14. I want to take gas on and off the transmission system where and when I want

What is this stakeholder priority about?

A network and commercial framework that allows customers to take gas on and off the transmission system where and when they want, has many benefits for our customers and consumers of gas. We make it possible for a diverse range of supplies to come onto the network and this allows the cheapest sources of gas to reach the market, lowering energy costs for consumers and improving security of supply. As a joint transmission owner (TO) and system operator (SO), our activities under this priority include maintaining and operating our physical network, and the day-to-day processes that support the market. We must avoid the serious consequences of a potential asset failure, such as an uncontrolled release of gas, fire, explosion or failing to deliver gas to consumers. If parties connected to the transmission network can't operate efficiently because of restrictions on the gas transmission network, the increased costs will ultimately be passed on to end consumers; or businesses could opt to close and relocate outside of Great Britain.

During RIIO-1, we have maintained reliability and facilitated the delivery of 99.99%[30] of gas requirements in 2018/19, allowing consumers to use gas as and when they want. Customers have been able to change the volumes, profiles and locations of their gas flows, often at short notice. We have achieved this despite periods of cold weather, such as the March 2018 'Beast from the East' and periods of local flooding in 2013.

What have stakeholders told us?

Stakeholders have told us they value being able to flow gas without restriction. For consumers of gas, a resilient and reliable supply is essential, whether it's for heating, electricity generation or for operation of industrial processes. Consumers of large amounts of gas have told us that continuity of gas supplies is essential to avoid detrimental impacts on their business processes, finances and global reputations. For some industrial consumers, loss of gas supply would cause irreparable damage to facilities, potential closure and loss of employment. Stakeholder feedback confirms that our customers want to be able to alter the location, volume and profile of their gas flows in response to prevailing market conditions.

What will we deliver?

- £835.3m of investment in our asset health programme to provide a resilient network that maintains our current level of reliability and availability, supported by an annual process to assess and define the capability of the network.
- Commit to remove £2.96m of monetised risk value over RIIO-2, delivering a long-term risk benefit of £296m.
- A redeveloped terminal at Bacton.
- Address subsidence at King's Lynn compressor site.
- Increased network resilience at Blackrod and Tirley above ground installation (AGI). Blackrod provides a **consumer value proposition** valued at £173m.
- A risk-based approach to environmental resilience, specifically to manage the threats associated with pipeline watercourse crossings.
- Investment in systems and capabilities to optimise maintenance and operation of our network to meet customer requirements.

Overall, to deliver on our proposals in this chapter, we plan to spend an average £279.8m each year with a total spend during RIIO-2 of £1.4bn. This is an increase from our RIIO-1 annualised spend, which was on average £206.6m. The change is mainly due to our increased asset health programme to maintain our current level of reliability and availability. This chapter's expenditure accounts for 51 per cent of the overall RIIO-2 expenditure.

[30] One power station experienced flow restrictions for a three day period

I want to take gas on and off the transmission system where and when I want

Figure 14.01 RIIO-1 and RIIO-2 spend profile 'I want to take gas on and off the transmission system where and when I want'

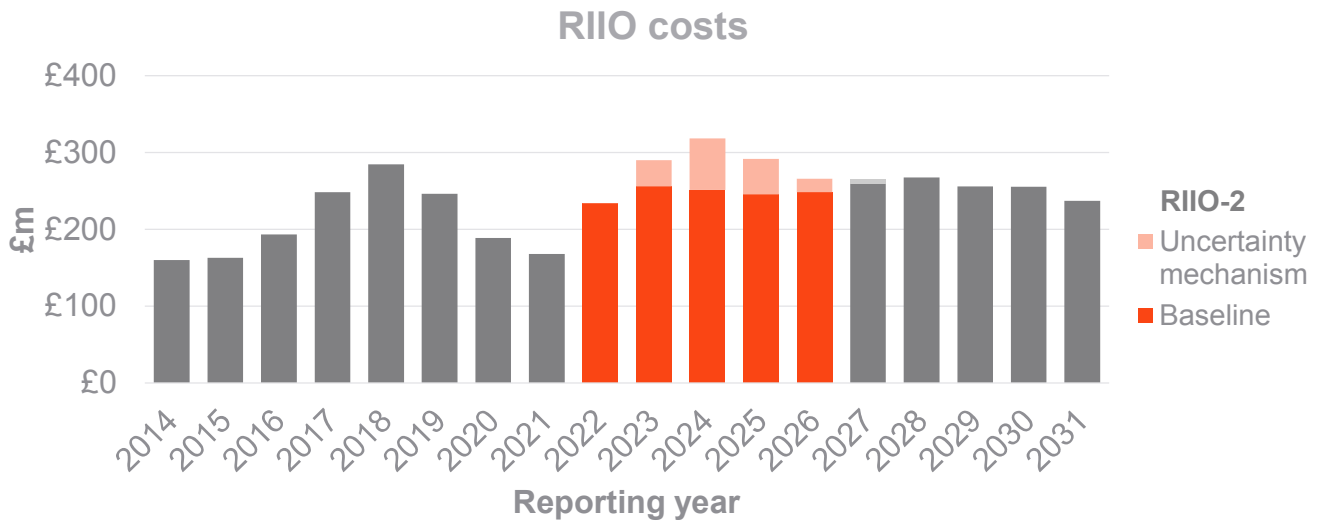


Table 14.02 summary of gas on and off costs by activity

(£m in 18/19 prices)	2022	2023	2024	2025	2026	Total RIIO-2	Annual RIIO-2	Annual RIIO-1
Asset health (general + GRAID)	119.9	138.6	131.1	133.4	140.8	663.9	132.8	86.6*
Asset health (Specific large projects) [31]	7.1	34.0	66.7	46.3	17.3	171.4	34.3	22.7
Asset management	64.7	66.7	68.7	65.5	65.8	331.6	66.3	60.4
Network resilience	0.3	4.5	4.2	0.5	0.3	9.9	2.0	0.0
Environmental resilience	0.8	0.7	0.8	1.0	0.8	4.2	0.8	0.5
Gas System Operation	39.4	44.0	45.2	43.5	39.4	211.6	42.3	36.4
Pension costs	1.3	1.3	1.3	1.3	1.3	6.5	1.3	N/A
Total	**233.6**	**289.9**	**318.1**	**291.6**	**265.8**	**1399.1**	**279.8**	**206.6**

**Note this includes RIIO-1 gas quality and metering, and control systems which are included in chapter 15 for RIIO-2.*

Table 14.03 summary of gas on and off costs by RRP category

RRP category (£m in 18/19 prices)	2022	2023	2024	2025	2026	Total RIIO-2	Annual RIIO-2	Annual RIIO-1
Closely associated indirects(BPDT 2.02)	37.2	37.6	37.9	38.1	38.7	189.4	37.9	31.1
Direct costs(BPDT 2.02, 2.04)	47.0	47.4	47.5	46.9	46.3	235.1	47.0	41.7
Load related (BPDT 3.01)	0.3	4.5	4.2	0.5	0.3	9.9	2.0	0.0
Non load related (BPDT 3.01, 3.03)	123.9	169.5	194.8	176.6	155.0	819.8	164.0	109.2
Non-operational capex (BPDT 3.07)	11.4	13.0	14.7	12.5	12.8	64.3	12.9	10.8
SO capex (BDPT 3.08)	12.5	16.6	17.8	15.6	11.5	74.0	14.8	12.2
Total non-controllable costs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
Controllable Pension costs (BDPT 2.02)	1.3	1.3	1.3	1.3	1.3	6.5	1.3	N/A
Grand total	**233.6**	**289.9**	**318.1**	**291.6**	**265.8**	**1399.1**	**279.8**	**206.6**

Please note we have provided costs to one decimal place and hence some columns may not equal to the totals. Pension costs are based on proportion of total TOTEX.

We will now cover the five sub-topics of this chapter in detail:

- asset health, including specific large projects at Bacton and King's Lynn
- asset management
- network resilience
- environmental resilience
- gas system operation.

[31] RIIO-2 project costs for King's Lynn subsidence, redevelopment of the Bacton terminal, and £1m for project closure of Feeder 9 project.

Asset health

1. What is this sub-topic about?

Our asset health plan sets out how we will manage, maintain and invest in our existing asset infrastructure to deliver the resilient service stakeholders require. Our asset health proposals are vital to **maintain the necessary safety and reliability** of our network **and demonstrate compliance with legislation**. They will enable the gas transmission system to play an important future role in support of the **energy transition**. We have developed a series of asset management investment themes. They reflect strategic groupings of asset types and investment drivers and set out how the business will invest in asset health during the RIIO-2 period. This sub-topic also describes our asset management strategy, track record in RIIO-1, RIIO-2 engagement, overall RIIO-2 programme and then RIIO-2 proposal for each investment theme.

Network capability and fleet strategy

Our asset health plan focuses on making the right investments at the right time. We are looking to ensure reliability and affordability for customers, whilst retaining optionality for the future. Our asset health plan is aligned with our approach to network capability and our compressor fleet strategy contained in chapter 12, ensuring investment proposals are directly aligned to the customer needs of our network today and in to the future.

Defined price control deliverable projects

We are proposing projects at Bacton and King's Lynn with separate ring-fenced funding, specific price control deliverables (PCDs) and uncertainty mechanisms. These projects will deliver service risk benefits and will contribute to an improvement in reliability for customers. The justification for these projects is covered under separate sections of this chapter. Further information on PCDs and uncertainty mechanisms can be found in annexes A3.01 and A3.02.

Investment in cyber and control systems are considered separately under the network and information systems (NIS) directive and are covered in chapter 15. Investment in our compressors to address environmental legislation are covered in chapter 16.

2. Our activities and current performance

Our assets can have adverse impacts on our stakeholders and the environment if they aren't managed correctly. For example, an asset failure could lead to increased risk to life and property and/or cause significant customer disruption. Many of our asset decisions are complex. As we aim for world-class asset management, we make our asset decisions within a framework that is balanced, auditable, justifiable and designed to overcome challenges through innovation. We have a defined set of criteria to help us make our asset decisions and these reflect the different expectations of our stakeholders. We also have duties and obligations under the Gas Act and through our Gas Transporter Licence. These factors all draw together to underpin our asset management decisions. Our definition of asset management aligns to the international standard for asset management (ISO 55000:2014) and is: *"the coordinated capability to make lifecycle cost, risk and performance decisions and thereby create value for an organisation from its assets".*

Our key asset management obligations are:

- To develop and maintain a safe and efficient, coordinated and economic system of gas transmission, which supports competition in the supply of gas.
- To have regard for the effect of our activities on the environment.

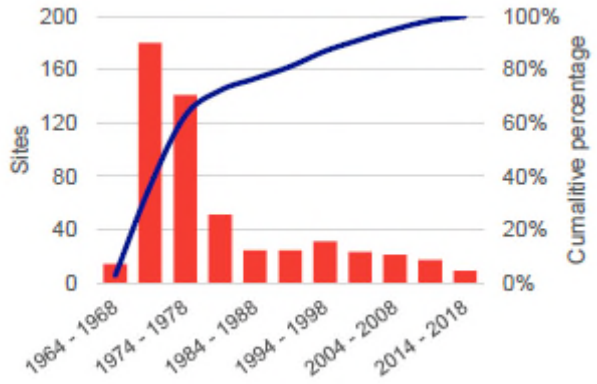
These obligations ensure we take a holistic view of our asset health work to support the network capabilities stakeholders want from us. This section expands on the wide range of inputs including tools, methodologies and data that underpin our asset management approach.

Our asset management maturity is underpinned by our routine maintenance activities, which proactively identify asset health issues. The information we collect enables us to prioritise investment decisions. We have set out our asset management approach in our strategic asset management plan (SAMP), describing our overall management strategy for the network's assets and how our practices, policies and procedures together form an integrated asset management system.

Track record and learning from RIIO-1

A significant proportion of the assets are reaching, or have reached, the end of their design life (30 years), see figure 14.04. Some systems face obsolescence and customers require an increasingly flexible network. Today, our network **delivers three times as much energy as the electricity network.** The extensive use and age of our critical infrastructure means our assets now require greater care, increased monitoring, refurbishment and replacement to maintain a safe, reliable transmission system. As a result, we changed the focus in our asset management approach in RIIO-1, considering both the risk and consequence of any proposed asset investment.

Figure 14.04 NTS sites age profile, excluding pipelines



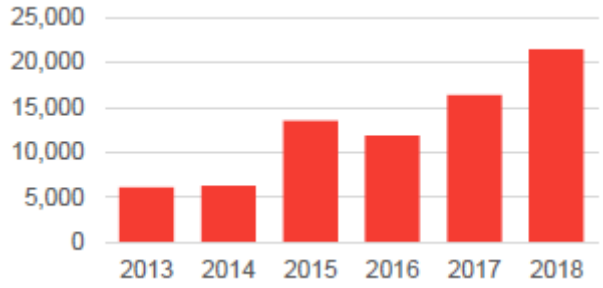
I want to take gas on and off the transmission system where and when I want

The RIIO-1 price control introduced the Network Output Measure (NOM) methodology[32] to assess whether we are delivering our asset health outputs. We have focused strongly on delivering work that will manage the level of risk at the lowest cost. We are on target to deliver the absolute level of network risk agreed as part of the RIIO-1 price control and maintain the service risk level our customers expect, but this has required significant additional investment in critical asset health work.

In our RIIO-1 business plan, we signalled the need for increasing expenditure to address the condition of our assets, forecasting £719m. Ofgem concluded that a lower level of investment was needed with more efficient delivery and we were granted an allowance of £593m. We are forecasting to spend in excess of our RIIO-1 allowance on asset health by over £100m to maintain the safety and reliability of our network. This includes investing over £40m at our Bacton terminal (no separate regulatory allowances in RIIO-1 were awarded). Our responsibilities to shareholders mean that we can't sustain the continued need to spend above our allowances to maintain the reliability and safety of the network beyond RIIO-1, and this will significantly impact our ability to meet the expectations of our customers.

Identifying the need for the additional investment in the asset health work was driven by our change in focus during RIIO-1 to capture more granularity on our asset defects and store these in central systems rather than at site locations. This has led to the recording of increased defects on the network as seen in figure 14.05. Furthermore, for our below ground assets, it is difficult to entirely understand the condition of our assets, until disruptive inspections take place. Where we have been able to carry out inspections, however, we have learnt that in many cases asset condition is worse than expected.

Figure 14.05 annual volume of asset defects recorded



The additional investment in RIIO-1 prioritised addressing the most critical defects to maintain the safety and reliability of the network. The potential risks of not making this additional investment are shown by our experience in RIIO-1. For example, having isolated Feeder [redacted] in response to a valve gas leak on a compressor tee system at [redacted], there was an urgent need to bring the pipeline back online following an increase in imports [redacted] due to colder weather. We achieved this successfully by developing a short-term mitigation for the leak, but isolations for the work were challenging due to the condition of valves in the area. In this instance, we were one isolation point away from disconnecting customers fed from a single fed offtake, disrupting supplies [redacted] and potentially UK gas supplies.

To address the challenges identified in RIIO-1, three main strategies were developed:

1. Procurement and contracting efficiencies – introduced to allow a more innovative and flexible approach to delivering future improvements and replacements of needed assets to the NTS.
2. Data enhancement – being able to access and use the asset and condition data more readily was recognised early on to better understand the needs of the NTS to meet required performance. Innovative technology and processes have allowed for continuous improvement in this area since the beginning of RIIO-1 through a comprehensive data transformation programme and new system capabilities.
3. Campaign approach – an initial three-year trial basis, revolutionising the way projects are delivered. To increase delivery volumes and significantly improve efficiency and delivery which has proved successful.

There have been comprehensive improvements because of the campaign approach, for example, our National Above Ground Installation Renovation Campaign (NARC) consisted of £150m of asset health works. During the first year of the campaign, £9m of financial efficiencies were realised with £4m coming from utilising pipe-through solutions instead of full site replacements and coordinating multiple works under single pipeline shutdowns. The rest was due to competitive tendering, contractor efficiencies and recompression efficiencies. The success of this approach has led us to propose asset groupings in our RIIO-2 plan and to ensure our proposed delivery plan is effective and efficient.

In response to the asset health challenges presented in RIIO-1, there are two further key initiatives under way to help prepare for RIIO-2:

1. Asset health prioritisation

We have carried out an exercise to list all known issues to be included in the RIIO-2 work plan. This process of prioritisation has allowed a risk-based-approach, allocating the budget to areas where spend will have the most impact. A series of strategic prioritisation objectives and themes were developed to guide the process to ensure that the key drivers of safety, network reliability and cost effectiveness were retained. The objectives were set to:

- support effective management of network risk, from a safety, reliability and environmental perspective
- demonstrate asset health performance to the regulator against the NOMs methodology
- establish a platform for an effective and efficient asset health programme of works for RIIO-2.

[32] http://www.talkingnetworkstx.com/network-output-measures.aspx - NARMs previously known as NOM methodology.

2. Survey work for RIIO-2 projects

Preparatory work, including surveys, will be conducted in the final years of RIIO-1 to ensure we are ready to deliver on our business plan proposals for RIIO-2.

Innovation in RIIO-1

Following our innovation strategy, we have driven efficiencies in the activities we have undertaken and sought innovative ways to continually improve our performance. This has included looking at how we deliver our asset health programmes of work as well as the information we can gather. The below table highlights some of the projects we have undertaken and how these are incorporated in our RIIO-2 proposals, which map to the fit for the future innovation theme.

Table 14.06 RIIO-1 innovation

Project	Description
GRAID network innovation competition (NIC)	We undertook a NIC funded project to provide a way of internally inspecting sections of our network during 'live' gas conditions. The Gas Robotic Agile Inspection Device (GRAID) was built to enable this. Following the successful completion of the project, a roll-out strategy has been proposed through RIIO-2, providing inspection across a number of sites helping to realise the benefits of preventing unnecessary excavations and early asset replacement. The estimated cost savings across RIIO-2 and RIIO-3 are £31.7m.
Composite transition piece	This project looked at using composite plastic replacement for concrete pit wall transition pieces preventing a time consuming and costly concrete excavation and reinstatement. A case study has been completed showing that across the design life there is a saving of over £200k per transition piece. During RIIO-2, we will look to embed these savings where possible.
Valve care toolbox	We used a valve care toolbox to prevent an early replacement of a valve, leading to significant savings. The learning from this project can be used across our asset base and be used for similar assets of gas distribution companies.
Business information modelling (BIM)	The aim of this innovation project was to develop and trial an intelligent 3D modelling process to inform project design for large-scale construction projects. To date, BIM has realised cost savings of £4.6m, having been used on four projects.

3. What have stakeholders told us?

Our plan has been shaped by stakeholder feedback to ensure we maintain reliability across the network, the right level of network capability and keep options open for future customers. Stakeholder engagement has been central to the development of the justification of our asset health investments. We engaged stakeholders to understand their views on how to manage our asset health challenge. We developed nine options to understand those stakeholders wanted us to develop into costed options. Three of these options moved forward with conclusions shown in the table 14.07. We received strong feedback that stakeholders wanted risk levels maintained, with a significant proportion wanting an improvement in reliability. We have consumer feedback that they want to maintain reliability levels (or possibly slightly increase). Our proposal is to maintain risk across our asset health work plan (excluding Bacton, funded through UM arrangements and at this key site specifically; reducing risk).

Table 14.07 asset health stakeholder engagement

	Asset health
SH segments engaged	All segments engaged.
Objective	What level of risk would stakeholders like to see?
Channel/ method	Geographically spread workshops, webinars, bilaterals, willingness to pay, acceptability testing.
Key messages	Customers and stakeholders value the reliability the gas transmission system provides. Any change to this would have significant impacts to their commerciality/ability to carry out their day-to-day business. Domestic consumers and non-domestic consumers also place a very high value in reliability. Consumers take for granted an uninterrupted, safe gas supply. It is sacrosanct. It gives them peace of mind, allowing them to focus on other things. Across a range of stakeholder segments, there is no support for any increase in safety risk – with consumers willing to pay more to prevent this. Many of our stakeholders have also called for improvements in reliability across our network, although our customers who ultimately pay have a stronger preference for keeping risk at current levels, in order to ensure stable bills. For more information on our engagement on this subject, please see annex A10.03.
Trade-offs and stakeholder influence on the plan	Overall, there was marginally more support for increasing reliability, by 10% compared to keeping risk the same as RIIO-1. However, the frequency of response is similar across these two options, and the one with more responses recorded varies according to which stakeholder group we focus on. Stakeholders who pay the bills slightly preferred to keep risks the same. Our initial option was to improve reliability by 10%, but **we have based our plans on stakeholder feedback and triangulation supported by external consultancy to maintain reliability as per RIIO-1**. We traded off the higher supported option to the one which was supported more by those who paid the bills, which at the time was 40% cheaper than improve reliability by 10%. Stakeholders have also challenged us to ensure our asset health plans are built on robust analysis, are efficient and affordable for end consumers and drive innovation. We have used improved decision support tools and monetised risk modelling to assess the right level of investment in these assets.

SUG and Challenge Group feedback	We have expanded the asset health section of this chapter to step through the optioneering and justification of our lead assets and expanded RIIO-1 performance from feedback from the SUG. Since October, we have also included more detail on non-lead assets, with additional PCDs. In response to our July draft plan, the Challenge Group asked us to provide information on cost drivers, consideration of options, justification of costs, including the proposed profiling of costs, and how efficiency and innovation will be used to reduce costs. Our revised lead asset sections in asset health address these points.

4. Our proposal for RIIO-2 and how it will benefit consumers

Our asset health plan will invest £1,422.7m over a ten-year period and specifically £663.9m for the five years of RIIO-2 to deliver the network availability and reliability, necessary to maintain the desired level of service required by our customers and stakeholders. We will achieve this through condition-related investments; reducing risk through separately justified projects including Bacton site redevelopment, and compressor investments. This section sets out the key drivers, decision criteria and outputs which underpin our planned investment for RIIO-2.

Network asset risk metric (NARM) methodology

Our NARMs methodology, developed with Ofgem and with stakeholder reviews, uses monetised risk as a common currency for safety, reliability and environmental measures to enable better engagement with stakeholders. Monetised risk allows us to understand the level of network risk, at the start and end position of the price control period with and without investment intervention. Without intervention, the current asset risk will increase by £3.22m through network ageing. For RIIO-2 we are committing to remove £2.96m (92%) that will be removed during RIIO-2 for the level of investment. Although monetised risk increases by £260,000 over RIIO-2, we are maintaining service risk in line with customer and stakeholder expectations. The total long-term benefit of this investment programme delivers £296m[33].

Broadly our asset health plan for RIIO-2 has been developed around three key principles:

1. Ensuring we only deliver the network capability our stakeholders require, whilst maintaining optionality for future customers.
2. In response to RIIO-1 challenges, we have undertaken an asset health prioritisation exercise and planned surveys at the end of the current price control in preparation for RIIO-2. This work is a reactive approach to maintaining network reliability and safety based on known issues.
3. Based on our learnings from RIIO-1 and the evidence from our CBAs and NARM outputs, we have planned preventive interventions in RIIO-2 to reduce long-term risk and cost.

Table 14.08 asset health proposals

What our stakeholders have told us	Commitment	Output type	Consumer benefit
Reliable gas supplies are essential for consumers of gas. In particular, consumers of high quantities see reliability of gas supply as a major priority.	Ensure we efficiently manage the network to be able to meet a 1 in 20 peak demand severe weather event.	Licence obligation	Facilitating a diverse range of supplies onto the network helps in delivering security of supply and keeping wholesale prices as low as possible. Providing high levels of reliability and resilience, protects against losses of gas supply for all consumers. It protects large consumers from any detrimental impacts on their business processes, finances, global reputations and long-term viability in GB. If connected parties can't operate efficiently because of restrictions on the network, their increased costs will ultimately be passed on to end consumers. By maintaining the most efficient network and linking with new or existing commercial framework and/or tools we can create additional value for stakeholders and consumers.
	We propose a relative Network asset risk metrics (NARM) target to measure delivery of our asset health investments with a justified over and under delivery mechanism. Our RIIO-2 asset health plan delivers a monetised risk output of £2.96m (measured as a level of monetised risk as part of NARMs).	Price control deliverable, (£466m). See annex A3.01 for further information.	
	We are proposing a separate PCD on asset health spend that is not covered by NARMs in the following areas: relifing of compressor cabs, site fences, site roads and replacement/refurbishment of pipe supports, pits, lighting systems and switchboards.	Price control deliverable, (£87m) See table 14.09 below and annex A3.01 for further information.	

76 per cent of our proposed RIIO-2 asset health submission delivers NARMs outputs, we propose that it is appropriate to treat certain projects or activities separately from the NARM mechanism even if they contribute

[33] Long-term risk benefits are being developed across the industry as part of a separate Ofgem engagement and are subject to further engagement and consultation before finalisation.

monetised risk benefits, as there is more refinement needed to the NARMs methodology which we will develop in RIIO-2.

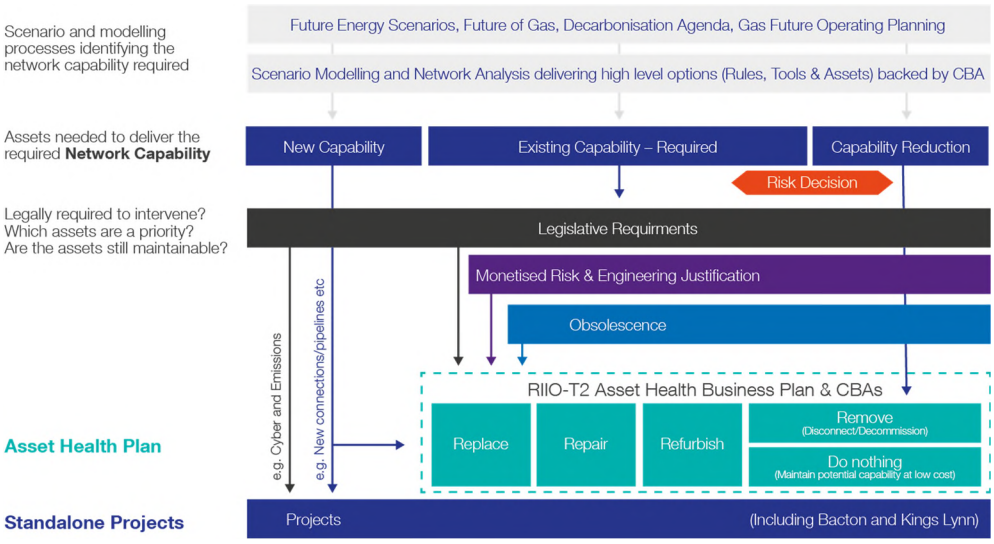
For such projects and activities, we propose ring-fencing with separate funding and, and discount the monetised risk benefit they deliver from any NARM output delivery.
By introducing PCDs, we are building on the lessons learned from the RIIO-1 Mid Period Review processes, where we identified several projects for which conditions around funding and delivery were not clearly identified up-front.
The PCD captures specific outputs that are directly funded through the price control, ensuring the conditions attached to the funding are clear up-front. The table below highlights our proposals for PCDs and are the output measures which apply to this part of our plan:

Table 14.09 asset health proposals for PCDs

Measure	RIIO-2 proposed measure	RIIO-2 spend for RIIO-2 delivery	RIIO-2 spend for RIIO-3 delivery	Percentage of plan
NARMs	Monetised risk	£465,824,602	-	75.61%
No. of cabs re-lifed	26 compressors cabs re-lifed	£24,056,392	£5,609,315	4.82%
No. of pits refurbished	245 pits refurbished	£19,465,136	£1,974,648	3.48%
No. of site fences re-lifed	76 site fences re-lifed	£12,354,940	£6,278,853	3.02%
No. of pipe supports refurbished	922 pipe supports refurbished	£12,550,880	£2,008,259	2.36%
No. of site lighting system replaced/refurbished	12 site lighting systems refurbished	£13,258,596	£213,896	2.19%
No. of site roads re-lifed	75 site roads re-lifed	£5,259,304	£2,541,997	1.27%
No. measure with RIIO-2 spend	N/A	£44,701,894	-	7.26%

The diagram below shows how our plan has been brought together.

Figure 14.10 approach to the inputs to building our asset health plan



Decision criteria and drivers

Our asset health plan focuses on providing a resilient network by making the right investments at the right time against the current and future network capability needs of our stakeholders. Overall, we are looking to ensure reliability and affordability for customers, whilst retaining optionality for the future.

Our RIIO-2 asset health plan uses three common drivers for investment across all themes.

Driver A: NARMs, legislation and safety case

Interventions that contribute to the NARM and are required to ensure compliance with relevant legislation and/or Safety Case, such as industry standards or original equipment manufacturer (OEM) compressor overhaul guidance to mitigate risk to individuals and environment. Work in this category is defined as requiring an approved deviation from the enforcement agency if the work is not carried out. Or there is a risk of enforcement action if National Grid is unable to demonstrate compliance with the legislation, regardless of if ultimate risk is realised or not.

Driver B: NARMs

The asset contributes to monetised risk through the NARM process and maintains reliability, but intervention is not directed through legislation or Safety Case explicitly. Asset condition deteriorates with age and this can be accelerated by harsh environments and asset utilisation. Factors that provide evidence supporting the condition and deterioration observed in our asset base include defect volumes reported, maintenance records (condition inspections) and increasing age profiles. Corrosion is a key condition driver; it is the second highest risk on the NTS (the highest being third-party

damage) and is the single biggest life-limiting factor of the NTS.

Driver C: Maintain reliability on non–lead assets
The asset investment either supports the lead assets covered through NARMs, is required to meet legislation or is driven by obsolescence. This covers a broad range of assets but predominantly structural integrity and electrical assets. The reliability of these assets reduces with age and use, and failure of these assets (e.g. pipe supports) can have a significant impact on the primary NTS assets (e.g. above ground pipework). For some assets, access to spares and expertise to carry out repairs becomes increasingly limited as equipment becomes obsolete. This is particularly a problem with electrical equipment, which has a much shorter asset support life than some of the mechanical assets. We manage relationships with OEMs so that we're aware of component lifecycles and we have advance warning of imminent obsolescence

An intervention can have multiple drivers. Each intervention in our plan has been assigned a primary driver from the above based on descending priority from A to C. The EJPs for each sub-theme provide a further breakdown of the investment that can be attributed to each driver. The above categories map to the Ofgem asset health plan structure with drivers A and B being 'monetised risk NARMs related assets' and driver C being 'non–monetised risk assets.'

To optimise our actions and potential investments in asset health, we consider four key risk factors: **safety, reliability, environmental and societal risk,** which are built into the NARM methodology**.** Through these service risk metrics and legislative requirements, we manage risks on the network as efficiently as possible.

Optioneering

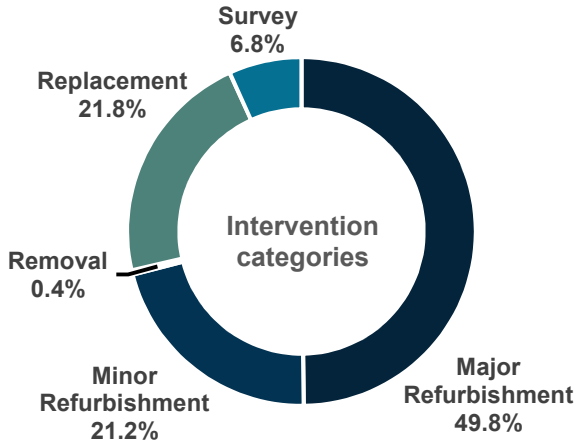
The next stage is to consider options. We have considered a range of intervention and programme options from the 'do nothing' position through to reductions in risk. Across the themes, four main options were considered, which our themes expand on:

1. do minimum or do nothing, fix on fail
2. minor refurbishment and minimised replacement
3. risk based re-lifing of assets
4. full re-life or replacement.

The programme options have been developed specifically for each investment area and contain a mix of different individual intervention options and varying intervention volumes. These programme options have been generated by our subject matter experts to explore the credible solutions for different levels of investment. Our experts have developed these credible options based on their knowledge of known asset health issues and asset defect data, combined with an understanding of the impact the investment has on our outcomes.

Each programme option has been fully costed and the impacts on our performance, legal compliance, risk position and stakeholders has been determined. We have also undertaken a full CBA for each of the options with the benefits of each option based on our NARMs methodology.

Figure 14.11 summary of chosen options for asset health programme



In choosing the preferred option to be carried forward into our plan, we have considered the results of our CBA amongst a range of other factors:

- The outcomes delivered by each of the options and whether these are supported by our stakeholders, i.e. maintain reliability and deliver the required level of network capability.
- The need to achieve legislative compliance may not necessarily be reflected through the quantified benefits delivered through a cost beneficial investment option, for example, the HSE will not tolerate a planned increase in safety risk.
- Where there are known asset defects, that need to be managed through our plans.
- Our understanding of individual asset condition has improved during RIIO-1 but there are still gaps in our knowledge. Our plan reflects the need for a likely practical mix of intervention types once specific assets are surveyed and their true condition and risk are understood. For example, a plan cannot be based upon 100% refurbishment as this may require a high number of replacements should a proportion of the assets be determined as non-serviceable.
- The need for a deliverable programme of work, both in terms of planning outages, resource availability and contract efficiency. For example, through "bundling" work it may be more cost-effective to undertake alternative interventions to achieve reductions in contract costs, minimise outage risks or avoid an early repeat intervention in future RIIO periods.
- The overall level of investment required and whether this is affordable for our stakeholders.

For a minority of the sub-themes we have limited alternative programme options. The proposed programmes for these sub-themes include a minimum level of intervention to meet legal compliance or maintain reliability at the lowest whole life cost.
Once our preferred programme options have been selected, based on the detailed CBA, the workload is

grouped based on the common drivers A to C as described above.

Programme level options we have discounted

Our CBAs and NARMs both use the same monetised service risk benefits. The changes in service risk delivered by our final plan and alternative options are set out in table 14.12. Service risk represents changes in level of service received (e.g. increased risk of an outage), and changes in monetised risk values are calculated through NARMs. Row one, 'do nothing', is RIIO-2 end state risk levels in comparison to the end of RIIO-1 period with no investment. Row two; shows the risk levels if we maintained the same level of spend in RIIO-2, comparatively, from the RIIO-1 period. The third row shows the levels of risk if the interventions proposed for asset health investment were realised at the end of the RIIO-2 period.

Table 14.12 shows broadly risk maintained in RIIO-2, with a 21% improvement on societal risk specifically. At Ofgem's request, we have included cyber control systems which overall contributes to a 2-3 per cent reduction across the service risk categories, however we are excluding from the NARMs output, and propose a specific PCD outlined in chapter 15. As such, RIIO-2 will deliver slightly less risk reduction and we will achieve stable risk over a 10-year period.

Table 14.12 changes in service risk delivered inclusive of control systems

	Fatalities & injuries risk *(% risk increase)*	Transport disruption risk *(% risk increase)*	Outage risk *(% risk increase)*	Volume of gas emitted *(% risk increase)*
Do nothing	10%	231%	849%	212%
Spend same as RIIO-1	8%	5%	365%	38%
RIIO-2 plan	-1%	-21%	1%	-1%

Figure 14.13 shows our monetised risk position at the start of the RIIO-2 period (£6.24m), and at the end, with and without intervention. Over the RIIO-2 period, our monetised risk remains broadly the same, with a small increase of £260,000. However, as shown in the service risk table 14.12, the interventions we are proposing for the period, the service risk impacts to our stakeholders remains broadly stable. The proposed interventions in RIIO-2 will remove £2.96m of monetised risk in the period. In determining our plan, we have listened to our stakeholders and are looking to maintain our resilience and risks levels over a 10-year period.

Figure 14.13 RIIO-2 asset health monetised risk

5. How will we deliver?

Deliverability and portfolio planning

Asset health work is considered alongside all other requirements to access the network and our resources to deliver our plan. We've set out our delivery plan in chapter 21, which provides further detail on how we have developed a comprehensive outage and delivery plan.

Efficiency and innovation

We continually compare ourselves against other asset-intensive organisations, including those outside the utility sector to identify areas of improvement. We have increased our investment in innovation, both to drive increased unit cost efficiency and to improve confidence in our maintenance techniques when it comes to assessing the condition of our assets.

Overall, £42.96m of forecast savings from innovation projects in RIIO-1 are anticipated in RIIO-2, with further projects still in development. In table 14.06 detailed earlier in this section, we described the projects from RIIO-1 and the benefits they are delivering. During RIIO-2, we will also look to invest more in innovation to realise more benefits. The table below describes some of the areas we will look to innovate in and how this aligns with our overall RIIO-2 innovation strategy.

Table 14.14 asset health RIIO-2 innovation projects

Theme	Projects
Fit for the future	We will build upon project GRAID and look at further enhanced methods of asset inspection, including looking at how robotics could help with managing the asset health of our network.
Ready for decarbonisation	We will look at how our assets can be used to transport hydrogen and how technologies such as artificial intelligence can be used in managing our assets.
Decarbonised energy system	The focus of this project will be on how we assess the impacts of hydrogen on our network and how we would monitor the health of our assets and the processes we would need to change.

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6. Risks and uncertainty

The most significant risk we need to manage is an unexpected asset failure or need to isolate due to an unacceptable safety risk that affects our ability to meet the requirements of stakeholders. This could be as a result of climate change (e.g. a landslip caused by significant rainfall, requiring an urgent pipeline diversion) or the discovery of an asset type fault (e.g. a particular valve or pipeline section) that is used across the network. These could result in unexpected and unforecastable costs requiring a mitigation activity that can't be deferred and could cost millions of pounds to manage and rectify in addition to the potential consumer disruption.

Given the large potential risks described above, we are proposing that the RIIO-1 mechanisms for justified over and under delivery of NARMs outputs are retained for RIIO-2, which is consistent with Ofgem's Sector Specific Methodology Decision in May 2019.

Whilst undertaking our proposed asset health works, we are likely to find additional issues only found when completing intrusive work. Some of these new issues will be best dealt with while we're working on site, but we'll be able to defer others until a later date. We need the ability to trade off risk across our asset categories, so we can deliver the best outcome for consumers.

These smaller materiality unexpected occurrences that require a mitigation activity during the RIIO-2 period would be managed by trading off risk across asset types, as permitted under the NARMs methodology.

7. Our proposed costs for RIIO-2

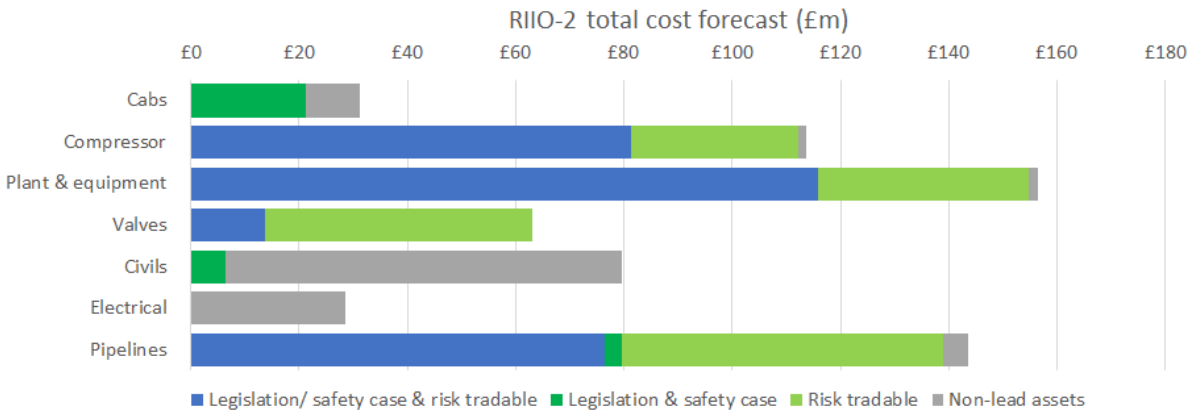
To deliver our NARM monetised risk target and defined PCDs, our annualised planned investment in asset health increases in RIIO-2 compared to RIIO-1 and is expected to further increase in RIIO-3.

Table 14.15 asset health cost summary

(£ in 18/19 prices)	2022	2023	2024	2025	2026	Total RIIO-2	Annual RIIO-2	Annual RIIO-1 *
Cab Infrastructure	7.0	8.9	6.0	4.2	5.2	31.3	6.3	2.6
Compressor Train	50.0	29.3	7.3	9.1	17.9	113.7	22.7	9.8
Plant and equipment	17.8	33.1	38.8	38.6	28.2	156.4	31.3	9.5
Valves	6.4	13.9	14.6	13.9	14.4	63.1	12.6	19.2
Pipelines	20.1	26.9	32.0	30.8	33.7	143.5	28.7	16.2
Structural Integrity	7.0	9.6	19.5	22.0	21.4	79.5	15.9	13.0
Electrical	1.1	6.0	6.8	5.9	8.6	28.5	5.7	2.8
St Fergus (subsidence)	4.0	0.0	0.0	0.0	0.0	4.0	0.8	0.0
OPEX	3.1	3.1	3.1	3.1	3.1	15.5	3.1	N/A
GRAID	3.4	3.4	3.0	4.8	3.8	18.3	3.7	1.0
Stopples	0.0	4.5	0.0	1.0	4.5	10.0	2.0	N/A
Total	**119.9**	**138.6**	**131.1**	**133.4**	**140.8**	**663.9**	**132.8**	**74.1**

Please note we have provided costs to one decimal place and hence some columns may not equal to the totals.
**Annualised RIIO-1 costs taken from RRP data tables (table 4.2), RIIO-1 gas quality & metering, and control systems not included in this table. RIIO-2 numbers included in chapter 15.*

Figure 14.16 asset health theme costs by driver



Unit costs and benchmarking

We use native competition to obtain value from our supply chain 100 per cent of our capital expenditure above £100k during RIIO-1 was subject to native competition.

Our asset health work involves a wide range of activities, from repeatable standard jobs, with low levels of differentiating factors, through to those that are more bespoke, and therefore, more difficult to apply standard costing. We have, however, employed an approach that considers historical outturn information as the strongest

indicator of future unit costs, with over **70% of our plan using unit costs** calculated in this way. Only where this level of information is not available have we turned to either supplier quotations (which underpins 15% of our plan), or other estimation techniques (upon which the remaining 15% of our plan is built).

The availability of representative cost information for the more bespoke gas transmission activities is challenging, given the low number of directly relevant external reference points available to us and the limited levels of certain types of historical asset interventions. Improvements driven by our transformation programme have enriched our available data and will capture cost data moving forward. Our methodology therefore uses the best available information for each unit cost, including (in preferential order):

- historical outturn cost information, where we can match like-for-like units against delivered programmes;
- supplier quoted costs, matching like for like units against a tendered but not delivered programme of work;
- extrapolation to similar types of work or sub-components of work; and
- review of industry wide benchmarking or internal cost data.

We have incorporated increasing efficiencies in the forecast cost to deliver the required asset health programme, driven by known innovation (that was not available at the time historical works were completed) and changes to policy we are already making in the pursuit of greater levels of whole life cost efficiency. We have continued attempts to benchmark our costs externally, through the Gas Transmission Benchmarking Initiative (GTBI), Arcadis and comparisons to our US business; however, due to the complexity of data architecture, commercial sensitivities and challenges in achieving true like for like comparisons, we, and the externally appointed third-parties have not achieved a comprehensive way to benchmark our unit costs. Please refer to the unit cost annex A20.17 for further detail on our unit cost methodology and confidence.

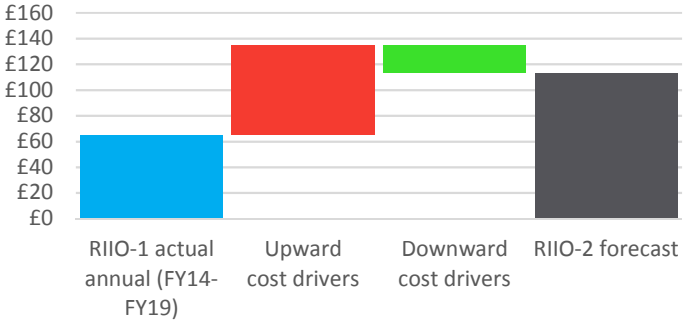
Efficiency

We have set a challenging 4 per cent cost efficiency on our direct capital investment plan that we will set out to deliver in RIIO-2. This sets out to leverage benefits from our transformation programme and our campaign approach.

Cost waterfall

We present a summary of the total upward and downward change in annualised cost between RIIO-1 and RIIO-2 based on changes to volume and unit costs. The downward drivers are attributable to unit cost reduction and efficiencies and the upward driver is exclusively related to increase in volume of work.

Figure 14.17 asset health cost waterfall (£m/yr)



The cost information is annualised to provide a comparative cost per year. The total RIIO-2 forecast includes the efficiencies described above. This is the same for all sub-themes and waterfalls that follow. Further detail on the specific upward and downward drivers for each investment theme is presented in the EJPs.

Each of the seven asset health themes is covered separately with a breakdown of the asset types, options considered and the upward and downward drivers for costs here:

Lead assets

Cab infrastructure

There are 54 compressor cabs containing gas generator powered compressor trains and 7 containing electric powered compressors across the NTS (excluding St. Fergus). Cabs infrastructure is made up of a weather-tight **cab enclosure**, an **air intake** for the compressor train, a **ventilation system** to cool the compressor train within the enclosure, an **exhaust system** to remove combustion gases and attenuate noise, and a **fire suppression system** to deal with emergencies within the enclosure.

These assets were installed at the same time as the compressor fleet and as such are towards the end of their design lives. There is evidence of increasing defects and failures on these assets leading to compressor unit trips and the associated unavailability of compressor units for the duration of any investigation and repair. When any significant work is undertaken on the fire suppression systems they are required to be re-certified to PM84 HSE/ISO21789 standard. This will involve additional work to bring all the existing assets to this standard as it was not in place when they were installed. Significant manual handling issues also exist on these assets.

Impacts of no investment

Cab infrastructure is essential in enabling the optimal and efficient operation of the gas turbine generators whilst maximising their life and minimising expensive overhaul costs. They are an essential element of our legal compliance with PM84 HSE/ISO21789 Control of Risk around gas turbine enclosures. They are also instrumental in maintaining our compliance with environmental legislation and permits regarding noise and exhaust emissions. Without a functioning and compliant

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cab, a compressor cannot be operated. An inability to operate critical compressor equipment would have considerable impacts on the ability to balance supply and demand on the NTS to meet the needs of our customers.

Proposal development

Our proposed investment is fully integrated with our compressor fleet strategy and provides for replacement or full re-lifing of those cab infrastructures whose compressors are required in the longer term as set out in our network capability chapter 12. Fire suppression systems must be upgraded to meet current standards. Those compressors that will be decommissioned or subject to lower running hours will receive investment corresponding to their shorter remaining life. It is vital for the supply of gas to our customers that our compressors remain available and resilient to the demands and changes on the NTS and investment in our compressor cab infrastructure is essential to ensuring this availability is not compromised.

In defining our proposed intervention approach, we have considered a range of programme options and compared these against a baseline option that assumes a reactive intervention stance. In deciding on the proposed intervention strategy, we have considered the ability to meet the desired engineering and stakeholder outcomes and the resulting cost-benefit.

The three options considered for both sub-themes of cab infrastructure against a baseline option that is purely reactive were; a maintain risk option, a refurbishment only option to manage short term risk in compressor cabs and ensures legal compliance in fire suppression, and a full re-life option to significantly reduce risk on the assets, with the preferred option being to maintain risk.

Table 14.18 cab infrastructure option summary

Sub-theme	RIIO-2 Plan (£)	Percentage of theme	Options considered	Option summary/considerations
Cab infrastructure	£24,327,297	77.7%	3	A range of options have been assessed and our chosen option is the least non-cost beneficial option that maintains risk whilst maintaining compliance with standards.
Fire suppression systems	£6,963,797	22.3%	3	A range of options have been assessed and our chosen option is the least non-cost beneficial option that maintains risk whilst maintaining compliance with standards.

Compressor cab asset health investment proposal summary

- The total RIIO-2 proposed expenditure for this theme is £31.3m.
- **Two thirds of the compressor cab interventions are driven directly by legislation and ISO standard requirements** (PM84 HSE/ISO21789 and Pressure System Safety Regulations 2000 (PSSR)). The remaining third relates to air intake and exhaust interventions and is justified separately.
- Compressor cab investments are not included in our NARMs model. Price control deliverables will be agreed on the significant areas of this proposal to assure the outputs are delivered.
- The volume of cab infrastructure work when compared to RIIO-1 is increasing, the majority of this plan is built on known defect issues gathered through inspection work carried out in RIIO-1.

Table 14.19 cab infrastructure volume and cost

[redacted]

Figure 14.20 compressor cab asset health theme outputs

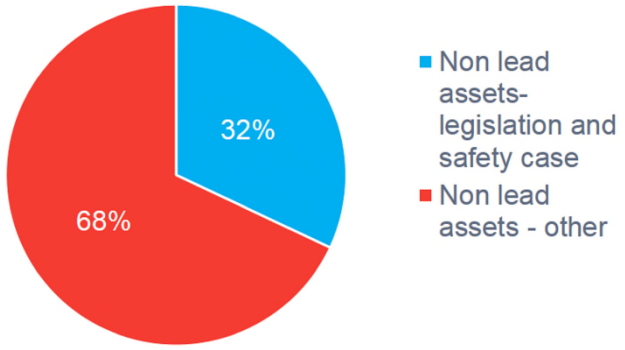
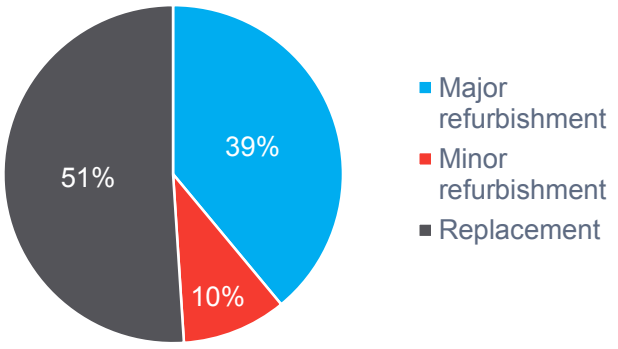


Figure 14.21 compressor cab asset health theme intervention types



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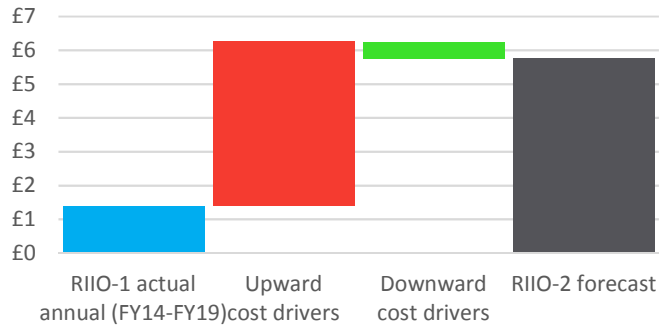
Comparing our RIIO-2 proposal to our RIIO-1 programme

The annualised RIIO-2 spend has increased when compared to RIIO-1 from £1.4m to £5.8m for the compressor cab asset health theme.

Figure 14.22 compressor cab cost waterfall (£m/yr)



Upward drivers

Asset health prioritisation during RIIO-1 focused spend on high criticality assets resulting in lower overall investment in compressor cabs compared to forecasts at the start of RIIO-1. In part, this has been driven by a significantly lower compressor utilisation, (25% reduction in running hours from that forecast at the start of RIIO-1) but also a recognition that emissions legislation and lowering demand forecasts both made the future of our compression fleet requirements uncertain. There are a significant number of compressor cab defects that require resolution in the near term. Furthermore, there is a need to bring many of our fire suppression systems up to standard and this investment is a priority for RIIO-2.

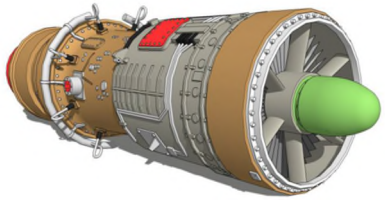
Downward drivers

All efficiencies in this area are driven through our business transformation programme. Better asset data, enhanced planning tools and a sharp focus on unit costs all enable lower overall cost to delivery through enhanced, longer term delivery contracting. In preparing our compressor cab asset health plans, we have ensured consistency with network capability and our compressor fleet strategy. This has resulted in lower overall costs by avoiding spend at cabs planned for decommissioning and driving down interventions and costs at cabs with low use units in RIIO-2 and RIIO-3.

Compressor train

There are 54 gas generator powered compressor trains and 7 electrically powered compressor trains across the NTS (excluding St Fergus). Compressor trains are made up of a centrifugal **compressor** that pressurises the gas in the NTS. This may be powered by an **electric drive** or a **power turbine**. The latter is driven by a **gas generator** which, in turn, requires a **starter motor** to commence operation. Under certain circumstances the pipework containing gas around the compressor is depressurised through a **vent system**.

Figure 14.23 gas generator



Due to the pattern of gas flows required by our customers and consumers becoming increasingly variable across the network. The patterns of gas movement across the network have changed, with increased, and much more complex demand on the compression fleet. This has increased the stresses on the compressor machinery due to greater frequency of start/stop cycles and more volatile running hour periods.

Changes in usage and especially start/stops on the compressors has resulted in the need to increase the number of overhauls. These interventions ensure that compression assets remain supported by the manufacturer and continue to operate at an acceptable level of availability. The frequency of overhauls and general maintenance on the compressors can be further increased by the poor performance of the associated assets. The overhaul of a compressor train can typically take 13 to 26 weeks. There is evidence of increased defects and failures on the compressor train leading to compressor unit trips and the associated unavailability of the compressor unit for the duration of any investigation and repair. There is also a decreasing start reliability meaning gas generators fail to achieve stable running on demand.

Impacts of no investment

Compression balances the flow of gas and linepack levels across the network, ensuring that all terminals and offtakes are maintained at the right pressure. This requirement is routinely tested and analysed by the system Operator and the network capability required by our customers underpins the need for these assets. The loss of compression in sections of the NTS has significant impact on customers flowing gas on and off the network. This has knock-on effects for the operation of gas production facilities, power generation, and domestic and industrial consumers. These impacts are currently managed by ensuring that there is redundancy in the compressor fleet, allowing loss of a compressor to be compensated for by another machine. However, this requires maintaining a fleet of ageing machines at a constant state of readiness.

Proposal development

In defining our proposed intervention approach, we have focussed our effort on developing a least whole-life cost option with a minimum level of intervention in line with OEM guidance and expected machine running requirements. Significant expert challenge and review has underpinned the levels of intervention and the proposed phasing ensures we meet the desired engineering and stakeholder outcomes whilst smoothing out this workload and aligning outages across our fleet.

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Much of the cost associated with gas generators is derived from duty profiles (run hours and number of start/stops) that have been agreed with other EU-based gas generator operators. These are described in best practice integrity management policies based on OEM guidelines which we always aim to adhere to as a safety requirement for operating these machines.

In all cases, the least cost option (do minimum) has been proposed to maintain compliance with OEM guidelines and associated internal policy to maintain our fleet at expected levels of reliability and therefore stable risk. A maintain risk option compliant with OEM guidelines and associated internal policy was the selected option for compressors.

Table 14.24 compressor train options summary

Sub-theme	RIIO-2 plan (£)	Percentage of theme	Options considered	Option summary/considerations
Gas generator power train	£89,392,120	78.6%	1	Least whole life cost option to maintain compressor capability in line with OEM/safety guidelines to overhaul at preset running hour quantity with additional budget for breakdown in line with historic costs.
Compressor	£7,075,528	6.2%	1	Least whole life cost option proposed to resolve known defects and running hour interventions in line with manufacturers' guidelines and internal policy.
Electrical variable speed drives	£15,793,266	13.9%	1	Least whole life cost blend of intervention types to meet the minimum requirements to maintain risk and therefore operating reliability. Proposal is built on known defects and largely driven by OEM guidelines.
Vent systems	£1,424,709	1.3%	1	Least whole life cost option proposed to resolve known defects through lowest cost refurbishment approach.

Compressor train asset health investment proposal summary

- The total RIIO-2 proposed expenditure for this theme is £113.7m.
- **99%** of this asset health work is condition driven and delivers **NARMs outputs**. Only the work associated with vents falls outside of NARMs measures.
- 71% of this work is driven by OEM guidance to overhaul gas generators and compressors at predetermined trigger points (e.g. running hours, no. of starts).
- £16.3m of the compressor train costs relate to the compressor breakdown budget and fleet management (engine swap-out and strategic spares) and this represents an annual run rate based on historic performance.
- A significant proportion of our compressor theme is built on known defects.

Table 14.25 compressor train volume and cost

[redacted]

Figure 14.26 compressor train asset health theme outputs

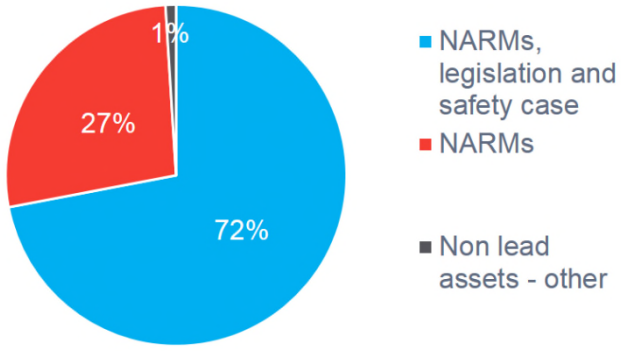
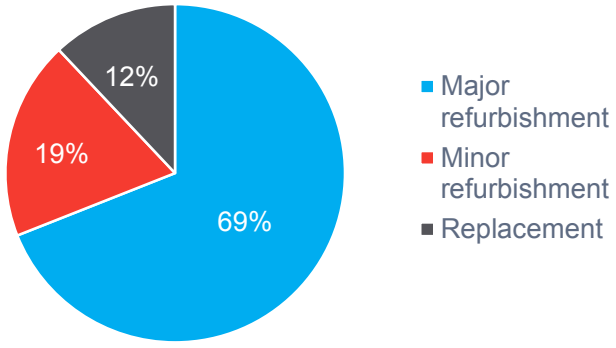


Figure 14.27 compressor train asset health theme intervention types



Comparing our RIIO-2 proposal to our RIIO-1 programme

The annualised RIIO-2 spend has increased when compared to RIIO-1 from £7.7m to £20.9m for the compressor train asset health theme.

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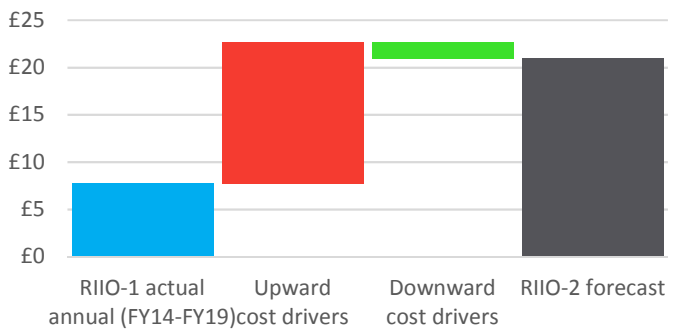
Figure 14.28 compressor train cost waterfall (£m/yr)



Upward drivers

A significant proportion of compressor unit gas generators are now at or beyond the guideline running hours and in need of major overhaul work by the OEM. Virtually all the compressor asset health plans for RIIO-2 are driven from known defects.

A significant increase in compressor overhaul work has been undertaken during RIIO-1 already, with further increases in the final two years of RIIO-1 to ensure we can continue to operate a resilient network. Total RIIO-1 forecast spend in this area is now forecast to be almost double that which was forecast at the start of RIIO-1.

Our RIIO-2 plans also include much more work on our electric drive compressor assets when compared to RIIO-1. These assets were commissioned in the run up to RIIO-1 and are now requiring overhaul and upgrades to assure continued reliability and availability.

Downward drivers

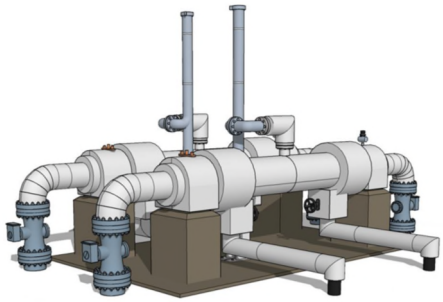
In preparing our compressor train asset health plans, we have ensured consistency with network capability and our compressor fleet strategy. This has resulted in lower overall costs by avoiding spend at units planned for decommissioning and driving down interventions and costs at low use units in RIIO-2 and beyond.

Most of the cost efficiencies in this area are driven through our business change programme. Better asset data, enhanced planning tools and a sharp focus on unit costs all enable longer term overhaul programmes with which to engage OEMs on. In turn, we have overlaid efficiency forecasts onto our fleet overhaul programme on the basis that we can achieve lower overall cost to delivery through enhanced, longer term delivery contracting.

Plant and equipment

The plant and equipment assets comprise equipment on all of our compressor stations and 504 above-ground installations (AGIs). It includes **pipework** which is **coated** as a primary means of corrosion prevention and protected by **cathodic protection** (CP) as a secondary means where it is underground; **pipe cladding** to mitigate noise and thermally insulate the pipework; **filters, scrubbers and strainers** to remove particulates and liquids from the gas flow; **preheaters** to prevent condensate after **pressure reduction** points that meet customer requirements; and **slamshut** valves that close to protect plant and equipment from over pressurisation.

Figure 14.29 preheaters & heat exchangers



The plant and equipment assets were installed at the same time as the sites were built and, by the start of the RIIO-2 period, 70% of these sites will have been commissioned for over 40 years and as such have reached or exceeded their original design lives. Pipework is subject to the Pipeline Safety Regulations (PSR) and therefore needs to be designed, constructed and operated so that the risks are as low as is reasonably practicable. They are subject to a regular inspection regime with the associated resolution actions and repairs. Whilst the equipment is varied in nature and purpose, except for cladding and cathodic protection, they operate at full NTS gas pressure and as such are subject to PSSR. These regulations drive a regular regime of inspections (6-year and 12-year) and a managed resolution of any issues that are identified.

The HSE have recognised that managing the integrity of ageing plant and equipment, is a key issue for the industry. In particular, degradation due to corrosion, erosion and fatigue. Our external inspection and subsequent remediation of defects or ‘features’ to industry standards, supplemented by internal policy and procedure, is accepted by the HSE as an appropriate way of operating safe plant and equipment, to comply with legislation.

Impacts of no investment

Lack of investment will result in an unsustainable situation where the volume of corrosion defects will grow to a level where the performance on the NTS cannot be maintained and any level of remediation would not keep pace with degradation. This would place the NTS in a state where only significant asset replacement would counter the corrosion issues at significant cost to customers and consumers.

Proposal development

In defining our proposed intervention approach, we have focused our effort on developing a least whole-life cost option that enables an optimised ongoing, rolling programme of work. Significant expert challenge and review has underpinned the levels of intervention and the proposed phasing ensures we meet the desired engineering and stakeholder outcomes whilst smoothing out the workload. A range of options has been considered for each sub-theme of the plant and equipment interventions as set out in table 14.30.

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For the pipework sub theme, four options were considered against a baseline option that is purely reactive; a reactive compliance option to maintain compliance with PSSR and other legal obligations, a minimal proactive compliance option which maintains compliance through minimal proactive investment and reactive investment in corrosion defects, a proactive option to undertake proactive painting and corrosion management, and an increased proactive option which would add cladding replacement to the previous option, with the preferred option being a proactive option to maintain risk levels.

For the remaining two plant and equipment sub themes, three options were considered against a baseline option that is purely reactive, they were: a PSSR, legal compliance and safety impact option that only includes investment to maintain necessary compliance; a direct customer impact option that includes investment to support assets that will impact directly connected customers; and a direct customer and NTS option, which includes investment to mitigate risks of failure on the NTS; with the preferred option being the direct customer and NTS option.

Table 14.30 plant and equipment options summary

Sub-theme	RIIO-2 plan (£)	Percentage of theme	Options considered	Option summary/considerations
Above ground pipework, cladding and CP systems	£130,776,585	83.6%	4	Range of options identified to balance cost/risk detailed within this EJP for this significant area of work. The selected option is the least cost option to meet outputs and legislative requirements.
Filters, scrubbers and preheaters	£17,157,246	11.0%	3	Range of options identified to balance cost/risk detailed within this EJP for this significant area of work. The selected option is cost beneficial and the least cost option to meet outputs and legislative requirements.
Pressure reduction, flow control and slamshut systems	£8,506,360	5.4%	3	Range of options identified to balance cost/risk detailed within this EJP for this significant area of work. The selected option is cost beneficial and the least cost option to meet outputs and legislative requirements.

Plant & equipment asset health investment proposal summary

- **99% of the plant and equipment proposals deliver NARMs outputs, with 74% of the proposal driven by legislation/safety case requirements.**
- Two of the three sub-themes are cost beneficial (filters, scrubbers & preheaters and the “pressure reduction, flow control and slamshut systems” sub-theme).
- All elements of the “above ground pipework, cladding and CP systems” sub-theme is driven by safety legislation except for the patch, partial and full site painting element (£24.5m). This work delivers NARMS outputs and avoids significant future corrosion defect remediation costs.

Figure 14.32 plant and equipment asset health theme outputs

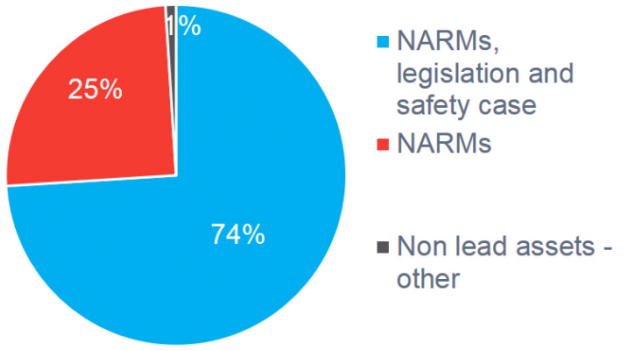
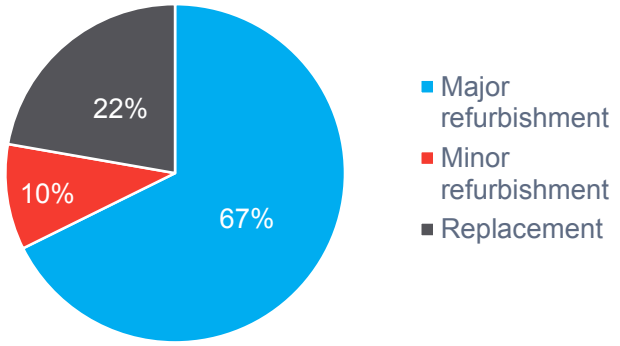


Table 14.31 plant and equipment volume and cost

[redacted]

Figure 14.33 plant and equipment asset health theme intervention types



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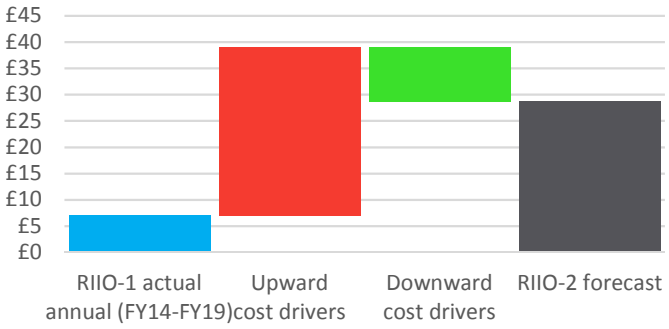
Comparing our RIIO-2 proposal to our RIIO-1 programme

The annualised RIIO-2 spend has increased when compared to RIIO-1 from £7.0m to £28.8m for the plant and equipment asset health theme.

Figure 14.34 plant and equipment cost waterfall (£m/yr)



Upward drivers

There are several differences in our approach to managing our plant and equipment assets in RIIO-2 when compared to RIIO-1. It is of note that our forecast total spend for RIIO-1 in this area is double that which was originally anticipated and we no longer classify above ground pipework and coating asset health work as opex.

Throughout RIIO-1, we have sought to significantly increase our understanding of the condition and deterioration rates of our assets. A new corrosion management process was put in place implementing more detailed assessments of corrosion defects on our AGIs. This is data that was not available ahead of RIIO-1 and now shows widespread corrosion issues that require resolution during RIIO-2 to ensure significant end of life asset risks do not materialise in the medium term.

Better information is now available on the condition and effectiveness of our cathodic protection assets at our AGIs. This information has shown many ineffective systems and widespread condition issues. These CP systems are the primary protection systems for our AGIs; failure to bring these systems back to a good working order will result in significant risks to these assets and in turn significantly higher costs in later years to replace AGI assets wholesale.

Downward drivers

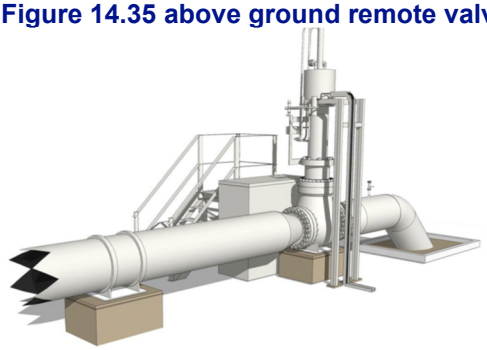
Project GRAID provides a novel robotic technique for inspecting sections of pipeline which were previously difficult to inspect using a pipeline inspection gauge (PIG), primarily associated with AGIs. Investment is required to use this technique on AGIs, costs will vary depending on complexity of pipework unique to sites. Currently, it is estimated to be used on [redacted] sites (5+5-year period), with associated rollout costs of £28.45m. [redacted]

Further benefits of GRAID include the ability to validate the extended life of assets; it is estimated that one major project could be avoided in RIIO-2 at a cost of £10.9m, generating an estimated saving of £31.7m (5+5-year period).

Valves

The valve asset base includes over 30,000 isolation and control valves in the range of ½" to 48" in diameter. 66% of these are less than 4" diameter. The valves asset is made-up of **locally actuated valves (LAV)** which enable sites, pipelines or pipework sections to be isolated, **remote isolation valves (RIV)** which enable a site or pipeline to be isolated remotely in the event of an emergency or planned operation, **process valves (PV)** which allow isolation of a site or section of site pipework as part of normal site operations, and **non-return valves (NRV)** which ensure process gas flows in the desired direction whilst preventing reverse flow and segregating pressure between systems.

Figure 14.35 above ground remote valve configuration



Valves are an essential part of a functioning NTS, controlling the flow of gas and isolating it to allow safe intervention for operational or integrity reasons. These installations tend to be at above ground installations, terminals and off-takes. However, a high proportion of the valves are buried. The distributed and hidden nature of the asset makes it time consuming and expensive to inspect and test the valves.

Over 68% of the valves, of 4" diameter and above, are over 40 years old with original design lives of around 30 years. This would increase to over 81% by 2031 without intervention. The number of defects associated with valves is predicted to rise significantly as the relevant deterioration mechanisms are time and use dependent. Proactive intervention is required to avoid unmanageable levels of defects, together with the associated adverse impacts on the safety, operation and availability of the NTS and any potential legislative non-compliance.

Impacts of no investment

- Safe isolations will become increasingly complex, time consuming and expensive due to internal leakage across isolation valves.
- Isolations will require increasing lengths of the NTS to be vented with an increased environmental impact.
- The continual passing of gas from vent and sealant lines and stem extensions to atmosphere will increase safety hazards as well as environmental impacts.
- Increased outage time due to valve failures related to obsolete assets and the unavailability of spares.

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- Increased risk of impacting supplies, as a growing number of outages on the NTS are required to resolve valve defects.

The increasing age of the asset and the related defect count means that these consequences become more likely and drive an increasing risk profile over the period.

Proposal development

The development of the final valve proposals for RIIO-2 have focused on ensuring the right blend of interventions (refurbish, replace, etc.) whilst balancing cost and risk. Learning from RIIO-1 has heavily influenced our approach and our plans aim to maintain a steady rate of investment to ensure deliverability and consistency to maintain risk. In defining our proposed intervention approach, we have considered six programme options and compared these against a baseline option that assumes a reactive intervention stance. In deciding on the proposed intervention strategy, we have considered the ability to meet the desired engineering and stakeholder outcomes and the resulting cost-benefit. All options considered are cost beneficial over the 45-year period. The proposed option is to maintain risk which pays back in 36 years and is significantly cost beneficial after 45 years.

The six options considered were: a maintain risk option; four variations to do a level of minimal investment on select sub-groups of valve assets; and an increased proactive investment option; with the preferred option being to maintain risk.

Table 14.36 valves volume and cost

Sub-theme	RIIO-2 plan (£)	Percentage of theme	Options considered	Option summary/considerations
Valves	£63,145,760	100%	6	A wide range of options assessed to balance cost/risk are detailed within this EJP for this significant area of work. The preferred option represents the lowest whole-life cost to maintain the current levels of risk on our valve assets.

Valves asset health investment proposal summary

The total RIIO-2 proposed expenditure for this theme is £63.1m.

- **100% of the valve asset health proposals deliver NARMs outputs and 22% of this is driven by legislation/safety case.**
- The valve asset health theme in its entirety is cost beneficial and pays back within the period defined by Ofgem.
- Valve asset health costs are reducing from RIIO-1.
- Volume data confidence is high across the whole theme as these proposals and the associated work packages reflect the RIIO-1 programmes of work and is largely based on known defects.

Table 14.37 valves volume and cost

[redacted]

Figure 14.38 valves asset health theme outputs

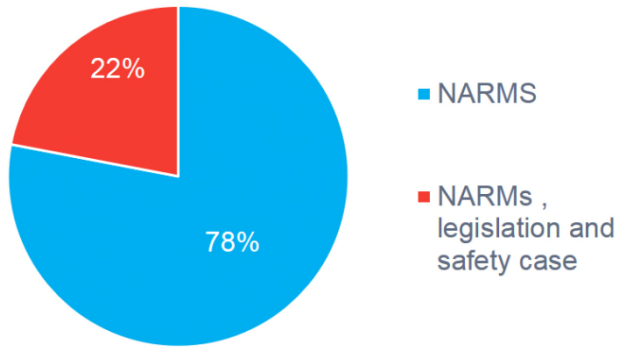
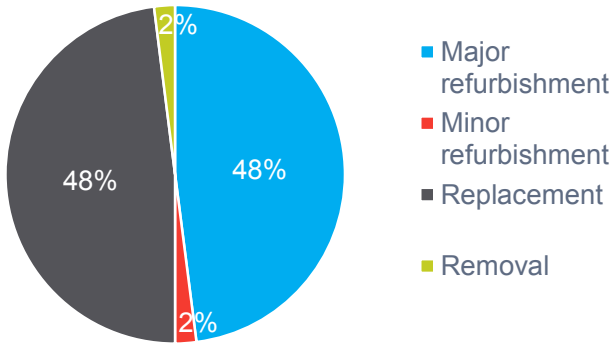


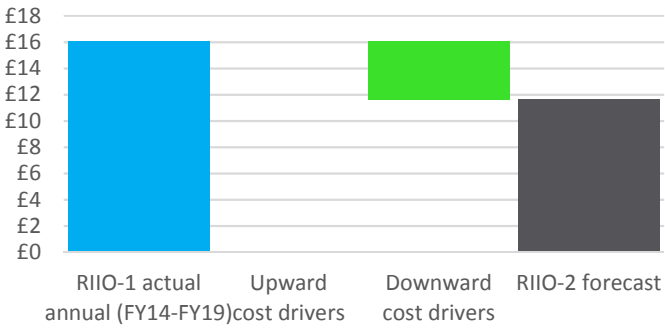
Figure 14.39 valves asset health theme intervention types



Comparing our RIIO-2 proposal to our RIIO-1 programme

The annualised RIIO-2 spend has decreased when compared to RIIO-1 from £16.1m to £11.6m for valves.

Figure 14.40 valves cost waterfall (£m/yr)



Upward drivers

Knowledge of the condition of our valve assets entering RIIO-1 was well understood. These assets come under primary containment as well as safety systems to isolate our pipelines in emergency situations. Therefore, effort

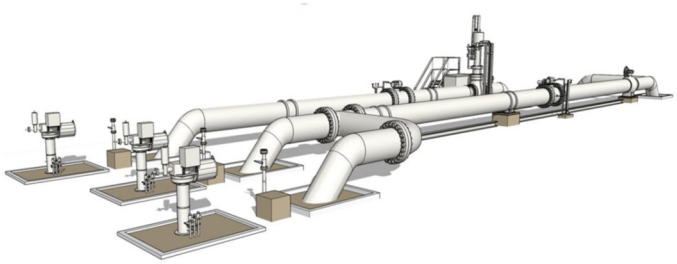
and expenditure were focused on these assets during RIIO-1. We continue to assess and invest in our valve assets on an ongoing basis and, whilst volumes of interventions are largely similar in RIIO-2, lessons learned and best practice from RIIO-1 ensures a lower overall cost per unit whilst we maintain a smoother delivery profile.

Downward drivers

Several specific innovations have been developed during RIIO-1 and these continue to be benefitted from through our RIIO-2 valve campaigns. We have reviewed our valve technical standards with a focus on efficiency within our transformation programme which will lower costs for all future valve replacement. We have also recently launched the Refurb and Re-life team within our Pipelines Maintenance Centre (PMC) department. This team will enable the lowest cost interventions on valves and a range of other assets through expert knowledge, detailed surveys and a strong incentive to minimise costs to extend asset life that can be gained though in-house experts.

Pipelines

Figure 14.41 pipelines connect to our assets



Pipeline assets comprise ~7,600km of mostly buried **pipeline** which is **coated** as a primary means of corrosion prevention and protected by **cathodic protection** as a secondary means. **Protection sleeves** guard the pipeline at locations of high risk such as road crossings. **PIG traps** allow in-line inspection (ILI) of below ground pipeline without requiring an outage. In addition, the monitoring of the **depth of cover** of the buried pipeline both on dry land and at **watercourse crossings** is included in the EJP.

Pipelines are the primary asset within the NTS that enables transportation of gas, and maintaining their integrity is critical to the safe and reliable operation of the NTS. The design, construction, operation and maintenance of our pipelines are subject to both the Pressure System Safety Regulations 2000 (PSSR) and Pipeline Safety Regulations 1996 (PSR). We have an obligation to complete the necessary maintenance activities, under these regulations, to manage the process safety risks that are associated with operating high-pressure natural gas pipelines.

For some of the pipeline network, alternative gas paths are available. However, there are many sections where redundancy is not present, and these pipelines represent a single point of failure. Also, a high proportion of our pipeline network is buried, and the remote and hidden nature of the asset makes it time consuming and expensive to inspect and maintain. The key technical challenges for the pipeline are:

- Corrosion as the primary degradation mechanism managed through robust inspection and mitigation strategies, carrying out PIG runs (i.e. in-line inspections), maintaining coating protection and cathodic protection.
- Third-party interference which can damage the pipeline, addressed by having appropriate depth of cover, watercourse crossings and protection sleeves, where appropriate, and pro-active and reactive maintenance regimes.
- PIG traps deteriorate with age and use. They require on-going care to maintain their condition and must be available to enable regulatory safety compliance to deliver our in-line inspection requirements.

Although most of our pipelines are over 40 years old, it is external corrosion defects and damage that limits the life of the asset. Coatings are generally degrading which puts more emphasis on the performance of cathodic protection systems to limit defect growth. However, these systems need increasing maintenance and upgrading to meet a growing performance demand.

Proposal development

The pipelines asset health programme is split across five sub-themes, each of which considered a number of options. The four options considered for the pipelines, CP and coating sub-theme were: a baseline option of ‘do minimum’; a maintain risk option; an option to not remediate the CP systems; and an option to investigate and remediate all close interval protection system (CIPs) defects found; with the preferred option being to maintain risk.

Table 14.42 pipelines options summary

Sub-theme	RIIO-2 plan (£)	Percentage of theme	Options considered	Option summary/considerations
Pipeline, coating and CP	£131,440,882	91.6%	4	Range of options identified to balance cost/risk detailed within the EJP for this significant area of work.
Impact sleeves	£4,642,360	3.2%	1	Least whole-life cost option deployed to mitigate high risk issues using grout where ILI defect aligns to nitrogen sleeve. This represents the ‘do minimum’ option to maintain compliance.
Pig traps	£4,267,913	3.0%	1	Least whole-life cost option to meet PSSR ILI requirements to convert failed PIG traps where possible to portable traps, repairing/replacing failed PIG traps where conversion is not possible. This represents the ‘do minimum’ option to maintain compliance.

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Watercourse crossings	£2,100,046	1.5%	1	Least whole-life cost solution to meet TD/1 standards chosen to mitigate risk through intervention on high risk/defect issues only. This represents the 'do minimum' option to maintain compliance.
Depth of cover	£1,081,724	0.8%	1	Least whole-life cost option deployed to mitigate risk on an ongoing basis (do minimum) in line with legislation.

Impacts of no investment

Lack of investment would result in an unsustainable situation where the volume of corrosion defects will grow to a level where the performance on the NTS cannot be maintained and any level of remediation would not keep pace with degradation. This would place the NTS in a state where only significant asset replacement would counter the corrosion issues at significant cost to customers and consumers.

RIIO-2 pipelines asset health investment proposal summary

- The total RIIO-2 proposed expenditure for this theme is £143.5m.
- **94% of the pipeline asset health proposals deliver NARMs outputs.**
- All the pipeline asset health intervention sub-themes have been subject to a CBA and all sub-themes are cost beneficial.
- Volume confidence is high due to significant historic data and the repeatability of this work.

The RIIO-2 asset health pipelines theme and intervention costs and volumes by output are provided below.

Table 14.43 pipelines volume and cost

[redacted]

Figure 14.44 pipelines asset health theme outputs

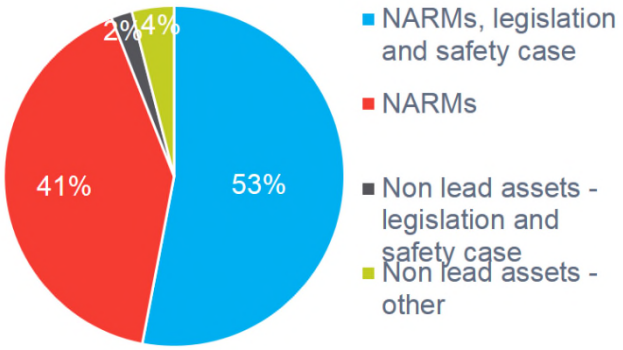
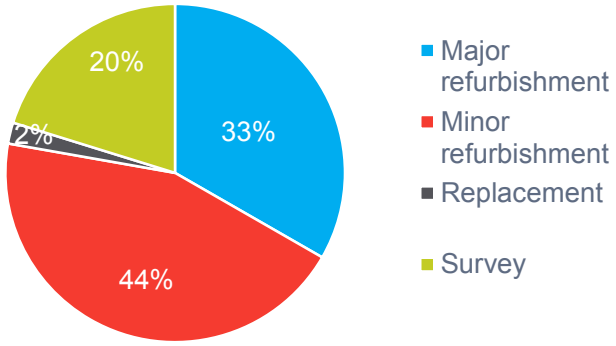


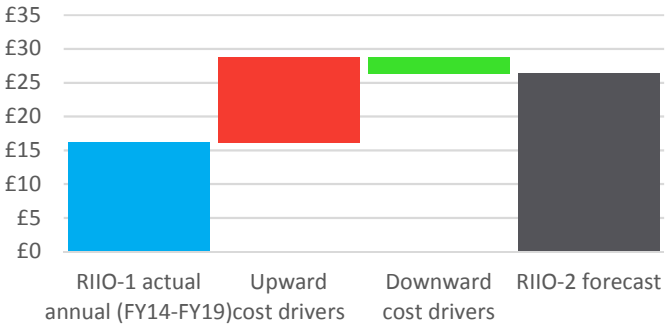
Figure 14.45 pipelines asset health theme intervention types



Comparing our RIIO-2 proposal to our RIIO-1 programme

The annualised RIIO-2 spend has increased when compared to RIIO-1 from £16.2m to £26.4m for pipelines asset health theme.

Figure 14.46 pipelines cost waterfall (£m/yr)



Upward drivers

The RIIO-1 pipeline strategy focussed on in-line inspection defect investigation and remediation as a priority. Our RIIO-2 strategy brings greater volumes of the CIPs defects (an area we are spending over forecasts in RIIO-1) into the plans, increasing the overall cost of the pipelines theme to dig and remediate potential end of life pipeline coating issues. These issues degrade our cathodic protection system effectiveness and failure to act in the nearer term will result in significant pipeline failure risk and/or whole-life cost issues. Note that the annualised allowance for RIIO-1 is comparable to what we are requesting for RIIO-2, for all activities except CIPs.

Downward drivers

Several innovations have been developed in pipelines during RIIO-1, (epoxy sleeves, seam weld identification, etc.) which will be rolled into RIIO-2. In addition, we found a better way to deal with river crossing asset health risks in RIIO-1 reducing costs significantly from the original RIIO-1 forecast and these lower cost interventions

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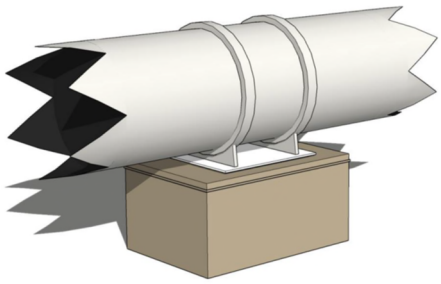
continue to feature in our RIIO-2 plan. These have all been built into our proposed unit cost for RIIO-2.

We continue to bundle work around feeder outages which is a primary driver to keep pipeline work costs low, as well as minimising impacts to our customers. The enhancements through our transformation programme related to enhanced planning processes and systems and the integration of all elements of our asset risk and planning data enables ongoing improvements in this area.

Structural integrity

The structural integrity theme consists primarily of **pipe supports and pits** that ensure pipework is accessible and imposed stresses are limited, **ducting** that provides a safe routing for pipework and cabling, **security and fencing** to protect assets from breaches by external parties, **access** allowing movement around sites, **buildings** in a range of sizes and roles, **tanks and bunds** providing liquid containment and **sewerage treatment and drainage** to stop pollution leaving the site and flooding occurring.

Figure 14.47 pipe supports



The structural assets have been grouped as follows:

- supports, pits and ducting protecting the primary assets
- security, fencing, buildings and access ensuring the primary assets are secure
- tanks, bunds, sewage treatment and drainage protecting the environment.

As such, the continued provision of a basic required level of performance is necessary, with the most critical elements such as buildings, concrete foundations and pipe supports being essential. In some cases, these support compliance with the Pressure Systems Safety Regulations (PSSR) and the Pipeline Safety Regulations (PSR) as well as some environmental obligations.

Impacts of no investment

As many of the NTS sites are now older than their original design lives, an increase in failure of the structural integrity assets is to be expected, with an increasing need for assessment and re-lifing. Many assets are reinforced concrete and are subject to age-based deterioration, signs of which are often visible, in the form of cracks and delamination. Not investing at this stage can lead to further severe deterioration where spalling occurs, at which point the safety and structural integrity of the asset is prejudiced, and the cost of repair dramatically increases. This principle applies to assets constructed of other materials such as roads, security fencing and access platforms. External factors such as weather and ground movement impact the integrity of the structural assets and can consequentially affect critical operational equipment. Failure of assets associated with site access can impede critical maintenance which in turn can affect the operational reliability of the primary NTS assets.

It should also be noted that good access routes, ladders and platforms are essential for safe working on sites, and access roads are often used by members of the public.

Within the structures remit are also containment and treatment facilities for required liquid consumables and for dealing with waste water. Failure to manage deterioration of these assets would undermine our ability to meet the requirements of fire response plans and environmental discharge permits as well as continued operation.

Proposal development

In defining our proposed intervention approach, we have focused our effort on developing a least whole-life cost option that enables an optimised ongoing, rolling programme of work. Significant expert challenge and review has underpinned the levels of intervention and the proposed phasing ensures we meet the desired engineering and stakeholder outcomes whilst smoothing out the workload. The five options considered across the three sub-themes for structural integrity against a baseline option that is purely reactive were: a fix on fail option which included investment for health and safety legislation; a primary proactive re-life option which considers assets with a direct potential impact on the safety of staff and members of the public; a minimal proactive re-life option which focuses on the worst performing or condition assets; a risk based re-life option which considers the asset's condition, criticality and age; and an increased proactive re-life option with all assets considered for replacement at an earlier condition grade; with the preferred option being the risk based re-life option.

Table 14.48 structural integrity options summary

Sub-theme	RIIO-2 plan (£)	Percentage of theme	Options considered	Option summary/considerations
Pipe supports/pits and ducting	£39,287,182	49.4%	5	Range of options identified to balance cost/risk detailed within this EJP. Chosen option takes a risk based re-life approach to maintain stable risk.
Security and fencing, access and buildings	£33,685,071	42.4%	5	Range of options identified to balance cost/risk detailed within this EJP. Chosen option takes a risk based re-life approach to maintain stable risk.

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Treatment and drainage, tanks and bunds	£6,564,960	8.3%	5	Range of options identified to balance cost/risk whilst maintaining environmental compliance detailed within this EJP. Chosen option takes a risk based re-life approach to maintain stable risk.

Table 14.49 structural integrity volume and cost

[redacted]

Structural integrity asset health investment proposal summary

- The total RIIO-2 proposed expenditure for this theme is £79.5m.
- **Our entire structural integrity programme is based on known defects.**
- Spend levels are broadly consistent with that of RIIO-1.
- None of the structural integrity investments are included in our NARMs model. We propose price control deliverables to assure the outputs are delivered.
- Spend is forecast to increase in RIIO-3 as we have taken the view that we will manage the risk through operational means and risk mitigation practices can be deployed where appropriate.

Figure 14.50 structural integrity asset health theme outputs

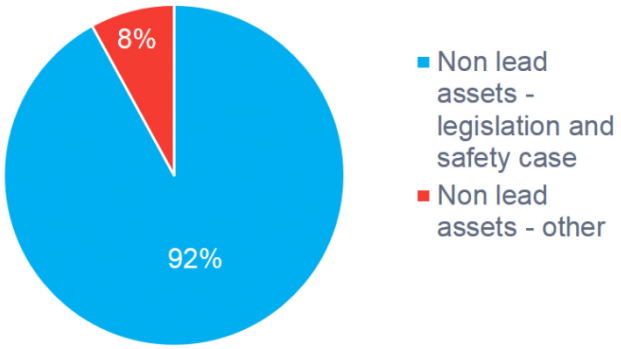
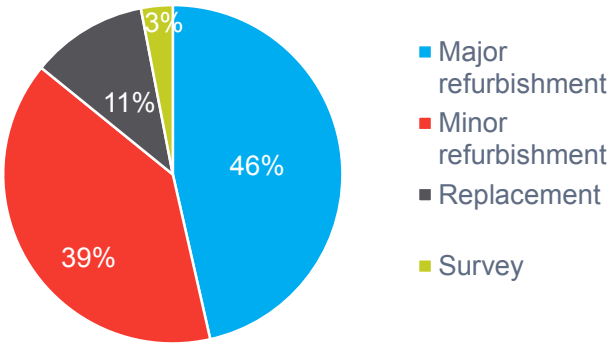


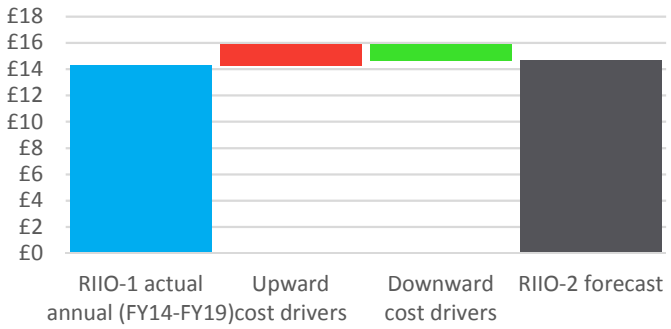
Figure 14.51 structural integrity asset health theme intervention types



Comparing our RIIO-2 proposal to our RIIO-1 programme

The annualised RIIO-2 spend has increased compared to RIIO-1 from £14.3m to £14.6m for the structural integrity asset health theme.

Figure 14.52 structural integrity cost waterfall (£m/yr)



Upward drivers

There are minor upward cost drivers related to increased volumes of work compared with RIIO-1. Our RIIO-2 plan is based on known defects – there are significant known end of life issues across the network that require resolution.

Downward drivers

We continue to bundle structural integrity work with AGI renovation work. Our NARC programme has a proven track record of delivering this work on time and budget. Enhancements to our unit costing and long-term planning processes and systems through our transformation program will support the potential for longer term contracting for this type of work generating consistency in delivery and ongoing delivery contract performance improvements.

Electrical

The electrical infrastructure provides power to enable the safe operation of sites across the NTS. Most assets within the gas transmission system rely on an electrical supply to fulfil their function or are protected by equipment that requires an electrical supply. Key components of this asset include **standby power supplies** that ensure critical services are powered should an electrical outage happen, **HV switchgear** and **transformers** which supply high voltage machines such as compressor electric drives, **LV switchboards and distribution** that provide power to equipment across the sites, **standby generators** that provide the only means of site power should a longer term electrical outage occur, **site lighting** to illuminate the site and support safe work activities and **site electrical systems** that provide general power across the site.

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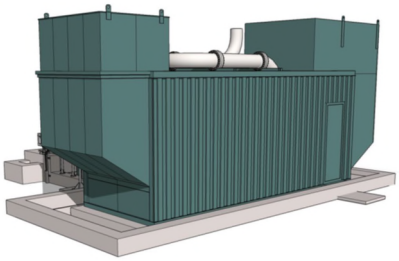
Figure 14.53 standby generator



Electrical supply is taken from the local electrical distribution network but is supported as necessary by standby power supplies and generators. HV machines are the exception where the back-up function of that machine would be covered by other gas generators.
Many elements of the electrical infrastructure are beyond their design life and the ageing infrastructure is deteriorating with the number of defects associated with it rising. The impacts of the increasing defects on the electrical infrastructure are:

- The failures of standby power supplies and standby generators have prevented compressor units starting, reducing the resilience of the NTS. This could have potential impacts on the availability of gas or increase potential for buy backs.
- Several of the ageing standby generators have safety issues associated with their age, type and the location within the site.
- Site lighting is becoming a safety risk across all sites with many cable failures, corroding floodlight columns and specific task lighting that is inappropriate for the work being undertaken.
- There are increased outage times when failures do occur due to obsolete assets and unavailability of spares.

Impacts of no investment

Without investment in the electrical infrastructure, an increasing number of elements may need to be isolated to maintain compliance with the Electricity at Work Regulations (EAWR) and Dangerous Substances and Explosive Atmospheres Regulations (DSEAR). These isolations will lead to increasing impact on the ability to operate the NTS, network capability and ultimately the availability of gas for our customers. Age and obsolescence are significant factors that increase the risk of these assets failing. Many of the electrical assets are at or beyond their intended design life. Failure to continue to invest in these assets can ultimately lead to significant impacts in operating and controlling key NTS sites.

Proposal development

A proactive intervention programme is proposed to avoid unmanageable levels of defects, together with the associated adverse impacts on the safety, operation and availability of the NTS and any potential legislative non-compliance. It should also be noted that robust electrical infrastructure facilitates the intervention programmes during RIIO-2. The four options considered for both sub-themes of electrical against a baseline option that is purely reactive were: a fix on fail option with age-driven replacement of batteries; a minimal proactive re-life option; a risk based re-life option that considers performance, criticality, condition and age of assets; and an increased proactive re-life option which significantly improves risk, with the preferred option being risk-based re-life of assets.

Table 14.54 electrical options summary

Sub-theme	RIIO-2 plan (£)	Percentage of theme	Options considered	Option summary/considerations
Site electrical systems	£23,238,811	81.6%	Various	A balanced blend of refurbishment and replacement intervention options has been proposed to mitigate risk on an ongoing basis to maintain stable risk.
Standby power supplies	£5,237,397	18.4%	4	Range of options identified to balance cost/risk detailed within this EJP. Chosen option takes a risk based re-life approach to maintain stable risk.

Electrical asset health investment proposal summary

- The total RIIO-2 proposed expenditure for this theme is £28.5m.
- All the electrical asset health intervention sub-themes have been subject to a CBA and all sub-themes are cost beneficial, paying back within the period defined by Ofgem.
- None of the electrical asset health investments are included in our NARMs model. We propose price control deliverables to assure the outputs are delivered.
- A significant proportion of the proposed electrical interventions are **replacement interventions** due to the nature of these assets and the interventions required to remove obsolescence and failure risk.

Table 14.55 electrical volume and costs

[redacted]

I want to take gas on and off the transmission system where and when I want

Figure 14.56 electrical asset health theme outputs

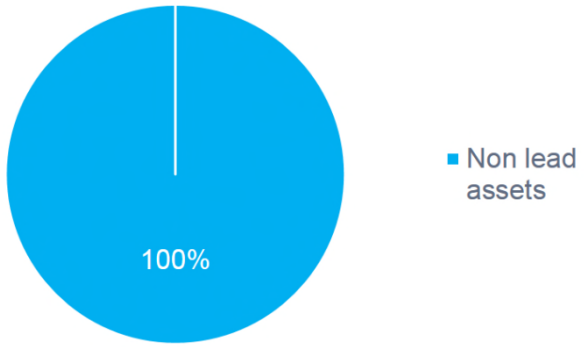
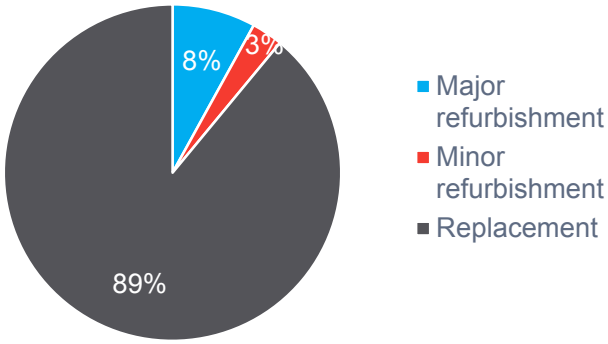


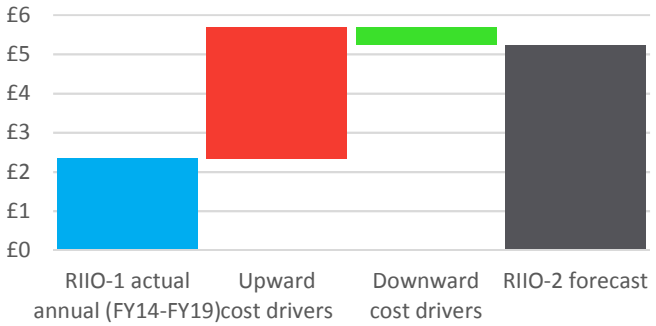
Figure 14.57 electrical asset health theme intervention types



Comparing our RIIO-2 proposal to our RIIO-1 programme

The annualised RIIO-2 spend has increased when compared to RIIO-1 from £2.3m to £5.2m for the electrical asset health theme.

Figure 14.58 electrical cost waterfall (£m/yr)



Upward drivers

Significant end-of-life issues are driving up volumes of electrical interventions in RIIO-2. We have faced significant obsolescence issues on electrical systems for some time and this has been managed in part through grey spares in RIIO-1. Without additional investment in new systems, this approach is unsustainable into RIIO-2 and beyond.

Downward drivers

Our delivery strategy ensures lower delivery costs by bundling site electrical system upgrades with control system work. This alignment of outages and contractor resource reduces the overall cost to deliver and minimises the impact of electrical outages on our sites. Additional efficiencies in this area are driven through our transformation programme. Better asset data, enhanced planning tools and a sharp focus on unit costs all enable lower overall cost of delivery through enhanced, longer term delivery contracting.

Bacton

1. What is this sub-topic about?

Bacton terminal is a key site for the network. It delivers supplies from the southern North Sea, through interconnector pipelines from the Netherlands and Belgium. Bacton is also a key demand on the network, connecting the GB gas market to the European gas market and delivering exports to Europe, as well as to the Great Yarmouth power station and to a gas distribution network offtake. Over the last two years, we have seen days where the terminal delivered 39% of GB gas supplies and days where it met 30% of GB gas demand.

Bacton is the only terminal on the network that switches from being net supply to net demand. It is one of two top tier control of major accidents and hazards (COMAH) sites on the network. The terminal also allows pressure and flow control of the various pipelines connected to it, which delivers safe pressures and security of supply for customers and consumers in the South East (including London). The terminal was commissioned in 1968 to meet stakeholder needs envisaged at that time. Many of the assets have been operational since then and they are over design life (30 years). It is acceptable to extend life (dependent on asset condition) but we are now seeing an increased rate of deterioration and greater intervention will be needed in future. Many asset health issues will need attention during RIIO-2.

2. Our activities and current performance

The high importance of Bacton to the security of supply in the South East, and our obligations to parties connected to the site, both limit the ability to take outages. During RIIO-1, completion of the asset health works at Bacton would have been delivered more efficiently through extended terminal or sub-terminal outages but, given the criticality of the site, we scheduled work around sub-terminal outages and completed it in a less efficient, piecemeal fashion. During RIIO-2, we will need to align disruptive works around customer outages. Other parties connected to our Bacton terminal are experiencing similar issues with their own assets and needing to investment in them; for example, Shell invested £350m in its Bacton rejuvenation project.

3. What have stakeholders told us?

Table 14.59 Bacton stakeholder summary

	Bacton
Stakeholder segments engaged	Consultant/supply chain, customer – entry, customer – exit (ten individuals from four organisations), customer – shipper, energy network operator, GDN, industry/trade body, other energy industry, other non-energy industry, regulator/government, university/think tank.
Objective	To understand how we should approach the asset health issues at the Bacton terminal.
Channel/ method	Targeted one-to-ones, workshop, webinars. We are welcomed as regular attendees at Southern North Sea CEO forum and have a collaborative relationship with Oil and Gas Authority (OGA) and local councils
Key messages	Stakeholders have long-term strategies for southern North Sea gas and interconnectors that go beyond 2040; so our investment at Bacton needs to consider the long term. *"Investment is required for the long-term reliability and safe operation of the terminal, therefore something fit for purpose is preferable"* – [redacted], entry customer There is consensus that any disruption to service at Bacton needs to be carefully planned and minimised; for some parties, it is possible to agree and align an outage for up to two weeks each year, but more than this has significant financial impact. The stability and absolute level of gas pressure at Bacton are important for maximising recovery of southern North Sea gas, reducing offshore compression requirements, facilitating interconnector flows (import and export) and for Great Yarmouth power station connected to the site.
Key trade-offs and how engagement has influenced our plan	There is consensus that a re-developed terminal will deliver the most efficient solution. We asked, "do you support our decision to progress with a new terminal?" Responses 67% – yes, 33% – unsure. *"Excellent opportunity to get ready for future flow scenarios"* – [redacted] customer. *"The best option and future-proof"* – [redacted] entry customer. *"New terminal will ensure capacity and efficiency to support longer-term plans for customers. Not clear to me though if some tweaks to existing would also do the same at lower cost"* – [redacted] entry customer. Some customers would like us to expand our services to include blending and pressure services whilst others disagree. Given the level of interest in blending, this is an area we are exploring and will consider further in our final design options.

4. Our proposals for RIIO-2 and how they will benefit consumers

We propose to redevelop the terminal at Bacton, Norfolk, as the most efficient way of meeting future customer requirements[34], which is advocated by stakeholders[35]. Doing so will create a site with appropriate capabilities to meet the needs of customers and it avoids the need for a more expensive and disruptive asset health programme. Our ongoing work on network capability will not affect the need to address the issues at Bacton. Longer term, this redevelopment will also reduce the hydrocarbon inventory and improve site safety.

During front end engineering design (FEED), we will evaluate options and cost to make our Bacton terminal a net zero emissions site, in line with the government ambition. We will work with onsite stakeholders, considering aspects such as how can we reduce venting through design, what sustainable modes of transport and

[34] FES indicates Bacton will still play a significant role beyond 2040.

[35] Bacton EJP includes copies of letters of support for our proposal.

energy can we implement, can we use waste heat from compression on site.

In developing our proposal, we have considered a range of options including: 'do nothing'; continuing with an asset health approach; continuing with an asset health option but with reduced terminal capabilities; and brownfield redevelopment of the terminal. The options considered, and their relative costs, can be found in the Bacton EJP annex A14.02 and CBA annex A14.03. We have discounted the 'do nothing' option for the site because of the rising number of defects experienced on the site during RIIO-1 and our obligations to manage the major hazard risks of this upper tier COMAH site.

We have considered whether an asset health programme, including a reduction in terminal capability, could be adopted, either to avoid the terminal redevelopment or to allow a decision on the long-term future strategy for the site to be deferred until RIIO-3. We discounted this because the site has several issues that must be addressed during RIIO-2 and RIIO-3, including:

- obsolescence of the fire and gas system, the distributed control system and the gas quality system
- issues with corrosion and non-sealing valves, and
- increased costs associated with operating and maintaining redundant assets.

Cost benefit analysis has confirmed that the redeveloped terminal is a cheaper option than adopting a long-term asset health programme. Such an asset health programme would take many years to complete due to limited opportunity to take the required outages without significant customer disruption. The payback period for a new terminal is 12 years from 2021 (2033). There is still some uncertainty over the final design of the redeveloped site, including the requirement for pressure or blending services and the potential charging implications of these.

The complexity of the site (five feeders, UKCS, import and interconnector import/export) means a simplified site design like those at Easington or Milford Haven is not feasible. The increased risks of not meeting network pressures and of damage to our customer's plant and equipment due to liquid entrainment or dust are considered too high. Many stakeholders raised strong concerns about a simplified site operation[36].

As there remains a level of uncertainty over final site design and hence costs. We are proposing a ring-fenced PCD and requesting baseline funding subject to an uncertainty mechanism to protect consumers' interests. This will facilitate further exploration of stakeholder needs from the site and any potential charging implications of providing these. These outcomes can then be fed into the final site requirements, design and costs through the uncertainty mechanism.

Table 14.60 our proposals

What our stakeholders have told us	Commitment	Output type	Consumer benefit
Stakeholders see a long-term need for the Bacton terminal. There is consensus that a re-developed terminal will deliver the most efficient solution to our asset health challenges.	We will redevelop the Bacton terminal to meet the future customer need and allow for potential future changes (e.g. connection of storage or compression if required and the facilitation of decarbonisation). Once the redeveloped terminal is operational, the existing terminal will be decommissioned.	Price control deliverable to reach FEED for the Bacton terminal (£4.7m). See annex A3.01.	Lower network costs compared to the alternative option of an extended and intrusive asset health programme. Access to gas supplies, providing security of supply and helping keep wholesale gas prices as low as possible. Redeveloping the terminal would also reduce the amount of gas at the Bacton site, moving from a top tier COMAH site to a lower tier COMAH site, reducing ongoing compliance costs for consumers.
	Uncertainty mechanism to be used to adjust the requested baseline funding for the terminal redevelopment, once the final terminal design is confirmed and there is a more accurate view of the costs.	Uncertainty mechanism (£139.6m) ***Trigger:*** *Year 1 (end of FEED).* See annex A3.02. UM to be used to set a second PCD for delivery of the final design.	Adoption of an uncertainty mechanism around the costs of redeveloping the terminal gives consumers cost protection from this uncertainty.

5. How will we deliver?

Redeveloping the terminal offline allows efficient construction. We will reduce construction risk by building a modularised solution offline and offsite, avoiding the need for extended periods of outage. This option also reduces the requirement for site personnel to work close to live gas assets during construction. Connection of the redeveloped terminal to existing site assets would require short outages (two weeks at most) but these could be staggered and aligned with customers' own outages. The terminal can be designed to meet customers' future needs efficiently, including the efficient recovery of gas reserves and operation of interconnectors.

We will continue to engage stakeholders on their requirements from the Bacton terminal to support the development of the final site requirements and design. We will also continue to use our close strategic and operational relationships to ensure open discussions are undertaken to plan works that might cause disruption.

[36] More information in annex A14.02 Bacton EJP.

Innovation

In designing and delivering this project, we will look to use innovation from RIIO-1, business information modelling, which uses intelligent 3D modelling process for design of construction projects. We will also look to future proof the design as much as possible, looking at how the site could be used in a net zero world, including applying a net zero construction approach.

Competition

This project meets the Ofgem criteria for competition from a cost materiality point. We are proposing to unflag this for early competition. For late competition, we are currently proposing to unflag for new. We are exploring the separable category with Ofgem and will continue to do this. We detail more on our approach to competition can be found in chapter 20.

6. Risk and uncertainty

We have engaged specialist external consultancy support from Petrofac. They have confirmed the feasibility of the option to redevelop the Bacton terminal but there are risks, including extensive construction and commissioning difficulties. We will use an uncertainty mechanism to protect consumers' interests as stakeholder requirements are clarified, and final design and costs are refined. Further information can be found in annex A3.02.

7. Our proposed costs for RIIO-2

Construction of the redeveloped terminal will give rise to higher costs during RIIO-2 compared to the alternative of maintaining the existing terminal, but it delivers considerable savings in the long-term. During the RIIO-2 period, minimal asset health works will still be required on the existing terminal to ensure it remains operational whilst the new terminal is constructed; they will cost significantly less than those we'd need to undertake if we opted to retain the existing terminal for a longer period. The EJP for Bacton includes costs that are not included in table 14.61. The opex costs form part of the asset management costs in this chapter and the costs of decommissioning the existing Bacton terminal are captured in chapter 16.

Table 14.61 costs at Bacton for construction of the redeveloped terminal and asset health on the existing terminal

(£m in 18/19 prices)	2022	2023	2024	2025	2026	Total RIIO-2	Annual RIIO-2	Annual RIIO-1
Bacton – FEED	4.7	0.0	0.0	0.0	0.0	4.7	0.9	0.0
Bacton – UM	0.0	29.2	43.3	44.7	17.3	134.6	26.9	0.0
Bacton[37] – asset health on existing terminal	0.5	2.7	2.3	2.6	0.9	9.0	1.8	------[38]
Bacton – total	**5.2**	**31.9**	**45.6**	**47.4**	**18.2**	**148.3**	**29.7**	**0.0**

Table 14.62 level of cost evidence for redevelopment of the Bacton Terminal

Cost realised from RIIO-1 actuals	Cost forecast based on competitive process	External benchmark	NARM or volume-driven PCD
Not currently – part of FEED	Not currently – part of FEED	Yes (partially)[39]	No

Please note we have provided costs to one decimal place and hence some columns may not equal to the totals.

8. Next steps

- We will continue to engage stakeholders on their requirements from the Bacton site and the charging implications of these.
- We will work with Ofgem on the detail of the proposed uncertainty mechanism and the approach to competition for this project.

King's Lynn subsidence

1. What is this sub-topic about?

King's Lynn is an important site providing compression and connecting three pipelines [redacted] The combination of compressors and pipelines is important in meeting customers' entry and exit capacity at the Bacton terminal. This part of our asset health plan proposes rebuilding part of the King's Lynn compressor site. The investment is needed because of ground movement (subsidence) that has put unacceptable stress on valves and associated pipework at the site. 'Do nothing' is not an acceptable option. Without intervention, there are safety risks (uncontrolled release of gas at the site), and wider risks to meeting customer requirements at Bacton (both for entry and exit) and security of supply.

2. Our activities and current performance

Recently, the bi-directional area at King's Lynn compressor has been suffering from a large amount of

[37] Note: these costs are included in our asset health spend and not our Bacton project costs.
[38] The RIIO-1 asset health cost relating to Bacton are contained within the RIIO-1 annualised average asset health cost in table 14.02.
[39] Costs developed with the help of Petrofac, who have developed a preliminary design, construction strategy and timeline to prove deliverability during RIIO-2.

ground movement. During RIIO-1, we've carried out work to find out the extent of this. Excavations have found that the ground is of poor quality and is not supporting the pipework. We also found that drainage was poor, and water wasn't being removed in a timely manner. During the excavation works we found concrete attached to some of the small pipework placing extra stress on it; this has since been removed. Throughout 2017 and 2018, Premtech carried out stress surveys on the pipework and found that some of it had a stress level over three times the acceptable limit. One of the most concerning parts of the report shows that the subsidence and pipe movement between 2017 and 2018 continued to worsen and this is likely to continue if we don't intervene. We have considered whether it is possible to underpin the ground and repair the existing assets; however, investigations have found no supporting rock in the current location so there is no guarantee that this option would stop the subsidence and costs are unpredictable. In addition, as the pipework has already suffered irreversible damage it would still have to be replaced.

3. What have stakeholders told us?

As this is an issue with an existing site, we have not specifically engaged stakeholders about it. However, maintaining the capability of the site is necessary to provide the entry and exit capabilities that stakeholders have told us they need at the Bacton terminal.

Table 14.63 King's Lynn stakeholder summary

What our stakeholders have told us	Commitment	Output type	Consumer benefit
They see a long-term need for capability at the Bacton site (King's Lynn site supports delivery of this) and we should meet all our safety obligations.	We will build a new bi-directional area within the boundary of the existing King's Lynn site. This will remove any reliance on existing pipework, which is under stress due to ground subsidence.	Price control deliverable to reach FEED (£1m). See annex A3.01.)	Removes the risk of constraining import or export flows at Bacton and any limitations on operation of the network. This provides the GB gas market with access to gas supplies, improves security of supply and helps keep wholesale gas prices (ultimately prices to consumers) as low as possible.
	Reopener to be used to adjust the funding allowances once the final design is confirmed and there is a more accurate view of costs.	UM to set a second PCD for delivery of the final design. (£30.2m) ***Trigger:*** *Year 1 (end of FEED).* See annex A3.02.	

4. Our proposals for RIIO-2 and how they will benefit consumers

In developing our proposal, we have considered a range of options including: do nothing; rebuilding the site; underpinning; site decommissioning; and redevelopment of the site with uni-directional capability. The options considered, and their relative costs, can be found in the King's Lynn EJP annex A14.04 and CBA annex A14.05.

5. How will we deliver?

This project will be delivered using native competition during RIIO-2. We will also look to apply RIIO-1 **innovation** using BIM, an intelligent 3D modelling process for design of construction projects. We will also look at applying a net zero construction approach.

Risk and uncertainty

Although Premtech has worked with us on the issues with the King's Lynn site, we have more work to do to finalise the design, work programme and costs. Because of the cost uncertainty this creates, we are proposing baseline funding subject to an uncertainty mechanism to protect consumers, please see annex A3.02 for further detail.

6. Our proposed costs for RIIO-2

Our proposed costs have been informed by the work we have undertaken with Premtech. Please note we have provided costs to one decimal place and hence some columns may not equal to the totals. Pension costs are based on proportion of total TOTEX.

Table 14.64 cost for addressing King's Lynn subsidence

(£m in 18/19 prices)	2022	2023	2024	2025	2026	Total RIIO-2	Annual RIIO-2	Annual RIIO-1
King's Lynn- FEED	1.0	0.0	0.0	0.0	0.0	1.0	0.2	0.0
King's Lynn- UM	0.5	4.7	23.4	1.6	0.0	30.2	6.0	0.0
King's Lynn- total	**1.6**	**4.7**	**23.4**	**1.6**	**0.0**	**31.2**	**6.2**	**0.0**

Table 14.65 level of cost evidence for addressing King's Lynn subsidence

Cost realised from RIIO1 actuals	Cost forecast based on competitive process	External benchmark	NARM or volume-driven PCD
Not currently – part of FEED	Not currently – part of FEED	Yes (partially)[40]	No

7. Next steps

- We will work with Ofgem on the detail of the proposed UM for this project.
- During RIIO-2, we will undertake further work to finalise the design, plan the work programme and update the costs (to feed into the uncertainty mechanism).

[40] Costs contained in this chapter were developed with the help of Premtech

Asset management

1. What is this sub-topic about?

To provide a safe and reliable network that is protected from third party threats, we must invest in the right levels of resource, supported by the right processes, systems, tools and equipment. These investments can be summarised and grouped as:

- **People** – the costs associated with the employees/contractors to develop our asset management strategies, deliver maintenance activities, carry out reactive maintenance/repairs, respond to call-outs[41] and operate the St Fergus and Bacton terminals. This also includes the operational training required to equip people with the capabilities and competences they need for these activities.
- **IT systems** – the costs associated with running and improving the IT systems we use to support the management of network assets.
- **Asset support costs** – the costs associated with running and maintaining our network assets. This includes having the right tools, equipment, consumables and strategic spares to maintain the network as well as commercial vehicles for the operational field force, and paying utility bills for our operational sites.

Our RIIO-2 plan contains an increase in work from RIIO-1 and it calls for additional project support headcount within our central and operational teams. To deliver this efficiently and safely, we plan to build on our RIIO-1 asset management tools and techniques to enhance our capabilities during RIIO-2.

2. Our activities and current performance

People

Our ability to deliver the service our customers expect depends on the availability of suitably skilled people. During the last ten years, there has been high demand for critical engineering skill sets and a consequent reduction in suitable candidates from traditional routes across the utilities and oil and gas industries. This shortage is particularly acute in the North Sea area, impacting Scotland and the East of England. With up to four-year training requirements for many of our staff, we have had to respond by investing in skills development and education to grow the workforce of the future as well as recruitment, training and retention to give the business continuity of skills.

Our resourcing business model to deliver this has flexed over time, moving to a combination of pro-active, 'grow your own' approaches, supplemented by experienced external hires with contractor support where cost effective. Primarily, we seek to hire talented and experienced people across all our core business areas using our in-house recruitment team and direct sourcing capability. This provides the most cost-efficient delivery of new talent into the organisation.

Some of our core roles have a scarce talent pool and are recognised on the shortage occupation list in the UK; where required, we make use of the General Work Visa (Tier 2) to support recruitment activity in these areas. We supplement this with support from agency partners, particularly when looking for niche skills such as cyber or legal experts. In addition, we are continually looking to grow our own talent in core science, technology, engineering and maths (STEM) areas through our annual apprenticeship and graduate programmes. Finally, in some areas it is prudent to supplement our permanent workforce with contingent labour to maintain flexibility in delivering peaks of work such as for major capital projects; to deliver this we use dedicated managed service providers.

Early in RIIO-1, we undertook a major restructuring programme[42] and in 2018/19 we again reviewed our organisation and costs to create:

- an outcome-led organisation, including both customer and service outcomes
- specialisation and focus to drive efficiency
- simplified team interfaces that clarify responsibilities
- clear accountabilities, especially between commercial, strategic, engineering and delivery activities.

The opex efficiencies in our operating model will start to be realised ahead of the RIIO-2 period.

This recent restructure followed asset management best practice and has created three functions: asset owner, asset manager[43] and asset steward. These functions work together to set and deliver our business objectives as shown in figure 14.66 below.

Our asset owner teams are accountable for setting the strategic direction of the transmission owner and managing overall business performance against our customers' and shareholder expectations. They provide independent, risk-based, second-line assurance as part of the three lines of defence, to ensure continued, safe and compliant operations. We manage the risks associated with our operations through a '3 lines of defence' model. The first line of defence is provided by the first line supervisor during normal supervisory activities. The second line of assurance is conducted by a team within the business who audit and assure a range of work activities in a targeted programme. The third and final level of assurance is provided by our corporate audit function who conduct periodic audits as set out in their audit plan. Most issues will be identified and corrected or escalated by the supervisor, with the second and third level assurance teams identifying more systematic and process issues.

[41] Including to compressor trips/breakdowns, site alarms, aerial sightings of third-party interference, third party requests (emergency, minor work requests and planned works) and contractual obligations in Network Exit Agreements.

[42] The total efficiencies resulting from these programmes can be found in chapter 20.

[43] For the purposes of our data tables, the asset owner and asset manager resources are combined together since they tend to be more centrally based roles, whereas asset steward resources tend to be more geographically based.

I want to take gas on and off the transmission system where and when I want

Our asset manager teams provide a centre of engineering expertise to create and implement asset management strategies and plans that deliver the level of service, risk appetite and performance targets set by the strategy and performance team, while remaining compliant with safety and legislative requirements.

Our asset steward teams perform maintenance, repair and operation activities for the network and for external customers. The teams are geographically spread, and they operate and maintain two upper tier control of major accident hazards (COMAH) terminal sites. They also maintain the compressor stations, above ground installations (AGIs) and high-pressure pipelines. Our asset steward team also includes our specialist Pipeline Maintenance Centre (PMC) depots, providing support across the gas industry. PMC is the emergency responder to gas pipeline emergencies across Britain's distribution and transmission networks. They also deliver emergency and reliability response on a 24/7/365 basis across the network, both for our own assets and for those operated by external customers. The opex costs of running PMC are not included in the business plan. These costs are funded through asset projects, emergency response and income for services to other networks and customers.

Figure 14.66 asset management roles

IT systems

Managing the network requires numerous IT systems that enable customers to connect, report events and request information to ensure safety. We use other IT systems to analyse vast amounts of data and prioritise, plan and schedule work, carrying it out in an effective and safe way.

Understanding the condition of our IT assets is key to ensuring they are secure and reliable and that we are managing interventions on them in the most cost-efficient way. During RIIO-1 we have developed multiple, targeted condition-monitoring techniques that capture data about our assets as well as a data and analytics platform to make sense of this data.

Asset support costs

Costs to support the running of the assets can be broadly categorised into three main areas:

- commercial vehicles
- utility bills
- equipment, consumables and spares.

Asset support costs (commercial vehicles)

Our commercial vehicle fleet attends remote sites and provides emergency response, with around three million miles per year driven. We will manage these vehicles in line with our existing replacement and maintenance framework and our cost profile reflects the cyclical nature to deliver this.

We are increasing the number of commercial vehicles from 175 (2018/19) to 243 by the end of RIIO-1, as we move 68 employees from company cars to commercial vehicles. Transferring these employees from to commercial vehicles will reduce costs. We estimate this will save ~£0.5m during RIIO-1 and embed an enduring saving into our RIIO-2 opex costs

Asset support costs (utility bills)

Utility costs for our operational sites include electricity, water and gas with electricity accounting for ~99% of the total (this is expected to continue over the RIIO-2 period).

We use electricity for ancillary equipment associated with compressors, pipelines cathodic protection systems that have above ground installation (AGI) site security and monitoring systems. Of our electricity consumption, 82% relates to ancillary equipment associated with compressors.

Asset support costs (equipment, consumables and spares)

This part of our business plan captures costs of the tools, equipment, consumables and strategic spares required to maintain a reliable network. It also includes our non-operational capital costs (e.g. vehicles) for PMC.

I want to take gas on and off the transmission system where and when I want

3. What have stakeholders told us?

Customers have told us about the value of having unrestricted access to the network, and the impacts on them of any disruption to their ability to use the network. Our asset management activities ensure we have the right levels of resource, supported by the right processes, systems, tools and equipment to deliver the unrestricted access they want. As these aren't topics where there have been specific options to explore with external stakeholders we have not engaged with stakeholders about them.

4. Our proposals for RIIO-2 and how they will benefit consumers

Table 14.67 our proposals

Commitment	Output type	Consumer benefit
Our asset management activities will continue to be led by good asset management principles and we will continue our external accreditation to ISO55001. We will ensure we have the right level of human resource, trained with the right capabilities, supported by the tools, vehicles, spares and IT systems, to efficiently deliver customers' requirements.	Commitment	Efficient management of costs, lowering consumer bills.
Contribute towards the joint gas networks emergency response and enquiry service.	Licence Obligation	Ensure gas is available as and when consumers want.

5. How will we deliver?

We will continue to source fleet procurement, maintenance and fuel card contracts as a competitively tendered procurement process. Through benchmarking exercises, we know this aligns with other utility companies and industry best practice. We will develop robust controls to ensure that our commercial vehicles are managed through their whole lifecycle as effectively and efficiently as possible throughout the RIIO-2 period.

For equipment, consumables and spares, we will continue to buy these efficiently in line with strategy and supply chain principles as in RIIO-1. We will use competitive tendering wherever possible, leverage suppliers during contract extensions, use multi-year contracts to limit rate rises and seek reductions in demand from the operational business. We will continue to participate in European benchmarking activities and other industry groups to ensure adoption of best practice and cost efficiency.

Innovation

Table 14.68 RIIO-2 asset management innovation

Theme	Projects
Fit for the future	We will look to investigate how we can enhance our IT system to gather better and more data to feed into how we approach our asset management activities and what systems we may require to deliver these.
Ready for decarbonisation	We will investigate how the use of artificial intelligence, machine learning and augmented reality can help our workforce undertake their activities in a more agile, safer and efficient way.
Decarbonised energy system	Understand how the pipeline safety case needs to change for hydrogen transportation and how this affects our asset management activities.

6. Risk and uncertainty

A key risk is the availability of the appropriately skilled and trained resources in the right geographic areas to deliver our business plan. This can be impacted by factors such as actual retirement profiles and the wider North Sea gas market. This market affects the availability and cost of securing resources and specialist contractors.
There is also uncertainty over future decarbonisation strategies, which may impact on our assets and consequentially our asset management costs.

7. Our proposed costs for RIIO-2

Table 14.69 asset management costs

(£m in 18/19 prices)	2022	2023	2024	2025	2026	Total RIIO-2	Annual RIIO-2	Annual RIIO-1
People	37.3	37.1	37.6	36.9	36.6	185.3	37.1	31.6
IT systems	9.0	11.3	12.0	10.8	11.1	54.2	10.8	7.9
Asset support costs	18.5	18.3	19.1	17.9	18.2	92.0	18.4	20.9
Total	**64.7**	**66.7**	**68.7**	**65.5**	**65.8**	**331.6**	**66.3**	**60.4**

Please note we have provided costs to one decimal place and hence some columns may not equal to the totals.
Notes: Further explanation of our IT costs can be found in the IT annex 20.03.
The breakdown of annualised asset support costs for RIIO-2 is: equipment, consumables and spares £12.4m (68%), utility bills £3.1m (17%) and commercial vehicles £2.9m (15%).

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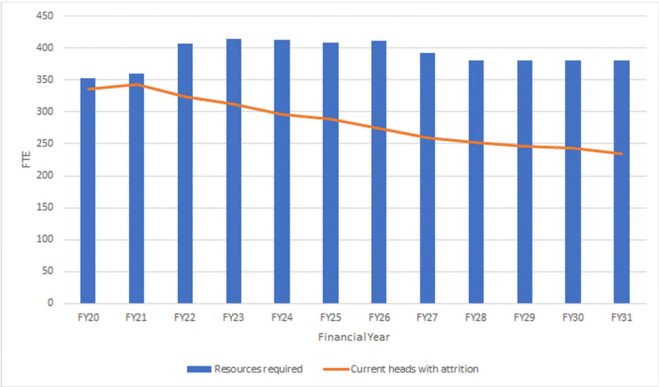
People (cost drivers) Several drivers will increase our headcount in RIIO-2 so that we can deliver our levels of service and investment plans.

Workforce attrition, including retirement: to secure a sustainable, resilient workforce, allowing for skills retention and knowledge transfer, we have included additional resources, particularly in the asset steward teams for RIIO-2. They will ensure we can manage attrition and allow for apprentices, graduates and engineering trainees to cover the retirement profile. We've included an overlap, so they can develop capabilities, competencies and authorisations on the job rather than filling vacant roles after they finish their studies. These have been shown as a recruitment peak of an additional 26 in year one of RIIO-2 to prepare for the forecast retirement profile as well as covering for normal attrition, which is higher in the asset steward population (9%) than it is in the wider business (average 2%). These people will be required across the country for a range of disciplines to allow knowledge transfer from retiring team members, so our teams can continue to deliver maintenance, operate the network and respond as required.

Figure 14.70 forecast asset steward[44] resources required against forecast attrition from current headcount



Supporting increased project work: because we plan to increase our asset health work, we will need more people for project support and enabling activities. Most of the cost will be directly attributable to projects and so be part of project cost, but there is a small element that will be opex (e.g. operational training, and other non-capitalisable activities). We will also need a few people to support development of IT projects (e.g. asset health methodology refresh).

Our RIIO-2 resource proposal assumes asset health funding is aligned to the submission investment values, ensuring reliability of the network is maintained; as such, we don't need additional resources to respond to increasing rates of failure.

The resourcing requirements of our asset owner and asset management teams in the first year of RIIO-2 are based on the organisational efficiencies being delivered through the 2018/19 restructure. Plus, an additional six full time equivalent (FTE) for graduates (4 FTEs) and IT projects (2 FTEs). The FTE then grows incrementally to enable delivery of the asset health plan.

IT (cost drivers)

In the RIIO-2 period, multiple core systems that manage our assets, work and field force will be reaching their end of life. This is an opportunity to reassess our systems so that we continue to maintain our safety and reliability performance while extracting best value for money from our systems. Our overall RIIO-2 IT strategy can be found in annex A20.03.

Asset support costs (cost drivers)

Equipment, consumables and spares – the drivers behind these costs focus on asset resilience, legislative compliance and national spares stock requirements, and they are based on the expected workload on the network over the RIIO-2 period. Our RIIO-2 costs are lower than RIIO-1 due to procurement process efficiencies and a RIIO-2 5% Opex procurement efficiency commitment. This is partly offset by a small increase in RIIO-2 costs, relating to increased project workload.

Utility bills – there is a direct link between electricity consumption and compressor running and standby hours, so our RIIO-2 forecast costs take into consideration past and forecast RIIO-1 consumption. Actual costs will be driven by the requirements to run compressors to meet customers' supply and demand patterns, therefore fluctuations in costs are expected.

Commercial vehicles – we will require an additional eight vehicles for the new cyber technicians.

Table 14.71 level of cost evidence

Cost realised from RIIO-1 actuals	Cost forecast based on competitive process	External benchmark	NARM or volume driven-PCD
Yes (resources, asset support costs)	Yes (Vehicles and utility bills)	Yes (resources)	No

[44] Data excludes PMC resources

Network resilience

1. What is this sub-topic about?

We plan new investments at two locations to increase the resilience of the network and protect consumers from disruptions to supply that arise from planned or unplanned maintenance activities.

We are proposing to increase the resilience of gas supplies to [redacted] area, by building a short new pipeline and above ground installation (AGI). [redacted]

At the Tirley AGI site, we need to install additional isolation valves to allow filter maintenance to be undertaken without creating restrictions on gas flows in South Wales, including to the important Milford Haven entry terminal. These valves are necessary because of a 2017 revision to company standards for safe isolation of assets and adoption of a company minimum standard for isolations.

2. Our activities and current performance

In developing our RIIO-2 plan, we initially identified 62 areas where increased resilience might be beneficial for consumers. These included offtakes that rely on a single pipeline and areas of the network that are difficult to maintain, test or inspect without risking disruption to entry or exit customers.

We refined this list based on the significance of the issue, levels of existing mitigations (including use of maintenance days where the impact was on a single industrial or power station consumer), views of impacted stakeholders and cost-effectiveness of the potential solutions.

Gas distribution network (GDN) offtakes that are connected to single transmission pipelines were highlighted as a key area, as there is an increased risk of disruption to consumers when planned or unplanned maintenance impacts these offtakes.

Blackrod

During RIIO-1, we experienced issues along feeder [redacted] (which supplies Blackrod) and these have been addressed without disruption to end consumers. However, under different circumstances they would have resulted in end consumer disruption. Cadent (the GDN connected at Blackrod) is only able to swap offtake flows away from Blackrod up to 85% of peak winter demand levels. Such flow swaps are also reliant on Cadent having an intact network (i.e. not having assets out for maintenance).

In 2013, safe inspection of corrosion at various sites was only possible with Cadent undertaking flow swaps on its own network. If the pipeline had required isolation, demand had been higher, or if Cadent had been undertaking maintenance on its own network, then those flow swaps may not have been possible.

An additional risk for this section of feeder [redacted] has been identified at Heapey Dam. The overflow for the dam passes underneath feeder [redacted] and it doesn't have the capacity to deal with the required flow of water during flooding events. During heavy rainfall in December 2015, the limited capacity of the overflow resulted in water overtopping the dam. Several homes downstream were flooded but the dam was undamaged. The risk for us is that during a similar future event the top of the dam could wash out, with potential damage to (or loss of) feeder x[redacted] and the subsequent loss of capability to supply to the Blackrod offtake and potentially [redacted] consumers.

Tirley AGI

During RIIO-1, due to the inability to isolate individual filters for maintenance, we have delayed filter maintenance at Tirley to avoid causing constraints on the network. Safety policy means the filters can only be maintained by isolating the whole site from the network. This results in a flow restriction in South Wales, including reducing entry capacity at the important Milford Haven liquefied natural gas (LNG) terminal to ~20mcm/d (against a contractual capacity of ~86mcm/d). The restriction would also impact gas flows into South Wales to meet demand, should Milford Haven not be exporting LNG to the network.

Continuing to delay maintenance will result in non-compliance with policy, require emergency maintenance and/or result in entry constraints if filters become blocked. For these reasons, we decided that 'do nothing' wasn't an option for RIIO-2.

3. What have stakeholders told us?

We did not want to raise unnecessary concerns about security of supply, so we have chosen not to engage with wider stakeholders about Blackrod. For Tirley, as these are issues with existing site design and the ability to undertake routine maintenance safely and in accordance with policy, we have not sought external stakeholder input on our proposals.

Table 14.72 stakeholder engagement summary

	Network resilience
Stakeholder segments engaged	GDNs – Cadent and SGN.
Objective	Understand the most effective and cost-efficient way to improve the resilience of specific areas of the network
Channel/ method	Bilaterals
Key messages	Blackrod: working with Cadent, we have explored the issue of being unable to isolate the pipeline without risking disruption to domestic consumers, trying to find the best whole system solution. Solutions on the Cadent network were more expensive than those available on our network and Cadent is supportive of our proposed transmission solution to this issue. Working with SGN we explored and discounted investment in another location to increase resilience on that part of the transmission network.

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4. Our proposals for RIIO-2 and how they will benefit consumers

Table 14.73 our proposals

What our stakeholders have told us	Commitment	Output type	Consumer benefit
[redacted] supports our proposal for transmission investment to increase resilience of supplies to the Blackrod offtake	Deliver a new ~1km, 900mm pipeline and a new AGI . [redacted]	Commitment	**Blackrod provides a consumer value proposition valued at £173m (for more information on CVP1 please see annex A10.05).** [redacted] Increased ability to undertake planned and unplanned maintenance without disruption to gas supplies/operational pressures to customers in the North West.
N/A for Tirley	Install new isolation valves that will allow individual filters at the Tirley site to be isolated and maintained.	Commitment	Reduced risk of planned or unplanned disruption associated with filter maintenance at Tirley. Increased security of supply and market access to diverse gas supply sources, resulting in lower costs for all consumers.

Further explanation of our proposal for a pipeline at Blackrod can be found in the EJP, annex A14.06 and CBA, annex A14.07.

5. How will we deliver?

Native competition will be used for delivery of the projects at Tirley and Blackrod. We will look at how we can use our BIM innovation from RIIO-1 in delivering these projects.

6. Risk and uncertainty

For the pipeline connecting to the Blackrod offtake, the proposed pipeline route would be subject to obtaining planning permission and negotiation with land owners. The proposed pipeline is significantly shorter, and cheaper, than other pipeline connection options contained in Blackrod EJP and CBA (annexes A14.06 and A14.07).

7. Our proposed costs for RIIO-2

Table 14.74 network resilience costs

(£m in 18/19 prices)	2022	2023	2024	2025	2026	Total RIIO-2	Annual RIIO-2	Annual RIIO-1
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Network resilience total	**0.3**	**4.5**	**4.2**	**0.5**	**0.3**	**9.9**	**2.0**	**0.0**

Please note we have provided costs to one decimal place and hence some columns may not equal to the totals.

Notes:

- Costs for installation of Tirley valves have been based on the average of historic projects costs and unit costs for valves.
- Costs for Blackrod have been based on similar historic projects.

Table 14.75 level of cost evidence for network resilience

Cost realised from RIIO-1 actuals	Cost forecast based on competitive process	External benchmark	NARM or volume-driven PCD
Yes	Yes – RIIO-1 tenders	No	No

8. Next steps

For Blackrod, we will continue to test the design and cost of our proposed solution. Following agreement that the project is going ahead, we will further investigate land planning and access.

Environmental resilience

1. What is this sub-topic about?

Climate change is increasing the risks to our operations, for example, from increased risk of flooding or changes to riverbeds that contain pipelines. For RIIO-2, we will continue to survey our assets in accordance with industry standards to support the delivery of a reliable and safe network.

2. Our activities and current performance

Pipeline watercourse crossing surveys

During RIIO-1, we have experienced issues where pipelines cross watercourses. On feeder 9, rapid and unpredictable estuary movements have reduced the depth of cover on the pipeline under the Humber river and we are working on replacing this crossing. There have also been sand movements at Duddon Sands in Cumbria and there is a risk of the pipeline becoming exposed. We've responded by increasing monitoring to check for exposure or free-spanning of the pipeline. Working with a specialist marine consultancy, we have developed a contingency remediation plan covering the materials, resource, methodology and costs to reinstate cover over the pipeline.

During RIIO-1, we put the work for surveying the river crossings out for re-tender. As part of the exercise, we evaluated the performance of the incumbent supplier against the required specification and policy for the survey, which identified some areas for improvement. The process ensured that the new service provider was fully meeting all the necessary requirements and ultimately our obligations under the Pipeline Safety Regulations. This outcome increased costs during RIIO-1.

For RIIO-2, we will continue with the watercourse crossing surveys based on frequency and information on asset condition, or their immediate environment. We'll also re-tender the work periodically to ensure costs remain efficient.

Flooding risk

During RIIO-1, a number of environmental events have had a negative impact or had the potential to negatively affect the safe and reliable operation of our assets.

There were flooding events in 2013 and, at Goxhill above ground installation (AGI), these caused significant damage to electrical, communication and security assets with a remediation cost of ~£3m.

At the Gravesend Thames South AGI, the site was designed to accommodate flood water and no significant damage occurred during flooding in 2013, although minor site clean-up costs were incurred.

Figure 14.76 flooding at the Gravesend Thames South above ground installation in 2013

We have considered (and discounted) proactive installation of flood defences at our AGI sites as the pipeline and AGI assets are themselves largely unaffected by the presence of raised water levels[45]. Proactive investment therefore does not represent value for money for consumers. We are, however, proposing to repeat a survey across the network to assess the risk of buoyant lift on pipelines in the event of flooding and specific local ground conditions. The last survey in 2012 identified 501 pipeline sections that were classified as susceptible to lift, of which 71 were in the highest risk category. Completion of the survey would support our compliance with Pipeline Safety Regulations and identify sections with reduced depth of cover, and hence increased risk from third party damage.

3. What have stakeholders told us?

We have talked to stakeholders about environmental risks at various events and meetings, including with environmental regulators and consumer groups[46].

Table 14.77 stakeholder engagement summary

	Environmental resilience
Stakeholder segments engaged	Consumer interest groups, consultant/supply chain, customer-entry, customer-exit, customer-shipper, energy network operator, environmental interest group, GDNs , industry/trade body, other energy industry, other non-energy industry, regulator/government , university/think tank, domestic consumers, non-domestic consumers.
Objective	To understand stakeholders' views about the network's resilience to the impacts of climate change.
Channel/method	Geographically spread workshops, webinars, bilaterals.
Key messages	We asked, "Should we be proactive or reactive in managing these impacts?" • Proactive: mitigate against flooding by investing in flood defences etc. – 42% • Risk-based: mitigate high-risk sites and manage remaining as appropriate – 53% • Reactive: insure against these impacts and manage the clean-up – 5% We captured a variety of comments including: *"If you're in a flood zone, make sure your sites can cope with the floods."* [redacted] ***regulator*** *"The decision to manage impacts should be based on risk analysis."* [redacted] ***supply chain***

[45] Providing appropriate electrical equipment is on raised platforms.

[46] See our environment engagement log in annex A16.06.

	"National Grid need to have good risk management, so that they can maintain assets to deliver a reliable network for the customers." [redacted] ***network company*** *"In the circumstance that there is a large risk of harm you would have to take a proactive approach. Therefore, top risks should be prioritised such as erosion of pipelines under rivers, but everything else would fall into the reactive bracket."* [redacted] ***supply chain***

4. Our proposals for RIIO-2 and how they will benefit consumers

Table 14.78 our proposals

What our stakeholders have told us	Commitment	Output type	Consumer benefit
To adopt a proactive or risk-based approach to the management of environmental risks.	In response to feedback we are taking a risk-based approach to managing the threats associated with **pipeline watercourse crossings.** We will undertake condition-based monitoring surveys of pipeline watercourse crossings to identify whether the pipeline is at risk of additional loading, impact from reduced depth of cover, exposure or free-spanning. The drivers for this work are compliance with the Pipelines Safety Regulations 1996 and meeting the minimum requirements in the industry standard IGEM/TD/1.	Commitment	Minimising risk of unplanned disruption of supply to gas customers and consumers. Minimising risks of unplanned disruption to gas entry customers, ensuring consumers have security of supply and access to the cheapest sources of gas.
	We will continue to **maintain watercourse navigation markers** in accordance with our obligations under the Merchant Shipping Act 1995.	Commitment	
	We will undertake work to assess the **risk of buoyant lift on our pipelines in the event of flooding**, building on our 2012 survey work.	Commitment	

5. How will we deliver?

We will continue to use competitive tenders (native competition) for the contracts associated with managing environmental risks. Should we identify the need to install flood defences during RIIO-2, we will look to work with local communities to explore the best solution, rather than just for our site(s) in isolation.

6. Risk and uncertainty

We are adopting a risk-based approach. If any specific risks are identified during RIIO-2, we would consider whether these must be mitigated during RIIO-2 or could wait until RIIO-3. If RIIO-2 mitigation is required, our approach to managing this situation would be to consider risk trading across asset types, as permitted under the asset health methodology.

Given the potential risks, we are proposing that the mechanisms for justified over and under delivery of NARMs outputs are retained for RIIO-2, which is consistent with Ofgem's Sector Specific Methodology Decision in May 2019.

7. Our proposed costs for RIIO-2

River crossing surveys represent approximately 80 per cent of the costs in this part of our business plan. We have based the RIIO-2 costs for these activities on tendered contract rates from our procurement events and on the known volumes of activity (e.g. based on survey frequencies driven by the industry standard, which would be consistent with those undertaken in RIIO-1). For the remaining ~20% of the costs, our forecast expenditure has been based on RIIO-1 costs.

Table 14.79 environmental resilience spend

(£m in 18/19 prices)	2022	2023	2024	2025	2026	Total RIIO-2	Annual RIIO-2	Annual RIIO-1
Environmental resilience	0.8	0.7	0.8	1.0	0.8	4.2	0.8	0.5

Please note we have provided costs to one decimal place and hence some columns may not equal to the totals.

Table 14.80 level of cost evidence for environmental resilience

Cost realised from RIIO-1 actuals	Cost forecast based on competitive process	External benchmark	NARM or volume-driven PCD
Yes	Yes – RIIO-1 tenders	No	No

I want to take gas on and off the transmission system where and when I want

Gas system operation

1. What is this sub-topic about?

As the combined gas transmission system operator, we work hard to balance the system for Great Britain and enable our directly connected customers' need to move gas on and off the network when and where they want. This sub-topic focuses on the core system operator activities we undertake to minimise any restrictions, disruptions or constraints in the ability for customers to put gas on and take off the network. This means we need the ability to:

- accommodate and balance our customers' flows on and off the network
- maintain pressures below maximum design limits of the system (safety) and above the minimum requirements of our customers (contractual)
- maintain gas quality within strict limits to protect our customers and consumers (safety)
- enable access to allow asset development and maintenance to be undertaken across the NTS.

As transmission system operator, we want to continue to meet our obligations, customer requirements and deliver value for consumers. We work across multiple time horizons to ensure we maintain the right level of network capability for Great Britain's energy needs. The timescales of the activities included in this section range from ten years ahead for long-term network planning through to the real-time operation of our network. Figure 14.81 below provides a high-level illustration of these activities across the time horizons. For more detailed explanations on our system operator processes, please refer to the Gas Ten Year Statement (GTYS)[47].

Figure 14.81 system operation processes

The main activities captured in this chapter are:

- Responding to long-term customer requirements by comparing the capability of the network with those requirements, identifying gaps and carrying out engagement and CBAs on the options to meet customers' needs. These options include asset investments and/or contractual solutions. We use supply/demand data based on FES to carry out network analysis that identifies risk and supports efficient decision-making.
- Delivery of safe network access[48] for maintenance, asset health or connection activities and to allow external parties[49] to carry out their own maintenance. We analyse the risks to optimise access and coordinate maintenance activities with customers to minimise disruption to consumers. We publish seasonal maintenance plans and operate a permit-based process as part of the Safe Control of Operation framework.
- Implementing commercial/regulatory change around capacity/energy balancing processes; ensuring these processes are in place to reflect the regime and to facilitate the right network access, capacity products and balancing services for our customers.
- Compliance with our obligations relating to the balancing and capacity processes, including under the NGGT licence and Uniform Network Code (UNC), for example around quantities of capacity to be released, processes to be followed and provision of methodology statements
- Meeting varying customer needs in our day-to-day. operation of the network. Continuing to provide the critical continuity of real-time operation through the people, processes, systems and infrastructure associated with the Gas National Control Centre.
- Meeting our legal and regulatory obligations, as set out in our licence, safety case and the UNC.

It is worth noting that taking gas on and off the network has become increasingly complex throughout RIIO-1 and will continue to change in RIIO-2. Whilst the physical growth of the network has largely plateaued, the pressures of a rapidly changing energy landscape need to be considered against a backdrop of ageing pipelines and

[47] https://www.nationalgridgas.com/insight-and-innovation/gas-ten-year-statement-gtys

[48] Taking assets out of service to allow work to be undertaken.

[49] For example, GDNs, power stations, storage sites and large industrial customers.

compressor assets and new, more stringent environmental legislation affecting a large proportion of the compressor fleet. These changes have a substantial impact on the operation of the NTS. A few examples have been provided below:

- **Customer needs** – We are seeing a significant shift in our customers' needs and behaviour which is set to continue changing rapidly. These changes are driven by the evolving energy landscape, customers' changing physical operational requirements and the underlying market fundamentals. The flexibility our customers demand from the system continues to increase and our challenge is to accommodate this whilst maintaining a largely unconstrained network. Our customers' needs relate to the quantity, location, timing and profile of gas entering and leaving the network and can present challenges to real-time operation of the system. In order to try and accommodate these changes in requirements (e.g. increasing interest from non-traditional gas customers, speed of customer connections process and investment planning security linked with advanced capacity reservations)[50], we need to enhance our ability to predict and model these behaviours across the network time horizons to ensure appropriate levels of assets and tools can be put together with an effective operational strategy, which determines whether flows on the day can be met and enable us to manage the network risk safely.
- **Longer term 'uncertainty**' – The potential range and uncertainty in future energy pathways hinders our ability to theoretically predict and model a future level of connected load and behaviour on the system and our subsequent ability to manage this behaviour under real-time conditions and considerations. The real-time operational risk that this presents is a mismatch between the level of assets and tools available, and those required to manage the prevailing conditions that materialise on a gas day many years subsequent to the original planning time horizon (this may also include uncertainty of commercial and market frameworks as well as the physical NTS behaviours). We need to be able to predict and model these future uncertainties to inform our long-term investment decision to allow us to maintain a safe and reliable network with enough capability to meet GB's energy requirements.
- **Medium to short term 'variability'** – This is predominantly a result of the transition of GB to a net importer of gas, the associated surplus and diversity of supplies against a backdrop of reducing aggregate demand and the level, types and behaviour of the connected load. This results in a significantly greater number of supply and demand permutations that occur on any given day with complex market drivers. With the move away from UKCS gas, supplies are now linked to global markets and trends through LNG and other imports, as well as fluctuations associated with new renewable energy sources such as wind and solar. Market and physical operations are now much more complex and intertwined, resulting in a lack of predictability of behaviour of flows on and off the NTS that has previously been relied upon for planning purposes. The real-time operational challenge this then presents is that essential maintenance of the NTS assets, and therefore network capability, traditionally scheduled in the summer to align with reduced customer demand, has an increased risk of being misaligned with new flow requirements, reducing the effectiveness of operational and linepack management strategies.
- **Short term 'volatility**' – Inter (one gas day to the next) and intra (within day) flows, customer and market behaviours have become more volatile. These sudden, unpredicted and unexpected changes can result in mismatches in flow on and off the system which then can also exacerbate flow profiling/imbalance across the day and therefore linepack changes in the system. Examples of what the changes in behaviour by connected customers can be related to include plant preferences e.g. avoidance of TRIAD periods, increasing supply trips caused by offshore failures, changing weather patterns and fast cycle storage.

2. Our activities and current performance

Before the start of the RIIO-1 period, we discussed and predicted the decline in UKCS gas supplies; a transition away from traditional north to south system flows, of reducing aggregate demand, diverse connected supplies, uncertainty and variability of supply and demand patterns, within day volatility of connected load and the interactions between wind and combined coal and gas turbine (CCGT) generation sources. We also highlighted the impact of changing compression requirements and environmental investment drivers. All of these significant changes have come to fruition throughout RIIO-1. Over the RIIO-1 period so far, we have largely met our customer needs in managing a largely constraint-free system, despite a number of significant challenges associated with the changing energy landscape and network requirements.

RIIO-1 systems

The RIIO-1 period has seen an unprecedented change in the core systems required for real-time operation of the system. We refreshed and/or replaced the suite of systems and infrastructure that allow us to monitor and control the NTS. This investment in RIIO-1 enables us to continue to meet our operational and safety requirements and structures our IT infrastructure in such a way we can upgrade modular components as the network evolves now and in RIIO-2. One key component of this was the ageing control and market facilitation system – Integrated Gas Management System (iGMS), which was no longer fit for purpose and beyond its original design life. A new Gas Control Suite (GCS) and associated infrastructure has now largely been delivered with the physical control and market operations successfully moved over onto the new system in 2016. The system was scoped and designed to meet the current RIIO-1 requirements and configurable to meet future requirements relating to further cyber protection, data provision and data analytics. For

[50] https://www.nationalgridgas.com/insight-and-innovation/gas-ten-year-statement-gtys

example, we have delivered and integrated SIMONE online into the GCS suite to allow forward simulation of the NTS. These are all designated critical national infrastructure (CNI) systems. We've invested for the future in a system we can maintain and evolve in an evergreen approach. Therefore, whilst the cost to implement the system was higher than we envisaged at the outset of RIIO-1 this has been offset against reduced costs in maintaining it since implementation. Overall expenditure on GCS in RIIO-1, has been roughly in line with allowances.

RIIO-1 processes

During RIIO-1, we have focused on efficient delivery of our system operator activities including a company-wide efficiency programmes[51] that has informed our RIIO-2 proposals. We have matured some of our basic modelling capabilities by automating a number of our manual models and improved our data accuracy which has resulted in improved accuracy of our forecasts and some small efficiencies gains. For further information on how we have improved how we model the NTS in RIIO-2 and our gas planning and operational standards, please refer to A20.03 (IT annex).

In RIIO-2, we anticipate a much more challenging environment in optimising asset investment decisions and market solutions to meet the agreed level of network capability. This will drive the need to substantially improve our ability to analyse the network against multiple supply/demand scenarios and network configurations. In order to play our role in the changing energy landscape, we will require a step change in our analytics and modelling capabilities. We will also require a more dynamic operational strategy to extract maximum value and flexibility from the physical system. In RIIO-2, this means we will need to:

- enhance our energy forecasting requirements across all time horizons
- enhance real-time and forward simulation and evaluation of multiple scenarios; our ability to forecast and manage the risk associated with facilitating increased network access, and to identify and develop appropriate commercial options
- greater market intelligence capability both from external sources and further analytical interrogation of internal performance data
- increased monitoring, intelligence and optimisation of real-time plant performance
- a risk management system capable of making informed planning, and proactive and reactive strategy decisions.

Our manual processes today will not cope with the vast amount of data and information that needs to be processed in real-time and therefore we require greater automation and control and market facilitation systems enhancements to support this capability build.

RIIO-1 people

Our people are crucial for us to be able to adapt to industry change, to unlock the value of the proposed systems and process enhancements as well as being able to deliver value to our customers and consumers. We outline our proposed system operator capability requirements and associated investment in further detail in annex A14.25 of which a critical proportion is set out in this chapter. These capabilities are required in order to successfully deliver our business plan commitments.

3. What have stakeholders told us?

We talk regularly with stakeholders at events such as our Operational Forum meetings, both to discuss operational issues and to develop deeper understanding of customer needs. Through our wider RIIO-2 engagement, stakeholders have told us they require unconstrained access to a safe and efficient network. Please refer to annex A14.01 for a detailed log of the gas on and off the NTS engagement log. We have also been engaging with our stakeholders on our RIIO-2 incentive proposals, please see annex A3.03 which summarises the existing and new incentives we are proposing as part of our RIIO-2 business plan and will be subject to further consultation.

4. Our proposals for RIIO-2 and how they will benefit consumers

Table 14.82 our proposals

What our stakeholders have told us	Commitment	Output type	Consumer benefit
They have told us they value being able to flow gas without restriction	**Efficient operation of the system** – we will continue to drive efficiency, understand and meet customer needs using the assets and commercial tools available to us.	Commitment	Efficient and safe operation of the network and associated commercial processes.
	Maintaining IT systems – continue to invest in our core IT systems[52] to ensure they stay secure and up to date while delivering the level of performance required by the stakeholders we share data with. We must also maintain the non-CNI systems that support day-to-day processes for capacity management, balancing and information provision.	Commitment	

[51] Further information on these can be found in chapter 20.

[52] We use a suite of IT systems known as the Gas Control Suite to monitor and control the gas transmission network and to receive and share data with our directly connected operators and shippers. Elements of these systems are designated CNI and so they are subject to specific regulations governing their resilience and levels of security.

	Building new capabilities – we want to exploit technologies to develop new capabilities that can drive greater value for consumers from the networks and markets, we plan to[53]: • develop enhanced analytical and modelling tools to improve our insight to manage risks effectively • take advantage of automation where it is cost-effective to do so.	Commitment	Efficient operation of the network and associated commercial processes ensures consumers have the gas supplies they need at the lowest possible price.
Get the right incentive framework to deliver maximum benefit to consumers	**Please see annex A3.03 for further information on our incentive proposals.**		
	Residual balancing Retain scheme to drive minimisation of energy costs to operate the network. Our proposals are tougher to achieve against, recognising the impact of a changing energy landscape and we propose amending the. linepack component of the scheme to drive the right behaviour during seasonal transitions between winter and summer.	ODI ***Current proposed cap*** *£1.6m /* ***collar*** *£2.8m pa* ***Target (LPM):*** *5.6 mcm/d (shoulder months) and 2.8mcm/d (non-shoulder months)* ***Target (PPM):*** *1.5% SAP*	Efficiency of residual balancing activity, minimising impacts on the market, customers and ultimately cost to end consumers. Incentive integral to our role as residual balancer.
	Maintenance (use of days and changes schemes) Retain existing schemes and expand to cover the wider range of maintenance activities supported by stakeholder feedback. Our schemes will be tougher to achieve against, recognising that the volume of planned maintenance is likely to be higher in RIIO-2. Proposed expansion to include non-remote valve operation (RVO) maintenance.	ODI ***Current proposed cap*** *£1.2m /* ***collar*** *£1.5m pa* ***Targets:*** *Use of days – 11, Changes 7.25%*	Alignment of maintenance plans with customers to minimise potential disruption to them and wider markets. Ultimately reducing costs for end consumers.
	Entry and exit capacity constraint management Retain scheme. Remove a level of risk which represents "BAU" from cost target. Remove revenue from scheme where we scale back interruptible/off-peak capacity.	ODI	Efficient activities to avoid and manage constraints (i.e. provide the unconstrained access required by customers). This reduces overall costs and risks for consumers. Incentive integral to capacity regime (e.g. incentive efficiently managed risk associated with overselling capacity).

We outline our proposed system operator capability requirements and associated investment in further detail in annex A14.25.

5. Risk and uncertainty

Our proposals for the constraint management incentive are based on our business plan proposals, informed by our work on network capability. Final constraint management scheme parameters will need to be refined based on any changes, including those made to our proposed investment programme or the wider commercial regime (e.g. baselines, capacity regime etc.). We are continuing to engage stakeholder on the package of incentives for RIIO-2. Based on their feedback, this may change our proposals following submission of this business plan.

6. Our proposed costs for RIIO-2

Table 14.83 gas system operation costs

(£m in 18/19 prices)	2022	2023	2024	2025	2026	Total RIIO-2	Annual RIIO-2	Annual RIIO-1
IS and Xoserve	26.6	30.8	31.9	30.1	26.3	145.7	29.1	25.5
GSO	12.8	13.2	13.3	13.3	13.1	65.8	13.2	11.0
Total	**39.4**	**44.0**	**45.2**	**43.5**	**39.4**	**211.6**	**42.3**	**36.4**

Please note we have provided costs to one decimal place and hence some columns may not equal to the totals.
Further explanation of our IT costs can be found in the IT annex A20.03

Table 14.84 level of cost evidence

Cost realised from RIIO1 actuals	Cost forecast based on competitive process	External benchmark	NARM or volume-driven PCD
Yes	No	Yes for IS	No

7. Next steps

Following submission, we will be consulting on our proposed package of incentives. This may lead to subsequent change in our final incentive proposals. Further detailed information can be found in annex A3.03.

[53] Further detail on our proposed project investments during RIIO-2, and the justification of these can be found in the IT investment annex A20.03.