Compressor Emissions Reopener

Stakeholder Consultation

March 2018

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Introduction

Welcome to our Industrial Emissions Directive (IED) Compressor Reopener consultation.

As the sole owner and operator of the gas National Transmission System (NTS) in Great Britain, a majority of the gas consumed passes through our network. Our compressor stations are used to move gas from supply points to points of demand. They are also used to effectively respond to within-day changes in supply and demand patterns.

This document builds on the learning from our 2014/15 engagement process[1], May 2015 funding submission to Ofgem, together with the more recent feedback that you have given us since November 2017. In particular, based on your most recent feedback, we have focussed on the key issues and metrics, and on the operational impacts to our customers, as well as a more rigorous and robust Cost Benefit Analysis (CBA) approach.

In November 2017, we shared our process to develop a compressor strategy that delivers a network which is compliant with the legislative requirements of the IED, continues to maintain the right capabilities to meet your ongoing needs and offers the best value for consumers.

Using our CBA approach, we have narrowed down credible options for each of the compressor sites which are impacted by the IED legislation. Where an option is clearly shown to be the most economical solution for a site, we have proposed this as the recommended option; however, where necessary, we have outlined potential risks with the recommended option. Where there are several options which could be deemed economic, we would appreciate your views if you have any strong preferences between the options. We need your feedback (both on a site by site basis and an overall network perspective) to ensure our proposed recommendations will continue to support your current and future requirements of the NTS.

What you have told us so far has shaped our approach and thinking, from our first stakeholder workshop to the proposals in this consultation. Your feedback will form a critical part of the process to finalise the recommendations we include in our May 2018 funding submission to Ofgem.

This consultation will close on 29th March 2018. We would like to thank you for your continued engagement and input throughout this process. We look forward to continuing our work with you as we conclude this process and build towards our next stage of engagement on the gas system strategy.

[1] http://talkingnetworkstx.com/ied-what-is-ied.aspx

Executive Summary

New legislation has been introduced which applies strict new environmental limits to industrial activity. Many of our older, larger compressors are not compliant with these limits meaning they are operating under derogations which limit the number of running hours and some units will need to cease operating by 2023.

As part of our current regulatory price control we were granted allowances to address this issue, although much of the allowance was dependent on us proving the business case for our proposals.

In May 2015 we submitted proposals to Ofgem for 10 new compressor units across nine sites impacted by the legislation. This would have required an increase to our original allowances, but our proposals were rejected on the grounds that we had not demonstrated our business case rigorously enough. Ofgem were supportive of the way we had engaged with stakeholders, but said that we had not given you enough information about costs to enable you to make a fully informed decision about whether you agreed with our proposals.

In May 2018 we have an opportunity to submit updated proposals to Ofgem. Over the last few months we have engaged with you to explain how we have updated our approach and get your feedback on our proposals. In this document we explain how we have developed and assessed the options for each of our sites and provide updated proposals to deliver compliance with the legislation.

We have implemented a number of improvements to our approach compared to 2015:

- We have applied a more rigorous and robust Cost Benefit Analysis approach;
- We have considered new technological solutions such as Selective Catalytic Reduction (SCR);
- We have analysed the network in a more holistic way;
- We have given more emphasis to commercial solutions such as turn-up contracts where these provide an economic alternative to asset investment

As a consequence we expect our updated proposals to be for 5 new compressor units, delivered through a combination of new build and emissions abatement. The implementation costs of our proposals are significantly below our current allowances and we would therefore be proposing to return these unspent allowances and reducing charges to customers.

It is important to note that our proposals include higher ongoing costs associated with operating emissions abatement and turn-up contracts, however the implementation costs of our proposals are significantly less our current allowances. We would therefore be proposing to return these unspent allowances and reducing charges to customers.

The purpose of our consultation is to seek your feedback on our updated proposals to ensure that we have captured your views prior to submitting them to Ofgem.

Supporting Information

The legislation and how it affects us

Environmental legislation has been developed over recent years introducing new standards to ensure industrial activities have a limited impact on the environment. The legislation aims to reduce the quantity of air, water and land pollutants which are responsible for damage to the environment and to human health. National Grid's gas turbine driven compressors are affected by the legislation as a result of emissions of nitrogen oxide (NOx) and carbon monoxide (CO) to the environment from the combustion of natural gas.

It is mandatory for all EU countries to comply with the new minimum standards. The impact of BREXIT on environmental legislation although uncertain is considered unlikely to reduce the requirement set by these minimum standards.

This section covers the background of the two initial pieces of relevant emissions legislation and then goes on to discuss how these were brought together in the Industrial Emissions Directive (IED) and the effect of this new legislation on our compressor units.

Large Combustion Plant (LCP) directive 2001

The LCP directive applies to all combustion plants with a thermal input of 50 MW or more. Such combustion plants must meet the Emission Limit Values (ELVs) as defined in the directive. An ELV is the maximum permissible rate at which a pollutant can be released by an installation. The ELVs set out in this directive can be met in one of two ways: (1) Choose to opt in: comply with the ELV or plan to upgrade and achieve compliance by a pre-determined date or (2) Choose to opt out and comply with one of two restrictions defined by the derogations: Limited Lifetime Derogation or the Emergency Use Derogation.

Integrated Pollution Prevention and Control (IPPC) Directive 2008

Under the IPPC, any installation with a high pollution potential is required to have a permit. One of the pre-requisites for this permit is that Best Available Techniques (BAT) are used to prevent or reduce the emission of these pollutants. BAT assessments are required when developing a solution to avoid or reduce emissions resulting from industrial installations and to reduce the impact on the environment as a whole. They take account of the balance between costs and environmental benefits over the full lifecycle of the installation.

The impact of IPPC means that all of our compressor units are required to have a permit which specifies the maximum ELVs to air for that unit. We have an overarching IPPC strategy as agreed with the Environmental Agency (EA) and the SEPA (Scottish Environmental Protection Agency) which allows us to review our compressors as a fleet on an annual basis, targeting those sites that emit high levels of NOx to maximise the environmental return. This process is called the Network Review and to date we have undertaken three phases of IPPC works and we are currently in the process of agreeing Phase 4, which is covered within this consultation.

The Industrial Emissions Directive 2013

Subsequently, the IED brought together existing pieces of European environmental legislation, which include the LCP directive and the IPPC directive. The four major provisions of the IED which impact on National Grid and our compressor units are as follows;

1. The use of permits for installations

The IED specifies that all installations must be operated with a permit. These permits specify the ELVs for polluting substances, which are likely to be emitted from the installation concerned and also determines the environmental risk of that installation. This mirrors the specifications set out in the IPPC whereby installations have to comply with the ELVs set out in their permit, which are based on BAT.

2. Establishment of BAT Reference documents

The IED also introduces an increased emphasis on the status of the BAT Reference (BREF) documents. These BREF documents draw conclusions on what the BAT is for each sector to comply with the requirements of IED. This then forms the reference for setting the permit conditions mentioned above.

3. The updating of ELVs for installations above 50 MW

The IED states that for installations with a thermal input over 50 MW it is mandatory for the following ELVs to be complied with;

Carbon Monoxide (CO) – 100mg/Nm3
Nitrogen Oxide (NOx) – 75mg/Nm3 for existing installations
Nitrogen Oxide (NOx) – 50mg/Nm3 for new installations.

The IED mirrors the requirements set out in the LCP directive. These new limits introduced through IED affect 17 of 64 units in the National Grid compressor fleet. Compressors that could not meet the new ELVs for CO and NOx had to stop operating on 31st December 2015, unless the unit had received a derogation.

4. Limited Lifetime Derogation (LLD)

The requirements for a Limited Lifetime Derogation state that from 1st January 2016 to 31st December 2023 combustion plant may be exempted from compliance with the ELVs for installations above 50 MW provided certain conditions are fulfilled:

(a) The operator makes a declaration before 1st January 2014 not to operate the plant for more than 17,500 operating hours within the derogation period, which started on the 1st January 2016 and ends on the 31st December 2023;
(b) The operator submits each year a record of the number of operating hours since 1st January 2016

We have already made the declaration referred to above and have been permitted to utilise this derogation for some of our currently affected units. A number of our highest utilisation sites are operating under this derogation as the Emergency Use Derogation described below would not give sufficient hours to continue to operate the site. Additionally, if the installations can achieve the ELVs for new installations (rather than existing) using emissions abatement technology before the 2023 deadline, the unit would be deemed compliant.

5. Emergency Use Derogation (EUD)

The IED also makes a provision for emergency use for gas turbines and gas engines which applies to gas plant operating less than 500 hours per year. As with the Limited Lifetime Derogation, this has been applicable from 2016 and we have been allowed to utilise this derogation on some of our currently affected units.

6. 1,500 hours derogation

The IED legislation provides for a further derogation for gas turbines which were granted a permit before November 2002. This applies to units which do not operate for more than 1,500 hours per year as a rolling average over a period of 5 years, increasing the emission limit value for NOx to 150 mg/Nm3, with the limit for CO remaining at 100 mg/Nm3. However, our compressor units produce more NOx than the limit specified in this derogation and therefore this does not represent a viable option.

Upcoming Legislation: Medium Combustion Plant (MCP) directive

The MCP directive will apply specific limits on emissions to air from sites below 50 MW thermal input. This legislation will introduce ELVs that are differentiated according to the plant's age, capacity and type of installation. The gas compressor stations affected by MCP directive are exempt until 1 January 2030.

After this point we have assumed for the purposes of our analysis that units would be restricted to 500 operating hours per year, as a rolling average over a period of five years. This is a working assumption consistent with the wording of the legislation, but we are seeking formal clarification of how the legislation will be applied by the relevant agencies.

What this means? Each compressor site is affected in different ways by the legislation. There are the requirements of IPPC, known impacts of the LCP elements of IED, and the derogations which have already been put into place as well as the future implications of MCP that must also be considered as part of a full economic evaluation. Figure 1 illustrates the different units operating under the LLD and EUD across the NTS.

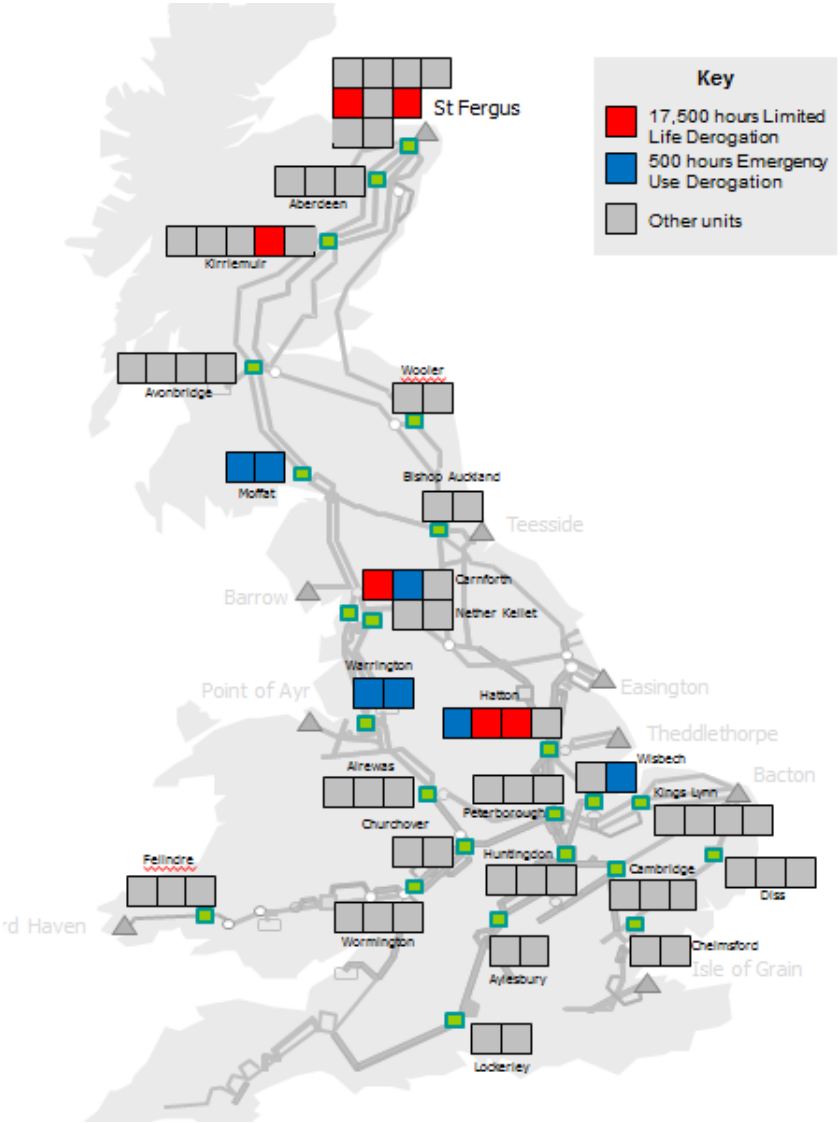


Figure 1: Compressor unit derogations

How we use compressors on the NTS

There has been a significant shift in the way the gas transmission network is utilised. Historically the NTS has operated on a north to south flow pattern with compression used to pull and push the gas from the main entry point at St Fergus to the high demand areas in England. However, over the last 20 years this has changed significantly. There are now more entry points onto the system and these are distributed around the country. The UK continental shelf supplies have declined and in 2004 the UK became a net importer of gas on an annual basis.

The main reasons we have compressors are;

- To transport gas from the supply points to the demand centres
- To maintain pressures within network design safety parameters
- To meet contractual capacity and exit pressure commitments
- To provide a network capable of responding to rapidly changing use and conditions
- To provide network resilience against supply losses or at times of very high demand
- Occasional use to facilitate maintenance

The evolution of the network has resulted in changes to compressor utilisation. Some compressors are now required to support reverse flows: moving gas in the opposite direction from their original design; some compressors have become increasingly important across a large demand range; and some are only used during peak demand conditions or certain supply patterns in order to avoid significant constraints. Figure 2 illustrates the distribution of the different types of units across the NTS.

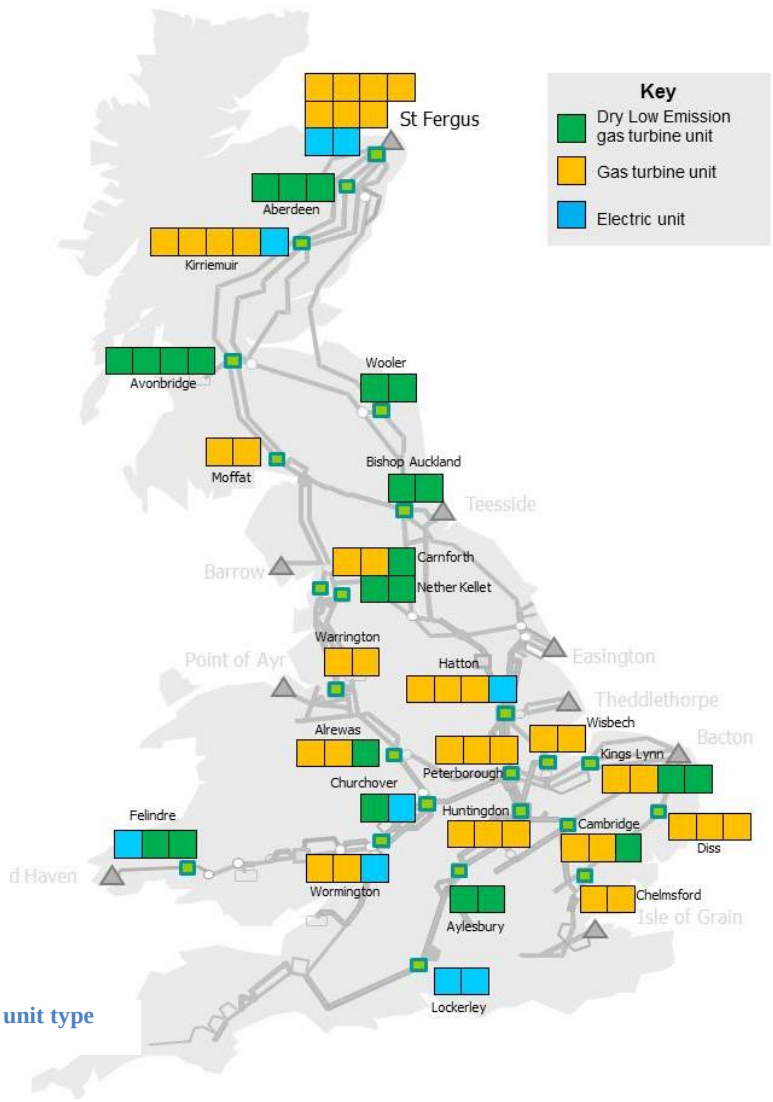


Figure 2: Compressor unit type

Compression in Scotland

There are six compressor sites located in Scotland which support the delivery of north to south gas flow. The utilisation of these sites is strongly influenced by the operational behaviour of the St Fergus entry point. The St Fergus compressor units directly support entry flows from the North Sea Midstream Partners (NSMP) sub terminal, and the other network compressors support the Scotland offtakes and demand centres to the south.

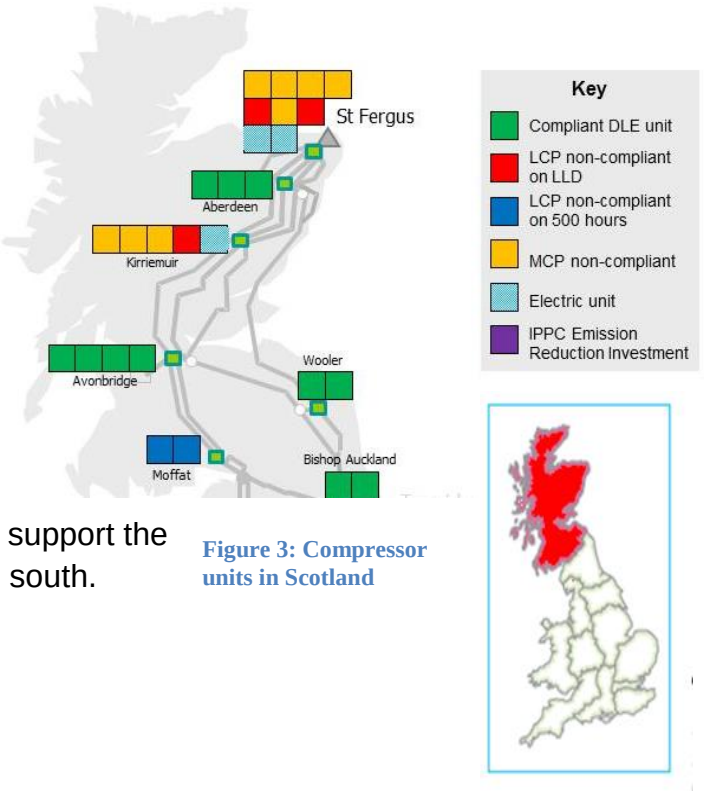


Figure 3: Compressor units in Scotland

Site	Utilisation: Run Hours per year*	Emissions: Kg of NOx per year*	Usage
St Fergus	11,200	170,000	Pressurises gas from the NSMP sub terminal
Aberdeen	4,800	19,300	Required under medium to high St Fergus flows and to maintain Scotland offtake pressures
Avonbridge	4,300	22,000	Supports Scotland offtake pressures
Kirriemuir	2,200	97,400	Required under high St Fergus flows, to maintain Scotland offtake pressures and as back up to Aberdeen and Avonbridge
Wooler	600	1,000	Required under high St Fergus flows and to manage gas stock in Scotland
Moffat	<100	400	Used for network resilience

*Four year average for the site from 2013/14 to 2016/17

Compression in the North and West

Compressor stations within the North region support the delivery of north to south gas flow. With variability in gas flow pattern, these compressors are required to provide increasing flexibility in their operation. Compressor stations in the west are most influenced by the flows of the Milford Haven entry point; compressing gas east when flows are high, or moving gas west into South Wales when Milford Haven supplies are low.

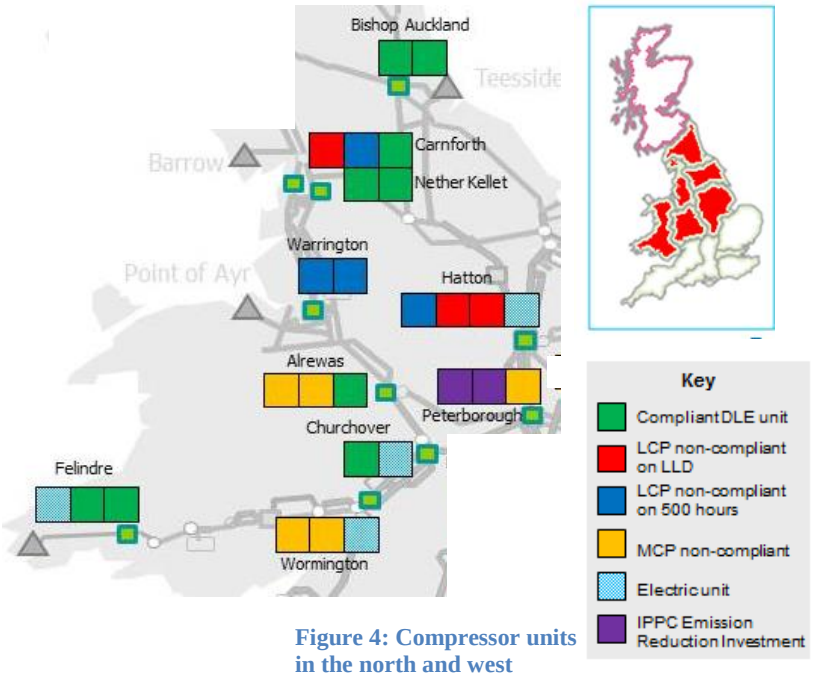


Figure 4: Compressor units in the north and west

Site	Utilisation: Run Hours per year*	Emissions: Kg of NOx per year*	Usage
Peterborough	5,200	79,200	Transmission of gas south, east and west and system flexibility
Hatton	3,500	94,100	Supports the Easington baseline and north to south flows on the East coast. Supports East to West flows including Teesside, Theddlethorpe and the I-UK interconnector.
Carnforth & Nether Kellet	2,400	5,800	Supports high flows north to south and high Easington flows
Bishop Auckland	2,000	3,800	Supports high Teesside and St Fergus flows
Wormington	1,500	500	Facilitates low and high Milford Haven flows and supports pressures in the South West and Wales.
Churchover	1,000	<100	Facilitates low and high Milford Haven flows and supports pressures in Wales.
Alrewas	100	600	Facilitates high Milford Haven flows and supports North West storage and pressures in Wales.
Warrington	<100	200	Specific activities e.g. maintenance and resilience
Felindre	<100	<100	Facilitates high Milford Haven flows

*Four year average for the site from 2013/14 to 2016/17

Compression in the South and East

Compressor stations located in the south of the system are most influenced by the southern demand whilst those in the east are most influenced by the performance of Bacton and Isle of Grain terminals. Variable supply and demand patterns create a need for flexibility in the compression in this area.

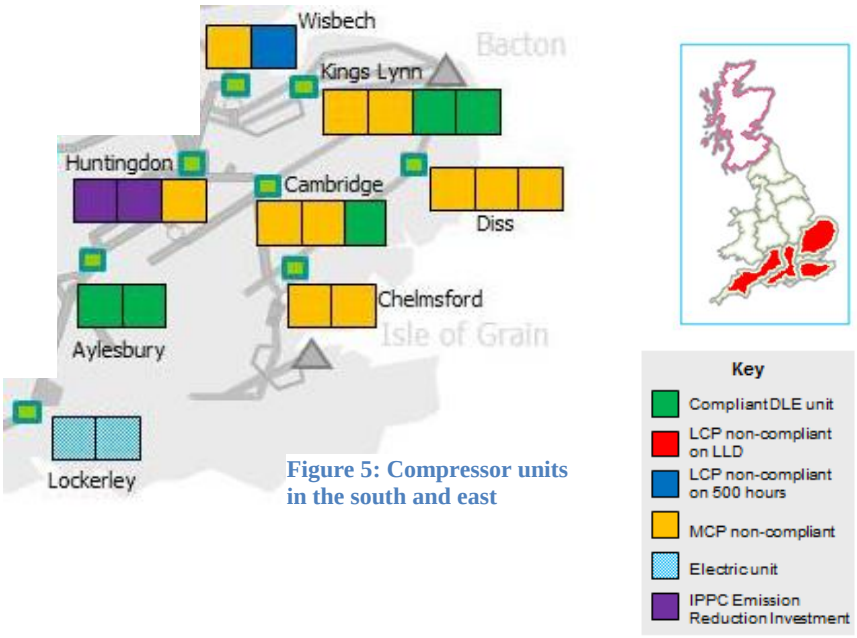


Figure 5: Compressor units in the south and east

Site	Utilisation: Run Hours per Year*	Emissions: Kg of NOx per Year*	Usage
Huntingdon	2,400	28,000	Supports southern flows into the South East and South West during high demand
Lockerley	500	0	Supports pressures in the South West during high demand
Wisbech	400	2,500	Supports high flows to Peterborough
Diss	400	900	Supports high Bacton flows and high South East demand
Chelmsford	300	500	Supports high Bacton flows
Cambridge	200	700	Facilitates low and high Isle of Grain flows
Kings Lynn	100	500	Facilitates Bacton high and low flows
Aylesbury	<100	<100	Supports pressures in the South West. (Low run hours due to recent site works)

*Four year site average for the site from 2013/14 to 2016/17

Potential solutions

The existing fleet of standard Rolls-Royce RB211 and Rolls-Royce Avon gas turbine driven compressors will ultimately be non-compliant with the environmental legislation. All the RB211 units are classified under the LCP directive, and are now operating under the 500 hours Emergency Use Derogation (EUD) or with restricted operating life under the IED Limited Life Derogation (LLD). This derogated plant will have to be permanently closed in 2023 or upgraded through emission abatement technology to meet the required ELVs for a new installation.

Looking forward, as described earlier, Avon units captured under the MCP directive are assumed to be subject to similar constraints to the Emergency Use Derogation under the LCP directive; run hours limited to 500 hours but with the flexibility that this restriction is applied on a rolling average basis.

Commercial and Regulatory Options

Commercial and regulatory options are the first consideration when assessing the various options to meet the network needs, as these solutions potentially avoid the physical use of compressors, and consequently reduce the emissions impact of the fleet overall. Importantly, as a gas transporter we have license obligations to facilitate the gas market. Our aim is to transport gas on behalf of our customers who have invested millions, and in some cases billions to bring gas to the UK market. Typically, the commercial and regulatory options are suited to short term scenarios, meeting a peak demand and supply pattern linked to a single entry point, rather than a complete alternative option to investment in the compressor fleet. In essence, there are three commercial and regulatory options to consider:

1. Reduce Obligated Baselines

The obligated entry capacity levels at specific entry points inform our decision making around network investment requirements. Where these baselines are significantly higher than the peak physical flows through the supply point, this can create uncertainty in the level of investment required. Reducing the baselines at specific supply points would give greater clarity to the required level of compressor investment to meet customer needs. In 2007, a process to reduce baselines was undertaken. This generated significant industry debate and was highly complicated. However, we are in a different environment today and this may be a less contentious option at certain entry points, as seen in the recent reduction of the Fleetwood baseline.

2. Turn up and turn down contracts for constraint management

Bi-lateral contract arrangements at either entry or exit points can be used to manage network flows. For example, to help meet the required pressure level at a distribution network offtake, a turn up contract could be negotiated with the relevant gas shippers at a particular entry point. Flows through that entry point are then increased on request by National Grid, boosting local pressures. A turn down contract at a power

station can be used in a similar way. As an alternative to investment in compressor assets, contracts of this type are likely to be the most effective options when linked to single entry points over the short term.

3. Disaggregation of entry points

This option would allow for capacity buyback mechanisms to be targeted at a single entry point; sub terminal rather than Aggregated System Entry Point (ASEP). This option is applicable at St Fergus terminal where the compression service carried out by National Grid is directly linked to flows through one individual sub-terminal, rather than the ASEP. If the compressor units were unavailable, only gas flows through one sub terminal would be constrained, and hence the capacity buy back mechanism would be targeted at the sub terminal, rather than ASEP level.

Investment Options

In addition to the commercial and regulatory options, for each site affected by IED there are a number of potential 'asset' options which can be considered either in isolation or in combination:

1) Retain under the Limited Life Derogation
2) Retain under the Emergency Use Derogation
3) Oxidation Catalyst
4) Selective Catalytic Reduction (SCR)
5) Replace with the same capability
6) Replace with different capability
7) Retrofit
8) Mothball
9) Decommission

1. Retain under the Limited Life Derogation

The Limited Life Derogation allows units to continue to operate for a maximum of 17,500 hours from 1st January 2016 to the 31st December 2023, after which time the unit would need to be decommissioned. We currently have six units operating under this derogation. Rather than initiate immediate decommissioning, this option buys time to consider and implement options e.g. replacement.

2. Retain under Emergency Use Derogation

A second option is to use the Emergency Use Derogation. This means affected units can be used for 500 hours per year or less. There are seven units operating under this derogation. Applied to the low utilisation units, this option leads to reduced capability (in terms of duration) and therefore a risk management strategy needs to be considered. For units that continue to operate under this derogation, or the limited life derogation, the age of the assets will mean there is an ongoing requirement for asset health investment.

3. Catalytic Converter: Oxidation of CO using an Oxidation Catalyst

One option to meet the required ELVs is to use a catalyst to treat exhaust gases emitted from the compressor flue stack. Catalytic converters can be used to either oxidise the CO or to reduce the NOx.

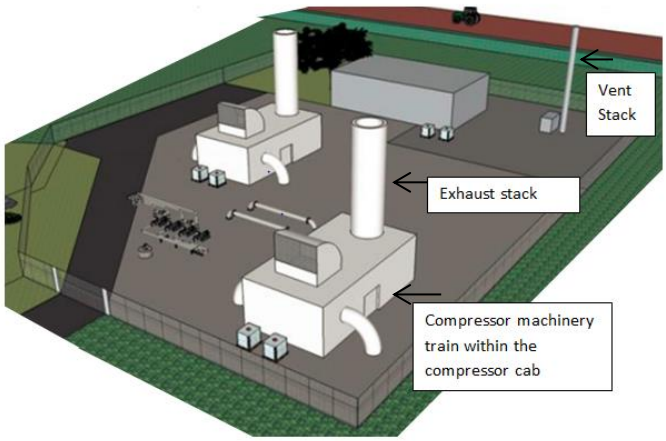


Figure 6: Compressor station overview (without a catalyst fitted)

An oxidation catalyst is used to convert CO and hydrocarbons to carbon dioxide and water vapour. When the CO in the exhaust gases is passed over a catalyst it reacts with the excess oxygen to produce CO_2. This solution requires sufficient physical space to fit the exhaust gas catalyst unit and in some cases continuous monitoring of the exhaust gas to ensure a sufficient degree of abatement (see figure 7). The oxidation catalyst can be used in combination with Selective Catalytic Reduction (SCR) for NOx control.

4. Catalytic Converter: Reduction of NOx with Selective Catalytic Reduction (SCR)

NOx can be reduced to nitrogen and water using SCR. Using this technique, ammonia is typically used as a reducing agent, and is injected in the exhaust gas upstream of the catalyst to break down NOx into nitrogen and water.

SCR is a more complex process to implement than an oxidation catalyst as it includes the catalyst units, storage of ammonia and process control and monitoring systems (see figure 7). Ammonia is considered hazardous and hence subject to its own specific control conditions under the Control of Substances Hazardous to Health legislation. Whilst this technology has not been applied on the NTS, it has been in use at two operational gas transmission sites in Europe. SCR offers significant reduction in NOx emissions; however a limiting factor could be longevity of the other compressor assets, which will continue to incur ongoing asset health issues. SCR options may therefore need to be accompanied with a range of asset health replacements and equipment re-lifing.

Figure 7: Compressor cab with SCR fitted

5. Replace with the same capability

Under this option the capability provided by each unit would be replaced with the same capability which would result in no change in risk profile. However due to the significant changes in supply and demand patterns over the last 15 years and the way in which shippers use capacity, this may no longer be an optimal solution. A replacement unit would not necessarily be exactly the same type of unit due to changes in technology, and for example, emissions limits for new technology could significantly reduce the operating range of a compressor. This could be addressed by the installation of multiple smaller units to provide the same operating range and capability.

6. Replace with different capability

Under this option, we determine the capability requirement for each site based on forecast flows, operating strategy and legal obligations and replace non-compliant technology with compliant equipment. This enables us to develop solutions that take account of the current and the future needs of the system.

7. Retrofit

A retrofit in this context is the exchange or modification of an aspect of the compressor unit with newer elements which offer lower emissions. Under this option only some of the unit will be upgraded, meaning that the unit as a whole will be limited to its original lifespan. Retrofitting of existing gas turbines is possible but can be limited due to increased space required and conformity with existing equipment. The environmental performance and total cost of ownership can be less favourable compared with a new low emission package. The LCP directive applies to our RB211 units, which are all in the region of 30-40 years old. Following assessment, none of the available retrofit packages are technically suitable in this instance.

8. Mothball

Mothball is an option to preserve the compressor unit in working order so that it could be restored and brought back online within a prescribed timeframe if needed. To build a new compressor takes up to seven years, so this option retains flexibility in circumstances where the future need for the site is not fully known. However, the environmental site permit for a NTS compressor station requires the unit to undergo regular emissions testing. A unit therefore would have to be kept in full working order, maintained in a similar way to a fully operational unit. If moving parts were taken offsite for preservation, the site would lose its permit and for certain sites it is likely that a new permit would not be granted in the future, consequently removing any advantages of mothballing. Hence this option is not one taken forward further.

9. Decommissioning

Decommissioning is the option of permanently removing a unit from service. This would include dismantling and disposal of the compressor train, all associated balance of plant and connecting pipework back to the level of the unit plinth. This may not mean that the site itself can be closed as it may have other functions, e.g. as a multi junction.

Stakeholder engagement

Stakeholder engagement is of fundamental importance to us. We have listened to our stakeholders' views and acted on what they told us. As we work to meet environmental legislation and replace ageing assets it is crucial that we are transparent and clear about the tasks ahead, and that we work with our stakeholders to produce a compressor strategy that meets their requirements**.**

In April 2014 we began our initial period of stakeholder engagement. We also publicised the start of the engagement through our Connecting website and a project specific website under the Talking Networks umbrella. We commissioned a video to provide an overview of the IED legislation and its impact on our network and its users.

Then, in July 2014 based on feedback, stakeholder consultations began with an initial workshop and subsequent workshops in September 2014, November 2014 and March 2015. Attendance (22 different attendees across all workshops), represented a wide range of industry participants including shippers, Distribution Networks (DNs) and trade associations.

In the first workshop to get a better understanding of stakeholders' requirements delegates completed a Gas Transmission Network Strategy scorecard, to identify the network capability criteria that are most important to them and why (Figure 9). This formed the basis for the development of a range of site options. On the 17th November 2014 we published the *IED Investments: Initial Consultation* document. In this consultation we asked for stakeholders views on a range of questions including the range of available options for compliance at each affected site.

The *IED Investments: Initial Consultation Stakeholder Feedback* document was then published on 16th January 2015 outlining what stakeholders told us in the responses and what we would do as a result, including providing more information on the different elements of legislation.

In February 2015 we presented at the Transmission Workgroup and we also held a number of bilateral discussions to address particular concerns for individual parties including all four Gas Distribution Networks (GDNs). On the 13th March 2015 we published the *IED Investments: Proposals Consultation*. This was a development of the initial consultation document in light of stakeholder feedback received. It also provided a recommended option to achieve compliance at each site. The consultation received responses from Centrica, RWE, Total, National Grid Distribution and Energy UK.

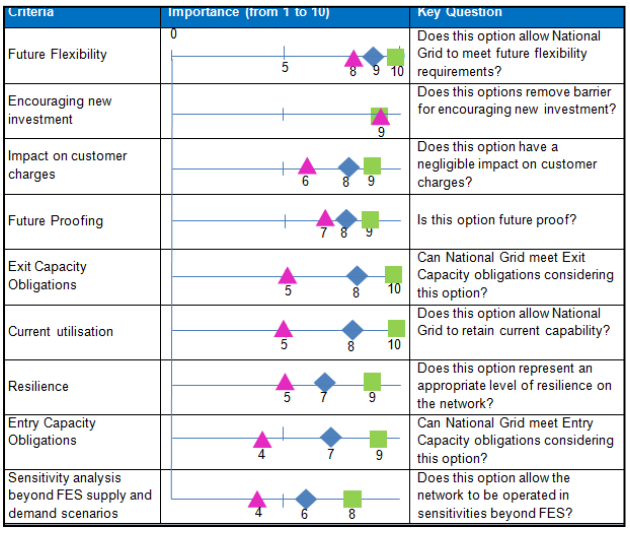


Figure 8: Overview of the network strategy scorecard

In their responses stakeholders broadly agreed with our recommendations. Ultimately this formed the basis for our IED reopener submission to Ofgem in May 2015. Ofgem, whilst positive about the stakeholder engagement process we had undertaken asked for the submission to be resubmitted in May 2018 with further work on costed options.
In preparation for the May 2018 reopener we are looking to build on the positive response from our 2015 stakeholder engagement, developing the factors stakeholders consider important with a robust Cost Benefit Analysis (CBA) methodology for the options presented.

The first events held as part of our second period of stakeholder engagement have been three workshops held in London, Edinburgh and Warwick in October 2017. These events attended by a range of stakeholders, have re-introduced the background to the legislation and provided an updated view on the impact on the compressor fleet. These workshops have also provided insight into the most effective way to continue stakeholder engagement in this second phase.

A key message from stakeholders was that views shared in the May 2015 reopener process are still very relevant and the themes identified are still appropriate. Having shared the key inputs with the stakeholder groups in November, many of the possible inputs have been captured appropriately in the CBA tool. Where stakeholders identified other factors, we will seek to either include these in the CBA tool, or to capture these within the stakeholder section within each site assessment. These additional factors are grouped under three themes, consolidated from the stakeholder themes from the 2015 reopener process:

- Future Flexibility: delivering a network fit for the future
- Impact on our Customers: minimal effect on consumers and our direct customers
- Resilience: maintaining network access and operation

In some cases the relevant information under each theme will be assessed qualitatively, whilst in other cases e.g. on customer bill impact, financial figures will be presented.

Since the workshops in October, we have conducted several bi-lateral meetings with interested parties and have incorporated their views into this formal consultation.

Cost Benefit Analysis (CBA)

In order to quantify the relative benefits of each option, we have built a Cost Benefit Analysis (CBA) tool. The CBA is a mathematical decision support tool, which, based on Ofgem feedback, has been developed to quantitatively assess and compare a range of compressor unit options in order to inform the optimal solution. The evaluation includes the costs of implementing each option and the relative advantages of doing so.

The tool generates a Net Present Value (NPV) of the options, and runs optional timing analysis. The assessment includes costs of maintaining and replacing assets, fuel usage, emissions costs, site operating costs, the costs of managing constraints and where relevant, the cost of commercial and regulatory options. These costs are spread across the full assessment period in order to represent the impact on consumer bills and to reflect the cost of capital investments, the regulated weighted cost of capital is applied. To allow for comparison between costs occurring over different time periods, future values are discounted using standard rates.

With the long time horizon of the model, out to 2050, most of these inputs have an associated uncertainty. The CBA tool uses Monte-Carlo modelling in order to account for these uncertainties and simulate the potential range of possible outputs. For every variable within the tool, an uncertainty distribution is applied to account for its potential range of values in the future. The Monte-Carlo simulation will pick values for every variable based on defined probability distributions. This process is iterated 10,000 times in order to produce an expected final NPV with an associated range representing the 5th and 95th percentile.

The NPV for each option is then compared against a Counterfactual option to produce a relative NPV. The Counterfactual represents current network with minimum interventions to comply with emissions legislation. The relative NPV will inform which of the options provides the greatest benefit to the consumer.

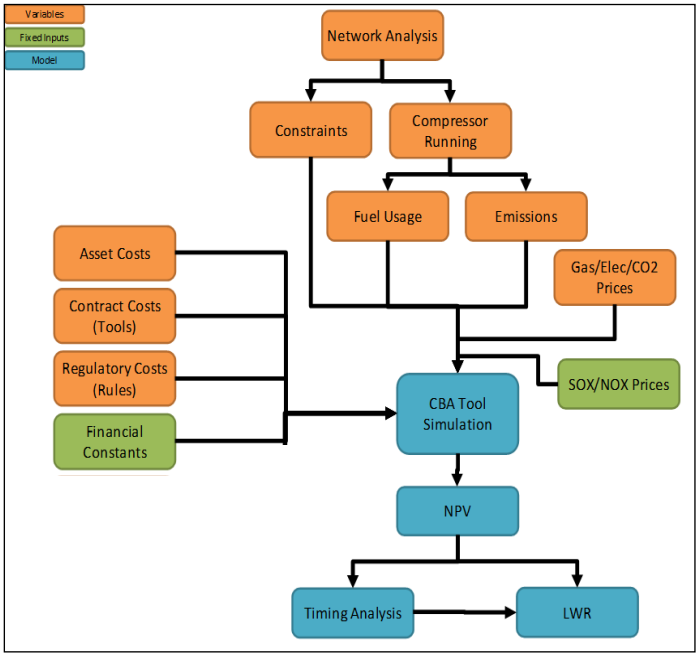


Figure 9: Overview of CBA tool

IED investment to date

Since the introduction of IPPC, LCP and then the combined requirements of IED, we have received funding for six sites to ensure compliance with the legislation.

As part of IPPC Phase 1, prior to RIIO-T1 baseline funding was agreed for works at St Fergus for two electric VSD (variable speed drive) units 3A and 3B, which were operationally accepted in
June 2015. Also funded under IPPC Phase 1 was a VSD unit at Kirriemuir. IPPC Phase 2 then established funding for Hatton Unit D, an electric unit which achieved operational acceptance in February 2016.

IPPC Phase 3 was agreed with funding at the start of RIIO-T1 for one unit at both Peterborough and Huntingdon. The early stages of the Front End Engineering Design (FEED) study concluded that the option of electrically driven compressors was not viable at Peterborough, but remained a possibility for the Huntingdon site. The tender process for Huntingdon included the option for suppliers to offer an electrically driven compressor option and a number of bids were received. The BAT assessment of all of the tender submissions, combined with further information on the availability and costs of an high voltage electrical supply to site concluded that the electric drives do not represent BAT. As a result of the assessment, the unit selected to reduce emissions at both sites is a 15.3 MW gas turbine unit. Construction works will begin in 2017. At both sites, it will be necessary to retain all three existing units until the new units have been operationally proven.

Aylesbury falls under the LCP element of the IED and upfront funding received under RIIO-T1 was to fund works on two units at this site. The existing engines at Aylesbury are prototype versions of an upgraded Rolls Royce Avon engine fitted with DLE technology to reduce emissions. These are the only engines of this type that we have within our fleet. Analysis of the performance of the Aylesbury engines showed that whilst they are able to achieve the required NOx limits within their operating range, they are unable to achieve the required ELV for CO. It was established through work with Rolls Royce that the CO ELV could be achieved by the addition of a CO oxidation catalyst in the exhaust stack. The construction phase of the catalyst installation was completed in the last quarter of 2016. Unit B was successfully commissioned to Operational Acceptance stage in early 2017. Unit A is expected to move from its commissioning phase to operational acceptance shortly, following the conclusion of asset health works.

Looking forward to the next phases of work, under IED- IPPC Phase 4 we have considered investment options and have begun further investment at St Fergus, Peterborough and Huntingdon to ensure compliance. Under IED – LCP we are considering commercial and investment options at seven sites: Wisbech, Carnforth, Hatton, St Fergus, Moffat, Warrington and Kirriemuir.

Our Proposals

Our approach

In response to feedback from our 2015 proposals, and in order to strike a better balance between holistic (whole-network) and site-by-site analysis, we have adopted the following approach to our analysis:

St Fergus

This is our most complex site, having the largest number of units, which are affected by LCP, IPPC and MCP. St Fergus performs a different role to the other sites in the network and has therefore been analysed separately.

IPPC sites: Huntingdon, Peterborough

These are two of our highest utilisation sites and both are critical during periods of high demand. The units at these sites are affected by both IPPC and MCP. The primary focus of the analysis for these sites is determining the most appropriate option to reduce emissions at these high use sites.

Holistic Analysis: Hatton and Carnforth / Nether Kellet

A range of emission-compliant options were considered at each of these sites to assess the impact on network capability, resilience, emissions and fuel costs. Alrewas was also included in this analysis, even though it is not within the scope of IED, as the site can also provide some resilience in this part of the network, and it was possible that this could prove to be more efficient overall.

'Independent' sites: Moffat, Warrington, Wisbech, Kirriemuir

These sites include units that are non-compliant with LCP. The affected units were put on the 500-hour Emergency Use Derogation in January 2016, because our future utilisation of these sites was forecast to be low. This also gave us greater flexibility to respond should our forecasts change. The key focus of our analysis at these sites is to establish whether it is justified to retain compression capability.

Over-arching Approach

We have taken the following high-level approach to our analysis:

Establish the Counterfactual

The 'Counterfactual' is defined for each site to act as a starting point for decision-making. It represents the current network with minimum interventions to meet the legislative requirements. We keep existing compressor units, unless we have already committed to decommission them (e.g. if they have a Limited Life Derogation).

For example, where a site is affected by IPPC, we need to take proactive steps to reduce our NOx emissions to comply with the IPPC legislation. Our Counterfactual in this case is therefore to install one new unit and decommission one higher-polluting unit once the new unit is operationally proven.

Develop the options

We developed an extensive list of all potential options which will ensure we meet our environmental legislative obligations in the most economic and efficient manner. These options include but are not limited to:

- Commercial or contractual alternatives to asset investment
- Decommissioning the non-compliant units
- Installing catalytic emission abatement on existing units as an alternative to new units
- Installing retro-fit dry low emission technology to existing units as an alternative to new units
- Merging site capability
- Re-wheeling existing units
- Installing new emission compliant units

Reduce the options

We shortlisted options to remove those which are not credible options, for example if the requirements are not achievable or sustainable, or if the technology is not currently fit for purpose.

We developed detailed assessments of the costs and benefits of each option, including:

- Investment costs
- Decommissioning costs
- Asset health costs
- Operating costs
- Fuel costs
- Constraint costs
- Contracting costs
- Emissions damage costs

More details on what is included in these costs and how they have been calculated are included in the next section of this document.

Cost Benefit Analysis

The costs associated with each of the options were incorporated into our Cost Benefit Analysis (CBA) model. This considers a range of supply and demand scenarios, together with uncertainty modelling through Monte Carlo analysis, over a 25-year time period to develop Net Present Value (NPV) estimates and distributions for each option.

Proposals

The output of the CBA identified the option or options which have the most favourable NPV. These are presented relative to the Counterfactual. If more than one option has a comparable NPV we may propose taking more than one option forward to the next stage of our network planning process for more detailed costing.

We may also apply some qualitative assessments to these options to incorporate factors that are more difficult to quantify, such as benefits in handling within-day changes in supply or demand.

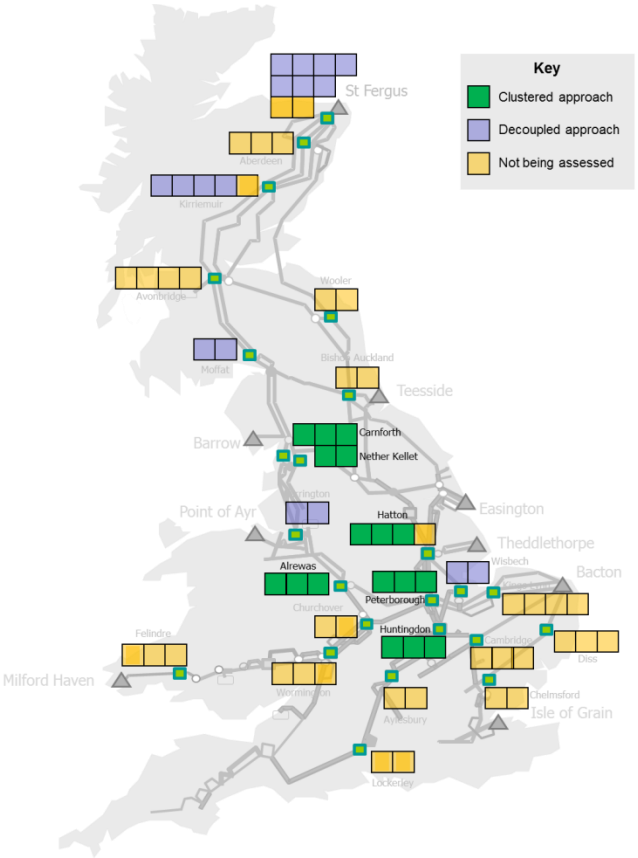
Risks

We captured risks associated with each of the options that have been selected, including the possibility that our forecasts of the future may change or that assumptions about the availability of existing assets may change.

Holistic Analysis

Introduction

The network analysis conducted for our 2015 submission was primarily undertaken on a site by site basis. This gave a good understanding of individual site requirements, but did not fully take into account interactions with other stations, particularly where they provide additional resilience. Our updated approach accounts for plausible operational scenarios, such as instances of other sites being unavailable due to planned or unplanned outages.



Approach

For this submission, we have taken more of an integrated approach to developing options that consider interacting sites together, thereby accommodating scenarios where more than one of the sites is unavailable.

A compressor strategy for the centre of the NTS was considered to include the additional compression requirements when two of Alrewas, Hatton, Peterborough, Huntingdon and Carnforth/Nether Kellet were unavailable to further determine the optimum investment strategy.

The compressors at Hatton, Peterborough and Huntingdon are in a chain along the eastern side of the NTS and therefore some interchangeability in the use of these sites could reasonably be expected dependent on the supply and demand pattern. Initial network analysis results identified that Carnforth / Nether Kellet and/or Alrewas could potentially be used as an alternative to Hatton so these compressors were also included in the holistic network analysis study.

Huntingdon and Peterborough are high-utilisation compressors that are required to meet system requirements at times of moderate or high demand. We have not therefore considered different levels of capability at these particular sites in this section of our analysis, but we do incorporate the possibility that compression at these sites may not be available due to planned or unplanned outages.

The network analysis considered a wide range of combinations of compressors being available, focussing on the alternative east coast or west coast routes to transmit gas from north to south.

Compressors Available	Compressors Unavailable
Alrewas, Hatton, Carnforth / Nether Kellet	Peterborough, Huntingdon
Alrewas, Peterborough, Carnforth / Nether Kellet	Hatton, Huntingdon
Peterborough, Huntingdon, Carnforth / Nether Kellet	Hatton, Alrewas
Alrewas,Huntingdon, Carnforth / Nether Kellet	Hatton, Peterborough
Alrewas, Peterborough, Huntingdon	Hatton, Carnforth / Nether Kellet
Hatton, Peterborough, Huntingdon	Alrewas, Carnforth / Nether Kellet
Peterborough, Huntingdon	Hatton, Alrewas, Carnforth / Nether Kellet

This analysis sought to identify the most efficient solution investment or commercial solutions for Hatton, Carnforth / Nether Kellet and Alrewas, incorporating the interactions between these sites and Huntingdon and Peterborough. We also included the possibility of investing at Alrewas as this could offer a more efficient solution overall.

The options considered, and results of this analysis, are presented in the individual compressor chapters for these sites.

Cost Assumptions

This section describes the different cost elements in our proposals, and how they have been incorporated into our Cost Benefit Analysis. We want your feedback on whether you agree with our approach, and whether we have provided enough information to enable you to reach an opinion.

Costs included in the CBA have been estimated to a level of accuracy which is appropriate for this stage of project development and will continue to be refined as more detailed project requirements developed.

Investment Costs

These are the asset costs associated with investing in new assets, either in new compressor units or in fitting catalytic abatement to existing units.

The unit costs for new compressor units have already been agreed with Ofgem for the duration of the existing price control. These unit costs are not published, as to do so would prejudice the competitive tendering process by which they are procured; however we can give an indicative range of £20m to £40m depending on site-specific considerations, size and power source.

Cost estimates for catalytic abatement have already been developed as part of the output from an innovation project we undertook in this area[2]. These need to be combined with any site-specific refurbishments required prior to installing emissions abatement. We have used a total cost of £25m to £30m per compressor unit depending on site specific factors.

Decommissioning Costs

We have estimated site-specific costs for decommissioning compression assets by applying standard unit costs to the specific activities required to decommission each unit to the level of its concrete plinth. These are in the range of £1m to £2m per unit.

Asset Health Costs

These are the ongoing maintenance costs for the compression-related assets. These have been calculated in two components:

- Site-specific estimates of any outstanding remediation work, calculated using standard costs for different types of work
- Forecasts of ongoing maintenance costs, calculated by applying our standard maintenance schedules and standard unit costs

These costs may represent an increase in allowances if not included in previous submissions, for example if we had previously assumed that the unit would be decommissioned.

Operating Costs

Site-specific estimates of the ongoing operating costs associated with the compression capability on the site, calculated with reference to historical actual costs for these activities.

[2] http://www.smarternetworks.org/project/nia_nggt0087

Fuel Costs

Cost estimates of the gas and electricity required to power our compressor units, based on forecast running hours and forecast energy costs under each FES scenario.

Constraint Costs

In those scenarios where the available compression capability is insufficient to maintain contractual pressures at system offtakes within acceptable limits, we assume that constraint actions are required to ensure that these pressures are met. These are assumed to take the form of locational buy actions[3], typically in the south, in which existing commercial mechanisms are used to 'buy on' gas at supply points closer to the points of demand. These will normally be accompanied by location sell actions at other points on the network to ensure that supply and demand remain balanced.

We have assumed locational buy costs of 3.2p/kWh (93p/therm) and locational sell revenues of 1.4p/kWh (41p/therm).

The exception to this approach is for the St Fergus analysis, for which standard constraint actions are not appropriate. In this instance we have assumed that compensation mechanisms have been applied as defined in the Unified Network Code (UNC), which are calculated by applying a multiplier of 6 to the weighted average price paid for long term firm capacity at the affected ASEP, which gives a value of 0.2p/kWh (6p/therm).

Contract Costs

Where commercial actions have been identified as required to meet our 1-in-20 planning obligations, e.g. in options where there is no resilience for compressors that network analysis identifies need to be run in 1-in-20 conditions, we have assumed that we would enter into contracts to ensure availability of turn-up services.

The costs of these contracts have been determined with reference to existing turn-up contracts such as those procured for Operating Margins, adjusted to reflect the volume being requested and the frequency of the contract being exercised.

Costs have been applied in the range 2.25 - 3.0p/kWh for the south east and 1.1 - 1.5p/kWh in the North West. The upper part of the range is applied where greater volumes are required, reflecting the greater impact on the operation of the site(s) providing the service.

Emissions Damage Costs

We have monetised the environmental impacts of different options by applying DEFRA's air quality damage costs[4] of £13,131/tonne for oxides of nitrogen to estimated levels of emissions calculated from unit-level forecasts of run-hours.

Feedback Questions:

1. Do you agree with the approach we have taken to estimate the costs of different options?
2. Have we given you enough information about our cost assumptions?

[3] As opposed to capacity buy-backs, which are used to reduce entry or exit flows

[4] https://www.gov.uk/guidance/air-quality-economic-analysis

How These Costs Will Be Recovered

It is important to note that these different elements of costs will be recovered through a combination of upfront and ongoing allowances. We have included all of these costs in our CBA model because this ensures that all relevant costs are included in the option evaluation.

The following categories of costs will be requested as upfront allowances to allow options to be implemented:

- Investment Costs
- Decommissioning Costs

The remaining categories of costs will be included in ongoing submissions or allocations to recover the costs associated with maintaining the delivery of options:

- Asset Health Costs
- Operating Costs
- Fuel Costs
- Constraint Costs
- Contract Costs

Our proposals – St Fergus

Site description

The St Fergus compressor site is used to raise the pressure of gas entering the National Transmission System (NTS) via the North Sea Midstream Partners (NSMP) sub-terminal. As such compression at the site is continually operated on a 24/7 basis and any loss of service immediately impacts on the volume of gas that can enter the NTS via this entry point.

The existing site contains two electric units installed in 2015 and seven gas-powered units (2 larger RB211s and 5 smaller Avons) installed between 1977 and 1978.

Drivers for change (IPPC, LCP and MCP)

The high utilisation of the St Fergus gas-powered units means that the site remains one of our top three most polluting sites on the NTS. In order to comply with the requirements of the IPPC we need to further reduce NOx emissions from this site.

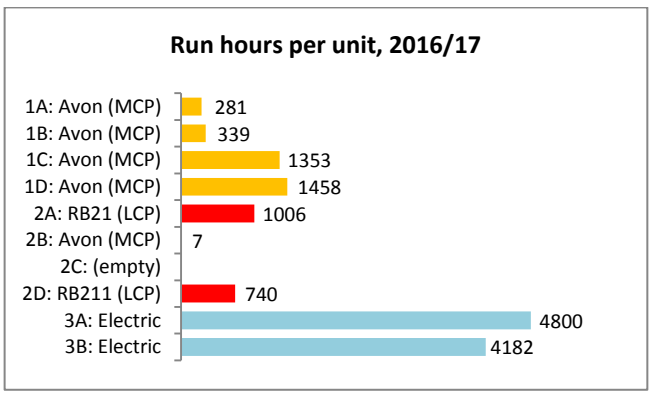
The two RB211 gas units are non-compliant with LCP. These were placed on Limited Life Derogation in January 2016 which means each unit must be taken out of service either once the unit reaches 17,500 run hours or by 31st December 2023, whichever comes first.

The remaining five Avon gas units are non-compliant with the emissions limits specified by the MCP Directive and therefore each unit will be restricted to 500 hours per year from 2030 onwards[5].

Running hours

Due to the requirements at this site the compressors at St Fergus are continually operating to bring gas onto the NTS. We installed the two electric units at the site as part of a previous phase of IPPC compliance. These are now operational and are the lead units for the site.

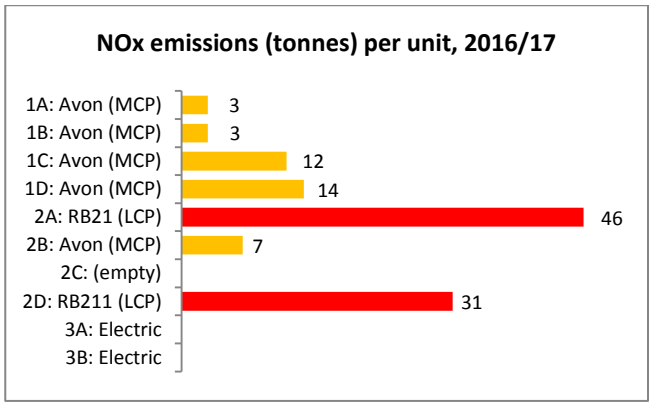
The gas-powered units are used when supply flows are outside the range of the electric units, or if the electric units are on planned or unplanned outage. For these reasons we are still seeing a significant number of run hours on the gas-powered units on the site, which must be reduced in order to meet our obligations under IPPC.



[5] This is our working assumption pending clarification of how the legislation will be applied.

NOx emissions by unit

The following chart shows NOx emissions at the site during 2016/17.



This chart shows that the RB211 units are the most polluting, both in absolute terms but also relative to the number of run hours. This is due to the RB211 units being larger, and older technology, than the Avon units.

Definition of Counterfactual

The Counterfactual is defined as maintenance of existing assets, including any decisions already made (e.g. under previous phases of IPPC); plus any minimum intervention required to comply with legislative obligations under a 'business as usual' approach.

For St Fergus, we need to demonstrate a plan to reduce NOx emissions at the site; therefore the do minimum option under business as usual would be to install one new Avon-sized unit on an existing empty berth (2C) on site.

Options considered

We have developed options that deliver a range of emissions-compliant resilience capabilities through combinations of new and emissions abated units. The options were grouped as follows:

Group	Description
Counterfactual	1 new Avon-sized unit in empty berth
0	Alternative mechanisms to deliver 1 Avon-sized unit
1	2 Avon-sized units
2	1 RB211-sized unit + 1 Avon-sized unit
3	1 RB211-sized unit + 2 Avon-sized units
4	6 Avon-sized units

Within each of the groups in the above table there are a number of sub-options which provide similar resilience and capability; for example, Group 0 - 1 Avon-sized gas unit includes sub-options for a new greenfield gas unit or emissions abatement on one of the existing Avon units. Each sub-option has been costed and evaluated separately by the Cost Benefit Analysis (CBA).

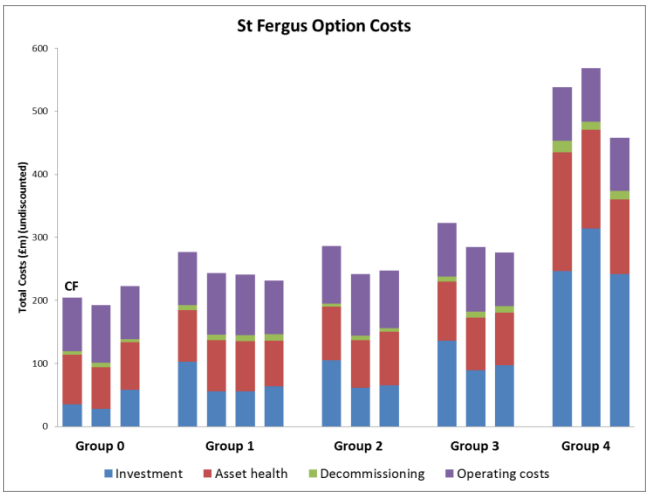
Commercial options such as turn-down contracts, baseline reductions and aggregated single entry point (ASEP) dis-aggregation have been assessed but they are not considered viable for this site due to the high number of run hours, meaning that the frequency of exercise would be unacceptably high to customers.

The commercial impact of having to constrain gas entering the sub-terminal due to flows exceeding capability has been estimated using Network Code liabilities for the failure to accept gas.

CBA Inputs

The following chart illustrates the costs that have been input to the CBA model prior to running the Monte Carlo simulations, with separate bars for each option within each group. These represent the total fixed costs for each option, undiscounted, over the 25-year period being evaluated. The cost categories included at this stage include asset investments, asset

health, decommissioning costs and site operating costs.



For example the first option in Group 0 is for the Counterfactual, a new Avon-sized gas unit on an existing plinth, and the second option is for emissions abatement on an existing Avon unit. The chart shows the lower investment cost associated with emissions abatement, although this is partially offset by higher operating costs.

Investment costs increase as the number of new compressor units increases. Variations within each group are due to the different modes of delivery, with emissions abatement capable of being delivered at a lower cost than new units.

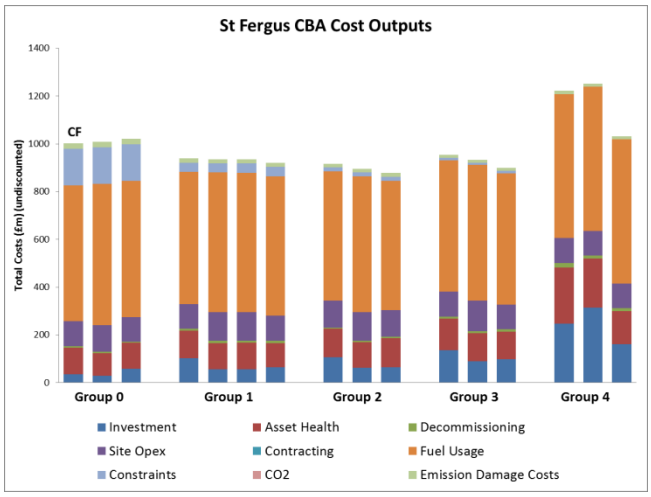
Results

The decision making process for St Fergus is made more complex by the need to demonstrate the most cost-effective solution to meet the requirements of both the LCP and IPPC components of IED.

Therefore, we are seeking to demonstrate that the most cost-effective solution for LCP will also provide a significant contribution to NOx emission reduction at the site.

Total option costs

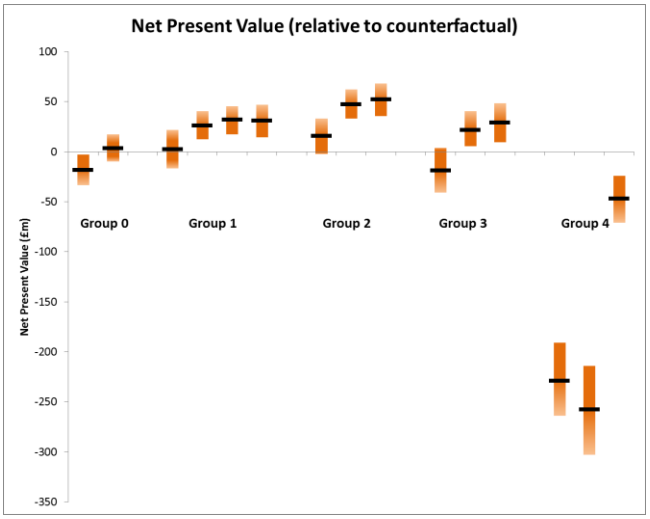
The following chart shows the total undiscounted costs associated with each option, once compressor fuel, constraint costs and emissions damage costs have been included.



This shows that, although the Counterfactual and other options in Group 0 had the lowest fixed costs, the addition of fuel costs and constraint costs makes these options more expensive than groups 2, 3 and 4. The higher levels of asset investment in these groups are more than offset by reductions in constraint costs due to higher resilience, and reductions in fuel usage associated with newer, more efficient units.

CBA outputs

The following chart shows the provisional Net Present Value (NPV) of each of the options that have been considered, relative to the Counterfactual. As described above, within each group, there are a number of different options that deliver a similar level of capability. Note that the values shown are the difference between each option and the Counterfactual. A positive value indicates a better return (lower overall cost) than the Counterfactual.



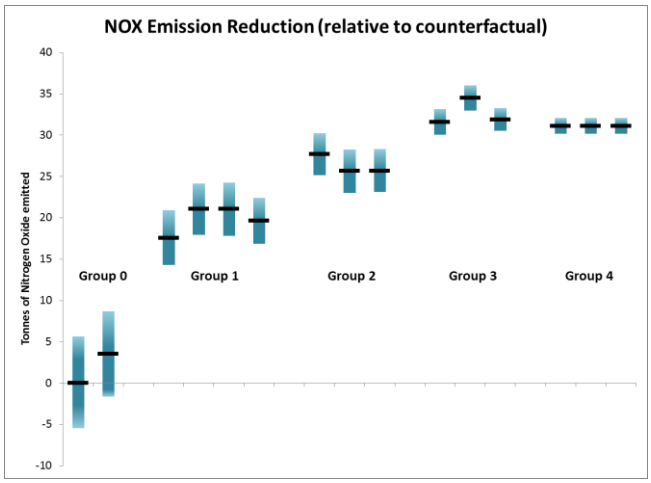
This chart shows that a number of options have a positive NPV relative to the Counterfactual, meaning they offer a better return overall.

Two options in Group 2 (1 RB211-sized unit and 1 Avon-sized unit) have the highest NPV and therefore provide the most cost-effective solution to reducing NOx emissions and meeting our obligations under IPPC. Specifically, these options are:

- Emissions abatement on one existing RB211 unit; *plus*
- Emissions abatement on one existing Avon unit *or*
- One new Avon-sized unit

NOx Emissions Reduction

The following chart shows the estimated annual reduction in NOx emissions associated with each of the options that have been considered, relative to the counterfactual.



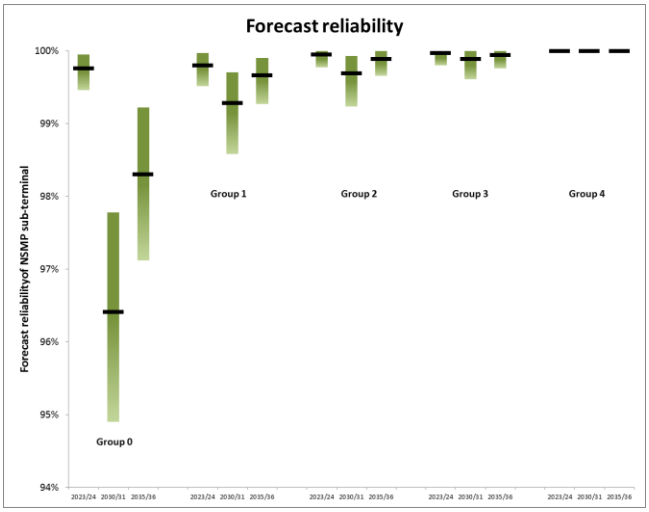
This shows that the reduction in NOx emissions improves as additional low-emission capability is added to the site to reduce the running hours on the existing Avon units, although the incremental benefit reduces with Groups 3 and 4.

Reliability

The following chart shows our forecasts of reliability at the NSMP sub-terminal under the different options, with the percentage reliability representing the proportion of days on which sufficient compression capability is available to transport the full quantity of gas being supplied.

A value of 95%, for example, implies that there will be some restriction to gas flows on 1 day in 20, due either to flows exceeding installed capability, or installed compressors being unavailable due to planned or unplanned outages.

Reliability is shown for three years for each group: 2023/4, 2030/1 and 2035/6.



In Group 0 we can see a significant reduction in reliability in 2030/1 once the use of the existing Avons is restricted by MCP, implying that there is insufficient resilience in these options. As the resilience at the site increases through groups 1 to 4, reliability also increases.

Our Proposal

Our CBA has identified that two of the options in Group 2 provide the highest NPV when compared to the Counterfactual. These also provide a significant reduction in NOx emissions whilst maintaining a high level of availability at this strategically important sub-terminal.

Our provisional proposal to deliver compliance with the requirements of LCP is therefore:

- Install emissions abatement on one existing RB211 unit; *and*
- Decommission the remaining RB211 unit;

Our provisional proposal to deliver a reduction in NOx emissions under IPPC is therefore:

- Install emissions abatement on one existing Avon unit *or*
- Install one new Avon-sized unit

The NPVs for these two options are sufficiently close that our provisional proposal is to take both options forward to the next stage of our network planning process for more detailed costing and evaluation.

Risks

If supplies through the NSMP sub-terminal are higher than assumed, this may lead to higher constraint costs than estimated in the CBA.

Feedback Question

3. Do you agree that our proposals for St Fergus strike the right balance between investment cost, reduction in NOx emissions and availability?

Our proposals – Huntingdon

Site description

Huntingdon is predominantly used for bulk transmission of gas from Peterborough or Wisbech to meet demand in the south east and south west. It is also a critical compressor to support 1 in 20 peak demand obligations in the south east and south west.

The site currently contains three Avon gas-powered units which are all approximately 35 years old. The site is frequently operated with two units used in parallel during periods of high national demand.

Drivers for change (IPPC)

Based on historic operation, this site has been identified as one of the top three most polluting sites on the network. In order to comply with the requirements of the IPPC we need to significantly reduce NOx emissions from this site.

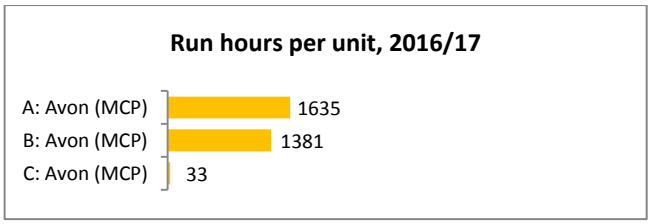
We are in the process of installing one new gas-powered unit, which has already been funded by Ofgem, as part of our Phase 3 IPPC programme of works. This unit will be operational by late 2019. Even with this new unit in place there will still be an ongoing need to operate the site with two units in parallel which means that the Phase 3 solution will only partially reduce NOx at the site. Over the last 5 years there has been a need to operate the site in parallel 42% of the time, therefore there is a need to do something further to reduce NOx at this site.

The three Avon gas units are non-compliant with MCP and we have assumed that each unit will be restricted to 500 hours rolling operation per year from 2030 onwards. IPPC is the main driver for change now; however, the restricted operation beyond 2030 to comply with the MCP legislation has been taken into account in the options considered for the site. Any change to this assumption will require the options to be re-evaluated and could change our proposals.

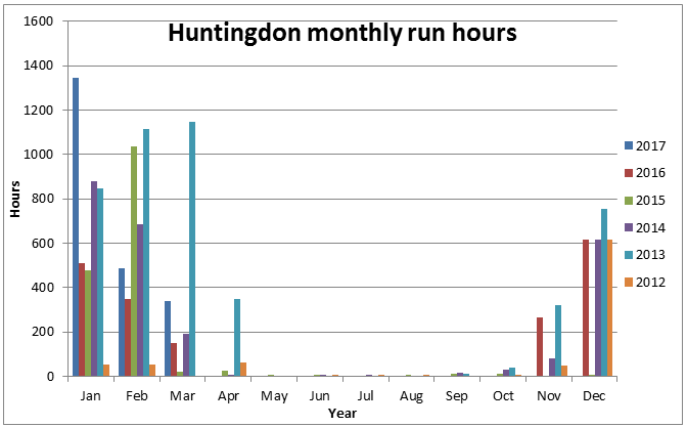
We will be developing proposals to address the requirements of the MCP legislation across our compressor fleet in due course, and this may result in further works at Huntingon.

Running hours

In 2016/17 units A and B were the lead units used at Huntingdon.

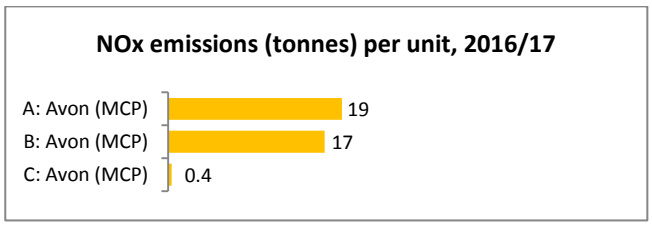


Huntingdon compression is predominantly used during the winter months when demand for gas is highest.



NOx emissions by unit

The following chart shows NOx emissions at the site during 2016/17.



Definition of Counterfactual

Install one new gas-powered unit (in addition to the one being installed as part of IPPC Phase 3 works) and decommission two existing Avon units once the new units are operational. The third existing Avon unit would be retained and rolled onto the 500-hour derogation from 2030 to comply with MCP.

Options considered

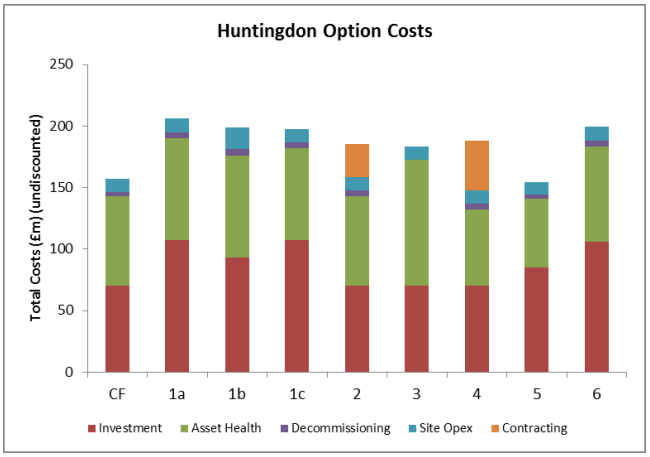
As described above, given the high running hours on the existing units at Huntingdon, our starting point for the options has been that we need to take further action in addition to the Phase 3 works already planned to comply with our obligations under IPPC. The further options considered for Huntingdon have primarily focussed on new units (gas or electric) and whether there is a need to provide further resilience to the two lead units beyond the 500-hour derogation that will be imposed as part of MCP on any remaining units on site.

Commercial options such as turn-up contracts have been included in options with lower levels of resilience, e.g. those including one new unit rather than two, to provide resilience for unplanned outages of short duration. We have not included any provision for longer-term unplanned outages, e.g. scenarios in which a compressor unit is unavailable for several months.

Option	Description
Counterfactual	1 new Avon-sized gas unit now, decommission 2 existing Avons once the new units are operationally proven, retain 1 existing Avon on 500 hours
1a	1 new Avon-sized gas unit now, 1 new Avon-sized gas unit in 2030, decommission all existing Avons in 2030
1b	1 new Avon-sized gas unit now, 1 abated existing Avon from 2030
1c	As 1a, decommission 2 existing Avons now
2	1 new Avon-sized gas unit now, decommission 3 existing Avons in 2030
3	1 new Avon-sized gas unit now, retain 3 existing Avons on 500 hours beyond 2030
4	1 new Avon-sized gas unit, decommission 3 existing Avons units now
5	1 new Avon-sized electric unit, decommission 2 existing Avons in 2030, retain 1 existing Avon on 500 hours
6	2 new Avon-sized gas units now, decommission all existing Avons once new units operationally proven

CBA Inputs

The following chart illustrates the fixed option costs that have been included in the CBA model over the 25-year evaluation period.



The Counterfactual and Options 2, 3 and 4 have the lowest investment costs as these options only include 1 new unit, whereas the other options include additional new or emissions-abated units.

New electric units would be significantly more expensive than new gas units at Huntingdon, which is reflected in the higher investment cost in option 5.

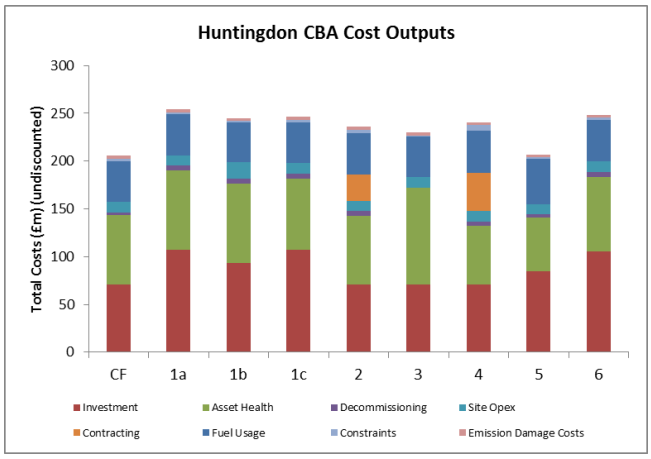
Option 3 has the highest asset health costs, associated with retaining all 3 existing Avon units beyond 2030.

Options 2 and 4 do not include any physical resilience over and above the two gas units that would remain at this site under these options. Given the requirement to run two units at Huntingdon in many scenarios across a range of demands, we have included the contracting costs that we believe would be required to meet our planning obligations and ensure the availability of turn-up services which would be required in the event of planned or unplanned outages of one or both units.

Results

Total option costs

The following chart shows the total costs associated with each option, adding the estimates of compressor fuel, constraint costs and emissions damage costs from the CBA model to the fixed option costs previously shown.

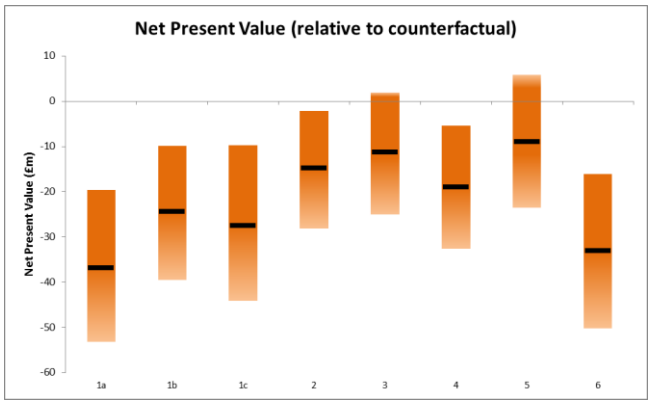


Constraint costs include the exercise costs associated with turn-up contracts.

The Counterfactual (one new unit) has the lowest total cost of the options considered.

CBA results

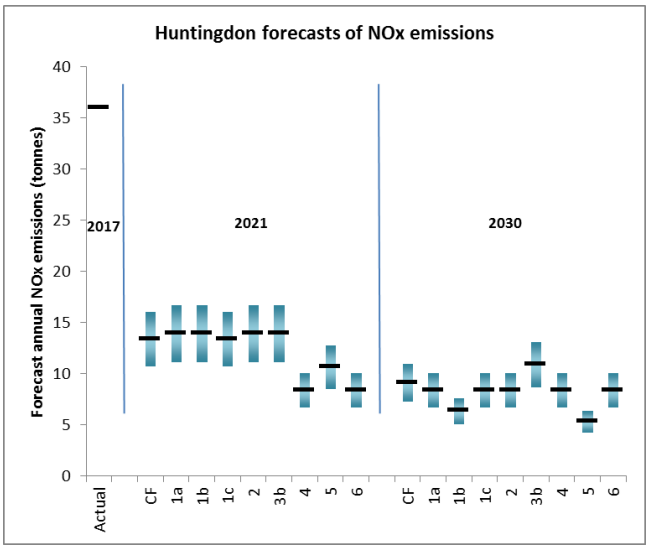
The following chart shows the provisional Net Present Value of each of the options that have been considered, relative to the Counterfactual.



This shows that all of the options considered have a negative Net Present Value relative to the Counterfactual.

NOx Emission Reduction

The following chart shows the estimated annual level of NOx emissions compared for each of the options that have been considered, for years 2021 and 2030, compared to recent actuals.



This shows that all of the options provide similar reductions in NOx emissions.

Our Proposal

When compared to the Counterfactual in our CBA, none of the other options had a higher NPV for this site. The opportunity to bundle the delivery costs for this option alongside the works currently being completed as part of Phase 3 of our IPPC programme meant this option was the most economical solution for this site. It will also provide a significant reduction in NOx emissions whilst maintaining a high level of availability at this site.

Our provisional proposal for Huntingdon is therefore the following:

- One new Avon-sized gas unit
- Retain one existing Avon unit beyond 2030 on the 500-hour MCP derogation
- Decommission the two remaining Avon units once the new units are operationally proven

Risks

Huntingdon is a critical compressor site that is required to support 1 in 20 peak demand obligations in the south east and south west. Under the proposed option, physical resilience at Huntingdon will be provided by one existing Avon unit which will be limited to an average of 500 hours per year under our current understanding of the planned application of MCP in the UK. Should network conditions change, or if we experience a long-term outage on one of the lead units, this may mean that constraint costs are higher than forecast.

We will keep requirements at the site under review and may propose further actions at Huntingdon as part of an overall proposal to deliver compliance with MCP.

Feedback Question

4. Do you agree that our proposals for Huntingdon strike the right balance between investment cost, reduction in NOx emissions and overall system reliability?

Our proposals – Peterborough

Site description

Peterborough is predominantly used for bulk transmission of gas to meet demand in the south east and south west. It can be used to support Bacton, Easington, Milford Haven and North West storage gas entry onto the network. It is also a critical compressor to support 1 in 20 peak demand obligations in the south east and south west.

Peterborough is a key strategic asset located at a critical point of the network where five feeders converge. This means that the station can be used to effectively and efficiently move gas in multiple directions to meet a variety of supply and demand patterns.

The site currently contains three Avon gas-powered units which were installed between 1973 and 1978. The site is frequently operated with two units used in parallel during periods of high national demand.

Drivers for change (IPPC)

Peterborough is one of the highest usage sites on the network which, because of the age and type of units installed at the site, means it is also one of our most polluting. In order to comply with the requirements of the IPPC we need to significantly reduce NOx emissions from this site.

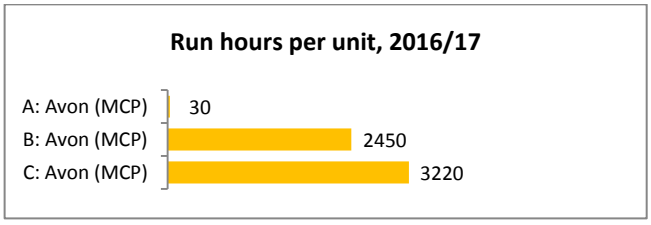
We are in the process of installing one new gas-powered unit which has already been funded by Ofgem as part of our Phase 3 IPPC programme of works. This unit will be operational by late 2020. Even with this new unit in place there will still be an ongoing need to operate the site with two units in parallel which means that the Phase 3 solution will only partially reduce NOx at the site. Over the last 5 years there has been a need to operate the site in parallel 38% of the time, therefore there is a need to do something further to reduce NOx at this site.

The three Avon gas units are non-compliant with MCP and therefore each unit will be restricted to 500 hours rolling operation per year from 2030 onwards. IPPC is the main driver for change now; however, the restricted operation beyond 2030 to comply with the MCP legislation has been taken into account in the options considered for the site. Any change to this assumption will require the options to be re-evaluated and could change our proposals.

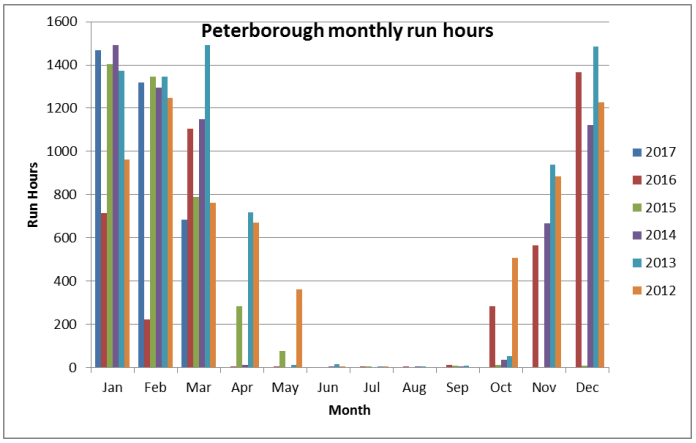
We will be developing proposals to address the requirements of the MCP legislation across our compressor fleet in due course, and this may result in further works at Peterborough.

Running hours (2016/17)

In 2016/17 units B and C were predominantly used at Peterborough.

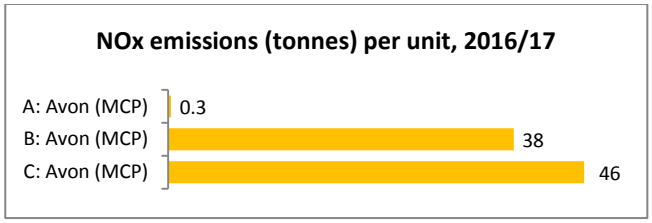


Peterborough compression is predominantly used during the winter months when demand for gas is highest.



NOx emissions by unit

The following chart shows NOx emissions at the site during 2016/17.



Definition of Counterfactual

Install one new gas-powered unit (in addition to the one being installed as part of IPPC Phase 3 works), decommission two existing Avon units once the new units are operationally proven. The third existing Avon unit would be retained and rolled onto the 500-hour derogation from 2030 to comply with MCP.

Options considered

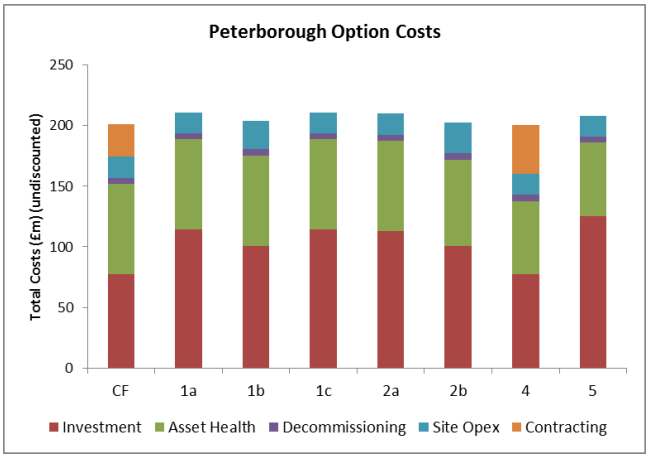
As described above, given the high running hours on the existing units at Peterborough, our starting point for the options has been that we need to take further action in addition to the Phase 3 works already planned to comply with our obligations under IPPC. The further options considered for Peterborough have primarily focussed on new units (gas or electric) and whether there is a need to provide further resilience to the two lead units beyond the 500-hour derogation that will be imposed as part of MCP on any remaining units on site.

Commercial options such as turn-up contracts have been included in options with lower levels of resilience, e.g. those including one new unit rather than two. We have not included any provision for longer-term unplanned outages, e.g. scenarios in which a compressor unit is unavailable for several months.

Option	Description
Counterfactual	1 new Avon-sized gas unit now, decommission 2 existing Avons once the new units are operationally proven, retain 1 existing Avon on 500 hours
1a	1 new Avon-sized gas unit now, 1 new Avon-sized gas unit in 2030, decommission all existing Avons in 2030
1b	1 new Avon-sized gas unit now, 1 abated existing Avon from 2030
1c	As 1a, decommission 2 existing Avons now
2a	2 new Avon-sized gas units now, decommission all existing Avons now
2b	1 new Avon-sized gas unit now, 1 abated existing Avon now, decommission 2 remaining Avons now
4	1 new Avon-sized gas unit now, decommission 3 existing Avons units now
5	1 new Avon-sized electric unit now, decommission 2 existing Avons in 2030, 1 new Avon-sized electric unit in 2030

CBA Inputs

The following chart illustrates the fixed option costs that have been included in the CBA model over the 25-year evaluation period.



The Counterfactual and Option 4 have the lowest investment costs as these options only include 1 new unit, whereas the other options include additional new or emissions-abated units.

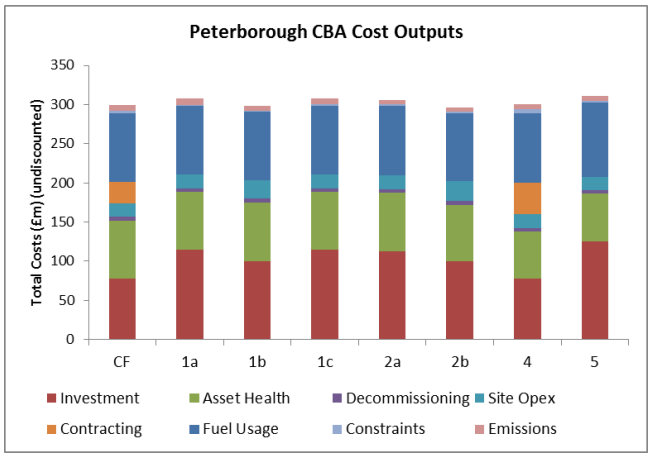
New electric units would be significantly more expensive than new gas units at Peterborough, which is reflected in the higher investment cost in option 5.

The Counterfactual only includes 500 hours of resilience and option 4 does not include any physical resilience over and above the two gas units that would remain at this site under these options. Given the requirement to run two units at Peterborough in many scenarios across a range of demands, we have included the contracting costs that we believe would be required to meet our planning obligations and ensure the availability of turn-up services which would be required in the event of planned or unplanned outages of one or both units.

Results

Total option costs

The following chart shows the total costs associated with each option, adding the estimates of compressor fuel, constraint costs and emissions damage costs from the CBA model to the fixed option costs previously shown.

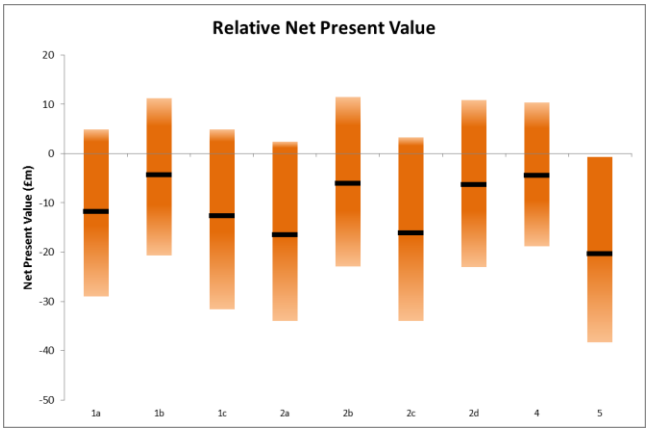


Constraint costs include the exercise costs associated with turn-up contracts.

The Counterfactual (one new unit) has the lowest total cost of the options considered.

CBA outputs

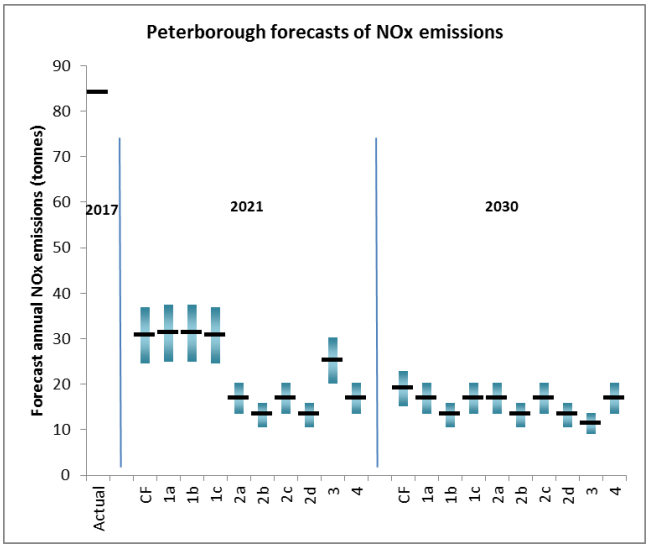
The following chart shows the provisional Net Present Value of each of the options that have been considered, relative to the Counterfactual.



This shows that all of the options considered have a negative Net Present Value relative to the Counterfactual, therefore we propose to progress the Counterfactual to the next stage of our network planning process.

NOx Emission Reduction

The following chart shows the estimated annual level of NOx emissions compared for each of the options that have been considered, for years 2021 and 2030, compared to recent actuals.



This shows that all of the options provide similar reductions in NOx emissions, particularly in 2030.

Our Proposal

When compared to the Counterfactual in our CBA none of the other options had a higher NPV for this site. The opportunity to bundle the delivery costs for this option alongside the works being completed as part of Phase 3 meant this option was the most economic solution for this site. It will also provide a significant reduction in NOx emissions whilst maintaining a high level of availability at this site.

Our provisional proposal for Peterborough is therefore the following:

- One new Avon-sized gas unit
- Retain one existing Avon unit beyond 2030 on the 500-hour MCP derogation
- Decommission the two remaining Avon units once the new units are operationally proven

Risks

Peterborough is a critical compressor site that is required to support 1 in 20 peak demand obligations in the south east and south west. Under the proposed option, physical resilience at Peterborough will be provided by one existing Avon unit which will be limited to an average of 500 hours per year under our current understanding of the planned application of MCP in the UK. Should network conditions change, or if we experience a long-term outage on one of the lead units, this may mean that constraint costs are higher than forecast.

We will keep requirements at the site under review and may propose further actions at Peterborough as part of an overall proposal to deliver compliance with MCP.

Feedback Question

5. Do you agree that our proposals for Peterborough strike the right balance between investment cost, reduction in NOx emissions and system reliability?

Our proposals – Hatton

Site description

Hatton is predominantly used for bulk transmission of gas from the north of the country to meet demand in the south east and south west. It is also a critical compressor to support 1 in 20 peak demand obligations in the south east and south west.

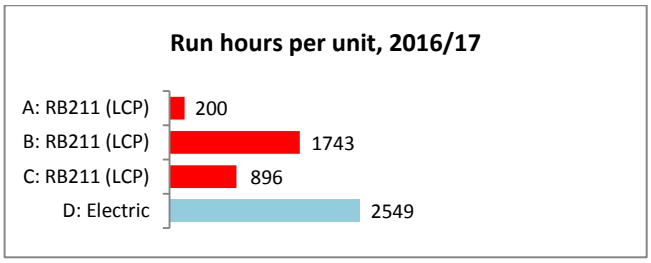
The site currently contains three RB211 gas-powered units which were commissioned in 1989, together with an electric unit which was commissioned in 2016 as part of an earlier phase of IPPC works.

Drivers for change (LPC)

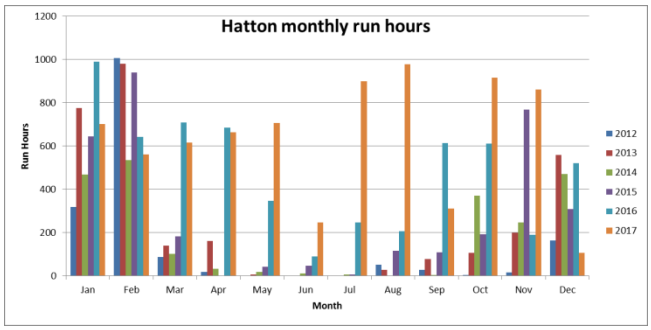
The three RB211 gas-powered units are non-compliant with LCP. Hatton is a high utilisation site so two of the units (B and C) were placed on the 17,500-hour Limited Life Derogation in January 2016. This means that these units can be run for 17,500 hours or until 31st December 2023, whichever comes first. The remaining RB211 (unit A) was placed on the 500-hour Emergency Use Derogation. This means that this unit is limited to 500 run hours per annum with no end date.

Running hours

The electric unit (D) has been the lead unit at Hatton since it was commissioned in the summer of 2016.



Historically, Hatton compression has been predominantly used during the winter months when demand for gas is highest.



As the above chart shows, however, run hours were significantly higher throughout 2016/17, associated with higher levels of supply from St Fergus and a greater requirement to use Hatton to move gas north to south.

Definition of Counterfactual

Decommission the two RB211s that were placed on the Limited Life Derogation, at the end of 2023. Retain the RB211 unit A on 500 hours and the electric unit D. Although this retains existing capability at the site, resilience has been removed; therefore, we have assumed that turn-up contracts would need to be in place to satisfy our 1 in 20 obligations.

Options considered

The alternative options considered for Hatton in the holistic analysis were as follows:

- Low: retain unit D only
- Medium: retain unit D plus one RB211 (replacement unit or abate emissions on existing). Retain RB211 unit A on 500-hour Emergency Use Derogation
- High: retain unit D plus two RB211s (replacement units or abate emissions on existing). Decommission RB211 unit A.

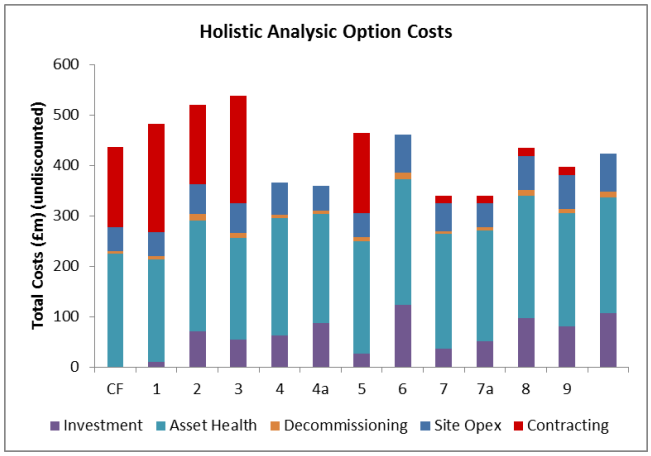
Our network analysis has shown that both units A and D are required to meet our 1 in 20 obligations. In options where the level of constraints is shown to be high, or where there is no physical resilience for units A and D, we have assumed that long-term turn-up contracts will be required in the south east and north west of the network to ensure the availability of constraint management services, and thereby meet our 1 in 20 obligations.

The options entered into the CBA are combined with Carnforth / Nether Kellet as follows:

Option	Carnforth / Nether Kellet	Hatton	Alrewas
CF	CF	CF	CF
1	Low	Low	CF
2	High	Low	High
3	Low	Low	High
4	Low	High (abated units)	CF
4a	Low	High (new units)	CF
5	High	Low	CF
6	High	High	High
7	Low	Medium (abated units)	CF
7a	Low	Medium (new units)	CF
8	High	Medium	High
9	Low	Medium	High
10	Low	High	High

CBA Inputs

The following chart illustrates the total fixed option costs for Hatton, Carnforth / Nether Kellet and Alrewas that have been included in the CBA model over the 25-year evaluation period:



Investment costs are related to the number of new or abated units in each option. The Counterfactual option includes no new or abated units, whereas option 6 includes 5 new or abated units across the three sites.

A number of options include contracting costs where we have assessed that contracts would be required in the south east and/or north west in order to deliver our obligations and manage constraints efficiently.

For example, the ‘low’ option at Hatton gives insufficient capability in the network to meet assured pressures in the south east and north west under 1 in 20 conditions. In this scenario, contracts would be needed in both parts of the network to demonstrate compliance with our 1 in 20 planning obligation.

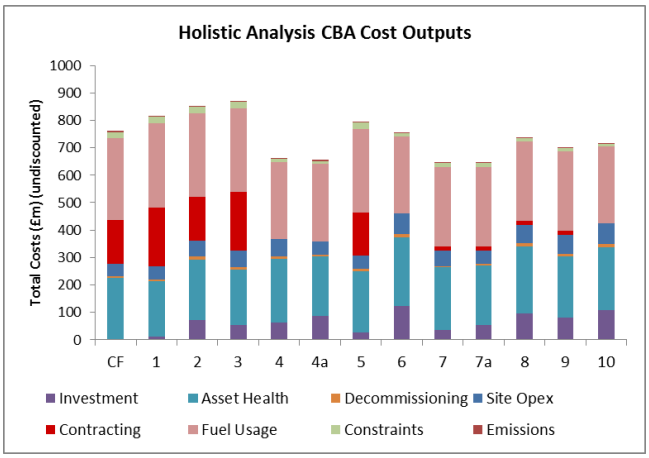
The ‘medium’ option at Hatton gives sufficient capability to meet these obligations, but without a lower level of physical resilience than we have today. Therefore we would expect to put contracts in place to secure the availability of constraint management services in the south east of the network.

In both of these scenarios, the lower level of physical resilience comes at a lower investment cost, but users of the network should expect higher levels of constraints as a consequence.

Results

Total option costs

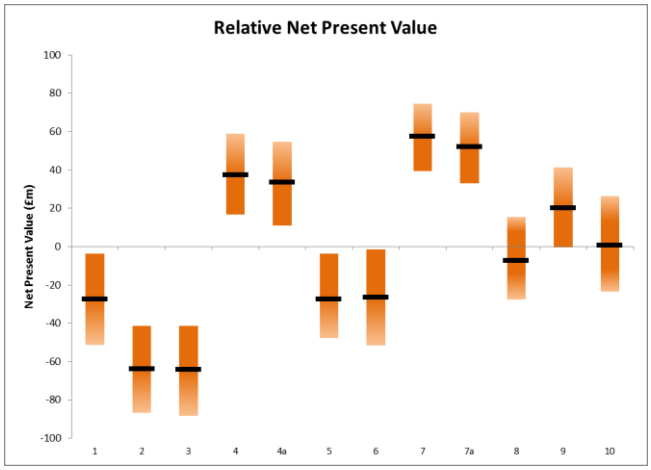
The following chart shows the total costs for Hatton, Carnforth / Nether Kellet and Alrewas associated with each option, adding the estimates of compressor fuel, constraint costs and emissions damage costs from the CBA model to the fixed option costs previously shown.



This shows that options 4 and 4a, and 7 and 7a, have the lowest overall combination of asset investment and ongoing constraint management costs.

CBA outputs

The following chart shows the provisional Net Present Value of each of the options that have been considered in the holistic analysis, relative to the Counterfactual.



Options 7 and 7a have the highest positive NPV, closely followed by options 4 and 4a.

Our Proposal

Our CBA has identified that the highest positive NPVs are given by options 7 and 7a (one additional RB211-sized unit). These options would also require contracts to be put in place to provide resilience to meet our 1 in 20 planning obligations, which could require disruption to flows at times of very high demand on the network.

The next most positive NPVs are given by the options for two RB211-sized units (options 4 and 4a). These options provide a greater level of physical resilience and would provide the same or enhanced outputs to our customers for a relatively small increase in costs, while reducing disruptions to flows at times of high stress on the network.

Our provisional proposal for Hatton is therefore the following:

- Emissions abatement on two existing RB211 units; *or*
- Two new gas RB211-sized units
- Decommission the remaining RB211 unit(s)

Risks

We have assessed that the proposed option provides a lower risk of disruption to flows at times of high demand on the network.

Feedback Question

6. Do you agree that our proposals for Hatton strike the right balance between investment cost, commercial costs and system reliability?

Our proposals – Carnforth / Nether Kellet

Site description

Carnforth and Nether Kellet are two adjacent compressor sites in the north-west which are used for bulk gas transmission of gas, predominantly from the northern terminals of St Fergus, Barrow and Easington, south down the west coast towards the Midlands.

The Carnforth site contains two RB211 gas-powered units one which was commissioned in 1989 and the other in 1992, together with a LM2500 Dry Low Emission unit which was commissioned in 2000. The Nether Kellet site contains two SGT400 Dry Low Emission units which were commissioned in 2003.

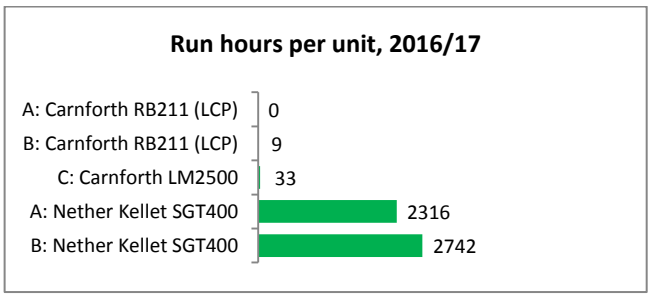
Drivers for change (LPC)

The two RB211 gas-powered units are non-compliant with LCP. One of the RB211s (unit A) was placed on the 17,500-hour Limited Life Derogation in January 2016. This means that these units can be run for 17,500 hours or until 31st December 2023, whichever comes first. The remaining RB211 (unit B) was placed on the 500-hour Emergency Use Derogation. This means that this unit is limited to 500 run hours per annum with no end date.

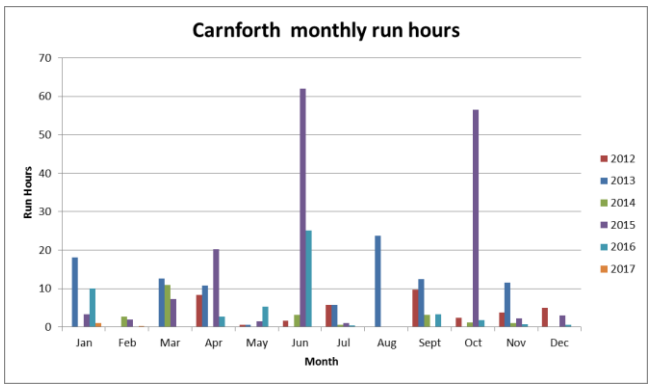
The other unit at Carnforth and the units at the adjacent Nether Kellet compression site are emission compliant.

Running hours (2016/17)

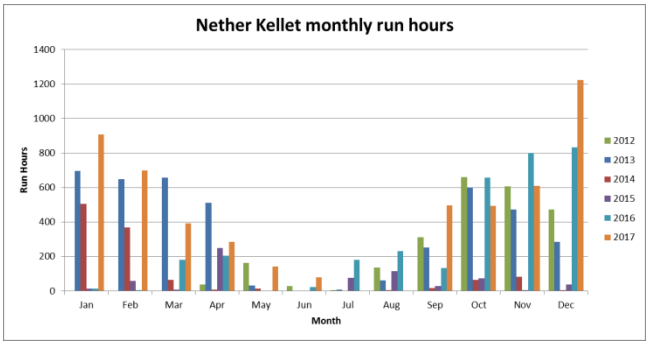
The DLE units (shown in green) are the lead units at both Carnforth and Nether Kellet. In 2017, significant asset health issues were identified with Carnforth compressor unit A which were deemed uneconomic to resolve. This meant that the unit was disconnected from the network and is no longer operational.



Carnforth compressor is infrequently used due to the availability of the less polluting units at Nether Kellet:



The units at Nether Kellet are typically run when national demand levels are higher. Running hours were higher in 2017 due to the increase in supplies at St Fergus.



Definition of Counterfactual

Decommission the disconnected RB211 Carnforth unit A immediately. Retain RB211 Carnforth unit B on the 500-hour Emergency Use Derogation. Retain the LCP-compliant DLE Carnforth unit C and Nether Kellet units A and B as is.

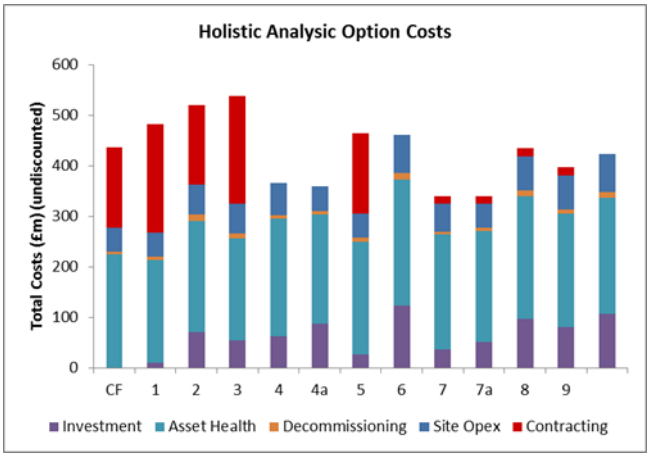
Options considered

The alternative options considered for Carnforth in the holistic analysis were as follows:

- Low: decommission units A and B, reconfigure the site to create a common pressure tier between Carnforth and Nether Kellet, to mitigate the loss of capability associated with the decommissioning of the RB211 units at Carnforth
- High: emissions abatement on RB211 unit B

CBA Inputs

The following chart illustrates the total costs for Hatton, Carnforth / Nether Kellet and Alrewas that have been included in the CBA model over the 25-year evaluation period:

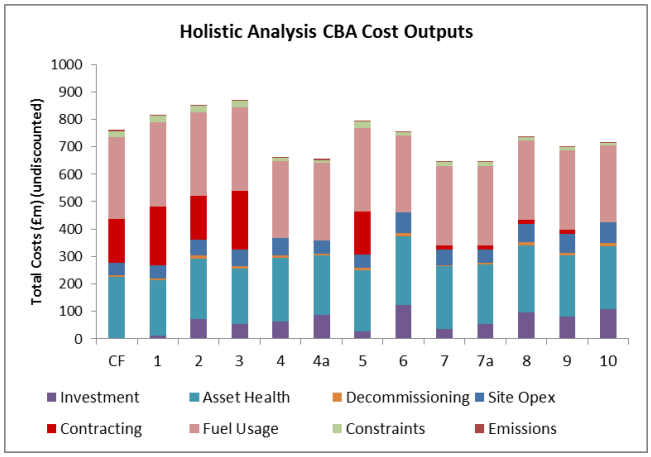


For further explanation of these costs please refer to the Hatton section.

Results

Total option costs

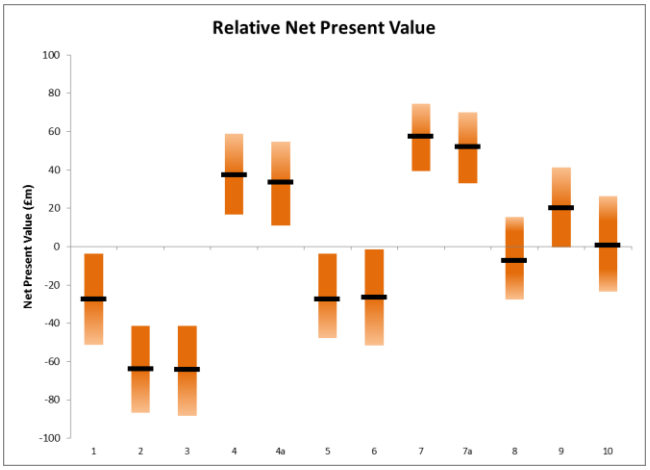
The following chart shows the total costs for Hatton, Carnforth / Nether Kellet and Alrewas associated with each option, once compressor fuel, constraint costs and emissions damage costs have been included.



This shows that options 4 and 4a, and 7 and 7a, have the lowest overall combination of asset investment and ongoing constraint management costs.

CBA outputs

The following chart shows the provisional Net Present Value of each of the options that have been considered in the holistic analysis, relative to the Counterfactual.



Options 7 and 7a have the highest positive NPV, closely followed by options 4 and 4a.

Our Proposal

Our CBA has identified that options 7 and 7a provide the highest NPV when compared to the Counterfactual. These options strike the optimum balance between the asset investment cost and contractual costs that are necessary to meet the requirements of the network going forwards.

Our provisional proposal for Carnforth / Nether Kellet is therefore the following:

- Decommission the disconnected RB211 Carnforth unit A
- Site reconfiguration to create a common pressure tier between the two sites
- Decommission the RB211 Carnforth unit B.
- Retain the LCP-compliant DLE Carnforth unit C and Nether Kellet units A and B as is.

Risks

If the common pressure tier is not delivered this will limit the operability of the site, since resilience is not currently interchangeable between the two sites and connectivity to some feeders is limited.

Feedback Question

7. Do you agree that our proposals for Carnforth / Nether Kellet strike the right balance between investment cost, commercial costs and system reliability?

Our proposals – Moffat

Site Description

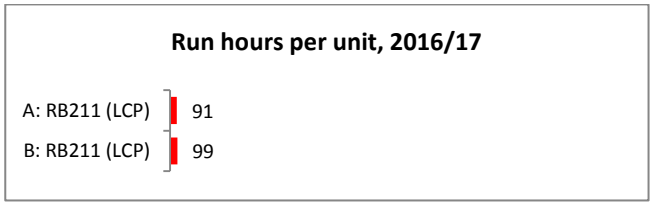
The Moffat compressor site is used to move gas out of Scotland towards the South. It can also be used to support entry capability at St Fergus during high supply scenarios (>100mcm/d).

The site contains two gas-powered RB211 units with both units installed in 1980.

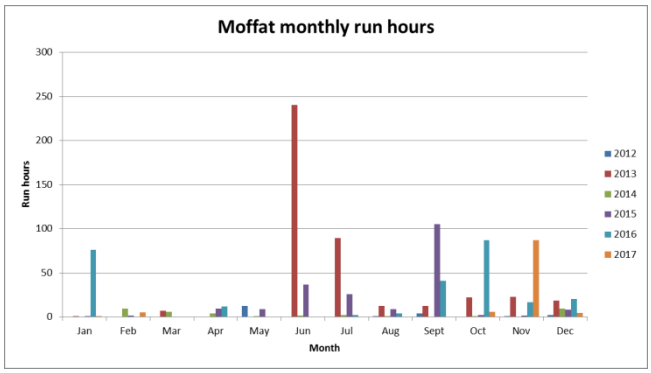
Driver for change (LCP)

The two RB211 gas-powered units are non-compliant with LCP. Utilisation at the site was forecast to be low so both units were placed on the 500-hour Emergency Use Derogation in January 2016. This means these units are limited to 500 run hours per annum with no end date.

Running hours (2016/17)



Over the last five years (to 2012), the run hours at this site have been in decline with an average of 192 run hours across the site in comparison to 817 hours on average in the five years prior (to 2007). The site is now predominantly used for system resilience when there are multiple outages (planned and unplanned) at the Scottish compressor sites upstream during high St Fergus supply conditions.



Definition of Counterfactual

For Moffat, the Counterfactual is defined as the least intervention option of retaining both units on the 500-hour Emergency Use Derogation.

Options

Given the low historic and forecast running hours at Moffat, the key decision is whether to retain the compression capability at the site.

The CBA has considered the trade-off between the one-off costs of disconnecting and decommissioning the compressor units at the site, compared to the ongoing costs of operation and maintenance.

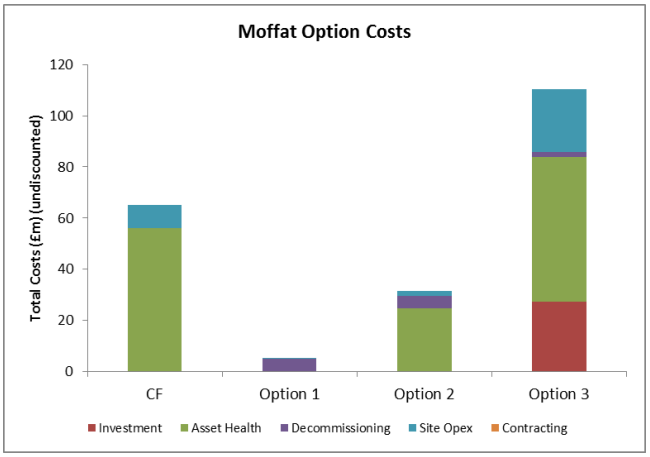
The specific options that have been considered at Moffat are:

- Counterfactual: retain both units under the 500-hour Emergency Use Derogation
- Option 1: decommission both units now
- Option 2: decommission both units in 2024, to retain optionality should network conditions change
- Option 3: apply emissions abatement to both units to allow unrestricted operation

No constraint costs have been included in the decommissioning cases as network constraints as a result of the removal of compression at Moffat are very unlikely, based on current forecasts of supplies from St Fergus.

CBA Inputs

The following chart illustrates the fixed option costs that have been included in the CBA model over the 25-year evaluation period:

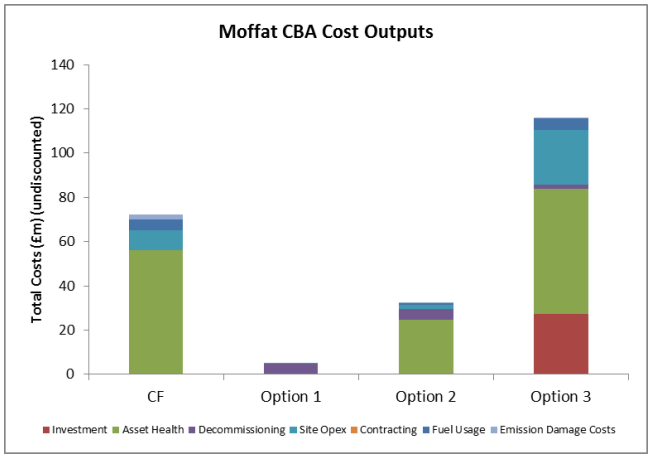


The asset health costs associated with retaining compression capability at Moffat are significant, even in the short term.

Results

Total option costs

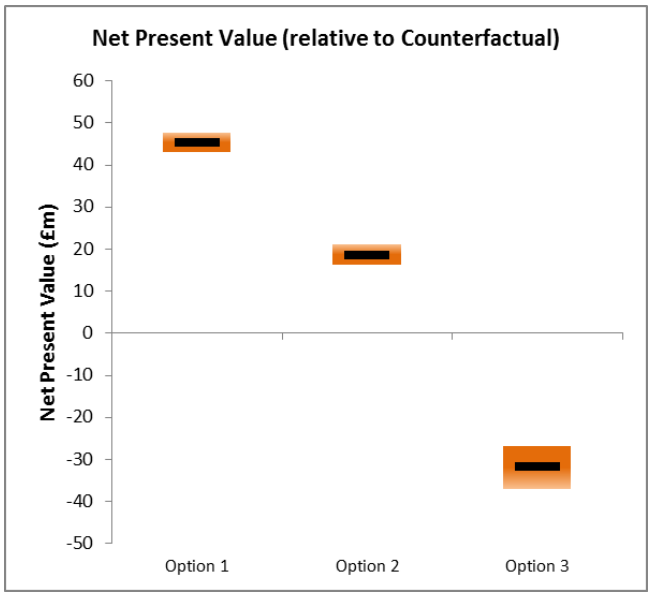
The following chart shows the total costs associated with each option, once compressor fuel and emissions damage costs have been included.



Due to the low forecast run hours at Moffat, the addition of fuel and emissions damage costs does not materially affect the ranking of the options.

CBA output

The following chart shows the provisional Net Present Value of each of the options that have been considered, relative to the Counterfactual.



When compared to the Counterfactual in our CBA, the option to decommission both units had the highest NPV. The ongoing cost of maintaining and operating the compressor units is higher than the one-off cost of decommissioning them. The benefits of the additional capability, resilience and flexibility that these units provide are not sufficient to offset

the costs of keeping them operational under current forecasts of demand and supply.

Risks

There are many uncertainties associated with the future of gas transmission in the UK. Decommissioning compression capability at Moffat could expose the industry to greater risk of constraint costs. These include:

- A significant increase in supplies at St Fergus; or
- The simultaneous loss of compression capability across a number of sites in Scotland.

Feedback Question

8. What are your views on the merits of retaining compression capability at Moffat?

Our proposals – Warrington

Site Description

The Warrington compressor site provides network compression to move gas from Scotland and the entry terminal at Barrow south.

The site contains two gas-powered RB211 units with both units installed in 1984.

Drivers for change (LCP)

The two RB211 gas-powered units are non-compliant with LCP. Utilisation at the site was forecast to be low so both units were placed on the 500-hour Emergency Use Derogation in January 2016. This means these units are limited to 500 run hours per annum with no end date.

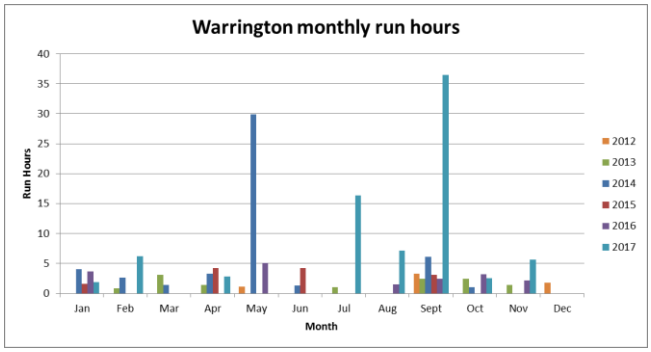
Running hours (2016/17)

Run hours per unit, 2016/17

A: RB211 (LCP)	14
B: RB211 (LCP)	8

Over the last five years (to 2012), the run hours at this site have been in decline with an average of 22 run hours across the site in comparison to 320 hours on average in the five years prior (to 2007).

The run hours on the units at Warrington have tapered off since the commissioning of the trans-Pennine pipeline between Pannal and Nether Kellet at the end of 2007. Since this pipeline was commissioned the compressors located at Carnforth and Nether Kellet (both approximately 100km to the north) have been used in preference to Warrington.



The site is now predominantly used for system resilience when there are multiple outages (planned and unplanned) at the compressor sites upstream.

Definition of Counterfactual

For Warrington, the Counterfactual is defined as the least intervention option of retaining both units on the 500-hour Emergency Use Derogation.

Options

Given the low historic and forecast running hours at Warrington, the key decision is whether to retain the compression capability at the site.

The CBA has considered the trade-off between the one-off costs of disconnecting and decommissioning the compressor units at the site, compared to the ongoing costs of operation and maintenance.

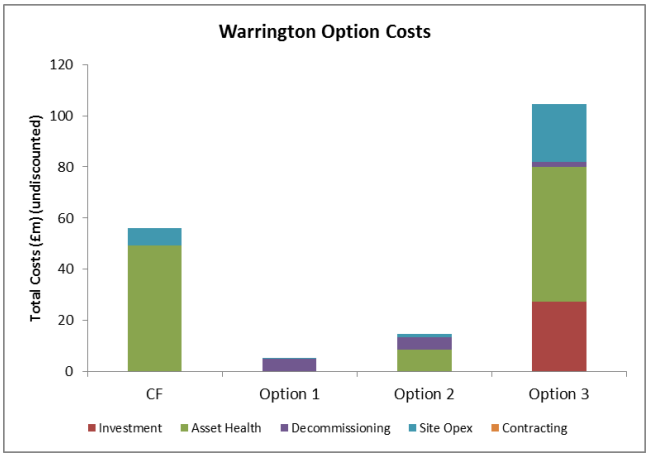
The specific options that have been considered at Warrington are:

- Counterfactual: retain both units under the 500-hour Emergency Use Derogation
- Option 1: decommission both units now
- Option 2: decommission both units in 2024, to retain optionality should network conditions change
- Option 3: apply emissions abatement to both units to allow unrestricted operation

No constraint costs have been included in the decommissioning case as no network constraints are forecast to occur as a result of the removal of compression at Warrington under current forecasts of supply and demand

CBA Inputs

The following chart illustrates the fixed option costs that have been included in the CBA model over the 25-year evaluation period:

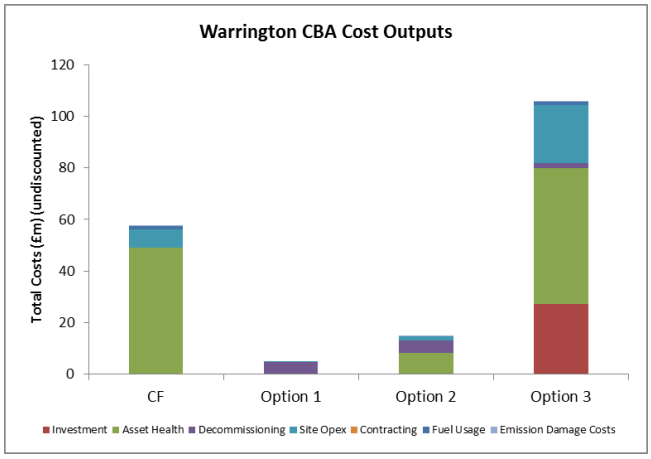


The asset health costs associated with retaining compression capability at Warrington are significant, even in the short term.

Results

Total option costs

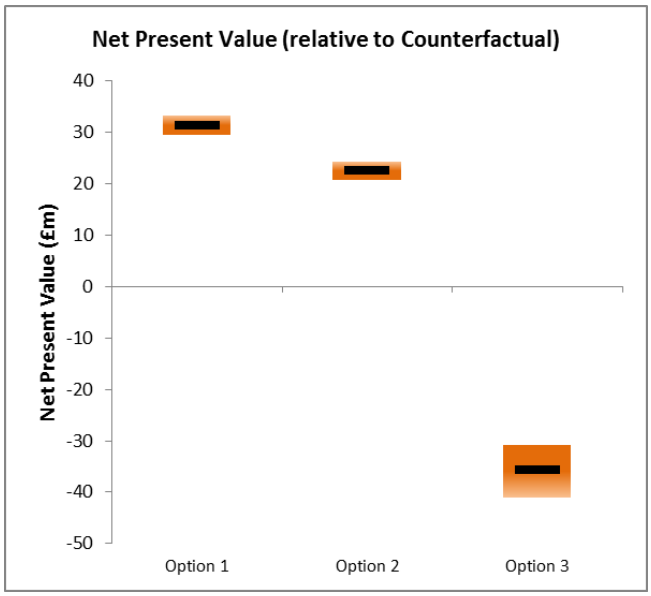
The following chart shows the total costs associated with each option, once compressor fuel and emissions damage costs have been included.



Due to the low forecast run hours at Warrington, the addition of fuel and emissions damage costs does not materially affect the ranking of the options.

CBA output

The following chart shows the provisional Net Present Value of each of the options that have been considered, relative to the Counterfactual.



When compared to the Counterfactual in our CBA, the option to decommission both units had the highest NPV. The ongoing cost of maintaining and operating the compressor units is higher than the one-off cost of decommissioning them. The benefits of the additional capability, resilience and flexibility that these units provide are not sufficient to offset

the costs of keeping them operational under current forecasts of demand and supply.

Risks

There are many uncertainties associated with the future of gas transmission in the UK. Decommissioning compression capability at Warrington could expose the industry to greater risk of constraint costs. These include:

- A significant increase in supplies at St Fergus; or
- A significant increase in supplies at Barrow; or
- A significant supply of unconventional gas such as shale in the North West; or
- The simultaneous loss of compression capability across a number of sites in Scotland.

Feedback Question

9. What are your views on the merits of retaining compression capability at Warrington?

Our proposals – Wisbech

Site Description

The Wisbech compressor site was built to provide network compression to move gas from the entry terminals at Easington, Theddlethorpe and Bacton into the south and west of the country.

The site contains two gas-powered units, an RB211 (installed in 1980) and an Avon (which was converted from a larger Maxi-Avon in 2015).

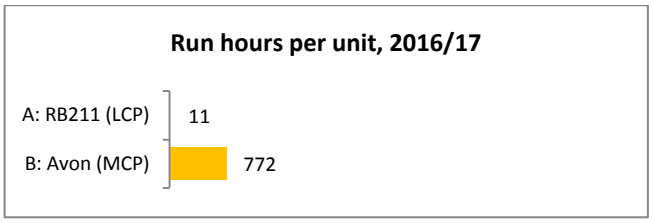
Drivers for change (LCP)

The RB211 gas-powered unit is non-compliant with LCP. This unit was placed on the 500-hour Emergency Use Derogation in January 2016. This means this unit is limited to 500 run hours per annum with no end date.

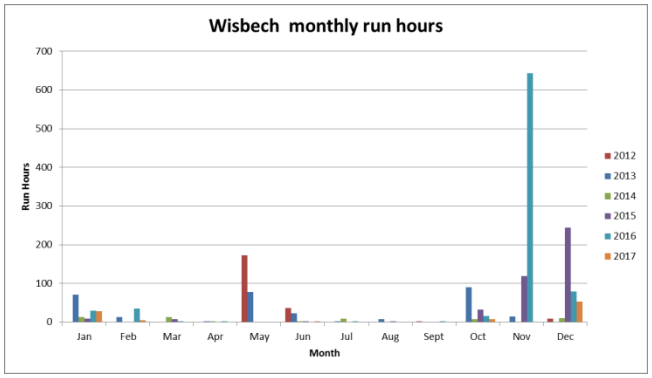
The Maxi-Avon was also non-compliant with LCP. To ensure one unrestricted unit remained on site the unit was converted in late 2015 to an Avon. The Avon gas unit is non-compliant with MCP and therefore this unit will be restricted to 500 hours rolling operation per year from 2030 onwards.

Running hours (2016/17)

In 2016/17, unit B was predominantly used at Wisbech.



The use of compression at Wisbech has become increasingly variable. This is in part due to the increase in demand in the southern half of the country which resulted in feeders being added between Peterborough and Huntingdon reducing the need for Wisbech to operate to support demand in the south west. Flows from Theddlethorpe entry terminal have continued to decline reducing the need for compression in this location. A further impact on this compressor site was the commissioning of the trans-Pennine pipeline between Pannal and Nether Kellet at the end of 2007 which introduced an alternative route to move gas over onto the west coast.



The site is now predominantly used to provide back up to Peterborough and Huntingdon during outage periods. This was the predominant reason behind the conversion of the Maxi-Avon, to provide resilience during the IPPC works

being carried out at both Peterborough and Huntingdon. Wisbech is the most appropriate compressor site to provide compression capability when one or both of these sites are unavailable.

Definition of Counterfactual

For Wisbech the Counterfactual is defined as the least intervention option of retaining the RB211 unit on the 500-hour Emergency Use Derogation and applying the 500-hour MCP derogation to the Avon beyond 2030.

Options

Given the low historic and forecast running hours at Wisbech, the key decision is whether to retain the compression capability of the RB211 at the site.

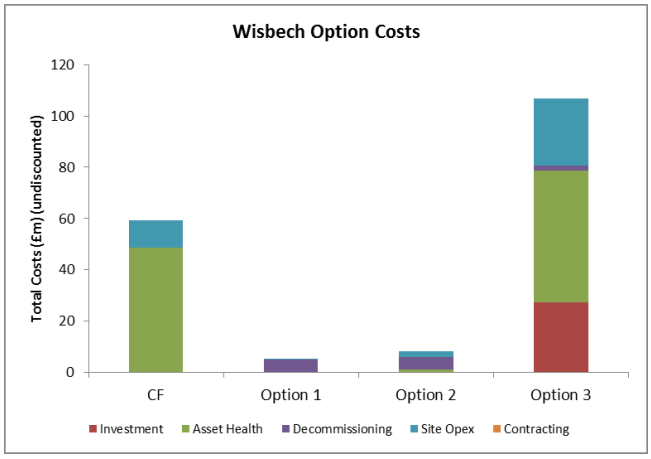
The CBA has considered the trade-off between the one-off costs of disconnecting and decommissioning the compressor units at the site, compared to the ongoing costs of operation and maintenance.

The specific options that have been considered at Wisbech are:

- Counterfactual: retain the RB211 under the 500-hour Emergency Use Derogation
- Option 1: decommission the RB211 now
- Option 2: decommission the RB211 in 2024, to retain optionality should network conditions change
- Option 3: apply emissions abatement to the RB211 unit to allow unrestricted operation

CBA Inputs

The following chart illustrates the costs that have been included in the CBA model over the 25-year evaluation period:

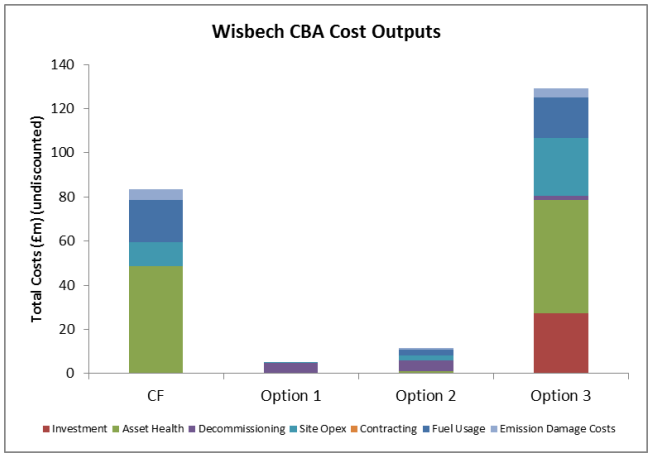


The asset health costs associated with retaining the RB211 unit at Wisbech are significant in the longer term, but not in the short term.

Results

Total option costs

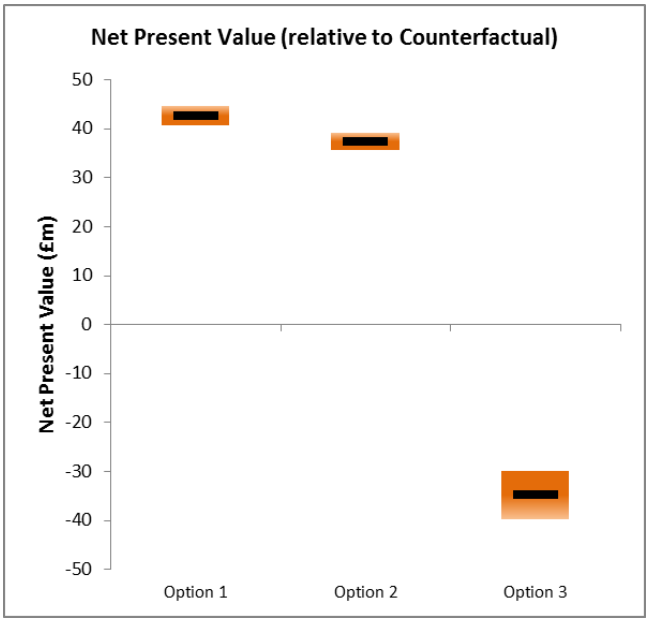
The following chart shows the total costs associated with each option, once compressor fuel and emissions damage costs have been included.



Due to the low forecast run hours at Warrington, the addition of fuel and emissions damage costs does not materially affect the ranking of the options.

CBA Output

The following chart shows the provisional Net Present Value of each of the options that have been considered, relative to the Counterfactual.



Our Proposal

When compared to the Counterfactual in our CBA the option to decommission the RB211 unit had the highest NPV. The ongoing cost of maintaining and operating the compressor unit is higher than the one-off cost of decommissioning. The benefits of the additional capability, resilience and flexibility that this unit provides are not sufficient to offset the costs of keeping it operational under current forecasts of demand and supply.

We would only intend to implement this option once the IPPC works at Huntingdon and Peterborough had been concluded.

Risks

There are many uncertainties associated with the future of gas transmission in the UK. Decommissioning compression capability at Wisbech in advance of concluding the IPPC works at Huntingdon and Peterborough would expose the industry to unnecessary constraint costs. Subsequent to these works completing, other risks exist which could also expose the industry to significant constraint costs which could otherwise be avoided if Wisbech was available. These include:

- The simultaneous loss of compression capability across a number of sites in the middle of the country.

Feedback Question

10. What are your views on the merits of retaining compression capability at Wisbech once the IPPC works at Huntingdon and Peterborough have been concluded?

Our proposals – Kirriemuir

Site Description

The Kirriemuir compressor site is used to move gas out of Scotland towards the South. It is also used to support entry capability at St Fergus.

The site contains four gas-powered units, three Avons (installed in 1977), an RB211 (installed in 1985) and one electric unit (installed in 2015).

Drivers for change (LCP)

The RB211 gas-powered unit is non-compliant with LCP. The unit was placed on Limited Life Derogation in January 2016 which means the unit must be taken out of service either once the unit reaches 17,500 run hours or by 31st December 2023, whichever comes first. However, since then significant asset health issues have been identified with the compressor unit which were deemed uneconomic to resolve. This meant that the unit was disconnected from the network in September 2016 and is no longer operational.

Our Proposal

As a result of network analysis completed, the existing three Avons and electric unit were deemed to provide a sufficient level of capability on site to deal with a wide range of credible supply and demand patterns. Therefore, we are proposing to decommission the RB211 unit at this site. No further investments, including those included in our 2015 proposals, are being proposed as part of the LCP element of IED at this site.

Risks

This option is considered low risk although there is uncertainty associated with future supplies at St Fergus.

Summary of Proposals

In this section we summarise our draft proposals and show how these have changed since our 2015 submission.

IED site	2015 Proposed Options	Cost Range (£m)	2018 Proposed Options	Change in Costs
St Fergus (IPPC)	Two replacement units and decommission two units	50 – 100	Emissions abatement on one RB211; and *either* emissions abatement on one Avon *or* one new gas unit	
Peterborough (IPPC)	Two replacement units and decommission three units	50 – 100	One replacement unit and decommission two units	
Huntingdon (IPPC)	Two replacement units and decommission three units	50 – 100	One replacement unit and decommission two units	
St Fergus (LCP)	17,500-hour derogation on two units and then decommission	< 10	17,500-hour derogation on units 2A and 2D and then decommission by 31st December 2023	
Hatton	Three replacement units and decommission three units	> 100	Retain one unit on 500-hour derogation; and *either* emissions abatement on one RB211 *or* one new gas unit	
			Emissions abatement on two RB211s *or* two new gas unit	
Carnforth	17,500-hour derogation on unit A and then decommission; retain unit B on 500-hour derogation; site reconfiguration	10 - 20	Decommission both RB211s by 2023; site reconfiguration	
Kirriemuir	17,500-hour derogation on LCP unit then decommission; de-rate and re-wheel existing electric unit; decommission and replace existing MCP unit	50 - 100	Decommission the LCP unit now (already disconnected)	
Moffat	500-hour derogation both units	< 10	500-hour derogation both units	
			Decommission both units	
Warrington	500-hour derogation both units	< 10	500-hour derogation both units	
			Decommission both units	
Wisbech	Convert Unit B to Avon (completed); 500-hour derogation on RB211 unit A	< 10	Decommission RB211 unit A	
Overall	**10 new units**	**322.9**	**2 new units; 1 emissions abatement; 2 or 3 new units *or* emissions abatement**	

Our costs are based on the best information currently available, but are subject to refinement through currently ongoing work; our proposals may also change based on your feedback. It is therefore not possible to be precise about the impact on allowances at this stage. We do expect our allowances in the current regulatory period to be reduced from the provisional allowances provided for in the RIIO-T1 settlement.

This reduction has a number of components:

- Reductions in the scope of the funding being requested, such as the lower number of units at Hatton and some of the works at Kirriemuir no longer being required
- Potential deferral of funding requests to RIIO-T2 such as the third new units at Peterborough and Huntingdon, for which we may submit a future business case
- Re-phasing of works at St Fergus and Hatton such that some expenditure will be incurred in RIIO-T2 (but the full funding request will be included in our submission to Ofgem in May)

How to give us feedback

We welcome your feedback on our *Compressor Emissions Reopener Stakeholder Consultation*. In this consultation we have presented our provisional proposals for each site, falling under both the Large Combustion Plant and the Integrated Pollution Prevention and Control elements of the Industrial Emissions Directive. We would particularly welcome your feedback on our approach, the level of information we have provided, and the proposals themselves.

Your feedback is very important to us and we appreciate the time you take to provide it. This consultation is open for responses until close of business Thursday 29th March 2018. Please send written responses to Jon Dutton at ntsinvestment@nationalgrid.com.

You may also respond online via this link: https://www.surveymonkey.co.uk/r/QDHRKJC

If you would like a bilateral meeting to discuss our Proposals consultation in more detail please contact Jon Dutton at Jon.Dutton@nationalgrid.com and we will arrange a mutually convenient date.

Summary of feedback questions:

1. Do you agree with the approach we have taken to estimate the costs of different options?
2. Have we given you enough information about our cost assumptions?
3. Do you agree that our proposals for St Fergus strike the right balance between investment cost, reduction in NOx emissions and system reliability?
4. Do you agree that our proposals for Huntingdon strike the right balance between investment cost, reduction in NOx emissions and overall system reliability?
5. Do you agree that our proposals for Peterborough strike the right balance between investment cost, reduction in NOx emissions and system reliability?
6. Do you agree that our proposals for Hatton strike the right balance between investment cost, commercial costs and system reliability?
7. Do you agree that our proposals for Carnforth / Nether Kellet strike the right balance between investment cost, commercial costs and system reliability?
8. What are your views on the merits of retaining compression capability at Moffat?
9. What are your views on the merits of retaining compression capability at Warrington?
10. What are your views on the merits of retaining compression capability at Wisbech once the IPPC works at Huntingdon and Peterborough have been concluded?