure uprating, particularly when applied to the east of Felindre compressor station (i.e. uprating of the pipeline from Felindre towards Three Cocks). Referring to Table 19, the greatest difference between sub options is between those including the 102 Barg uprating from Felindre (options c, d and e) and the option which omits uprating (option f). Pressure uprating on the Felindre to Three Cocks section is anticipated to require relatively low investment cost and complexity, so this is a beneficial conclusion. For clarity, the system configuration requires that if uprating of the Felindre to Three Cocks section occurs, then uprating is also required of the Felindre to Cilfrew section and this has been included within the costs.

164. Pressure uprating between Milford Haven and Felindre (option c only) is also shown to have the potential to add significant capability though may be more complex to implement as a number of third parties would be impacted by the change. Changes would be required at both South Hook and Dragon terminals to facilitate an increase in pressure.

165. The difference to capability made by varying the pipe diameter of the Wormington to Honeybourne pipeline (option d versus e; from 1200mm to 900mm) is shown in Figure 21 to be relatively small. This is consistent with the explanation given earlier in this document that the reinforcement is effectively addressing a specific bottleneck on the NTS, so that the benefit comes from installing a pipeline with enough capacity that matches other sections of the route to Churchover. The 900mm pipe largely fulfils this need, although does begin to incur a significant pressure drop in low demand scenarios with the highest

flows through the region, scenarios under which the larger diameter pipe does provide a little more capability. It is notable that modelling was also carried out based on a 600mm pipeline and this was found to provide substantially lower capability, such that this option did not merit consideration in the CBA. This is unsurprising as a 600mm pipe offers approximately double the resistance to flow of a 900mm pipe.

166. Both the selection of F6.6 as the strategic option and the refinement of F6.6, aimed to maximise capability at the demand levels where it was needed most, while minimising the investment required. Figure 22 below shows the density of supply/demand points against all scenarios against the capability of the options along with the intact network. The selected option increases capability over the intact network significantly at lower demands, where flows are most concentrated. This minimises the number of points which are above this capability, the consequences of these breaches are detailed as part of the CBA assessment.

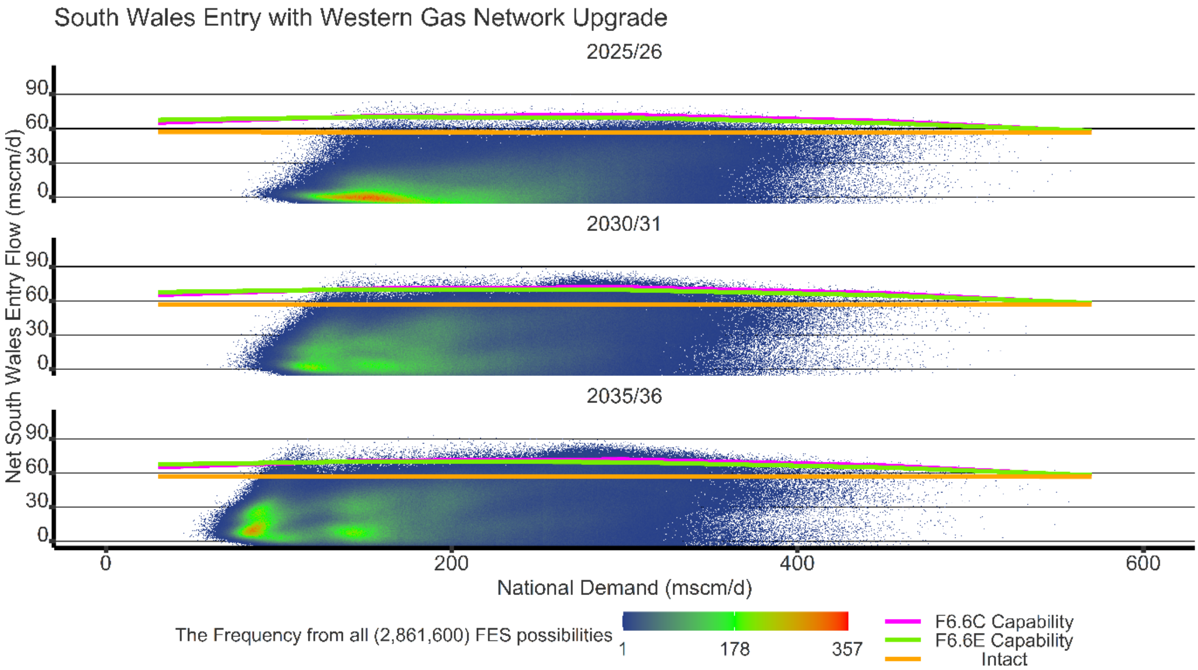

Figure 22: F6.6 Capability for all scenarios in 2025, 2030 and 2035

167. Note that all Strategic Option Refinements make a simplified assumption for Wormington compressor power. The current assumption is that the MCP project will deliver two new 17.5 MW Gas Turbine compressors which will be available from 2028. One of these compressors would run in parallel with the re-wheeled 15 MW Variable Speed Drive (VSD) to provide 32.5 MW total power. For simplicity, the capabilities provided for CBA assume this 32.5 MW power is available from January 2025.

168. The WGN project notes that assumptions for Wormington MCP project are evolving and there may be feasible power upgrades to the existing GT's and retrofit emissions technology which could represent an enduring MCP compliant solution. Further

information is provided in the Related Projects section above and will be provided on an ongoing basis during continued Ofgem engagement, MCP Ofgem touchpoints including FEED Feasibility report and the WGN FIOC project direction submission.

Cost Benefit Analysis of sub-options and Business Case Drivers

169. As with the strategic option selection there were several sensitivities undertaken, based on when constraints occur, considered as part of the selection process. The key focus was on the 10-year view to 2035. As detailed in the strategic option selection, F6.6 is a modular option with the potential to expand post 2035 if required. As such, focussing on the period to 2035 is key to understanding the optimal configuration for the F6.6 option.

170. An additional sensitivity was considered by only considering constraints up to 2030. Based on the configurations of F6.6 it was clear some elements could be deferred and deployed by 2030 if required, so understanding the performance over the first 5 years of operation was key in evaluating the options.

171. The relative costs of the options can be seen in Figure 23 below. These are detailed further in Appendix V: Optioneering Cost Breakdowns. As would be expected the investment costs decrease as different elements of the projects are removed.

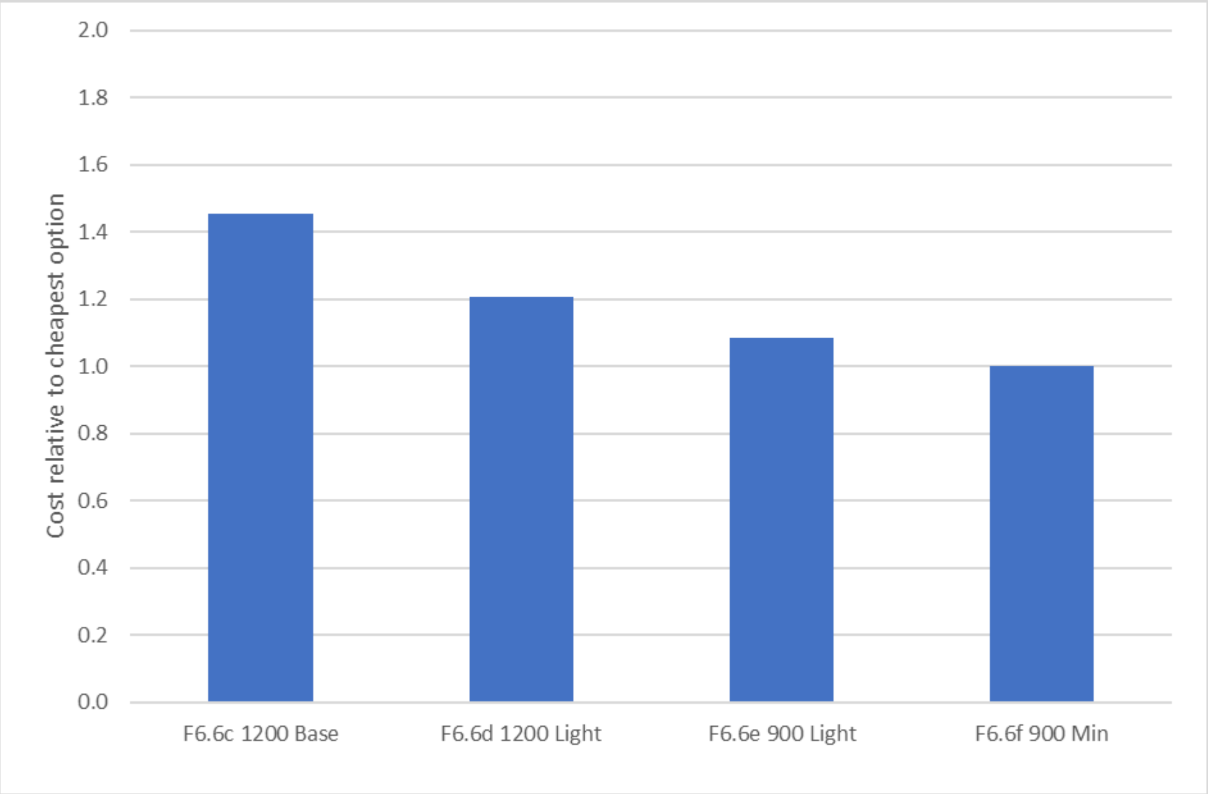

Figure 23: F6.6 sub option costs

172. The constraints up to 2035 can be seen in Figure 24 below. Only in Steady Progression do the annual constraints rise significantly for many of the options. Option F6.6f is the only option which sees a noticeable rise in the other scenarios.

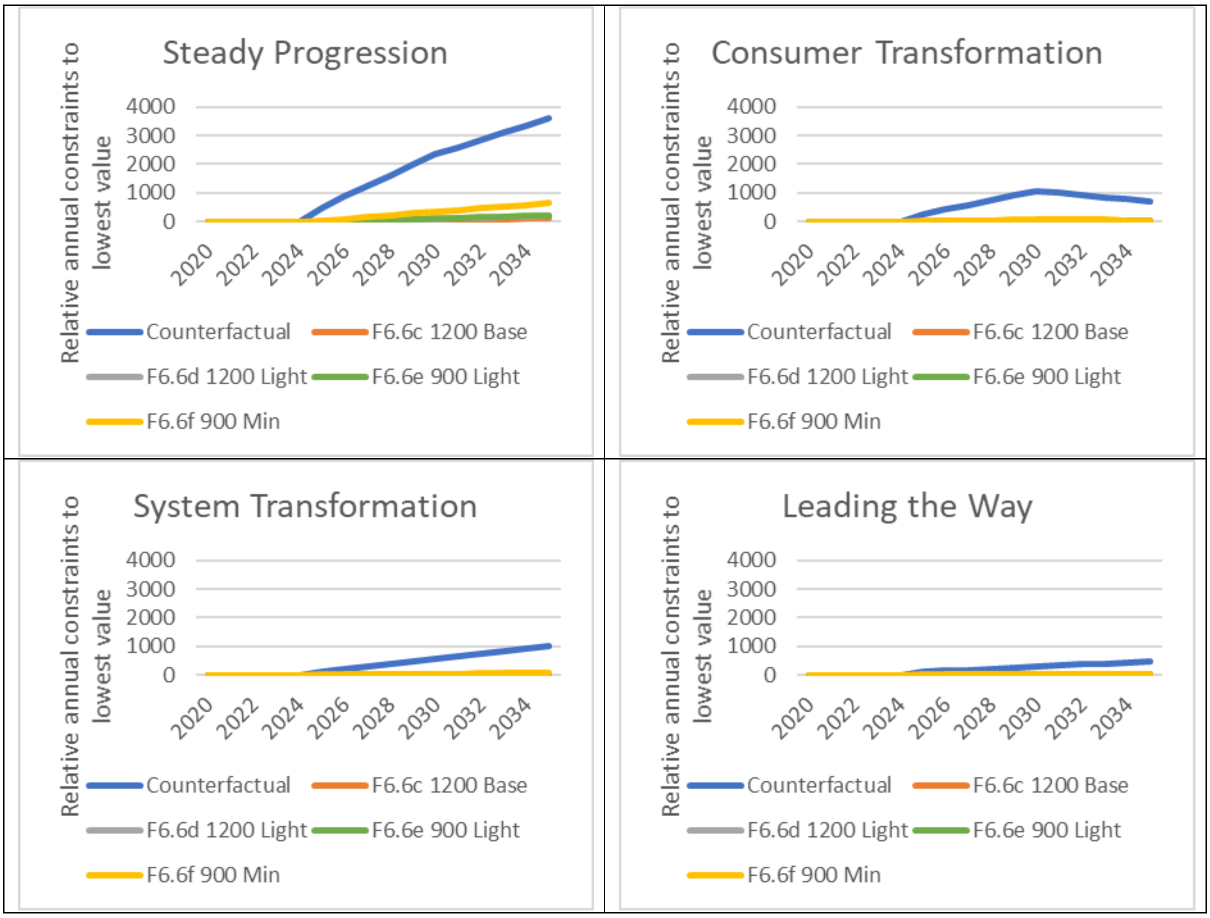

Figure 24: Constraints (all scenarios)

Sensitivities and Key Assumptions for sub-option evaluation

173. As with the Strategic Options selection process, all of the sub options have been tested against all four scenarios from FES 2020. In addition, the probabilistic modelling considers High LNG and High Continent supply cases in the same way as described earlier.

174. The key assumptions are detailed in Table 20 below. We have applied sensitivities to the assumptions which could have an impact on the investment decision to test what would need to change for another decision to be favoured.

	Assumption	Base Assumption	Rationale	Sensitivities Considered	Sensitivity Outcome
CBA parameters	WACC	2.81%	Defined in RIIO-2	N/A	
	Social Time Preference Rate	3.5% (Years 0 – 30) / 3.0 % (30+)	Defined in Green Book	N/A	
	Regulated Asset Life	45 years	Defined in RIIO-2	N/A	
	Assessment Period	10 years from installation.	Consistent with Strategic Option selection	Until 2030, tests investment performance over first 5 years	F6.6 favoured in all scenarios
	Depreciation	SOYD	Defined in RIIO-2	N/A	
	Capitalisation	75%	Defined in RIIO-2	N/A	
Investment Costs	Investment Costs	Detailed in Appendix V: Optioneering Cost Breakdowns	Detailed in Appendix V: Optioneering Cost Breakdowns		
Operating Costs	Supply/Demand Scenario	FES2020 – All Scenarios	Wide range of uncertainty, all scenarios given equal weight	N/A	
	Constraint management method	50% buy backs / 50% locational actions	Reflective of tools available to manage constraints.	N/A	
	Constraint Costs	BEIS Reference scenario	As defined by Commercial Constraint Price Methodology		

Table 20: Key Assumptions for sub option evaluation

175. The absolute and relative NPVs for the sub options can be seen in Table 21 and 22 below. When we consider constraints up to 2035 we can see that option F6.6e is the lead option in three out of the four scenarios. Only in Steady Progression is Option F6.6c the lead option, driven by the higher constraints in the other options, as shown in Figure 24.

Option	Steady Progression	Consumer Transformation	Leading the Way	System Transformation
Counterfactual	[redacted]	[redacted]	[redacted]	[redacted]
F6.6c 1200 Base	[redacted]	[redacted]	[redacted]	[redacted]
F6.6d 1200 Light	[redacted]	[redacted]	[redacted]	[redacted]
F6.6e 900 Light	[redacted]	[redacted]	[redacted]	[redacted]
F6.6f 900 Min	[redacted]	[redacted]	[redacted]	[redacted]

Table 21: Absolute NPV, no constraints post 2035

Option	Steady Progression	Consumer Transformation	Leading the Way	System Transformation
Counterfactual	£0 m	£0 m	£0 m	£0 m
F6.6c 1200 Base	£1234 m	£401 m	£100 m	£278 m
F6.6d 1200 Light	£1222 m	£415 m	£115 m	£291 m
F6.6e 900 Light	£1226 m	£421 m	£122 m	£297 m
F6.6f 900 Min	£1087 m	£404 m	£120 m	£283 m

Table 22: Relative NPV, no constraints post 2035

176. To test the nearer term impact of the options, a CBA was run with no constraints after 2030. This shows how the options perform over the first five years. At this point it would be possible to introduce additional measures, such as to apply the uprating from the Milford Haven ASEP to Felindre, if the additional capability was required. The absolute and relative NPVs can be seen in Table 23 and 24 below.

177. In the lowest use scenario, Leading the Way, the F6.6f 900 Min is the lead option. In all other scenarios the lead option when only constraints up to 2030 are considered the lead option is F6.6e 900 Light.

Option	Steady Progression	Consumer Transformation	Leading the Way	System Transformation
Counterfactual	[redacted]	[redacted]	[redacted]	[redacted]
F6.6c 1200 Base	[redacted]	[redacted]	[redacted]	[redacted]
F6.6d 1200 Light	[redacted]	[redacted]	[redacted]	[redacted]
F6.6e 900 Light	[redacted]	[redacted]	[redacted]	[redacted]
F6.6f 900 Min	[redacted]	[redacted]	[redacted]	[redacted]

Table 23: Absolute NPV, no constraints post 2030

Option	Steady Progression	Consumer Transformation	Leading the Way	System Transformation
Counterfactual	£0 m	£0 m	£0 m	£0 m
F6.6c 1200 Base	£427 m	£162 m	-£11 m	£47 m
F6.6d 1200 Light	£433 m	£176 m	£4 m	£61 m
F6.6e 900 Light	£440 m	£183 m	£11 m	£68 m
F6.6f 900 Min	£396 m	£177 m	£14 m	£67 m

Table 24: Relative NPV, no constraints post 2030

Conclusion for Sub Option Evaluation

178. The CBA demonstrated that in the short term, F6.6e 900 Light was the most beneficial sub option to progress. When we consider the CBAs for both time horizons, it clearly represents the optimum balance between investment and capability. It is the lead option in three of the four scenarios in both assessments and could be expanded by applying uprating to the Milford Haven to Felindre section in 2030 if this is required, as it would be in the Steady Progression scenario.

179. By delaying the decision to uprate the section from Milford Haven to Felindre until there is a clearer requirement for the additional capability, we avoid overinvesting in capability which may not be needed. As with the Strategic Option selection, considering a modular approach ensures we can deliver the capability required while protecting consumers from overinvestment.

180. The main conclusions drawn from the sensitivity review of certain components of the F6.6 strategic option are summarised as follows:

- Uprating should not be progressed from Milford Haven to Felindre for the purposes of meeting the PARCA. Whilst excluding this section may under some circumstances require the use of constraint mechanisms to reduce flow below the PARCA level, pressure uprating was not advantageous in the short to medium term in CBA terms. This element could therefore be deferred until a future date and either introduced in isolation or as part of a broader package addressing increased constraints cost risk. As a result of taking this element out of option F6.6, the effect is that no works would be required at the adjacent Dragon facility and no extensions or modifications would be required at Herbrandston AGI, Blackbridge PRS, Upper Neeston AGI, Newton Noyes AGI or Llangynog AGI. There would also be no need to include any additional pipeline protection works which were identified to be required for a ~500m section of the existing pipeline to maintain safety standards at Pontardulais, just to the west of Felindre. It is pertinent to note that no additional protection requirements are expected on the section of pipeline proposed to be subject to uprating.
- 900mm pipeline was preferred for the Wormington to Honeybourne section. It allows for simpler connections that can be accommodated within existing operational land

boundaries, avoids the need for two TCPA applications and offers potential to re-use (after validation) previous design material. Whilst there was some indications of potential CBA advantage out to 2050 from larger pipeline, this was against considerable uncertainty and a likelihood that the level of constraint would require a more extensive solution than would be achieved by selection of larger pipe at this stage.

- Tirley and Three Cocks pressure boundary requirements could be safely met through modifications to existing assets. In both cases this removes the need for any TCPA applications, removes the need for EIA screening at Tirley and allows works at both sites to be progressed as Permitted Development
- Churchover Tee - the simplified arrangement making greater use of bypass was favoured as it substantially simplifies required connection with the compressor site.

181. Modelling also considered the interface of the WGN project with ongoing studies responding to the MCPD requirement for the replacement of two gas turbine compressors at Wormington. These studies identified a need for the WGN project to include the re-wheel of the remaining Wormington VSD compressor unit to achieve necessary capability under credible flow scenarios, even if the MCP project installs two new Gas Turbine compressor units.

Long Term Consumer Value

182. Throughout the project to date, all investigation, analysis and review has been undertaken to identify the strategic proposal that provides the most economical and efficient solution to safely provide the reserved capacity using the defined methodologies in place. The following elements summarise the processes that National Grid use to ensure long term value for consumers, or are specific topics referenced in the RIIO-2 FIOC Guidance and Submissions Requirements Document.

Options Appraisal

183. Options Appraisal is a robust and transparent process used by National Grid to compare options and to assess the positive and negative effects they may have across a wide range of criteria including environmental, socio-economic, technical and cost factors.

184. The options appraisal process followed is summarised in the Strategic Options Report (See Appendix IV) with main summary points noted here:

I. The SOR considered a comprehensive range of theoretically viable options which were reduced to a shortlist using technical and benefit filters to allow focus on those options expected to provide the most economic and efficient option. This approach ensures that there is a fresh review of options in the current policy and decision making context whilst being efficient and timely.

II. The adoption of a wide range of factors within the decision making ensures a balanced decision is taken that optimises consumer value across those factors ensuring compliance with National Grid’s various duties and obligations including its Stakeholder, Community and Amenity policy.

III. The preferred strategic option minimised the requirement for new infrastructure by increasing the operating pressure in some pipelines (uprating) and facilitates future flexibility without over-investing when uncertainty may modify the future requirement.

CBA Methodology

185. Inherent within the options appraisal process is consideration of value to consumers, which is balanced against factors such as environmental effects. To ensure that identified options for solutions represent the best value for end consumers, we assess the options using CBA. This involves calculating the net present value for each option to compare the costs and benefits of a project. The CBA produces an NPV by considering a wide range of costs for each option, such as purchasing new assets, ongoing asset health, changes to site configuration, compressor fuel usage, constraint management costs, site operation and commercial contracts. We continue to develop our CBA methodology to include real options and wider energy system and environmental impacts.

PARCA/ECR Economic Test

186. An economic test is applied prior to the decision to release incremental obligated capacity, further details of this test can be found within the Entry Capacity Release Methodology Statement (ECR).

187. For the purposes of determining the required commitment from PARCA signatories to trigger the release of Incremental Obligated Entry Capacity, an estimated project cost will be calculated for the requested amount of Incremental Obligated Entry Capacity. The final estimated project cost will be provided to the applicant prior to the allocation of capacity, and shall be calculated by annually applying inflation, to the initial estimated project cost, each year that has passed from the moment that capacity was reserved.

188. The Milford Haven ASEP PARCA had progressed into Phase 2 when ECR version 5.0 was implemented, therefore the initial estimated project was the prevailing Estimated Project Value at that time. The final estimated project cost will be determined by applying inflation annually from the date of implementation of v5.0 of the ECR.

189. In the event that the NPV test is not passed and capacity (excluding Non-obligated Entry Capacity) is not allocated, the PARCA will be terminated.

190. Licence Special Condition 9.18 Part B determines the NPV test threshold; the discount rate, and; the period over which the NPV test is calculated. These elements exist in the Licence to protect the interest of existing and future consumers of gas, as these three aspects of the NPV test determine how much consumers pay towards new investments. Consumers bear the costs of the portion of new investment that is not covered by revenues from capacity sold.

Net Zero, Capability and Future Expansion

191. FES 2020 presented a new scenario framework, introducing the axis of ‘level of societal change’ to accompany the ‘speed of decarbonisation’ from previous editions. This allowed the development of the FES 2019 net zero sensitivity to explore three pathways to meet the UK’s legally binding net zero target announced in June 2019.

192. The FES 2020 data set has enabled us to run our network capability assessments and CBA, to ensure our investment option still provides the most economic and efficient solution for consumers in these pathways. The CBA has demonstrated that in the short to medium term, our preferred option is the most beneficial to progress across all scenarios.

193. If we find ourselves in a future more aligned to the only non-net zero compliant scenario of Steady Progression, when considering constraints up to 2035, further capability would be required. Beyond 2035, constraints that are observed deeper within the network would trigger the need for further investment in Steady Progression. The approach that has been adopted retains this opportunity for further network development, but without the risk of overinvestment now to address constraints that may not materialise.

194. The only net zero scenario that would also potentially signal a need for an expanded option, is the high hydrogen world of System Transformation, where constraints increase dramatically from 2035. However, this once again supports a modular approach, as this would likely represent a significant shift in how the network operates which may be more beneficially addressed through a different response. Again, the approach adopted retains the opportunity for future response without overinvestment in a potentially poorer performing solution at this stage. We would signal any such future requirements in our ANCAR publication.

195. Thanks to the range of options considered from the start of this project, we have a number of variations from the strategic optioneering process that would represent a modular approach to increase capability in future. Below, Table 25 represents our current estimate of costs and timeframes associated to the two most likely expansions.

	Indicative Cost [redacted]	**Lead Time from Need Case (4.0) and Funding Agreement**	**Suggested Start and Completion date**	**Comments**
Uprating Milford Haven to Felindre to 99barg MOP	[redacted]	Approx 3 years	Assumed 2026 start in RIIO-T3, completion by 2030	Cost excludes financial impact of works required at third party sub-terminal, which could be significant for this option. Alternatives to uprating may require additional compression capability and/or new pipeline infrastructure to facilitate the PARCA flow requirement at substantially greater cost.
26km Pipeline Tirley to Wormington	[redacted]	Approx 6 years	Assumed initiation of consenting during RIIO-T3 in 2029, completion by 2035	Leadtime assumes that although only 26km, the pipeline will require a Development Consent Order to be secured. Whilst below the mandatory 40km threshold for a Nationally Significant Infrastructure Project, the environmental effects of an alignment through an Area of Outstanding Natural Beauty are expected to require DCO process to be adopted.

Table 25: Expansion options and associated costs and timeframes

8. Preferred Option Scope and Project Plan

Preferred Option Scope

196. The project being progressed has been identified following a comprehensive evaluation process of options capable of meeting the PARCA and a detailed optimisation process to focus from the preferred strategic option. F6.6e is the optimum solution to meet the needs of the PARCA in an economic and efficient manner at least cost to UK consumers, and consists of:

I. Pressure uprating of part of the existing Feeder 28 pipeline between Felindre and Three Cocks which also includes the section Felindre to Cilfrew;

II. 9km of new pipeline between Wormington and Honeybourne and 2km of new pipeline between Churchover Compressor and Churchover Multijunction; and

III. Related works at several existing AGI and compressor stations to facilitate the pressure uprating, connection of new pipelines and effective compression at existing stations.

Project Spend Profile

197. Table 26 shows the high-level indicative project spend profile.

£m	RIIO-T1	RIIO-T2					RIIO-T3	Total
	Prior years	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	
2018/19 Prices	[redacted]							
Outturn Prices								

Table 26: Western Gas Network Project forecast spend profile [redacted]

Efficient Cost

198. The WGN project team has, and continues to, progress the project through a number of specific actions to ensure the project progresses efficiently. Some examples are summarised below:

<u>Lessons learnt that have been incorporated</u>

- Experience from previous projects has highlighted the consequences of changes in the outturn costs of strategic options, as further detail is added. This may lead to a need to change the option being addressed with programme and additional cost implications. The WGN project has therefore sought to define strategic and shortlisted options at a suitable level of detail to reduce risks of future sensitivity testing. All major elements of strategic options were identified (e.g. approx. pipeline length, need for compression etc) to ensure that comparisons were made based on options close to likely final design. This approach reduces the potential for later back-checks and sensitivity testing to lead to an alternative option being more optimum.

Ongoing efficiencies that have been realised

- Use of a District Licensing approach for Great Crested Newts where this is available. This approach is different from the traditional newt surveying and mitigation approach and provides the potential for programme and cost savings. It is only available for the proposed new 9km Wormington to Honeybourne pipeline section, but is being adopted (in agreement with Natural England) and is estimated to reduce costs by in excess of [redacted].
- Consent Strategy in combination with a proactive approach to mitigation within pipeline routeing is allowing the project to progress as permitted development with limited need for TCPA applications. The alternative to this would have been to seek a DCO, likely to have added an estimated 18 months to 2 years to programme and additional costs estimated in the order of [redacted].

Historical benchmarks, both internal and external

- Capital Cost comparisons have been made on a consistent basis across options using National Grid ehub estimates. These are based on an agreed methodology and informed by previous outcome experience. This approach reduces the risk that the wrong strategic option is being progressed by reducing the potential for inter-option cost variation.

Expert view on technical options

- Early consultation with pipeline operational expertise (DNV and Pipeline Integrity Engineers) gave early confidence that pressure uprating was a viable technique to contribute to meeting the requirements of the PARCA. This ensured this option was progressed. This has allowed the adaptation of existing equipment to be part of the solution, which provides cost and programme efficiencies and reduced environmental effects compared with the alternatives that would require either additional length (potentially between 26km or 55km depending on solution) of new pipeline or the provision of additional compression capability.
- NG expertise has contributed to the proposed adoption of a staged approach to the network reinforcements project reflecting the fact that future uncertainties may under some circumstances lead to overinvestment. A phased approach to response is therefore taken forward with the proposed project addressing needs to around 2030 – 2035, but with the potential requirement for additional investment in future depending on gas supply and demand requirements about which there is a high degree of uncertainty.

Procurement efficiencies

- The use of suppliers off frameworks and services and equipment secured through competitive tendering is being adopted where possible, to ensure best value is achieved. In combination with pro-active negotiation over scope of works this is reducing the costs of the design and consenting stage of the project. Examples include:
  - Environmental support – Three framework suppliers were invited to tender with the one offering best value (combining cost, experience, method and quality) selected. This provided a saving estimated at [redacted].
  - Uprating assessments. Pro-active negotiation with the supplier with relevant expertise on scope of work reduced the costs by an estimated [redacted] compared with their initial fee scope estimate.

Project Plan

199. The milestones are based on our current view of investment in the proposed new infrastructure, taking into consideration wider works planned across the network. Please note, these are subject to change as the project progresses through the ND500 process. Table 27 is an indicative project plan showing progression through the stage gate process, purchasing of long lead items, commissioning dates and key operational milestones.

Cycle	Network Development Stage Gates		Indicative Dates
Pre-FEED Stage 4.0 and 4.1	T0	Generation of Need Case	May 2018 - January 2019
	T1	Accept Need Case	May 2019
	F1	Initial Sanction	May 2019
	T2	Define Strategic Approach & Outputs Required to Deliver GT Handover to Delivery Unit	October 2020
FEED Stage 4.2	F2	FEED Sanction and Feasibility Sanction	June 2021
	T3	Agreement to Proceed to Conceptual Design	May 2022
	F3	Conceptual Design Sanction and Sanction of long lead items	June 2022
Tender Award Stage 4.3	T4	Scope Freeze	June 2023
Project Execution Stage 4.4	F4	Detailed Design AND Build Sanction (T4-F4-T5)	August 2023
	T5	DDS Challenge, Review & Sign off Maintenance Requirements Identified	February 2024
Acceptance Stage 4.5	T6	Post Commissioning Handover to GT; Operational & Maintenance Complete or Planned	November 2025
	F5	Project Closure	May 2026

Table 27: Project Plan

200. In order to progress to the timeline above, Project Direction submission is anticipated in Q1 2023. Between this Need Case Submission and then, several elements included in this need case will be updated or refreshed, as the project develops. These include:

- FES data refresh
- CBA refresh
- Design Studies finalised
- Cost estimate and confidence improvements for the selected option

Engagement with Stakeholders

201. National Grid has engaged with a wide variety of stakeholders in progressing its plans for the WGN.

202. Regular engagement has been held with representatives from the shipper (SHGCL) and terminal operator (SHLNG) associated with the PARCA and Network Entry Agreement respectively to appraise them of progress and seek to support their own project development process. Engagement has also been held with Dragon to discuss the potential effects on their operational activities, though these are now avoided with the adjacent part of the NTS not being subject to pressure uprating.

203. The requirement to consider whether the WGN programme of works constituted development for which Environmental Impact Assessment (EIA) was required led to engagement with planning and technical stakeholders and a screening request to be submitted to the Department for Business, Energy & Industrial Strategy (BEIS), including:

    I. Statutory consultees – Environment Agency (EA), Natural England (NE), Historic England (HE), and Natural Resources Wales (NRW)

    II. Planning Officers & Technical Consultees – Relevant planning officers (at Unitary, District and/or County level as appropriate) and technical officers on disciplines such as: Traffic & Transport; Ecology; Landscape; Rights of Way; Heritage; Noise & vibration)

204. Feedback was considered and, in some cases, led to additions to future scope of survey work or modified the working assumptions. For example, after engagement with the EA a presumption of trenchless crossing of all watercourses was adopted until such time as field survey information was available to allow the implications of whether a lower cost alternative open-cut technique could be agreed with the EA.

205. All parties consulted in respect of EIA screening agreed that the pipeline works did not constitute EIA development with the BEIS screening opinion issued to that effect in December 2020.

206. Further engagement was undertaken with Swansea Council and Neath & Port Talbot Council (NPTC) to consider the need for EIA for works at Felindre compressor site and Cilfrew Pressure Reduction Station. Swansea Council confirmed that the works at Felindre do not constitute EIA development (March 2021). Likewise NPTC have also confirmed that works at Cilfrew do not constitute EIA development (April 2021).

207. Additional technical engagement has progressed, and is ongoing, with relevant national (EA, NE, HE) and council technical specialists such as Environmental Health Officers to consider the findings of field surveys and the requirements (if any) for mitigation of any predicted effects.

208. There is of course a need to engage directly with landowners potentially affected by the project. National Grid are committed to securing the land and rights needed for the project by voluntary agreement if at all possible. However, in order to provide certainty that the land and rights required for the project can be secured within a reasonable timeframe to enable the project to be delivered, it is necessary for National Grid to start preparations for making a Compulsory Purchase Order (CPO) in parallel with private treaty negotiations. Running the CPO process in parallel with continuing landowner engagement and negotiations is expressly envisaged by paragraphs 2 and 17 of the Government's Guidance on Compulsory purchase process and The Crichel Down Rules, and National Grid is fully committed to continuing to progress the negotiations throughout the CPO process.

209. It was decided from the outset to undertake an engagement programme with not just political stakeholders but with members of the public.

210. Our engagement programme sought to inform the following key stakeholders about the project and was co-ordinated with initial approaches to landowners:

- political office holders and local representatives (MPs, parish councillors, officers, etc.); and
- members of the general public.

211. Due to the COVID-19 pandemic, we had to rethink our approach to stakeholder engagement. After careful consideration, we decided to take a digitally-led approach to our stakeholder engagement programme but ensured that it was supported with a more traditional approach for those who can't access online resources.

212. The team created a number of channels to communicate the project information as described below.

213. A project website has been set up as the main vehicle for project information. Online meetings have been held with elected representatives to introduce the project and garner feedback. Members of the public have been able to comment on and meet the team through a series of online webinars and feedback forms.

214. Between January 2021 and May 2021, the communications team has held 16 online meetings with key political stakeholders including five MPs, three parish councils, two council leaders and 10 ward councillors.

215. Two public webinar sessions using Zoom were held specifically to discuss the proposed pipeline routes. These sessions were promoted via a number of methods both digitally and traditionally. Flyers were sent out to 118 properties closest to the Churchover pipeline and 649 properties based around the Wormington to Honeybourne pipeline. A social media campaign was also arranged targeting Facebook users that lived within a 1-mile radius of the pipeline. The engagement programme has been split into two phases, one to introduce the project and the proposed new pipelines and the second to introduce the AGI and compressor works.

216. Engagement around proposed AGI and compressor works are still ongoing. The main feedback from political stakeholders has been to request that consideration is made to avoid traffic build up which could lead to diversions through local villages. National Grid would note that the preparation of Traffic Management Plans (TMP) to address this potential was proposed as part of the screening requests to BEIS with these currently being developed and informed by surveys of typical traffic levels, speeds and composition.

217. Feedback from all parties on the specific proposals has been captured and considered in finalising the siting and route alignment and methods of construction to be taken forward as part of relevant planning submissions.

218. Feedback from political stakeholders received during online meetings and over email centred around a need to ensure good communications channels are made available during the construction phase for local stakeholders. They also raised an expectation for National Grid to give back to the local communities they are working in through educational support, volunteering and financial help for local charities.

219. Feedback from members of the public, which was received during our webinar sessions around the new pipelines and via email was more focused around traffic. For example, concerns were raised by those living between Wormington and Honeybourne that if sections of the A44 were suspended it would cause delays and push vehicles into local roads. Another comment was for appropriate signage and directions be given to HGV drivers to ensure they don't drive through local villages. Such measures will be addressed within the TMP as indicated above.

220. As the project approaches the start of construction, design changes will be shared on the project website and communicated as necessary to stakeholders. A robust communications plan will also be created to support the Traffic Management Plan ahead of any construction work starting to ensure all stakeholders are kept informed.

221. A Freephone line, email and Freepost address have been set up to support the project from now right through to commissioning. Public facing staff have been given contact cards / QR codes to hand out to stakeholders.

222. In the main the WGN programme of works can be progressed as Permitted Development requiring some prior notification procedures to be adopted and various management plans (Traffic Management Plan and Construction Environment Management Plan) to be submitted to outline various procedures to be implemented during the execution of the works. TCPA applications are only expected to be required at two locations (where

permanent extensions to AGI are required) and potentially (subject to confirmation through ongoing design work) for a number of temporary means of access.

223. Further engagement has been scheduled to take place later this year as the project continues to progress so that all stakeholders are kept informed.

Key Business Risks and Opportunities

224. Key risks to the WGN project and associated mitigation actions are summarised in Table 28 as follows.

Risk (Description, Cause, Impact)	Mitigation Actions
The project may not be able to secure the pipeline outages required to complete the works due to prevailing network conditions, leading to programme delay and increased costs	Work with the NG Portfolio Planning team to ensure outages work alongside other network interventions Discuss outage requirements and timings with shippers to start early planning Work with the Milford Haven terminals to assess required and likely flow rates at the time of any outages
Delays to Ofgem approvals cause missed NG governance milestones, delaying key activities such as long lead item procurement and main works contract award, leading to programme delay and increased costs	Regular liaison with Ofgem around the FIOC guidance interpretation and implementation, and the specifics of the WGN timeline and critically constrained activities
Protestor action on WGN survey or construction sites causes programme delay and increased costs	Ongoing engagement with the NG security team, developing and implementing a plan tailored to the project Regular assessment of online indicators of heightened risk levels in relation to the project
Legal challenges of the CPO process raised by persons with an interest in land required multiple and protracted hearings leading to delayed land access, increased costs and the possibility of programme delay	Leading up to the CPO, NG is consulting with landowners to have voluntary agreements to enable construction Early engagement with landowners throughout the survey phase to build working relationships ahead of construction access
Unforeseen engineering or safety issues arise during the ongoing uprating assessments lead to an increase in scope in relation to the planned increase of feeder 28 maximum operating pressure, increasing costs and causing programme delay	Uprating working and steering groups meet regularly to discuss latest progress and findings of the ongoing assessments to address any issues Uprating viability studies have already been completed and concluded uprating will be achievable

Table 28: Current (June 2021) Top Project Risks and Mitigations

225. Key opportunities for additional efficiency and cost saving substantially focus on effective integration of the works with other project activities at relevant locations. On the basis of what is known to be being planned at present these potential opportunities include:

- Bundling works with MCPD impacted Wormington site, bringing contracting efficiencies
- Enhanced efficiency of Churchover Compressor due to the removal of network constraints, which currently cause the compressor to be used in a non-optimal configuration in certain supply and demand conditions[8]
- Bundling of works at Tirley PRS with those relating to Filter inspections and other asset health works (and combining of feeder outage)
- Possible bundling of work with asset health investments at Churchover compressor, Tee and Multijunctions

Key dates and Deadlines

226. As detailed in the procurement section below, long lead items required for the WGN project will trigger a significant increase in spend. Due to the length of the manufacturing and delivery processes of some of these items, the procurement activities will need to start at the end of 2021.

227. As a result, we would like to request an Authority decision by the end of 2021 to maintain our project plan communicated above. This would represent 6 months for assessment, consultation and decision. This will enable National Grid to progress efficiently and meet our PARCA obligations, or conversely avoid starting a costly process if it not deemed necessary by Ofgem.

228. The PARCA is a bilateral contract that allows long-term capacity to be reserved for a customer while they develop their own project. Throughout the process to date, we have been engaging with South Hook Gas Company Ltd and have been made aware of key dates relating to their development upstream of the NTS. [redacted]. It should be noted that SHGCL have already demonstrated commitment to the reserved capacity through the annual provision of financial security as required by Phase 2 of the PARCA framework.

[8] Essentially the existing twin 600mm pipes mean that at higher MH flows Churchover has to either be run with an inefficient flow loop (discharging some gas back via Honeybourne MJ back onto the suction of the compressor), or by isolating Fdr 14 at Churchover. Both of these are done to protect Rugby pressures and mean that the Compressor is not being used very effectively.

Procurement Strategy

Introduction

229. The purpose of this chapter is to introduce the procurement processes that will be followed for the different packages of work that constitute the WGN project, taking into account lessons learned from previous projects. The different packages are:

I. Compressor Works

II. Uprating of Feeder 28

III. New Pipelines

IV. Long Lead Items

230. The right procurement strategy is essential to the efficient delivery of a project. WGN is a complex project with different activities spanning through different years (see procurement overview in figure 26 below) and the procurement strategy will be adapted to the nature and value of the works to be delivered, always aiming at using competition to achieve the most economic price. The key learning from previous similar projects delivered by National Grid, is the importance of providing MWC with enough information in the scope of works to allow them to price accurately. FEED activities are essential in the achievement of this and will set the base for a successful delivery of the construction works and prevent any unexpected overspend.

Compressor Works

231. At this stage we estimate that two re-wheels will be needed at Felindre and three at Wormington. The estimated value of those works ranges between [redacted], with the start of the works planned for the beginning of 2024. As these will be OEM led works, the most appropriate contracting mechanism will be a call-off through the Compressor Maintenance Framework, with a potential to bundle with other RIIO-T2 works with the OEMs in question if planning and timing allows for this. Procurement activities for these Compressor Works will start in the first months of 2023.

Uprating of Feeder 28

232. The uprating assessment and revalidation activities have already been awarded through the Technical Consultancy Services (TCS) Framework and the ILI Services Contract to allow the timeline of the project to be maintained. The next step will be the award of the Conceptual Design works using the Gas Design Services Framework. These works are expected to start in the first quarter of 2022 and their estimated value ranges between [redacted]. They will lead to a defined scope that will be used to run the tender of the Detailed Design and Build works end of 2022.

233. The Detailed Design and Build phase of the uprating of Feeder 28 has an estimated value of [redacted]. Depending on the characteristics and estimated value of the final scope, there are different routes that Procurement can follow for the award of these works:

- Use of the Minor Gas Construction Framework
- Award through the Asset Health RIIO-T2 Framework
- Spot tender following the Strategic Sourcing Process (SSP)

234. Given the challenging timescales of the project, the use of one of the available frameworks is at this stage the preferred option for an efficient and competitive delivery of the works.

New Pipelines

235. Design studies were completed on a number of potential pipeline routes as part of the original South Wales Expansion Project (SWEP) in 2007. After appropriate validation, this work will be re-used in this project, thus providing savings and efficiencies in the FEED activities required for the two new pipelines. As with the Uprating Conceptual Design, FEED has been awarded through a mini-competition under the Gas Design Services Framework, which includes contractors with the expertise required for this type of works. These works have a value of [redacted].

236. The outcome of the FEED phase will be a scope document that will allow us to go out to market for the Detailed Design and Build phase in 2022. Due to the value of the works, estimated between [redacted], the route to market will be a spot tender that will allow National Grid to test the full market and identify the best positioned MWC with a successful track record of delivering pipeline projects. This competitive event will allow National Grid to explore the market capabilities, capacity and competitiveness. Delivery and implementation time are key drivers in the WGN project, and by undertaking a detailed analysis of resources at tender stage, National Grid will protect the objective end date of 2024.

237. Although the Design and Build of the new pipelines is the highest value work package of the WGN project, it will not necessarily be attractive for contracting organisations, as these are capable of building very large schemes. The availability of qualified and experienced contractors in the required timeframes is key for the success of this project. An early engagement with the supplier base to understand their interest in the project and their capacity will therefore be an essential part of Procurement activities in 2021.

Long Lead Items (LLI)

238. National Grid will procure and free issue the pipelines and other equipment to support the build activities described above. This is a standard practice adopted by National Grid in order to take advantage of volume aggregation. Additionally, it allows tight control of specification requirements and quality to ensure asset integrity and offers a reduction in overall capex costs as an MWC fee is avoided.

239. Long lead items required for the WGN project have an estimated value between [redacted]. Because of the length of the manufacturing and delivery processes of some of these items, the procurement activities will need to start at the end of 2021. The route to market will vary depending on the nature of the item:

- Line pipe: supplied through Line Pipe Sourcing Agent
- Pipe fittings: supplied through Material Stockist Framework
- Valves and Actuators: supplied through Valves and Actuators Framework

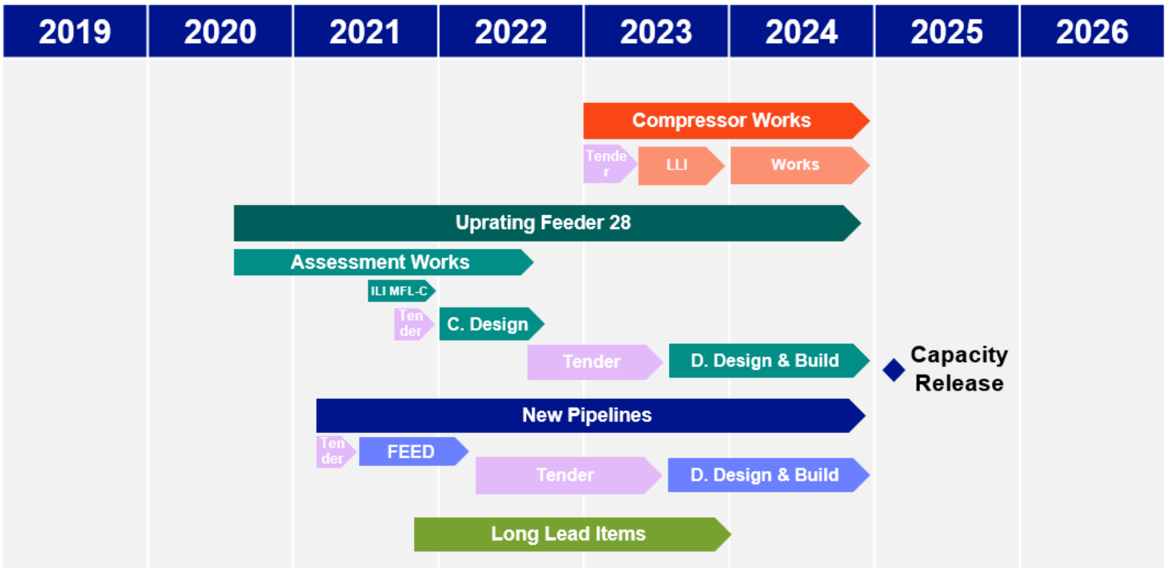

Figure 25: Procurement Timeline Overview

9. Conclusion and Next Steps

240. In conclusion, National Grid is submitting this Need Case under the RIIO-T2 FIOC Re-Opener Price Control Deliverable Uncertainty Mechanism, to seek Ofgem approval of the project need and options analysis, providing a detailed view of the project and its associated timings, setting out the different options considered and the preferred strategic option.

241. This is in response to the SHGCL PARCA application for 163 GWh/d in excess of the prevailing level of Firm Entry Capacity at the Milford Haven ASEP.

242. The preferred strategic option includes modifications to the existing network and requires the least new infrastructure, therefore minimising the impact of the project on communities and the environment. This option has the lowest capital cost with the greatest consumer benefit and therefore represents the most economic and efficient solution for UK consumers.

243. This preferred strategic option contains the following main elements:

- Pressure uprating of part of the existing Feeder 28 pipeline between Felindre and Three Cocks and the section from Felindre to Cilfrew;
- 9km of new pipeline between Wormington and Honeybourne and 2km of new pipeline between Churchover Compressor and Churchover Multijunction; and
- Related works at several existing AGI and compressor stations to facilitate the higher flows, pressure uprating, connection of new pipelines and effective compression at existing stations.

244. The WGN project is designed to accommodate the immediate requirements triggered by a customer request for incremental capacity without over-investing in infrastructure which may not be required. As such it does not resolve the potential wider network constraints that may appear in some of scenarios in the longer term. It is however, a scalable, modular option that would support any future investment that is needed.

245. Ofgem are invited to assess and approve the project need and options analysis and publish those views as per the FIOC Guidance and Submission Requirements Document.

Appendix I. Glossary

AGI – Above Ground Installation: Above ground gas assets (including, but not limited to; pipework, valves, pig traps, meters and regulators) located within a fence line for the safe operation and maintenance of the National Transmission System

AONB – Area of Outstanding Natural Beauty a designated exceptional landscape whose distinctive character and natural beauty are precious enough to be safeguarded in the national interest. AONBs are protected and enhanced for nature, people, business and culture.

ANCAR - Annual Network Capability Analysis Report

APV – Absolute Present Value

ASEP – Aggregated Supply Entry Point

BEIS – Business, Energy & Industrial Strategy, the relevant government department for consideration of whether the project required the completion of an Environmental Impact Assessment

BCM – Billion Cubic Metres

CBA – Cost Benefit Analysis

CCUS – Carbon Capture Usage and Storage

CDM – Construction Design Management Regulations 2015, also known as CDM Regulations or CDM 2015, which came into force on 6 April 2015, are regulations governing the way construction projects of all sizes and types are planned.

CPO – Compulsory Purchase Order, a legal that allows certain bodies to obtain land or property without the consent of the owner. It may be enforced if a proposed development is considered one for public betterment.

CSRP - Control System Restricted Performance

DCO – Development Consent Order - is a statutory instrument granted by the Secretary of State to authorise the construction and development of a Nationally Significant Infrastructure Project. The nature of these projects are defined by ss. 14-30 of the Planning Act 2008.

EA – Environment Agency - is a non-departmental public body, established in 1995 and sponsored by the United Kingdom government's Department for Environment, Food and Rural Affairs (DEFRA), with responsibilities relating to the protection and enhancement of the environment in England (and until 2013 also Wales).

EIA – Environmental Impact Assessment - The process by which the impacts of a proposed development upon all aspects of the receiving environment are identified and analysed. Projects must be of a certain type and scale or have the potential to lead to significant environmental effects for EIA to be a mandatory requirement.

ECC – Estimated Cost to Complete

ECR – Entry Capacity Release Statement

EJP – Engineering Justification Paper

ES – Environmental Statement - Document that reports the findings of an Environmental Impact Assessment.

FEED – Front End Engineering Design – Provides enough engineering and technical detail to achieve a desired level of certainty with respect to the cost estimate, risk register and project programme.

FES – Future Energy Scenarios (TD – Two Degrees, CT – Consumer Transformation, LTW – Leading the Way, ST – System Transformation, SP – Steady Progression)

FID – Final Investment Decision

FIOC – Funded Incremental Obligated Capacity

GNDP/ND500 – Gas Network Development Process

HE – Historic England

HGV – Heavy Goods Vehicle

ILI – In Line Inspection

ISS – Integrated Security Solutions

LLI – Long Lead Items

LNG – Liquified Natural Gas

MCM / MSCM – Million Cubic Metres / Million Standard Cubic Metres

MCP/D – Medium Combustion Plant / Directive

MFL - Magnetic Flux Leakage

MWC – Main Works Contractor - A Main Works Contractor is responsible for providing all of the material, labour, equipment (such as engineering vehicles and tools) and services necessary for the construction of the project. The MWC hires specialised subcontractors to perform all or portions of the construction work

NE - Natural England

NGO – Non-Governmental Organisation - Non-governmental organisations, commonly referred to as NGO's are international organizations and generally non-profit organisations independent of specific governments (though often funded by governments) that are active in humanitarian, educational, healthcare, public policy, social, human rights, environmental, and other areas to effect changes according to their objectives.

NIA – Network Innovation Allowance

NPV – Net Present Value

NPTC – Neath & Port Talbot Council

NRW - Natural Resources Wales

NSIP – Nationally Significant Infrastructure Project

NTS – National Transmission System

OAST – Options Appraisal Summary Table

OEM – Original Equipment Manufacturer

PARCA – Planning and Advanced Reservation of Capacity Agreement

PIG – Pipeline Inspection Gauge

PINS - Planning Inspectorate - On 1 April 2012, under the Localism Act 2011, the Planning Inspectorate became the agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs). The Planning Inspectorate examines the application and will make a recommendation to the relevant Secretary of State, who will make the decision on whether to grant or to refuse development consent.

PSSR – Pressure System Safety Regulations

PRS – Pressure Reduction Station

RCIS – Route Corridor Investigation Study - An appraisal of the high-level planning and environmental constraints to identify potential Route Corridor options within a defined Area of Search.

RFP – Request for Proposal - is a document that solicits a proposal, made through a bidding process, by an agency or company interested in procurement of a commodity, service, or valuable asset, to potential suppliers to submit business proposals.

RFI – Request for Information - is a standard business process whose purpose is to collect written information about the capabilities of various suppliers.

SAC – Special Area of Conservation - Protected sites designated under the EC Habitats Directive. The listed habitat types and species are those considered to be most in need of conservation at a European level (excluding birds).

SHGCL – South Hook Gas Company Limited

SHLNG – South Hook LNG Terminal Company Limited

SOCC – Statement of Community Consultation

SoCG - Statements of Common Ground

SOR - Strategic Options Report

SoS – Security of Supply

SPA – Special Protection Area - Areas selected by the national government on the advice of English Nature, designated for the protection of particularly sensitive bird species, or for regularly migrating birds.

SSP – Strategic Sourcing Process

SSSI – Site of Special Scientific Interest - An area of land of special interest by reason of its flora, fauna, geology or physiographical features notified under section 28 of the Wildlife and Countryside Act 1981.

SWEP - South Wales Expansion Project

TCPA – Town and County Planning Act

TCS - Technical Consultancy Services

TMP - Traffic Management Plans

TPI – Third Party Interference

UKCS – United Kingdom Continental Shelf

UM – Uncertainty Mechanism

UNC - Uniform Network Code

VSD – Variable Speed Drive

WACC – Weighted Average Cost of Capital

WGN – Western Gas Network project

Appendix II. Phase 1 PARCA Outputs

PARCA Phase 1 Report

II. PARCA Phase 1 Report.pdf

PARCA Phase 1 Report Appendix A – Need Case

II. PARCA Phase 1 Report - Need Case.pc

PARCA Phase 1 Report Appendix B – Technical Options Report

II. PARCA Phase 1 Report - TOR.pdf

Appendix III. PARCA Publications

NOTICE: PARCA APPLICATION – COMPLETION OF PHASE 1 WORKS AND PROPOSAL FOR THE RESERVATION OF NTS CAPACITY 18th January 2019

https://www.nationalgrid.com/uk/gas-transmission/document/125146/download

PARCA Notice
Milford Haven_v1 0.p

NOTICE: PARCA APPLICATION –RESERVATION OF NTS CAPACITY 15th March 2019

https://www.nationalgrid.com/uk/gas-transmission/document/126451/download

PARCA Notice
Capacity Reservation_

Appendix IV. Phase 2 PARCA SOR

Due to file size, document is provided separately.

Appendix V: Optioneering Cost Breakdowns

246. This Appendix provides an overview of the approach to the identification of costs for the options progressed through the assessments described in this report. It explains the basis for estimating costs and identifies the level of uncertainty associated with those costs.

Strategic Option Costing

247. There is overlap between the component elements that are combined into various strategic options for the purpose of cost development. These individual components are referred to as common elements (CEs). The costs for these common elements were built up as follows.

<u>CE0 - Uprating</u>

248. The Uprating cost estimate totalled [redacted]. This estimate was developed from a combination of:

- Effort estimates by Pipeline Integrity Engineers Ltd compiled during the Uprating Viability Assessment
- Known survey/inspection/condition assessment requirements, using framework rates
- An estimation of remediation activity following survey/inspection/condition assessment, based on outturn costs from similar works
- High level estimates for Above Ground Installation modifications (acknowledging that scope of works will be confirmed by ongoing Uprating Assessment phase)
- An estimate of pipeline slabbing works based on a unit cost of [redacted] and likely interventions required following Uprating Viability
- A high level allowance for third party works at South Hook and Dragon terminals
- A legal allowance
- The cost estimates include a [redacted] risk allowance (included to reflect the cost risks associated with the technical complexity of the proposals)

<u>CE1 – CE11 Remaining Common Elements</u>

249. The remaining common element (CE1-CE11) costs were derived from the following components.

Components

Rate	eHub rates (£ Prices Q3 calendar 2019)
Onshore pipeline through rural area per km.	[redacted]
Onshore pipeline through 'S area' as defined by TD/1 per km	[redacted]
Onshore pipeline minor road crossing, open-cut, traffic control per unit	[redacted]
Onshore pipeline major road crossing, other trenchless techniques, per unit	[redacted]
Onshore pipeline minor tributary crossing, open cut and overpump, per unit	[redacted]
Onshore pipeline major river crossing, other trenchless techniques, per unit	[redacted]
Recompression, vent and purge, per go	[redacted]
Two directional stopple operation at 48", per operation	[redacted]
Double stopple and bypass operations at 48", per operation	[redacted]
PIG Trap AGI (per site)	[redacted]

Block Valve per site (assumed Remotely Operable Valve (ROV))		[redacted]
New 3x15MW CS, per station		[redacted]
15MW compressor re-wheeling		[redacted]
Control system modifications at CS		[redacted]

250. For each common element, the rate above was simply multiplied by the quantity within the common element. These quantities are listed in the table below with the calculated cost in the final row.

Common Elements

Common Element or Uprating Option/ Quantity	CE0. Feeder 28 Uprating	CE1. Compressor mods at Felindre	CE2 Wormington to Honeybourne 9km pipeline	CE3 Tirley to Wormington 26km pipeline	CE4 Churchover Mods and 2km pipeline	CE5 New compressor to west of Three Cocks	CE5A New compressor ivo Three Cocks	CE6 Tirley to Wormington 33km pipeline avoid AONB	CE7 Compressor mods at Wormington	CE8. Pipeline duplication Felindre to Llanwrda	CE9. Pipeline Three Cocks to Alrewas	CE10. Other elements to G1.1	CE11. Other elements to G1.3
Uprating where MOP stays below CL600 limit)	1												
Onshore pipeline through rural area (km)			9.675	27.95	2.15			36.8		63.25	109.375	74.175	76.325
Onshore pipeline through ‘S area’ as defined by TD/1 (km)				1				1		1	25	1	1
Onshore pipeline minor road crossing, open-cut, traffic control (number)			5	16	2			17		40	125	50	50
Onshore pipeline major road crossing, other trenchless techniques (number)			1	2	1			4		8	25	8	8
Onshore pipeline minor tributary crossing, open cut and overpump (number)				5				6		3	2	1	1
Onshore pipeline major river crossing, other trenchless techniques (number)				1				2			6	6	6
Recompression, vent and purge (number)			1	1				1					
Two directional stopple operation at 48” (number)						2	2				1		
Double stopple and bypass operations at 48” (number)										1			
PIG Trap AGI (number)			2	2	2			2		2	4	2	2
Block Valve per site (assumed ROV) (number)				1				1		2	6	4	4
New 3x15MW CS (number)						1	1						
15MW compressor re-wheeling (number)		2			1								
Control system modifications at CS (number)		1							1			1	1
Total cost for common element (£)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Strategic Option Selection

251. The strategic options were then assembled from the relevant common elements as follows, with the costs for each of the 11 shortlisted strategic options in the final column. These costs were used in comparisons of the Strategic Options. For later cost benefit analysis, including the FES2020 CBA re-run for Strategic Option Selection, these costs were replaced with those detailed in the subsequent sections of this appendix as more accurate information had become available. This did not affect decision making since the costs for F6.6 increased, lowering the NPV, but F6.6 still performed best in the short-term horizon CBA across all FESs.

(£)	Uprating (where MOP stays within flange classification limits)	CE1. Compressor mods at Felindre	CE2 Wormington to Honeybourne 9km pipeline	CE3 Tirley to Wormington 26km pipeline	CE4 Churchover Mods and 2km pipeline	CE5 New compressor to west of Three Cocks (3 of 15MW)	CE5A New compressor ivo Three Cocks (3 of 15MW)	CE6 Tirley to Wormington 33km pipeline avoid AONB	CE7 Compressor mods at Wormington	Pipeline duplication Felindre to Llanwrda (4.1 and 4.2)	Pipeline Three Cocks to Alrewas	Other elements to G1.1	Other elements to G1.3	Totals (nearest £10k)
F3.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F3.2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F3.3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F4.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F4.2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F6.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F6.2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F6.6	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F7.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
G1.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
G1.3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

252. Both scope and estimating approach varies between the estimates for Strategic Option Selection and Strategic Option Refinement. The scope of F6.6c (1200 Base) is closest to the scope assumptions used for Strategic Option Selection, but the following variances remain:

- 3x re-wheels added at Wormington, following the output of a Process Duty Specification led by the Wormington Medium Combustion Plant Directive project team
- Tirley modifications added, following identification of the requirement to significantly reduce the pressure drop across the site to facilitate flows in excess of 60mcmd supported by the other reinforcements
- Removal of Churchover re-wheel, following the identification of a partial bypass arrangement which removed the requirement for it
- Removal of control system modifications to compressor stations Felindre and Wormington due to improved understanding of possible running configurations
- Removal of requirement for recompression since feasibility/conceptual design studies indicate that pipeline connections can be facilitated without it
- Addition of stopple operations since feasibility/conceptual design studies initially identify a requirement for 4 at Churchover
- Changes in assumptions concerning the extent of equipment replacement that may be required to facilitate uprating (note that this predominantly considers the larger extent of uprating included in F6.6c since there are a higher number of AGI's on Milford Haven to Felindre and a greater population density in the surrounding areas)
- Removal of costs for third party works at LNG terminals due to ongoing uncertainty (only relevant for F6.6c)
- Removal of some condition assessments and repairs for uprating on the basis that these will be performed, in most cases, as business as usual activities funded from Operational Expenditure. One exception to this is the decision to include Magnetic Flux Leakage (MFL) Circumferential In Line Inspection (ILI), in addition to MFL Axial, for the pipelines to be uprated. This is to increase the probability of detection of small steep sided corrosion defects associated with Alternating Current corrosion and will be funded by this project.

253. Regardless of these scope changes, there are material differences in the estimates including:

- An increase in pipeline costs due to an increase in the effective rate/km of new pipeline. The rate used for Strategic Option Selection was derived from outturn costs on pipelines approximately 20km-40km in length and therefore includes an economy of scale which is not realised by the smaller pipeline lengths in the Strategic Option Refinement. Furthermore, inflation and increase in commodity prices have increased the cost of the raw materials for pipeline construction.
- There is a reduction in cost associated with pipeline crossings. Strategic Options Selection was based on a very wide route corridor. Strategic Options Refinement benefits from the Route Corridor Study and Preliminary Route, which identifies most road crossing as smaller B roads and lanes
- Cost for 'PIG Trap AGIs' has reduced significantly since the feasibility/conceptual design studies indicate that new pipeline connections can be accommodated mostly within existing AGIs (except for Churchover Tee which may require extension).
- An increase in the risk allowance due to availability of a quantified Predict Risk Register that was not available for Strategic Options Selection. For Strategic Options Selection the only risk included was a [redacted] risk on uprating to account for the technical complexity and uncertainty surrounding scope. This risk remains and is represented as conservatism in the modification cost assessments and within risks on the Predict! Risk Register.

Strategic Option Refinement

254. As noted elsewhere in this document, a process of refinement sought to optimise the detail of the preferred strategic option by comparing alternatives such as pipeline dimensions. For this refinement eHub estimates were developed and are summarised as follows. As will be apparent there was also some evolution in the cost confidence levels by this stage.:

Name	1200 Base	1200 Light	900 Light	900 Min
Identifier	**F6.6c**	**F6.6d**	**F6.6e**	**F6.6f**
Description	• 1200mm Wormington to Honeybourne pipeline • 900mm Churchover pipeline • All uprating • New 1050mm Tirley bypass • 2 Rewheels at Felindre • 3 Rewheels at Wormington	• 1200mm Wormington to Honeybourne pipeline • 900mm Churchover pipeline • Uprating East of Felindre • Reconfiguration of existing Tirley Bypass • 2 Rewheels at Felindre • 3 Rewheels at Wormington	• 900mm Wormington to Honeybourne pipeline • 900mm Churchover pipeline • Uprating East if Felindre • Reconfiguration of existing Tirley Bypass • 2 Rewheels at Felindre • 3 Rewheels at Wormington	• 900mm Wormington to Honeybourne pipeline • 900mm Churchover pipeline • No uprating • Reconfiguration of existing Tirley Bypass • 3 Rewheels at Wormington
Replacement of any ancillary equipment not rated to uprated pressure (also includes Felindre re-wheels)				
	[redacted]	[redacted]	[redacted]	
Blackbridge New PRS and Site Extension.				
	[redacted]			
Tirley Upgrade (option 3)				
	[redacted]	[redacted]	[redacted]	[redacted]
Felindre MJ Feeder Move				
	[redacted]			
Cilfrew PRI Modifications & Heating				
	[redacted]	[redacted]	[redacted]	
Altwern AGI Modifications				
	[redacted]	[redacted]	[redacted]	
Three Cocks Boundary Control / HIPPS				
	[redacted]	[redacted]	[redacted]	
Wormington Compressor Re-Wheels				
	[redacted]	[redacted]	[redacted]	[redacted]
Wormington - Honeybourne Pipeline (9.45km)				
	[redacted]	[redacted]	[redacted]	[redacted]
Churchover Pipeline (1.77km)				
	[redacted]	[redacted]	[redacted]	[redacted]
Pipeline Protection				
	[redacted]			
Sub Total	[redacted]	[redacted]	[redacted]	[redacted]
Lower Confidence Level [redacted]				
Higher Confidence Level [redacted]				
Project Spend to Date (SOR and Need Case Development) **Project Support Services Forecast** (Consents, Land, Communications, Legal, PMO) **Risk / Contingency**	[redacted] [redacted] [redacted] [redacted] [redacted]	[redacted] [redacted] [redacted] [redacted] [redacted]	[redacted] [redacted] [redacted] [redacted] [redacted]	[redacted] [redacted] [redacted] [redacted] [redacted]
Grand Total Lower Confidence Level	[redacted]	[redacted]	[redacted]	[redacted]
Grand Total Higher Confidence Level	[redacted]	[redacted]	[redacted]	[redacted]
Average (for CBA)	[redacted]	[redacted]	[redacted]	[redacted]

Total Installed Cost for the Preferred (Refined) Option

255. This cost is the same as that used for Strategic Options Refinement but is broken down into more detail for the Preferred (Refined) Option:

F6.6e (900 Light)

- 900mm Wormington to Honeybourne pipeline
- 900 mm Churchover Tee to Multijunction and reconfiguration
- Uprating Felindre to Three Cocks and Felindre to Cilfrew only
- Reconfiguration of existing Tirley Bypass
- 2 Rewheels at Felindre
- 3 Rewheels at Wormington

Description	Quantity	Unit	Rate	Total
Replacement of any ancillary equipment not rated to uprated pressure.				
Felindre Compressor				[redacted]
Llanwrda BV				[redacted]
MWC PM				[redacted]
MWC Design				[redacted]
MWC Site Establishment				[redacted]
NG PM				[redacted]
MWC Construction				[redacted]
Support & Other Resource				[redacted]
				[redacted]
Tirley Upgrade (option 1)				[redacted]
Tirley PRI				[redacted]
MWC PM				[redacted]
MWC Design				[redacted]
NG PM				[redacted]
MWC Construction				[redacted]
Support & Other Resource				[redacted]
				[redacted]
Cilfrew PRI Modifications & Heating				[redacted]
Cilfrew PRI				[redacted]
MWC PM				[redacted]
MWC Design				[redacted]
NG PM				[redacted]
MWC Construction				[redacted]
Support & Other Resource				[redacted]
				[redacted]
Altwern AGI Modifications				[redacted]
Altwern AGI				[redacted]
MWC PM				[redacted]
MWC Design				[redacted]
NG PM				[redacted]
MWC Construction				[redacted]
Support & Other Resource				[redacted]
				[redacted]
Three Cocks Boundary Control / HIPPS				[redacted]
Three Cocks AGI				[redacted]
MWC PM				[redacted]

MWC Design				[redacted]
NG PM				[redacted]
MWC Construction				[redacted]
Support & Other Resource				[redacted]
				[redacted]
3 x Wormington Compressor Re-Wheels				[redacted]
Wormington Compressor				[redacted]
MWC PM				[redacted]
MWC Design				[redacted]
MWC Site Establishment				[redacted]
NG PM				[redacted]
MWC Construction				[redacted]
Support & Other Resource				[redacted]
				[redacted]
Wormington - Honeybourne Pipeline 900mm (9.45kM)				[redacted]
Pipeline				[redacted]
MWC PM				[redacted]
MWC Design				[redacted]
MWC Site Establishment				[redacted]
NG PM				[redacted]
MWC Construction				[redacted]
Support & Other Resource				[redacted]
				[redacted]
Churchover Pipeline (1.77Km) Option 6				[redacted]
Pipeline				[redacted]
MWC PM				[redacted]
MWC Design				[redacted]
MWC Site Establishment				[redacted]
NG PM				[redacted]
MWC Construction				[redacted]
Support & Other Resource				[redacted]
				[redacted]
4.2 Estimate Lower Confidence Level	[redacted]	%	[redacted]	[redacted]
4.2 Estimate Higher Confidence Level	[redacted]	%	[redacted]	[redacted]
Project Spend to Date (SOR and Need Case Development)				[redacted]
Project Support Services Forecast (Consents, Land, Communications, Legal, PMO)				[redacted]
Risk / Contingency				[redacted]
Grand Total Lower Confidence Level				[redacted]
Grand Total Higher Confidence Level				[redacted]
Average				[redacted]

Appendix VI: Technical Summary of Physical and Operational Changes

The following table summarises the planned changes associated with the project:

VI.
WGN_Technical_Sum