Annex

A16.14 King's Lynn Compressor Engineering Justification Paper

December 2019

As a part of the NGGT Business Plan Submission

nationalgrid

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1. Executive Summary

1.1 This paper sets out our proposals at the King's Lynn compressor site to ensure sufficient network capability to fulfil our customer and operational requirements, whilst also complying with the Medium Combustion Plant Directive (MCPD) emissions legislation. This justification paper supports the high level proposals in chapter 14 of the NGGT RIIO-2 business plan "I want to take gas on and off the transmission system where and when I want", and chapter 16 "I want to care for the environment and communities". . This justification paper should be read in conjunction with the Compressor Emissions Compliance Strategy (CECS) in Annex A16.05 to the business plan.

1.2 King's Lynn, which performs a critical role on the National Transmission System (NTS), is used to resolve supply-demand imbalances in the South East. This is a unique area on the network, including the bi-directional interconnectors (IUK and BBL) at Bacton and the Liquefied Natural Gas (LNG) importation facility at Isle of Grain. This means that the South East has the potential to be in a net supply or demand position at any time of year, depending on the flows from these entry terminals which are market driven and difficult to predict.

1.3 King's Lynn is a bi-directional compressor station that comprises two Rolls Royce Avon compressors (Units A and B) and two Siemens SGT400 compressor (units C and D). Units C and D are the lead units which may be operated singly or in parallel according to the flow levels required. Unit B provides resilience to units C and D. Unit A was disconnected in 2017 after becoming life expired and beyond economical to continue investing in for current and future requirements. The two Avon units are not compliant with the MCPD and therefore, a solution needs to be found prior to the compliance date of 1 January 2030.

1.4 We expect the volatility of continental and LNG flows in the South East to increase into the future as United Kingdom Continental Shelf (UKCS) supplies continue to decline. Our forecasts indicate that the 2030s could be a period of critical importance for King's Lynn in ensuring that the UK remains an attractive destination for gas by ensuring the availability of capability at these terminals.

1.5 The options considered for MCPD compliance were compared in a Cost Benefit Analysis (CBA). This compared the costs of installing and maintaining the proposed new units (the option with the highest positive Net Present Value (NPV)), together with estimates of constraint costs associated with the differing levels of capability and availability under each alternative option, to arrive at the lowest overall cost to consumers, see Table 1. The Future Energy Scenarios 2018 (FES 2018), Steady Progression scenario was used in our analysis as the base case for the CBA with sensitivities being run against the other three scenarios, these are given in Table 2. Further detail is provided in Section 7.

Table 1: CBA Cost Inputs (2018/19 price base)

Cost (£m) – over 25 years from 2030	Option							
	0-Counter factual	**1- Two new units**	**2-Two new units + uprate**	**3-One new unit**	**4-One new unit + uprate**	**5-Decommission 2029**	**6-SCR one unit**	**7-One new large unit**
Operating costs over 25 years	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Constraint cost*	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total CAPEX cost, including the below:	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
•Total installed costs	N/A	[redacted]	[redacted]	[redacted]	[redacted]	N/A	[redacted]	[redacted]
•Merging of control systems	[redacted]	N/A	N/A	N/A	N/A	N/A	[redacted]	N/A
•Station pipe uprating	N/A	N/A	[redacted]	N/A	[redacted]	N/A	N/A	N/A
•Asset health costs over 25 years	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
•Decommissioning costs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 2: CBA Results[1]

Short Name	Description	Central Case Steady Progression	High Sensitivity Two Degrees	Low Sensitivity Consumer Evolution	Additional Sensitivity Community Renewables
Option 0	0 - Counterfactual	£ 0m	£ 0m	£ 0m	£ 0m
Option 1	1 - Two new units	-£ 37m	£ 150m	£ 26m	-£ 47m
Option 2	2 - Two new units + uprate	-£ 54m	£ 132m	£ 3m	-£ 71m
Option 3	3 - One new unit	-£ 16m	£ 102m	£ 16m	-£ 25m
Option 4	4 - One new unit + uprate	-£ 29m	£ 115m	£ 4m	-£ 46m
Option 5	5 - Decommission 2029	-£ 16m	-£ 487m	-£ 251m	-£ 14m
Option 6	6 - SCR one unit	-£ 15m	£ 27m	-£ 7m	-£ 12m
Option 7	7 - One new large unit	-£ 31m	£ 96m	£ 5m	-£ 39m

1.6 Our preferred proposal is to proceed to Front End Engineering Design (FEED) with the option of building two new, gas–driven compressor units (of similar rated power to the existing Avon units - approximately 15MW each). Proceeding to FEED in the T2 period ensures this option can be delivered in time to achieve the related benefits should the FES Consumer Evolution and Two Degrees scenarios unfold. Recognising the uncertainty around the exact solution required, and the variables in the FES scenarios, we are proposing that investment taking place post FEED be subject to an Uncertainty Mechanism (UM) process. We are not requesting baseline funding for expenditure post-FEED at this time. Allowances and the price control deliverable will be set through the UM process. Please see Annex A3.02 for further detail on our UM proposal.

1.7 The current estimated cost for the preferred option is [redacted][2] (including FEED) in RIIO-2 for design and start of construction and [redacted] in RIIO-3 for completion of compressor build, in order that the site is fully available ahead of the MCPD deadline. Included is the cost of decommissioning of the two non-compliant units in RIIO-3 at [redacted]. Delivery will be measured through a Price Control Deliverable (please see annex A3.01 for further information).

1.8 We will undertake a preliminary Best Available Techniques (BAT) assessment on the options for MCPD compliance at King's Lynn. This established, stepwise assessment process is underpinned by an environmental Cost-Benefit Analysis (CBA) methodology, which draws together environmental and operational priorities to support decision making. The assessment will be undertaken independently from the CBA analysis and is a different methodological approach; it however incorporates consistent assumptions on cost, investment cases and future gas supply predictions.

1.9 In this paper, a 'Medium' unit refers to a unit of similar rated power to an existing Avon compressor unit – approximately 15MW. A 'Large' unit refers to a unit of similar rated power to an existing RB211 compressor unit – circa 27MW+.

[1] Note that these calculated NPVs assume a capitalisation rate of 73.5% as set out in CECS (Annex A16.05). This capitalisation rate has now been updated, and therefore there may be a minor mismatch between quoted NPVs between this document and the associated CBA (Annex A16.11). Please note that this does not affect the final proposed option. The impact of the updated capitalisation rate is reflected in the CBA document.

[2] Note that the CBA reflects project costs of [redacted] rather than [redacted]. This is because the CBA includes additional OPEX and asset health costs not covered by this specific RIIO-2 CAPEX investment.

2. Summary Table

The costs in this summary table and throughout the document are in 2018/19 price base.

Name of Project	King's Lynn MCPD		
Scheme Reference	TBC		
Primary Investment Driver	Compliance with MCPD legislation.		
Project Initiation Year	2019		
Project Close Out Year	2028		
Total Installed Cost Estimate (£)	[redacted] (two new units) [redacted] (decommissioning two units)		
Cost Estimate Accuracy	P50		
Project Spend to date (£)	£0.02m		
Current Project Stage Gate	4.1 - Establish Portfolio		
Reporting Table Ref	TBC		
Outputs included in RIIO-1 Business Plan	No		
Spend apportionment	**RIIO-1**	**RIIO-2**	**RIIO-3**
	£0.02m (spend to date)	[redacted][3]	[redacted]

3. Project Status and Request Summary

3.1 Existing levels of capability are required to be maintained at King's Lynn compressor site. National Grid is requesting funding at King's Lynn to ensure this capability is compliant with the Medium Combustion Plant Directive (MCPD). Two of the four compressor units are impacted by the legislation. Further information on the MCPD and legislative drivers can be found in the CECS in annex A16.05 of the business plan.

3.2 In our business plan, we have proposed proceeding to FEED with option 1 – build two new, gas–driven compressor units of similar rated power to the existing Avon units (approximately 15MW each). In two of the four FES 2018, investment is critical. Proceeding to FEED in the RIIO-2 period ensures this option can be delivered in time to achieve the benefits of this option should the Consumer Evolution and Two Degrees scenarios unfold. This also allows sufficient flexibility if at a later stage, with further information on the supply/demand pattern and volatility, it becomes clear that the Option 1 level of investment is not required, as it could be converted to a single unit option or the counterfactual. We will utilise the UM set out in Annex A3.02 if an alternative option is to be taken forward after FEED. However, recognising the uncertainty around the exact solution required, and the variables in the FES 2018 scenarios, we are proposing that investment taking place post FEED is subject to an UM process. We are not requesting baseline funding for expenditure post-FEED. Allowances and the price control deliverable will be set through the reopener process. Please see Annex A3.02 for further detail on our UM proposal. Key proposed timelines for this are as follows, full information on each stage is set out in annex A3.02:

- FEED feasibility – January to June 2022
- Ofgem touchpoint – July 2022
- Tender process & BAT – August 2022 to January 2023
- Reopener (with Ofgem) – February – May 2023
- Decision required – June 2023

[3] See footnote 2.

3.3 At King's Lynn, the current estimated cost is [redacted] (including FEED) in RIIO-2 for design and start of construction and [redacted] in RIIO-3 for completion[4]. Included is the cost of decommissioning the two non-compliant units in RIIO-3 at [redacted].

3.4 The project is currently in stage 4.1 ('Establish Portfolio') of the Network Development Process (ND500) – a process aimed at defining and managing the project lifecycle from inception to closure, ensuring we meet minimum requirements for each project phase (for more information refer to CECS). Decommissioning of Units A and B is planned to start in 2028 once the new units are fully operational.

3.5 We have considered and costed several options for the site which would meet its operational requirements. These options have been costed, both from an asset and commercial view. Our recommended solution is supported by a CBA which has considered investment costs for compressors; the costs of constraints and contracts; and compressor running costs.

3.6 The CBA assessment concluded it is more cost efficient to invest in new assets instead of managing operational restrictions commercially. The new units have been sized for the network need.

3.7 Preliminary Best Available Techniques (BAT) analysis will be undertaken to input to FEED to support our CBA and to feed into the decision-making process. BAT analysis is an assessment of the available techniques best placed to prevent or minimise emissions and impacts on the environment. Please refer to the CECS document for more information. Options to undergo Preliminary BAT assessment range from emissions abatement to new build solutions and are in line with those highlighted in Section 6 of this paper.

3.8 The decommissioning of Unit A is included in this justification paper and will occur in RIIO-3 at a cost of [redacted].

3.9 Related emissions legislation compliance work was not undertaken at King's Lynn site during RIIO-1. However, we undertook a number of other emissions compliance projects and learnings will feed into our RIIO-2 compressor emissions compliance projects. More information on this can be found in CECS.

[4] See footnote 2.

4. Problem / Opportunity Statement

4.1 The purpose of this project is to achieve compliance with the MCPD at King's Lynn compressor site and in order to provide the capability the network requires. For more information on the MCPD, please refer to CECS.

4.2 King's Lynn comprises four compressor units, as shown in **Figure 1** and **Table 3**. The two Rolls Royce Avons (Units A and B) are impacted by MCPD. However, Unit A was disconnected from the network in 2017 after becoming life expired and beyond economical to continue investing in for current requirements. The compressor cab for Unit A still remains but the compressor bundle has been re-deployed to Kirriemuir compressor station and the engine has been removed. This means that current site capability is lower than its designed capability. At present, Avon Unit B and Siemens SGT400 Units C and D are operational.

4.3 A significant increase in run hours at King's Lynn is forecast in some scenarios during the 2030s. The number of days on which parallel operation (running two compressors simultaneously) will be needed is forecast to peak during this period as UKCS flows continue to decline and supplies from interconnectors and LNG increase. This means we need a fully resilient parallel operation capability in order to maintain our customers' requirements to flow gas on and off the network. This supports the need to have two new, MCPD-compliant units to provide resilience to the two existing SGT units.

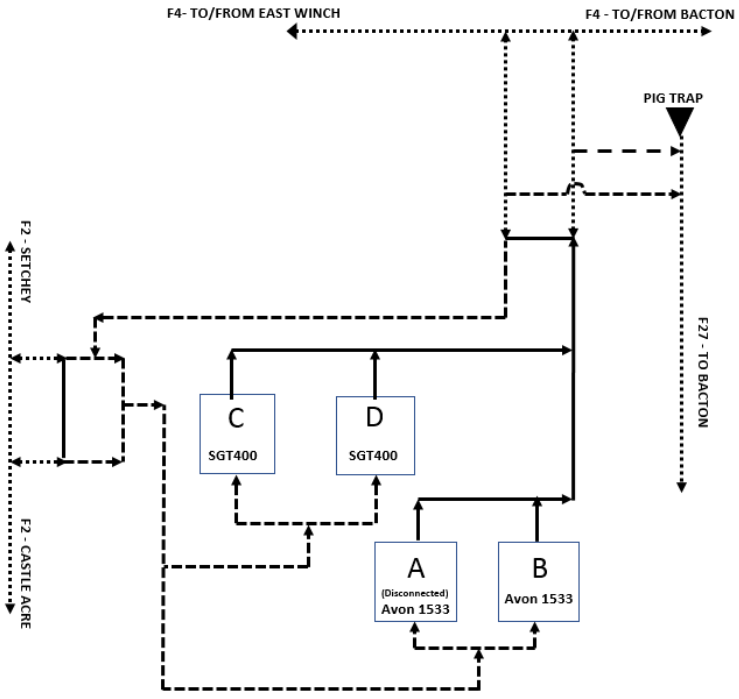

Figure 1: King's Lynn Site Schematic

Table 3: Existing Assets Summary

Unit	Engine	Fuel Type	Power Base (MW)	Installation Date	Minimum Operational Flow (mscm/d)	Nominal Capacity (mscm/d)	Maximum discharge pressure (barg)
A (disconnected)	RR/Avon	Gas	12.34	1971	13	56	75 – West 70 - East
B	RR/Avon	Gas	12.34	1971	9	56	
C	Siemens SGT400	Gas	12.9	2000	15	42	
D	Siemens SGT400	Gas	12.9	2003	16	42	

4.4 King's Lynn provides several functions on the network including:

- Supporting the Bacton terminal exit flows through the interconnectors
- Moving gas away from the South East when combined flows from the Bacton and Isle of Grain terminals exceed local demand.

4.5 The need for the site to be available all year round to support high entry flows in the winter and high exit flows in the summer makes scheduling of maintenance outages challenging.

4.6 A key feature of the proposed solution is to restore resilience of the site and allow access for maintenance without disrupting our customers' requirements to flow gas on and off the network.

4.7 The 2030s will potentially be a decade of critical importance for King's Lynn. As UKCS supplies continue to decline, this will lead to higher imports via interconnectors and/or LNG. This will result in higher net supplies into the South East during the winter, as the volume of gas entering the South East from the interconnectors and Isle of Grain LNG terminal rises relative to demand; and to higher net exports during the summer with a reduced offset of lower UKCS supplies at Bacton. Therefore, we expect utilisation of King's Lynn compression to increase both in summer and winter. In particular, the frequency of parallel operation (running two compressors simultaneously) to support higher exit flows is forecast to increase significantly.

4.8 If we do not invest in new compressors, i.e. place the units on derogation, we risk significant disruption to entry and exit flows in the Bacton area due to resilience only being provided by a single unit limited to 500 hours annually (on a rolling five-year average). This would lead to significant constraint costs to industry and could potentially increase costs to consumers by disrupting the efficient working of the market.

4.9 Our proposal, which gives us the potential to accommodate the wide range of possible scenarios, is to build two new, gas-driven compressor units (of similar rated power to the existing Avon units) on adjacent, unused land within National Grid land at King's Lynn, sized to meet the capability required for current and future customers. Building on adjacent land allows the existing compressor units to be used until the new units have been operationally accepted. This will optimise unit availability and provide support to a wide range of Bacton and South East flows. Once the new units are in service, Avon Units A and B would be decommissioned.

4.10 The ND500 stage gates (see 3.4 for explanation) ensure we meet minimum requirements for each project phase, for more information refer to CECS. The indicative dates for the key milestones are based on our current experience of investment in new compressors. Milestone dates have been informed by scheduling this project against other planned investment work. The start of Original Equipment Manufacturer (OEM) design and build phase is 2023 with operational acceptance and project closure in 2028. Therefore, our key milestones are estimated around this time scale, as shown in **Table 4**. **Table 42** in Section 8.8 provides more detail.

Table 4: Key Milestone Dates

New Build			
Cycle	**Network Development Stage Gates**		**Indicative Dates**
			King's Lynn
Pre-FEED Stage 4.0 and 4.1	**T0 – T2**	• Generation of Need Case • Accept Need Case • Initial Sanction • Define Strategic Approach & Outputs Required to Deliver • GT Handover to Delivery Unit	April 2019 – June 2022
FEED Stage 4.2	• **F2** • **F3**	• FEED Sanction and Feasibility Sanction • Includes BAT assessment and Compressor Machinery Train selection • Reopener process • Agreement to Proceed to Conceptual Design • Conceptual Design Sanction and Sanction of long lead items	• **June 2022** • **June 2023**
Tender Award Stage 4.3	**T4**	• Scope Freeze	September 2024
Project Execution Stage 4.4	• **F4** • **T5**	• Detailed Design AND Build Sanction (T4-F4-T5) • DDS Challenge, Review & Sign off Maintenance Requirements Identified	• September 2024 • June 2025
Acceptance Stage 4.5	• **T6** • **T5**	• Post Commissioning Handover to GT • Operational and Maintenance Complete or Planned • (Operational Acceptance) • Project Closure	• June 2027 • March 2028

4.11 We will know if the project has been successful through operational acceptance of the new assets, meeting customer demands throughout construction and complying with MCPD legislation as well as the project completed to time, quality and cost. Delivery will be measured through a Price Control Deliverable. Please see Annex A3.01 for more information on this.

4.12 The challenges to this project are summarised below and elaborated further in **Table *43***:

- Outages;
- Appropriate flows for commissioning;
- Land; and
- Contracts.

4.13 Circumstances that would lead to a change in the need or option for this project are summarised as:

- Changes in supply and demand patterns beyond the FES 2018;
  - Investment or new discoveries in UK gas production (UKCS, Shale and green gas). This could reduce important dependency but increase the compression requirements to support UKCS entry and interconnector exports.
  - New discoveries that increase UKCS gas supplies.
  - Changes in the interconnectors' operating models or services that either increase or decrease supplies from Europe.
  - UK moving towards a Hydrogen market sooner than 2030 and to a bigger scale.
  - Closure of storage sites that are no longer economic requiring additional LNG or interconnector flows to balance supply and demand.

    - Changes in Gas Safety (Management) Regulations (GS(M)R) requirements allowing entry of lower quality gas from UKCS fields and the blending of Hydrogen. This would reduce UK import dependency but allow non-compliant fields in the Bacton area to enter the system.
    - How the government implements the findings of the Climate Change Act 2008 (2050 Target Amendment) from May 2019;
        - Use hydrogen and electrification to replace fossil fuel.
        - Use electricity/hydrogen for transport without an interim biofuel step.
- Changes in European markets;
    - Conversion of European power stations to gas which could reduce imports through the interconnectors and increase UK dependency on LNG.
    - Europe and Norway move to a Hydrogen based market at different timescales to the UK. This reduces the flows through the interconnectors.
    - New pipelines from Russia reducing LNG requirements in other parts of the world results in additional cargoes to the UK.
- Changes in the 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 2007. This would result in greater flows through the interconnectors as UK import dependency increases.
- Uncertainty over the impact on the gas industry of net-zero target for 2050.
- Outcomes from Preliminary BAT assessment and tender which may influence the choice of technology, with alternative units being provided by OEMs such as proposed units offering hydrogen compatible compression.

Related Projects

4.14 Projects related to King's Lynn MCPD are:

- King's Lynn Above Ground Installation (AGI) rebuild;
- The RIIO-2 asset health works close to King's Lynn;
- Bacton site redevelopment;
- BBL reverse flow project;
- Technology investments (e.g. cyber projects, asset health etc.).

Project Boundaries

4.15 The scope of this project is only for costs associated with the implementation of the MCPD. For King's Lynn, these are costs for building two new units and decommissioning two non-compliant units. Other costs such as asset health costs and operational running costs are included in the CBA, although we are not requesting funding through this paper.

5. Project Definition

Supply and Demand Scenario Discussion and Selection

5.1 To fully assess the project, a network assessment and a risk and constraint assessment was carried out. The network assessment was done to define the capability boundaries, for more information refer to the Network Capability chapter and CECS. The boundaries feed into the constraint and risk assessment to define the associated costs. We have used the Steady Progression scenario from the FES 2018 as the base scenario for this proposal as it provides an appropriate central case for King's Lynn's expected use. Please see CECS Section 5 for full details.

Current Site Operation

5.2 The annual (financial year) running hours of the three units are shown in **Table 5.** The table shows that running hours are typically at a relatively low level with a marked increase during 2017/18. This was due to high Bacton exit flows during the summer and high Bacton entry flows during the winter.

Table 5: Run hours – as reported in the Regulatory Reporting Pack

	Individual Unit Running Hours *(financial year)*					
	2013/14	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**2018/19**
King's Lynn Unit A	2	4	0	13	N/A	N/A
King's Lynn Unit B	21	7	3	12	747	21
King's Lynn Unit C	194	16	14	22	10	72
King's Lynn Unit D	87	8	12	139	1,131	26
Total	**304**	**35**	**28**	**186**	**1,887**	**118**

Supporting South East Terminal Entry Flows

5.3 King's Lynn is primarily needed when supplies to the South East exceed demand. Historically this has happened at very high levels of supply at Bacton; for example, in the winter of 2017/18 we saw supplies close to 140 mscm/d at Bacton which led to high running hours at King's Lynn.

5.4 While UKCS supplies from Bacton are forecast to reduce, we expect the levels of supply from the Isle of Grain to increase. This will reduce the amount of Bacton supply that will be used to meet South East demand and increase the need to use King's Lynn to move Bacton supplies to other demand areas.

5.5 ***Figure 2*** to ***Figure 9*** show the risk of constraints under different asset availability assumptions. Each dot on the chart is associated with one day in that year and for every day there is 1000 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. The table at the top of the chart shows how the number of dots above a line translates into constraint days.

5.6 In scenarios with high entry levels and low demands in the South East we are at risk of entry constraints. **Figure 2** shows that in the Steady Progression scenario there is a small risk currently if two units operating in parallel at King Lynn is not available, but that this risk is declining.

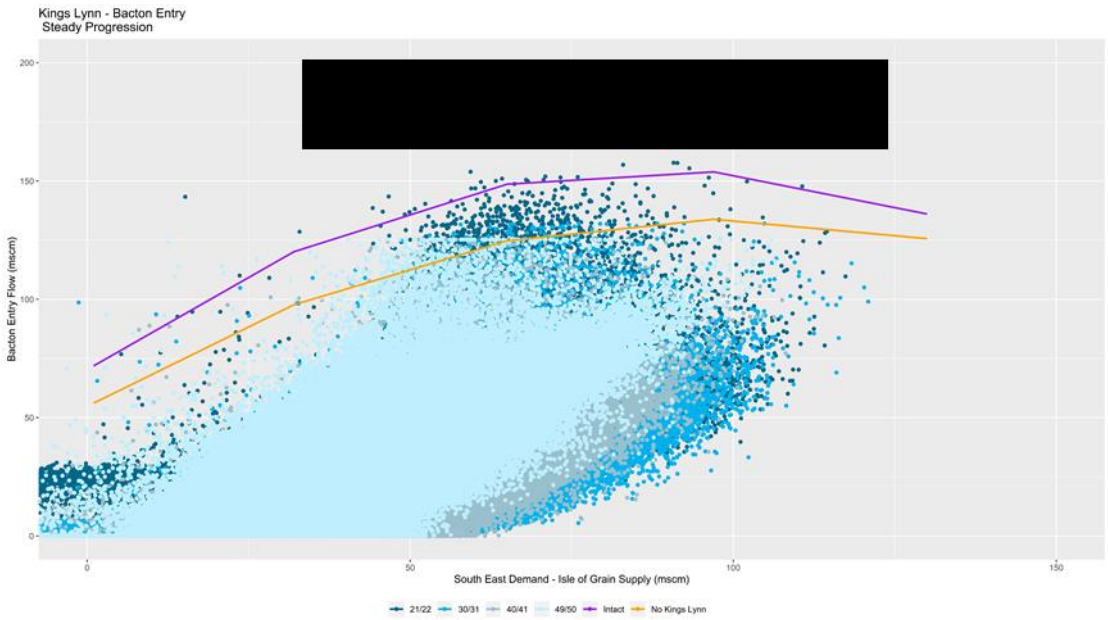

Figure 2: South East Entry Capability (Steady Progression 2018)

5.7 **Figure 3** shows capability in the high case scenario, Two Degrees. The declining demand in the South East combined with increased import dependence, through either the interconnectors or the Isle of Grain LNG terminal, result in the risk increasing after the 2030s.

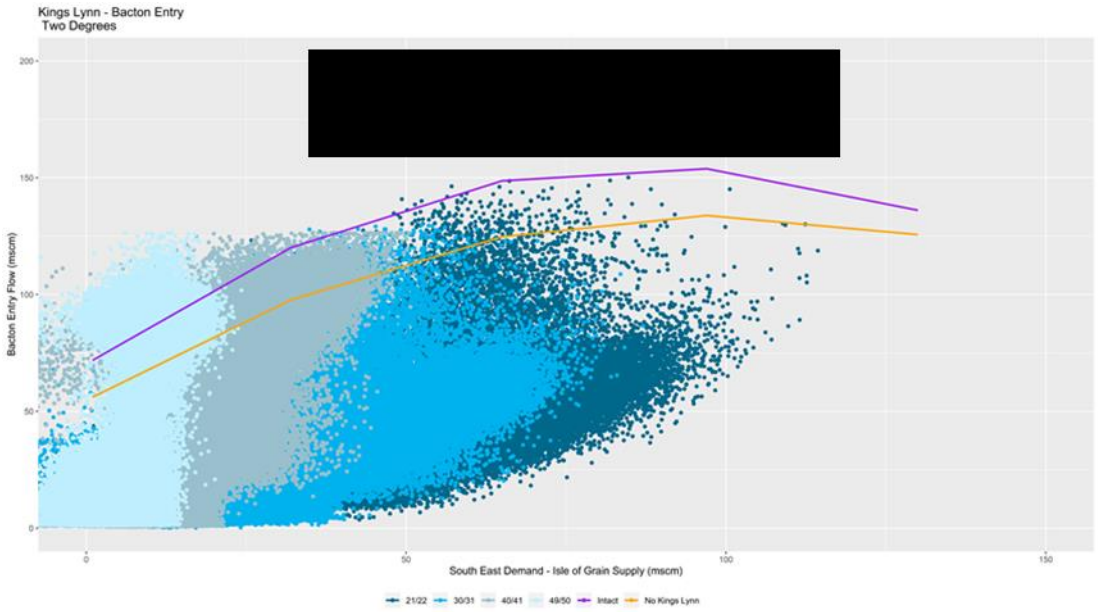

Figure 3 South East Entry Capability (Two Degrees 2018)

5.8 Figure 4 shows capability in the low case scenario, Consumer Evolution. This shows only a small risk in the Steady Progression scenario.

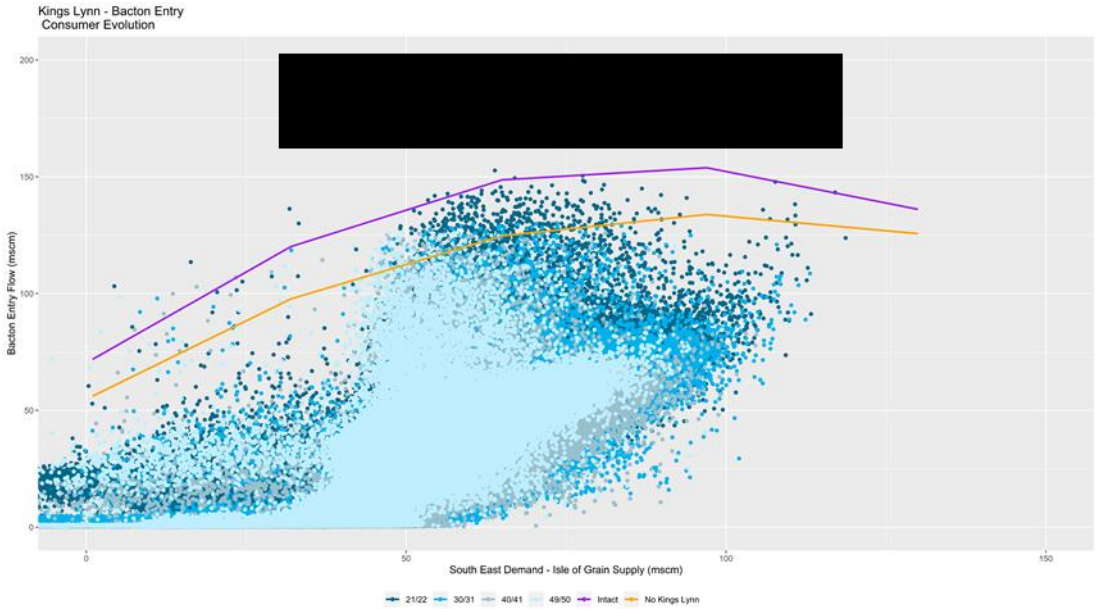

Figure 4: South East Entry Capability (Consumer Evolution 2018)

5.9 Figure 5 shows capability in the final scenario, Community Renewables. This is showing there is a small increase in risk from 2030 until 2041.

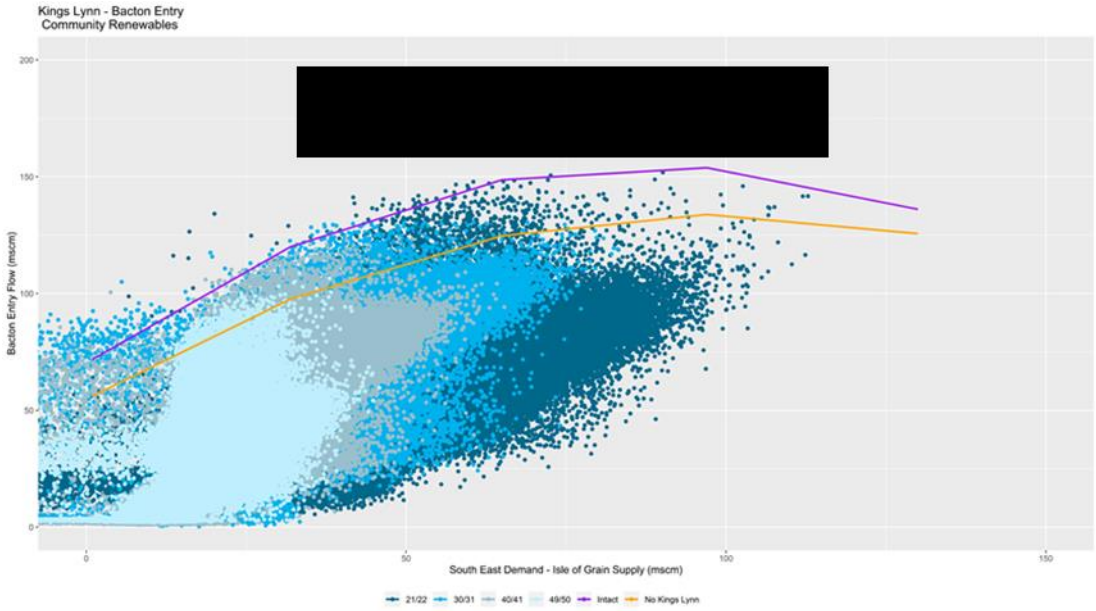

Figure 5: South East Entry Capability (Community Renewables 2018)

Supporting Bacton Terminal Export Flows

5.10 The following charts (**Figure 6**, **Figure 7**, **Figure 8** and **Figure 9**) provide a visual of Bacton Terminal exports for different FES 2018 scenarios. Below is a summary, explaining chart content:

- A single unit at King's Lynn can cope with flows up to 42 mscm/d, regardless of NTS demand – hence the one flat yellow line.
- The top of the dots is set by IUK capacity of 58 mscm/d, there would always be some flows at this level in all scenarios.
- **Figure *3*** to **Figure *6*** have a much stronger relationship with demand so the capability lines move and the flows tend to include some supply and demand elements so they fluctuate more based on the scenario.

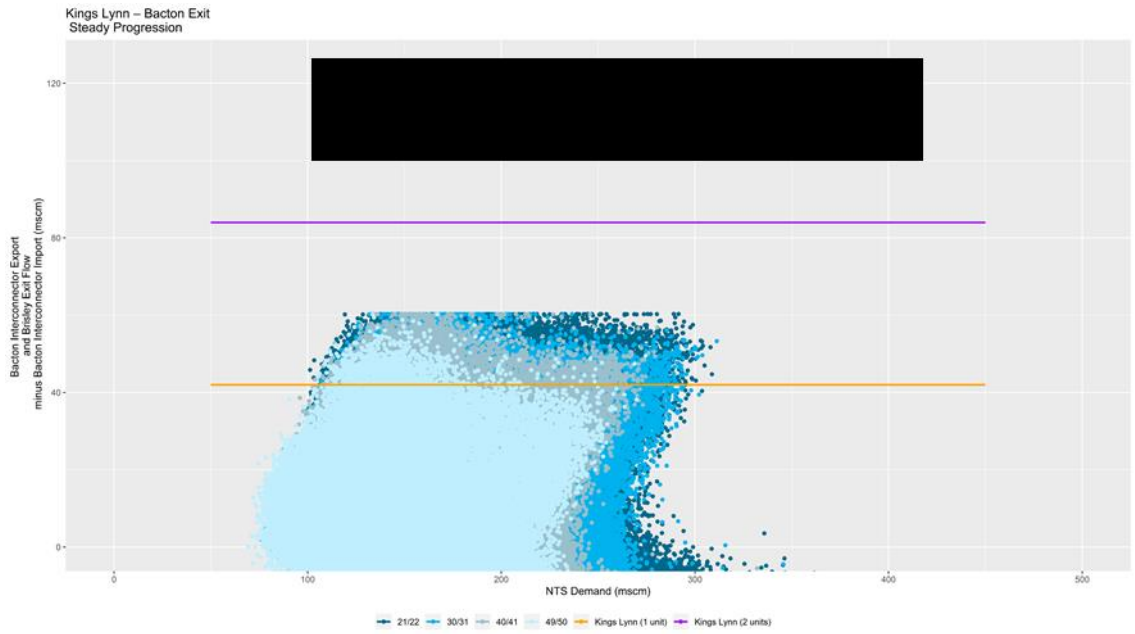

Figure 6 :Bacton Terminal exports (Steady Progression 2018)

5.11 The compression at King's Lynn is also used to support export flows from Bacton to both IUK and BBL. **Figure 6** shows that in the Steady Progression scenario, the requirement for two units to operate in parallel to support Bacton terminal exports remains high until after 2040/41.

5.12 **Figure *7*** shows the high case for Bacton exports, the Consumer Evolution scenario. In this scenario, there is an increase in the level of exports caused by a high level of supply of indigenous shale gas which exceeds demand in the summer and is available for export to Europe.

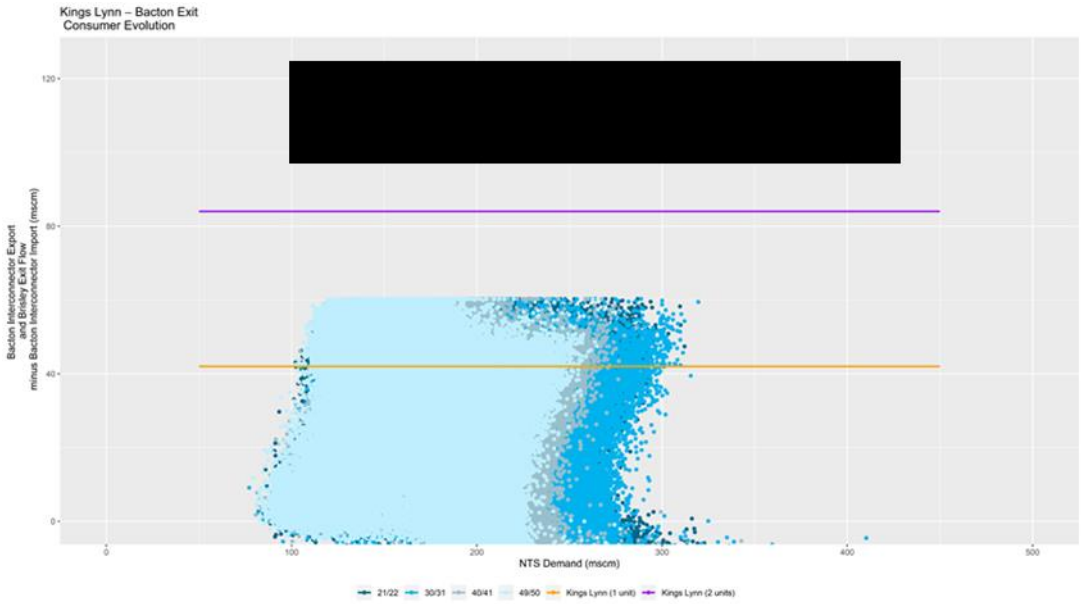

Figure 7: Bacton Terminal Exports (Consumer Evolution 2018)

5.13 **Figure 8** shows the low case for Bacton exports, the Two Degrees scenario. This scenario shows that two units are required until 2030/31 at which point exports decline and can be managed with a single unit.

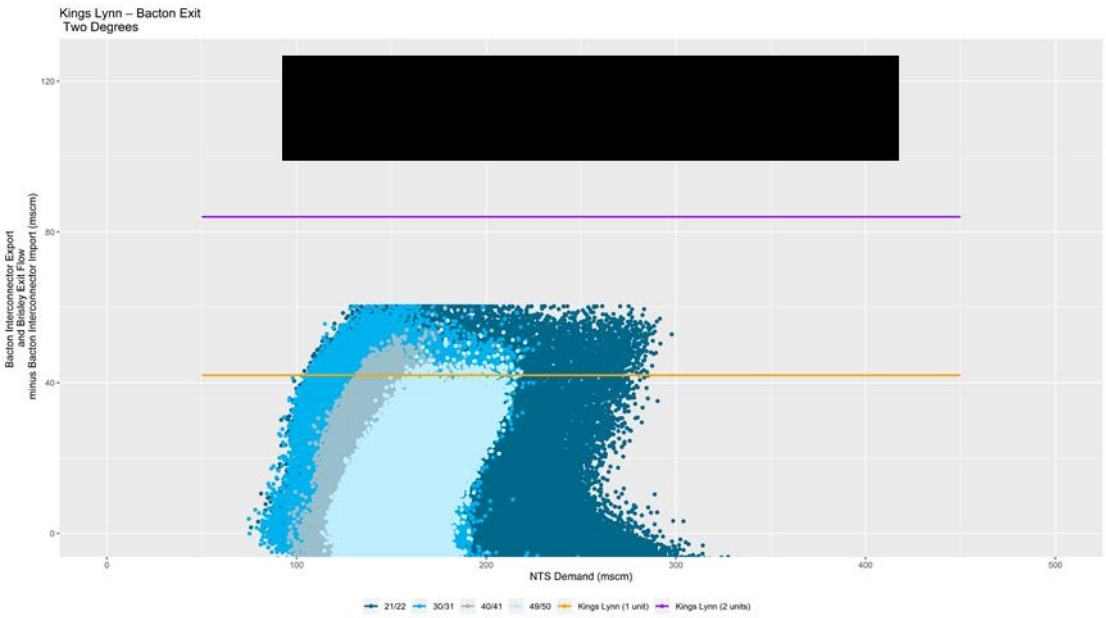

Figure 8: Bacton Terminal Exports (Two Degrees 2018)

5.14 The final scenario is Community Renewables, **Figure 9**. This scenario shows the levels declining from those seen today but that a need remains for parallel operation beyond 2049/50.

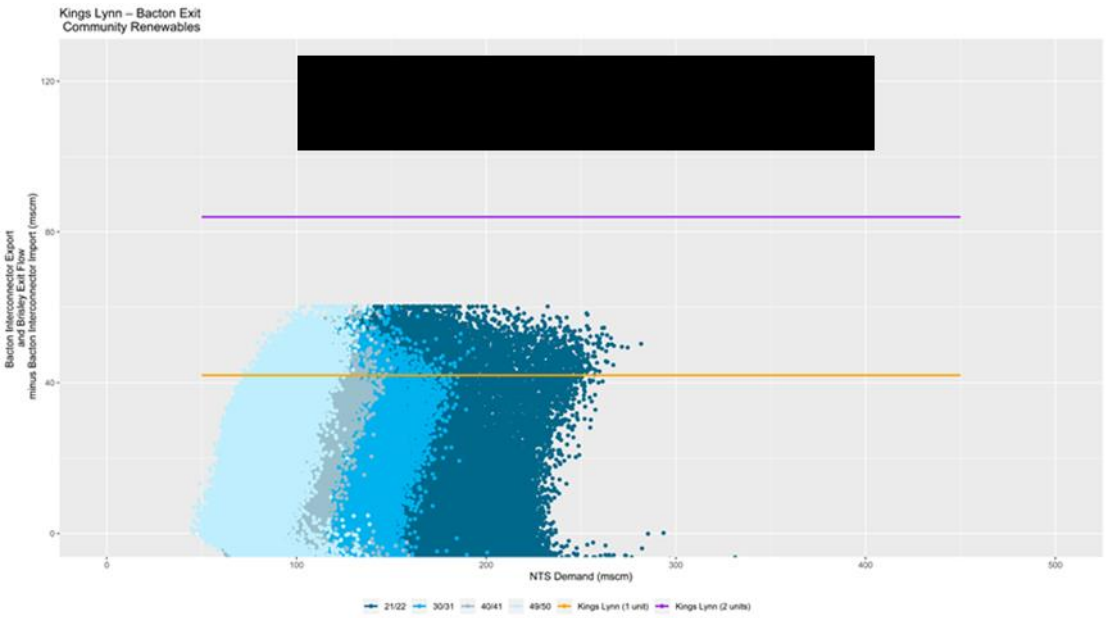

Figure 9: Bacton Terminal Exports (Community Renewables 2018)

Future Energy Scenario Requirements Summary

5.15 The Two Degrees scenario is the only scenario indicating significant entry constraints in the South East if two units at King's Lynn were not to be available. The main driver for compression is the support of export flows at Bacton towards Europe.

5.16 **Figure *10*** shows the decline in supplies from the UKCS sub-terminals. Stakeholder engagement with Shell, Perenco, upstream producers and the Oil and Gas Authority indicates that UKCS supplies into Bacton could continue beyond the date shown until at least 2042. Operators are looking to extend field life through reduced operational expenditure (OPEX), high oil prices and improved technology.

It is possible that a mixture of relaxed Gas Safety (Management) Regulations (GS(M)R) limits, increased field recovery and blending developments will lead to UKCS inputs into Bacton beyond 2035, until at least 2042.

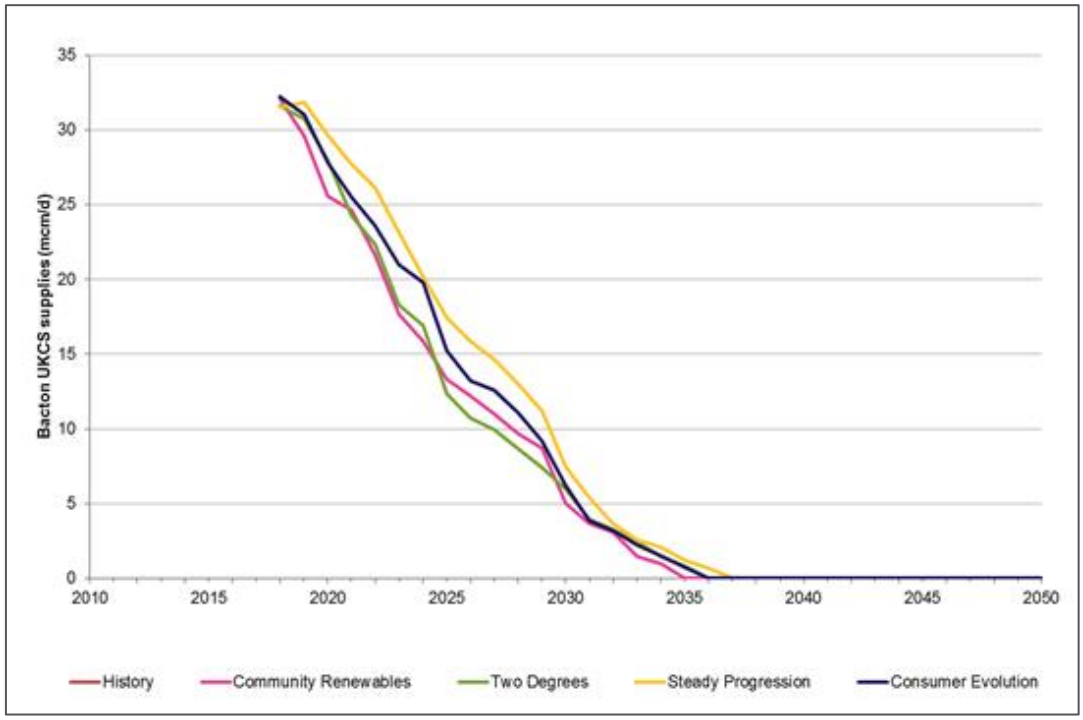

Figure 10: Bacton Terminal UKCS Supplies

5.17 We have not currently included an extension of Bacton UKCS supplies as a full sensitivity in our analysis; however, our qualitative assessment is that the net impact is likely to be marginal given the volumes of UKCS supply relative to interconnector exports.

5.18 Taken together, the increase in export demand and the reduction in UKCS supplies dependency will lead to an increase in the run hours at King's Lynn during the 2030s. The number of days on which parallel operation (running two compressors simultaneously) will be needed is forecast to peak during the 2030s as shown in **Figure *11***.

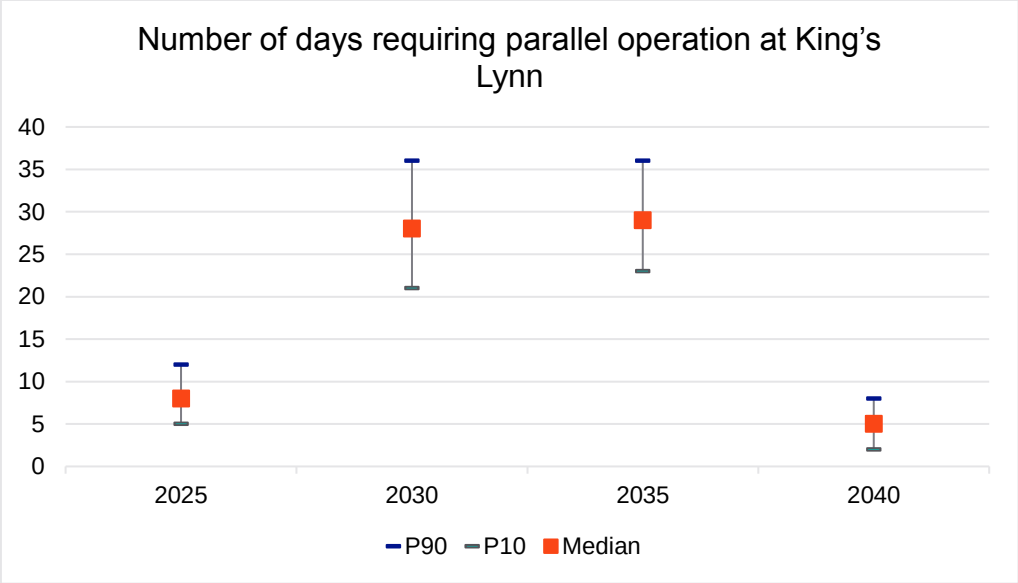

Figure 11: Number of days of parallel operation

5.19 The high number of days forecast for parallel operation, and the challenge of forecasting when they will happen, means we need a fully resilient parallel operation capability.

Forecast Running Hours

5.20 We have compiled forecasts of running hours, shown in **Figure 12**, based on the scenarios described in the preceding sections.

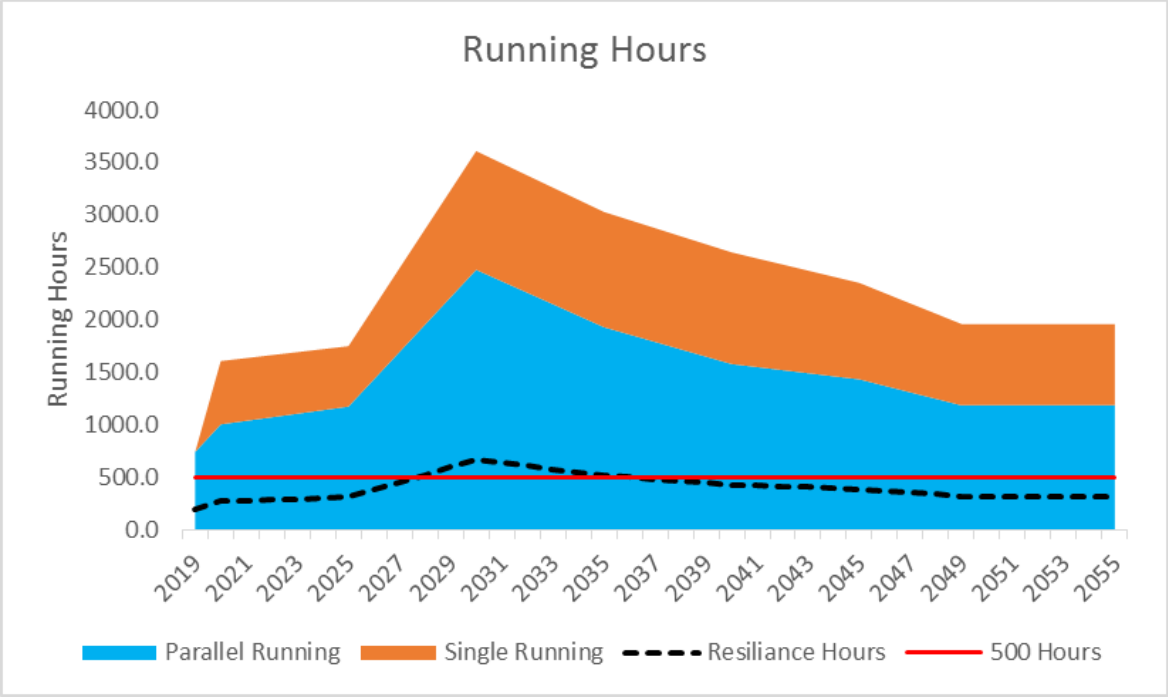

Figure 12: Station Forecast Running Hours

5.21 This predicts running hours up until 2025 at similar levels to the last few years. These then increase after 2025 as Bacton's net exports increase before dropping away at the end of the period. The forecast increased running hours during the peak periods would mean non-compliant MCPD units being needed for more than the 500 hours derogation limit shown by the red line in **Figure 12**.

Compressor Availability

5.22 We calculate compressor availability based on historical averages for each compressor type on the network. This calculation uses the number of trips per 1,000 hours in the last five years. We then estimate the expected outage duration for each trip based on our operational experience, giving the availabilities shown in **Table 6**.

Table 6: Compressor Availability

Unit	500 hr	>500 hrs
AVON 1533	85%	73%
SIEMENS SGT400	94%	86%
New Large Unit (based on circa LM2500 sized unit)	*93%*	*82%*
New Medium Unit (based on circa SGT400-sized unit)	*97%*	*88%*

Project Scope Summary

5.23 Our recommendation is to construct two new units at King's Lynn to give maximum resilience and availability to support Bacton terminal and South East flows. **Table 7** provides the project scope summary.

Table 7: King's Lynn Project Scope Summary

New build at King's Lynn	
Location	King's Lynn Compressor Station
Number of units	Two medium sized units
Size of units	Medium – circa 15MW
Type of unit	Gas Turbine (GT)
Scope boundaries	The scope of this project is for costs associated with achieving compliance with the MCPD only. For King's Lynn, these are costs associated with building two new medium sized units and decommissioning of two existing units
Station design discharge pressure	75 barg (West) 70 barg (East)
Station suction trip pressure	38 barg
Availability required	The optimum level of availability is determined by the selected option (99.9% for 2 x new units running in parallel, and 100% single unit running in 2030)

6. Options Considered

Option Summary

6.1 The options we considered cover a range of commercial, regulatory and physical solutions to provide capability for all compressor units captured by MCPD. These options are laid out within the CECS. In all cases the counterfactual is to retain all non-compliant units which would each be limited to 500 hours (derogated) per year from 1 January 2030.

6.2 Where new build options are assessed, at this stage we assume these will be built on adjacent unused land, within National Grid boundaries where existing sites cannot be guaranteed as suitable. An independent Geographical Information System (GIS) screening exercise will be undertaken, to input into FEED, to identify potential parcels of land for the King's Lynn compressor units considering constraints imposed by separation and safety distances, buried feeders and key infrastructure, HSE consultation distances to sensitive neighbourhood receptors and other environmental and statutory constraints. Further consideration will be given to, amongst other things, preliminary engineering review and appraisal and initial environmental constraints surveys. All options include decommissioning of Avon Unit A, which has already been disconnected from the NTS and is no longer available for service. Units C and D are not affected by MCPD.

6.3 A high-level summary of all options considered for King's Lynn is shown in **Table 8** below.

Table 8: Full Options List

Standard options for Avon	Assessed	In which Option and on which compressor units Or Why option wasn't considered
500 hours Derogation	✓	Option 0 (unit B)
Two new 15MW Gas Turbine Compressors, decommission Avon once new unit is operational.	✓	Option 1 Option 2
Control system restricted performance[5]	x	A study is underway to access the viability of this option at other sites with lower anticipated running hours as an alternative to derogation. If this option proves feasible, it may be considered to this site also. This option will be assessed further during FEED.
One new 15MW Gas Turbine Compressor, decommission Avon once new unit is operational.	✓	Option 3 Option 4
One new 30MW Gas Turbine Compressor, decommission Avon once new unit is operational.	✓	Option 7
Emissions abatement (Selective Catalytic Reduction (SCR)) on Avon	✓	Option 6 (unit B)
Disconnect and Decommission Avon prior to 2030[6]	✓	Option 1 (unit B), Option 2 (unit B), Option 3 (unit B), Option 4 (unit B), Option 5 (unit B), Option 7 (unit B), All Options (unit A)
Two new 15MW Electric Drive Compressors, decommission Avon once new unit is operational.	x	King's Lynn does not have sufficiently high running hours to warrant a VSD. [7]
One new 30MW Electric Drive Compressor, decommission Avon once new unit is operational.	x	
Commercial contracts to manage constraints and to ensure compliance with 1-in-20 obligations	x	Not required to comply with 1-in-20 obligations. Insufficient demand at times of constraint for turn down contracts with UK demand. Contracts to reduce interconnector flows would require agreement with several shippers, over several years. If the price spread is favouring imports, any reduction in demand with

[5] Control System Restricted Performance is where an Avon operating at full power emits a NOx level close to the 150mg/m3 legislative limit, it may be possible to permanently de-rate the Avon to limit the power in the control system and reduce emissions from the unit Please see CECS Annex A16.05 for more information.

[6] Between 2024 and 2031 depending on site, unit and option

[7] See CECS for more information.

Standard options for Avon	Assessed	In which Option and on which compressor units Or Why option wasn't considered
		contracted shippers may be counteracted with shippers who are following the price spread to import gas, therefore a net export of flow is not guaranteed.

6.4 Costs have been compiled internally by eHub, National Grid's Estimating and Cost team and by our Compressor team. Compressors, abatement and decommissioning costs are based on previous project experience. National Grid operational expenditure (OPEX) and asset health, including ongoing abatement spend, is calculated on a site-specific basis from historical data. We have assessed our costs used against Ofgem guidance and confirm the following view.

Cost realised from RIIO-1 actuals	Cost forecast based on competitive process or previous tenders	External Benchmarking	Proposed Price Control Deliverable mechanism
Yes	Yes	No	Yes

6.5 Cost estimates used in the CBA include a sensitivity range associated with P50. Refer to CECS for more information on where these costs originate.

6.6 Constraints/contracting costs are calculated through the supply and demand scenarios using FES 2018 scenarios. The pricing methodology is referenced in **Table *37***

6.7 We have developed a set of additional criteria to assess options alongside the CBA, which is summarised below in **Table *9***. More information on how this is used can also be found in the CECS

. **Table 9: Option Criteria**

Criteria	***Description***				
Can we meet FES predicted Entry levels?	Cannot meet FES Entry levels.	Meets FES Entry levels in less than 50% of the scenarios.	Meets FES Entry levels in 50% or more of the scenarios.	Meets FES Entry levels in all scenarios.	Increased Entry levels above predicted FES levels.
Can we meet FES predicted Exit levels?	Cannot meet FES Exit levels in all scenarios.	Meets FES Exit levels in less than 50% of the scenarios.	Meets FES Exit levels in 50% or more of the scenarios.	Meets FES Exit levels in all scenarios.	Increased Exit levels above predicted FES levels.
Does this option represent an appropriate level of resilience on the network?	Does not provide resilience for the loss of largest credible unit(s) at the station.	Reduces resilience considering the loss of units at interacting stations, where the affected units are currently next in line.	Reduces resilience for the loss of units at interacting stations, where the affected units are not currently first in line.	Provides similar level of resilience as the existing situation.	Increases the resilience of the network.
Does this option allow National Grid to retain current capability?	Will reduce capability and impact how the NTS is currently used.	Capability reduced to a level insufficient to meet sold capacity and/or FES levels.	Capability reduced to potentially be insufficient to meet sold capacity and/or FES levels.	Sufficient capability to meet sold capacity and/or FES levels.	Increased capability to meet sold capacity and/or FES levels.

Criteria	*Description*				
Does this option allow the network to be operated in sensitivities beyond FES?	FES cannot be met.	Significantly reduces capability to exceed FES.	Reduces capability to exceed FES.	Provides similar capability as the existing situation to exceed FES.	Enhances the ability over the existing situation to exceed FES.

Option Descriptions

6.8 Each option comprises asset actions, commercial actions, benefits, a summary and risks where necessary. They all include decommissioning of the disconnected Unit A and will achieve compliance with MCPD.

Option 0-Counterfactual

6.9 The counterfactual option is the option that minimises RIIO-2 and RIIO-3 investment in new build units or asset decommissioning whilst meeting compliance with legislation. This option removes the need for new MCPD driven asset investment and utilises the existing units.

Asset actions

6.10 This option maintains Avon Unit B until 31 December 2029 and places it on 500 hours' derogation from 1 January 2030. We include the merging of control systems to allow parallel operations of Units B (Avon) and C (SGT400) combined and Units B (Avon) and D (SGT400) combined.

Commercial actions

6.11 No commercial contracts were needed to ensure compliance with any National Grid requirements. Network constraints from this option would be managed using existing tools. The cost of these actions is calculated as part of the economic assessment based on frequency and size.

Benefits

6.12 A high-level qualitative view of how the option measures up against the criteria is summarised in **Table 10**.

Table 10: Counterfactual benefits

Can we meet FES predicted Entry levels?	Can we meet FES predicted Exit levels?	Does this option represent an appropriate level of resilience on the network?	Does this option allow National Grid to retain current capability?	Does this option allow the network to be operated in sensitivities beyond FES?

6.13 **Table *11*** shows how often either two medium-sized units or one large unit would be available for parallel operation of the site along with the availability of at least one medium-sized unit for single operation. This is calculated based on the individual availabilities of each unit and the potential combinations to achieve each of the capabilities.

Table 11: Counterfactual availability

Capability	Current	2023	2030
Parallel	94.5%	94.5%	86.1%
Single	99.7%	99.7%	99.0%

Risks

6.14 The Avon units are nearly 50 years old and this brings an increased maintenance burden and higher probability of unavailability due to failures. It is also possible they will no longer be supported by OEMs which would mean longer outages if they did fail. Additionally, the 500-hour limitation increases network risk if high running hours are required post 2029.

6.15 Parallel unit operation availability declines from 2030 as this is dependent on one 500-hour unit for backup. This creates a constraint risk where significant parallel operation is needed to meet high levels of exports at Bacton.

6.16 The cost breakdown of the option is given in **Table 12**.

Table 12: Counterfactual option cost

Title	Operating cost (£m)	Constraint cost (£m)	Total Installed cost (£m)	Asset Health cost (£m)	Decommissioning cost (£m)	Control Systems (£m)	Cost accuracy
0-Counterfactual 500 hours	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	P50

Option 1-Two New Gas Turbine (GT) Compressors (Two new units)

6.17 Build is assumed to be on adjacent unused land within National Grid boundaries and only requiring outages to connect the new units to the station pipework once they are built.

Asset actions

6.18 Construction of two new, medium-sized gas-driven compressors, by 2029. Avon Unit B would be decommissioned once the new units are operationally accepted.

Commercial actions

6.19 No commercial contracts were needed to comply with any National Grid requirements.

6.20 Network constraints would be managed using existing tools. Costs are calculated as part of the economic assessment based on their frequency and size.

Benefits

6.21 A high-level qualitative view of how the option measures up against the criteria is summarised in **Table 13**.

Table 13: Two new units benefits

Can we meet FES predicted Entry levels?	Can we meet FES predicted Exit levels?	Does this option represent an appropriate level of resilience on the network?	Does this option allow National Grid to retain current capability?	Does this option allow the network to be operated in sensitivities beyond FES?

6.22 **Table 14** shows how often either two medium-sized units or one large unit would be available for parallel operation of the site along with the availability of at least one medium-sized unit for single operation. This is calculated based on the individual availabilities of each unit and the potential combinations to achieve each of the capabilities.

Table 14: Two new units' availability

Capability	Current	2023	2030
Parallel	94.5%	94.5%	99.9%
Single	99.7%	99.7%	100.0%

6.23 Though site capability remains the same as designed (with both Avon Units A and B available), network risk is reduced due to newer and more reliable MCPD compliant compressor units. The addition of two new units will give maximum resilience and availability and support Bacton terminal and South East flows.

Summary

6.24 Parallel unit operation availability increases from 2030 once the two new units are installed to significantly reduce constraint risk.

Risks

6.25 Unused assets if gas volumes are insufficient to need the two new compressors.

6.26 The cost breakdown of the option is given in **Table *15***.

Table 15: Two new GTs option cost

Title	Operating cost (£m)	Constraint cost (£m)	Total Installed cost (£m)	Asset Health cost (£m)	Decommissioning cost (£m)	Control Systems (£m)	Cost accuracy
1-Two new units	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	P50

Option 2-Two New GT Compressors plus station uprating (Two new units + uprate)

6.27 Build is assumed to be on adjacent unused land, within National Grid boundaries. Design and build should be scheduled to minimise disruption during pipe uprating.

Asset actions

6.28 Construction of two new, medium-sized, gas-driven compressor units, built on adjacent unused land, within National Grid boundaries, by 2029. Avon Unit B would be decommissioned once the new units are operationally accepted. In addition, the compressor station would have its pipework uprated to allow higher pressures and more flow.

Commercial actions

6.29 No commercial contracts were needed to comply with any National Grid requirements. Network constraints would be managed using existing tools. Costs are calculated as part of the economic assessment based on their frequency and size.

Benefits

6.30 A high-level qualitative view of how the option measures up against the criteria is summarised in **Table *16***.

Table 16: Two new units + uprate benefits

Can we meet FES predicted Entry levels?	Can we meet FES predicted Exit levels?	Does this option represent an appropriate level of resilience on the network?	Does this option allow National Grid to retain current capability?	Does this option allow the network to be operated in sensitivities beyond FES?

6.31 Table 17 shows how often either two medium-sized units or one large unit would be available for parallel operation of the site along with the availability of at least one medium-sized unit for single operation. This is calculated based on the individual availabilities of each unit and the potential combinations to achieve each of the capabilities.

Table 17: Two new units + uprate availability

Capability	Current	2023	2030
Parallel	94.5%	94.5%	99.9%
Single	99.7%	99.7%	100.0%

6.32 The uprated pipework increases site capability and network risk is reduced due to newer and more reliable MCPD compliant compressor units. The addition of two new units will give the station high levels of resilience and availability to support Bacton terminal and South East flows to the levels required in FES.

6.33 Parallel unit operation availability increases from 2030 once the two new units are installed. This significantly reduces the constraint risk.

Risks

6.34 Unused assets if gas volumes are insufficient to need two new compressors.

6.35 The cost breakdown of the option is given in **Table 18**.

Table 18: Two new GTs + uprate option cost

Title	Operating cost (£m)	Constraint cost (£m)	Total Installed cost (£m)	Asset Health cost (£m)	Decommissioning cost (£m)	Pipe uprating (£m)	Cost accuracy
2-Two new units + uprate	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	P50

Option 3-One New GT Compressor (One new unit)

6.36 Build is assumed to be on adjacent unused land, within National Grid boundaries, and only requiring outages to connect the new unit to the station pipework once it is built.

Asset actions

6.37 Construction of one new, medium-sized, gas-driven compressor unit by 2029. Avon Unit B would be decommissioned once the new unit is in operation.

Commercial actions

6.38 No commercial contracts were needed to comply with any National Grid requirements.

6.39 Network constraints would be managed using existing tools. Costs are calculated as part of the economic assessment based on their frequency and size.

Benefits

6.40 A high-level qualitative view of how the option measures up against the criteria is summarised in **Table *19***.

Table 19: One new unit benefits

Can we meet FES predicted Entry levels?	Can we meet FES predicted Exit levels?	Does this option represent an appropriate level of resilience on the network?	Does this option allow National Grid to retain current capability?	Does this option allow the network to be operated in sensitivities beyond FES?

6.41 Table 20 shows how often either two medium-sized units or one large unit would be available for parallel operation of the site along with the availability of at least one medium-sized unit for single operation. This is calculated based on the individual availabilities of each unit and the potential combinations to achieve each of the capabilities.

Table 20: One new unit availability

Capability	Current	2023	2030
Parallel	94.5%	94.5%	97.2%
Single	99.7%	99.7%	99.9%

6.42 There is a reduction in the number of units to maintain.

Risks

6.43 Parallel unit operation availability remains at current levels (with Avon unit A disconnected). There are increased constraint risks if net exports at Bacton increase as forecast.

6.44 The cost breakdown of the option is given in **Table *21***.

Table 21: One new GT option cost

Title	Operating cost (£m)	Constraint cost (£m)	Total Installed cost (£m)	Asset Health cost (£m)	Decommissioning cost (£m)	Control Systems (£m)	Cost accuracy
3-One new unit	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	P50

Option 4-One New GT Compressor plus station uprating (One new unit + uprate)

6.45 Build is assumed to be on adjacent unused land, within National Grid boundaries. Design and build should be scheduled to minimise disruption during pipe uprating.

Asset actions

6.46 Construction of one new, medium-sized, gas-driven compressor unit, built on adjacent unused land, within National Grid boundaries, by 2029. Avon Unit B would be decommissioned once the new unit is in operation. In addition, the compressor station would have its pipework uprated to allow higher pressures and more flow.

Commercial actions

6.47 No commercial contracts were needed to comply with any National Grid requirements.

6.48 Network constraints would be managed using existing tools. Costs are calculated as part of the economic assessment based on their frequency and size.

Benefits

6.49 A high-level qualitative view of how the option measures up against the criteria is summarised in **Table *22***.

Table 22: One new unit + uprate benefits

Can we meet FES predicted Entry levels?	Can we meet FES predicted Exit levels?	Does this option represent an appropriate level of resilience on the network?	Does this option allow National Grid to retain current capability?	Does this option allow the network to be operated in sensitivities beyond FES?

6.50 **Table *23*** shows how often either two medium-sized units or one large unit would be available for parallel operation of the site along with the availability of at least one medium-sized unit for single operation. This is calculated based on the individual availabilities of each unit and the potential combinations to achieve each of the capabilities.

Table 23: One new unit + uprate availability

Capability	Current	2023	2030
Parallel	94.5%	94.5%	97.2%
Single	99.7%	99.7%	99.9%

6.51 The uprated pipework increases site capability.

6.52 There is a reduction in the number of units to maintain.

Risks

6.53 Parallel unit operation availability remains at current levels (with Avon unit A disconnected). There are increased constraint risks if net exports at Bacton increase as forecast.

6.54 The cost breakdown of the option is given in **Table *24***.

Table 24: One new GT + uprate option cost

Title	Operating cost (£m)	Constraint cost (£m)	Total Installed cost (£m)	Asset Health cost (£m)	Decommissioning cost (£m)	Pipe uprating (£m)	Cost accuracy
4-One new unit + uprate	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	P50

Option 5-Disconnect and Decommission Avon Unit B post 2029 (Decommission MCPD unit post 2029)

6.55 Unit B would continue to operate until 31 December 2029 when the number of units on site will reduce to the two SGT400s.

Asset actions

6.56 Retain Avon Unit B until 31 December 2029 and then decommission.

Commercial actions

6.57 No commercial contracts needed to comply with any National Grid requirements.

6.58 Network constraints would be managed using existing tools. Costs are calculated as part of the economic assessment based on their frequency and size.

Benefits

6.59 A high-level qualitative view of how the option measures up against the criteria is summarised in **Table *25***.

Table 25: Decommission MCPD unit post 2029 benefits

Can we meet FES predicted Entry levels?	Can we meet FES predicted Exit levels?	Does this option represent an appropriate level of resilience on the network?	Does this option allow National Grid to retain current capability?	Does this option allow the network to be operated in sensitivities beyond FES?

6.60 Table 26 shows how often either two medium-sized units or one large unit would be available for parallel operation of the site along with the availability of at least one medium-sized unit for single operation. This is calculated based on the individual availabilities of each unit and the potential combinations to achieve each of the capabilities.

Table 26: decommission MCPD unit post 2029 availability

Capability	Current	2023	2030
Parallel	94.5%	94.5%	73.8%
Single	99.7%	99.7%	98.0%

Risks

6.61 Avon Unit B is nearly 50 years old which brings an increased maintenance burden, and higher probability of unavailability due to failures out to 2030.

6.62 Parallel unit operation availability declines significantly from 2030 once Unit B is removed. This creates significant constraint risks both on entry and exit.

6.63 The cost breakdown of the option is given in **Table *27***.

Table 27: Decommission MCPD unit post 2029 cost

Title	Operating cost (£m)	Constraint cost (£m)	Total Installed cost (£m)	Asset Health cost (£m)	Decommissioning cost (£m)	Control Systems (£m)	Cost accuracy
5-Decommission MCPD unit post 2029	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	P50

Option 6-Emissions abatement (Selective Catalytic Reduction (SCR)) on Avon Unit B including merging of control systems (SCR one unit)

6.64 Emissions abatement would allow use of the unit post 2029.

Asset actions

6.65 Emissions abatement on Avon Unit B by 2029. This includes merging of control systems to allow parallel operations of Units B (Avon) and C (SGT400) combined and Units B (Avon) and D (SGT400) combined. This work is programmed for 2020.

Commercial actions

6.66 No commercial contracts were needed to comply with any National Grid requirements.

6.67 Network constraints would be managed using existing tools. Costs are calculated as part of the economic assessment based on their frequency and size.

Benefits

6.68 A high-level qualitative view of how the option measures up against the criteria is summarised in **Table *28***.

Table 28: SCR one unit benefits

Can we meet FES predicted Entry levels?	Can we meet FES predicted Exit levels?	Does this option represent an appropriate level of resilience on the network?	Does this option allow National Grid to retain current capability?	Does this option allow the network to be operated in sensitivities beyond FES?

6.69 **Table 29** shows how often either two medium-sized or one large units would be available for parallel operation of the site along with the availability of at least one medium-sized unit for single operation. This is calculated based on the individual availabilities of each unit and the potential combinations to achieve each of the capabilities.

Table 29: SCR one unit availability

Capability	Current	2023	2030
Parallel	94.5%	94.5%	94.5%
Single	99.7%	99.7%	99.7%

Risks

6.70 We estimate Unit B will be unavailable for two years during installation of abatement equipment, reducing site capability leading to significant disruption and

large constraints costs. Installation requires the existing unit to be completely refurbished. Emissions abatement technology increases the operational running costs of the compressor unit due to additional SCR related activities such as reagent usage, energy and replacement costs.

6.71 Emissions abatement is not a cost-effective option for our non-compliant MCPD units because of their age and asset characteristics.

6.72 Parallel unit operation availability remains at current levels (with Avon unit A disconnected). There are increased constraint risks if net exports at Bacton increase as forecast.

6.73 The cost breakdown of the option is given in **Table *30***.

Table 30: SCR one unit cost

Title	Operating cost (£m)	Constraint cost (£m)	Total Installed cost (£m)	Asset Health cost (£m)	Decommissioning cost (£m)	Control Systems (£m)	Cost accuracy
6-SCR one unit	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	P50

Option 7-One New Large GT Compressor (One new large unit)

6.74 The overall site capability is maintained, but with fewer units to maintain. The new large machine will be useful for large flows and low flow capability would be provided by the Siemens SGT400 compressor units.

6.75 Build is assumed to be on adjacent unused land, within National Grid boundaries and only needed outages to connect the new unit to the station pipework once it is built.

Asset actions

6.76 This option looks at building one new large gas-driven compressor unit, built on adjacent unused land, within National Grid boundaries, by 2029. Avon Unit B would be decommissioned once the new unit is in service.

Commercial actions

6.77 No commercial contracts were needed to comply with any National Grid requirements.

6.78 Network constraints would be managed using existing tools. Costs are calculated as part of the economic assessment based on their frequency and size.

Benefits

6.79 A high-level qualitative view of how the option measures up against the criteria is summarised in **Table *31***.

Table 31: One new large unit benefits

Can we meet FES predicted Entry levels?	Can we meet FES predicted Exit levels?	Does this option represent an appropriate level of resilience on the network?	Does this option allow National Grid to retain current capability?	Does this option allow the network to be operated in sensitivities beyond FES?

6.80 **Table 32** shows how often either medium-sized or one large units would be available for parallel operation of the site along with the availability of at least one medium-sized unit for single operation.

Table 32: One new large unit availability

Capability	Current	2023	2030
Parallel	94.5%	94.5%	97.6%
Single	99.7%	99.7%	99.8%

6.81 Parallel unit operation availability increases slightly once the new unit is available in 2030.

Risks

6.82 There could be an increase in constraint risks due to the reduced resilience for single unit operation.

6.83 Unused assets if gas volumes are insufficient.

6.84 The cost breakdown of the option is given in **Table *33***.

Table 33: One large unit cost

Title	Operating cost (£m)	Constraint cost (£m)	Total Installed cost (£m)	Asset Health cost (£m)	Decommissioning cost (£m)	Control Systems (£m)	Cost accuracy
7-One new large unit	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	P50

Options Cost Estimate Details

6.85 The costs used in this analysis have been sourced and reviewed through eHub (National Grid's internal estimation team). They are appropriate at this stage with a view of updating them once Preliminary BAT is complete. The breakdown of costs associated with the preferred option (build two new units) is summarised in ***Table 34***.

Table 34: Cost Estimate Details

MCP 2 x 15MW (2 x GT units)				
Item	**Ofgem Guidance Note**	**National Grid Notes**	**Cost (£m)**	**% of Total Installed Cost**
Engineering Design	Detail costs for Studies/FEED/Detailed Design as appropriate.	Feasibility Studies and FEED works.	[redacted]	[redacted]
		Detailed Design (by Main Works Contractor).	[redacted]	[redacted]
Project Management	Element of Project Costs attributed to Project Management, not direct or indirect company costs.	Main Works Contractor Project Management.	[redacted]	[redacted]
Materials	Bulk Materials, breakdown preferred.	Supplied by Main Works Contractor. (Included within 'Main Works Contractor' item cost).	[redacted]	[redacted]
Main Works Contractor	Project Construction Contractor costs.	Main Works Contractor to carry out Detailed Design, Supply of Balance of Plant, Construction and Commissioning. Detailed Design cost shown in 'Engineering Design' item cost.	[redacted]	[redacted]
Specialist Services	Costs for any additional services used to support the project i.e. surveys, data procurement etc.	Land and Easements.	[redacted]	[redacted]
Vendor Package Costs	Costs of packages purchased for project.	Compressor Machinery Train Detailed Design and Supply by Compressor OEM. Costs are taken from those received during tender event (evaluation ongoing at time of writing).	[redacted]	[redacted]
Direct Company Costs	Refer to Regulatory Instructions and Guidance for definition of direct company costs.	National Grid Project Management based on 52 weeks Detailed Design and 104 weeks Construction/Commissioning durations.	[redacted]	[redacted]

Indirect Company Costs	Refer to Regulatory Instructions and Guidance for definition of indirect company costs.	National Grid indirect costs (Costs of Function %).	[redacted]	[redacted]
Contingency	Contingency included in base cost estimate.	Technical and Commercial contingency associated with Compressor OEM tender (evaluation ongoing at time of writing).	[redacted]	[redacted]
		Main Works Contractor contingency.	[redacted]	[redacted]
Total Installed Cost	Forecast total project cost including contingency. Sum of all elements noted above.		[redacted]	**100.00%**
Cost Estimate Accuracy	This is an important element to give confidence that the engineering is mature, and the costs can be relied upon.	P50 Please see cost accuracy table overview in 6.4 and CECS in annex A16.05 for overview of option costs		

Options Summary Breakdown

6.86 ***Table 35*** compares the options with the option criteria in ***Table 9***.

Table 35: King's Lynn Option Summary

Options	Can we meet FES predicted Entry levels?	Can we meet FES predicted Exit levels?	Does this option represent an appropriate level of resilience on the network?	Does this option allow National Grid to retain current capability?	Does this option allow the network to be operated in sensitivities beyond FES?
Counterfactual 500 hours					
Two new units					
Two new units + uprate					
One new					
One new unit + uprate					
Decommission MCPD unit post 2029					
SCR one unit					
One new large unit					

Key Considerations

6.87 Two units operating in parallel are required to meet FES 2018 Entry and Exit forecasts. Decommissioning options provide no resilience, with no units available as back-up. The derogation option (counterfactual) provides resilience up to 500 hours, and this is forecast to be insufficient.

Resilience

6.88 One new, gas-driven compressor unit (of similar rated power to the existing Avon units - approximately 15MW) would provide a similar level of resilience to the current level. However, with exit flows forecast to increase, this is unlikely to provide an adequate level of resilience into the future.

6.89 Having one new gas-driven compressor unit (of similar rated power to the existing NTS RB211 units - circa 27+ MW) would increase availability when two units are needed. However, it is unlikely a large unit will have the necessary turn-down to cover the lower flow duty; meaning that resilience is increased at high flows but reduced at low flows. With three of the four FES scenarios suggesting exit flows will need two units operating in parallel, we have ranked it as having similar levels of resilience as today.

6.90 However, when comparing one RB211 size large unit and two Avon-sized units, we need to consider flexibility and BAT. Two Avon-sized units would provide higher flexibility. If two Avon-sized units were built, four Avon-sized units on the site in total would provide the most resilience if they were all able to work in parallel. The ability for any combination of units to run in parallel would be an essential part of the tender process. The Preliminary BAT assessment will provide further clarity on the benefits of each option.

6.91 Our CBA approach enables us to consider the costs and impacts of different levels of compression capability and availability and identify the most cost-effective solution. The FEED work will inform this assessment for resilience.

Current Capability and FES Entry and Exit levels

6.92 All options retain current capability apart from decommissioning Unit B; however, resilience and network capability are reduced if units are on outage, whether due to unplanned issues or planned maintenance. Decommissioning Unit B reduces capability while building two new units increases capability.

Flexibility and Sensitivities Beyond FES

6.93 King's Lynn compressor station offers a high level of flexibility to the operation of the Bacton and Isle of Grain terminals for entry and Bacton terminal for exit capability.

6.94 Two leading units are more flexible than one RB211 equivalent sized unit. It is better to run an Avon equivalent-sized unit at lower flows and run at higher flows with two units in parallel rather than turning down and running one RB211 equivalent sized unit inefficiently. Avon equivalent sized units can better support lower entry and exit flows.

Option Summary Breakdown

6.95 To achieve MCPD compliance by 2030 and taking into account compressor investment at other MCPD sites, any new build or emissions abatement project at King's Lynn would need to begin FEED in 2023. **Table 36** provides a comparison between all the options considered.

Table 36: Comparison of Options

Option Title	Project start date (Establish Portfolio)	Project commissioning date	Project Design life	Operating cost (£m)	Total Constraint cost (£m)**	Total CAPEX cost, including:	•Total Installed cost (£m) *	•Merging of control systems	•Station pipe uprating	•Asset Health cost (£m) *	•Decommissioning cost (£m) *	Cost Accuracy
0-Counterfactual 500 hours	2019	N/A	25yrs	[redacted]	[redacted]	[redacted]	N/A	[redacted]	N/A	[redacted]	[redacted]	P50
1-Two new units	2019	2027	25yrs	[redacted]	[redacted]	[redacted]	[redacted]	N/A	N/A	[redacted]	[redacted]	P50
2-Two new units + uprate	2019	2027	25yrs	[redacted]	[redacted]	[redacted]	[redacted]	N/A	[redacted]	[redacted]	[redacted]	P50
3-One new unit	2019	2027	25yrs	[redacted]	[redacted]	[redacted]	[redacted]	N/A	N/A	[redacted]	[redacted]	P50
4-One new unit + uprate	2019	2027	25yrs	[redacted]	[redacted]	[redacted]	[redacted]	N/A	[redacted]	[redacted]	[redacted]	P50
5-Decommission MCPD unit post 2029	2019	2029	25yrs	[redacted]	[redacted]	[redacted]	N/A	N/A	N/A	[redacted]	[redacted]	P50
6-SCR one unit	2019	2027	25yrs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	N/A	[redacted]	[redacted]	P50
7-One new large unit	2019	2027	25yrs	[redacted]	[redacted]	[redacted]	[redacted]	N/A	N/A	[redacted]	[redacted]	P50

*costs to 2055, 25 years following implementation of MCPD in 2030
**see section 7.2, figure 14 for explanation of constraint costs. Figure 14 is showing annual constraints - the table shows total constraints.

Cost accuracy lifespan

6.96 For the recommended option (two new medium-sized units), at this current ND500 4.1 stage, the cost is a P50 estimate. Our cost proposal of £88.0m (excluding decommissioning) for two new units is based on the assumptions in Section 8.6.

Preliminary BAT

6.97 Preliminary BAT analysis will be undertaken to input to FEED to support our CBA and to feed into the decision-making process.

7. Business Case Outline and Discussion

7.1 This section shows the breakdown of operational costs for each option. These costs along with the others detailed in this section are included in the CBA to produce an NPV for each option.

Key Business Case Drivers Description

Constraints

7.2 There is a moderate constraint risk until 2030 in all options so this does not impact the relative outcome of the CBA. After 2030 the options diverge in line with availability with both Option 5 – Decommission in 2029 and the Counterfactual increasing from the current level. Option 2 - Two new units with uprating sees the fewest constraints. All options with at least three unrestricted units show a reduction from the current level of constraints. This is shown in **Figure 13.**

Figure 13: [redacted]

Cost Breakdown

7.3 **Figure 14** and

Figure ***15*** show the breakdown of the costs in the CBA. This is split into the investment costs for compressors; the constraint costs; and compressor running costs. This allows a comparison over the relative costs for each option.

Figure 14: [redacted]

Figure 15: [redacted]

Operating Costs

7.4 These cover all operational activities on site. Where emissions abatement (installation of SCR) to control nitrous oxide (NOx emissions) is considered, there are additional annual operating costs covering items such as re-agent costs and energy usage. Also, the minimum life expectancy of the catalyst is five years, so there are additional costs for its periodic replacement.

7.5 While fuel costs are significant, they are not a key factor in the overall decision. As shown in **Figure *16***, the option with the lowest fuel costs is, as expected, 6 – Decommission MCPD unit post 2029. This option has lower compressor running but significant constraint costs. There are lower costs for 8 – One new large unit, as this is more efficient than running two medium-sized units in parallel.

Figure 16: xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Environmental Benefits

7.6 Replacing the Avon with new, cleaner unit(s) reduces emissions. Compared to 0-Counterfactual, the recommended option 1-Two new units reduces NOx by almost 178 tonnes, as shown in **Figure 17**. Significant improvements can also be seen in the other options, reducing NOx by between 78-178 tonnes below the counterfactual

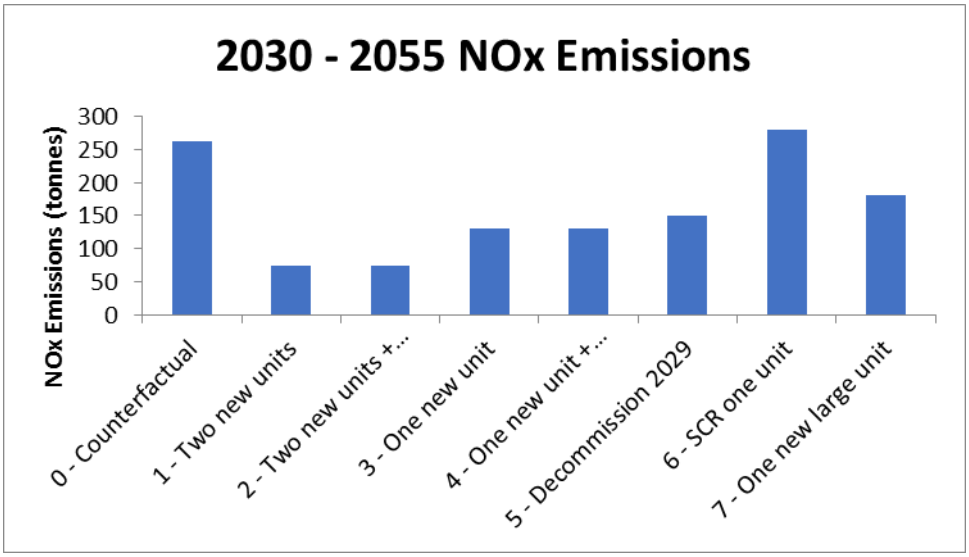

Figure 17: NOx Emissions

Sensitivities and Key Assumptions

7.7 To test the sensitivity of the Kings Lynn case to different supply and demand scenarios we have used all four FES scenarios. Since the proposals are based on the FES 2018 there is no specific scenario focussed on achieving the net zero target. However, the expected gas usage outlined in the net zero sensitivity in FES 2019 fell between the gas usage of the Two Degrees and Community Renewables scenarios which are examined here.

7.8 Community Renewables results in similar results to Steady Progression, although the drivers behind both scenarios differ. While, in Steady Progression, relatively high domestic production limits the need for high imports; the relatively high demands also limit the scope for significant exports. However, in Community Renewables, lower demands limit the requirement for imports despite declining domestic production. This also sees lower exports as gas use declines on the continent limiting the demand for exports.

7.9 The Consumer Evolution scenario has a high domestic production which sees increases in exports to the continent, driven by UK shale production. Two Degrees has declining domestic production but with moderate declines in demand as gas is used to produce Hydrogen using Steam Methane Reformation, this results in increased imports.

7.10 The effect, for both Consumer Evolution and Two Degrees, is a considerable increase in the need for parallel running at King's Lynn to support Bacton exports. For King's Lynn, a similar running pattern would be seen in a transit scenario, where LNG is imported at Milford Haven and exported through IUK. These are conditions we have seen recently on the NTS.

7.11 The constraints are the key driver in the King's Lynn case and these are driven primarily by the supply pattern selected. Flexing our assumptions on compressor availability or constraint resolution did not impact the results of the CBA for this case.

7.12 Other than the supply and demand scenario there were no other relevant sensitivities for the King's Lynn case. Altering assumptions on compressor availability and constraint resolution did not have an impact. The key assumptions behind the King's Lynn case are detailed in **Table *37***.

Table 37: Key Assumptions and Sensitivities

Category	Assumption	Base Assumption	Rationale	Sensitivities Considered	Sensitivity Outcome
CBA parameters	WACC	2.9%	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	Based on lifetime of asset	N/A	
	Depreciation	Straight Line	Defined in RIIO-2	N/A	
	Capitalisation	73.5%	Defined in RIIO-2	N/A	
Supply/Demand	Supply/Demand Scenario	Steady Progression (2018 FES)	Central case for utilisation of King's Lynn	Two Degrees (High Case), Consumer Evolution (Low Case), Community Renewables	Preferred option NPV significantly improved under both Two Degrees and Consumer Evolution
Investment Costs	Investment Costs	Option specific, see table 36 (P50)	Compiled by eHub and Compressor Team incorporating previous project experience	+/- 30% (Monte Carlo)	
	Timing of Investment	FEED beginning April 2021 leading to Operational Acceptance in March 2027	Advanced delivery to facilitate outages for subsequent works at additional affected sites	N/A	
	Asset Health Costs	Option specific, see table 36 (P50)	Site-specific basis from historic data	+/- 30% (Monte Carlo)	Other options not within range of Monte Carlo uncertainty

Category	Assumption	Base Assumption	Rationale	Sensitivities Considered	Sensitivity Outcome
Operating Costs	Site Operating Costs	Option specific, see table 36 (P50)	Site-specific basis from historic data	+/- 30% (Monte Carlo)	Other options not within range of Monte Carlo uncertainty
	Compressor Fuel Costs	Annual price 48 – 63p/th	BEIS reference scenario	N/A	
	Compressor Availability	Unit specific, see table 7 (LINK)	Based on observed running trips and expected return to service times	N/A	
	Constraint management volume	Specific to capability level	Output of network capability analysis	+/- 1 Standard Deviation (Monte Carlo)	Other options not within range of Monte Carlo uncertainty
	Constraint management pricing	As defined by Commercial Constraint Price Methodology	BEIS reference scenario	N/A	
	Constraint management method	50% buy-backs/50% locational actions	Reflective of tools available to manage constraints	25% buy-backs/75% locational actions	No change
Emissions	CO2 volume	Unit specific emission factors	Based on observed performance	N/A	
	CO2 cost	Annual price 12.8 – 42.7 £/tonne	BEIS reference scenario	N/A	
	NOx volume	Unit specific emission factors	Based on observed performance	N/A	
	NOx price	£6,199 £/tonne	DEFRA damage costs	N/A	

Business Case Summary

CBA Assessment

7.13 Based on our central scenario, none of the options had a positive NPV compared to the counterfactual. The asset health spend is similar across the options, with the cost of refurbishing the existing Avon comparable to the ongoing asset health of new units. The decrease in constraints is not significant enough to outweigh the cost of installing new units. The NPVs range from -£129.6m to -£158.7m, these can be seen in **Table 38**.

Table 38: CBA Summary[8]

Short Name	Description	NPV £m	Relative NPV £m
Option 0	Retain B on 500 hrs	-£129.9 m	
Option 1	2 new 15MW units	-£166.9 m	-£37.0 m
Option 2	2 new 15MW units + uprating	-£183.8 m	-£54.3 m
Option 3	1 new 15MW unit	-£145.8 m	-£15.8 m
Option 4	1 new 15MW unit + uprating	-£159.1 m	-£29.1 m
Option 5	Decommission B in 2029	-£146.1 m	-£16.1 m
Option 6	SCR unit B + merge control systems	-£144.3 m	-£14.6 m
Option 7	1 new large unit	-£160.7 m	-£31.0 m

[8] Note that these calculated NPVs assume a capitalisation rate of 73.5% as set out in CECS (Annex A16.05). This capitalisation rate has now been updated, and therefore there may be a minor mismatch between quoted NPVs between this document and the associated CBA (Annex A16.15). Please note that this does not affect the final proposed option. The impact of the updated capitalisation rate is reflected in the CBA document.

7.14 There will be a slight difference between the NPVs displayed in the justification papers and those in the Ofgem CBA template. The justification papers are based on our internal CBA model which uses Monte Carlo analysis to allow us to show the range of NPVs arising from the uncertainties in the cost, constraints and contracts. When the source data is entered into the Ofgem CBA template the predicted P50 of each element is used, this can be slightly different to the actual P50 of the simulation data. These differences in results only alter the overall NPV marginally and would not be sufficient to change the outcome of the CBA. The quoted NPV is based on 2071, 50 years after the start of RIIO-2. This ensures the spend in RIIO-2 has been fully recovered through the RAV, the NPV at other time periods are available in the CBA submission.

7.15 **Figure 18** displays the NPV of the options relative to the counterfactual (0 – Counterfactual 500 hours).

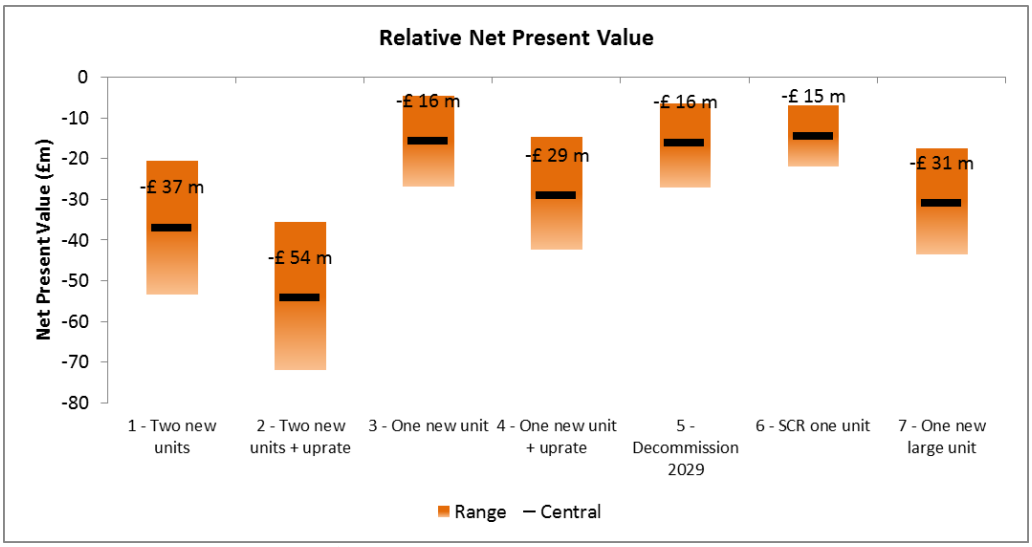

Figure 18: Relative NPV[9]

Assumptions and Sensitivities

7.16 CBAs were run under all four FES scenarios to understand how the results could change. As shown in **Table 39**, option 1 – Two new units is the most favoured option in both the Consumer Evolution and Two Degrees scenarios with positive NPVs of £155m and £34m compared to the counterfactual. Options 2,3,4 and 7, where new units are installed, have positive NPVs in both of these scenarios.

7.17 In the Steady Progression and Community Renewables scenarios no options have a positive NPV compared to the counterfactual.

Table 39: CBA sensitivities[10]

Short Name	Description	Steady Progression	Consumer Evolution	Two Degrees	Community Renewables
Option 0	0 - Counterfactual	£ 0m	£ 0m	£ 0m	£ 0m
Option 1	1 - Two new units	-£ 37m	£ 150m	£ 26m	-£ 47m
Option 2	2 - Two new units + uprate	-£ 54m	£ 132m	£ 3m	-£ 71m
Option 3	3 - One new unit	-£ 16m	£ 102m	£ 16m	-£ 25m
Option 4	4 - One new unit + uprate	-£ 29m	£ 115m	£ 4m	-£ 46m
Option 5	5 - Decommission 2029	-£ 16m	-£ 487m	-£ 251m	-£ 14m
Option 6	6 - SCR one unit	-£ 15m	£ 27m	-£ 7m	-£ 12m
Option 7	7 - One new large unit	-£ 31m	£ 96m	£ 5m	-£ 39m

[9] See footnote 8
[10] See footnote 8

CBA Summary

7.18 The recommended option at this stage is to proceed to FEED with option 1 – Two new 15MW units (see **Table *40***).

Table 40: Option flexibility

Option	RIIO-2 investment	RIIO-2 Cost	SP	CE	TD	CR
0 - Counterfactual	Refurbish unit B	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1 - Two new units (Proceed to FEED)	FEED Study / Essential Asset Health on unit B	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

7.19 Proceeding with the counterfactual would result in a significant delay in the implementation of a future-proofed compression solution if future flows require the capability of new units. This delay would result in significant constraint costs. In addition, we would have spent significant asset health to refurbish a unit which would no longer be required. However, recognising the uncertainty around the exact solution required, and the variables in the FES scenarios, we are proposing that investment taking place post FEED is subject to an UM process. This means that there will be a means to adjust allowances should a different solution be selected as part of that process. Please see Annex A3.02 for further detail on our UM proposal.

8. Preferred Option Scope and Project Plan

Preferred Option for this Request

8.1 Stakeholders have told us of the importance of sufficient network capability to ensure they are able to take gas on and off the system as and when they want and that we should ensure that we are taking steps to comply with air quality legislation. Ensuring sufficient capability at King's Lynn is key to achieving these stakeholder needs.

8.2 In our business plan, we have proposed proceeding to FEED with option 1 – Two new gas-driven compressor unit (of similar rated power to the existing NTS Avon units - approximately 15MW each). Proceeding to FEED in the RIIO-2 period ensures this option can be delivered in time to achieve the benefits of this option should the Consumer Evolution and Two Degrees scenarios unfold. This also allows sufficient flexibility if, at a later stage with further information on the supply/demand pattern and volatility, it becomes clear that the Option 1 level of investment is not required, as it could be converted to a single unit option or the counterfactual. We will utilise the UM set out in Annex A3.02 to confirm options. We are not requesting baseline funding for expenditure post-FEED. Allowances and the price control deliverable will be set through the reopener process.

8.3 The increase in export demand and the reduction in UKCS supplies will lead to an increase in overall and average export levels, and a significant increase in run hours at King's Lynn during the 2030s. The number of days on which parallel operation (running two compressors simultaneously) will be needed is forecast to peak during the 2030s as shown in **Figure *11***. The high number of days forecast for parallel operation, and the challenge of forecasting when they will happen, means we need a fully resilient parallel operation capability. This supports the need to have two new MCPD units to provide resilience to the two existing SGT units. The new units have been sized for the network need.

8.4 Following our October submission, we refined our analysis and forecasts, and engaged with our stakeholders, to provide an updated proposal in our December submission.

8.5 While this is the preferred option at this stage, we should not eliminate the other options from consideration. Further assessment of the technical aspects of the options through the BAT process will allow us to better understand the benefits they will deliver. Preliminary BAT analysis will be undertaken to feed into FEED to confirm potential powerbase and unit combinations based on OEM proposals.

Commissioning dates

8.6 For the selected option (two new medium units) the commissioning date is estimated to be 2027 aligned to our RIIO-2 and RIIO-3 outage plans. Decommissioning of the non-compliant units is expected to commence in 2028.

Project Spend Profile

8.7 Table 41 shows the high-level indicative project spend profile. Entries in blue, in 2028 and 2029, are for the decommissioning of units.

Table 41: Project Spend Profile

Unit	Driver	Action	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
New-build MCP FEED												
King's Lynn A	MCPD	Replace										
King's Lynn x 1 new medium (A)	MCPD	New										
King's Lynn B	MCPD	Replace										

King's Lynn x 1 new medium (B)	MCPD	New		[redacted]								

Efficient Cost

8.8 Our current costs are based on assumptions made as a result of our experience of tendering for ongoing compressor replacement projects at Peterborough, Huntingdon, Hatton compressor sites and the St Fergus terminal. This project will adopt our learning from ongoing compressor replacement projects covering items such as contracting strategy, surveys and bundling.

Project Plan

8.9 The milestones are based on our current view of investment in new compressors and expectation of the outcome of the Preliminary BAT assessment. We have also considered wider works planned across the network. Internal stakeholder engagement has identified the best time to build the two new units, so our milestones are based on this timescale. Please note, these are subject to change as the project progresses through the ND500 process.

8.10 ***Table 42*** provides an indicative project plan showing progression through the stage gate process, purchasing of long lead items, commissioning dates and key operational milestones.

Table 42: King's Lynn Project Plan

New Build			
Cycle	**Network Development Stage Gates**		**Indicative Dates**
			King's Lynn
Pre-FEED Stage 4.0 and 4.1	**T0**	Generation of Need Case	April 2019
	T1	Accept Need Case	April 2019
	F1	Initial Sanction	April 2019
	T2	Define Strategic Approach & Outputs Required to Deliver GT Handover to Delivery Unit	June 2022
FEED Stage 4.2	**F2**	FEED Sanction and Feasibility Sanction Includes BAT assessment and Compressor Machinery Train selection Reopener process	June 2022
	T3	Agreement to Proceed to Conceptual Design	June 2023
	F3	Conceptual Design Sanction and Sanction of long lead items	June 2023
Tender Award Stage 4.3	**T4**	Scope Freeze	September 2024
Project Execution Stage 4.4	**F4**	Detailed Design AND Build Sanction (T4-F4-T5)	September 2024
	T5	DDS Challenge, Review & Sign off Maintenance Requirements Identified	June 2025
Acceptance Stage 4.5	**T6**	Post Commissioning Handover to GT; Operational & Maintenance Complete or Planned (Operational Acceptance)	June 2027
	F5	Project Closure	March 2028

Key Business Risks and Opportunities

8.11 Key risks and mitigations currently identified include the following items which are summarised in **Table** *43*

Table 43**: Identified key risks and mitigations**

No.	Risk	Mitigation (based on current view)
1	Outcomes from BAT and tender which may influence the choice and availability of technology – possibly including hydrogen;	Undertake Preliminary BAT to provide indication of possible available technology.
2	Site conditions, such as, onsite drainage and unknown buried assets, limiting options;	Engage with site to enable early above and below ground site investigations.
3	Delayed regulatory funding which could delay the projects and make tenders more expensive due to contractors having to commit to holding prices or limited numbers of contractors tendering;	Robust engagement with Ofgem.
4	Changes in offshore operating models or new discoveries that increase UKCS supplies into Bacton resulting in lower LNG imports.	Early engagement with the Oil & Gas Authority (OGA) and environmental regulators.
5	There is a cyber security element to this project. Given the size of the cyber costs, there is a risk that external agencies may require additional levels of protection and security thus driving up costs.	Early engagement with external agencies and cyber technology providers on our preferred option and site requirements.
6	Wider changes affecting gas demand or supply such as an increase in shale gas or a move towards hydrogen not included in FES;	• Regular review and update of our FES analysis. • Proactive engagement with the wider energy industry to gain a view on trends to inform our technology choices.
7	Outages: • The overall potential volume of MCPD and other asset investment and maintenance works restricting outage availability which means King's Lynn work is scheduled for RIIO-2. Please refer to CECS for an overall timeline; • The unpredictability of customer flows, e.g. through Bacton; • Appropriate flows for commissioning	• Ensure a robust deliverability plan for T2 investment is built and kept up to date on a regular basis. • Early engagement with shippers to gain understanding on current and future energy trends.
8	Land: • Building on the existing site could require lengthy outages due to working near to existing plant; • Local planning permission; • Environmental concerns during and post construction, such as noise, wildlife, water courses.	• Early engagement with local government; • Community projects.
9	Contracts: • Lead times for equipment purchase – we are a very small part of OEMs' market; • Availability of appropriate skilled resources. • High level of dependency on a single supplier (both OEM and Main Works Contractor (MWC)) – risk of being beholden to supplier.	• We will use our recent project experience at Peterborough and Huntingdon to inform our approach to internal and external resource and suppliers.

8.12 Key opportunities include:

- Bundling works with other MCPD impacted sites, bringing contracting efficiencies;
- Standardisation of our compressor fleet bringing benefits such as improved maintenance, improved operational efficiency, lower parts cost, lower inventory costs;
- Integrated design with the proposed King's Lynn AGI rebuild giving efficient site operations;
- Potential use of Unit A site for new build;
- Off-site compressor modular construction.

Outputs included in RIIO-1 Plans

8.13 Please refer to the CECS document for RIIO-1 outputs.