UK Government

# RAF123/2122:

# Review of the Combined Heat and Power Quality Assurance Programme

Department for Energy Security and Net Zero (2026)

**Acknowledgements**

The Department for Energy Security and Net Zero and Ricardo Energy & Environment would like to thank all those who contributed to the project by completing the survey of CHPQA participating organisations or agreeing to be interviewed.

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# Main findings

**Evidence from this research suggests that the Combined Heat and Power Quality Assurance (CHPQA) Programme has delivered substantial benefits to society**[1]. This was achieved by encouraging efficient combined heat and power (CHP) Schemes that reduce fuel use and emissions compared with separate heat and power generation from the same fuel.

Using data on CHPQA operations, in 2019, CHPQA-supported Schemes delivered around £1.1 billion (2021 prices) of net social benefits, mainly through fuel savings, as well as from a small reduction in carbon emissions which is primarily driven by biomass CHP generation. The impact on air quality from CHPQA generation was slightly negative[2]. Large industrial CHP Schemes account for a significant share of these benefits.

**CHPQA has played an important role in encouraging investment in CHP.** Many CHP Schemes would not have been built, or would have been smaller or less efficient, without the incentives linked to CHPQA. This means the Programme has helped promote more efficient energy infrastructure and generation than would have otherwise existed.

**Ongoing operation of existing CHP Schemes continues to deliver net social benefits.** Even after Schemes are built, CHPQA certification continues to encourage efficient CHP operations, although this impact is limited to a small number of sites, typically within industrial sectors. In 2019, continued participation in CHPQA is estimated to have delivered £0.4 billion (2021 prices) of net social benefits by supporting efficient day-to-day operation.

**The value of benefits from unabated fossil-fuel CHP is expected to fall over time**: As the electricity grid becomes lower carbon, electricity generated from new unabated gas CHP Schemes will displace more lower-carbon electricity than in the past. While CHP can still be efficient, carbon emissions related to CHPQA generation will increase compared to equivalent heat from gas boilers and electricity from the national grid, as an alternative energy source.

**CHP can still play a useful role in the future energy system.** CHP remains important for sites that need reliable, efficient on-site heat and power, particularly in industry. Many operators see CHP as part of a transition towards net zero to then consider low carbon options such as hydrogen, biomethane, carbon capture usage and storage, and electrification technologies. These technologies can also be integrated with CHP operations.

**Results should be interpreted with appropriate caution** as findings are based on survey responses from a small sample of CHP operators. The analysis applied for this report is based on a single year providing illustrative findings and is not a full evaluation of the Programme.

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[1] The net social benefits value the impact on society associated with changes in fuel consumption, carbon emissions and air quality resulting from the CHPQA Programme.

[2] Results were established by comparing CHPQA operations to alternative energy sources from a sample of surveys completed by CHPQA operators. These alternatives were framed as energy sources that these organisations would have used in a hypothetical scenario where the CHPQA Programme did not exist, to therefore understand the extent to which the Programme has impacted their energy consumption.

# Executive Summary

The Department for Energy Security and Net Zero is responsible for ensuring the UK has a secure and reliable supply of energy that protects bill payers whilst supporting commitments to achieve Net Zero emissions by 2050. Operating Combined Heat and Power (CHP) plants can support these aims by offering the efficient cogeneration of heat and power, produced on the same site as where it is consumed. This promotes low cost, flexible energy generation. CHP technologies also have the capability to run on low carbon fuels such as biofuels and low carbon hydrogen.

The Combined Heat and Power Quality Assurance (CHPQA) Programme is a voluntary Programme that has been running since 2001 and is administered by, or on behalf of, the Department for Energy Security and Net Zero. The CHPQA Programme provides a method for assessing the efficiency of all types and sizes of CHP Schemes in the UK, with successful CHPQA certification granting eligibility to a range of financial benefits.

A CHP essentially comprises an electricity generating plant combined with equipment for recovering and using the heat produced by the CHP, providing the cogeneration of heat and power. CHP can operate on renewable fuels and fossil fuels, and the CHPQA Programme covers a wide range of sectors from education to paper mills and vary in size from several kilowatts up over 1000 megawatts in capacity.

Since 2001, the policy context and energy systems in the UK have changed significantly. Nevertheless, the CHPQA Programme has continued to incentivise efficient operations of CHP by granting eligibility to receive financial benefits to CHP Schemes producing primary energy savings relative to the separate generation of power and heat.

Financial benefits available to CHP Schemes that meet the CHPQA efficiency criteria, or 'Good Quality' CHP, principally include Climate Change Levy (CCL) and Carbon Price Support (CPS) relief for fossil fuel Schemes. Eligible renewable schemes can receive uplifted Renewables Obligation Certificates (ROCs) and Non-domestic Renewable Heat Incentive (NDRHI) payments. ROCs and NDRHI are considered 'grandfathered' financial benefits as they are now closed to new applicants but continue to provide benefits to existing eligible recipients. Financial benefits such as CCL and CPS relief, fuel duty and preferential Business Rates are considered 'non-grandfathered' financial benefits as they remain available to new CHP Schemes[3]. For the financial year 2023/24, CCL relief on fuel inputs and CPS relief for 'Good Quality' CHP are estimated to total £370 million[4] which are believed to account for a large majority of the financial support offered via CHPQA eligibility. On 16 April 2026, the Government announced CPS will be removed from April 2028, so the associated CPS reliefs

[3] Non-grandfathered financial benefits include Carbon Price Support relief, Climate Change Levy, and preferential Business Rates.

[4] CCL relief on fuel inputs and CPS relief are estimated to account for a large majority of the financial benefits associated with CHPQA. Estimates do not account for overlaps with related exemptions, such as CCL exemption for electrical generators over 2MWe in capacity and oil refineries (https://www.gov.uk/government/statistics/main-tax-expenditures-and-structural-reliefs)

will be available up until this point. This does not impact the research or outcomes of this review which assess the social benefits of CHPQA certification in 2019.

Beyond the cost saving benefits to those operating CHP Schemes, the on-site generation and efficiency gains available from CHP also produce benefits and costs to wider society. These include carbon emission savings, energy supply savings as measured by the long-run variable cost, air quality damage costs, security of energy supply and contributions to the resilience of the national grid.

This study reviewed the social benefits associated with the CHPQA Programme, feedback on the administration of the Programme and solicited information on the low-carbon energy options being considered by CHPQA participants to decarbonise and meet Net Zero targets.

Due to the diversity of CHP applications, the variety of financing and management mechanisms available to CHP projects and the variety of financial benefits available to CHPQA certified schemes, a fully comprehensive review of the CHPQA was not possible. Limitations with the methodology and number of responses for this study also means caution should be applied when interpreting results which provide illustrative evidence on the social benefits associated with the Programme, based on 2019 data.

Tax policy is administered by HM Treasury and HM Revenue and Customs (HMRC), therefore, this study focuses on the impact from delivering the CHPQA Programme, which is managed by DESNZ, as a mechanism in which CHP operators can gain certification for financial support. In addition, tax relief and subsidy payments are economic transfers based on the Green Book guidance, where spending power is transferred from one party to another and therefore does not make society as a whole better or worse off. As a result, these transfers are not in scope of the social benefits analysis of the Programme[5].

As designated CHPQA contacts, a selection of appropriate Responsible Persons (RPs), representing the range of CHP archetypes, covering different technologies, applications and financing mechanisms, were surveyed and interviewed by a team of consultants to gather evidence of their organisation's investment and operational decisions. This included investigating how and the extent to which the CHPQA Programme may have affected these decisions. The aim here was to assess the additional net social benefits derived from the Programme. The net social benefits estimate the key benefits and costs that affect the welfare and wellbeing of the UK population, such as environmental and health effects, as referenced in the government's Green Book for appraisal guidance[6]. The analysis in this report aligns with the Green Book's supplementary guidance for appraising energy use and emissions[7].

In the context of this study, the net social benefits assessed include carbon emissions, energy supply costs and air quality impacts. Social benefits associated with security of energy supply

[5] See Green Book Chapter 6: https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government#introduction
[6] Ibid. (Chapter 2)
[7] See Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal: https://assets.publishing.service.gov.uk/media/65aadd020ff90c000f955f17/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal.pdf

and grid resilience were not addressed in this study due to complexities with estimating the monetary value of these impacts. To help understand the additionality of net social benefits associated with the CHPQA Programme, two counterfactuals were used[8]:

1. The investment counterfactual investigated what organisations would have done to meet their energy demand in the absence of the CHPQA Programme at the time of the CHP investment referenced in the study.
2. The operational counterfactual investigated what organisations, having already installed their CHP, would have done to meet their day-to-day site energy demands in the absence of CHPQA eligibility for non-grandfathered financial benefits, including fuel duty, CCL and CPS relief, as well as preferential business rates. The focus on non-grandfathered benefits was selected because this support remains available to new CHP installation and the eligibility criteria can be adapted via policy changes, whereas eligibility for grandfathered Schemes is tied into contracts under the Non-domestic Renewable Heat Incentive (NDRHI) or Renewables Obligation, both of which are now closed to new Schemes[9].

These two counterfactuals were then applied using 2019 data to produce four analytical scenarios:

1. The investment scenario applied the investment counterfactual to consider the extent to which the CHPQA Programme impacted historical investment decisions for **all** types of Schemes and the subsequent net social benefits these Schemes produced in 2019.
2. The operational scenario applied the operational counterfactual to consider the extent to which CHPQA eligibility for non-grandfathered financial benefits was additional to operational decisions, in order to estimate the social value associated with this additionality for around 1,200 incumbent Schemes in 2019.
3. The new schemes scenario applied the investment counterfactual for around 100 Schemes new to CHPQA in 2019 and considered the net social benefits generated over their lifetime as the alternative energy counterfactuals also evolve. This estimates the annualised social value these new Schemes deliver assuming the CHPQA Programme is unchanged.
4. The combined scenario sums the net social benefits from the operational scenario (in 2) and the new Scheme scenario (in 3) as an illustration of the social value forgone if the CHPQA Programme were to cease in 2019. Given incumbent Schemes are installed and running, the social benefits forgone would be those from changes in operations. In addition, there would be social benefits forgone from new Schemes who would not have otherwise pursued their CHP investment without the Programme, which is captured in the 'new Schemes' scenario. In sum, the operational scenario and

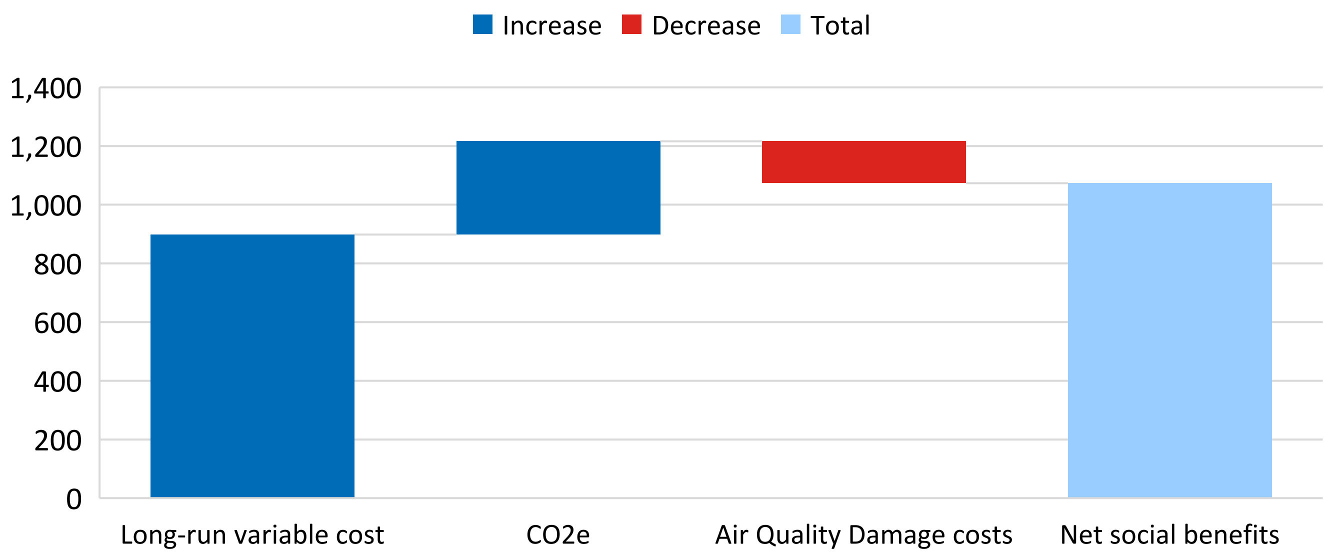
[8] Assessing additionality establishes the extent to which a policy can been considered to have added value compared to a baseline. In this case, identifying how CHPQA resulted in changes to energy consumption compare to energy consumption in the absence of the CHPQA Programme and the associated net social benefits.
[9] The Renewables Obligation closed to most new Schemes (CHP generators) in March 2017 (and to all in September 2018) and the NDRHI closed in March 2021.

'new Schemes' scenario estimates the social value added by the CHPQA Programme in 2019.

The evidence collected through the survey and interviews, coupled with the available CHPQA performance data, was reviewed and analysed, leading to the following findings.

Firstly, this illustrative evidence suggests that the CHPQA Programme delivered significant social value in 2019. For the investment scenario, the evidence and analysis suggest that the CHPQA Programme generated around £1,070 million (2021 prices) of net social benefits in 2019. Energy supply savings, as measured by the long-run variable cost, accounted for £900 million of the net social benefits, with 1.3 mega-tonnes of CO2e savings (MtCO2e)[10] amounting to £320 million of benefits. There is an increase in air quality damage costs, negatively impacting the benefits by £140 million[11] due to greater local fuel combustion compared to the counterfactual (see **Figure 1**). A large majority of the net social benefits were from energy supply savings for CHP classed as combined cycle gas turbines (CCGT), which are typically large industrial Schemes which represent the majority of CHP capacity in the UK. There is a **notable degree of uncertainty around these results,** which are derived from the application of survey answers from a small sample of CHPQA operators and extrapolation of this to the total population of Schemes.

**Figure 1: Net social benefits under the investment scenario in 2019 (£m, 2021 prices)**

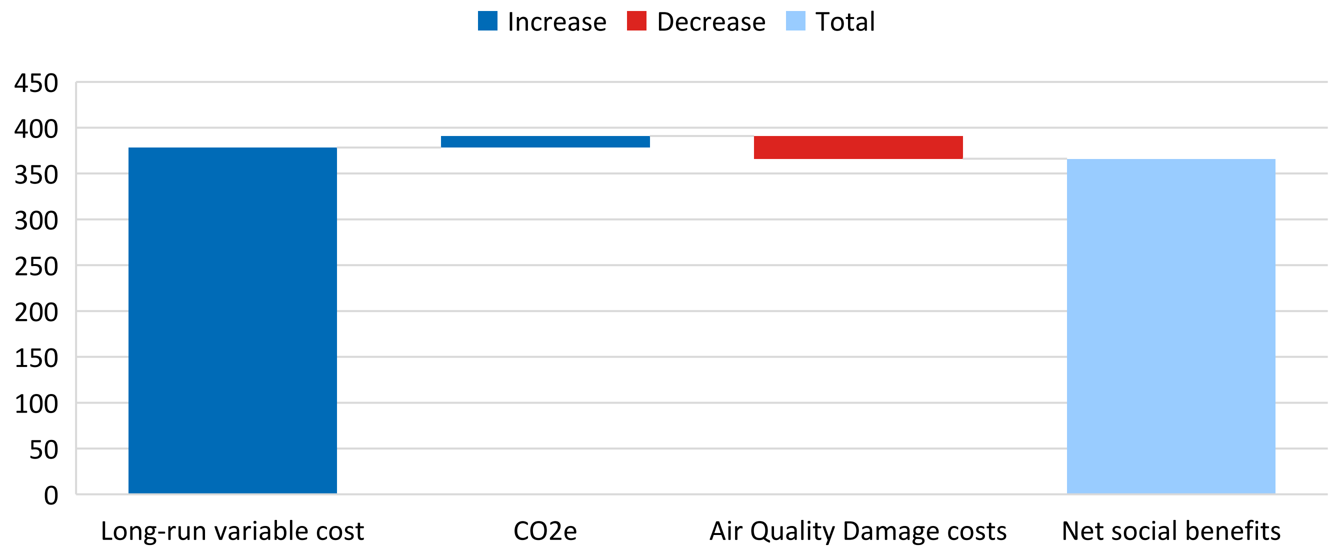



Secondly, CHPQA eligibility for non-grandfathered Schemes produced social value through the operations of incumbent Schemes in 2019[12]. The evidence and analysis suggest the operational scenario generated £370 million (2021 prices) of net social benefits in 2019. Energy supply savings accounted for £380 million of the net social benefits, with 0.2 MtCO2e savings amounting to £10 million, and air quality damage costs negatively impact the benefits by £20 million. Again, the reduction in energy supply costs from combined cycle gas turbine

[10] Carbon savings refer to carbon dioxide equivalent ($CO_2e$) which describes different greenhouse gases in a common unit signifying the amount of $CO_2$ which would have the equivalent global warming impact.
[11] Totals might not add up exactly due to rounding.
[12] Does not include schemes which enrolled onto CHPQA in 2019.

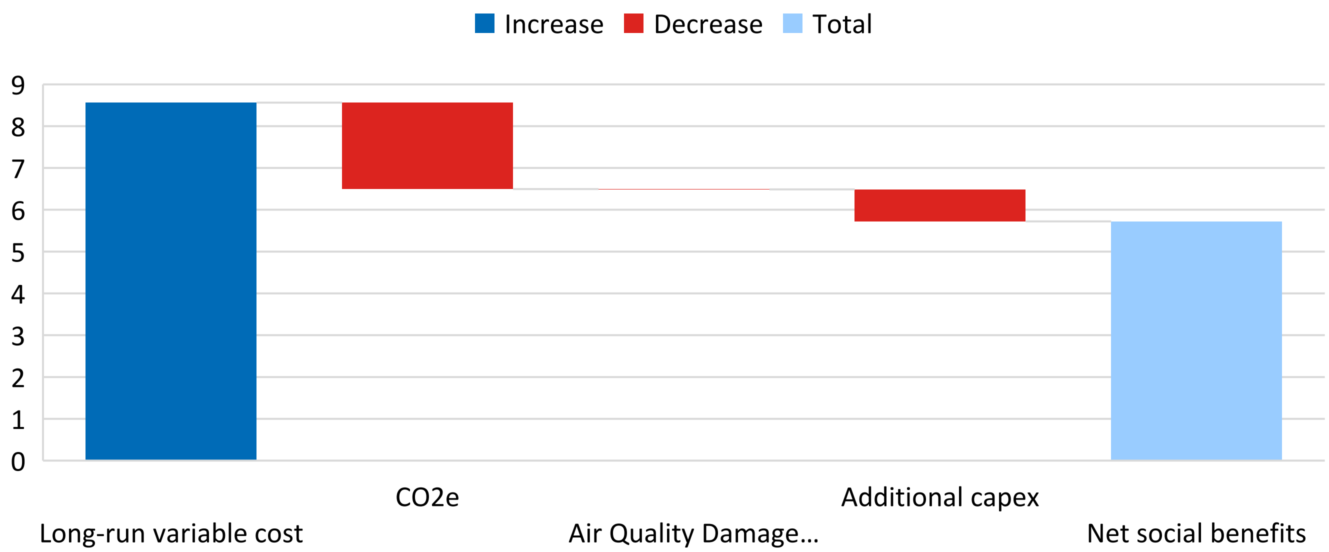
(CCGT) CHP accounted for a large majority of the net social benefits in this scenario at around £330 million (90%). Carbon savings were much lower compared to the investment scenario as biomass and EfW CHP were not included as these Schemes are not relevant for non-grandfathered financial benefits unless they consume some fossil fuel. Again, results carry a high degree of uncertainty as they were derived from a small sample of CHP operators.

**Figure 2: Net social benefits under the operational scenario in 2019 (£m, 2021 prices)**




Thirdly, if the CHPQA Programme were to continue with its current eligibility criteria, the Programme is likely to produce lower levels of social value in the future. The evidence and analysis suggest that the c.100 new Schemes installed in 2019 would generate around £6 million (2021 prices) of net social benefits when annualised (see Figure 3). As the CHPQA programme may have incentivised organisations to invest the CapEx for new CHP, and these CHP are likely to run for many years, an annualised estimate is presented to assess the components of the net social benefits over the lifetime of the asset. For this analysis the asset lifetime is assumed to be 20 years. This scenario for estimating the net social benefits of *new* CHP installations in 2019 is referred to as the 'new Schemes' scenario in this study. This 'new Schemes' scenario produced an annualised net social benefit of £7 per MWh of fuel consumed compared to the investment scenario of £9 net social benefits per MWh. The lower, annualised net social benefits in the 'new Schemes' scenario is primarily driven by the anticipated decarbonisation of the electricity grid over this 20-year period and the consequent increase in carbon emissions savings from natural gas fired CHP Schemes compared to alternative energy source.

**Figure 3: Net social benefits under the 'new Schemes' scenario in 2019 (£m, 2021 prices)**




**Overall, whilst not being a full evaluation, our illustrative evidence suggests that the CHPQA Programme has delivered significant net social benefits in 2019** and will certainly have done so prior to 2019. However, net social value is likely to decrease in the future as alternative options for energy supply decarbonise.

The CHPQA Programme is viewed positively by participants in terms of its effectiveness at driving improvements in CHP energy efficiency. Ninety-five per cent of Responsible Person (RP) survey respondents reported that their organisation believes that the CHPQA Programme and its services are valuable to them in the near future (e.g. in the next few years), and 90% of RP respondents agreed that the CHPQA Programme could be used for implementing new policies to achieve greater energy efficiencies. Many operators are already exploring their options for decarbonisation including CHP fired with alternative fuels such as natural gas/hydrogen blends and biomethane, the use of carbon capture, and alternatives to CHP such as heat pumps and electric boilers alongside electricity from the grid.

The work presented in this report shows that the financial benefits received by Schemes participating in CHPQA significantly exceeded the additional costs to businesses for activities associated with participation for the Programme. Analysis shows that, overall, comparing the annual cost incurred by Schemes in participating in CHPQA accounts for just 4% of the financial benefits received from CCL fuel input and CPS relief account.

# Glossary

| Term | Definition |
|---|---|
| Additionality | A real increase in social value that would not have occurred in the absence of the intervention that is being appraised. |
| Air Quality Damage (AQD) | The health impact costs on society relating to airborne emissions of pollutants. |
| Calorific value (CV) of a fuel | The energy density of a fuel, which is typically on a mass basis when the fuel is a solid/liquid and on a volume basis when gaseous. |
| Carbon Price Support (CPS) | A tax (CPS rates of CCL) on fossil fuels used to generate electricity implemented under the Climate Change Levy (CCL) taxation regime but separate from the Main Rates of CCL. Specifically for CHP Schemes, CPS is a tax on fossil fuels used to generate electricity not qualifying as Good Quality or any electricity exported via the grid. There are CPS rates of CCL (on gas, coal and liquid petroleum gas (LPG)) and CPS rates of fuel duty (on oils).<br>On 16 April 2026 the government announced CPS will be removed from April 2028. |
| Climate Change Agreement (CCA) | CCAs are a Department for Energy Security and Net Zero led scheme under which voluntary agreements are made between UK industry and the Environment Agency (the scheme administrator) to improve energy or carbon efficiency. In return businesses can claim significant reductions in the main rates of CCL. |
| Climate Change Levy (CCL) | The main rates of CCL are a tax on natural gas, LPG, electricity and solid fossil fuels paid by non-domestic consumers (with some exceptions). The tax is charged by energy suppliers on the bills they issue to liable consumers. |
| Combined Cycle Gas Turbine | A gas turbine generator system from which exhaust heat is used to raise steam to drive a steam turbine to generate further power. |
| Combined Heat and Power (CHP) | Energy technologies that can provide simultaneous generation of heat and power in a single process. |
| Combined Heat and Power Quality Assurance Programme (CHPQA, CHPQA Programme, or the Programme) | A voluntary management and administrative process under which Registration and Certification of CHP Schemes is undertaken. It proceeds through the application for Registration and Self-Assessment of CHP Schemes by a Responsible Person to Certification in accordance with the criteria for Good Quality CHP. Certification enables CHP Schemes to receive certain financial benefits. |
| CHP Scheme (or Scheme) | All the equipment, operating systems and monitoring systems for the total system defined to be within the Scheme boundary, being that to which CHPQA applies. This can include, for example, ancillary heat-only boilers. |

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| Counterfactual | An alternative scenario to the actual (factual) circumstances. |
| Energy Service Company (ESCo) | A specialist company providing some or all of a range of engineering services, including design, build, operation, maintenance and third-party financing of energy plant and systems. |
| Enhanced Capital Allowance (ECA) | Enhanced Capital Allowances allowed businesses to write off 100% of their investment in those energy saving technologies that are listed in the Energy Technology Criteria List against the taxable profits of the period during which they made the investment. ECAs were withdrawn from April 2020. |
| Energy from Waste (EFW) CHP | Generation of partly renewable electricity and usable heat from non-recyclable waste through incineration. |
| Form F4 | CHPQA Form F4 (or Form F4s for simple Schemes of less than 2 MWe capacity) is used to undertake the annual Self-Assessment of the actual performance of an existing CHP Scheme by the Scheme's Responsible Person. Completion and submission of the form is required for Scheme certification. |
| Gas turbine | A device that converts fuel energy into mechanical energy by using the energy contents of the products of combustion to drive a turbine. |
| Good Quality CHP | CHP that delivers primary energy savings and overall efficiency at or in excess of the thresholds defined in the CHPQA Standard (CHPQA Standard Issue 8, March 2021 (publishing.service.gov.uk)) |
| Grandfathered Schemes/ financial benefits | Financial benefits available at the time of a CHP Scheme enrolling onto CHPQA which are now closed to new applicants. This includes Renewables Obligation Certificates (ROCs) and non-domestic Renewable Heat Incentive (NDRHI) payments. |
| Long-run Variable Cost of energy supply (LRVC) | The components of the retail energy price that represent actual costs to society that vary according to the level of consumption[13]. |
| Megawatt (MW) | A measure of power output equal to one million watts or one thousand kilowatts. A watt is a standard unit of power (energy per unit time), the equivalent of one joule per second |
| Net social benefit / Social value | Monetises the overall impact of significant, quantified costs and benefits that affect the welfare and wellbeing of the population, not just market effects. |
| Non-domestic Renewable Heat Incentive (NDRHI) | The Non-domestic Renewable Heat Incentive (NDRHI) is a government environmental programme designed to increase the uptake of renewable heat. Accredited installations receive quarterly payments over 20 years based on the amount of renewable heat used for eligible purposes. |
| Non-grandfathered Schemes/ Financial benefits | Non-grandfathered Schemes receive financial benefits that are currently available to new CHPQA applicants, hence have not been grandfathered, which include Carbon Price Support relief and exemption from the Climate Change |

[13] For further details see: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1024040/valuation-energy-use-greenhouse-gas-background-documentation.pdf

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| | Levy main rates for Good Quality energy inputs (fuel) and outputs (electricity), relief from fuel duty and reduced Business Rates. |
| Organic Rankine Cycle | A turbine system which utilises a low boiling temperature organic working-fluid to generate power from lower temperature heat sources. |
| Own finance | The financing of a capital project, such as a CHP Scheme, by the organisation operating the site that the project serves. |
| Pass-out condensing (POCO) steam turbine | A steam turbine from which steam can be extracted from one or more stages at different pressures prior to the final exit of the remaining steam, which is fully condensed. |
| PP10 and PP11 Forms | HM Revenue and Customs (HMRC) forms used for claiming various reliefs from Climate Change Levy (CCL) main rates, including CHPQA relief for exempt fossil fuel inputs. See: Excise Notice CCL1/3: Climate Change Levy – reliefs and special treatments for taxable commodities – GOV.UK (www.gov.uk) |
| Power efficiency | Total annual power output divided by the total annual fuel input. |
| Primary energy | Comprises the energy used by consumers (delivered energy) plus that lost in electricity generation and other transformations |
| Prime mover | The core component of an electricity generating plant that converts fuel energy or energy in a working-fluid into mechanical energy. |
| Quality Index (QI) | One of two key parameters for assessing a CHP Scheme (the other being Power Efficiency) under CHPQA. QI is an indicator of the energy efficiency and environmental performance of a Scheme, relative to the generation of the same amounts of heat and power by separate, alternative means. |
| Reduced Business Rates | Specified CHP power-generating plant and machinery within an eligible CHPQA-certified Scheme are exempt or receive reduced Business Rates valuation, reducing the site's overall Business Rates liability. Reduced Business Rates are available for "embedded" CHP, where the CHP plant is physically and functionally integrated within the site or building, and is not treated as a separate, standalone power station for business-rates purposes.<br>Heat recovery plant and machinery are explicitly excluded from reduced Business Rates. Eligibility and valuation are administered through the Valuation Office Agency (VOA) (or devolved equivalents), and outcomes depend on site-specific and geographic factors, meaning the benefit is not uniform across all CHPQA schemes. |
| Renewables Obligation Certificate (ROC) | The Renewables Obligation places an annual obligation on electricity suppliers to present to Ofgem a specified number of Renewables Obligation Certificates (ROCs) per megawatt hour (MWh) of electricity supplied to their customers during each obligation period (1 April – 31 March).<br>ROCs are issued to operators of accredited renewable generating stations for the eligible renewable electricity they generate. Operators can trade ROCs with other parties or sell them directly to a supplier. |

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|---|---|
| Responsible Person (RP) | The person registered with CHPQA as responsible for the operation of a Scheme. |
| Steam turbine | A turbine device that converts the energy in steam into mechanical energy. The steam will normally be raised in a steam boiler. |
| UK Emissions Trading Scheme (UK ETS) | The UK ETS applies to regulated activities which result in greenhouse gas emissions, including combustion of fuels with a total rated thermal input exceeding 20MWth (except for activities whose primary purpose is the incineration of hazardous waste). Emissions trading systems work on the 'cap and trade' principle, where a cap is set on the total amount of certain greenhouse gases that can be emitted by sectors covered by the system, limiting the total amount of carbon that can be emitted. |

# 1. Introduction

A CHP Scheme essentially comprises an electricity generating plant combined with equipment for recovering, and putting to good use, the heat produced by that plant; thus, providing the cogeneration of heat and power at the site of use. The core component of a CHP Scheme is a prime mover that drives an electrical generator and converts fuel into mechanical energy and then into electricity. Prime movers can run on a wide range of fuels, both fossil and renewable, and include reciprocating internal combustion engines, gas turbines and steam turbines[14]. CHP can also be used to export heat and electricity to neighbouring entities, and export electricity to the national grid network. CHP Schemes range in size from several kilowatts to over 1000 megawatts in power generating capacity and are found in a wide range of sectors from hospitals and leisure centres to chemicals and food manufacturing.

The UK's **Combined Heat and Power Quality Assurance Programme**[15] (CHPQA, or the Programme) was introduced alongside the Climate Change Levy (CCL) in 2001. The CCL legislation made provisions for CHP installations to receive full or partial CCL relief on relevant input fuels and output electricity. The extent of relief depends on efficiency characteristics as determined annually via certification under CHPQA. The government's aim was to increase the deployment of combined heat and power (CHP) in recognition of the primary energy savings[16].

CHPQA provides a determinate method for assessing the primary energy efficiency of all types (prime movers and fuels) and sizes of CHP Schemes. It is not linked to any CO2 emissions performance benchmarks. Certification of an installation under CHPQA (referred to as a *'CHP Scheme'*) grants to its operator or owner eligibility for one or more of the financial benefits listed below, depending on the nature of the particular Scheme.

Since its introduction, CHPQA has developed to provide the basis for access to separate financial measures to help improve the incentives of the Programme[17], specifically these financial benefits are:

- CCL main rate relief for qualifying taxable fuel input and qualifying electricity directly used on site. Relief was also available to exported Good Quality CHP electricity generated before 1 April 2013, known as LEC (Levy Exempt Certificate)[18];

[14] Further information on CHP prime movers can be found at: https://www.gov.uk/government/collections/combined-heat-and-power-chp-developers-guides

[15] https://www.gov.uk/guidance/combined-heat-power-quality-assurance-programme

[16] Primary energy comprises the energy used by consumers (delivered energy) plus that lost in electricity generation and other energy transformations.

[17] See also: https://www.gov.uk/guidance/combined-heat-and-power-incentives

[18] CHPQA guidance note 41: Use of CHPQA to obtain exemption from climate change levy and relief from fuel duty - GOV.UK

- Relief from Carbon Price Support (CPS) rates of CCL where relevant fuels are used to generate Good Quality electricity that is directly supplied (up until April 2028, after which CPS will be removed as announced on 16 April 2026)[19];
- exemption from the business rating of plant and machinery[20]; and
- Enhanced Capital Allowances (ECAs) (no longer available closed in 2021).
- Fuel duty relief for electricity generation using hydrocarbon oils.

Also, for renewable CHP:

- Renewables Obligation Certificates are awarded for Good Quality electricity generation
- Non-domestic Renewable Heat Incentive (NDRHI) support on Good Quality heat output[21]; and,
- eligibility for certain Contracts for Difference for dedicated biomass and Energy from Waste CHP on Good Quality electricity generation, paying the difference between a specified ‘strike price’ and ‘reference price’[22]

The main objective of CHPQA is therefore to objectively assess the performance of CHP Schemes in their role of promoting greater energy efficiency. Figure 4 provides a timeline for the introduction and, for some, the cessation of each of these measures.

From the list of financial benefits[23], ECA is no longer available and ROCs and NDRHI are no longer available to new applicants but can still be accessed by CHP Schemes that originally received these payments from when they enrolled onto CHPQA. ROCs and NDRHI are therefore considered ‘grandfathered’ financial benefits and can continue to be accessed by grandfathered Schemes over a 20-year period[24]. Financial benefits available to non-grandfathered Schemes include CCL main rate and CPS rate relief, Enhanced Capital Allowances and reduced Business Rates for embedded CHP Schemes and are known as ‘non-grandfathered’ financial benefits[25]. In the financial year 2023/24, CCL relief on fuel inputs were estimated at £325m and CPS relief for ‘Good Quality’ CHP were £45m,

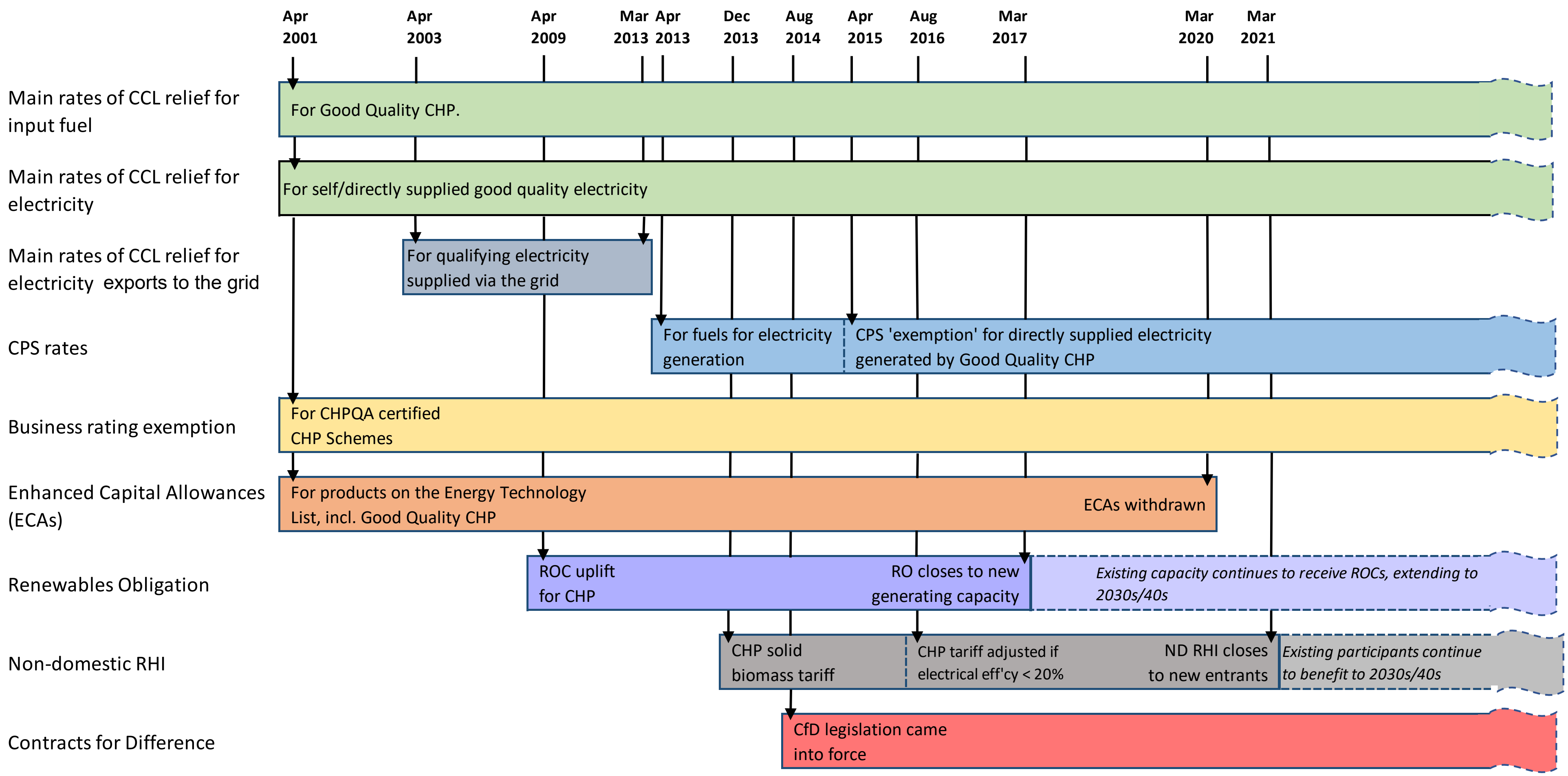
[19] See link to CPS removal **here**
[20] CHPQA guidance note 43: Use of CHPQA to obtain exemption from business rating of CHP plant and machinery - GOV.UK
[21] Non-Domestic RHI main guidance | Ofgem
[22] CHPQA guidance note 44: Use of CHPQA in respect of the Renewables Obligation and Contracts for Difference - GOV.UK
[23] ‘Financial benefits’ is interchangeable with the term ‘fiscal benefits’ which is used in CHPQA guidance.
[24] ROC and NDRHI payments can continue to be accessed by grandfathered schemes for 20 years post enrolment. Last payments will end by around 2041.
[25] Embedded CHP Schemes for reduced Business Rates are CHP that are physically and functionally integrated within a larger site or building.

totalling £370m[26] [27]. This financial support is estimated to account for the majority of support offered via CHPQA eligibility.

To access these financial benefits, the criteria for Good Quality CHP requires a total power and heat efficiency score, known as the Quality Index (QI), equal to or greater than a threshold of 100 and power efficiency equal to or greater than 20%[28]. The QI is calculated by comparing the energy efficiency of a Scheme relative to separate heat and power generation (using reference values for separate generation of electricity in a power station and heat in a boiler). These criteria are mechanisms for incentivising operators to improve the energy efficiency of their CHP Schemes. Achieving the power efficiency threshold currently allows operators to claim full CCL relief on all fuels, and achieving the QI threshold allows operators to claim full CCL relief on all Good Quality electricity which is generated and directly used on site or supplied to neighbouring sites via a direct wire. Failing to meet these criteria leads to scaling back of qualifying fuel and electricity leading to a reduction in the financial benefits.

[26] CCL relief on fuel inputs and CPS relief are estimated to account for a large majority of the financial benefits associated with CHPQA. Estimates do not account for overlaps with related exemptions, such as CCL exemption for electrical generators over 2MWe in capacity and oil refineries
[27] https://www.gov.uk/government/statistics/main-tax-expenditures-and-structural-reliefs
[28] The CHPQA guidance notes – Simple guide to good quality CHP and the quality index (QI) value. URL: https://www.gov.uk/guidance/chpqa-guidance-notes

**Figure 4: Timeline of financial support measures available via CHPQA**



The UK Government is keeping CHP policies under review, including their alignment with its Net Zero Strategy, supported by two calls for evidence[29] [30]. To build upon this, the Department for Energy Security and Net Zero (DESNZ) commissioned Ricardo Energy & Environment (Ricardo) to undertake **a review of the additionality of CHPQA and the associated net social benefits.**

The main objectives of the review have been to explore and determine:

- how CHPQA certification has influenced investments in CHP Schemes;
- how operational decisions in relation to those plants may have been affected by the need to maintain certification from year to year;
- the net social benefit from the CHPQA Programme;
- how effective the Programme's operation and administration is perceived to be by participating organisations, and how it might be improved to better support those organisations;
- whether participating organisations see a role for CHP and CHPQA in contributing to the UK's net zero target; and
- scope for the development of CHPQA in implementing future policies to support deployment of CHP Schemes that contribute to achieving the 2050 net zero target.

This report describes the methodology of the review and its outcomes in respect of these objectives.

The HM Treasury Green Book defines additionality as *'a real increase in social value that would not have occurred in the absence of the intervention'*. The review has drawn on the Treasury methodologies (the UK Green Book[31] and Magenta Book[32]), working alongside Department for Energy Security and Net Zero analysts, to develop a bespoke theory-based methodology for capturing evidence with which to estimate the additionality of net social benefits from the CHPQA Programme. A bespoke approach was needed to overcome the inherent complexities arising from the fact that the CHPQA Programme has been running for over 20 years with developments over time, accompanied by multiple incentivising policies, and a varying population of certified CHP Schemes from year to year. Whilst not being a full evaluation, the evidence collected in this report provides an

[29] Combined Heat and Power (CHP): the route to 2050 - call for evidence. (12 June 2020). https://www.gov.uk/government/consultations/combined-heat-and-power-chp-the-route-to-2050-call-for-evidence

[30] Combine Heat and Power: pathway to decarbonisation - a call for evidence. (27 Sept 2021). https://www.gov.uk/government/consultations/combined-heat-and-power-pathway-to-decarbonisation-call-for-evidence

[31] The Green Book: appraisal and evaluation in central government (2026), HM Treasury. https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

[32] The Magenta Book: Central Government guidance on evaluation (March 2020), HM Treasury. https://www.gov.uk/government/publications/the-magenta-book

illustration of the social value to the UK of the CHPQA Programme from different scenarios to help inform how the Programme influences CHP investment and operational decisions.

The rest of this document is structured as follows:

- Section 2 describes the review methodology, including commentary on its limitations.
- Section 3 presents the results of the review.
- Section 4 sets out conclusions from the research.
- The Annexes provided additional detail on the methods, analysis and outputs carried out and produced for this study.

# 2. Study Methodology

## 2.1 Overview

The methodology for this research broadly comprised four main activities:

- Design of a research approach, online survey and scripts for structured interviews targeting CHP Scheme operators (Section 2.2);
- Online survey of all organisations with certified CHP Schemes (Section 2.3);
- Structured interviews with appropriate representatives of a selected sample of CHP Schemes (Section 2.4);
- Analysis of the responses to the survey and interviews, together with annual CHP Scheme performance data held by the CHPQA Programme, to evaluate the net social benefits associated with the Programme (Section 2.5).

CHPQA has been running for over twenty years, has developed over that period, and the population of CHP Schemes has naturally changed as new Schemes are introduced, and old Schemes are closed or replaced. The value and availability of different financial benefits have also changed over the years, affecting the mix of operational Schemes. The carbon intensity of the grid has also fallen and will continue to do so, thus changing the context in which fossil fuelled CHP operates.

In order to manage this complexity and gather evidence effectively through a stakeholder consultation, the analysis of the net social benefits has focussed on a specific year, 2019. This was chosen as a year for which operational data was judged to be representative of CHP Schemes' normal operating conditions, given the impacts of the COVID-19 pandemic in 2020 and 2021. This was considered a proportionate approach given that the aim of this study was not to carry out a full ex-post evaluation nor business case of the future of the

Programme, but rather to collect additional evidence that would facilitate the timely and proportionate estimation and understanding of the net social benefits from the CHPQA Programme.

These four main activities are described in the following sections and are followed by a brief outline of the study's limitations.

## 2.2 Design of the Online Survey and Structured Interviews

The online survey and interviews were designed primarily to establish the counterfactuals for the CHPQA Programme for each individual Scheme. The counterfactuals in this case describe:

- what organisations would have done in the absence of the CHPQA Programme when they considered their investment options – the investment counterfactual; and
- how operators would have operated their CHP Schemes in the absence of CHPQA eligibility for non-grandfathered financial benefits[33] – the operational counterfactual.

Establishing these two counterfactuals was a key part of this study, as comparing these to the factual, or outturn data, allows an estimate to be made of the potential net social impacts from the CHPQA Programme.

The online survey and interviews also sought to answer other specific research questions, in line with the objectives of the study. The core questions are grouped into the three themes and summarised in Table 1 below.

**Table 1: Research Questions**

| Themes | Research questions |
|---|---|
| **CHP Scheme investment decisions, counterfactuals and implications** | *How important was the CHPQA Programme and the financial benefits secured via CHPQA certification in reaching the investment decision?*<br>*What would the investor have done if the CHPQA Programme and associated financial benefits were not available at the time of the investment decision? Or, in other words, what is the investment counterfactual for each CHP Scheme?*<br>*How would the electricity and heat be supplied in this investment counterfactual?* |

[33] Non-grandfathered Schemes can access non-grandfathered financial benefits such as Carbon Price Support relief, Climate Change Levy relief, and reduced Business Rates. They exclude the Renewable Heat Incentive, Renewables Obligation and Contracts for Difference, which are grandfathered financial benefits.

| | |
|---|---|
| **Operational decisions, scenarios and implications (now and future)** | *How important was the CHPQA Programme and financial benefits secured via CHPQA certification in determining how Schemes were operated?*<br>*What would CHP Scheme operators have done to meet their heat and electricity needs in 2019 if non-grandfathered financial benefits were no longer available? Or, in other words, what is the operational counterfactual for each CHP Scheme?*<br>*Given the UK's Net Zero target, might CHP Scheme operators consider any CHP (or other) options for the future?* |
| **CHPQA Programme's administration and user feedback** | *What is the administrative burden of the CHPQA Programme on businesses?*<br>*Have businesses used CHPQA Programme services and found them helpful?*<br>*How could the CHPQA Programme be improved?*<br>*Could the Programme be used to achieve greater energy efficiencies?* |

Whilst contact for the survey and interviews was always made via the Responsible Person (RP), who is a principal point of contact for the Programme, the individuals completing the survey or participating in interviews were not necessarily limited to the RP as other roles in the organisation may have had better knowledge of the decisions being referenced.

Annual operating data held by the Programme has been used in estimating various parameters for the review's analysis, for example, the heat and power efficiencies of Schemes. The review has principally been based on the population of those CHP Schemes operating in 2019.

Given the wide range of CHP Scheme types and sizes, and the expectation that study results would vary between them, the population of CHP Schemes was first divided into 13 archetypes. The intention was that this might allow specific conclusions to be drawn from the analysis for particular types of CHP installation and help target survey sampling to achieve coverage of Schemes that are estimated to receive a large share of the financial benefits. As shown in Table 3 the archetypes selected were based on prime mover type, fossil or renewable fuel, electrical capacity, and apparent finance method – own finance or third-party finance via an Energy Service Company (ESCo)[34].

[34] CHPQA does not hold specific information on how individual Schemes were financed; categorisation was determined from the nature of the appointed Responsible Person's organisation, but this is not wholly reliable since ESCos provide a range of services including plant operation and maintenance without necessarily providing capital finance.

## 2.3 Online Survey

RPs have varying numbers of CHP Schemes under their responsibility; 387 RPs representing 1,300 Schemes were identified as the contact points for the online survey as summarised in Table 2.

**Table 2: The population of RPs and Schemes**

| Groups | No. of RPs | No. of Schemes |
|---|---|---|
| RPs with 1–3 Schemes | 347 | 440 |
| RPs with 4–9 Schemes | 23 | 124 |
| RPs >9 Schemes | 17 | 736 |
| **Total** | **387** | **1,300** |

The survey was structured into three sections with a maximum of 39 questions (depending on responses to preceding questions) that reflected the key research questions set out in Table 1. It was implemented via a proprietary online survey and feedback platform between 12th April and 20th May 2022, having first been piloted with five RPs in late March. A full list of the survey questions is provided at Annex 1.

All RPs were contacted via e-mail as soon as the survey became available with a request to complete the survey and an explanation of its purpose. RPs with 1–3 Schemes were asked to complete a survey for each Scheme, and RPs with more than three Schemes were asked to complete 4–5 surveys or more if possible. During the final week of the survey, follow up e-mails were sent to all RPs who had not responded to encourage further submissions, even if these were partial. Direct telephone calls were also made to those RPs responsible for four or more Schemes.

Full or partial responses to the survey were received covering 204 individual CHP Schemes representing approximately 16% of all Schemes that were certified under CHPQA in 2019. The breakdown by archetype is shown in Table 3. Since the response rates shown include **complete and partial responses**, in respect of particular questions the effective response rate (the sample) can be much lower than indicated.

**Results should be interpreted with caution given the limited sample.** For all CHP Schemes, the number of survey responses falls short of statistical significance with a 90% confidence interval, meaning there is not sufficient evidence to suggest the observed results are representative for the population of CHP Schemes. Response rates achieved varied from 2% to 67%, focusing on larger capacity archetypes, which are likely to receive a greater proportion of the financial benefits. When considering the responses by archetype, 9 out of 13 would require responses from 80% of Schemes or above to achieve statistical significance given the small number of Schemes, which is not realistic for the scope of this study. Whilst being some way off statistical significance, these results offer the best evidence on the net social benefits associated with the CHPQA Programme to date. However, the interpretation of the findings should acknowledge limitations with this research, in particular archetypes with low response rates namely Biomass (Small), Engine (Mid, Own finance), Engine (Small, ESCo), as well as Engine (Large, ESCo) and Engine (Mid, ESCo) since a number of responses were partial.

Given the low number of completed surveys from the CCGT (ESCo) and 'Other' archetypes, responses have been suppressed to avoid the potential disclosure of answers from individual operators.

**Table 3: The survey population as of 2019, response rate and interviews by archetype**

| CHP Archetype | Total Population | Survey responses (complete and partial) | Response rate (%) | Interviews |
|---|---|---|---|---|
| Biomass (Large)* | 16 | 7 | 44% | 4 |
| Biomass (Small)* | 74 | 10 | 14% | 0 |
| CCGT (ESCo) | 6 | [s] | [s] | 0 |
| CCGT (Own Finance) | 25 | 8 | 32% | 6 |
| Energy From Waste (EfW) | 6 | 4 | 67% | 2 |
| Engine (Large) >3,000 kWe (ESCo) | 39 | 8 | 21% | 3 |
| Engine (Large) >3,000 kWe (Own Finance) | 60 | 19 | 32% | 5 |
| Engine (Mid) >500 kWe ≤3,000 kWe (ESCo) | 108 | 29 | 27% | 5 |
| Engine (Mid) >500 kWe ≤3,000 kWe (Own Finance) | 125 | 19 | 15% | 4 |
| Engine (Small) ≤500 kWe (ESCo) | 367 | 9 | 2% | 5 |
| Engine (Small) ≤500 kWe (Own Finance) | 345 | 71 | 21% | 0 |
| Single-Cycle Gas Turbine (SCGT) – (Own Finance) | 58 | 12 | 21% | 3 |
| Other | 71 | [s] | [s] | 0 |
| **Total** | **1,300** | **204** | **16%** | **37** |

**For biomass, large Schemes are those with electrical capacity > 10 MWe and small ≤ 10 MWe, both with the total fuel use > 50% solid biomass*

*[s] data suppressed due to avoid potential disclosure of survey responses*

*The 'Other' archetype comprises Schemes that do not fit with the chosen archetypes; these are* disparate other types of CHP, such as different types of steam turbine of a range of sizes, that do not have any particularly common features. Overall, the data regarding these are valid, but no clear conclusions can be drawn for this group.

## 2.4 Structured Interviews

The interviews were undertaken by pre-arranged video conference. The interviewers were experienced senior Ricardo staff members with a good appreciation of commercial and industrial investments in energy efficiency and low carbon infrastructure, including CHP, and the relevant regulatory and policy landscape.

To ensure consistency of approach the interviews were structured via the use of three pre-prepared scripts: one for self-financed Schemes, one for ESCo-led Schemes; and the third for non-participants of the CHPQA Programme. A full list of the questions for each is provided at Annex 2.

A total of 35 interviews of around an hour duration was held covering 37 Schemes as shown in Table 3. Two of the interviews were held with representatives of prospective CHP projects who had made preliminary contact with the Programme. At the time of the interviews, one of these projects had been abandoned and the other was under development.

Interviewees were selected to provide as much balance across the archetypes as possible, focussing on Schemes where the investment had been made within recent years. Seventeen of the interviewees had already completed the survey, hence the interview was used in part to confirm and expand on the survey responses provided. Interviewees that had not completed the survey were encouraged to do so following the interview. All of the interviews sought to provide more in-depth engagement on the key research questions than was possible via the survey. This was particularly the case regarding organisations' future plans for responding to the challenge of Net Zero and the barriers they face.

## 2.5 Analysis

This subsection summarises the approach employed to analyse the evidence collected, both through the survey and interviews.

### 2.5.1 Review and assurance of data collected

The survey and interview data collected were checked for completeness, internal consistency, and consistency with data held by the CHPQA Programme. Where inconsistencies were identified, appropriate adjustments were made through a combination of following up with RPs and applying expert judgement in combination with the information to hand where it was reasonable to do so.

There were 156 complete and consistent responses. An additional 48 participants provided incomplete responses, offering ‘other’ or ‘don’t know’ as their options for the investment counterfactual. These were compared with their responses to other queries and, where sufficient evidence was identified, an expert-based assumption was made as to which of the counterfactual options would be the most appropriate.

Given this uncertainty, two sub-samples of respondents were created: a smaller sample of 156 respondents, who provided complete and concrete answers; and a larger sample of 204 respondents, which included the 48 participants that required follow-up with RPs and expert-based judgement to revise or specify answers to all of the essential questions.

### 2.5.2 Approach to the quantitative and qualitative analysis

The final dataset was analysed quantitatively to respond to the specific research aims outlined in Table 1 at the sample level. This included:

- establishing the investment and operational counterfactuals (i.e., how energy demand might be met at the Scheme sites in the absence of the CHPQA Programme and CHPQA eligibility for non-grandfathered financial benefits respectively);
- quantifying the additionality of the CHPQA Programme in driving investment in CHP Schemes;
- determining for the sample's outturn in 2019 (or factual) and estimating for the established investment and operational counterfactual alternatives:
    - primary fuel consumption (megawatt-hours, MWh);
    - electricity and heat output (MWh);
    - long-run variable costs (LRVC) of energy supply (GBP, 2021 prices);
    - carbon dioxide equivalent ($CO_2e$) emissions (in tonnes and social value i.e. GBP, 2021 prices); and
    - air quality damage (AQD) costs (GBP, 2021 prices).

The investment and operational counterfactuals were established from survey responses to determine whether a Scheme's investment or operational decisions were materially influenced by the CHPQA Programme and its eligibility criteria or not. For instance, a respondent may state that their investment counterfactual, in the absence of the CHPQA Programme, would have differed from the CHP Scheme that was implemented, such as purchasing electricity from the grid and generating heat via a gas boiler. Alternatively, a respondent may have stated they would have invested in a smaller CHP or would have made the same CHP investment anyway.

Responses which stated an alternative counterfactual to the factual were deemed to generate additionality in that the CHPQA Programme influenced the decision that led to an increase in social value that would not have occurred in the absence of the intervention. If no change was selected in the counterfactual, stating the same CHP investment would have taken place without the CHPQA Programme, the investment is not considered to provide additionality.

The difference in fuel use between the factual and counterfactual was calculated across the sample to enable the monetisation of social benefits generated by the CHPQA Programme. Fuel metrics were based on Green Book supplementary guidance, making adjustments where there was a reasonable case to deviate from guidance[35]. For example, certain Schemes used by-products from production processes as a fuel, implying there is no additional cost to use the fuel, hence there is no long-run variable cost associated (e.g., blast furnace gas, refinery off-gases). Also, biomass CHP plants of over 1 MW rated thermal input adhere to legal restrictions on pollution levels which were used to calculate a bespoke air quality damage costs in place of Green Book values[36].

The outputs from the analysis of the sample of respondents were used to develop assumptions for the population of certified CHP Schemes in 2019 for each of the archetype groupings defined in Table 3 above. This was achieved as follows:

- Firstly, the percentage differences between the factual and counterfactuals were calculated within the sample by archetype (e.g., differences in carbon emissions between Large Engines (ESCo) in the factual situation versus the carbon emissions that would have been generated in the investment or operational counterfactual).
- Secondly, these percentage differences were assumed to represent the archetype's population, that is, all of the Schemes in 2019 that are categorised within the same archetype (e.g., Large Engines (Own Finance)).
- Finally, the percentage differences between the factual and counterfactuals in the sample for each social benefit (e.g., CO2e emissions) were multiplied by the factual population totals for each archetype to estimate what would have occurred in the counterfactual at the population level (see Figure 5 below).

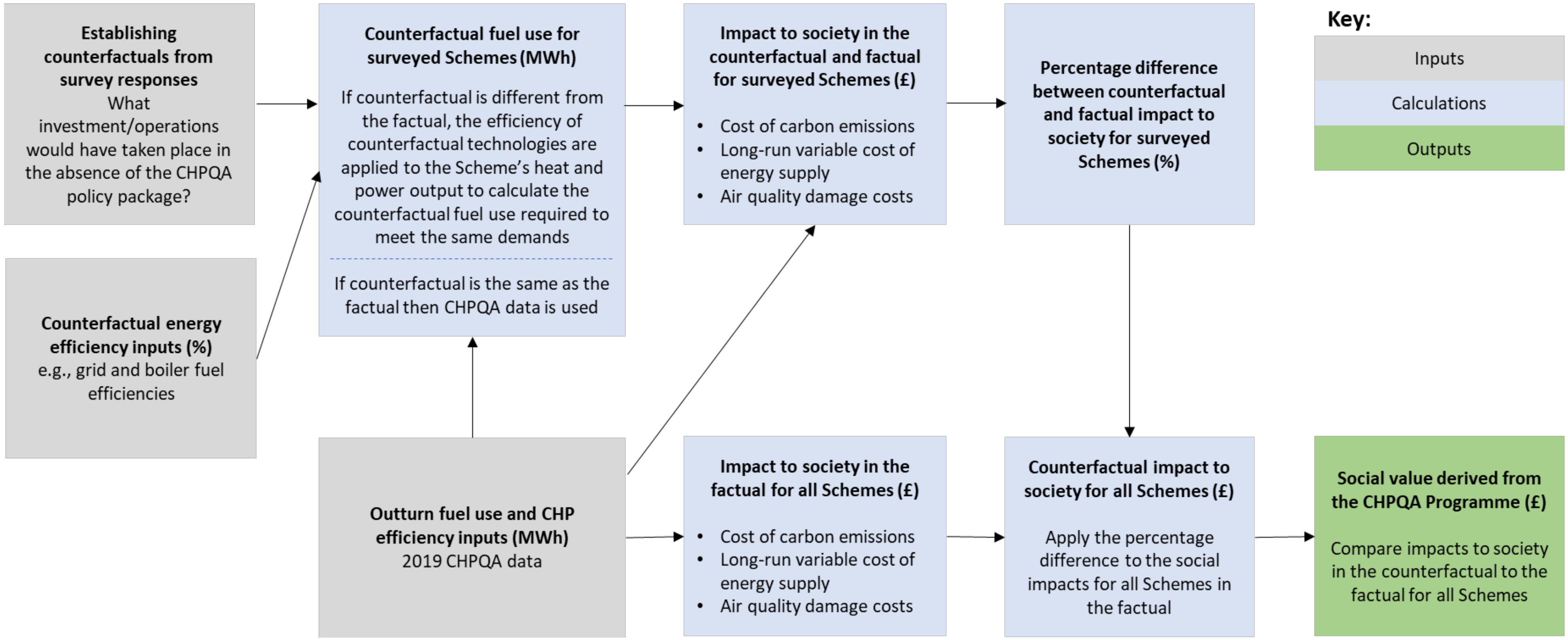
These study findings are used to estimate the extent to which the CHPQA Programme influenced investment and operational decisions at the sample and population level. The interview data was also analysed to contrast against the data provided via the survey. The evidence collected from the interviews was coded, where possible, to align with the answer key and structure employed for the survey.

A qualitative analysis of evidence to the additional interview queries was performed to identify key themes that complement the survey data analysis to provide insights into low-

[35] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal: www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal (2021 version)
[36] This bespoke value for biomass Air Quality Damage costs (expressed in units of £/MWh) is derived based on the assumption that any biomass burning plant with rated thermal input >1 MWth would be permitted under the Medium Combustion Plant Directive (MCPD), and that under this Directive limits on PM and NOx emissions (expressed in units of mg/Nm$^3$) would have to be adhered to for the plant to continue running. The cost associated with biomass burning therefore assumes that these emission limits are not exceeded but occur at the limit values, as a conservative assumption. Applying damage costs (£/tonne of emission) for PM and NOx pollutants has returned an air quality damage cost of £7.28/MWh for biomass, and this is the value used in this study.

carbon options being considered by CHPQA participants and RPs’ experiences and ways to improve the administration of the Programme.

## Figure 5: Model map for analysis



### 2.5.3 Net social benefit analyses

The evidence available and collected through the survey and interviews was analysed to estimate:

1. The net social benefits that were generated by the CHPQA Programme in 2019[37] as a consequence of the original investment.
2. The net social benefits that were generated by CHPQA eligibility for non-grandfathered financial benefits due to the influence on the operation of incumbent Schemes in 2019.
3. The net social benefits that might be generated by the current CHPQA Programme going forward, based on the reported influence to invest in CHP by the CHPQA Programme and the evolving energy system in the UK.

These analyses of the net social benefits in different contexts allowed Ricardo consultants to consider quantitatively the potential net social benefits as a result of the CHPQA Programme from the perspective of investment and operational decisions made and over different time horizons. The three scenarios applied in this review of the CHPQA Programme are:

1. The investment scenario: Net social benefits generated by the CHPQA Programme in 2019, by identifying the CHP investment was influenced by the financial benefits available from CHPQA certification. This helps answer the questions: 'Has the CHPQA Programme encouraged investment in CHP Schemes that would not otherwise have happened? And: 'Has this produced net social benefits?'
2. The operational scenario: Net social benefits arising from the influence on the operation of CHP Schemes of eligibility for non-grandfathered schemes in 2019. This illustrates the extent to which the day-to-day operations of the CHP Schemes are influenced by the non-grandfathered financial benefits available from CHPQA certification such as CCL and CPS relief. This helps answer the questions: 'Does CHPQA eligibility for non-grandfathered financial benefits impact operational decisions?' And, thus: 'Has this produced net benefits to society or not?'
3. The new Schemes scenario: Annualised net social benefits generated from *new Schemes in 2019* assuming the Programme runs as-is to illustrate the extent to which net social benefits are generated in the future in the context of an evolving

[37] This was achieved by calculating the net social benefits for the year 2019, as this was the last year for which pre-covid CHPQA data were available. The net social benefits for a gas fired scheme (the majority of schemes in CHPQA) for years before 2019 would be higher than that evaluated for 2019, since CHP would be displacing grid electricity of progressively higher $CO_2e$ intensity as one goes back in time. As such, the historical net social benefits of the CHPQA Programme evaluated in this report is very likely to underrepresent the net social benefits delivered by CHPQA in previous years.

energy system. This helps answer the question: 'Can the CHPQA Programme as-is continue to deliver positive net social benefits?'

These three scenarios are used to provide evidence on how the Programme has impacted CHP investment and operational decisions, allowing the associated net social benefits in 2019 to be estimated. The review does not assess the financial benefits available from CHPQA certification which are administered by HM Treasury and HM Revenue and Customs (HMRC). These financial benefits are made up of tax reliefs (e.g., CCL and CPS relief, ECA) and renewables payments (ROCs and NDRHI) which are seen as economic transfers in the Government's Green Book guidance for appraisal and evaluation and hence are not part of this assessment of social value. This is because, in respect of these financial benefits, spending power is transferred from one party to another and, therefore, does not make society as a whole better or worse off[38].

Section 3 provides answers to these questions based on the evidence collected and analysis carried out for this study.

More technically, these analyses compare the outturn (or actuals) – i.e. energy consumed to meet heat and power demands at the sites which are supplied by the CHPQA Schemes – with the same for alternative counterfactuals[39] (e.g., *investment and operational counterfactuals* described earlier), identified through the online survey and interviews.

As outlined, given the complexity and demands for evidence and data, 2019 was selected as an illustrative year.

**The investment scenario**

For the analysis of the net social benefits of the Programme compared to the investment counterfactual, CHPQA outturn fuel use in 2019 was compared against a scenario in which the CHPQA Programme is absent at the time of the investment decision. This comparison provides an estimate of the impacts (or net social benefit) of the CHPQA Programme in 2019 when compared to what would have been the case without the CHPQA Programme, i.e., the investment counterfactual. This does not attempt to estimate the total lifetime costs and benefits from the Schemes that might be expected in a full evaluation. Instead, a 'snapshot' of net costs and benefits is estimated for 2019 for all Schemes.

The assessment focussed on the implications for the year of 2019 and quantified the differences in the outturn carbon emissions, primary energy used and the associated fuel and air quality damage costs. Given that the grid is the relevant counterfactual for many Schemes, and the grid has decarbonised over the period that many Schemes have been

[38] The Green Book (2026) – Chapter 6 Economic Transfers. URL: www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government#introduction

[39] These analyses were based on the principles set out in the UK Green Book and Magenta Book, including but not only to establish the counterfactual and assess and monetise social costs and benefits.

operating, the net benefits estimated in 2019 are likely to be an underestimate of those achieved annually over the operation of CHPQA Programme.

**The operational scenario**

For analysis on the impact on Scheme operations, the fuel use of 'live' non-grandfathered Schemes in 2019 were compared against the *operational counterfactual;* that is, a scenario in which CHP Schemes installed prior to 2019 (i.e., around 1,200 Schemes) would no longer be eligible for non-grandfathered financial benefits[40]. This comparison provides an estimate of the impacts (or net social benefits) associated with the eligibility of non-grandfathered Schemes in 2019, which reflects how sensitive the day-to-day operations of the CHP Schemes are to the non-grandfathered financial benefits received. The focus was on non-grandfathered financial benefits as new Schemes can still access them via CHPQA and eligibility could be adapted with new policy. Grandfathered financial benefits were not involved in this scenario as these are no longer applicable to new CHP Schemes and the criteria for receiving them are tied into contracts for renewables.

This assessment also quantifies the differences in the 2019 outturn carbon emissions, primary energy consumed, and the associated fuel and air quality damage costs against those that would be generated in the same year but under the alternative scenario. This alternative scenario is, therefore, one in which the CHPQA Programme does not provide eligibility for non-grandfathered financial benefits for 'live' CHP Schemes in 2019.

**The new Scheme scenario**

The new Scheme scenario analysed Schemes that were new to CHPQA in 2019 (i.e., those commissioned in 2019 of which there were around 100) and established what could have happened in the absence of the CHPQA Programme in 2019 and the impacts on social benefits going forward. The impact of the CHPQA Programme on these Schemes was compared against the *investment counterfactual* or the absence of the CHPQA Programme over the life of the assets, whereby they would receive no financial benefits. This scenario applies the findings from the investment counterfactual to the cohort of new schemes and does not apply any scheme specific findings on additionality relating to these new Schemes.

Using the investment scenario findings, this comparison provides an illustration of the social value that could be generated by the CHPQA Programme going forward without changes to the policy. The assessment included the quantification of differences in carbon emissions, primary energy consumption and air quality damage costs, as well as additional capital expenditure between the outturn (or factual) and the counterfactual scenarios over the lifetime of the assets. The asset life of all new CHP was assumed to be 20 years. Additional fixed operating costs were not included as the majority of the cost was likely to be within the long-run variable cost of fuel and fixed costs were unlikely to vary

[40] Non-grandfathered financial incentives include Carbon Price Support relief, Climate Change Levy relief, Enhance Capital Allowances and reduced Business Rates.

significantly between CHP and the alternative satisfaction of heat and power demand. The estimated net impacts over time were annualised to enable a comparison against the investment and operational scenarios to be made.

It is useful to amalgamate the results of the 'operational scenario' and the 'new schemes' scenario to understand the social value foregone should the CHPQA Programme as it currently stands come to an end but with existing renewable contracts still in place. Considered separately, the 'operational scenario' asks the policy question: "What would happen if, in 2019, CHPQA eligibility for non-grandfathered financial benefits ceased to be available for CHP Schemes (grandfathered financial benefits, such as ROC uplift, continuing to be honoured)?". For the 'new Schemes' scenario the policy question is: "What would happen if, in 2019, the CHPQA Programme ceased to be available in its entirety (i.e., both grandfathered and non-grandfathered financial benefits) for all new Schemes?". Putting it another way, taken together, these two scenarios provide an insight into the total social value *added* by the CHPQA programme over 2019. The implications of taking this view are explained in Section 3.

The potential social benefits from on-site CHP heat and power generation providing greater security of energy supply for organisations were not assessed due to complexities and uncertainties with quantifying this impact; considered disproportionate for the scope of this report.

These analyses provide an assessment of the net social benefits of the CHPQA policy package when compared to alternative policy scenarios (or counterfactuals, such as purchasing electricity from the grid and generating heat at the site via a gas boiler instead of having a CHP), thus offering insights as to the social value that might have been or could be facilitated by the CHPQA programme going forward.

### 2.5.4 Sensitivity Analysis

Low, central and high scenarios were developed to capture the sensitivity of the central results to seven core assumptions, which include the sampling, the efficiency of boilers, emissions from the grid, the social value of carbon, air quality damage costs and long-run variable costs of energy supply. The resulting uncertainty ranges estimates are provided within the respective output tables in section 3 and Annex 6.

## 2.6 Limitations of the Review

This subsection outlines the limitations of the evidence and analysis underpinning the review. It is structured in three parts:

- limitations inherent to gathering evidence ex-post;
- survey design and implementation; and
- data quality and granularity.

Finally, a summary of the mitigations that were introduced is also provided.

### 2.6.1 Limitations inherent to gathering evidence ex-post

The CHPQA Programme has been running for over two decades. CHP performance data is gathered annually; however, this concerns monitoring the Programme's implementation rather than its impact. Therefore, the review has required that evidence, such as the extent to which the CHPQA Programme influenced investment decisions, be gathered ex-post and, often, of activities that were taken a long time ago and harder to recall. The study sought answers concerning more recent investments where possible, to promote a more comparable sample, however naturally there were variations in the installation scenarios respondents selected. Therefore, the comparability, quality and accuracy of such evidence will have limitations.

### 2.6.2 Survey design and implementation

The survey was designed to answer specific research questions, whilst ensuring that it was not onerous or took too long to complete (around 30–60 minutes), appreciating that CHP Scheme RPs (or other representatives) had resource limitations. This has meant that some of the information collected lacks depth and requires interpretation.

The targeted stakeholders receive financial support via certification under CHPQA and, thus, could be prone to answer with bias. Furthermore, given that it was anticipated that RPs could struggle to find time and resources to respond to the survey, a tailored and proportionate engagement with different types of RP was required and despite this, response rates achieved were relatively low. This approach could have also affected the randomness of responses. A lack of randomness in the sample may have led to additional biases (e.g. selection bias) and, thus, affect the statistical validity of the results.

### 2.6.3 Data quality, granularity, and analysis

There could be limitations with the quality of responses, due to limited capacity and/or a lack of understanding of particular questions. Also, the low sample sizes for certain archetypes (e.g. 2%) increases the likelihood of the data not being representative of the whole population of those archetypes. Atypical responses regarding, for example, the counterfactual can have a disproportionate impact on the results particularly with a small sample.

The response rates shown in Table 3 include complete and partial responses so in respect of particular questions the effective response rate (the sample) can be much lower than indicated in that Table. It is clear the response rates varied noticeably across the archetypes. Larger capacity archetypes received greater focus during the sampling, achieving higher response rates, however none of the archetypes reached statistical significance[41]. In aggregate, the overall sample for the 1300 Schemes was closer to

[41] To reach a reasonable confidence interval of 90% with a margin for error of 5%.

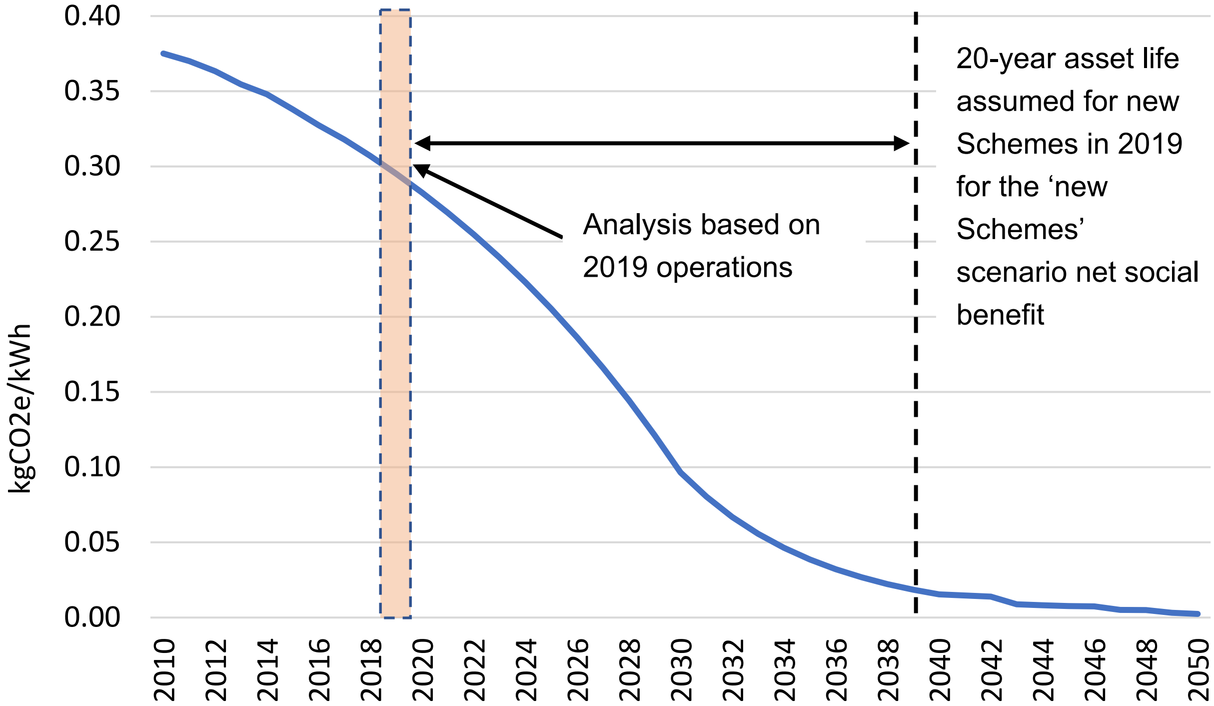
statistical significance but still fell short. Consequently, caution should be taken when interpreting the overall results and, in particular, when doing so for archetypes with low response rates.

The data limitations also affect the methods employed and analysis carried out. For example, there are limitations with the carbon emissions projections developed for the analysis of the social benefits for the 'new Schemes' scenario. Calculations of annualised carbon savings delivered by the current fleet of gas-fired CHP Schemes in this scenario are uncertain and likely to be conservative. The long-run marginal emission factor assumed for grid electricity displaced is 0.3 kgCO2e/kWh in 2019 and this decreases to 0.1 kgCO2e/kWh by 2030 based on the 2021 version of the Green Book Supplementary guidance. If this assumed value is lower than the actual grid emissions factor, then the carbon savings from CHP will be underestimated[42]. Many CHP operators interviewed during this work gave the view that their plant is likely to displace electricity generated by CCGT plant now and into the near future, as they believe CCGT is the most easily dispatched generation type. If this is the case in practice, then the carbon intensity of grid displaced electricity in the early years after 2019 will be somewhat higher than the values assumed in this study, leading to an underestimation of the carbon savings produced by CHP.

This could mean that the net social benefits reported here are underestimated, particularly for the 'new Schemes' scenario for Schemes newly enrolled in CHPQA in 2019. Figure 6 illustrates how the carbon emission factor for electricity from the national grid is profiled[43]. More specifically, the chart presents the long-run marginal emission factor for electricity generation consumed by industry in kilograms of CO2e emitted per kilowatt hour produced. By 2039, when Schemes installed in 2019 are assumed to reach the end of asset life, the long-run marginal emission factor of the grid is projected to have decreased to very low levels, significantly affecting the carbon emission savings attributed in the analysis to these new Schemes. In the analysis, Schemes are assumed to use the same quantity and type of fuel as reported in 2019 over the 20-year period.

[42] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal (2021 version)
[43] Ibid.

**Figure 6: Carbon emission from electricity generation – long-run marginal emission factor for industry (kgCO2e/KWh)**




Source: Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal (2021).

### 2.6.4 Mitigations

These limitations were identified during the scoping and design phase of this study, and actions were taken to mitigate or manage them as effectively as possible, including:

- The survey and stakeholder engagement strategy embedded approaches that sought to mitigate these issues, such as clarifying the questions to improve the respondents' understanding, reaching out to additional RPs to improve sample representativeness, overlaying the data with expert input to produce assumptions that allowed for a generalisation of the findings at the population level, etc.
- In some of the interviews, discussions took place to clarify, challenge, and review the evidence that had been provided via the survey. Most survey and interview data comparisons exhibited a good level of consistency, and only a few adjustments were made to the survey data based on the evidence gathered in the interviews.
- A comprehensive sensitivity analysis of the outputs from the survey data analysis was undertaken. This exercise considered how different sub-samples of the survey data and adjustments to core assumptions could affect the results.

Overall, the survey and interview data collected and the analytical outputs can be considered informative and useful for the formulation of policy, but only alongside other insights, studies and expert input. However, the data collected do not provide a statistically significant assessment of the CHPQA Programme. The experts leading this project consider the findings a reasonable reflection of the additionality of the Programme, providing the best evidence available to date, although caution should be exercised when interpreting results, particularly at the archetype level and for those with low response rates. Moreover, the study cannot capture the actual value of the social benefits that the CHPQA Programme has delivered since its inception in 2001, but only for the discrete year (2019) considered.

# 3. Review Outcomes

## 3.1 Net Social Benefits

Section 2.5.3 defined the investment and operational counterfactuals that were used to evaluate the additionality of the CHPQA Programme for a number of scenarios. It was further explained that these scenarios were established purposefully to examine the additionality of the CHPQA Programme and allow the net social benefits to be understood from a time perspective, i.e.:

- Net social benefit in 2019, by employing the investment counterfactual and evaluating the balance of societal costs and benefits for Schemes in operation (the investment scenario);
- Via operations, by employing the operational counterfactual and evaluating the balance of societal costs and benefits based on 2019 data (the operational scenario); and
- For new Schemes commissioned in 2019, by employing the investment counterfactual for new Schemes in 2019 and evaluating the balance of societal costs and benefits over the lifetime of the assets (the 'new Schemes' scenario).

The investment counterfactual describes what each Scheme operator would have done in the absence of the CHPQA Programme and eligibility for the financial benefits it confers. The operational counterfactual is how the operator would choose to operate their CHP Scheme if CHPQA eligibility for non-grandfathered Schemes was discontinued in 2019 together with the financial benefits conferred i.e., the reliefs from the main and CPS rates of CCL.

### 3.1.1 Investment scenario

Overall, the net social benefit in 2019 from the investment counterfactual was £1,070 million (2021 prices) with an uncertainty range of £480m to £2,570m from the sensitivity analysis. Results for the investment counterfactual are presented in Figure 7 and Table 4. As discussed elsewhere in this report, many Schemes have operated for a number of years and are, therefore, likely to have generated greater net social benefits in the past when the electricity grid was more carbon intensive than in 2019.

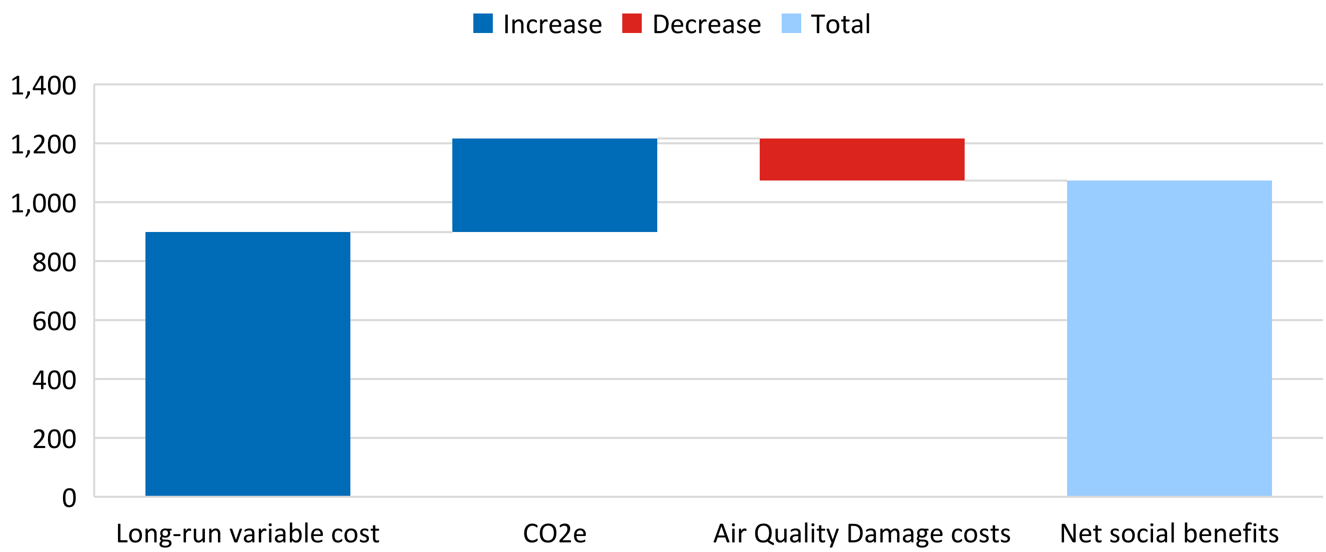
The CHPQA Programme is estimated to have accounted for 1.3 MtCO2e savings in 2019. For comparison, Chapter 7 of the Digest of UK Energy Statistics (DUKES)[44] estimates that carbon savings from CHP compared to the separate generation of heat and power were 3.5 MtCO2 in 2019. The estimate from this study is lower for the following reasons:

- In DUKES, all CHP output is assumed to be additional; i.e., that the counterfactual in every case is assumed to be grid electricity and heat generated in a boiler with a particular carbon intensity, whereas in this Additionality study only a proportion of schemes (defined by the survey responses) is additional with respect to a counterfactual;

The carbon intensity of the counterfactual heat in the DUKES calculation is for a hypothetical boiler that uses a mix of fossil fuels, not just natural gas; and

The carbon savings (CO2, not CO2e) estimated in DUKES are based on all CHP schemes, not just those in CHPQA, while the Additionality study is confined to CHPQA schemes.

**Figure 7: Investment scenario social costs and benefits in 2019 (£ million, 2021 prices)**




[44] https://www.gov.uk/government/statistics/combined-heat-and-power-chapter-7-digest-of-united-kingdom-energy-statistics-dukes

**Table 4: Investment scenario - Net Social Benefits in 2019**

| Schemes by archetypes | Monetised CO2e savings, (£m, 2021 prices) | Monetised LRVC savings, (£m, 2021 prices) | Monetised AQD impacts, (£m, 2021 prices) | Net social benefits 2019 (£m, 2021 prices) | Net social benefits from *low to high* sensitivity analysis, 2019 (£m, 2021 prices) | Net social benefits per MWh of fuel consumed (£/MWh, 2021 prices) |
|---|---|---|---|---|---|---|
| **Total*** | **320** | **900** | **-140** | **1,070** | **480 to 2,570** | **8.7** |
| Biomass (Large) | 290 | -20 | -90 | 180 | 10 to 510 | 15.1 |
| Biomass (Small) | 40 | -20 | -10 | 10 | -20 to 40 | 2.7 |
| CCGT – (ESCo) | [s] | [s] | [s] | [s] | [s] | [s] |
| CCGT – (Own Finance) | <5 | 480 | <5 | 480 | 270 to 990 | 10.2 |
| EfW | -30 | 60 | -20 | 10 | 0 to 30 | 1.9 |
| Engine (Large) > 3000 kWe (ESCo) | 10 | 20 | <5 | 20 | 10 to 60 | 7.5 |
| Engine (Large) > 3000 kWe (Own Finance) | 10 | 50 | -10 | 40 | 20 to 120 | 8.7 |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | -10 | 10 | <5 | <5 | 0 to 10 | 0.1 |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | <5 | 10 | <5 | 20 | 10 to 30 | 7.7 |
| Engine (Small) <= 500 kWe (ESCo) | <5 | <5 | <5 | <5 | 0 to 10 | 6.2 |
| Engine (Small) <= 500 kWe (Own Finance) | <5 | 10 | <5 | 10 | 0 to 20 | 11.1 |
| SCGT (Own Finance) | <5 | 20 | <5 | 20 | 10 to 50 | 2.8 |
| Other | [s] | [s] | [s] | [s] | [s] | [s] |

*Totals might not add up exactly due to rounding. Figures have been rounded to the nearest £10m apart from the last column on net social benefits per MWh of fuel consumed.*

*[s] data suppressed due to avoid potential disclosure of survey responses*

There is notable variation in the net social benefits across the archetypes when comparing the central estimates. These variations will be driven by the number of Schemes within the archetype, capacities, and general technology and fuel characteristics. This picture is likely to be further complicated by differing survey response rates, particularly if atypical responses were received for a particular archetype. However, general explanations that can be confidently advanced to explain the range seen are as follows:

- Additionality is represented in percentage terms by total power output for each archetype, indicating whether the CHPQA Programme was likely to have caused a CHP investment or whether it would have occurred regardless. The net social benefits are directly impacted by the additionality of the CHPQA Programme relative to an investment scenario where the Programme did not exist. For example, the two archetypes Engine (Small, ESCo) and Engine (Small, Own finance) have a similar number of Schemes and a similar capacity; however Engine (Small, ESCo) has 27% additionality when weighted by gross energy output compared to 64% for Engine (Small, Own finance) (see Table A6.1 in Annex 6). The higher additionality for Engine (Small, Own finance) results in a net social benefit per MWh fuel consumed of £11 per MWh compared to Engine (Small, ESCo) at £6 per MWh.
- The fuel efficiency benefits offered by a CHP Scheme relative to the counterfactual is also a driver of the net social benefits, since it leads to a reduction in primary energy consumption for the generation of heat and electricity, which has beneficial effects on LRVC and potentially carbon savings.
- Efficiency benefits from larger capacity Schemes such as from CCGT, which are typically large industrial Schemes, offer greater LRVC savings on fuel due to the scale of their operations.
- The technology and fuel of the CHP can impact the efficiencies offered. For example, Biomass (Large) predominantly uses pass-out condensing (PO/CO) steam turbines as the prime mover whereas in many cases for Biomass (Small) the prime mover technology is Organic Rankine Cycle (ORC). Electricity generating efficiencies are lower for ORC prime movers than for PO/CO steam turbines, and both tend to be lower than other CHP prime movers. Consequently, there tends to be increased long-run variable costs of fuel for Biomass (Large) and Biomass (Small), particularly the latter where ORC plant is commonly used.
- The carbon intensity of the fuel used impacts the carbon saving benefits accrued. An example is comparing the carbon savings from Biomass (Large) and EfW. The technology used in these two archetypes is predominantly PO/CO steam turbine and so efficiency of heat and electricity generation are expected to be similar. However, waste assumes a carbon emissions factor of 0.170 kgCO2e/KWh and biomass 0.015 kgCO2e/KWh resulting in very different monetised carbon impacts - positive in the case of biomass and negative for EfW.

The results of the net social benefits in the investment scenario are considered in more detail at the individual archetype level below, in order of decreasing total energy consumed.

### *Combined Cycle Gas Turbine (CCGT) (Own Finance) and CCGT (ESCo)*

The net social benefits for CCGT (Own Finance) in 2019, under the central sensitivity scenario were £480m. Nearly all net social benefits came from LRVC savings with marginal carbon savings. CCGT (ESCo) results are suppressed to avoid disclosure given the low number of survey respondents.

The LRVC savings will be driven by the energy efficiency benefits from generating large scale heat and power at these sites compared to the investment counterfactual which in many cases is stated as electricity from the grid and natural gas boiler for heat. The additionality of CHPQA in driving investment in CCGT CHP has been relatively high, with the responses for approximately 70% of the gross energy output (from 45% of Schemes) stating that, in the absence of the Programme, investment in CHP would not have taken place (see Table A6.1 and A6.2 in Annex 6).

Security of supply was a key factor in the investment decision, suggesting additional benefits from local energy generation, particularly when supplying heat to neighbouring customers. Environmental credentials and access to financial benefits were also both rated highly for CCGT Schemes, each at 4 out of 5. About a third of CCGT Scheme operators provided responses to the survey on their investment decision providing reasonable insights for this archetype.

### *Biomass (Large)*

The net social benefits for Biomass (Large) were £180m in 2019. The vast majority of social benefits are driven by the monetised carbon savings at £290m (2021 prices). Monetised air quality impacts are negative owing to an increase in local air quality issues resulting from greater biomass fuel combustion (-£90m). The impact on the LRVC of fuel is also negative (-£20m) due to the higher cost of supplying biomass fuels, whereas for all non-biomass archetypes there are positive LRVC savings. This is also a consequence of lower power and heat generating efficiencies from biomass than those typically seen in non-biomass CHP technologies.

The most important factors cited in making the decision to invest in this archetype included environmental credentials and financial benefits associated with CHPQA eligibility, which speaks to the carbon savings derived from this archetype (discussed above) and the importance of ROCs and NDRHI uplift in stimulating investment in this technology. The high importance of financial benefits is in agreement with the additionality of CHPQA in driving investment, with 100% of respondents stating that, in the absence of the CHPQA Programme, investment in biomass CHP would not have taken place.

Approximately 30% of Biomass (Large) RPs provided responses to the survey on their investment decision providing reasonable insights for this archetype.

### *Simple Cycle Gas Turbine (SCGT) (Own Finance)*

The net social benefits for SCGT (Own Finance) were £20m in 2019, almost entirely driven by LRVC fuel savings. Very low additionality was recorded for this archetype (21%), which had a significant impact on the social benefits. There is no salient evidence from the survey and interviews that explains this low additionality. One interpretation could be due to security of supply being a key factor for investment, potentially suggesting these Schemes would have happened regardless of CHPQA support, promoting secure energy supply above financial justifications. Also, full responses to the survey constituted just 17% of the total population of Schemes for this archetype, which is low, hence this sample may not be representative of the population.

A likely explanation for low additionality for older, more complex CHP Schemes is that the original investment may have been made before the CHPQA Programme began. Seven out of 10 of the survey responses for this archetype were for Schemes where the original investment was pre-2000, before the CHPQA Programme commenced, which is likely to explain the low additionality seen here. In this case, the infrastructure to serve these complex Schemes will already be in place, hence when the investment cycle comes around again, the tendency may be to just replace the existing plant on a like for like basis.

### *Energy from Waste (EfW)*

The net social benefits for the EfW archetype were £10m in 2019. While monetised LRVC savings are positive for this archetype (£60m), the monetised carbon and air quality impacts are both negative at -£30m and -£20m respectively.

The additionality for this archetype is 61%, which is approximately the average across all archetypes. The additionality is lower than for Biomass (Large), which would use the same technology (POCO steam turbines), and a likely explanation is that incinerating waste rather than sending it to landfill is a key driver and the logic of recovering power and heat from this incineration made a clear case for investing in CHP. This would make CHPQA less additional to the decision to invest than it would be in the case of Biomass (Large). This interpretation is supported by the ratings of factors driving the decision to invest in CHP, with the importance of financial benefits being quoted as the lowest amongst all the archetypes.

Survey responses were received from four of the six EfW CHPQA Schemes, indicating fairly good sample coverage of the total population.

### *Engines (Large) (Own Finance and ESCo)*

The net social benefits for the Engine (Large) archetypes were £40m and £20m for the Own Finance and ESCo archetypes respectively. For both archetypes LRVC savings was the single largest positive contributor to the social value at £50m and £20m, followed by the monetised carbon savings at £10m for both archetypes. The air quality savings were negative for the Own Finance archetype at -£10m which is explained by increases in local fuel combustion.

The additionality for both these archetypes is relatively high at around 60%. This tends to accord with the cited investment factors driving investment in CHP, with the score given for financial benefits from CHPQA being just “important” and no higher.

Complete survey responses were received from 27% of Schemes in the Own Finance archetype, but only 5% in the ESCo archetype, so the coverage of the total population is reasonably good for the Own Finance archetype but poor for the ESCo archetype.

### *Engines (Mid) (Own Finance and ESCo)*

The net social benefits for the Engines (Mid) archetypes were £20m for Own Finance and negligible for the ESCo archetypes, respectively. A small sample size means that results considered for these archetypes must be treated with care. For both archetypes the LRVC savings are positive at £10m, but the monetised carbon savings offset much of this benefit at -£10m for the ESCo archetype and <£5m for the Own Finance archetype. Air quality impacts are both negligible.

The additionality for these two archetypes is low (averaging around 35% as the upper estimate), which has a suppressing effect on the net social benefits. There is no salient feature in the survey responses that account for the low net social benefit, but a response rate of 14% and 11% for fully completed surveys for ESCo and Own Finance archetypes respectively, casts some doubt as to whether responses are representative of the population. Within the ESCo sample, one Scheme operator had selected an unusual investment counterfactual for a gas fired CHP, specifically a biomass boiler and grid electricity. It appears that this is skewing the result within the sample resulting in negative carbon savings, which is the main driver for the low net social benefits generated. This would also explain the positive air quality savings for the ESCo archetype, since a biomass boiler counterfactual would be associated with higher levels of air quality damage compared to a natural gas boiler. A more typical counterfactual would have been a gas rather than a biomass boiler, which has been seen across all archetypes.

### *Biomass (Small)*

The net social benefits for this archetype were £10m. While the monetised carbon savings are large (£40m), a great deal of this is cancelled out by negative LRVC savings (-£20m) and AQD savings (-£10m). The typically low efficiencies of CHP Schemes within this archetype – comprised often of Organic Rankine Cycle (ORC) units with inherently low power generation efficiency – is the main driver for the negative LRVC savings. The net social benefits are reduced further by the fact that biomass CHP produces high levels of air pollutants compared to the predominant counterfactual for this archetype (biomass boiler and grid), where the latter is associated with less biomass combustion.

The additionality for this archetype is high (approx. 98%) which compounds the low efficiency of generation and impact from air pollutants. The high levels of additionality are explained by the fact that financial benefits from CHPQA was cited as “very important” as a factor in driving the decision to invest in this archetype. Complete survey responses were received from 12% of Schemes within this archetype.

### *Engines (Small) (Own Finance and ESCo)*

The net social benefits for the Engines (Small) archetypes were £10m and <£5m for the Own Finance and ESCo archetypes, respectively. The sample size for the ESCo archetype is very low at 2%, the lowest of all the CHP archetypes, indicating a risk with making inferences from the results. The sample size for the Own Finance archetype is higher but still relatively low at 17%.

The additionality for the Own Finance archetype is found to be significantly higher than for the ESCo archetype (75% versus 42%) and this in part explains the differences in net social benefits between these two archetypes. This is supported by the financial benefits from CHPQA being cited as “very important” in the case of the Own Finance archetype, but just “important” in the case of the ESCo archetype.

## Key Points

Overall, the CHPQA Programme has produced significant net social benefits from supporting investment in CHP Schemes, generating £1,070m (2021 prices) of net social benefits in 2019 as a central estimate.

The net social benefits for any particular archetype is a complex combination of investment decision making (i.e. what is the counterfactual to CHP), technology (which determines efficiency and, therefore, LRVC savings) and fuel type (which determines carbon emissions savings). The diversity of net social benefits across archetypes is driven by different contributions made by each of these components. For example, Biomass (large) and both CCGT archetypes account for the majority of the social value at £180m for Biomass (large) and £480m for CCGT Own finance. The very high value of net social benefits for CCGT archetypes is explained above and relates to benefits from economies of scale to produce greater energy supply savings from the long-run variable costs. On the other hand, while producing high carbon savings, Biomass (Large) produces poor LRVC savings. This highlights a role for the CHPQA mechanism in promoting social value by driving greater efficiencies in the use of lower carbon fuels.

The sensitivity analysis suggests a large potential range in net social benefits from £480m to £2,570m. The CHPQA Programme is therefore likely to have delivered substantial social value even in the most pessimistic scenario at just under half the central estimate and has potential to be more than double in the optimistic scenario. The main drivers of this range are the carbon values, the long-run marginal emissions factor of the grid and boiler efficiencies assumed for the high and low scenarios in the counterfactual calculations.

### 3.1.2 Operational scenario

The net social benefits from the CHPQA Programme from an operational perspective is £370 million (2021 prices) of net social benefits in 2019. The results are presented in

Figure 8 and Table 5. The uncertainty range of net social benefits is £190m to £800m. The value of the net social benefits for this operational scenario is appreciably lower than for the investment scenario (£1,080m) but indicates that, overall, there is still notable social value from continuing with the CHPQA Programme for providing non-grandfathered benefits to Schemes.

Looking at the variation of net social benefits across archetypes, for all the non-biomass and non-waste archetypes (which are the archetypes most affected by this scenario, since EfW and biomass Schemes primarily receive non-grandfathered financial benefits) the total net social benefits are lower than in the investment scenario and significantly lower for many of the archetypes.

This result stems from the fact that the additionality brought about by this scenario (cessation of non-grandfathered benefits) is low for the affected archetypes because most CHP Schemes in these archetypes would choose to operate as they do at present, even in the absence of the financial benefits brought by the CHPQA Programme.

**Figure 8: Operational scenario social costs and benefits in 2019 (£ million, 2021 prices)**

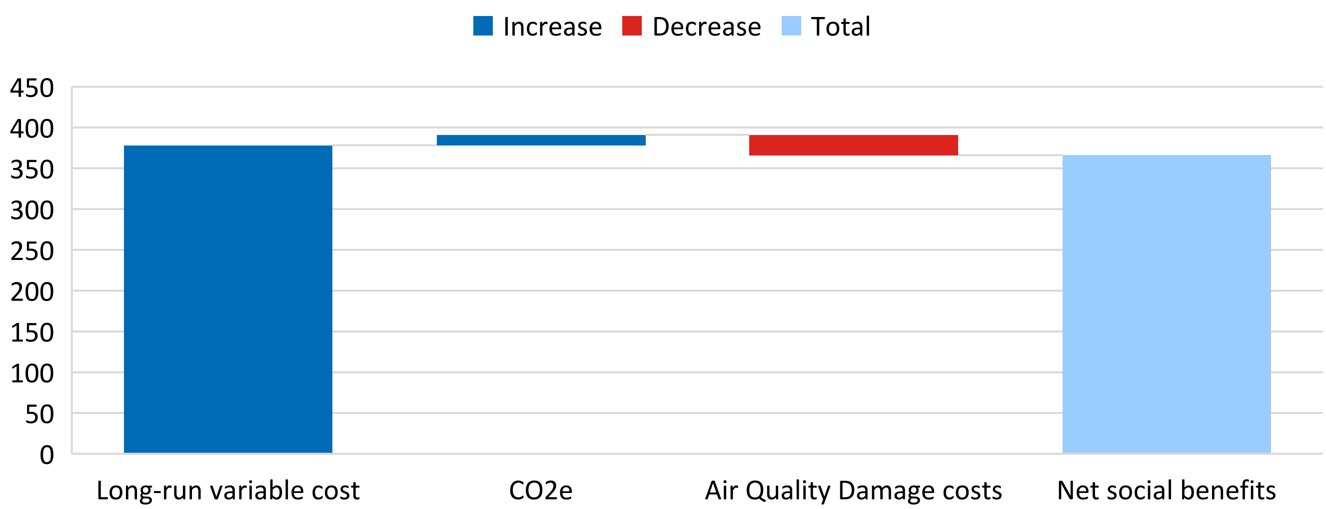


**Table 5: Operational social benefits in 2019 (2021 prices) (Biomass and EfW Schemes omitted since not relevant in this scenario)**

| Schemes by archetype | Monetised CO2e savings, 2019 (£m, 2021 prices) | Monetised LRVC savings, 2019 (£m, 2021 prices) | Monetised AQD impacts, 2019 (£m, 2021 prices) | Net social benefits 2019 (£m, 2021 prices) | Net social benefits low to high from sensitivity analysis, 2019 (£m, 2021 prices) | Net social benefits per MWh of fuel consumed (£/MWh, 2021 prices) |
|---|---|---|---|---|---|---|
| **Total** | **10** | **380** | **-20** | **370** | **190 to 800** | **3.0** |
| CCGT - (ESCo) | [s] | [s] | [s] | [s] | [s] | [s] |
| CCGT - (Own Finance) | <5 | 330 | -20 | 310 | 160 to 680 | 6.6 |
| Engine (Large) > 3000 kWe (ESCo) | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Engine (Large) > 3000 kWe (Own Finance) | <5 | 30 | <5 | 40 | 20 to 60 | 7.2 |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | <5 | 10 | <5 | 10 | 0 to 20 | 3.4 |
| Engine (Small) <= 500 kWe (ESCo) | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Engine (Small) <= 500 kWe (Own Finance) | 0 | 0 | 0 | 0 | 0 | 0.0 |
| SCGT (Own Finance) | <5 | 10 | <5 | 10 | 10 to 30 | 1.8 |
| Other | [s] | [s] | [s] | [s] | [s] | [s] |

*Totals might not add up exactly due to rounding. Figures have been rounded to the nearest £1 million. The last column presents units in net social benefits per MWh of fuel consumed.*

*[s] data suppressed due to avoid potential disclosure of survey responses.*

There are two possible explanations for these findings:

- The energy cost savings associated with continuing CHP operations present notable value to the operator, even in the absence of non-grandfathered financial benefits, since the plant has already been invested in;

and/or:

- Some CHP operators have obligations to 3rd parties to supply heat and electricity which cannot be met by other energy supply options, and so, regardless of the impact of the removal of non-grandfathered benefits, the CHP would continue to be operated in the same way. There is evidence for this second point in the results where, within archetypes of the same technology and size, the net social benefits tend to be lower or even zero for the ESCo option than for the Own Finance option, as ESCos are more likely to have obligations to 3rd parties.

There is also evidence for this from the interviews carried out, where a number of interviewees have cited exactly these two factors.

This finding that net social benefits for the operational scenario are lower than the investment scenario is consistent with evidence from the interviews. A number of interviewees stated that, while the financial benefits available via the CHPQA mechanism were important in getting the decision to invest in CHP over the line, the value of the energy savings delivered thereafter are sufficient to justify the continued operation of the CHP even in the absence of the financial incentives.

The greatest CHPQA additionality and net social benefit in this operational scenario is found in the CCGT (Own Finance) archetype. There is also evidence in the survey results that larger CHP Schemes would be more likely to change away from their current CHP operation in response to this scenario. For example, 45% and 42% (weighted by gross energy output) respectively of Large Engines (Own Finance) and SCGT (Own Finance) operators indicated that they would either run their existing CHP less or stop running it altogether if non-grandfathered financial benefits were ceased. By contrast, only 9% of Small Engine (Own Finance) operators indicated that they would change from their current CHP operations in response to this scenario. These large CHP archetypes are more likely to be found at industrial sites. The significance of this is explained in more detail below.

## Key Points

There is a quantitative difference between the additionality offered by the CHPQA Programme at the time when investment decisions are being made and when the CHP Scheme has been in place and been operating for many years. The results presented for the net social benefits under the investment scenario for 2019 indicate that the CHPQA Programme and the benefits it confers has a material influence on investment decisions, with CHPQA tending to promote an investment choice in favour of CHP. On the other hand, the results presented for the operational scenario indicate that, where a Scheme receives non-grandfathered financial benefits, the removal of these financial benefits would affect fewer operational decisions than investment decisions, with decisions to continue operating in the same way predominating. One explanation for this is that the investment may already have been recovered and only the marginal operating cost is affected.

There is an indication in the results that “Own Finance” archetypes tend to display more additionality compared to the “ESCo” archetypes of the same technology. This is consistent with a situation where ESCos have obligations to third parties to continue supplying electricity and heat, whereas for own finance Schemes there is greater freedom to react to such a change in the financial benefits by changing the way in which heat and electricity are sourced.

There is also some evidence from the interviews that some sites would find the cessation of non-grandfathered financial benefits material to the overall cost effectiveness of operations to the extent that a crucial competitive advantage would be lost. In the case of industrial sites, this could lead to a loss of competitiveness against other European sites, with a possible implication for production being lost overseas. This is consistent with the highest additionality being found for CCGT (Own Finance) – an archetype almost exclusively found at industrial sites.

This, taken with the investment scenario, indicates that the additional cash flows associated with financial benefits via CHPQA eligibility are material to getting the investment decision over the line. While a combination of normal operational cost savings associated with CHP and third-party obligations to continuing running CHP can provide sufficient financial incentive or reason to continue CHP operations in the absence of the non-grandfathered financial benefits.

Once the investment is made, Schemes that have already achieved payback would experience lower positive cash flows than before if non-grandfathered financial benefits were stopped. For Schemes still in the payback period, these would have to accept a slightly longer payback and, after payback had been achieved, lower positive cash flows. The additionality results indicate that these reductions in cash flows are more likely to have a material impact on operational decisions at industrial than at non-industrial sites.

### 3.1.3 ‘New Schemes’ scenario – Annualised net social benefits from new Schemes in 2019

The annualised net social benefits for the ‘new Schemes’ scenario is £6 million (2021 prices) with a sensitivity range from -£7m to £15m. In this scenario, only new Schemes in 2019 were assessed over an investment lifecycle of 20 years and the cash flows included capital expenditure. During 2019 there were 105 new Schemes certified under CHPQA. The results are presented in Table 6 and Figure 9.

Assessing the net social benefits over the lifetime addresses an issue with the CapEx skewing the impact in the first year of operation and incorporates the fact that newly installed CHP is likely to run for many years, during which time grid electricity displaced in the counterfactual becomes progressively less carbon intensive.

The survey response rate for CHP Schemes relevant to the ‘new Schemes’ scenario was noticeably low, hence caution should be applied when interpreting the results of this scenario.

Annualised energy supply savings were £9m, with emissions of 7 ktCO2e resulting in a cost of £2m, negligible air quality impacts and annualised additional capital expenditure (CapEx) of £1m. CapEx is included since this scenario observes the lifetime of the asset and so it is appropriate for the analysis to include the CapEx of CHP which is over and about that of the relevant counterfactual technology (i.e. additional CapEx). The analysis assumes that there is no increment of additional CapEx associated with grid connections for the counterfactual with respect to the CHP investment case.[45].

[45] Electrical grid network constraints will mean some new sites may require network investments to satisfy their electrical demand currently being met through CHP operations. This is more likely for sites with high-capacity CHP in network constrained regions.

**Table 6: ‘New Schemes’ scenario – Annualised net social benefits – new Schemes in 2019 (2021 prices)**

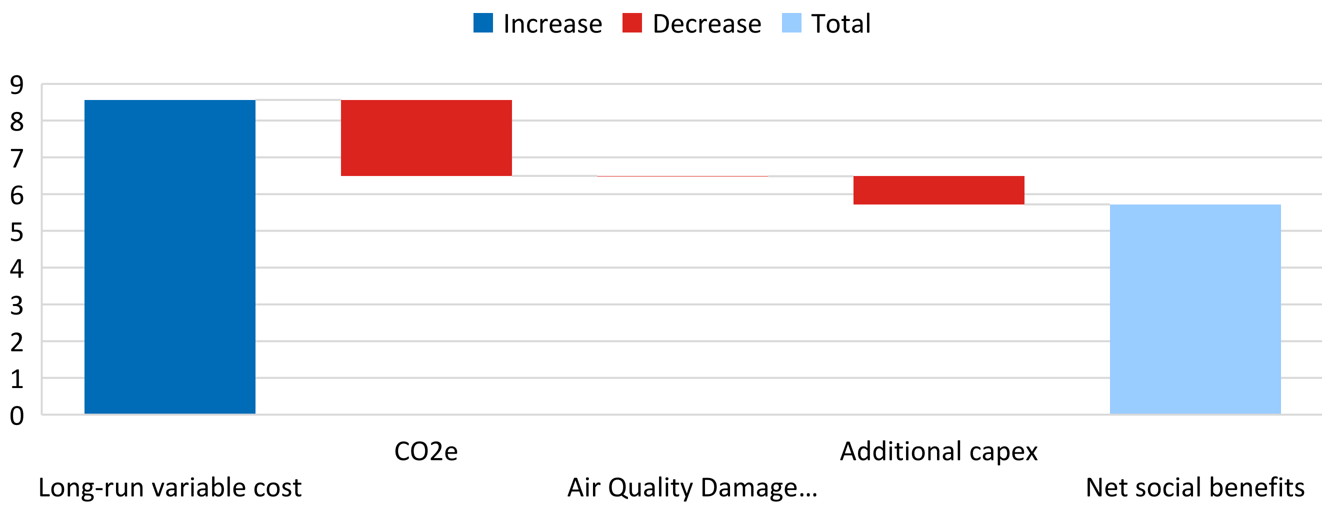
| Schemes by archetype | No. of new Schemes in 2019 | Monetised CO2e savings, (£m, 2021 prices) | Monetised LRVC savings (£m, 2021 prices) | Monetised AQD impact (£m, 2021 prices) | Additional capital expenditure, (£m, 2021 prices)* | Net social benefits (£m, 2021 prices) | Net social benefits low to high from sensitivity analysis (£m, 2021 prices) | Net social benefits per MWh of fuel consumed (£/MWh, 2021 prices) |
|---|---|---|---|---|---|---|---|---|
| Total | 105 | -2 | 9 | <0.5 | -1 | 6 | -7 to 15 | 6.8 |
| Biomass (Small) | 3 | 0.2 | <0.5 | <0.5 | <0.5 | <0.5 | 0 to <0.5 | 6.3 |
| Engine (Large) > 3000 kWe (ESCo) | 5 | <0.5 | 4 | <0.5 | <0.5 | 3 | -4 to 8 | 9.7 |
| Engine (Large) > 3000 kWe (Own Finance) | 5 | -1 | 2 | <0.5 | <0.5 | 1 | -1 to 2 | 4.3 |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | 11 | -1 | 1 | <0.5 | <0.5 | <0.5 | -1 to 1 | 2.9 |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | 7 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 to 1 | 7.0 |
| Engine (Small) <= 500 kWe (ESCo) | 41 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 to 1 | 7.0 |
| Engine (Small) <= 500 kWe (Own Finance) | 26 | <0.5 | 1 | <0.5 | <0.5 | <0.5 | 0 to <0.5 | 3.7 |
| SCGT (Own Finance) | 4 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 0 to <0.5 | 4.6 |
| Other | [s] | [s] | [s] | [s] | [s] | [s] | [s] | [s] |

*Compared capital expenditure for equivalent generation of heat and power separately

*[s] data suppressed due to avoid potential disclosure of survey responses*

*No new Schemes from Biomass (large), CCGT (ESCo), CCGT (Own Finance) and EfW archetypes occurred in 2019, hence have been excluded from the table.* Note change in rounding compared to other tables from tens of millions to one million.

**Figure 9: 'New Schemes' scenario annualised social costs and benefits from CHPQA schemes commissioned in 2019 (£m, 2021 prices, discounted)**




It was not possible to assess four of the archetypes (Biomass (Large), CCGT (ESCo), CCGT (Own Finance) and EfW), as there were no examples of these archetypes appearing as new Schemes in 2019. The vast majority (92%) of the fuel is consumed in engines and a large majority of this is natural gas. In these cases, the net social benefits accrue from good LRVC savings relative to the counterfactual, which in turn are a result of the primary energy savings that CHP offers relative to the usual counterfactual of grid and heat only boiler. However, these are more than outweighed by negative value of carbon savings (£CO2e) accrued over the period of the investment. This arises from the assumption that the carbon intensity of the grid electricity displaced by the CHP falls appreciably over the period of the evaluation while over the same period the carbon intensity of the gas used in gas fired CHP is assumed to be constant. The gap between the two intensities grows over time such that the discounted carbon savings are negative (i.e. suggesting that gas fired CHP plants will not generate future carbon savings when compared to the counterfactual).

## Key Points

When evaluating net social benefits over an extended period of time, any differences between the CHP Scheme and the counterfactual accumulate. This is especially the case for carbon savings, where the electricity displaced in the counterfactual is from a steadily decarbonising grid, producing negative carbon savings that grow over time.

The reduction in net social benefits is predominantly driven by negative carbon savings returned over the lifetime of the asset as progressively lower carbon grid electricity is displaced.

Social value from CHPQA will decrease noticeably in the future if CHP Schemes continue to burn 100% natural gas. From our interactions with the market, we believe that this issue is well understood by CHP developers and options for flexible CHP capable of burning natural gas/hydrogen blends at a range of hydrogen concentrations are now available on the market. Under this likely scenario, the increase in monetised carbon costs will be lower and could lead to carbon savings. This is discussed further in Section 3.2 below.

### 3.1.4 Combining the Operational scenario with the 'New Schemes' scenario

As discussed in Section 2.5.3, amalgamating the results of the 'Operational scenario' and 'new Schemes' scenario allows us to answer the policy question: 'what would happen if a policy decision was taken in 2019 to remove eligibility for all financial benefits currently conferred by CHPQA (predominantly being the non-grandfathered financial benefits). This means that existing Schemes in 2019 would have their access to non-grandfathered financial benefits stopped and new Schemes would have no access to the same financial benefits. This provides an indication of the net social benefits forgone in this combined scenario and most closely aligns with what the CHPQA Programme would offer today in 2026. When amalgamating the operational scenario for existing Schemes and the investment scenarios for new Schemes results in total social benefits of £372m (2021 prices) for 2019. The operational scenario contributes £366 million when expressed to the nearest £1 million (rather than the nearest £10 million) and adding £6m of benefits from the 'new Schemes' scenario gives the combined total of £372 million).

These scale of the net social benefits support the view that continuing with CHPQA in its current form derives social value. This analysis assumes the findings using 2019 data is a reasonable representation of the impact from the CHPQA Programme today, in 2026. It is likely the operational impacts from the CHPQA Programme in 2019 are similar to today's as the CHPQA eligibility criteria for non-grandfathered financial benefits have not been changed recently, and in the last few years a similar quantity of new CHP capacity has enrolled onto the Programme. However, this view is sensitive and susceptible to change, depending on the number and type of new Schemes that would join CHPQA during the year under consideration. A large number of gas-fired CHP Schemes joining CHPQA (larger than in 2019) is likely to negatively impact the net social benefits as the grid continues to reduce emissions from electricity generation. It is worth noting that NDRHI incentives were only available to new CHP Schemes up to 2021 and this may lead to a decrease in the quantity of new biomass

## 3.2 Low carbon technologies being considered by CHPQA participants

The survey and interviews sought to explore what low carbon technologies (CHP and other options) CHPQA participating organisations were considering in the context of the UK's net zero targets.

In the survey, RPs were asked (question 37) what generic options they might consider over the next 10 to 20 years to align with the government's 2050 Net Zero target. Respondents were able to select more than one option. The outcome is shown in Table 7 -

respondents were able to select more than one option so the percentages for particular archetypes and all archetypes can add up to more than 100%.

Weighting the responses by gross energy output and extrapolating to the total population suggests that operators of an estimated 86% of CHP Scheme heat and power output would consider continuing with their CHP Schemes and abate any associated carbon and/or pay carbon costs; almost 75% would also consider replacing their CHP Schemes with non-CHP renewable sources of energy generation, such as heat pumps; and nearly 40% would consider replacing fossil fuelled CHP with CHP operating on renewable fuels such as biomass, biomethane or hydrogen. An estimated 30% would consider alternative locations for production, indicating a risk of the UK losing industrial capacity if the costs to industry prove too high. Finally, only a few percent would consider undertaking resource or energy efficiency measures.

**Table 7**: **Generic future options being considered by CHPQA participants in the context of the UK's 2050 Net Zero target**

| Scheme by archetype | Continue with CHP and abate any associated carbon and/or pay carbon costs | Replace fossil fuel CHP with renewable CHP e.g., biogas, biomass, hydrogen | Replace CHP with non-CHP renewable energy generation e.g., heat pumps | Undertake resource or energy efficiency measures | Consider alternative locations for production | Other |
|---|---|---|---|---|---|---|
| Total | 49% | 42% | 67% | 6% | 13% | 19% |
| Biomass (Large) | 0% | 33% | 33% | 0% | 33% | 67% |
| Biomass (Small) | 20% | 30% | 40% | 0% | 20% | 40% |
| CCGT - (ESCo) | [s] | [s] | [s] | [s] | [s] | [s] |
| CCGT - (Own Finance) | 100% | 63% | 100% | 0% | 25% | 25% |
| EfW | 100% | 100% | 100% | 0% | 0% | 0% |
| Engine (Large) > 3000 kWe (ESCo) | 33% | 33% | 33% | 0% | 33% | 67% |
| Engine (Large) > 3000 kWe (Own Finance) | 78% | 44% | 72% | 11% | 6% | 6% |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | 62% | 77% | 77% | 15% | 8% | 31% |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | 59% | 53% | 47% | 18% | 12% | 18% |
| Engine (Small) <= 500 kWe (ESCo) | 71% | 14% | 29% | 0% | 0% | 0% |
| Engine (Small) <= 500 kWe (Own Finance) | 30% | 34% | 79% | 2% | 13% | 13% |
| SCGT (Own Finance) | 50% | 40% | 50% | 10% | 20% | 30% |
| Other | [s] | [s] | [s] | [s] | [s] | [s] |

*Note respondents could select multiple options hence totals across rows can exceed 100%. Sample of participant, N = 156*

*[s] data suppressed due to avoid potential disclosure of survey responses*

### 3.2.1 Low-carbon CHP options

The interviews allowed more technology specific responses to be explored and this section describes the outcomes.

#### Hydrogen

Combustion of a natural gas/hydrogen blend in existing CHP plants was the most frequently cited route towards decarbonising CHP, as it allows for existing plants to be used without the need for significant modification or replacement of equipment (depending on the percentage of hydrogen in the blend). The operators of 26 out of 35 Schemes interviewed responded that they were considering hydrogen options, and a further five have either installed or are actively considering installing hydrogen-ready boilers to enable 100% hydrogen usage.

A significant number of interviewees (12 out of 35) emphasised the prevailing uncertainty as to what sources of hydrogen might become available and when; although generally there was a presumption that hydrogen will become available in a blended form within the gas grid.

In respect of hydrogen, interviewees made the following policy suggestions:

- Provide clearer policy direction on hydrogen supply and transport infrastructure.
- Provide grant funding to overcome the large capital costs of installing new or modified CHP plant that can run on pure hydrogen, and to cover the cost of hydrogen production infrastructure.
- Introduce additional incentives via CHPQA certification to encourage the adoption of low carbon fuels, such as hydrogen, for CHP.

#### Carbon Capture Utilisation and Storage (CCUS)

From the interviews, operators of eight large industrial CHP Schemes are considering CCUS as a decarbonisation option. These are all located near industrial hubs that have access to proposed CO2 transport links within the East Coast Cluster, Scottish Cluster, and HyNet cluster (Liverpool Bay area). Despite this, all raised concerns over the risk of insufficient development of CO2 transport infrastructure to make CCUS possible.

Interviewees made the following policy suggestions:

- Government incentives are needed to encourage the selling and trading of negative emissions - this could be implemented via the existing UK ETS.
- New levies could be introduced to encourage the adoption of CCUS.
- Link CHPQA financial benefits to carbon to motivate decarbonisation, including via CCUS.

### Biogases and bioliquids

The potential for the use of biogases (particularly biomethane) and liquid biofuels were cited by a number of respondents, with most considering biomethane sourced through the gas grid or biomethane/ biogas production on-site, using locally sourced organic material as a practical solution. Views on liquid biofuels were less positive with insufficient supply, unclear fuel specifications, and a lack of infrastructure cited as issues.

Interviewees made the following policy suggestions:

- Flexibility in the treatment of off-site biomethane generation in respect of using certificates for compliance in policies such as CHPQA and UK emissions trading Scheme (ETS) to encourage investment at the most economically advantageous locations, which may not necessarily be the site needing to comply.
- The government should incentivise the adoption of low-carbon fuels by linking their cost back to traditional fuels.
- The cost of new fuels should be levelled out to encourage competition with fossil fuels.

### Solid biomass

Biomass appears to not be viewed by respondents as a significant opportunity for decarbonisation. Challenges relating to fuel delivery, uncertain green credentials, the need for large spaces for fuel storage and plant, and high labour requirements were cited. Biomass could play an important role in decarbonisation in some sections of the economy, provided that sufficient safeguards are in place to ensure its sustainable use. However, it is recognised that it is a limited resource and should be prioritised where it provides the greatest benefits.

## 3.2.2 Low-carbon non-CHP options

### Heat pumps

Of non-CHP options, heat pumps were the most frequently cited (by 12 of the 35 interviewees) alternative to fossil fuelled CHP, particularly where the heat requirement is already at a relatively low temperature, or where a switch from steam to low temperature hot water is feasible, such as hospitals and higher education campuses. Nevertheless, the high costs associated with converting away from an existing steam network, space requirements for ground arrays and boreholes, and electricity network reinforcement costs can restrict the opportunities for heat pump deployment.

Interviewees made the following policy suggestions:

- Disincentivise the use of unabated natural gas to help encourage the adoption of heat pumps.

- Incentivising power export from on-site complementary renewables (PV and wind) to support grid stressed areas could improve the case for heat pumps in some circumstances.

## 3.3 CHPQA and its administration

Through the survey and interviews, feedback was sought from RPs on:

- costs incurred by organisations from participation in the CHPQA Programme;
- whether they and their organisations used and found helpful the CHPQA Programme's services;
- suggestions as to how the Programme could be improved from the user's perspective; and
- whether they thought the Programme could be used to achieve greater energy efficiencies in the future, and whether they agreed that a carbon metric should be introduced into CHPQA given the government's 2050 Net Zero target.

### 3.3.1 Recurring costs of participation for CHPQA Certification

Some recurring costs cited in responses as being associated with administrative aspects of a CHP Scheme could not reasonably be attributed solely to the reporting requirements for CHPQA, while others could. It is likely, therefore, that some of the high values provided by survey participants are due to respondents including costs for activities that are not purely additional as a result of CHPQA certification and compliance.

Table 8 groups the responses given for recurring costs under generic activities. These are categorised according to whether these can be considered activities required for CHPQA certification, as opposed to activities which would have to be undertaken anyway in respect of the day-to-day operation of the CHP Scheme, irrespective of CHPQA requirements. Justification for this is also given. Table 9 also includes a bottom-up estimate from first principles of the time and costs associated with each activity. The most significant recurring administrative cost associated with a Scheme is likely to be meter calibration.

Regarding the costs of meter calibration, we have carried out, for all CHP Schemes in 2019, an estimate of this based on CHPQA data identifying all meters and meter types, approximate costs of calibration and calibration intervals. This gives estimated mean and median calibration costs as shown in Table 8.

**Table 8: Participant administrative activities and attribution to CHPQA**

| Generic Activity Type Cited by Survey Response | Attributable to CHPQA Certification | Justification | Approximate Cost (where deemed relevant) |
|---|---|---|---|
| Meter calibration | Yes | Explicit requirement under CHPQA. Performance penalty paid if requirements not met. | Mean: £8,000<br>Median: £5,850 |
| Meter repairs. | No - not additional. Would have to do this anyway. | Good functioning meters are a commercial imperative for a well-run CHP Scheme, regardless of CHPQA status. | |
| Collection of data (monthly). | No - not additional. Would have to do this anyway. | Collection of data at a monthly granularity is considered the bare minimum for the efficient running of a CHP Scheme, regardless of CHPQA status. | |
| Manual meter readings (some sites) | No | Reading meters is part of data collection and is part of running an efficient CHP Scheme, regardless of CHPQA status. | |
| Preparation of F4 form (2 hours for F4s, 1 day for F4) | Yes | Explicit requirement of CHPQA. No certification without it. | F4s = 2 hrs/Scheme/year x £250/day = £63/Scheme/year; F4 = 1 day/Scheme x £250/day = £250/Scheme/year. Take £250/Scheme/year as worst case. |
| Preparation of PP10 and PP11 forms | No – not a CHPQA requirement (HMRC forms) | Not a requirement of CHPQA – a tax matter. | |
| Attendance at audits (once every 3 years. 1 day to attend plus 1 day to prepare. | Yes | Explicit requirement of CHPQA. Certification not granted if audit is not attended. | 0.67 days/Scheme/year x £250/day = £168/Scheme/year |
| Attendance at training workshops. (1 day per year) | Yes | Deemed to a necessary for an RP to keep abreast of developments. | 1 day/RP/year x £250/day = £250/RP/year |
| Total | | | Mean: £8,670<br>Median: £6,520 |

Using this bottom-up approach, the annual recurring costs for all CHP Schemes in 2019 comes to an estimate of £12m. This represents just 4% of the CPS and CCL reliefs on fuel inputs estimated by HMRC for the financial year 2023/24 (£370m). This estimate does not account for overlaps with other tax exemptions or other financial benefits such as CCL relief on power output, NDRHI and ROCs.

Whilst the range of recurring costs was very large, the median derived from survey respondents was very similar to that derived bottom-up for the whole population of Schemes; in both cases the financial benefits derived by the Scheme significantly outweigh the annual recurring costs.

### 3.3.2 Usefulness of CHPQA Programme services

Survey respondents were asked to rank different aspects of CHPQA services; the collated outcomes of the responses by archetype are presented in Table 9

**Table 9: Participant scoring of CHPQA services - not useful (1) to very useful (5)**

| Scheme Archetypes | Helpline/ online help facility | Workshops/ learning modules | 'Simplified' guides | Detailed guidance notes | Audit function | CHP Focus on gov.uk, |
|---|---|---|---|---|---|---|
| Biomass (Large) | 4 | 3 | 4 | 4 | 3 | 2 |
| Biomass (Small) | 3 | 3 | 2 | 3 | 3 | 2 |
| CCGT – (ESCo) | [s] | [s] | [s] | [s] | [s] | [s] |
| CCGT – (Own Finance) | 4 | 4 | 4 | 4 | 4 | 2 |
| EfW | 4 | 3 | 2 | 5 | 4 | 1 |
| Engine (Large) > 3000 kWe (ESCo) | 5 | 4 | 3 | 5 | 4 | 1 |
| Engine (Large) > 3000 kWe (Own Finance) | 3 | 3 | 3 | 4 | 3 | 1 |
| Engine (Mid) > 500 kWe <= 3000 kWe (ESCo) | 5 | 3 | 3 | 5 | 4 | 1 |
| Engine (Mid) > 500 kWe <= 3000 kWe (Own Finance) | 3 | 4 | 3 | 3 | 3 | 1 |
| Engine (Small) <= 500 kWe (ESCo) | 2 | 4 | 3 | 4 | 2 | 2 |
| Engine (Small) <= 500 kWe (Own Finance) | 4 | 3 | 3 | 3 | 1 | 1 |
| SCGT (Own Finance) | 1 | 3 | 3 | 3 | 3 | 1 |
| Other | [s] | [s] | [s] | [s] | [s] | [s] |
| **Average** | **3.5** | **3.2** | **3.0** | **3.7** | **2.8** | **1.3** |

*Sample of participant, N = 201*

*[s] data suppressed due to avoid potential disclosure of survey responses*

Overall, RPs highlighted that they have found the detailed guidance notes particularly useful, followed by the helpline or online help facility that offers support to CHPQA participants and the workshop and learning modules. RPs have consistently found the CHP focus web pages and case studies on the Gov.UK page, which are aimed at those exploring CHP investment, as the least useful. This is perhaps not surprising as RPs represent organisations that have already invested in CHP.

There was a mixed response regarding the CHPQA website/portal, with 21% saying that they found it useful, and 21% saying that they had experienced issues. Additional feedback from interviewees suggested that query responses times were good with only two respondents saying that response times were slow. Two respondents reported that they had experienced difficulties in setting up a new RP on the system, which suggests that there is scope for an improvement in the administrative process in this respect.

### 3.3.3 Suggestions for improvements

Out of a total of 102 responses, 63 suggested minor adjustments that would improve the Programme. The majority of suggestions concerned adjusting the online forms and template (54 of the 63), two suggested that the portal could be improved, and a range of potential improvements were suggested by one respondent each, including in relation to the guidance notes, submission dates, annual webinars, and alignment with other related systems. Annex 3 provides a breakdown of responses by archetype.

The interviews provided a few further suggestions:

- There would be value in providing training for new RPs and junior engineers, including more basic information or guidance.
- More automation could be introduced (e.g., bulk uploads/downloads) along with other portal improvements.
- More guidance for other related systems would be useful, such as CPS, CCL, and EU ETS.

### 3.3.4 Future value of the Programme

95% of RP survey respondents reported that their organisation believes that the CHPQA Programme and any services it provides will be valuable to them in the next 3 years, and 90% of the same RP respondents also agreed that the CHPQA Programme could be used for implementing new policies to achieve greater energy efficiencies.

A range of comments were made regarding implementation of carbon benchmarking within CHPQA as follows:

- Consistency was needed across all policies in respect of carbon dioxide accounting, including CHPQA, CCAs, UK ETS, the Energy Savings Opportunity Scheme (ESOS), etc.
- There needed to be a consistent government approved methodology for assigning CO2 emissions factors to Energy from Waste and Heat Network systems.
- Inclusion of emissions that damage air quality (e.g., NOx and particulates) in CHPQA should be considered alongside carbon.
- There was a risk of duplication with other policy measures, particularly UK-ETS (see section 3.4.1).
- CHP carbon emissions should be compared on the basis of the actual power generation that would be displaced, which would be gas-fired CCGT plant and not renewables such as wind and hydro.
- Individual operators should not be penalised if lower carbon fuels were not available to them or were disproportionately expensive. Ultimately, the cost of alternative fuels needed to be levelised or socialised.
- Flexibility in achieving any carbon benchmarks via the use of green gas certificates for biomethane should be allowable under CHPQA, though currently not allowed under the UK ETS (see section 3.4.1).

## 3.4 Other insights

### 3.4.1 Interactions with UK Emission Trading Scheme (ETS) and Climate Change Agreements (CCAs)

Interactions between CHPQA with the UK ETS and CCAs were raised as complicating issues by a number of RPs during interviews. The key points raised are as follows:

- There is a policy disjuncture between the financial benefits arising from high efficiency via CHPQA and the costs imposed by the UK Emissions Trading Scheme where the allocation of free allowances was being reduced and the allowance price was increasing.
- RPs have to gather data and submit across different portals for CHPQA, UK ETS and CCAs. Some rationalisation to reduce duplication and simplify reporting, perhaps via a common system/platform, would be beneficial. All relevant policies need to be aligned on common standards and protocols for reporting as far as possible and thus streamline energy and carbon reporting.
- Government should recognise biomethane as a low carbon fuel demonstrated by green gas certificates in a revised CHPQA and in the UK ETS.
- There is a risk of offshoring of emissions if abatement or plant replacement become too expensive as a consequence of UK ETS and/or revised CHPQA requirements.

### 3.4.2 Sector specific issues

#### Controlled Environment Horticulture

Representatives of the controlled environment horticulture sector highlighted the risk that CHP Schemes in their sector would be severely penalised if carbon sequestration by the crops was not recognised by government in CHP policy and the UK ETS future policies. Much of the controlled environment horticulture industry uses gas-engine CHP to provide carbon dioxide (as well as heat and power) to enrich the growing atmosphere of the greenhouses. CHP is the most cost-effective way of providing the carbon.

If for example such Schemes were exposed to the full ETS (currently they tend to be covered by the small emitter provisions) or to full CPS then the viability of business models underpinning controlled environment horticulture in the UK would experience a negative impact.

#### Paper Industry

Paper industry representatives emphasised that CHP was a critical factor for most UK papermills in maintaining a competitive position within Europe. This is due to the energy intensity of the industry requiring significant and almost continuous demands for process heat and power and the close fit of the balance of CHP outputs with these energy demand patterns.

# 4. Conclusions

## 4.1 Analytical conclusions

Since 2001 when the CHPQA Programme was introduced alongside the Climate Change Levy (CCL) and other related mechanisms such as the Climate Change Agreements (CCAs), there have been various policy changes affecting CHPQA, including:

- Changes in Quality Index (QI) formulae parameters (X and Y values)[46] in response to improvements in the efficiencies of power generating and heat raising equipment, thereby maintaining consistency with the EU reference values for the separate generation of heat and power.
- Employing CHPQA as the route to accessing additional financial benefits under the Renewables Obligation and Non-domestic Renewable Heat Incentive.

[46] Simple guide to good quality CHP and the quality index value

Since 2001 new CHP Schemes have joined CHPQA, and old Schemes have closed. This review of the additionality of CHPQA and its associated net social benefits are therefore a snapshot, using operations in 2019 as being the most recent representative year for Scheme data held by the Programme given the upheavals of the COVID-19 pandemic.

- The review has demonstrated that the CHPQA Programme has delivered significant social benefits by inducing investment in new CHP Schemes, delivering reductions in primary energy use and associated carbon dioxide emissions. The overall net social benefit of the CHPQA Programme is estimated at £1,070 million (2021 prices) in 2019.
- The CHPQA annual certification process, coupled with commercial drivers, means that CHP Scheme operators have a continuous incentive to maintain or enhance the performance of their Scheme. Whilst the additionality of CHPQA once a Scheme is in place may not be as high as for the original investment it still promotes social value, estimated to be £370 million in 2019 (2021 prices). Naturally, once the investment in a significant capital asset has been made, its continued use beyond its breakeven point will, in most cases, be more cost-effective than plant replacement even if its operational savings decline. There are indications from the survey results and the interviews that industrial sites operating CHP are operationally more sensitive to the current availability of incentives than non-industrial sites, and that this may arise because of higher levels of competition between industrial sites.
- As the electricity grid decarbonises the social value of new fossil fuelled CHP Schemes reduces, providing an annualised social value of £6 million (2021 prices) in 2019 over the assumed 20 years life cycle of projects. In principle CHP starts to displace lower-carbon intensity centralised electricity generation. However, this depends on the assumed displaced plant; as a number of the interviewees pointed out during the review, on-site generation will tend (at least for the time being) to displace marginal fossil fuel generation, i.e., gas-fired combined cycle gas turbines (CCGT) or open-cycle gas turbines (OCGT) rather than renewables such as wind, hydro and solar.
- Combining the operational scenario for existing Schemes and the investment scenarios for new Schemes in 2019 results in total social benefits of £372m (2021 prices). The operational scenario contributes £366 million when expressed to the nearest £1 million (rather than the nearest £10 million) and adding £6m of benefits from the ‘new Schemes’ scenario gives the combined total of £372 million). This indicates that, if eligibility for new Schemes and the operation of non-grandfathered Schemes were to cease, substantial social benefits would be forgone. This tends to validate the running of CHPQA in its current form. However, the inevitability of this social value falling over time is clear - driven by decarbonisation of the electricity grid and against a background of continued new investment in gas fired CHP.

The net social benefits vary by Scheme archetype. Whilst it is possible to attribute reasons for this in some cases from the nature of the Schemes (e.g., biomass compared with natural gas-fired Schemes), this is not so for all and this difficulty is likely due to small sample sizes for certain archetypes. Further to this point, there is remaining uncertainty regarding the origin of differences in additionality between different archetypes in the operational scenario and further work on this scenario would be valuable.

From the net social benefits analysis associated with the CHPQA Programme, broad conclusions can be drawn from the sample, noting limitations with sample size of certain archetypes as set out in section 2.6.3. The net social benefits for the investment scenario by archetype implies that, for 2019:

- Biomass (Large) provided significant social benefits through carbon savings compared to the stated counterfactuals due to the use of biomass fuels. Biomass (Large) has shown a high net social benefit of £15 per MWh of fuel consumed.
- Biomass (Small) provided carbon savings from the use of biomass fuels, however these social benefits were largely offset by lower plant efficiencies compared to gas CHP leading to higher LRVC of energy supply and air quality damage costs from the combustion of biomass, resulting in a low net social benefit of £3 per MWh of fuel.
- CCGT (ESCo) and CCGT (Own Finance) realised significant LRVC savings arising from the large-scale operations of a number of these sites and marginal carbon and air quality impacts, both producing a net social benefit of £10 per MWh of fuel.
- Energy from Waste (EfW) CHP saw reasonable LRVC savings but these were largely offset by higher carbon emissions and air quality damage costs due to the combustion of waste fuels such as municipal solid waste. This led to a net social benefit of £2 per MWh of fuel consumed which is low, although EfW provides other environmental benefits from the incineration of waste rather than it going to landfill.
- Engine (Large, ESCo and Own Finance) produced notable LRVC savings and carbon savings from efficient cogeneration of heat and power, resulting in net social benefits of £8 and £9 per MWh of fuel respectively.
- Engine (Mid, ESCo) had smaller LRVC savings that were heavily offset by higher carbon emissions, leading to a net social benefit of £0.1 per MWh of fuel. This appears an irregular outcome and is believed to be due to an uncommon counterfactual being cited in one response resulting in greater carbon emissions from this archetype. Engine (Mid, Own Finance) saw most social benefits come from LRVC savings, a smaller amount of carbon savings and slightly negative air quality damage costs, producing a net social benefit of £8 per MWh of fuel.
- Both Engine (Mid, ESCo and Own Finance) had low investment additionality which dampens the total net social benefits generated, however both archetypes experienced low response rates with several incomplete or unsure responses.

There is limited evidence to suggest why the investment additionality for Engine (Mid, ESCo and Own Finance) is noticeably lower than other archetypes.

- Engine (Small ESCo and Own Finance) net social benefits are predominantly from LRVC savings, resulting in net social benefits of £6 and £11 per MWh of fuel consumed respectively. Engine (Small, Own Finance) had a marginally negative carbon impact and notably higher investment additionality compared to Engine (Small, ESCo) although the ESCo archetype had a very low response rate.
- SCGT (Own Finance) had low investment additionality, producing a net social benefit of £3 per MWh of fuel consumed. The low additionality could be because investment of a number SCGT installations included in the study sample took place before the CHPQA Programme commenced and are unlikely to have been affected by the Programme. Security of supply was rated as an important factor to the investment of SCGT (Own Finance), hence is likely to be delivering social benefits beyond those assessed by this study.
- Differences in net social benefits between Own Finance and ESCo archetypes, notably for the operational scenario, were driven by differences in additionality established from the survey responses, for example between ESCo and Own Finance for the medium-sized Engine archetype. In general, CHP efficiencies across the Own Finance and ESCo archetypes would be within similar ranges.

Many CHP operators recognise that modifications to CHPQA to incorporate a measure of carbon emissions performance would be consistent with the government's 2050 Net Zero target. Many are already considering how they will respond to the Net Zero agenda and are exploring the options for using alternative fuels such as hydrogen and biomethane, carbon capture, and non-CHP technologies such as heat pumps and on-site renewable generation. At the same time there is uncertainty over future availability and costs of hydrogen and of carbon capture technologies. There is consequently concern amongst RPs that CHP Schemes are treated equitably under any revisions to CHPQA, and that allowance is made for the practical difficulties that will arise with decarbonising their CHP Schemes.

CHP operators would like to see flexibility in the future policy treatment of green gas certificates in meeting carbon benchmarks, arguing that this will help maximise the production of biomethane in the UK as a substitute for natural gas.

### 4.1.1 CHPQA Administration

Administration of CHPQA has generally been viewed as effective, with some improvements being suggested by RPs. The Programme should consider ways in which CHPQA online forms and the CHPQA online portal could be improved to become more user friendly and automated and provide more introductory resources for new RPs.

The fact that some RPs have to deal with multiple separate but overlapping policies (CHPQA, UK ETS, CCAs, ESOS), each with their own systems, appears from the interview responses to be of some significance for participants. However, the research team recognises that the inherent difficulties and costs of rationalising multiple IT systems mean it is unlikely that this issue can be addressed in at least the short to medium term.

IT systems aside, there is also a strong wish amongst CHP operators for greater consistency and integration of related policy measures and their day-to-day implementation, particularly UK ETS, CCAs and CHPQA. The Department should seek to identify inconsistencies between policy measures and resolve them wherever possible and practicable to do so.

### 4.1.2 Sector specific impacts

In any further development of CHPQA, the Department should consider any impacts and possible adverse consequences for particular sectors of the economy. This study has identified the following but given the limitations of the exercise these should not be seen as exhaustive.

- Reducing carbon dioxide emissions from CHP is a particular issue for the protected horticultural industry since the cost-effective supply of carbon for enhancing the yield of food crops such as tomatoes and cucumbers has been the principal driver for this industry's investment in CHP.
- Responses from operators of large CHP Schemes at manufacturing sites, particularly within the paper industry, have made it clear that the continuity of the CHPQA eligibility and associated financial benefits are essential for their competitiveness and continuity.

# Annexes

**Annex 1: Survey questions**

**Annex 2: Interview scripts**

**Annex 3: Suggestions for improvements to CHPQA - survey outcomes**

**Annex 4: Methods and assumptions**

**Annex 5: Sensitivity Analysis**

**Annex 6: A summary of core survey outputs**

# Annex 1: Survey Questions

| Question number | Question | Written answer? | Multiple choice |
|---|---|---|---|
| 1 | The recipient's relation to the CHP Scheme? | P | N/A |
| 2 | First Name? | P | |
| 3 | Surname? | P | |
| 4 | Email? | P | |
| 5 | Organisation name? | P | |
| 6 | Please select any of the following that may apply to your organisation. | N/A | My organisation is an owner/operator of a CHP Scheme. |
| | | | My organisation is an administrator of a CHP Scheme. |
| | | | My organisation is a third-party service provider or Energy Service Company. |
| | | Provide detail | Other |
| 7 | How many CHP Schemes do you own, operate, administer, and/or service in the UK? | N/A | 1 |
| | | | 2 |
| | | | 3 |
| | | | >3 |
| 8 | Please provide the exact number of CHP Schemes that you own, operate, administer, and/or service in the UK. | P | N/A |
| 9 | Provide below the CHPQA Reference Number of the Scheme for which you will now complete the rest of this questionnaire. | P | N/A |
| 10 | Did your organisation make its decision to invest in these Schemes that it owns, operates, administers and/or services as one decision? | N/A | Yes, it was one decision or a very similar decision-making process for the Schemes |
| | | | No, it was more than one decision or a very different decision-making process for the Schemes (e.g., different considerations were made for each Scheme, etc.) |
| | | | Don't know |
| 11 | As of today, what is the remaining CHP Scheme's estimated primary asset life (i.e., the number of years | N/A | Select dropdown from 1 to 31 years |

| Question number | Question | Written answer? | Multiple choice |
|---|---|---|---|
| | you expect this asset to operate without any of the prime movers being replaced)? | | |
| 12 | Please select the financial benefits gained as a result of CHPQA certification for this Scheme that you have received in 2019. | N/A | None |
| | | N/A | Renewables Obligation Certificates |
| | | | Carbon Price Floor (heat) relief |
| | | | Carbon Price Floor (Good Quality electricity directly supplied) relief |
| | | | Climate Change Levy relief (in respect of Qualifying Fuel Input) |
| | | | Climate Change Levy relief (in respect of good quality electricity directly supplied) |
| | | | Contract for Difference |
| | | | Enhanced Capital Allowances |
| | | | Preferential Business Rates |
| | | Provide detail | Other |
| 13 | You should have now identified the investment associated with your CHP Scheme that you wish to tell us about. Please select the year when your organisation (or the owner of the CHP Scheme) made this decision to invest. | N/A | Select year |
| 14 | Could you confirm whether this investment concerns the installation, replacement, or refurbishment of the CHP Scheme? | N/A | Installation of the CHP Scheme |
| | | | Major refurbishment of one or several CHP Scheme(s) |
| | | | Major replacement of one or several CHP Scheme(s) |
| | | Provide detail | Other |
| 15 | Could you please also provide an estimate to the upfront capital expenditure associated with the CHP Scheme, in £/kW? | N/A | Don't know |
| | | | 0 £/kW |
| | | | >0 to ≤ 500 £/kW |
| | | | >500 to ≤ 1000 £/kW |
| | | | >1000 to ≤ 1500 £/kW |
| | | | >2000 to ≤ 2500 £/kW |
| | | | >2500 to ≤ 3000 £/kW |
| | | | >3000 to ≤ 3500 £/kW |

| Question number | Question | Written answer? | Multiple choice |
|---|---|---|---|
| | | | >3500 £/kW |
| | | Provide detail | Other |
| 16 | Were any other CHP or non-CHP options considered during this investment decision-making process? | N/A | A ‘do nothing’ (e.g., continue with your current supply from the grid, etc.), or no other investment option was considered |
| | | | Other CHP options were considered at the same site, e.g., of different sizes and types. |
| | | | Other non-CHP options were considered at the same site e.g., different types of heat and/or power auto generation, energy efficiency, etc. |
| | | | A different option e.g., a non-energy investment at the same or different UK site. |
| | | | An energy-related investment on a different UK site. |
| | | | Don’t know |
| 17 | Please select the ‘second best’ alternative CHP configuration that was considered in the investment decision-making process.<br><br>Select an integer for the number of installations that would make-up this alternative configuration across the various energy types as well as capacity. | N/A | Matrix provided which considers the following:<br>1. Energy type (renewable, non-renewable, and other)<br>2. Prime Mover type (engine, organic Rankine cycle, and turbine)<br>3. Total power capacity (TPC) (TPC ≤ 100 kWe, 100 kWe ≤ TPC ≤ 1000 kWe, 1,000kWe ≤ TPC ≤ 10,000kWe, TPC > 10,000kWe) |
| | Please describe this alternative CHP Scheme(s) in your own words, including capacity kWe, the ‘fuel type’ (i.e., coal, natural gas, biomass, etc.) and ‘prime mover type’. | P | N/A |
| 18 | Please select the ‘second best’ alternative non-CHP configuration that was considered in the investment decision-making process. | N/A | Gas boiler(s) and thermal electricity only auto generation |
| | | | Gas boiler(s) and non-thermal electricity auto generation (e.g. PV, wind) |
| | | | Biomass boiler(s) and thermal electricity only auto generation |
| | | | Biomass boiler(s) and non-thermal electricity auto generation (e.g. PV, wind) |
| | | | Oil boiler(s) and thermal electricity only auto generation |
| | | | Oil boiler(s) and non-thermal electricity auto generation (e.g. PV, wind) |

| Question number | Question | Written answer? | Multiple choice |
|---|---|---|---|
| | | | Other boiler(s) and thermal electricity only auto generation |
| | | | Other boiler(s) and non-thermal electricity auto generation (e.g. PV, wind) |
| | | | Energy efficiency measures implemented on your site(s) to reduce energy needs at the site |
| | | Provide detail | Other |
| 19 | Please describe this alternative non-CHP option in your own words. | P | N/A |
| 20 | Please describe the different option and/or any other energy related investments on different UK sites, as relevant. | P | N/A |
| 21 | Thinking about your organisation's (or the owner of the CHP Scheme's) decision to invest, please review how important each of the following were during the investment decision-making process.<br>(Answer key: Not applicable, 1-Not very important, 2-Somewhat important; 3-important, 4-very important, 5-critical).<br><br>• Site compatibility (i.e., CHP critical if no other options would be compatible with the site's needs, etc.)<br>• Security of supply (for heat and/or electricity)<br>• Cost of capital<br>• Payback period<br>• Income expectations from exporting energy<br>• Environmental credentials<br>• Financial benefits from CHPQA | N/A | 1-5 |
| | | Provide detail | Other |

| Question number | Question | Written answer? | Multiple choice |
|---|---|---|---|
| 22 | If relevant, to what extent might the following financial incentives play a material part in your organisation's (or the owner of the CHP Scheme's) decision towards investing in a CHP Scheme?<br>(Answer key: Not applicable, 1-Not very important, 2-Somewhat important; 3-important, 4-very important, 5-critical).<br><br>• Renewable Heat Incentive<br>• Renewables Obligation Certificates<br>• Carbon Price Floor (heat) relief<br>• Carbon Price Floor (Good Quality electricity directly supplied) relief<br>• Climate Change Levy relief (in respect of Qualifying Fuel Input)<br>• Climate Change Levy relief (in respect of Good Quality electricity directly supplied)<br>• Contract for Difference<br>• Enhanced Capital Allowances<br>• Preferential Business Rates<br>• Other | N/A | 1-5 |
| | | Provide detail | Other |
| 22 | If the CHPQA Programme and associated financial benefits were not available at the time of the investment decision, what would have happened? | N/A | Would have invested in a CHP Scheme(s) of the same type and scale |
| | | | Would have invested in a CHP Scheme(s) of the same type and smaller scale |
| | | | Would have invested in a CHP Scheme(s) of a different type and scale |
| | | | Would have invested in a non-CHP installation(s) |
| | | | Would have bought electricity and/or gas from the grid |
| | | | Other |
| | | Provide detail | Don't know |
| 23 | As a follow up to the previous query, in the alternative scenario, would your organisation (or the owner of the alternative installations) have produced the same, more or less heat and electricity at the site? | N/A | Produced the same |
| | | | Produced less… |
| | | | Produced more… |
| | | | Don't know |
| | If you can, please provide a numerical estimate of how the non- | P | N/A |

| Question number | Question | Written answer? | Multiple choice |
|---|---|---|---|
| | CHPQA alternative scenario would have differed in % terms against your 2019 heat output | | |
| | If you can please provide a numerical estimate of how the non-CHPQA alternative scenario would have differed in % terms against your 2019 electricity output | P | |
| 24 | At the time of making your investment decision, was your organisation aware of any other non-financial public Programmes or policies that could have influenced the decisions to invest on the CHP Scheme(s)? | N/A | Yes |
| | | | No |
| | | | Don't know |
| | Please provide further details on this? | P | N/A |
| 26 | Please describe in your own words the rationale and/or elaborate as to how the final investment decision was reached based on the information you have access to. | P | N/A |
| 27 | Please consider the CHPQA Programme and its services (that is, the non-monetary or non-financial benefits). Please rate any of following services that your organisation has used. (Selecting; Not used, not relevant; and from not useful (1) to very useful (5)).<br>• Helpline/ online help facility that offers support to Programme participants<br>• Workshops/learning modules<br>• 'Simplified' guides<br>• Detailed guidance notes<br>• Audit function<br>• CHP focus webpages and case studies on gov.uk that are aimed at those exploring CHP investment as an option | N/A | 1-5 |
| | Please elaborate on your rationale. | P | N/A |
| 28 | Please consider any investments and/or administrative activities that your organisation has undertaken to secure CHPQA certification and/or engage with the Programme in 2019. | N/A | £0 |
| | | | >£0 to ≤ £10,000 |

| Question number | Question | Written answer? | Multiple choice |
| --- | --- | --- | --- |
| | Please estimate the recurring, average annual administrative costs (e.g., monitoring and reporting activities, annual submissions of forms and performance data, maintaining and calibrating the metering infrastructure, etc.): Monetary estimate (GBP£)<br><br>What are the recurring and/or one-off administrative costs associated with the completion of tasks required for CHPQA Programme certification (per CHP Scheme)? | | >£10,000 to ≤£50,000 |
| | | | >£50,000 to ≤£100,000 |
| | | | >£100,000 to ≤£500,000 |
| | | | >£500,000 |
| | Please describe the administrative activities you have undertaken and/or undertake to comply with the CHPQA Programme. | P | |
| 29 | Please consider the ways in which your organisation engages with the CHPQA Programme now (e.g., recurring data submissions, etc.). Can you think of any suggestions for how these processes could be streamlined and/or improved based on your experience? | P | N/A |
| 30 | Please review how important each of the following factors were in your organisation's (or the owner of the CHP Scheme's) operational decisions in 2019.<br>(Answer key: Not applicable, 1-not very important, 2-somewhat important; 3-important, 4-very important, 5-critical).<br><br>• Security of supply (for heat and/or electricity)<br>• Contractual obligations<br>• Financial performance<br>• Income expectations from exporting energy<br>• Environmental considerations<br>• Market conditions<br>• Government support<br>• Other | N/A | 1-5 |
| | | Provide detail | Other |
| 31 | Please now consider the following scenario. Let us imagine that the CHPQA Programme and any non-grandfathered financial benefits | N/A | I would have operated my CHP Scheme(s) as I have done. |
| | | | I would have operated my CHP Scheme(s) but at a lower output. |

| Question number | Question | Written answer? | Multiple choice |
|---|---|---|---|
| | would have no longer been available in 2019, as a relatively 'normal' year of operation. Please note that non-grandfathered financial benefits include Carbon Price Floor relief, Climate Change Levy relief, Enhanced Capital Allowances and Preferential Business Rates. That is, all benefits linked to CHPQA Programme excluding RHI, ROC, and Contracts for difference. What would your organisation (or the owner/operator of the CHP Scheme) have done in this 2019 scenario? | | I would have stopped operating this CHP Scheme(s) as-was and moved to an alternative CHP option. |
| | | | I would have stopped operating my CHP Scheme(s) and moved to a non-CHP alternative source of heat and/or electricity. |
| | | Provide detail | Other |
| 32 | As a follow up to the previous question and in this alternative scenario for 2019 (i.e., turning off non-grandfathered financial benefits), please confirm whether your organisation (or the owner/operator) would have produced the same, more or less heat and electricity overall. | N/A | Produced the same … |
| | | | Produced less… |
| | | | Produced more… |
| | | | Don't know |
| | Please provide a numerical estimate of this scenario in % terms against your 2019 heat output | P | N/A |
| | If you can please provide a numerical estimate of this scenario in % terms against your 2019 electricity output | P | |
| 33 | Does your organisation think that the CHPQA Programme, including the certification process and any of the services it provides e.g., helpline, etc., will be valuable to you in the next 3 years? | N/A | Yes, certainly |
| | | | Yes, with some opportunity for improvement |
| | | | No, I do not |
| | | | Don't know |
| 34 | Does your organisation believe the CHPQA Programme, including the certification process, could be used for implementing new CHP policies to enhance greater energy efficiencies? | N/A | Yes, certainly |
| | | | Yes, with some opportunity for improvement |
| | | | No, I do not |
| | | | Don't know |
| | Please describe the rationale and any suggestions, e.g., as to how CHPQA could contribute to achieving greater energy efficiency, etc. | P | N/A |
| 35 | Looking ahead to 2023, if the CHPQA Programme and associated | N/A | I would continue to operate my CHP Scheme(s) as I have been doing. |

| Question number | Question | Written answer? | Multiple choice |
|---|---|---|---|
| | financial benefits continued as they are now, how may your organisation (or the owner of the CHP Scheme) change your operations given the expected market conditions (e.g., fuel prices, etc.)? | | I would continue to operate my CHP Scheme(s) but at a lower output. |
| | | | I would stop operating this CHP Scheme(s) as-is, and move to an alternative CHP option (e.g., switching fuels, etc.). |
| | | | I would stop operating my CHP Scheme(s) and move to a non-CHP alternative source of heat and/or electricity. |
| | | Provide detail | Other |
| 36 | Acknowledging the Government's Net Zero by 2050 target, what CHP options might you consider for your site in the next 10-20 years to align with this ambition? | N/A | I would consider continuing with CHP and abate any associated carbon and/or pay carbon costs |
| | | | I would replace fossil fuel CHP with renewables e.g., biogas, biomass, hydrogen |
| | | | I would replace CHP with a renewable source of energy generation e.g., heat pump, other renewable energy sources |
| | | | I would undertake resource or energy efficiency measures |
| | | | I would consider alternative locations for production |
| | | Provide detail | Other |
| 37 | If your organisation is considering a CHP investment in the near future, please rate the significance of the following potential barriers that your organisation might be facing. (Answer key: not applicable, 1-not very significant, 2-somewhat significant; 3-significant, 4-very significant, 5-critical).<br>• Significant upfront capital costs<br>• Limited or uncertain access to government support (including through the CHPQA)<br>• Other regulatory and/or policy actions (or lack thereof)<br>• Risks or uncertainty associated with the payback period<br>• Suitability for the energy that is being demanded<br>• Unclear or uncertain options for exporting energy to a network<br>• Other | N/A | 1-5 |
| | | Provide detail | Other |

| Question number | Question | Written answer? | Multiple choice |
|---|---|---|---|
| | Any further feedback you may wish to share on the CHPQA Programme and associated financial benefits? | P | N/A |
| 38 | Finally, please select whether you would be content to have follow-up conversations with the CHPQA team | Discussing CHP and/or non-CHP options considered to achieve Net Zero by 2050 | We would be happy to be contacted by the CHPQA team for an interview and/or conversation following our completion of the survey. |
| | | | We would prefer not being contacted by the CHPQA team for an interview and/or conversation following our completion of this survey. |

# Annex 2: Interview Scripts

| Question | Own Finance | ESCo | Non-participating |
|---|---|---|---|
| 1 | Please explain your role in the organisation | | |
| 2 | What is your involvement in decision-making on investments and operating the CHP Scheme(s)? | How is your organisation involved with CHPQA and what is the business model?<br><br>What is the relationship between the ESCo and its client?<br>Who claims financial benefits?<br>Who pays CapEx/opex fees?<br>Where does CHPQA fit in your business model? | What is your involvement in decision-making on investments and operations relating to CHP? |
| 3 | How long have you been involved with CHPQA? | | |
| 4 | What sector is your organisation in? | | |
| 5 | What are the main activities of your organisation? | | |
| 6 | Please confirm and explain which Scheme was used for the survey and will be the topic of this interview.<br><br>Check whether it was an installation or a significant refurbishment | | When you completed the F1 form, you were considering investment in XXX CHP Scheme. Please can you confirm that is correct?<br><br>Check whether it was an installation or a significant refurbishment |
| 7 | Was there any other capital expenditure associated with the installation? (e.g., infrastructure for networks to export surplus heat or electricity) | | |
| 8 | When was the CHP/ prime mover last upgraded?<br>How often do you expect to refurbish the Scheme? | | N/A |

| Question | Own Finance | ESCo | Non-participating |
|---|---|---|---|
| 9 | Looking at the survey for reference, what key factors influenced this decision to invest in CHP? Please explain why?<br><br>How did financial benefits from CHPQA influence decision-making (was it important)? | | What did you decide to do and what were the key factors that influenced the decision? Please explain why?<br><br>How did financial benefits from CHPQA influence decision-making (was it important)? |
| 10 | N/A | Why was CHP via ESCo the chosen approach for ESCo clients? | N/A |
| 11 | How did you decide what specification and configuration of CHP to install?<br><br>- How does it meet your organisation’s heat and electricity demands?<br>- Was capacity influenced by potential to export energy? | | If investing in CHP and not seeking CHPQA certification, how did you decide what specification and configuration of CHP to install?<br>How does it meet your organisation’s heat and electricity demands?<br>Was capacity influenced by potential to export energy? |
| 12 | Does your organisation manage many sites? (If yes), was your decision to invest in CHP made as part of an investment policy or on a site-by-site basis? | | Does your organisation manage many sites? (If yes), was your decision not to invest in CHP (or not to seek CHPQA certification) made as part of an investment policy or on a site-by-site basis? |
| 13 | Why did you decide to apply for your CHP plant to become CHPQA-certified? | | N/A |
| 14 | Was any other financial support received which aided the investment? | | |
| 15 | The survey references that alternative options to CHP were /were not considered when deciding how to serve your organisation’s heat and electricity demand. Why were these options considered?<br><br>Were any alternative investments considered, such as investing in other energy projects on other sites or non-energy investments? | | What options to CHP were considered when deciding how to serve your organisation’s heat and electricity demand? Why were these options considered?<br><br>Were any alternative investments considered, such as investing in other energy projects on other sites or non-energy investments? |
| 16 | If CHPQA financial support was not available at the time of investment, the survey mentions you would have done XX to meet your heat and electricity demands. Please could you explain why? | | Would the decision have been different if more or different CHPQA financial |

| Question | Own Finance | ESCo | Non-participating |
|---|---|---|---|
| | - If their answer to the investment counterfactual does not reconcile with their answer to survey Q22, then ask why?<br>- If a different option chosen to the incumbent CHP Scheme<br>Why was this the 'next best' option?<br>What would have been the associated impact on fuel use compared to your current configuration?<br>- If a different CHP option was chosen, how would the capacity and operation have differed compared to your current configuration? | | support had been available at the time of investment?<br><br>- Was there a change in production/ output?<br>- Was there a change in exported energy? |
| 17 | Following the installation of CHP was there an associated change in heat or electricity use, and if so, why?<br><br>- Was there a change in production/ output?<br>- Any changes prompted by changes in energy prices? | N/A | |
| 18 | What payback period made CHP a viable option?<br><br>How did this compare to other investment options considered? | | |
| 19 | What key factors influence how to run the CHP? What capacity and efficiency? Please explain why?<br><br>- What other operational options did you consider to meet your heat and electricity demands?<br>- Does this differ for heat compared with electricity?<br>- How does CHPQA financial support influence how the CHP is run/operated (is it important)? | N/A | |
| 20 | If you have many sites, do you run your CHP similarly for your other Schemes? | N/A | |
| 21 | What energy alternatives do you consider when assessing how to meet your heat and electricity demands? | N/A | |
| 22 | In a 2019 scenario, if CHPQA financial benefits were no longer available, the survey mentions the | N/A | |

| Question | Own Finance | ESCo | Non-participating |
| --- | --- | --- | --- |
| | organisation would have done XX to meet heat and electricity demands. Please could you explain why?<br><br>- If their answer to the operational counterfactual does not reconcile with their answer to survey Q31, then ask why<br>- If a different level of operation chosen why was this the 'next best' option? | | |
| 23 | In this alternative scenario, would there be an associated change in heat or electricity use?<br><br>Would this be associated with a change in production/ output? What would be the change in exported energy? | N/A | |
| 24 | Do you have any feedback on how the CHQPA Programme operates or on the services it provides? | | |
| 25 | Do you have any suggestions on how to improve the CHPQA Programme and its and services? | | |
| 26 | What are your views on modifying the CHPQA Quality Index to incorporate its potential to reduce carbon emissions? Why? | | N/A |
| 27 | Do you have views on having the QI formulae or a separate carbon threshold (grams per KWh) as part of certification? Why? | | N/A |
| 28 | How is the organisation planning to operate its CHP in the next year?<br><br>Have there been any implications from current energy prices or the market outlook – on how you operate your CHP? Why? | N/A | How is the organisation planning to operate its CHP (if any) in the next year?<br><br>Have there been any implications from current energy prices or the market outlook – on how you operate your CHP? Why?<br>How might you operate CHP in the next five years? |

| Question | Own Finance | ESCo | Non-participating |
|---|---|---|---|
| | How might you operate CHP in the next five years? | | |
| 29 | Do you have plans to invest in CHP, whether that be into new Schemes or to refurbish current Scheme(s)?<br><br>If so, please explain. Would you seek CHPQA-certification? | N/A | Do you have plans to invest in CHP, whether that be into new Schemes or to refurbish current Scheme(s)?<br><br>If so, please explain. Would you seek CHPQA-certification? |
| 30 | What are the organisation's plans to reduce your greenhouse gas emissions from energy use? Why?<br><br>Do you see CHP within your decarbonisation plans?<br>What is your current capability to use low carbon fuels in your CHP?<br>Do you consider retrofitting or installing CHP capable of operating on low carbon fuels as a future option?<br>Are there other low carbon energy alternatives that you think might be able to meet your heat and electricity demands? Why? | | |
| 31 | What barriers are there/ What barriers are you experiencing to invest in CHP?<br><br>What barriers are there to invest in decarbonisation ready CHP?<br>Do you have view as to how the CHPQA Programme could support switching to lower carbon fuels? Why?<br>Do you think other government assistance would be needed to support a transition away from fossil fuels in CHP? What policies/support do you think would be needed? | | |

# Annex 3: Suggestions for improvements to CHPQA – survey outcomes

Survey participants were also asked to consider the ways in which their organisation engages with the CHPQA Programme now (e.g., recurring data submissions, etc.). Respondents (N=102) made suggestions, which were encoded and analysed to provide a strategic understanding of these suggestions. These are summarised in the Table 3.1 below.

**Table A3.1: Response on room for improvements for the CHPQA Programme**

| Schemes by Archetype | Sample | Keep as-is | Minor adjustments | Multiple adjustments | Don’t know |
|---|---|---|---|---|---|
| Biomass (Large) | 4 | 100% | 0% | 0% | 0% |
| Biomass (Small) | 5 | 60% | 20% | 20% | 0% |
| CCGT - (ESCo) | [s] | [s] | [s] | [s] | [s] |
| CCGT - (Own Finance) | 6 | 50% | 50% | 0% | 0% |
| EfW | 2 | 50% | 50% | 0% | 0% |
| Engine (Large) > 3000 kWe (ESCo) | 0 | 0% | 0% | 0% | 0% |
| Engine (Large) > 3000 kWe (Own Finance) | 12 | 25% | 67% | 0% | 8% |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | 11 | 55% | 45% | 0% | 0% |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | 10 | 70% | 20% | 0% | 10% |
| Engine (Small) <= 500 kWe (ESCo) | 2 | 0% | 100% | 0% | 0% |
| Engine (Small) <= 500 kWe (Own Finance) | 40 | 5% | 93% | 0% | 3% |
| SCGT (Own Finance) | 7 | 57% | 43% | 0% | 0% |
| Other | [s] | [s] | [s] | [s] | [s] |
| **Total** | **102** | **34%** | **62%** | **1%** | **3%** |

*[s] data suppressed due to avoid potential disclosure of survey responses*

# Annex 4: Methods and assumptions

This Annex sets out a summary of the core methods and assumptions employed in this study, building on Section 2. As defined in this section, the main purpose of the online survey of CHP Schemes was to establish counterfactual scenarios to the outturn performance of the Programme: the investment counterfactual, that is a scenario in which the CHPQA Programme did not exist; and the operational counterfactual, a scenario in which the non-grandfathered financial benefits would be withdrawn from 2019. Annex 1 sets out the survey questions that were employed to gather evidence that would allow us to establish these counterfactual scenarios.

Further, CHPQA Programme monitoring and performance data was accessed on outturn fuel consumption by live CHP Schemes in latest normal operating year (assumed to be 2019), the heat and electricity output, the technology or archetype of the CHP Scheme capacity, the financial benefits received as estimated by the CHPQA Programme, etc.

This outturn evidence was combined with the evidence collected through the online survey of CHPQA RPs to develop answers for the following research questions, which were the original survey aims agreed during the design phase:

1. What is the investment counterfactual for each Scheme i.e., the likely option in a scenario in which the CHPQA Programme and financial benefits were not available?
2. What was the relative importance of the CHPQA Programme in reaching their investment decision?
3. What is the estimated fuel use in the 'non-CHPQA scenario' (i.e., the counterfactual)? And how does this compare to the factual fuel use?
4. What is the relative importance of CHPQA eligibility for non-grandfathered Schemes and associated financial benefits in the CHP operational decisions?
5. How would CHPQA participants meet their heat and electricity needs in 2019 if CHPQA eligibility for non-grandfathered Schemes and associated financial benefits were no longer available?
6. Other (not specified) on the impact of market conditions: Looking ahead at 2023, if CHPQA and benefits remained, what would organisations do, given market conditions?
7. Given the Net Zero targets in the UK, might CHPQA RPs consider any CHP (or other) options for the future?
8. What are the main business barriers that businesses face when considering future investments in CHP Schemes?

9. What is the type and magnitude of the capital expenditure or investment made by the RP's organisation (or otherwise) on the CHP Scheme?

10. What is the administrative burden of the CHPQA Programme on businesses?

11. Have businesses used and found helpful the CHPQA Programme services?

12. How could the CHPQA Programme be improved?

13. Could the Programme be used to achieve greater energy efficiencies?

Multiple survey and analytical outputs were produced to answer each of these questions (see Annex 6 for additional insights).

Building on this evidence, it was also agreed to develop an estimate of the net social benefits of the CHPQA Programme.

Multiple methods were considered to develop an evidence base that would allow the study to compare the impacts or core social contributions of the factual or outturn against the counterfactual scenarios, and, in doing so, better understand the potential social value of the Programme. However, the CHPQA has been running for over twenty years, has developed over that period, and the population of CHP Schemes has naturally changed as new Schemes are introduced, and old Schemes are closed or replaced. The value and availability of the different financial incentives (e.g., CCL Main and CPS rates, ROC and RHI) has also changed over the years. Consequently, in order to manage this complexity and gather evidence effectively through a stakeholder consultation, the analysis of impacts of the CHPQA Programme has focussed on a specific year: 2019 was chosen as it is the most recent year for which operational data was considered to be representative of CHP Schemes' normal operating conditions, given the impacts of the COVID-19 pandemic in 2020 and 2021.

In this context, the review of the potential social benefits of the CHPQA Programme was carried out and the most significant impacts were selected for a balanced quantification in a specific and ‘representative’ year. The following were calculated in the factual (outturn performance) and the counterfactuals to estimate the impact (or potential net social benefits) of the CHPQA Programme:

- Carbon emissions (CO2e) and their social value
- Air quality damage costs
- Fuel consumed and Long-Run Variable Costs (LRVC), which were estimated as total primary fuel or electricity consumed valued at unit LRVC (NB variable non-fuel operating costs and fuel costs assumed to be mostly captured within LRVC and these would capture the vast majority of operating costs)
- Capital costs were considered for the analysis of ‘new Schemes’ scenario, that is, applicable to the 'new 2019 Schemes' (105 Schemes), based on the data collected

through the survey for the factual, and assumptions were drawn up to estimate capital costs in the counterfactual.

This means such a quantitative analysis excluded:

- Fixed non-fuel operating costs, as these were not considered to be significant nor was it possible to develop proportionate assumptions for the factual and counterfactual for this study.
- Costs of finance would differ across technologies. CHP Schemes could be more costly to finance than their alternatives. However, these differences are likely to be dwarfed by the potential energy savings from investing in CHPQA (by definition more so than capital costs). These impacts were not selected for in-depth quantification due to proportionality.
- Financial benefits from the UK Government were not included in the net social benefit analysis as these are transfers from society's perspective, and, thus, should not be included in such calculations (See Chapter 6 of the HMT's Green Book).
- Any other non-quantifiable impacts (costs or benefits), such as security of supply and/or resilience impacts, indirect land use change, transportation, Gross Value Added impacts, etc.

Overall, it was considered that these impacts were the most significant and their estimation would allow for a balanced and proportionate assessment of the scale of net social benefits that might have been delivered by all or parts of the CHPQA Programme in or around 2019.

All of these impacts were estimated and monetised using UK Green Book methods, the appropriate real social discount rate as necessary, and all monetary values were estimated in 2021 GBP. The assumptions, which were reviewed and agreed with the Department for Energy Security and Net Zero, are outlined in the Table below and the rest of this Annex.

**Table A4.1: List of assumptions**

| Assumption | Description and purpose |
|---|---|
| Year of analysis (or discount year for 'new Schemes' scenario analysis) | 2019 as noted. |
| Price year | 2021, that is, all monetary values were estimated using 2021 GBP |
| GDP deflator | The GDP deflator was employed to adjust all monetary values to 2021 prices when this was necessary. Values for the GDP deflator were provided by the DESNZ in line with the latest evidence used in government appraisals. |
| Social real discount rate | 3.5% in line with the UK Green Book. |

| Assumption | Description and purpose |
|---|---|
| Asset life (for 'new Schemes' scenario analysis) | Asset life assumptions were required for the 'new Schemes' scenario analysis. A simplifying assumption was introduced setting out that, on average, assets would last around 20 years. This was based on the evidence from the CHPQA performance data and expert input. |
| Counterfactual | Counterfactual assumptions were developed based on the survey responses, also described in Section 2. |
| Fuel consumption and its long-run variable cost | Factual fuel consumption was sourced from the CHPQA performance data. When fuel consumption data was provided in Gross Calorific Value and Net Calorific Values were required, conversion factors provided by and agreed with the DESNZ were employed.<br>Fuel consumption in the counterfactuals was estimated by assuming that the same heat and electricity would need to be consumed at the CHPQA sites and sites that consume their excess energy production. Therefore, efficiency assumptions were developed to estimate the fuel required to meet those energy needs.<br>As relevant, it was assumed that heat was generated either through a gas or biomass boiler, based on survey inputs and simplifying assumptions, with efficiencies of 80% and 77% respectively.[47]<br>It was also assumed that electricity would be imported from the grid and a reverse fuel conversion assumption of 2.6 was employed to estimate fuel differentials between the factual and counterfactual scenarios[48]. The ratio of primary energy input to electricity supplied changes, but this is a simplifying assumption that was only employed as part of the net social benefits estimations.<br>The fuel or electricity consumed in both scenarios was monetised using the relevant LRVC factors.[49] Please note that in cases where fuels were considered by-products, their LRVC was assumed to be zero. |
| Carbon emissions and impacts (CO2e) | These were estimated in Net Calorific Value using fuel-to-CO2e emission conversion factors provided by the DESNZ (kgCO2e/kWh of fuel NCV) for both the factual and counterfactuals, based on the latest agreed evidence aligned with the UK Green Book. These emissions were monetised using 'carbon values for appraisal'. Long-run marginal emissions factors (industrial consumption) were employed to estimate the emissions from electricity consumed.[50] |

[47] Sources: Multiple, including https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/831083/Full_technical_report.pdf
[48] Source: CCA Technical Annex Para 13. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/953320/cca-scheme-technical-annex.pdf
[49] Sources: DESNZ and data tables 1-19 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1024043/data-tables-1-19.xlsx
[50] Sources: DESNZ and https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal; https://www.britishgas.co.uk/home-services/boilers-and-heating/guides/boiler-efficiency.html#_content_britishgas_home-services_boilers-and-heating_guides_boiler-efficiency_jcr_content_par_carousel_container

| Assumption | Description and purpose |
|---|---|
| Air quality damage costs | Damage costs of £/MWh of fuel consumed were provided by DESBZ, based on Green Book supplementary guidance except for biomass. Rather than using Green Book values of Air Quality Damage (AQD) costs (expressed in units of £/MWh), a bespoke value for biomass has been derived for and used in this study. This bespoke value is derived based on the assumption that any biomass burning plant with rated thermal input >1 MWth would be permitted under the Medium Combustion Plant Directive (MCPD), and that under this Directive limits on PM and NOx emissions (expressed in units of mg/Nm3) would have to be adhered to for the plant to continue running. The cost associated with biomass burning therefore assumes that these emission limits are not exceeded but occur at the limit values, which is a conservative assumption. Applying the DESNZ damage costs (£/tonne of emission) for PM and NOx pollutants has returned an AQD cost of £7.28/MWh for biomass, and this is the value used in this study. |
| Capital costs | CHP capital costs were estimated based on evidence provided in the survey. Capital costs for the counterfactual technologies were estimated assuming: 1) biomass or gas boiler capital costs of £/kWe based on previous Ricardo analysis for the "National Comprehensive Assessment for Efficient Heating and Cooling in the UK"; 2) assuming CCGT capital costs for the marginal grid generation technology[51]. |
| Retail fuel prices | Retail fuel prices were estimated using £/MWh in GCV in line with the Green Book and using an assumption for biomass provided by the DESNZ. These were used to estimate billable savings, albeit these estimates were not considered as part of the net social benefit analysis for proportionality reasons -such an analysis would require system-wide modelling which was not possible for this study. |
| 'New Schemes' scenario analytical assumptions | Around 100 'new' 2019 Schemes employed for this analysis, as a relatively representative sample of the CHPQA 'enrolment' rate over the last few years in numbers and types of archetypes. It was also assumed that new CHP Schemes would be installed and operating at the start of 2019.<br>Assumed a flat profile of fuel/energy consumption based on 2019 outturn and counterfactual evidence for the life of the assets.<br>Generation capacity was estimated based on outturn energy consumed, assumed efficiency of the counterfactual technologies and generation requirements over a year. |

[51] Sources: Page 77 and expert input for simplification https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/65716/71-uk-electricity-generation-costs-update-.pdf

# Annex 5: Sensitivity Analysis

The net social benefit analysis required a number of assumptions based on the evidence collected from an online survey and the CHPQA performance data. Annex 4 sets out all the assumptions. These were reviewed and seven core assumptions that were deemed to have clear uncertainties were identified to carry out sensitivity analysis of the net social benefit estimates developed for this study.

Given the scope and timetable for this study, it was agreed that three scenarios would be developed for the test and estimation of a low, central and high net social benefits of the CHPQA Programme. The Table below outlines the assumptions in these scenarios, which were reviewed and agreed with the DESNZ, followed by a brief explanation for their selection.

**Table A6.1: Scenarios developed for the sensitivity analysis of the Net Social Benefit estimations of the CHPQA Programme**

| Dimension or area of sensitivity | Low net social benefit scenario | Central net social benefit scenario | High net social benefit scenario |
|---|---|---|---|
| Sampling (affecting the counterfactual conclusions by archetype) | The lowest effects from two sub-samples (156 responses versus 204 responses) | The lowest effects from two sub-samples (156 responses versus 204 responses); and the mid-point of impact from the two sub-samples considered for the net social benefit analysis of new Schemes | The highest effects from two sub-samples (156 responses versus 204 responses) |
| Efficiency of boilers (or fuel use in the counterfactual) | More efficient boilers (87-90%) | A central assumption of boiler efficiency (77-80%) | Less efficient boilers (66-70%) |
| Emissions from the grid (or emissions in the counterfactual)[52] | 10% lower long-run marginal emissions than central values | Central estimate of long-run marginal emissions from source | 10% higher long-run marginal emissions than central values |
| Carbon social value (CO2e)[53] | Low estimates from source (-50% of central values) | Central estimates of unit value from source | Higher estimates from source (+50% of central values) |
| Air Quality Damage costs[54] | +20% of the central unit costs | Central estimates of unit costs from source | -20% of the central unit costs |

[52] DESNZ UK Green Book supplementary guidance (2021 version); URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1024043/data-tables-1-19.xlsx
[53] Ibid.
[54] Ibid.

| Dimension or area of sensitivity | Low net social benefit scenario | Central net social benefit scenario | High net social benefit scenario |
|---|---|---|---|
| Long-Run Variable Costs of energy | Lower estimates from source (-20% of central values for electricity, gas and coal; -40% for oil) | Central estimates of unit costs from source | Higher estimates from source (+20% of central values for electricity, +35% for gas and coal, and +45% for oil) |

The sensitivity of the sample was considered by selecting sub-samples that were more or less complete or coherent, to ensure that as much of the information provided was tested as possible.

Fuel consumption estimates in the counterfactual were dependent upon efficiency assumptions, which are uncertain. Thus, ranges were explored based on the evidence available of more or less efficient boilers, or the low and high emission factors from the electricity grid, based on the UK Green Book supplementary evidence.

UK Green Book evidence of low and high estimates for carbon (CO2e) social values and LRVC were also employed to test the sensitivity of the results to these assumptions.

Reasonable uncertainty ranges were developed for Air Quality Damage Costs with expert-input based on the understanding that CHP Schemes and other energy generation options may employ more or less abatement technologies, among others.

Overall, these low, central and high scenarios provide us with an in-depth understanding of the cumulative uncertainties associated with core assumptions employed in the net social benefit analysis of the CHPQA Programme. Therefore, it is very likely that the actual social value of the CHPQA Programme is within the estimated uncertainty ranges resulting from this sensitivity analysis.

# Annex 6: A summary of core survey outputs

This Annex provides a brief outline of all main outputs from the review and analysis of the survey evidence and the net social benefit analysis of the CHPQA Programme, organised by the main research questions or survey aims.

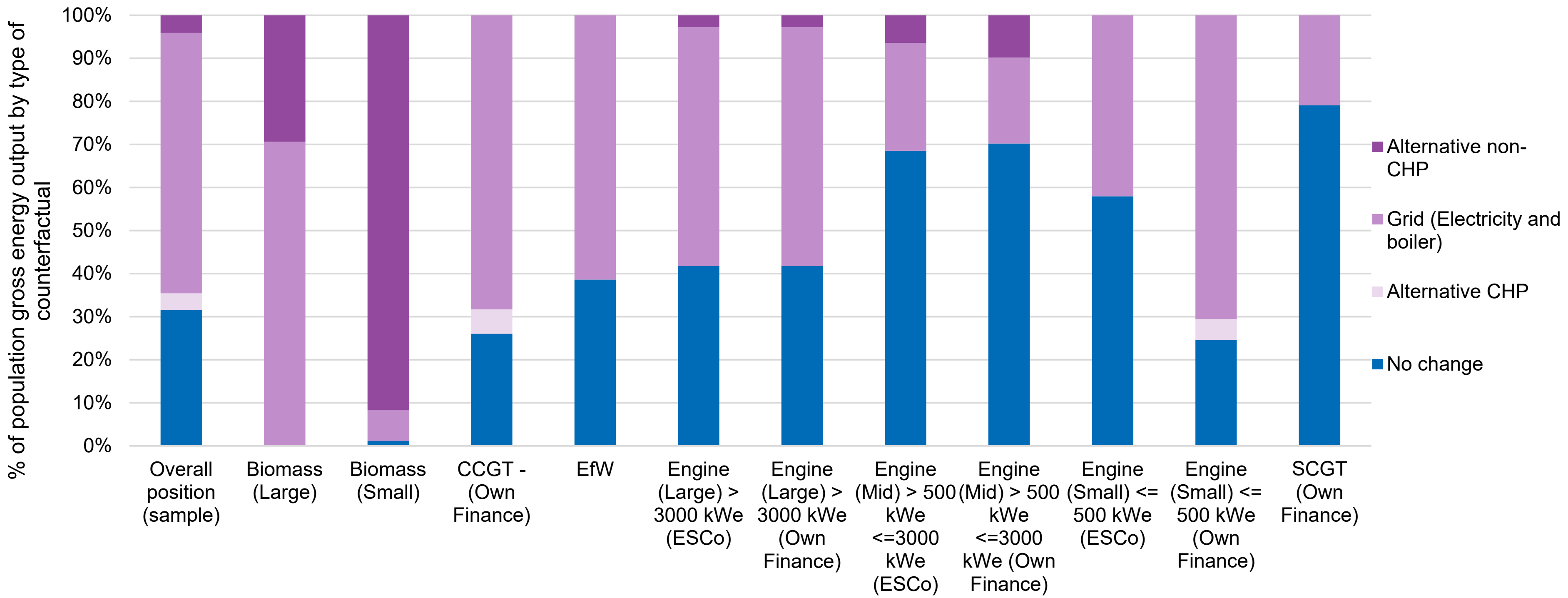
In particular, this Annex covers the outputs aligned or answering the following research questions numbers1-9. Outputs related to questions 10-13 are covered by earlier Annexes.

1. What is the investment counterfactual for each Scheme i.e., the likely option in a scenario in which the CHPQA Programme and associated financial benefits were not available?
2. What was the relative importance of the CHPQA Programme in reaching their investment decision?
3. What is the estimated fuel use in the 'non-CHPQA scenario' (i.e., the counterfactual)? And how does this compare to the factual fuel use?
4. What is the relative importance of CHPQA eligibility for non-grandfathered Schemes and associated financial benefits in the CHP operational decisions?
5. How would CHPQA participants meet their heat and electricity needs in 2019 if CHPQA eligibility for non-grandfathered Schemes and associated financial benefits were no longer available?
6. Looking ahead at 2023, if CHPQA and current eligibility to financial benefits remained, what would organisations do, given market conditions?
7. Given the Net Zero targets in the UK, might CHPQA RPs consider any CHP (or other) options for the future?
8. What are the main business barriers that businesses face when considering future investments in CHP Schemes?
9. What is the type and magnitude of the capital expenditure or investment made by the RP's organisation (or otherwise) on the CHP Scheme?
10. What is the administrative burden of the CHPQA Programme on businesses?
11. Have businesses used and found helpful the CHPQA Programme services?
12. How could the CHPQA Programme be improved?
13. Could the Programme be used to achieve greater energy efficiencies?

**1. What is the investment counterfactual for each Scheme i.e., the likely option in a scenario in which the CHPQA Programme and eligibility to financial benefits were not available?**

The evidence collected through the survey by archetype suggests that the CHPQA Programme had a real impact on investment decisions, facilitating additional investment in CHP Schemes.

**Figure A6.1: Investment counterfactual (that is, likely investment in a non-CHPQA scenario)**




Extrapolated to the total population from N=156.

*CCGT (ESCo) and 'Other' archetypes have been excluded from graph to avoid* potential disclosure of survey responses.

Based on an analysis and extrapolation of their survey and interview responses, more than 65% of the respondents reported that they would have not invested in the current CHP Scheme in the absence of the CHPQA Programme. Given their responses, it is estimated that 68% of the gross energy output produced by CHP Schemes in 2019 would have been produced by an alternative to the current CHP Schemes in the counterfactual or non-CHPQA scenario. In particular, in this investment counterfactual:

- 60% of the 2019 gross energy output would be supplied by electricity from the grid and heat from on-site gas boilers.
- 4% of the 2019 gross energy output would be supplied by other non-CHP alternatives.
- 4% of the 2019 gross energy output would be supplied by an alternative and slightly different CHP Scheme (generally assumed to be a similar albeit potentially smaller CHP Scheme).
- 32% of the 2019 gross energy output would be supplied by the current CHP Scheme, as investors would have still gone ahead with their commitment even without the CHPQA Programme and associated financial benefits.

An 'additionality score' was developed based on these data, which captures the extent to which the CHPQA Programme would have led to more investment in CHP Schemes than in the counterfactual. This score is defined as the percentage of gross energy output that is supplied by CHP Schemes certified by CHPQA due to investments spurred by the CHPQA Programme and financial benefits, that is, the investments that would have not occurred without CHPQA benefits. At the population level, it is estimated that overall additionality would range from 62% to 68%. This is presented at the overall and Scheme archetype level in Table A6.1 below.

**Table A6.1: CHPQA additionality for the investment counterfactual: Proportion of energy output attributed to the CHPQA Programme having a real impact on investment decisions, facilitating additional investment in CHP Schemes (% of gross energy output)**

| Schemes by archetypes | Additionality (Lower Bound), % of gross energy output | Additionality (Upper Bound), % of gross energy output |
|---|---:|---:|
| Total | 62% | 68% |
| Biomass (Large) | 100% | 100% |
| Biomass (Small) | 97% | 99% |
| CCGT - (ESCo) | [s] | [s] |
| CCGT - (Own Finance) | 68% | 76% |
| EfW | 61% | 61% |
| Engine (Large) > 3000 kWe (ESCo) | 16% | 58% |
| Engine (Large) > 3000 kWe (Own Finance) | 57% | 58% |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | 16% | 31% |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | 30% | 38% |
| Engine (Small) <= 500 kWe (ESCo) | 27% | 42% |
| Engine (Small) <= 500 kWe (Own Finance) | 64% | 75% |
| SCGT (Own Finance) | 21% | 29% |
| Other | [s] | [s] |

Extrapolated to the total population from a sample, N=156

*[s] data suppressed due to avoid potential disclosure of survey responses*

### 2. What was the relative importance of the CHPQA Programme in reaching their investment decision?

Given the evidence identified above with regards to the additionality of the CHPQA Programme, it is not surprising that CHPQA financial benefits were considered an either 'important' or 'very important' factor for most organisations when reaching an investment decision to invest in a CHP Scheme.

Survey responses are presented as simple averages for each archetype in Table A6.2 below. The rows (archetypes) are in descending order by the average level of importance (i.e., score) allocated to 'financial benefits from CHPQA eligibility'.

**Table A6.2: Importance of different investment factors in reaching a decision to invest in a CHP Scheme**

| Scheme Archetypes | Security of supply (for heat and/or electricity) | Contractual obligations | Financial performance | Income expectations from exporting energy | Environmental considerations | Market conditions | Financial support from CHPQA eligibility |
|---|---|---|---|---|---|---|---|
| Engine (Small) <= 500 kWe (Own Finance) | 3 | 1 | 4 | 0 | 3 | 3 | 4 |
| Biomass (Large) | 4 | 4 | 4 | 4 | 3 | 4 | 4 |
| Other | [s] | [s] | [s] | [s] | [s] | [s] | [s] |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | 4 | 4 | 5 | 2 | 3 | 3 | 4 |
| Biomass (Small) | 4 | 2 | 4 | 2 | 4 | 3 | 4 |
| Engine (Large) > 3000 kWe (ESCo) | 4 | 5 | 5 | 3 | 3 | 2 | 4 |
| EfW | 4 | 5 | 4 | 4 | 5 | 3 | 4 |
| CCGT - (Own Finance) | 4 | 2 | 4 | 3 | 4 | 3 | 3 |
| SCGT (Own Finance) | 4 | 2 | 4 | 2 | 3 | 2 | 3 |
| Engine (Large) > 3000 kWe (Own Finance) | 3 | 2 | 4 | 1 | 3 | 3 | 3 |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | 3 | 2 | 4 | 1 | 4 | 3 | 3 |
| CCGT - (ESCo) | [s] | [s] | [s] | [s] | [s] | [s] | [s] |
| Engine (Small) <= 500 kWe (ESCo) | 2 | 3 | 3 | 1 | 2 | 2 | 2 |

*Estimated based on a sample of N=204. Note that the scores signify the following: 0-not applicable, 1-not very important, 2-somewhat important; 3-important, 4-very important, and 5-critical.*

*[s] data suppressed due to avoid potential disclosure of survey responses*

When exploring the most important CHPQA benefits, respondents generally found the Climate Change Levy reliefs important or very important. For the biomass archetypes, Renewables Obligation Certificates and Renewable Heat Incentives were also very important.

**3. What is the estimated fuel use in the 'non-CHPQA scenario' (i.e., the counterfactual)? And how does this compare to the factual fuel use?**

Based on the methods outlined in this study and the factual evidence of gross energy output and primary energy input for each Scheme in operation in 2019, it is estimated that the factual CHPQA scenario requires 11% less primary energy input than the counterfactual (non-CHPQA scenario). That is, CHPQA contributes to a reduction in primary energy usage of around 11% overall, which was equivalent to 15 TWh in 2019.

**Table A6.3: Primary fuel consumed in the factual or outturn versus the investment counterfactual in 2019**

| Scheme Archetypes | Total primary energy input (TWh) in NCV | | |
|---|---|---|---|
| | Factual (CHPQA) | Counterfactual (non-CHPQA) | % factual against counterfactual |
| Total | 123 | 138 | -11% |
| Biomass (Large) | 12.1 | 10 | 24% |
| Biomass (Small) | 2 | 2 | 32% |
| CCGT - (ESCo) | 30 | [s] | [s] |
| CCGT - (Own Finance) | 47 | 56 | -17% |
| EfW | 5 | 5 | 11% |
| Engine (Large) > 3000 kWe (ESCo) | 3 | 4 | -16% |
| Engine (Large) > 3000 kWe (Own Finance) | 5 | 6 | -16% |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | 2 | 2 | -5% |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | 2 | 3 | -12% |
| Engine (Small) <= 500 kWe (ESCo) | 1 | 1 | -12% |
| Engine (Small) <= 500 kWe (Own Finance) | 1 | 1 | -19% |
| SCGT (Own Finance) | 6 | 7 | -6% |

| | | | |
|---|---|---|---|
| Other | 7 | [s] | [s] |

*Note: Total primary energy inputs are rounded to whole units for presentation. Percentage changes are calculated using unrounded values.*

*Fuel consumption in the 'Factual' column will differ to DUKES Chapter 7 data. DUKES data concerns all UK CHP, excluding CHP categorised as Major Power Producers, and 'Good Quality' fuel consumption. The CHPQA dataset feeds into DUKES but only covers CHPQA Schemes. This includes CHP Major Power Producers and all fuel consumption.*

*Extrapolated to the total population from a sample, N=156.*

*[s] data suppressed due to avoid potential disclosure of survey responses.*

For non-renewable CHP options, the primary energy savings against the counterfactual are estimated at around 16% (5%-19%). Renewable CHP options (biomass and EfW) are estimated to consume more primary energy than the counterfactual; i.e., mostly relative to electricity from the grid and onsite boilers for heat production.

Please note, again, that assumptions used for establishing counterfactual energy consumption are based on the counterfactual technologies reported in the survey responses, and not those used for establishing Good Quality CHP at the individual Scheme level in the CHPQA Programme, i.e., the use of fuel specific reference values for the separate generation of electricity and heat.

These impacts on the level and composition of fuel consumption are the key drivers of other parameters such as Carbon emissions, air quality damage costs, and fuel costs (LRVC). For example, it is estimated that the factual CHPQA scenario emits 6% fewer Carbon emissions than the counterfactual (non-CHPQA scenario). That is, CHPQA contributes to a reduction in carbon emissions of around 6% overall against the counterfactual, which was equivalent to 1.3 MtCO2e in 2019.

**Table A6.4: CO2e emissions in tonnes in the factual or outturn versus the investment counterfactual in 2019**

| **Scheme Archetypes** | **Total Carbon emissions (MtCO2e)** | | |
|---|---|---|---|
| | Factual (CHPQA) | Counterfactual (non-CHPQA) | % factual against counterfactual |
| Total | 20.7 | 22.0 | -6% |
| Biomass (Large) | 0.2 | 1.4 | -84% |
| Biomass (Small) | <0.05 | 0.2 | -85% |
| CCGT - (ESCo) | 5.8 | [s] | [s] |
| CCGT - (Own Finance) | 8.9 | 8.9 | <0.5% |
| EfW | 0.9 | 0.7 | 17% |
| Engine (Large) > 3000 kWe (ESCo) | 0.6 | 0.6 | -4% |

| | | | |
|---|---|---|---|
| Engine (Large) > 3000 kWe (Own Finance) | 0.8 | 0.8 | -4% |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | 0.5 | 0.4 | 6% |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | 0.4 | 0.4 | -4% |
| Engine (Small) <= 500 kWe (ESCo) | 0.2 | 0.2 | -2% |
| Engine (Small) <= 500 kWe (Own Finance) | 0.1 | 0.1 | 1% |
| SCGT (Own Finance) | 1.3 | 1.3 | -<0.5% |
| Other | 1.1 | [s] | [s] |

*Extrapolated to the total population from a sample, N=156.*

*Figures rounded to the nearest 0.1 of a megatonne of carbon (MtCO2e)*

*[s] data suppressed due to avoid potential disclosure of survey responses.*

**Table A6.5: Retail value of fuel (£, millions) in the factual minus the investment counterfactual in 2019**

| Scheme Archetypes | Total retail value of fuel (£ million, 2021 prices) | | |
|---|---|---|---|
| | Factual (CHPQA) | Counterfactual (non-CHPQA) | % factual against counterfactual |
| Total | 5,530 | 3,970 | -28% |
| Biomass (Large) | 390 | 320 | -17% |
| Biomass (Small) | 60 | 80 | 27% |
| CCGT - (ESCo) | 1,500 | [s] | [s] |
| CCGT - (Own Finance) | 2,400 | 1,680 | -30% |
| EfW | 130 | 0 | -100% |
| Engine (Large) > 3000 kWe (ESCo) | 150 | 110 | -29% |
| Engine (Large) > 3000 kWe (Own Finance) | 260 | 190 | -29% |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | 90 | 80 | -11% |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | 100 | 80 | -18% |
| Engine (Small) <= 500 kWe (ESCo) | 40 | 30 | -21% |
| Engine (Small) <= 500 kWe (Own Finance) | 40 | 30 | -34% |
| SCGT (Own Finance) | 260 | 230 | -12% |

| | | | |
|---|---|---|---|
| Other | 100 | [s] | [s] |

*Extrapolated to the total population from a sample, N=156.*

*Figures rounded to the nearest £10 million*

*[s] data suppressed due to avoid potential disclosure of survey responses.*

Total retail value of fuel sum to a saving of around £1.6 billion (2021 prices) arising from primary energy savings compared to the counterfactual are estimated at -28%. Biomass (Small) has higher a retail fuel prices compared to the counterfactual. EfW has a reduction in the retail value of fuel of 100% as the combustion of waste, often municipal solid waste, is typically paid to the site to dispose of the waste. Therefore, EfW may actually produce revenue from waste disposal, going beyond just bill savings, however for this analysis it is assumed that the retail fuel price of municipal solid waste is zero.

**4. What is the relative importance of CHPQA relief in the CHP operational decisions?**

The survey and interview data were also analysed to establish the relative importance of CHPQA eligibility for non-grandfathered Schemes in the CHP operational decisions, including what CHPQA participants would do in 2019 if non-grandfathered financial benefits were no longer available in 2019.

For most archetypes ‘financial performance’ was the most important factor considered by the RPs and their organisations when taking operational decisions in 2019, with the exception being Small Engines ≤500 kWe (Own Finance) where financial support from CHPQA eligibility was the highest scored factor.

Security of supply, environmental considerations and financial support from CHPQA eligibility (including the CHPQA Programme) were also important operational factors. The latter, ‘financial support from CHPQA eligibility’, ranks in the top 3 of most important factors considered when taking operational decisions for four archetypes: Small Engines (Own Finance), Biomass Large, Mid-sized Engines (ESCo) and Biomass Small.

Table A6.6 presents the average score (1–5) against each factor across the archetypes. The rows (archetypes) are in descending order of the average level of importance (i.e., score) allocated to ‘financial support from CHPQA eligibility’.

**Table A6.6: The relative importance of a range of factors in the CHPQA organisation's operational decisions in 2019**

| Scheme Archetypes | Security of supply (for heat and/or electricity) | Contractual obligations | Financial performance | Income expectations from exporting energy | Environmental considerations | Market conditions | Financial support from CHPQA eligibility |
|---|---|---|---|---|---|---|---|
| Engine (Small) <= 500 kWe (Own Finance) | 3 | 1 | 4 | 0 | 3 | 3 | 4 |
| Biomass (Large) | 4 | 4 | 4 | 4 | 3 | 4 | 4 |
| Other | [s] | [s] | [s] | [s] | [s] | [s] | [s] |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | 4 | 4 | 5 | 2 | 3 | 3 | 4 |
| Biomass (Small) | 4 | 2 | 4 | 2 | 4 | 3 | 4 |
| Engine (Large) > 3000 kWe (ESCo) | 4 | 5 | 5 | 3 | 3 | 2 | 4 |
| EfW | 4 | 5 | 4 | 4 | 5 | 3 | 4 |
| CCGT - (Own Finance) | 4 | 2 | 4 | 3 | 4 | 3 | 3 |
| SCGT (Own Finance) | 4 | 2 | 4 | 2 | 3 | 2 | 3 |
| Engine (Large) > 3000 kWe (Own Finance) | 3 | 2 | 4 | 1 | 3 | 3 | 3 |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | 3 | 2 | 4 | 1 | 4 | 3 | 3 |
| CCGT - (ESCo) | [s] | [s] | [s] | [s] | [s] | [s] | [s] |
| Engine (Small) <= 500 kWe (ESCo) | 2 | 3 | 3 | 1 | 2 | 2 | 2 |

*Estimated, based on a sample, N=204. Scores signify the following: 0-not applicable, 1-not very important, 2-somewhat important; 3-important, 4-very important, 5-critical.*

*[s] data suppressed due to avoid potential disclosure of survey responses.*

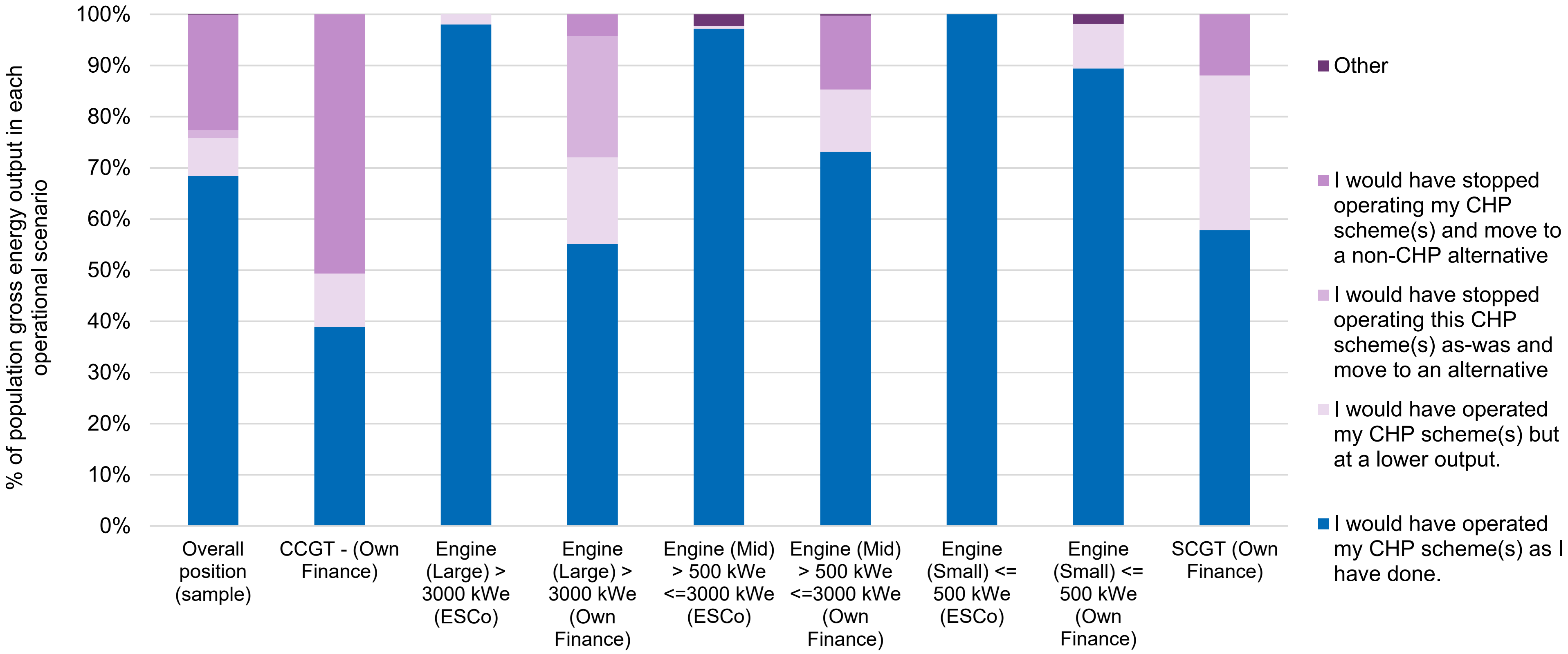
It is, therefore, evidenced that RPs and their organisations find financial support from CHPQA eligibility to be a relatively important factor when considering whether and how to operate their CHP Scheme in a given year.

**5. How would CHPQA participants meet their heat and electricity needs in 2019 if CHPQA eligibility for non-grandfathered financial benefits were no longer available?**

RPs were asked to consider what their organisation might have done in 2019 in the event that non-grandfathered financial benefits were no longer available. Non-grandfathered financial benefits include the Carbon Price Support, the Climate Change Levy reliefs, fuel duty, Enhanced Capital Allowances and reduced Business Rates. That is, all benefits linked to the CHPQA Programme excluding the Renewable Heat Incentive, Renewables Obligation Certificates and Contracts for Difference.

In this context, RPs and their organisations suggested that, overall, they would have generally operated their CHP Scheme in 2019 in the same way they have done with all the financial benefits available. 68% of the total energy output produced by the CHP Schemes in 2019 would have been supplied in the same way. The results by archetype are presented in Table A6.2 below.

**Figure A6.2: Operational decisions in 2019 in a scenario where CHPQA eligibility for non-grandfathered Schemes were not available.**




*Survey answers extrapolated to the total population from N=156.*

*CCGT (ESCo) and 'Other' archetypes have been excluded from graph to avoid* potential disclosure of survey responses.

Archetypes that are predominantly purple showcase a high likelihood that the current CHP operations would have change in 2019 if non-grandfathered financial benefits were stopped. Archetypes that are predominantly blue showcase a high likelihood that the CHP operations will continue as they were in 2019 even if non-grandfathered financial benefits were stopped.

Based on the evidence gathered, it appears that the archetypes that would be most affected by this scenario are CCGT (Own Finance), Large Engines (Own Finance), SCGT (Own Finance) and Mid-sized Engines (Own Finance).

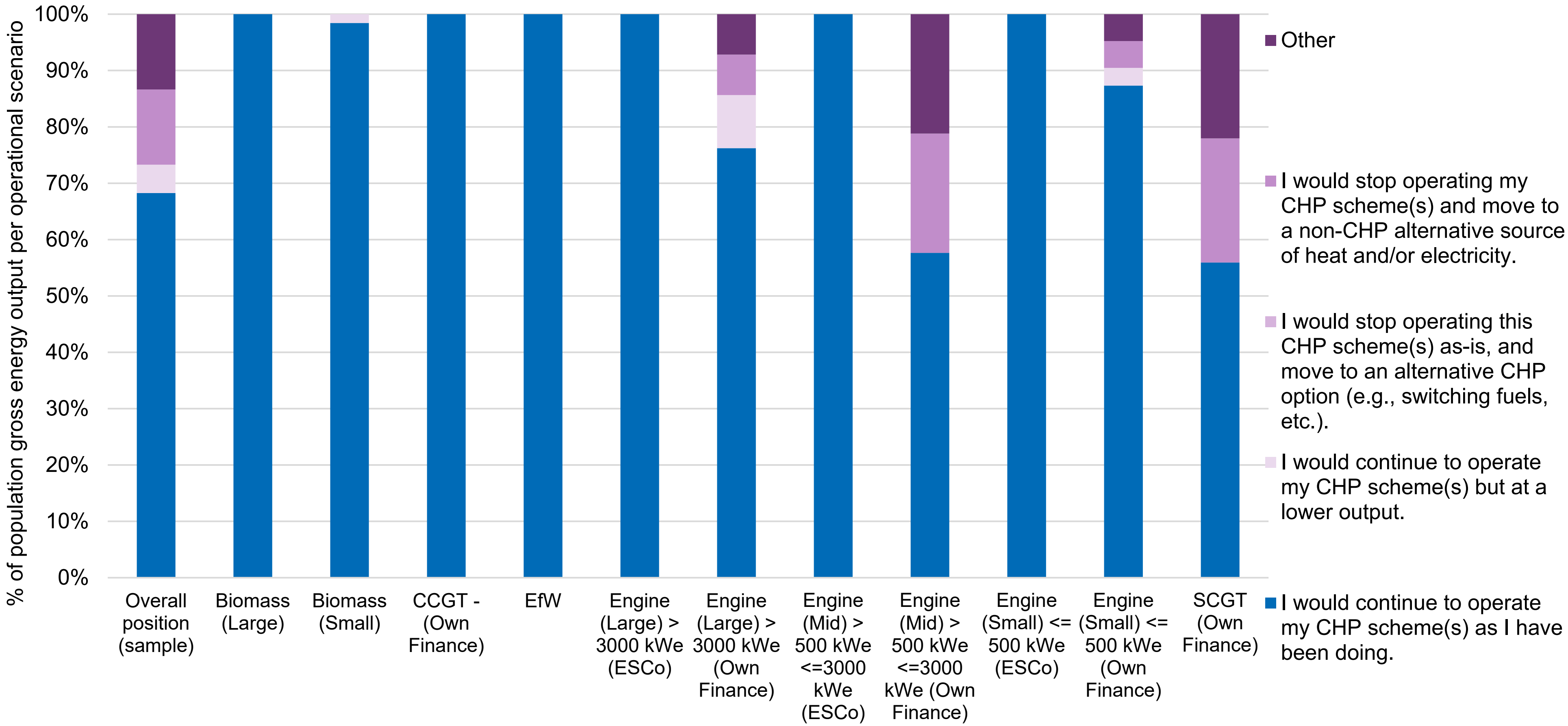
**6. Looking ahead at 2023, if CHPQA and benefits remained, what would organisations do, given market conditions?**

These RPs were also asked to look ahead to 2023 and consider what their organisations might do with regards to their CHP Schemes, given current market conditions and baseline financial benefits.

In this context, RPs and their organisations suggested that, overall, they would operate their CHP Scheme in 2023 in the same way they have done so far; 68% of the total energy output produced by the CHP Schemes in 2023 would be supplied in the same way as it has been to date.

In Figure A6.3 archetypes that are predominantly purple showcase a high likelihood that the current CHP operations would have changed in 2019 if non-grandfathered financial benefits were stopped. Archetypes that are predominantly blue showcase a high likelihood that the CHP operations will continue as they were in 2019 even if non-grandfathered financial benefits were stopped.

**Figure A6.3: Operational decisions in 2023 in a baseline scenario (assuming the same financial benefits and market conditions)**




*Extrapolated to the total population from N=156.*

*CCGT (ESCo) and 'Other' archetypes have been excluded from graph to avoid* potential disclosure of survey responses.

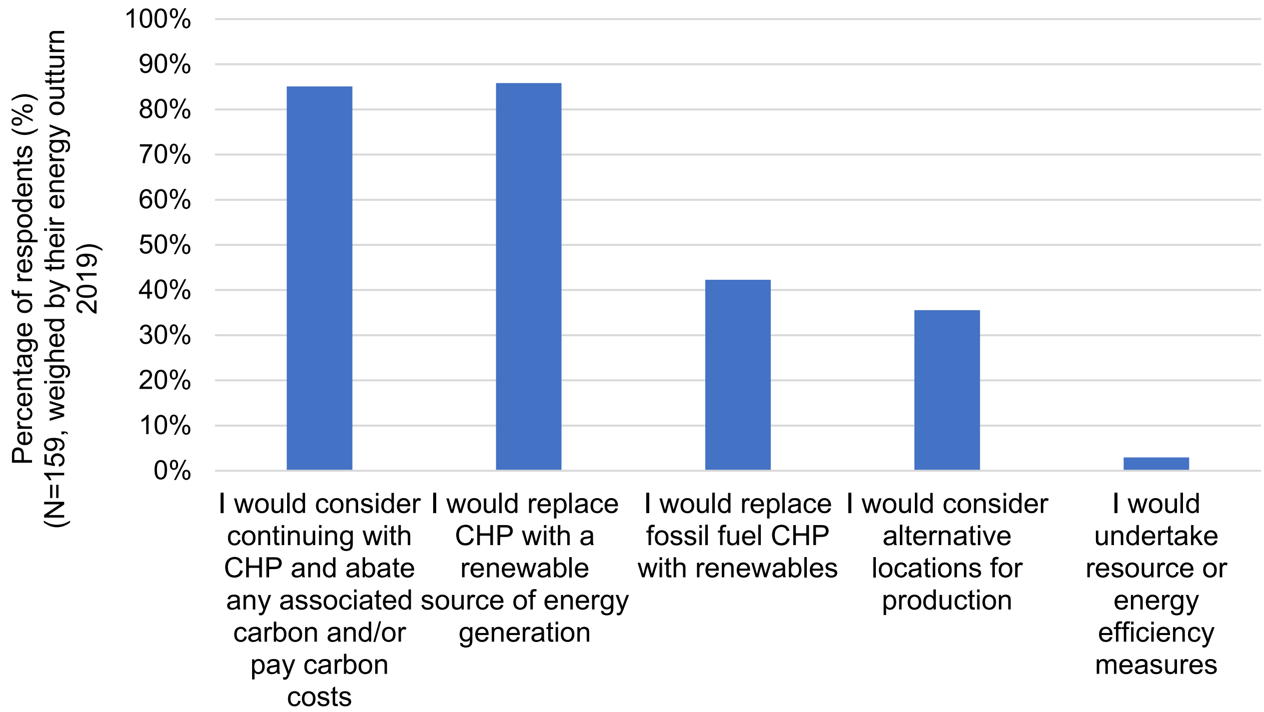
**7. Given the net zero targets in the UK, might CHPQA RPs consider any CHP (or other) options for the future?**

The evidence and analysis suggest that operators of certain archetypes might already be considering adjustments to their operations without any changes to the CHPQA Programme, including CCGT (ESCo), mid-sized engines (Own Finance), SCGT (Own Finance) and large engines (Own Finance). These are also archetypes that do not appear to deliver significant social value when compared to their direct public costs. Therefore, the operational changes they might consider for 2023 may not necessarily be of concern for the CHPQA Programme.

RPs were also asked to look further into the future and consider whether they might explore any CHP or other options in the context of the UK's net zero targets. An estimated 86% of the organisations would consider continuing with their CHP and abate any associated carbon and/or pay carbon costs, almost 80% would also consider replacing their CHP with a renewable source of energy generation (e.g., heat pump, other renewable energy sources), whilst other options are less popular amongst RPs and their organisations.

Figure A6.4 below provides a summary of the possible ways forward for RPs and their organisations in the context of the UK's Net Zero targets.

**Figure A6.4: CHP or other options that RPs and their organisations might consider for the future**




*Extrapolated to the total population from the sample of respondents, N=156.*

*Note respondents could select multiple options hence totals will sum to over 100%*

**8. What are the main business barriers that businesses face when considering future investments in CHP Plants?**

RPs were also asked about the barriers that their organisations might face when considering future investments in CHP plants. On average, significant barriers were identified across most Scheme archetypes, especially biomass, both large and small and CCGT. Respondents for small and mid-sized engines and SCGTs also identified significant barriers for future investments.

The relatively more significant barriers identified included limited or uncertain access to government support including CHPQA, other regulatory and/or policy actions (or lack thereof), and risks or uncertainty associated with the payback period. The evidence collated across the sample of respondents is presented in Table A6.7 below.

**Table A6.7: Barriers faced by businesses when considering future investments in CHP Schemes**

| Schemes by Archetype | Significant upfront capital costs | Limited or uncertain access to government support (including CHPQA) | Other regulatory and/or policy actions (or lack thereof) | Risks or uncertainty associated with the payback period | Suitability for the energy that is being demanded | Unclear or uncertain options for exporting energy to a network |
|---|---|---|---|---|---|---|
| Biomass (Large) | 3 | 4 | 4 | 4 | 3 | 3 |
| Biomass (Small) | 4 | 4 | 4 | 4 | 3 | 2 |
| CCGT - (ESCo) | [s] | [s] | [s] | [s] | [s] | [s] |
| CCGT - (Own Finance) | 3 | 4 | 3 | 3 | 3 | 2 |
| EfW | 3 | 1 | 1 | 2 | 2 | 3 |
| Engine (Large) > 3000 kWe (ESCo) | 1 | 0 | 1 | 1 | 2 | 1 |
| Engine (Large) > 3000 kWe (Own Finance) | 2 | 2 | 2 | 2 | 1 | 2 |
| Engine (Mid) > 500 kWe <=3000 kWe (ESCo) | 3 | 3 | 3 | 3 | 3 | 1 |
| Engine (Mid) > 500 kWe <=3000 kWe (Own Finance) | 2 | 2 | 2 | 2 | 2 | 1 |
| Engine (Small) <= 500 kWe (ESCo) | 2 | 4 | 4 | 3 | 3 | 1 |
| Engine (Small) <= 500 kWe (Own Finance) | 1 | 3 | 2 | 2 | 2 | 0 |
| SCGT (Own Finance) | 3 | 3 | 2 | 3 | 3 | 2 |
| Other | [s] | [s] | [s] | [s] | [s] | [s] |

*Analysis based on the sample of respondents. Scores signify the following: 0-Not applicable, 1-not very significant, 2-somewhat significant; 3-significant, 4-very significant, and 5-critical.*

*[s] data suppressed due to avoid potential disclosure of survey responses.*

**9. What is the type and magnitude of the capital expenditure or investment made by the RP's organisation (or otherwise) on the CHP Scheme?**

RPs were also asked to share any evidence of the upfront capital investment required to install their CHP Scheme. A sample of 149 respondents provided some data, which suggests that, on average, a non-renewable CHP Scheme would cost around 1,200 £/kWe (500–1,800 £/kWe), whereas biomass and/or EfW Schemes would cost more at around 3,000 £/kWe (2,800-3,500 £/kWe). These data have limitations, as they include investments that span over two decades and, thus, do not reflect the capital investment requirements that may be expected for Schemes in the near future. Moreover, some albeit more limited data were also provided on the costs of major replacements or refurbishments, which are estimated to be around 1,000 £/kWe for the sample of respondents. This estimate would be higher than what was expected by experts, which would suggest that major replacements or refurbishments would cost around 33%-50% of the original Scheme.

Finally, these data and others have been used to estimate the net social benefits of the CHPQA Programme.

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