Electricity Generation Cost Study – Extending the Life of Existing Generation Assets

Department of Energy Security and Net Zero

May 2025

FINAL REPORT

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Contents

ACRONYMS

Acronym	Detail
ACC	Air Cooled Condenser
capex	Capital Expenditure
CCGT	Combined Cycle Gas Turbine
CEPA	Cambridge Economic Policy Associates
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
DESNZ	Department of Energy Security and Net Zero
DUKES	Digest of UK Energy Statistics
EU	European Union
GB	Great Britain
GHD	Gutteridge Haskins & Davey Limited
GT	Gas Turbine
HRSG	Heat Recovery Steam Generators
kW	Kilowatt
kWh	Kilowatt Hour
MW	Megawatt
MWh	Megawatt Hour
OCGT	Open Cycle Gas Turbine
opex	Operational Expenditure
PEACE	Plant Engineering And Cost Estimator
UK	United Kingdom

1. INTRODUCTION

Unabated gas generation will remain an important part of the energy mix in Great Britain (GB) as the electricity system decarbonises. The Department for Energy Security and Net Zero (DESNZ) has appointed CEPA and GHD to assess the cost assumptions for new unabated gas electricity generation projects, as well as the costs of extending the life of existing unabated gas projects in GB.

This report outlines the findings of this analysis on the costs of extending the life of existing unabated gas projects.

1.1. SCOPE OF WORK

This analysis was conducted in two key phases:

- Phase 1: CEPA engaged GHD to provide independent technical expertise and to develop estimates for the cost of extending the life of existing CCGT gas generation and refurbishment options.
- Phase 2: CEPA designed a questionnaire to gather insights from stakeholders involved with the development of unabated gas projects in GB. The questionnaire was distributed to multiple stakeholders and included questions asking about the cost of extending the life of existing unabated gas generation projects. We received five responses to this questionnaire while follow-up interviews were also conducted with four respondents.[1]

The final conclusions of this report are based on findings from both phases.

1.2. REPORT STRUCTURE

The remainder of this report is structured as follows:

- Section 2 sets out the estimates developed as part of Phase 1 for end-of-life refurbishment and repowering costs.
- Section 3 sets out the findings from Phase 2 stakeholder engagement.

[1] One respondent to the questionnaire declined to participate in the interview process.

2. PHASE 1: COST OF END-OF-LIFE REFURBISHMENT

This section sets out the costs of refurbishing and repowering an unabated combined cycle gas turbine (CCGT) power plant in GB, developed by GHD in Phase 1. All costs provided in this report are referenced to 2024 prices.

2.1. PROJECT SPECIFICATION

The costs of refurbishing and repowering a power plant will be influenced by its type (i.e., CCGT vs reciprocating engine) as well as a range of site-specific characteristics. DESNZ requested that the cost of refurbishment and repowering of an unabated CCGT power plant be considered as part of Phase 1.

For this study, a 'H' class gas turbine with a nameplate capacity of 1,700 MW is assumed. This represents the largest and most efficient gas turbine model that is commercially available. The concept is based on two gas turbines, each with heat recovery steam generator (HRSGs) and a single steam turbine generator in a multi-shaft arrangement. The main cooling system is based on air cooled condenser (ACC) technology.

2.2. TECHNICAL APPROACH

The CCGT plant specification was developed by GHD using the commercial thermodynamic software package developed by Thermoflow Inc. The software is well-regarded and widely adopted by consultants and project developers and incorporates a suite of programmes that can model various types of plant to varying levels of detail. The GT Pro and GT Master software packages in particular allow a system based top-down development of a power plant model to be created and are ideal for the design and optimization of gas turbine (GT) based power plants.

The Thermoflow software includes a large technical library of gas turbines for which benchmark performance is provided, based on mathematical thermodynamic models and performance data supplied by Original Equipment Manufacturers (OEMs). The latest version (version 32) of the Thermoflow software, updated in July 2024 was used for this study.

This software was used by GHD to calibrate plant configuration, performance, and performance degradation. GHD utilised the Plant Engineering and Cost Estimator (PEACE) package within Thermoflow to develop cost estimates.

We also provide average annual maintenance costs as a benchmark for the cost of refurbishment and repowering in Section 2.3. For CCGT plants, maintenance outages are focused on the primary equipment items: the gas turbine, HRSG and steam turbine generator. In general, the maintenance regime is driven by the gas turbine with works on the HRSG and steam turbine generator being undertaken coincident with the gas turbine outage.

The gas turbine maintenance regime for a CCGT plant is driven by the accumulated number of operating hours and the number of starts/stops of the unit. The types of maintenance outage typically include:

- Minor inspections - being a short duration inspection of the equipment to confirm the conditions and identify any unexpected issues that may have arisen. A minor inspection is broadly carried out every 8,000[2] hours.
- Hot gas path inspections - being a relatively long duration inspection of the equipment and replacement and/or repair of components in the hot sections of the unit. A hot gas path inspection is broadly carried out every 24,000 hours.[3]

[2] Although 8,000 hours is equivalent to approximately 11 months, the time between maintenance outages depends on the assumed operating hours per year.

[3] 24,000 hours is equivalent to approximately 2.7 years (33 months).

- Major overhauls – being the longest outage duration, involving a full inspection of the equipment and replacement and/or repair of components throughout the unit. A major overhaul inspection is broadly carried out every 48,000 hours.[4]

The average costs associated with the maintenance activities have been derived on the basis of GHD's knowledge and experience in other similar generation projects in the UK.

2.3. Refurbishment and Repowering Options

Table 2.1 summarises the Refurbishment and Repowering Options that are considered in this report.

Table 2.1: Refurbishment & Repowering Options

Refurbishment & Repowering Option	Technology	Scenario	Description
1A	CCGT H Class	Standard maintenance benchmark.	Cost benchmark for typical maintenance of major CCGT equipment items.
1B	CCGT H Class	End of life extension.	Extending the life of the CCGT for 5 years by replacing and refurbishing key component of the major equipment items.
1C	CCGT H Class	Repowering at end of life.	Extending the life of the project site by 10-25 years by replacement of all major equipment items.

Source: Discussions with DESNZ

The scope of these study options was discussed and agreed with DESNZ. The approach and methodology in estimating costs associated with each option are explained in the following sections.

Option 1A: Benchmark

An average annual CCGT maintenance cost was estimated to provide a benchmark for comparison against the refurbishment costs estimates. The benchmark was based on a single CCGT maintenance cycle. The costs are dominated by the maintenance of the gas turbines.

For the gas turbines, this which would include multiple minor inspections and one hot gas path inspection leading up to and including the first major outage. There would not be any significant maintenance expected for the HRSG, and only a minor inspection of the steam turbine during this cycle. Gas turbine manufacturers have different definitions for outages and maintenance regimes, but generally these comprise regular minor inspections including the combustors which might require some replacement of minor combustor parts (combustor liners, fuel nozzles, etc); hot gas path inspections which concentrates mainly on the combustors and the turbine section requiring scheduled repair and/or replacement of parts such as blades and vanes; and major inspections which examine the entire gas turbine including the compressor section and will require further repair/replacement.

An average of all maintenance outage costs (excluding foregone revenues) was calculated from this maintenance cycle.

Option 1B: Life Extension

Estimating costs of extending the life of power plant beyond the original design intent (nominally 25 years) is very difficult. It is dependent on the general condition of the equipment and more complex factors, such as the creep life of high temperature components.

[4] 48,000 hours is equivalent to approximately 5.5 years (66 months).

Prior to making an investment decision, a detailed inspection would be carried out together with an assessment of the operating regime to date and the expected operating requirements going forward to establish the cost of the works required in order to realise the additional life.

In extending the life of a CCGT plant by 5 years, it is reasonable to expect that replacement and refurbishment / repairs works would be required on the gas turbines (e.g. compressor and turbine blade/vane replacement), the HRSG's (e.g. tube replacement and leak repairs), the steam turbine (e.g. blade replacement) and the wider balance of plant equipment (e.g. pump replacement).

GHD have estimated the cost of life extension on the basis of quotations from within the previous 5 years for refurbishment of other CCGT power plants and accordingly adjusted the costs to account for differences in technology, equipment configuration and power capacity, in comparison with Option 1A, and escalated the price to 2024 values.

Option 1C: Repowering

In extending the life of power plant by 10-25 years, beyond the original design intent, it has been assumed that all 'above ground' equipment would be dismantled, removed from site (having reached the end of the economic life) and replaced with new.

For the purposes of this study, it is reasonable to assume that the civil works (i.e. the foundations) would have an expected life of 50 years, although in reality, there would need to be extensive surveys of the civil works at the time of refurbishment to establish remnant life and whether the existing works are suitable for reuse.

For continued use of the existing civil works, it would be necessary to implement a like-for-like replacement of CCGT power plant equipment. Foundations are basically designed according to static and dynamic loading that would be imposed. Hence, it would not be feasible to remove a gas turbine (or any other major equipment item) of a particular type/size and replace it with a significantly larger unit, for example.

As such, this option is potentially prohibitive in that the equipment available on the market today may be replaced by more advanced machines by the time repowering is undertaken. There is also the potential for other regulatory influences that may prohibit this approach, but this is beyond the scope of this study.

2.4. Refurbishment Cost Summary

GHD have estimated costs for each of the refurbishment options and these are summarised in Table 2.2 below.

Table 2.2: Refurbishment Cost Summary

Option	Scenario	Summary of Works	Estimated Cost (2024 values)	
			£m	£/kW
1A	Standard maintenance benchmark.	Typical through life maintenance of major CCGT equipment items.	50	31
1B	End of life extension for 5 years.	Replacement and refurbishment of key components of the major equipment items and balance of plant.	140	81
1C	Repowering at end of life. For a further 10-25 years' service.	Replacement of all major equipment items and balance of plant.	930	545

Source: GHD analysis

3. PHASE 2: STAKEHOLDER ENGAGEMENT

This section sets out Phase 2 of our study where we engaged with stakeholders involved with the development of unabated gas projects in GB. The purpose of this Phase was to supplement and build on the bottom-up analysis developed as part of Phase 1.

This phase of work was delivered through two core parts:

- **Stakeholder questionnaire**: We created a questionnaire to collect stakeholder insights on the cost of developing new unabated gas projects in GB and the costs associated with extending the lifespan of existing units. Respondents were asked to provide cost information on real-world projects which they were directly involved across various stages, including the planning, developing, operating, or refurbishing of gas generation projects. Respondents were asked to provide separate responses for CCGT, OCGT, CHP, and reciprocating engine projects.
- **Follow-up interviews**: We held a series of follow-up interviews with those stakeholders that responded to our questionnaire. The purpose of these interviews was to clarify, verify, and challenge the responses where necessary, particularly in cases where reported costs differed from the estimates developed in Phase 1 by GHD.

This questionnaire was distributed to 25 organisations in February 2025 to which five responses were received. None provided information on the cost of extending the lifespan of existing gas generation units.

Follow-up interviews were however also held with four organisations that provided a response. These interviews also provided limited information on the costs of extending the life of existing generation. Some respondents noted that the cost of extension depends on factors such as the asset's condition and the length of the extension (e.g., a 2-year vs. a 5-year extension). One respondent estimated that extending the life of a CCGT plant could cost between £90 million and £150 million, but provided little context on what these investments would specifically deliver.

Phase 2 provided insufficient evidence to assess or challenge the cost estimates developed by GHD in Phase 1. While stakeholders provided more information on the costs of developing new unabated gas projects in GB, these responses fall outside the scope of this report.

Box 1: Confidentiality

All questionnaire responses and follow-up interviews were conducted on a confidential basis. The information gathered through this process was not directly shared with DESNZ or with any other stakeholder. The following commentary therefore does not make reference to any specific project or provide information that would allow a reader to identify which organisations have participated in this process.

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