# Gas Unit Cost Methodology Report

May 2026

NESO
National Energy System Operator

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[1] Jacobs, jacobs.com/

# Executive Summary

# Executive Summary

This report outlines the methodology used to develop cost estimates across the full lifecycle of major gas transmission assets. It complements the Gas Unit Cost Model and its associated instruction manual, providing transparency on how costs were derived, their sources, and the level of accuracy and granularity applied.

The approach is designed to help NESO and its stakeholders make informed investment decisions by providing consistent, traceable cost data. It also enables a better understanding of cost implications at each stage of asset development and operation.

The methodology details the cost build-up for key network components, including:

- Transmission pipelines
- Above Ground Installation (AGIs) - including block valves and Pressure Reduction Installations (PRIs)
- Compressors

Costs are mapped to each stage of the asset lifecycle, aligned with ISO 55001 principles:

- Identify need, plan, design and procure, build, commission
- Operate, maintain, and perform
- Modify or upgrade
- Decommission (replace or dispose)

**Data was sourced from suppliers, Jacobs' project experience, and publicly available industry data. Each data point was validated and benchmarked, and a confidence rating was applied based on the granularity and reliability of the source.**

Two main costing approaches were used:

- Bottom-up: Based on detailed breakdowns of materials, labour, and land costs, where the material cost was sourced directly from suppliers.
- Top-down: Using industry benchmarks from the UK and international sources, with assumptions clearly documented.

# Key Findings

# Key Findings

1. Hydrogen infrastructure data is still limited, particularly for compression assets. Where data was unavailable, assumptions were made and clearly documented. The methodology is designed to be updated as more data becomes available.

2. There is a lack of recent large-scale pipeline projects in the UK and Europe, making it difficult to benchmark certain costs. In these cases, data from the US and historical UK projects were used and adjusted for inflation and currency.

3. For 1200NB pipelines, supplier data was not available. Costs were extrapolated from smaller diameters using a linear regression model, which showed a strong correlation ($R^2 = 0.99$). While this provides confidence, it still introduces some uncertainty.

4. Material and manufacturing costs particularly for steel have been volatile due to global events. The report notes that prices spiked following the Ukraine conflict and recommends that cost data be reviewed regularly to remain current.

5. Each cost estimate is accompanied by a qualitative confidence rating based on data granularity and source reliability. This helps users understand the strength of each estimate and make informed decisions.

6. The gas unit cost library is designed to be flexible. As NESO identifies specific projects through the Gas Options Advice (GOA) process, the model can be tailored to reflect project-specific assumptions and inputs.

**This methodology underpins NESO's gas unit cost library, enabling robust cost-benefit analyses (CBAs) for the GOA and future advisory work. This approach supports investment decisions by providing transparent, consistent, and evidence-based cost data.**

# How to use this document

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**This document is intended for use by project leads and users of the gas unit cost library tool at NESO, who are responsible for generating the GOA document in response to National Gas' Strategic Planning Options Proposal (SPOP). It can be read in full for a comprehensive understanding of the methodology behind the cost library and the resulting estimations, or specific cost areas can be consulted selectively for an in-depth review of the approaches taken.**

This document is designed to be used in conjunction the gas unit cost library tool and the tools accompanying user guide. While the user guide provides detailed instructions on how to operate the tool, this document focuses on explaining the underlying methodology used to calculate the cost estimations and provide reference to where the sources and data originated. Together, these resources offer a complete and aligned view of the gas unit cost library, supporting consistency across all work streams.

# 1. Introduction

1.1 Project background

1.2 NESO objectives

1.3 Project scope

1.4 Purpose of this document

# Introduction

## 1.1 Project background

**The National Energy System Operator (NESO) is an independent public body established in the United Kingdom under the 2023 Energy Act. Officially launched in October 2024, NESO is tasked with overseeing the strategic co-ordination and operation of the UK's natural gas, electricity, and other forms of energy systems. Its core mission is to ensure that the country's energy infrastructure remains secure, efficient, and aligned with long-term net zero goals, whilst always keeping the cost to the customer in mind.**

NESO's responsibilities include long-term system planning, real-time energy balancing, market development, and the integration of emerging technologies such as hydrogen and carbon capture. As an impartial authority, NESO provides evidence-based insights to government and industry stakeholders, supports fair access to the grid, and enhances the resilience of the national energy system, playing a central role in shaping a sustainable energy future.

As part of NESO's responsibilities, it is subject to gas strategic network planning obligations, as outlined in condition C8 of NESO's Gas System Planner Licence conditions[2]. These new obligations are integrated into the two-year gas network planning cycle, which is conducted in collaboration with National Gas Transmission (NGT), the system operator for the National Transmission System (NTS).

In December 2024, NESO published the Gas Network Capability Needs Report (GNCNR), which outlines its assessment of the physical capabilities of the NTS over five and ten-year horizons, as well as projections extending to 2050. The report evaluates how the system's physical requirements are expected to evolve under various Future Energy Pathways, based on supply and demand forecasts.

Following the GNCNR, NGT is responsible for releasing the Strategic Planning Options Proposal (SPOP), which presents a range of potential responses to the system needs identified in the GNCNR. These options may include installation of new infrastructure or the expansion,

[2] Ofgem, ofgem.gov.uk/sites/default/files/2024-03/Annex%20G%20-%20Gas%20System%20Planner%20Licence%20Conditions.pdf

reinforcement, repurposing, replacement, or decommissioning of the existing infrastructure. The proposal also provides detailed cost estimates, feasibility assessments, and the projected impact of each option on network capability.

In December 2025, NESO published the Gas Options Advice (GOA) document, which evaluates the investment options proposed by NGT. This document assessed how effectively the proposed strategies address the capability needs outlined in the GNCNR, with a long-term view extending to 2050.

Through GOA, NESO will carry out an unbiased assessment of all investment options put forward by NGT against four aspects:

- Direct economic impacts (capital and operational costs)
- Environmental impacts
- Social impacts
- Deliverability

## 1.2 NESO objectives

As part of the GOA process, NESO is required to develop a cost-benefit analysis (CBA) to support the recommendation of a preferred investment option. Looking ahead, NESO may also be called upon by Ofgem to provide advisory input, which could similarly require robust CBAs. To ensure these assessments are based on reliable and independent cost data, NESO identified the need for a consistent and transparent view of gas infrastructure investment costs.

To support this, Jacobs was commissioned by NESO to develop a gas unit cost library. This tool is designed to provide standardised cost estimates, enabling NESO to carry out CBAs for the GOA and future advisory work. The library includes unit cost metrics such as £/km for pipeline projects and £/MW for compressor installations, offering a practical and scalable approach to cost estimation.

## 1.3 Project scope

The following asset classes, life cycle stages and cost categories included within the gas unit cost library are captured in Figure 1 below:

| Asset classes | Life cycle stages | Cost categories | Unit of measure |
|---|---|---|---|
| • Transmission pipelines<br>• Above ground installations<br>• Compressor stations | • Identify, plan, design, and build<br>• Consenting<br>• Commission<br>• Operate and maintain<br>• Modify or upgrade<br>• Decommission | • Material<br>• Labour<br>• Land acquisitions<br>• Permitting and regulatory fee<br>• Miscellaneous | • £/km (pipelines)<br>• £/MW (compressors) |

Figure 1: Asset life cycle stages

## 1.4 Purpose of this document

This document outlines the methodology used to calculate the costs associated with each asset class, covering all relevant lifecycle stages and cost categories. It also details the assumptions made and any exclusions applied during the development of the cost estimation tool.

# 2. Overall Methodology



# Overall Methodology

The gas unit cost library was developed following the steps illustrated below, for more detailed information on the specifics of each asset class, the corresponding life cycle stages and cost categories please refer to the subsequent sections.

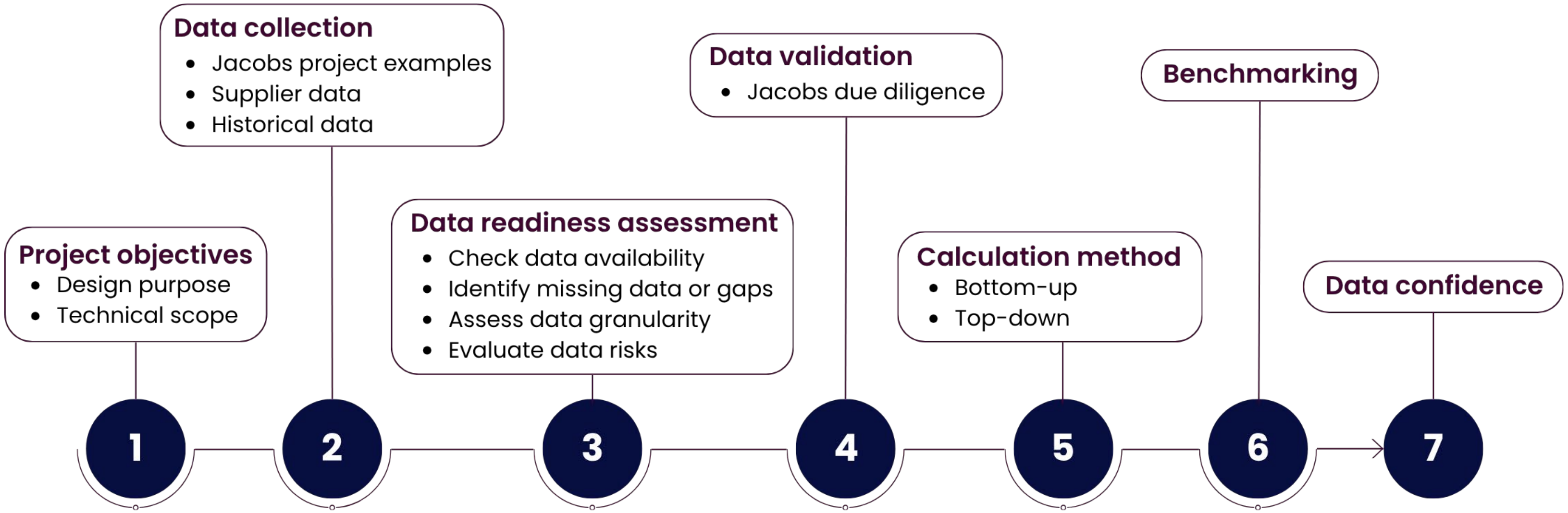

Figure 2: Overall methodology

## 2.1 Project objectives

In the first stage, we held several meetings with NESO to thoroughly understand the project's objectives and how they align with NESO's broader goals. Our aim was to develop a tool that meets NESO's needs. From a design perspective, we clarified how the end user will interact with the library, what questions they will ask, and what responses they expect. On the technical side, we identified the cost items that need inclusion, determined which elements can be grouped into asset classes, and outlined the lifecycle stages to be considered. We also addressed the need to account for regional and operational variation factors for specific cost items. Through this assessment, we gained insights into providing an understanding of costs per kilometre for various pipeline diameters and costs per megawatt for compressors, supported by underlying data and analysis. The analysis is translated into simple output metrics, allowing us to offer unit cost ranges with an approximate P50.

## 2.2 Data collection

Data was collected from three sources depending on the asset class and the data availability. These sources were:

- Suppliers/manufacturers
- Jacobs project experience
- Open data sources for historical projects and industry studies

Figure 3 summarises the data collection for each asset class for new builds along with the number of data points, illustrated with brackets. For specific sources per asset class please refer to the corresponding sections in this report.

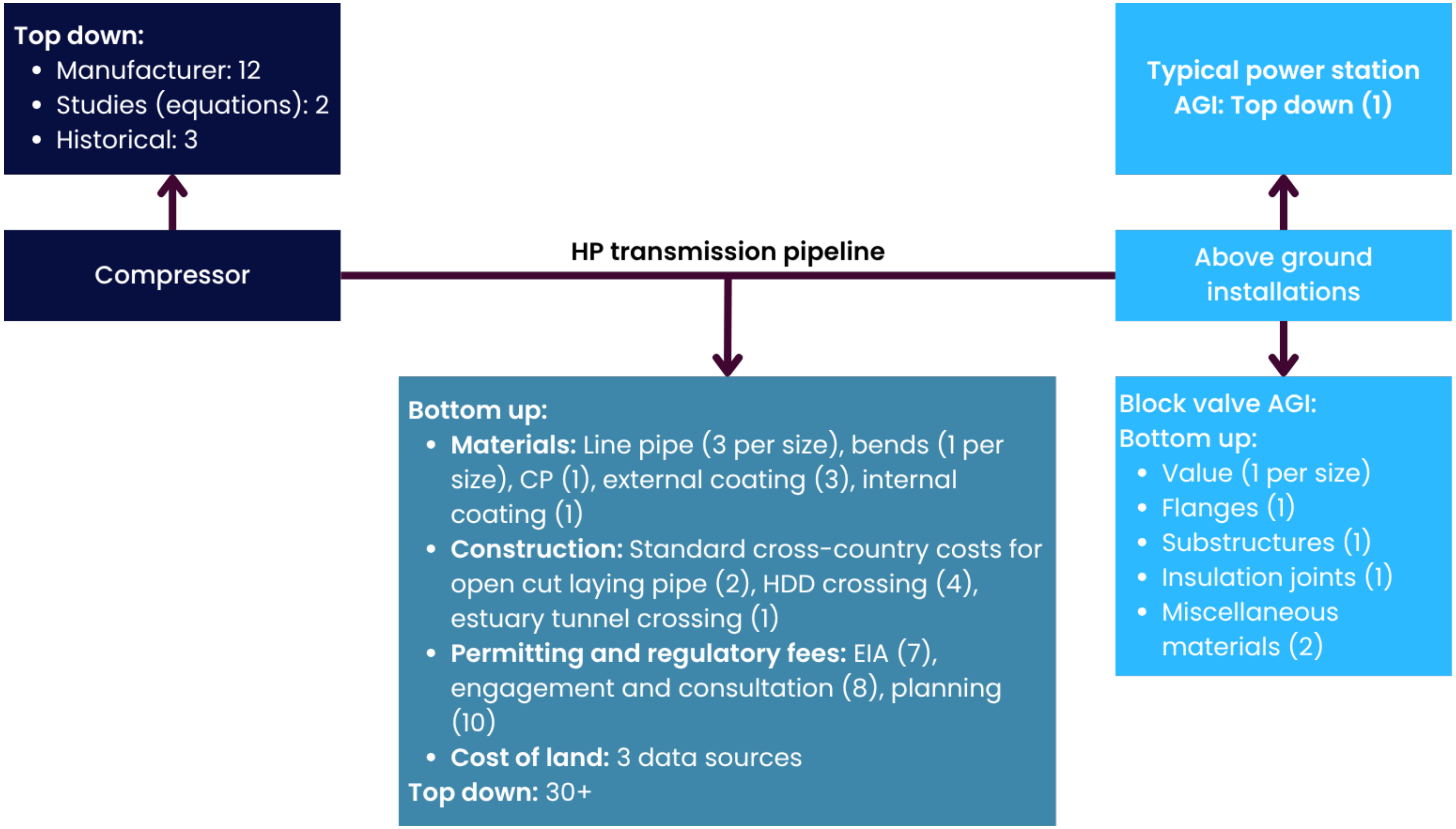


Figure 3: New build data collection summary

For the other project stages, Figure 4 provides a summary of the data sources along with the number of data points, illustrated within the brackets.

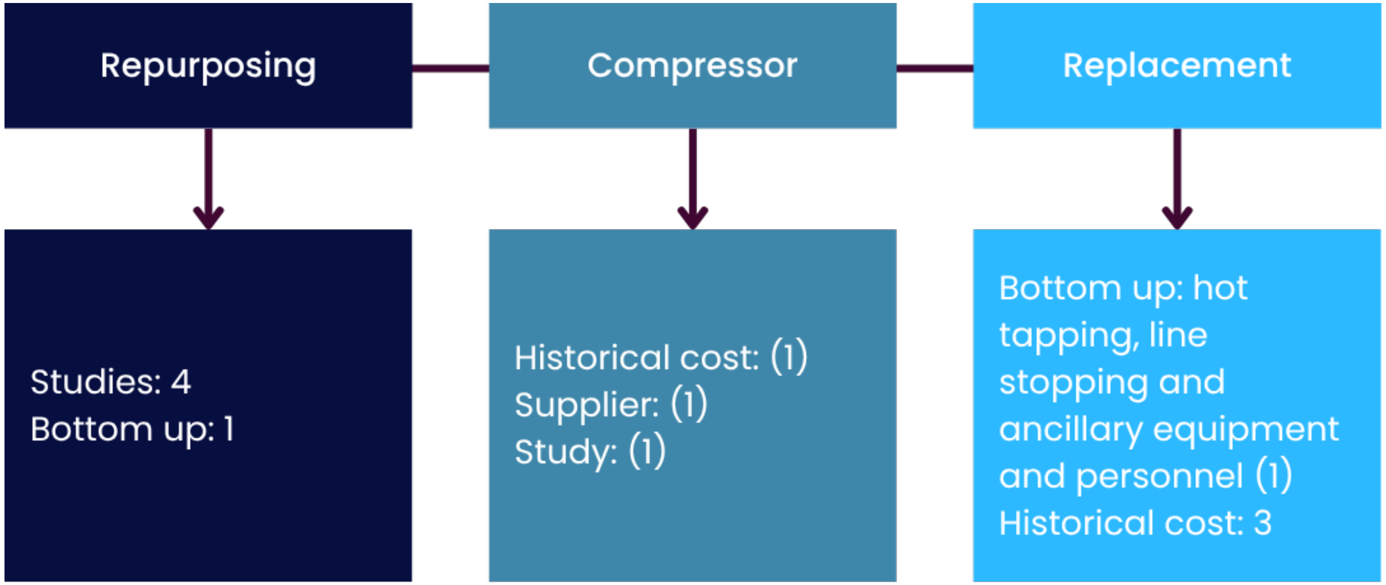


Figure 4: Other stages data collection summary

## 2.3 Data readiness assessment

Throughout the project, we continuously collected data to enhance the robustness of our information. A key strategy was identifying data gaps during our weekly calls and prioritising these gaps for the following week's data collection efforts. Concurrently, our experienced in-house team assessed the granularity of the data, ensuring clarity on what was included within the costs. For example, some suppliers included activities like pipe coating, while others did not. Each data point was meticulously reviewed to ensure accuracy. When granularity could not be confirmed due to source limitations, these instances were identified as risks and highlighted accordingly. This process informed our confidence in the data, which was used to determine the confidence rating, further explained in Section 2.7. In cases where information was unobtainable, assumptions were made, and the reasoning behind them was documented. Where assumptions were made, the resulting data confidence score reflects the availability of supporting information to make informed assumptions. Specific assumptions for each asset class are detailed in the subsequent sections of this report.

## 2.4 Data validation

The collated data underwent a thorough validation process, involving detailed review and cross-comparison against multiple available sources. This enabled the identification of consistencies and discrepancies between data sources and highlighted data that appeared inaccurate, over-inflated, or potentially unreliable. This approach allowed us to select the most credible data sources to feed into the costing model and facilitated constructive engagement with suppliers, providing valuable insight into the root causes of cost discrepancies and highlighted if equipment and materials quotes required further refinement. This filtered data was then benchmarked against trusted industry data to further validate the reliability of our inputs, which resulted in final cost estimates underpinned by validated, high quality data.

## 2.5 Calculation method

Based on the data available after the data readiness assessment and validation stages two approaches were used to calculate the costs per asset class and corresponding project stage:

**Bottom-up cost estimate:**

- This method involves calculating costs by obtaining detailed expenses for individual components such as materials, labour, and land costs, with these costs then totalled to provide an overall cost estimate. A crucial aspect of this approach is establishing clear assumptions regarding how these calculations are performed and documenting any assumptions made.

**Top-down estimate:**

- This approach is employed when suppliers provide fully loaded costs without breaking down individual component expenses. It is essential to understand precisely what materials, labour, and boundaries are included within these costs. Any assumptions made during this process are carefully recorded in the relevant sections of Section 4 in this methodology document to ensure transparency and accuracy.

## 2.6 Benchmarking

Data was collected on publicly available gas pipeline costs from a range of online sources[3], alongside previous projects and estimates from Jacobs. These values were provided for projects in the US and Europe. For the purposes of currency conversion and purchasing power parity (PPP)[1], where a European project did not specify its country of origin, the model assumes the project to be from Germany.

The benchmarking data sits as an input in the model and requires the user to input to total cost per km of the project as well as the currency of the cost, the year of the project and the country of the project.

The model then converts them into an appropriate equivalent value using the following steps:

- The model uses an annual purchasing power parity table sourced from the OECD[4] to convert the costs into GBP values for the relevant year. Exchanged rates were sourced from Bank of England database[5]. For example, if the project was completed in 2016, then this step converts the cost into 2016 GBP values accounting for purchasing power parity. All values are provided relative to USD but the conversion between any pair of currencies included is trivial.

- Next the cost is inflated in line with the annual CPIH rate provided by the ONS[6]. The model can handle inflating to any year provided and this is determined by user inputs in the model control panel. Details on model operation are provided in the model guide which is issued as a separate document.

Note that these datasets are regularly updated, and the version of the model issued has the datasets included as of June 2025. The user is expected to update these datasets over time.

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[3] Global Energy Monitor, gem.wiki/Oil_and_Gas_Pipeline_Construction_Costs
European Commission, data.europa.eu/doi/10.2833/122757
ACER, acer.europa.eu/sites/default/files/documents/Publications/ACER_UIC_indicators_table.pdf
[4] OECD, oecd.org/en/data/datasets/purchasing-power-parities.html
[5] Bank of England, bankofengland.co.uk/boeapps/database/index.asp? first=yes&SectionRequired=I&HideNums=-1&ExtraInfo=true&Travel=Nix
[6] ONS, ons.gov.uk/economy/inflationandpriceindices/timeseries/l55o/mm23

The benchmarks are assumed to only include CAPEX and do not include any elements of operating and maintenance costs:

- Purchasing Power Parity (PPP) compares the relative value of Gross Domestic Product (GDP) accounting for household final consumption expenditure and individual consumption.

## 2.7 Data confidence rating

A crucial aspect of successfully utilising the tool is clearly identifying the data confidence rating for the asset classes and their corresponding project stage. The data confidence rating is determined by two key vectors:

- **Data granularity**

This vector evaluates the level of detail and clarity within the data. It assesses how well-defined the data is, specifying what is included and excluded. High granularity indicates detailed and specific data, enhancing confidence in its applicability and relevance.

- **Data source reliability**

This vector examines the trustworthiness and credibility of the data provider. It considers the provider's reputation, track record, and the methods used for data collection and verification. Reliable sources boost confidence in the data's accuracy and validity.

By multiplying these two vectors, you can derive a comprehensive data confidence rating:

**Data confidence rating = data granularity × data source reliability**

Both vectors are rated on a scale from 1 to 5, where 1 indicates a low score and 5 indicates a high score. The data confidence is summarised below in Table 1.

Table 1: Data accuracy and confidence

| Asset class | Project stage | Costing method | Data granularity (DG) (1-5) | Data source reliability (DSR) (1-5) | Data confidence rating (multiple between DG and DSR) |
|---|---|---|---|---|---|
| Transmission pipeline | New build | Bottom-up | 5 | 5 | 25 |
| | Operation and maintenance | Top-down | 3 | 4 | 12 |
| | Pipeline diversion | Bottom-up | 4 | 5 | 20 |
| | Uprating | Bottom-up | 5 | 4 | 20 |
| | Repurposing | Top-down | 5 | 4 | 20 |
| | Replacement | Bottom-up | 4 | 5 | 20 |
| | Decommissioning | Bottom-up | 4 | 4 | 16 |
| Block valve | New build | Bottom-up | 5 | 4 | 20 |
| | Operation and maintenance | Top-down | 2 | 4 | 8 |
| | Repurposing and replacement | Top-down (new build cost excluding land acquisition and assumed 30% of new build regulatory fees) | 4 | 3 | 12 |
| | New build | Top-down | 5 | 4 | 20 |

| Asset class | Project stage | Costing method | Data granularity (DG) (1-5) | Data source reliability (DSR) (1-5) | Data confidence rating (multiple between DG and DSR) |
|---|---|---|---|---|---|
| **Pressure reduction installation** | Operation and maintenance | Top-down | 2 | 4 | 8 |
| | Repurposing | Top-down | 4 | 3 | 12 |
| | Replacement | Top-down (new build cost excluding land acquisition) | 4 | 4 | 16 |
| **Compressor medium 10-25MW** | New build | Top-down | 5 | 3 | 15 |
| | Operation and maintenance | Top-down | 3 | 3 | 9 |
| | Replacement | Top-down | 4 | 3 | 12 |
| | Uprating | Top-down | 5 | 3 | 15 |
| | Rewheeling | Top-down | 5 | 2 | 10 |

# 3. Asset Lifecycle Management



# Asset Lifecycle Management

## 3.1 Lifecycle stages (aligned with ISO 55001:2024 – Asset Management)

In line with industry best practice, and recognising that NGT are accredited to ISO 55001, we have considered the lifecycle stages of each of the asset classes in alignment with the ISO 55001 standard. The asset lifecycle has been applied to each of the three asset classes, however the length of time in each of the lifecycle sections during a project will vary depending on each asset.

As part of the asset lifecycle management, and in addition to ISO 55001, Jacobs have also considered the Ofgem funding process, which is inclusive of the time taken to produce and submit funding requests to the regulator, as well as allowing time for Ofgem to evaluate the requests and decide on funding allocations. Project timescales have been adjusted to accommodate these regulatory decisions.

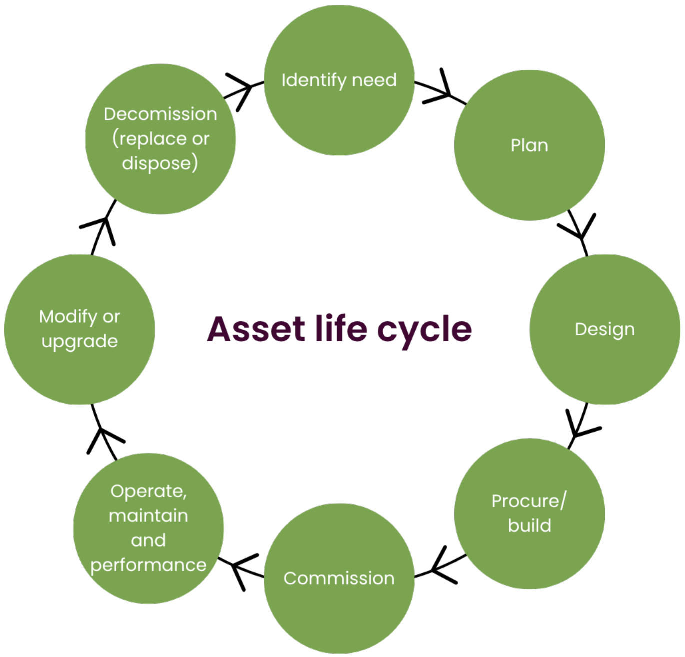



Figure 5: Asset life cycle management process

## 3.2 Asset lifecycle stage breakdown

The following sections will capture the different lifecycle stages and highlight the different areas within these stages that are factored into the overall costs. In addition to the activities required throughout the lifecycle stages, it is also important to note that the time requirements for each stage.

### 3.2.1 Identify, plan, design, build, and commission

The first five stages of the asset lifecycle (identify, plan, design, build, and commission) are grouped together under the category of "new build" for this methodology. This "new build" category captures the project from its initiation, through the subsequent design stages and up to the commissioning of the new asset.

The project stages and the associated high-level activities relevant to the design aspect of a new build are listed below in Figure 6 and these are derived from IGEM/TD/1 Edition 6[7] for the varying levels of route selection, Level 1 to Level 3. The costs applied to these stages are captured in Section 4.1.1.5.

For the project to progress through to the build and commission stage, where the associated materials and construction costs can be applied, it must first be developed through the relevant design stages and stage gates as shown in Figure 6. The stage gates are positioned between the design stages to manage progress, control risk, and ensure quality throughout the project lifecycle. The Engineering Justification Paper (EJP) stage gate is positioned after the initial feasibility and concept design to inform investment decisions and provide justification for the works and proposed designs. The Final Investment Decision (FID) stage gate marks a critical milestone in the progression from front-end planning to full-scale design and build.

The phasing of the costs associated with each of the design stages and stage gates is considered in the model and is used to calculate the front-end planning durations, as well as the detailed design stage, with typical durations for each of the design stages listed below. The durations of projects moving through these design stages can vary considerably depending on the scope and complexity of the works at hand and therefore, within the model, these design stage durations can be edited to specify known, or anticipated, project timescales. As a guideline we have provided below some approximate project durations based on pipeline lengths. These durations are intended solely as

[7] IGEM/TD/1 Edition 6, Communication 1848 – Steel pipelines for high pressure gas transmission

guidance for tool users and should not be interpreted as definitive timelines, as actual project durations can vary significantly depending on numerous influencing factors.

Table 2: Project durations

| Stage | Short length projects (from 2km up to 16.9km length) | Medium length projects (between 17km to 70km in length) | Long length projects (from 70km up to 180km in length) |
|---|---|---|---|
| Concept/feasibility | 2 months | 4 months | 6 months |
| Pre-FEED | 4 months | 8 months | 12 months |
| FEED | 18 months | 24 months | 36 months |
| Detailed design | 6 months | 10 months | 12 months |

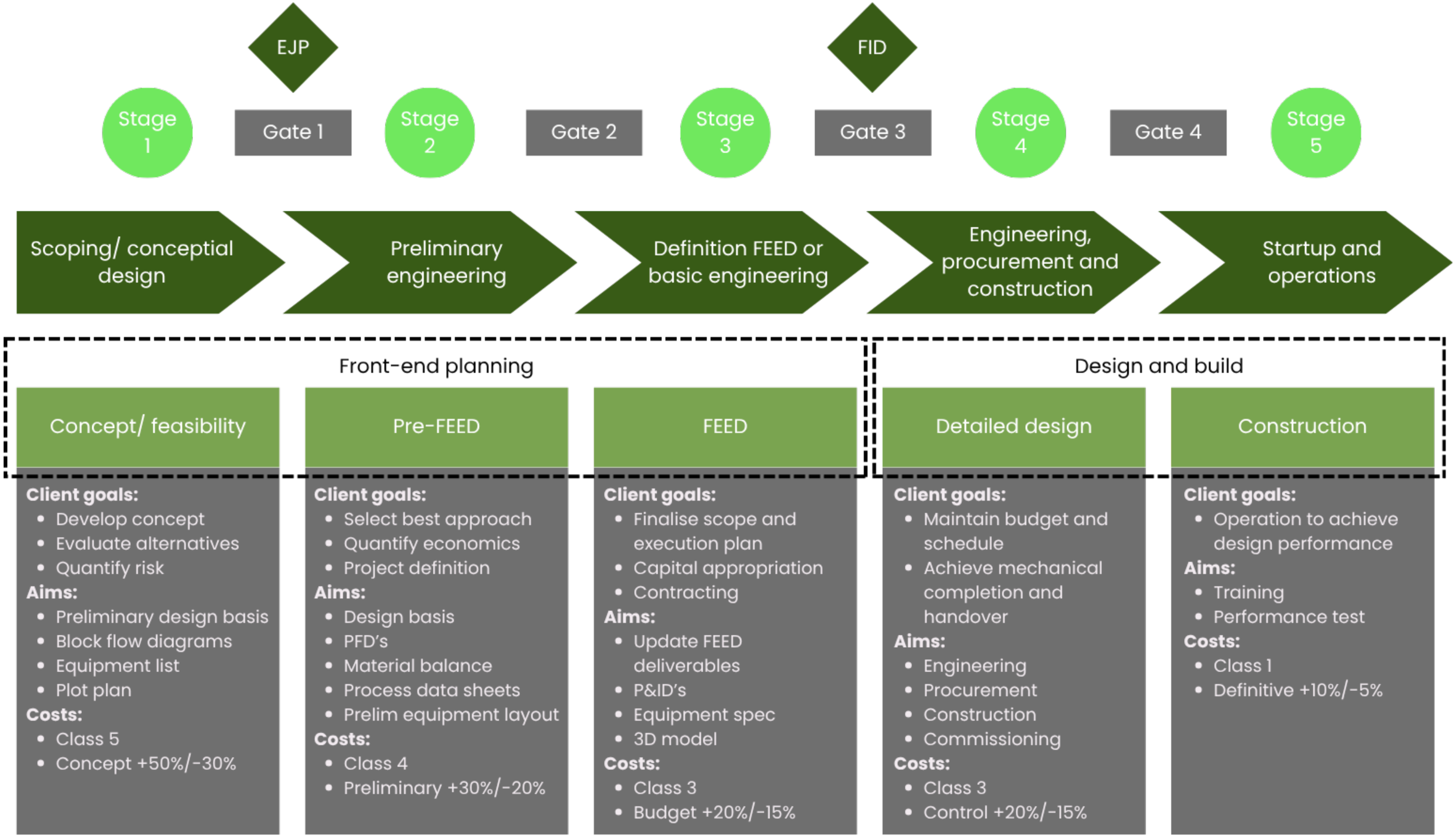



Figure 6: Phasing and stage gates

### 3.2.2 Operate and maintain, modify, and decommission

The remaining lifecycle stages for the relevant asset classes vary more considerably and as such have been discussed in detail in the associated asset class sections in 4.

# 4. Asset Classes



# Asset Classes

**The following sections will outline the methodology, considerations and assumptions applied to each of the three asset classes identified in Figure 1 and the corresponding lifecycle stages as identified in ISO 55001 and discussed in Section 3.**

## 4.1 Transmission Pipeline

The high-pressure transmission pipeline methodology is applicable to both natural gas and hydrogen service and follows the guidance set out in the IGEM/TD/1 Edition 6 and IGEM/TD/1 Edition 6, Supplement 2[8].

### 4.1.1 New Build Pipeline

For a new build pipeline, the fully loaded cost estimate includes the following key components as listed in Figure 7 below. The cost we have developed for the new build is inclusive of the first five stages of the asset lifecycle as described in Section 3.2.1.

[8] IGEM, igem.org.uk/resource/igem-td-1-edition-6-steel-pipelines-for-high-pressure-gas-transmission.html and igem.org.uk/resource/igem-td-1-edition-6-supplement-2-high-pressure-hydrogen-pipelines.html

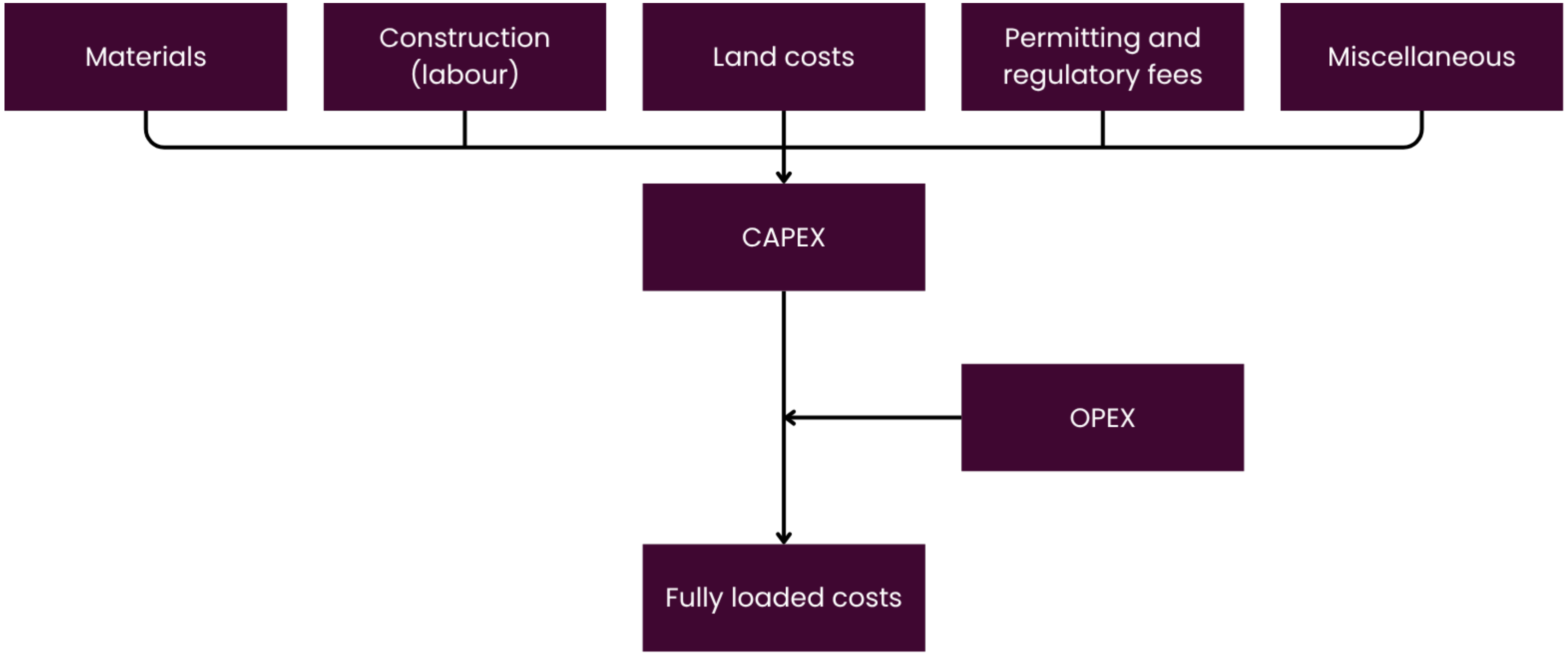



Figure 7: New build pipeline inputs

## Line pipe

- **Supplier:** Leading UK based pipe manufacturer.
- **Source verification:** Data verified through due diligence. Manufacturer operates two pipe mills and supplies prominent clients in the energy industry.
- **Specifications:** 12m pipe sections (sticks) compliant with GIS/DAT6 – standard sizes of carbon and carbon manganese steel pipe for operating pressures greater than 7bar, suitable for both methane and hydrogen (with uplift for sour service).
- **Pricing basis:** Based on 1km orders (minimum 25 sticks/310m), excluding delivery.
- **Extrapolation:** No direct pricing for 1200NB; extrapolated from smaller pipe sizes using a linear correlation ($R^2 = 0.99$).

- **Market trends:** Prices spiked 30–35% post-Ukraine conflict but have since declined. A future increase of no more than 10–15% is expected.
- **Lead time:** ~five months.

## Pipe coatings (internal and external)

- Provided by the pipe manufacturer's coating facility. Costs included in pipe pricing.

## Bends

- **Supplier:** Leading UK based fittings stockist, with multiple warehouses across the UK.
- **Standards:** GIS/DAT 6 compliant.
- **Pricing:** Excludes delivery; subject to steel price fluctuations.
- **Market trends:** ~50% spike post-Ukraine conflict; future increases expected to be <10%.
- **Lead time:** ~six months.

## Cathodic Protection

- **Source:** Jacobs' historical project data, cross-verified for accuracy.

## Assumptions

- Standard wall thickness and Class 600 fittings.
- 45° bends assumed as standard.
- Uplift applied for hydrogen sour service.
- 1200NB (nominal bore) costs extrapolated with high confidence ($R^2$ = 0.99).

Table 3: Materials data sources

| Materials | Data source | Comments |
| --- | --- | --- |
| **Line pipe**<br>**External coating**<br>**Internal coating** | Leading UK pipe manufacturer | The leading UK pipe manufacturer provides pipes to prominent clients in the energy industry and other sectors.<br>The manufacturer operates a dedicated facility that provides both internal and external pipe coatings. The costs for these coatings have been included in the pricing provided.<br>Pricing was supplied for 12-meter pipe sections with wall thickness in accordance with GIS/DAT 6 standards. The pricing covers both methane and hydrogen applications, with hydrogen costs reflecting an uplift due to sour service requirements.<br>Prices are based on a 1 km order, with a minimum order quantity of 25 sticks (equivalent to 310 meters). Delivery to site is not included. Final pricing is subject to fluctuations in steel prices at the time and size of the order.<br>No value for 1200 NB pipe was provided, so this value was extrapolated from the data provided, as there was a clear linear correlation between diameter and price, across the multiple wall thicknesses.<br>The estimated lead time for delivery is approximately five months. |
| **Bends** | Leading UK fittings stockist | A leading UK pipe stockist and manufacturer of fittings for the gas sector, with multiple sites across the UK, provided the bends data.<br>All fittings are compliant with the GIS/DAT6 standard. Delivery to site is not included, and final pricing is subject to fluctuations in steel prices at the time and size of the order.<br>The primary cost driver is the price of steel. Following the onset of the war in Ukraine, there was a significant spike of approximately 50%. However, prices are |

| Materials | Data source | Comments |
| --- | --- | --- |
| | | not expected to rise by more than 10% going forward, barring unforeseen events such as geopolitical conflicts.<br>Values were not provided for 1200 NB bends, so this value has been linearly extrapolated based on the data from the fittings manufacturer. Additionally, costs of bends specifically for hydrogen use were determined by applying the same 6% multiplier that was evident in the pipeline costs supplied by pipe manufacturer.<br>The estimated lead time for delivery is approximately six months. |
| **Cathodic protection** | Jacobs project expertise | The information was derived from cost estimates developed by Jacobs for previous projects, with the estimates validated against the processes discussed in Section 2.4. |

**Key materials notes:**

- The bends will be a standard wall thickness, and any fittings used on the pipeline will be rated to Class 600.
- All bends have been assumed to be 45 degrees as generally they are the most common.
- An uplift has been applied to account for sour service conditions in case the pipeline is used for hydrogen. This represents a worst-case scenario; less stringent specifications may be acceptable depending on the specific requirements of the project.
- It should be noted that no data was obtained from suppliers on 1200NB pipelines, at this stage we were able to extrapolate the cost based on the cost of other pipe sizes and wall thicknesses based on the linear relationship. The $R^2$ value for this extrapolation is 0.99 across all wall thicknesses and for both natural gas and hydrogen, and therefore we can be confident in the accuracy of the result.

### 4.1.1.2 Construction

A baseline estimate for a metre rate cost for installing steel welded gas pipelines was developed using a combination of internal and external rates and pricing books. This estimate considers major cost components such as:

- **Excavation:** Taking into consideration depth, method of excavation, disposal of excavated materials (including bulkage), topsoil and vegetation removal, dewatering and shoring up/battering sides.
- **Remediation:** Remediation of the sites, compaction and seeding of the work areas to ensure they are left in a similar state than prior to works.
- **Site establishment:** Weekly costs associated with the ongoing costs maintaining of a medium sized compound providing onsite facilities such as small offices, power, storage and security.
- **Crossings:** Rates for horizontal directional drilling (HDD) where it is determined trenchless crossings are most suitable.
- **Pipe installation:** Pipe welding costs labour material and plant, in addition to installation of pipelines into position. Testing and commissioning of the pipeline is also included.

The Jacobs quantity surveying team, in collaboration with the construction advisory team and the hydrogen, methane, and carbon team, developed a metre rate for all pipeline sizes within scope (600NB – 1200NB). This metre rate was calculated for two scenarios: easy ground dig, which assumes soft, flat, and accessible terrain, and hard ground, which includes rocks and/or significant elevations.

This was aligned with industry standards such as:

- IGEM/TD/1 Edition 6 – Steel Pipelines for High Pressure Gas Transmission
- National Gas Specification T/SP/P/10 November 2011 – Specification for General Pipelining Designed to Operate at Pressures Greater Than 7 Barg

These standards ensure that minimum depths of cover are achieved, as well as minimum trench widths and construction methodologies used in the gas sector.

The general assumptions used for the estimate were:

- There is a bend every 0.6km.
- There will be 1km of pipe laid per month.
- There will be one utility crossing every 0.8km.

The following trench depths and widths required for the different pipeline diameters are shown in Table 4.

Table 4: Pipeline trench dimensions

| Diameter (NB) | Trench depth (mm)[9] | Trench width (mm)[10] |
|---|---|---|
| 600 | 2110 | 910 |
| 750 | 2262 | 1062 |
| 900 | 2414 | 1514 |
| 1050 | 2567 | 1667 |
| 1200 | 2719 | 1819 |

It should be noted that the 1 km per month construction rate is based on a single front-end setup comprising:

- 1 × excavation gang
- 1 × installation gang
- 1 × welding gang
- 1 × remediation gang

[9] As per P/10 and IGEM TD1 the minimum depth of cover (distance between the lowest ground surface level to the top of the pipe) should be 1.2m and 300mm has been assumed for the bedding material.
[10] As per P/10 standard, for pipes no greater than 900mm diameter, the trench width of the pipe should be the outside diameter of the pipe plus 300mm. For pipe greater than 900mm size, it should be pipe diameter plus 600mm.

For larger projects, contractors may deploy multiple front-end teams operating concurrently, depending on their construction strategy. This approach can significantly increase the monthly installation rate and reduce overall project duration.

The actual duration can only be determined during the pre-construction phase, once the appointed contractor defines their strategy based on the specific characteristics of the project. However, to support NESO's assessment, in Table 5, we have developed potential cost adjustments per kilometre, based on resource intensification aimed at accelerating delivery:

Table 5: Construction cost adjustments per km based on resource intensification

| Construction rate | Cost multiplier | Length (km) | Duration (months) |
|---|---|---|---|
| 1 km/month | 1 | 180 | 180 |
| 2 km/month | 1.8 | 180 | 90 |
| 3 km/month | 2.6 | 180 | 60 |
| 4 km/month | 3.4 | 180 | 45 |
| 5 km/month | 4.2 | 180 | 36 |

The cost multiplier reflects the need for additional gangs for each activity, which constitutes most of the cost and scales almost linearly. Some cost efficiencies may be achieved in preliminaries (such as shared site offices, planning resources, and welfare facilities). However, any further cost savings would depend on the contractor's ability to manage the project effectively and minimise downtime.

## Specific assumptions for the construction cost components:

**Excavation and remediation:**

- Excavation in easy ground assumes soft, level terrain that is readily accessible, allowing for straightforward movement and efficient excavation activities. It also assumes no underground structures, services, or other overly difficult excavations need to take place.

- Excavation in difficult ground assumes hard ground with rocks and small boulders requiring breaking out with heavy machinery, which considerably slows the excavation speed versus easy excavations.
- Seeding allowance is for re-turfing of disturbed areas and includes the spreading and initial watering.
- Topsoil is assumed to be 150mm deep in all easy ground areas.
- Topsoil is assumed to be 50mm maximum in difficult ground areas.
- Topsoil and turf are assumed to be set aside to be reused.
- Spoil from excavation is assumed to be set aside to be re-used with the excess removed to tip off site.
- Vegetation removal allowance is a linear km clearance allowance based on an assumed width of working area of 35m.

**Site establishment:**

- Cost for site establishment inclusive of drop off and collection.

**Crossings:**

- It is assumed that all crossings facilitated by horizontal directional drilling (HDD) do not exceed 100 metres in width.
- Cost estimates are based on a previous assessment provided by a specialist contractor for the M56 project. This estimate considered constraints related to launch and receiver pit setup, crossing width, and potential risks. These figures have been adapted by experts within Jacobs to reflect smaller-scale crossings.
- A small crossing is defined as a two-lane carriageway and/or small streams where HDD is considered the appropriate method.
- A large crossing is defined as a two-lane carriageway with a central reservation and/or crossings up to 100 metres in width.
- The cost difference between small and large crossings is minimal, as the majority of the expense is driven by the setup requirements rather than the crossing length.
- HDD costs include all materials, pipeline connections, and welding.
- Installations are assumed to be completed in a single continuous HDD operation.

**Pipe installation:**

- Four welding tents as per the assumed welding output rate.
- Installation of main run assumes five side booms and a telehandler.

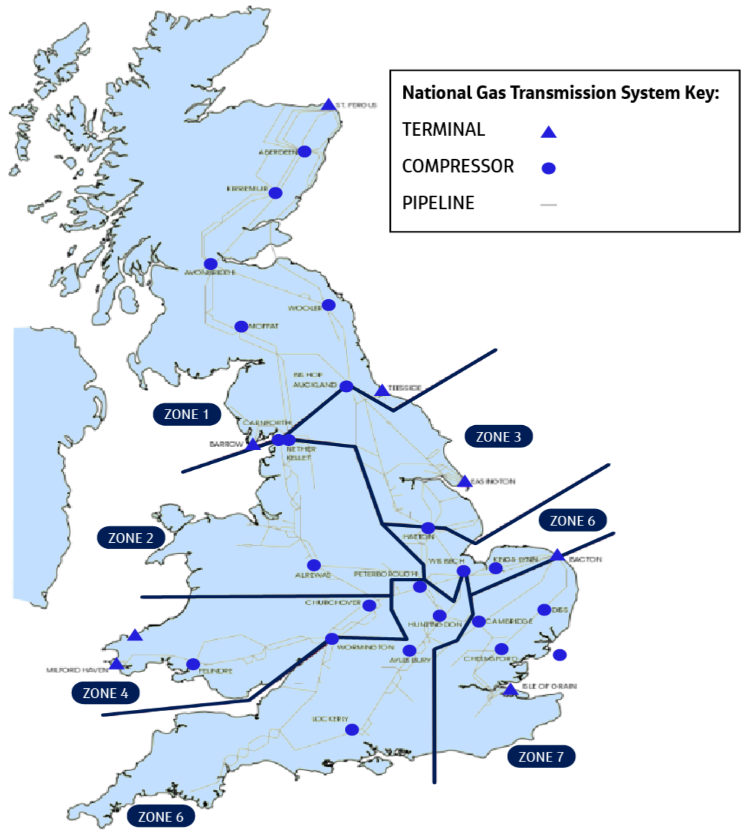
### 4.1.1.3 Land costs

This is calculated from agricultural land values across all regions based on 2024 data from the farmers market update. The regions were matched to the RIIO zones (pictured below) and then averaged across each RIIO zone.

Table 6: Average land costs (£/m) by NTS zone

| Layer | Avg. £/m |
|---|---|
| Zone 1 | 18.25 |
| Zone 2 | 21.22 |
| Zone 3 | 20.95 |
| Zone 4 | 21.87 |
| Zone 5 | 24.15 |
| Zone 6 | 21.64 |
| Zone 7 | 24.00 |

Figure 8: UK National Transmission System (NTS) overview with Zones and key assets



#### 4.1.1.4 Permitting and regulatory fees

Permitting costs have been developed using the following hierarchy of development consent:

1. Development Consent Orders (DCO) – in accordance with the Planning Act 2008
2. Pipe-line construction authorisation (PCA) – in accordance with the Pipe-Lines Act 1962
3. Planning Permission (TCPA) – in accordance with the Town and Country Planning Act 1990

A logic flow has been developed to determine the appropriate route for the provision of development consent, as set out in the flowcharts included below. Each consenting pathway has then been linked to a series of cost components which have been outlined in Table 11 in Appendix A.

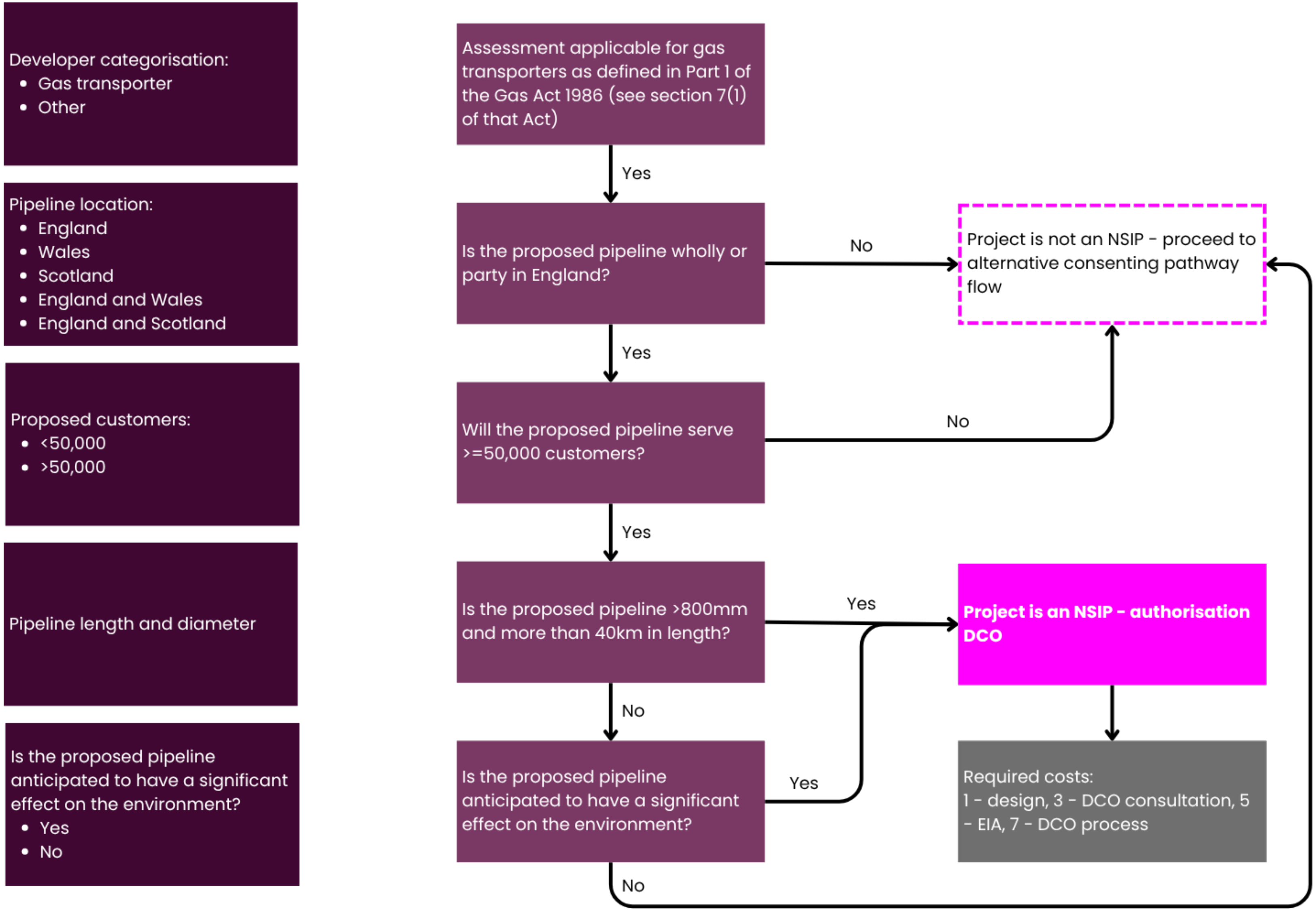



Figure 9: Consenting route options (Planning Act 2008 checks – section 20 test)

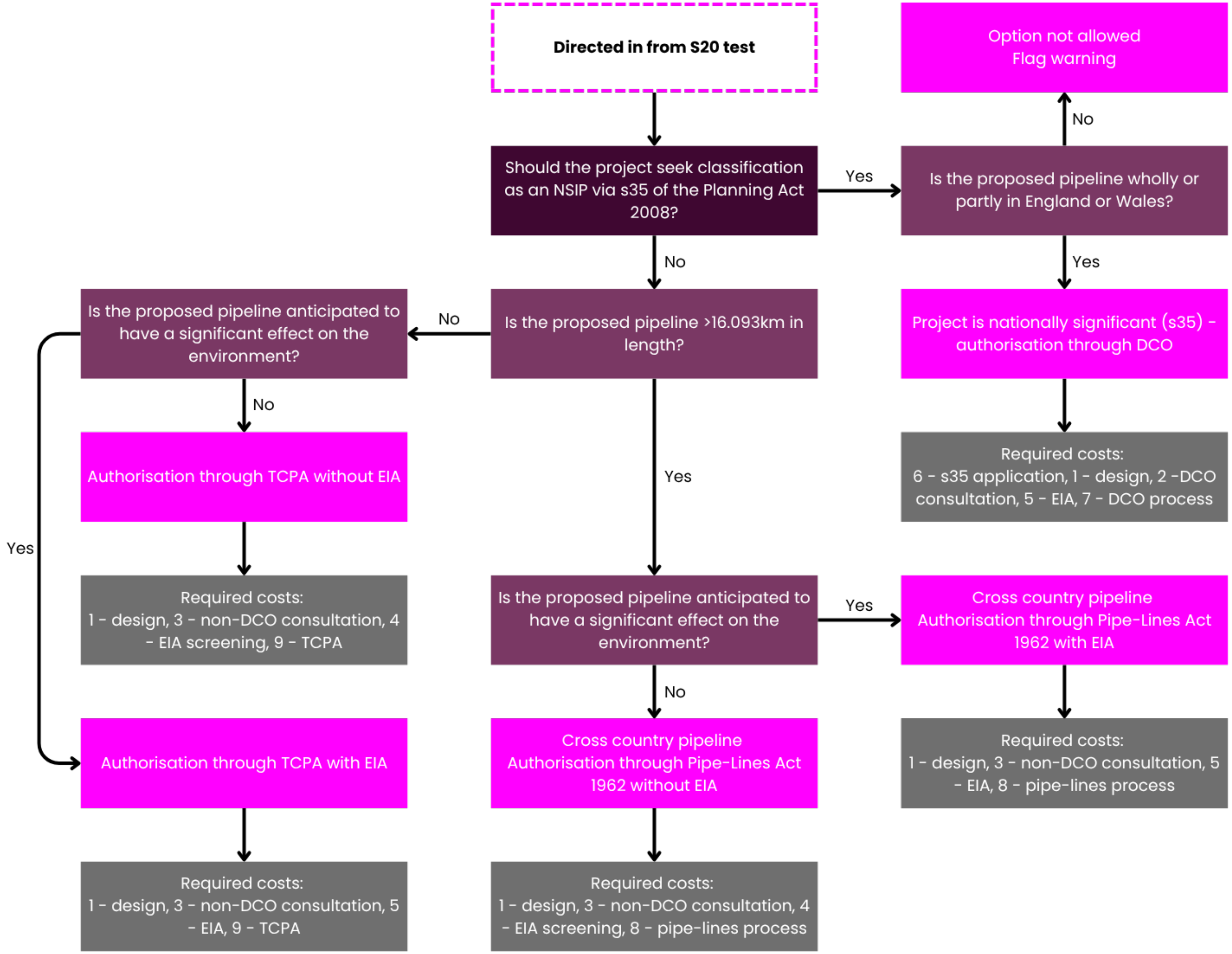



Figure 10: Alternative consenting checks

**Consenting flowchart notes:**

- This decision flowchart excludes the following series of cases that require specific consideration, in which case specialist advice should then be sought:
    - Developments not undertaken by gas transporters.
    - Developments in Northern Ireland.
    - Schemes that are located within renewable energy zones in Scotland.
    - Proposal to divert a project that is consented via a DCO, prior to construction of that project.
- This decision flowchart assumes some consent is required (i.e., cannot be entirely completed under permitted development rights. This is likely to be true for any project with above ground elements.

#### 4.1.1.5 Miscellaneous

The following miscellaneous costs are factored into the overall cost evaluation as percentage-based allowances applied to the cost of construction. Standard rates for high-pressure transmission pipelines are presented below; however, these percentages are adjustable and can be refined by the end user to suit project-specific requirements.

**Traffic management**

Includes temporary traffic control measures, lane closures and diversions and any necessary co-ordination with the council and permitting. This has been given a low percentage of the CAPEX as it is expected that the high-pressure pipeline routes will mostly be routed through rural land and will require trenchless crossing methods to bypass any local infrastructure, watercourses, or railways lines.

**Preliminaries**

Covers initial and ongoing site setup and support requirements, including welfare facilities, temporary accommodation, health and safety controls, and general site management resources. This cost of preliminaries is expected to be 20% of the construction cost due to the complexity associated with site setup and management needs for pipeline projects.

**Overhead and profit (OHP)**

Represents the contractor's corporate overheads and profit margin, typically within the 10-20% range for complex construction projects.

**Project management and design fees**

Encompasses costs related to project management, engineering, and detailed design. This is based on Jacob's experience and typical industry values.

Table 7: Miscellaneous cost percentage

| Category | Percentage of construction cost |
| --- | --- |
| Traffic management | 1% |
| Preliminaries | 20% |
| Overhead and profit | 15% |
| Project management and design fees | 15% |

### 4.1.2 Operation and maintenance

The operational expenditure (OPEX) costs for the asset classes are listed in Table 8 below and these are based on UK gas transmission data and regulatory insight (from Ofgem's RIIO-2 framework[11]) and Jacobs' professional experience of working with gas distribution networks and National Gas.

The percentages highlighted in Table 8 are indicative averages and can vary based on:

- asset age and condition
- hydrogen readiness upgrades
- environmental and regulatory factors
- operational strategy (e.g., risk-based vs time-based maintenance)

[11] Ofgem, ofgem.gov.uk/publications/riio-2-gas-transmission-annual-report-2023-2024

Table 8: Maintenance costs as % of CAPEX

| Asset type | Estimated O&M % of CAPEX (annual) | Notes |
|---|---|---|
| High-pressure pipelines | 1–2% | The OPEX for pipeline infrastructure encompasses a wide range of essential activities that ensure safety, regulatory compliance, and long-term asset integrity. These include:<br>In-line inspections to detect internal defects, typically conducted every 5–15 years depending on the pipeline's risk profile.<br>Aerial and ground patrols to monitor for third-party interference, land movement, and vegetation overgrowth.<br>Defect investigation and remediation, which involves reducing pipeline pressure to 15% to safely excavate and assess anomalies. If a fault is confirmed, a further pressure reduction is required to carry out repairs.<br>Repair and replacement of corroded sections, which can be frequent depending on environmental conditions and pipeline age.<br>Cathodic protection system maintenance, critical for preventing corrosion and extending asset life.<br>Vegetation and tree management to maintain access and visibility, and to prevent root damage.<br>Easement reinstatement following excavations or inspections, ensuring landowner agreements are respected and land is restored.<br>Emergency response preparedness, including regular drills and equipment maintenance.<br>Pressure and flow monitoring, often requiring continuous data collection and system calibration.<br>Compliance audits and documentation, ensuring adherence to the Pipeline Safety Regulations (PSR) and fulfilling regular reporting obligations to Ofgem and the HSE.<br>Direct and indirect costs associated with all of the above, including labour, equipment, logistics, and administrative overhead. |

| Asset type | Estimated O&M % of CAPEX (annual) | Notes |
|---|---|---|
| Pressure reduction stations | 3–5% | Although less costly per intervention than pipelines, PRIs require frequent and intrusive maintenance, contributing significantly to OPEX. Each site is typically visited at least three times per year, with each stream depressurised before inspection—adding time and complexity. These include routine inspections and maintenance, including functional testing of regulators and slam-shut valves, leak detection, and SCADA checks.<br>Preventive tasks such as filter changes, lubrication, sensor calibration, and battery replacement.<br>Corrective maintenance for seals, actuators, and control valves.<br>Major overhauls and asset replacements at end-of-life or for capacity upgrades.<br>Emergency preparedness, including simulation drills and remote isolation checks.<br>Compliance and reporting under IGEM/TD/13, PSSR 2000, and RIIO-GT2/GT3.<br>These activities, while individually lower in cost, are labour-intensive and frequent, driving up overall operational expenditure. |
| Block valve sites | 1–3% | Block valves require regular inspection and functional testing to ensure reliable isolation capability, especially in emergency scenarios.<br>Routine inspections, including visual checks for corrosion, leaks, and chamber integrity.<br>Functional testing of valve operation, slam-shut mechanisms, and remote-control systems.<br>Preventive maintenance, such as lubrication, cleaning, and telemetry system upkeep.<br>Corrective actions like seal replacement, actuator repairs, and corrosion treatment.<br>Asset integrity monitoring, including vibration, acoustic, and cathodic protection checks.<br>Emergency preparedness, with isolation drills and coordination with response teams.<br>Compliance and reporting under IGEM/TD/1, PSSR 2000, and RIIO-GT2/GT3. |
| Compressors | 4-8% | Compressors are complex, high-value assets requiring frequent monitoring, preventive care, and periodic overhauls.<br>Daily operations, including performance monitoring, SCADA checks, and alarm logging. |

| Asset type | Estimated O&M % of CAPEX (annual) | Notes |
| --- | --- | --- |
| | | Preventive maintenance, such as oil and filter changes, vibration analysis, and system lubrication.<br>Inspections using visual checks, thermal imaging, ultrasonic testing, and emissions monitoring.<br>Corrective maintenance for seals, valves, motors, and control systems.<br>Scheduled overhauls, involving full teardown, component replacement, and system recalibration.<br>Asset health monitoring through condition-based analytics and root cause investigations.<br>Environmental and safety compliance, including LDAR, blowdown system checks, and ESD testing.<br>Regulatory documentation under PSSR 2000, IGEM/TD/13, and RIIO-GT3.<br>Due to their mechanical complexity and environmental obligations, compressors carry some of the highest OPEX demands in the network. |

### 4.1.3 Modify/upgrade

The modification and upgrade stage of the asset lifecycle for a transmission pipeline is inclusive of three main areas: pipeline diversions, pipeline uprating and pipeline repurposing. The three categories are defined below and each of the methodologies will be further described in the respective sections:

- **Pipeline diversion:** This is considered to be the re-routing of an existing pipeline to accommodate any conflict in the existing pipeline alignment such as changes in land use, infrastructure development or safety requirements.
- **Pipeline uprating:** This is the process of increasing the pipelines operating pressure to increase pipeline capacity for a number of reasons such as network expansions, growing demand, or change to operational requirements.

- **Pipeline repurposing:** This is the action taken to re-use and/or adapt a pipeline for another purpose, such as the conversion of the pipeline from natural gas to hydrogen or carbon dioxide. It should be noted that for the purposes of calculating repurposing costs, the cost methodology mirrors the approach taken to calculate the cost for uprating.

### 4.1.3.1 Pipeline diversion

The diversion methodology involves full design, procurement and construction to the relevant specifications. The cost estimates for the diversions were developed using a bottom-up methodology structured around four primary components: materials, equipment, construction, and project management and design fees as outlined below. The pipeline diversion methodology mirrors the new-build pipeline methodology and is inclusive of permitting and regulatory fees, land costs and miscellaneous items as discussed in Section 4.1, however the diversions have also accounted for the works and safety requirements to undertake under pressure drilling and isolations, welding, and other such activities.

- **Materials**: Jacobs sourced cost data directly from a broad network of industry suppliers for all required materials and fittings, including new pipe, bypass pipework, bypass valves, weldoflanges, and similar components.
- **Equipment**: This section accounts for the equipment required to facilitate the pipeline isolations and enable the diversion works. These costs were provided by a leading contractor in the field, and covers items such as split-welded tees, line-plugging tools, associated ancillary equipment, and contractor labour. Leveraging the contractor’s expertise ensures a high degree of pricing, accuracy and reliability.
- **Construction**: Construction-related costs were determined across three core activities: excavation and reinstatement, site establishment, and pipe installation. These figures were developed collaboratively between Jacobs' Quantity Surveying and Construction Advisory teams to produce scalable cost models for new pipe installations.
- **Project management and design**: The project management and design costs are based on a percentage of the overall cost for the works, calculated across the materials, equipment, and construction. This provides a scalable cost for the management and design fees that are related to the scale of the project being undertaken.

To maximise the data confidence rating, we engaged directly with industry leading suppliers to source accurate costs for the development of the bottom-up calculation. Any specific influences on the overall cost that were not directly sourced from the suppliers have been listed below.

**Key diversion assumptions:**

- Each diversion involves No. 4 line stopping/plugging tools with all associated fittings.
- Bypass sections between line-plugging tools are assumed to be 12m in length to accommodate temporary works installations and pipe connections.
- All diversion work is to be carried out using open-cut methods.
- Bypass pipework includes an in-line valve and two pressure points (upstream and downstream of the valve).
- Site establishment costs are fixed, based on a 26-week programme duration.
- Diversions are assumed to proceed without pipeline outages.
- A 45° bend will be introduced every 50m of diverted pipeline.
- A £/km rate has been calculated for pipeline diameters ranging from 600NB to 1200NB, incorporating all the above factors.

### 4.1.3.2 Pipeline uprating

Consideration of the uprating of pipelines on the network is required when there is either a need to increase the pipeline's capacity or its operating pressure, mitigating the requirements for a new installation and the associated land and permitting costs. To uprate an existing pipeline, there are several activities that are required first before it is determined that a given pipeline is suitable for uprating. To produce a cost estimate which evaluated uprating pipelines, the National Gas specification, T/SP/TR/7 – transmission system uprating, was reviewed and the relevant activities were priced accordingly to form a bottom-up approach.

The key activities identified were:

- **Design review:** Confirm pipeline is suitable to accommodate increase in capacity or pressure, review the associated TD/1 report, review material specifications, wall thickness and joint types and assess the historical operating procedures.
- **Engineering evaluation:** Stress analysis and structural integrity checks, assessments of welds, fittings, and corrosion protection systems.
- **Pipeline inspection and testing:** Pigging operations, hydrostatic testing to validate integrity, verification of coating condition and cathodic protection effectiveness.
- **Operational readiness and commissioning:** Review and update operational procedures, training, and emergency response planning.

The design review and engineering evaluation are predominantly desktop-based exercises to review the suitability of uprating the pipeline and as such, the costs associated with these works are calculated on hourly rates for engineers evaluating the pipelines' suitability. In addition to reviewing the relevant pipeline documentation, an in-line investigation (ILI) will be conducted by running a PIG through the pipe to detect any pipeline defects or causes for concern. The costs of the pigging run have been included in the overall costs for the pipeline uprating activities, and this has been calculated at a £/km rate.

From previous Jacobs projects and industry experience, it has been calculated that a pipeline defect will be encountered every 2kms, however the severity of each of those identified defects is variable and not every defect will require remediation. As part of the cost estimate for pipeline uprating, we have supplied low and high-value defect remediation cost options, both of which include the welding of a steel sleeve to cover the defect. The selection of the high or low-value remediation costs will thereby influence the frequency of defects requiring remediation, with high-value remediation anticipating a higher frequency of pipeline defects. If significant defects are found along the pipeline that require greater remediation procedures, then it is recommended that the pipeline diversion costing assessment is undertaken, as described in Section 4.1.3.1.

#### 4.1.3.3 Pipeline repurposing

The methodology for calculating repurposing costs follows the same approach as the pipeline uprating discussed in Section 4.1.3.2 due to the requirements for initial desktop-based exercises to determine the feasibility of modifying the existing pipelines and undertaking ILI procedures for material quality checks. To support the transition from natural gas to hydrogen, we have assumed that the frequency rate for defect remediation is high, whereas pipeline uprating is low, which prescribes that any defect found on the pipeline is treated.

### 4.1.4 Decommissioning

The end-of-life considerations for pipeline assets have been developed across two main categories, replacement of the existing pipeline and the full decommissioning of the pipeline, achieved via disposal of the pipe and grout filling. In cases involving long pipeline lengths, typical of transmission pipelines, it is considered impractical to remove the full pipeline from the ground and therefore pipelines left in situ must be treated accordingly to ensure the abandoned pipe does not lead to ground subsidence or environmental impact.

#### 4.1.4.1 Replacement

A cost estimate for pipeline replacement has been developed, which identifies the costs associated with installing a new pipeline within the existing pipelines trench, following the same route alignment, and connecting at the existing tie-in locations. By installing a like-for-like pipeline replacement along the existing alignment, the approach minimises the need for new land acquisition, environmental approvals, and complex permitting – significantly reducing regulatory burdens. The replacement costs are calculated using the same methodology as the new build pipeline, however the land costs and permitting and regulatory fees will be omitted.

The costs for a pipeline replacement are built-up using the following areas:

- Materials
- Construction
- Miscellaneous (See Section 4.1.1.5)

For a more detailed review of the cost build up for replacement pipelines, see Section 4.1.

#### 4.1.4.2 Disposal

For decommissioning of pipelines, we have considered a grout filling solution. Engagement with a specialist decommissioning contractor gave prices on the cost of grout filling which is scalable to a cost per km. Typically, grout filling does not exceed 1500m in length. In our model we have provided a cost for decommissioning per km based upon a 1km stretch of each pipeline size, combined with a base flat rate of enabling works for access to the pipeline to commence the grouting.

Materials priced for the grout filling process include grout, end gaps, foam bags for gapping, and water. Due to the large quantities of water involved, water is typically shipped in 30,000 litre tanks rather than putting pressure on the local water networks.

Next, all the construction costs were determined for two tie-in locations, using the same construction costs method as tie-ins, described in Section 4.1.3.1. These were used as the base rate fixed cost regardless of decommissioning length. It is assumed that the main is already dead and ready for decommissioning in this process. This is a very high-level estimate with a +-50% accuracy rating in accordance with an AACE Class 5 cost estimation.

## 4.2 Above ground installations

The above ground installation (AGI) asset class considers two AGI types in this section, which comprises block valve stations (BVS) and pressure reduction stations (PRS). Due to the significant nature and complexity of gas compression, the compressor station AGIs are discussed in detail in Section 4.3. The definitions of the two AGIs are outlined below:

- **Block valve stations:** Block valve stations are strategically located AGIs that enable the isolation of sections of pipeline for safety, maintenance, or emergency response. They are located typically every 16km to allow operators to shut off flow without disrupting the entire system.
- **Pressure reduction station:** Pressure reduction installations are more complex systems that are designed to reduce and control the pressure of the gas as it moves from higher pressures to lower pressures. A PRS is used for continuous regulation, rather than simple isolations, and is comprised of pressure regulators, control valves, safety relief valves, filters and sometimes include gas pre-heat systems.

## 4.2.1 New build AGI

### 4.2.1.1 Block valve

To determine the block valve costs the process shown in Figure 11 below was followed.

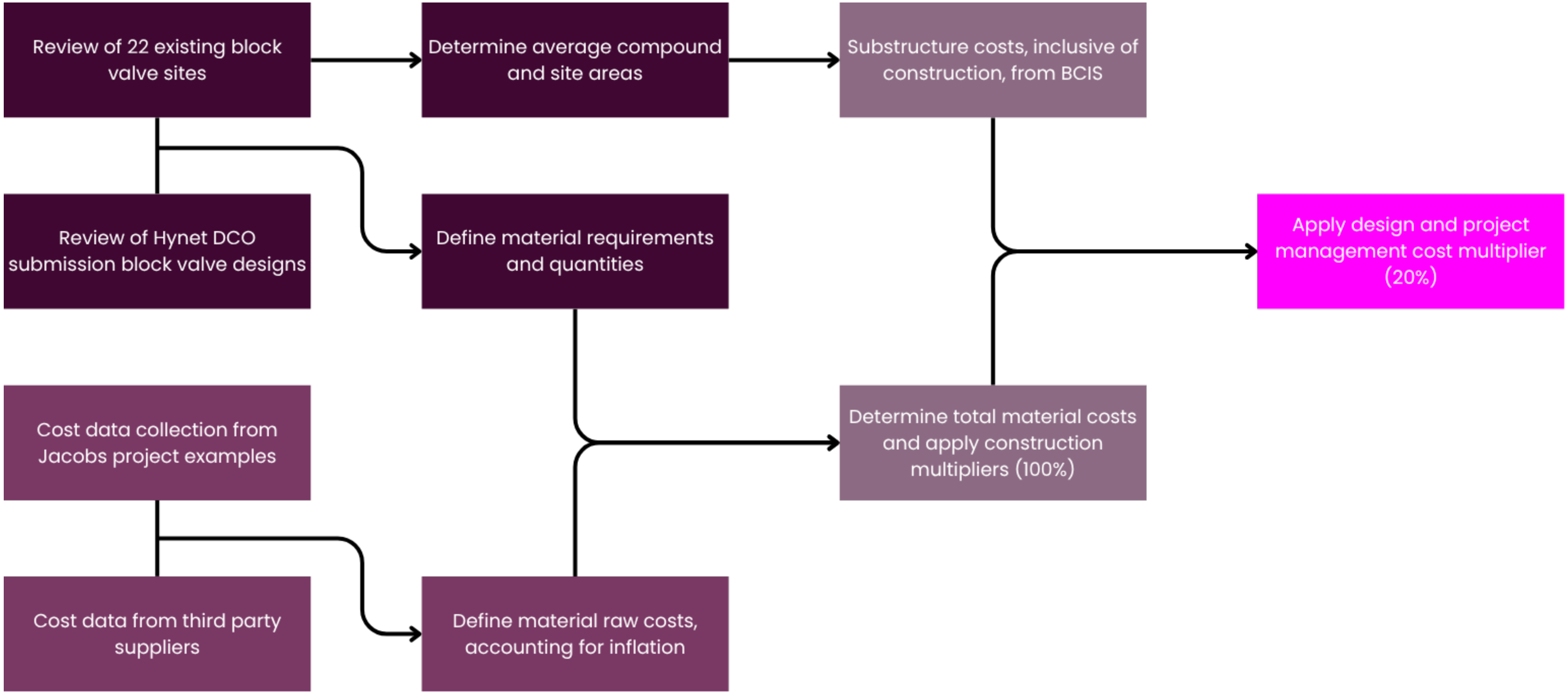



Figure 11: Bottom-up block valve costing methodology

Records of 22 existing block valve sites (one from each National Gas Transmission network area code) were studied to produce an itinerary of block valve components. Based on the sites studied this included: perimeter fencing, compound security fencing, bell-mouth access road, security gates, main line welded isolation valve, bypass pipework valves, small bore vent and purge points, bypass flanges, reducing tees, equal tees.

Block valve stations elevations were studied from publicly available records from the Hynet DCO environmental statement to determine any additional modern requirements for the block valve sites. Based on this the requirements for a GRP kiosk, lighting columns and equipment, and CCTV columns and equipment were added to the itinerary.

Average perimeters and areas for the site compound, and overall groundworks area were determined from the existing 22 block valve site records, with the average compound (area within security fencing) perimeter found to be 95 m and an area of 661 $m^2$. For the wider site works (area within site boundary post and rail fence) the average perimeter is 169 m, and the area at 1597 $m^2$.

Substructure costs for the compounds were based on the BCIS cost average for electrical substations (in lieu of natural gas sites) and the average compound area as determined above. The lowest value from the BCIS data was used to reflect that gas substructures within the compound area are less complex on average, and do not usually fill the entire compound area.

A preference for below ground and welded valves was identified based upon analysis of the existing compounds. £40,000 has been assumed for required stem extensions for a 900NB valve.

Based on construction figures from Jacobs project examples, it has been assumed that total costs are split 40% material, 40% construction, and 20% PM and design. This ratio was applied to the material costs to determine the overall cost.

A 900NB mainline and 200NB branch line has been identified as preferred based on existing National Gas block valve sites. Material costs were determined using data collected from several Jacobs project examples and suppliers within industry. Where an exact match of material was not possible, the closest similar part was used.

Additionally, for project records and vendor price lists that are from previous years, an inflationary rate of 5% per annum was applied to the material cost.

#### 4.2.1.2 Pressure reduction station

The information for the pressure reduction station was obtained through previous Jacobs projects information for a typical pressure reduction station. A typical pressure reduction station costs approximately £10M in total (based on actual costs in a facility in 2023). This includes £4M for materials and £6M for other expenses such as project management, full design and build, and civil and mechanical construction. Of the £6M, around £4M covers civil works, fencing, purging, uninterruptible power supply (UPS), filtration, metering, and pressure reduction.

Based on industry knowledge, a typical pressure reduction station includes the following components:

- Odoriser skid
- Filter skid
- Heating skid
- Pressure reduction skid
- Metering skids
- Electrical cabinet
- Odoriser and RTU control cabinet
- Light poles
- Fencing

The typical compound perimeter is 508 meters with an area of 8,226 square meters. It is assumed that the pig trap will be temporary and is therefore not included in the cost.

### 4.2.2 Operation and maintenance

See Section 4.1.2.

### 4.2.3 AGI repurposing and replacement

The repurposing and replacement of full-site block valve stations and pressure reduction stations have been assessed using a cost methodology consistent with that applied to new-build sites, but with reductions to account for excluded land acquisition and lower regulatory costs. In both cases, the installation of new assets, whether driven by equipment degradation or the need to accommodate hydrogen and $CO_2$ service, entails similar scopes of work. As these projects are assumed to take place within existing land boundaries, the associated AGIs are effectively treated as new installations for construction and costing purposes, while benefiting from cost reductions related to land and permitting.

### 4.2.4 Decommissioning

The decommissioning of AGIs was out of the scope of these works.

## 4.3 Compression

The data collection process for compression stations focused on the construction of new compression facilities, compressor re-wheeling, compressor uprating, and the operation and maintenance of natural gas and hydrogen systems. Typically, compressor stations comprise compressors, liquid separators (including scrubbers and filters) to capture unwanted liquids and particles, gravel access roads, explosion-proof compressor buildings, cooling fans, a control building, and potentially two or three small auxiliary buildings[12]. These costs are generally included in the reporting of compression facility costs, as utilised in this model.

Data from the UK was prioritised first, followed by the EU, the US, and other countries. Data availability from US-based sources was more accessible, whereas data from the UK and EU proved more challenging to obtain. The accessibility of US data is attributed to the extensive size of the US natural gas transmission network, which, as shown in Table 9, is significantly larger than those of the UK and EU.

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[12] JRC, publications.jrc.ec.europa.eu/repository/handle/JRC122592
ACER, acer.europa.eu/gas-factsheet
IPIECA, ipieca.org/resources/energy-efficiency-compendium/compressors-2022

Table 9: Network sizes by location

| Location | Transmission network size (miles) | Compressor stations (compressors) | Metering stations |
|---|---|---|---|
| UK[13] | 5,000 | 21 (<60) | - |
| EU | 124,000 | - | - |
| US[14] | 305,000 | 14,000 | 16,000 |

As illustrated in Table 9, the US has over 14,000 compressor stations, reflecting the scale of its natural gas transmission system, compared to the UK's 21 stations, which comprise over 60 compressors. However, despite having fewer compression stations, the UK stations are equipped with larger compressors, capable of reaching up to 35 MW.

The data for compression systems was sourced from the US national gas transmission regulatory body, the Federal Energy Regulatory Commission (FERC), which oversees the construction, operation, and decommissioning of all interstates natural gas transmission pipelines and associated infrastructure. Historical project cost data, with a detailed breakdown of costs was collected and processed for several projects completed between 2003 and 2020. An excerpt of this data for a new-build compressor station is provided in Table 10 to illustrate the costs considered for these projects.

[13] NGT, nationalgas.com/our-businesses/national-gas-transmission#:~:text=Gas%20is%20critical%20to%20Britain's,transported%20by%20the%20electricity%20grid
Cadent, cadentgas.com/getmedia/7e80b7d6-9530-4c3a-9303-4306b078f4d9/2024_Future-of-the-Gas-Network_vFinal_1.pdf
[14] EIA, eia.gov/naturalgas/archive/analysis_publications/ngpipeline/index.html
EIA, eia.gov/energyexplained/natural-gas/natural-gas-pipelines.php#:~:text=The%20U.S.%20natural%20gas%20pipeline,and%20storage%20facilities%20with%20consumers

Table 10: FERC data breakdown

| **Year** | **Power (MW)** | **Total cost** (US$) | **Right of way** |
|---|---|---|---|
| 2017 | 23.86 | $72,449,514.00 | $746,133.00 |
| **Damages** | **Survey** | **Materials** | **Taxes** |
| - | $ 341,830.00 | $35,039,171.00 | - |
| **Freight** | **Pipe coating** | **Labour** | **Engineering and inspection** |
| - | - | $22,769,886.00 | $5,219,011.00 |
| **Linepack** | **Cathodic protection** | **Other** | **Overheads** |
| $20,720.00 | - | $3,035,486.00 | $509,482.00 |
| **Contingency** | **Legal/regulatory fees** | **Environ. and other services** | **AFUDC** |
| - | - | - | $4,767,795.00 |

The granularity and reliability of the FERC data make it an excellent source of cost information. However, due to the age of some data and its US origin, all data was converted from US dollars for the respective year to British Pound Sterling (GBP) for a common year. The purchasing power parity (PPP) index was used to convert the currency from US$ to GBP for the respective year.

The chemical engineering plant cost index (CEPCI) was employed to convert the costs from GBP for the year of project completion to the common year, 2020. The CEPCI was chosen as it is a more appropriate method of accounting for inflation than other indices, such as the consumer price index. Additionally, the year 2020 was selected because the CEPCI data only extended up to 2022, with the years 2021 and 2022 significantly affected by the COVID-19 pandemic, which would provide an unrealistic representation of construction costs.

It should be noted that using the CEPCI for periods extending beyond five years significantly reduces the reliability of some data points. However, it was determined that the increase in sample size afforded by utilising older data would be more beneficial for data processing.

### 4.3.1 New build

Cost data was gathered and initially processed for the construction of new natural gas compression facilities using FERC, as described above, alongside the power of the compression facility.

As stated previously, the US has far more compression facilities; however, generally, these compression facilities are made up of smaller compressors than those in the UK. The data gathered was used to create an average cost of compression stations per MW of compression station power, using a combination of the US and the UK's compression station sizes as a cost guide to produce small, medium, and large cost estimates. The range used for each was up to 10 MW for small, between 10 MW and 25 MW for medium, and greater than 25 MW for large. The data indicated a reduced cost per MW of compression power when moving up the sizes. Due to the lack of large-scale compressors seen in the US compared with the UK, the large cost category additionally consists of data points where several large compression station projects costs were reported together. The large-scale figure aligns well with the cost estimates from a currency and inflation adjusted estimate for compressor station costs of approximately £1.67M/MW, while the small and medium scaled compressor station cost predictions predict a more expensive cost per MW[15]. It should be noted that the majority of the UK compression stations fall into the large size scale, with a few falling into the medium scale, and the size of the UK's largest compressor stations reach the limit of the data sources utilised.

Historical cost data for hydrogen compression facilities is very challenging to find in the public domain, and as of 2022, there were only 2,800 miles of hydrogen pipelines in operation worldwide, 1,600 miles of which are in the US[16]. Most of these pipelines exist to transport

[15] Yipeng, Z., & Rui, Z. (2014). Pipeline Compressor Station Construction Cost Analysis. Oil, Gas & Coal Technology. Retrieved from: datenpdf.com/queue/pipeline-compressor-station-construction-cost-analysis-pdf_pdf?queue_id=-1

[16] IEA, iea.org/energy-system/low-emission-fuels/hydrogen

US Department of Energy, energy.gov/eere/fuelcells/hydrogen-pipelines hydrogen between production facilities and nearby industrial facilities that utilise hydrogen as a feedstock or for high-temperature heating. As a result of these short distances, hydrogen compressor station data is limited in the public domain.

Generally, hydrogen compressors require minimal modification to standard reciprocating compressors, with the primary modification being the seals to account for the greater diffusivity of small hydrogen molecules compared to other gases[17]. Therefore, the model assumes that hydrogen compression stations cost the same as natural gas compressor stations.

### 4.3.2 Operation and maintenance

Operation and maintenance (O&M) costs are typically unavailable in the public domain; therefore, O&M costs were estimated as a percentage of the CAPEX per year and given as a range of 4-8%. This estimation was derived from the US Department of Energy's (DoE) hydrogen delivery scenario analysis model (HDSAM) and is applicable to both hydrogen and natural gas.

The value of 4% was selected for natural gas as these systems typically use gas turbine or centrifugal compressors, although gas engine reciprocating compressors are also often utilised. Gas turbine and centrifugal compressors generally require less maintenance than reciprocating compressors. This is because centrifugal and turbine compressors compress gas by accelerating it using an impeller, whereas reciprocating compressors compress gas by systematically reducing the volume of the gas in a chamber using pistons. Reciprocating compressors have more moving parts, noise, and vibration than centrifugal alternatives, which increases their O&M costs[18].

An 8% value was used for hydrogen as hydrogen compressors are typically reciprocating compressors and oil free compressors (which often experience more frequent failure of sealant rings because of uneven pressure distribution) are often preferred to maintain high purity of hydrogen[19]. Centrifugal (or turbine) driven compressors are not currently a readily available option for hydrogen compression

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[17] Apt, J., Newcomer, A., Lave, L. B., Douglas, S., & Dunn, L. (n.d.). An Engineering Economic Analysis of Syngas Storage. Retrieved from: researchgate.net/publication/267204724_An_Engineering-Economic_Analysis_of_Syngas_Storage

[18] Genovese, M., Francesco Piraino, A. K., Marcius, D., Pagnotta, L., & Fragiacomo, P. (2025, February). Integration of hydrogen compressors and turbines into current and future hydrogen infrastructure. Journal of Power Sources, 629. Retrieved from: sciencedirect.com/science/article/pii/S0378775324019177

[19] Khan, M. A., Young, C., MacKinnon, C., & Layzell, D. B. (2021). The Techno-Economics of Hydrogen Compression. The Transition Accelerator.

due to hydrogen's low molecular weight, which requires centrifugal compressors to operate at significantly higher impeller velocities (up to three times faster) than those of other gas compressors. This necessitates expensive structural enhancements to the impellers[20].

### 4.3.3 Replacement

Replacement costs have been provided as the cost of constructing new compression stations, excluding land and right-of-way (RoW) costs, consistent with the methodology used in the previous sections.

### 4.3.4 Uprating

Cost data for compressor uprating was gathered from the FERC, focusing on the costs associated with increasing compression power to process these costs into a cost per MW of power uprated. The number of data points used was small, although they covered a relatively wide range of power increases. The small data pool arises from the fact that compressor uprating often occurs in parallel with rewheeling, replacement, and other performance improvements. Consequently, the costs for these activities are rarely reported separately, making it difficult to determine the cost of any individual compressor station improvement or modification.

### 4.3.5 Rewheeling

Similarly, to uprating, cost data for rewheeling was gathered using FERC, with the compression power of the station used to determine the cost per MW of compression station power. The number of data points was small for the same reasons stated for compressor uprating.

### 4.3.5 Decommissioning

The decommissioning of compressors was out of the scope of these works.

[20] Stewart, M. (2019). Reciprocating Compressors - Surface Production Operations Volume IV.

# 5. Findings and Recommendations

## Findings and Recommendations

The development of the gas unit cost library has successfully consolidated a wide range of data, industry experience and previous projects to produce a tool that enables a consistent cost estimation across several different asset classes and asset lifecycle stages. This methodology report has explained the approach undertaken to calculate the cost estimations across these different areas and is supplementary to the costing tool and the costing tool user guide.

**The key findings and recommendations are listed below:**

1. Hydrogen infrastructure data is still limited, particularly for compression assets. Where data was unavailable, assumptions were made and clearly documented. The methodology is designed to be updated as more data becomes available.

2. There is a lack of recent large-scale pipeline projects in the UK and Europe, making it difficult to benchmark certain costs. In these cases, data from the US and historical UK projects were used and adjusted for inflation and currency.

3. For 1200NB pipelines, supplier data was not available. Costs were extrapolated from smaller diameters using a linear regression model, which showed a strong correlation ($R^2 = 0.99$). While this provides confidence, it still introduces some uncertainty.

4. Material and manufacturing costs particularly for steel have been volatile due to global events. The report notes that prices spiked following the Ukraine conflict and recommends that cost data be reviewed regularly to remain current.

5. Each cost estimate is accompanied by a qualitative confidence rating based on data granularity and source reliability. This helps users understand the strength of each estimate and make informed decisions.

6. The gas unit cost library is designed to be flexible. As NESO identifies specific projects through the Gas Options Advice (GOA) process, the model can be tailored to reflect project-specific assumptions and inputs.

# Glossary

# Glossary

| Acronym | Abbreviation |
|---|---|
| AGI | Above ground installation |
| BVS | Block valve station |
| CAPEX | Capital expenditure |
| CBA | Cost-benefit analysis |
| CEPCI | Chemical engineering plant cost index |
| CPIH | Consumer prices index including owner occupiers' housing costs |
| DCO | Development consent order |
| DG | Data granularity |
| DSR | Data source reliability |
| EIA | Environmental impact assessment |
| EJP | Engineering justification paper |
| EU | European Union |
| FEED | Front-end engineering design |
| FERC | Federal Energy Regulatory Commission |

| Acronym | Abbreviation |
|---|---|
| FID | Final Investment Decision |
| GOA | Gas Options Advice |
| GNCNR | Gas Network Capability Needs Report |
| HDD | Horizontal directional drilling |
| HDSAM | Hydrogen delivery scenario analysis model |
| $H_2$ | Hydrogen |
| IGEM | Institution of Gas Engineers and Managers |
| ILI | In-line inspection |
| ISO | International Organization for Standardization |
| MW | Megawatt |
| NB | Nominal bore |
| NESO | National Energy System Operator |
| NG | Natural Gas |
| NGT | National Gas Transmission |
| NTS | National Transmission System |

| Acronym | Abbreviation |
|---|---|
| O&M | Operation and maintenance |
| OECD | Organisation for Economic Co-operation and Development |
| Ofgem | Office of Gas and Electricity Markets |
| OHP | Overhead and profit |
| OPEX | Operational expenditure |
| PCA | Pipeline construction authorisation |
| PM | Project management |
| PPP | Purchasing power parity |
| PRI | Pressure reduction installation |
| PRS | Pressure reduction station |
| PU | Polyurethane |
| RIIO | Revenue = Incentives + Innovation + Outputs |
| RoW | Right of way |
| SPOP | Strategic Planning Options Proposal |
| TCPA | Town and Country Planning Act |
| UK | United Kingdom |
| US | United States |

# Appendix A

# Appendix A

Table 11: Data sources for permit and consent costs

| Class | Type | Unit | Data type | Data source | Additional narrative |
|---|---|---|---|---|---|
| **EIA** | Environmental screening - base cost | £/Project | Estimate | Benchmarked estimate | Consultancy costs benchmarked against actual spend on a pipeline project |
| **EIA** | Environmental screening - scaling cost | £/km | Estimate | Benchmarked estimate | Consultancy costs benchmarked against actual spend on a pipeline project |
| **EIA** | Preliminary environmental information - base cost | £/Project | Estimate | Benchmarked estimate | Consultancy costs benchmarked against actual spend on a pipeline project |
| **EIA** | Preliminary environmental information - scaling cost | £/km | Estimate | Benchmarked estimate | Consultancy costs benchmarked against actual spend on a pipeline project |
| **EIA** | Environmental impact assessment - base cost | £/Project | Estimate | Benchmarked estimate | Consultancy costs benchmarked against actual spend on a pipeline project |

| Class | Type | Unit | Data type | Data source | Additional narrative |
|---|---|---|---|---|---|
| **EIA** | Environmental impact assessment - scaling cost | £/km | Estimate | Benchmarked estimate | Consultancy costs benchmarked against actual spend on a pipeline project. |
| **EIA** | Environmental surveys | £/km | Estimate | Professional judgment Estimate | Estimate based on professional judgment. |
| **Engagement and consultation** | Stakeholder engagement and consultation - DCO - high complexity | £/Project | Estimate | Bottom-up estimate | Engagement - bottom-up estimate based on anticipated rates and requirements using data from recent project.<br>Consultation - consultancy costs benchmarked against actual spend on a pipeline project, delivery costs benchmarked against costs from a non-pipeline linear project. |
| **Engagement and consultation** | Stakeholder payments - DCO - high complexity | £/Project | Estimate | Benchmarked estimate | Bottom-up estimate based on anticipated rates and requirements using data from recent projects. |
| **Engagement and consultation** | Stakeholder engagement and consultation - DCO - low complexity | £/Project | Estimate | Benchmarked estimate | Engagement - bottom-up estimate based on anticipated rates and requirements using data from recent project.<br>Consultation - consultancy costs benchmarked against actual spend on a pipeline project, delivery |

| Class | Type | Unit | Data type | Data source | Additional narrative |
|---|---|---|---|---|---|
| | | | | | costs benchmarked against costs from a non-pipeline linear project. |
| **Engagement and consultation** | Stakeholder payments - DCO - low complexity | £/Project | Estimate | Benchmarked estimate | Bottom-up estimate based on anticipated rates and requirements using data from recent projects. |
| **Engagement and consultation** | Stakeholder consultation - non-DCO - high complexity | £/Project | Estimate | Benchmarked estimate | Engagement - bottom-up estimate based on anticipated rates and requirements using data from recent project.<br>Consultation - consultancy costs benchmarked against actual spend on a pipeline project, delivery costs. |
| **Engagement and consultation** | Stakeholder payments - non-DCO - high complexity | £/Project | Estimate | Benchmarked estimate | Bottom-up estimate based on anticipated rates and requirements using data from recent projects. |
| **Engagement and consultation** | Stakeholder consultation - non-DCO - low complexity | £/Project | Estimate | Benchmarked estimate | Consultancy costs benchmarked against actual spend on a pipeline project.<br>Consultation delivery costs benchmarked against costs from a non-pipeline linear project. |
| **Engagement and consultation** | Stakeholder payments - non-DCO - low complexity | £/Project | Estimate | Benchmarked estimate | Bottom-up estimate based on anticipated rates and requirements using data from recent projects. |

| Class | Type | Unit | Data type | Data source | Additional narrative |
|---|---|---|---|---|---|
| **Planning** | Section 35 application | £/Project | Estimate | Professional judgment Estimate | Estimate based on professional judgment. |
| **Planning** | Legal expenditure - DCO | £/Project | Estimate | Estimate | Estimate based on professional judgment. |
| **Planning** | Legal expenditure - non-DCO | £/Project | Estimate | Estimate | Estimate based on professional judgment. |
| **Planning** | Application development - DCO | £/Project | Estimate | Benchmarked estimate | Consultancy costs benchmarked against actual spend on a pipeline project. |
| **Planning** | Application development - Pipe-lines Act | £/Project | Estimate | Estimate | Consultancy costs scaled against benchmarked DCO application development costs to reflect reduced requirements. |
| **Planning** | Application development - TCPA | £/Project | Estimate | Estimate | Consultancy costs scaled against benchmarked DCO application development costs to reflect reduced requirements. |

| Class | Type | Unit | Data type | Data source | Additional narrative |
|---|---|---|---|---|---|
| **Planning** | DCO application fees | £/Project | Calculated | gov.uk/government/publications/nationally-significant-infrastructure-projects-application-fees | Assumptions made regarding scale of examination (three inspectors). |
| **Planning** | TCPA application fees | £/Project | Calculated | gov.uk/guidance/fees-for-planning-applications | |
| **Planning** | Examination costs | £/Project | Estimate | Benchmarked estimate | Consultancy costs and delivery costs benchmarked against actual spend on a non-pipeline linear project. |
| **Planning** | Public enquiry costs | £/Project | Estimate | Estimate | Consultancy costs scaled against benchmarked DCO Examination costs to reflect reduced requirements. |

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