Cost-benefit assessment for combustion installations

Draft guidance on completing cost-benefit assessments for installations under Article 14 of the Energy Efficiency Directive

V0.9 April 2015

From 21 March 2015, operators of certain types of combustion installation need to carry out a cost-benefit assessment (CBA) of opportunities for cogeneration (also known as combined heat and power) or supplying a district heating or cooling network when they apply for a new environmental permit, or for a variation when substantially refurbishing an existing installation. This guidance tells you what the requirements are and how to comply with them.

- Section 1 explains when you will need to do a CBA
- Section 2 explains when you will be exempt from needing to do a CBA
- Section 3 explains how to complete the CBA template
- Section 4 explains how to enter industrial CHP information into the CBA template.

Section 1: Requirements for cost-benefit assessments

What are the legal requirements for carrying out a cost-benefit assessment?

Schedule 7A and Schedule 8 of the Environmental Permitting Regulations 2010 (EPR) require CBAs to be carried out for certain installations listed in Part 2 of Schedule 1 of EPR.

Which types of combustion installations need to do a cost-benefit assessment?

Table 1 below shows the types of combustion installation which may need to carry out CBAs. Note that certain types of thermal electricity generation plant are exempt – see Table 2 in Section 2 below for a list of exempt plant.

Table 1 – requirements for cost-benefit assessment

Installation type reference	Type of combustion installation	What should the cost-benefit assessment (CBA) cover?
14,5(a)	New thermal electricity generation installation with a total aggregated net thermal input of more than 20 MW (e.g. power station or energy from waste plant)	CBA for the operation of the installation as a high-efficiency cogeneration installation (see Diagram 1 below).
14,5(b)	Existing thermal electricity generation installation with a total aggregated net thermal input of more than 20 MW which is substantially refurbished (e.g. power station or energy from waste plant)	CBA for the operation of the installation as a high-efficiency cogeneration installation (see Diagram 1 below).

Installation type reference	Type of combustion installation	What should the cost-benefit assessment cover?
14,5(c)	New industrial installation with a total aggregated net thermal input of more than 20 MW generating waste heat at a useful temperature level, or an existing such installation where the combustion unit is to be substantially refurbished (e.g. cement kiln, steel works, factory)	CBA of utilising the waste heat to satisfy economically justified demand by connection of that installation to a district heating and/or cooling network, or CBA of supplying the installation's needs with a cogeneration plant (see Diagram 2 below).
14,5(d)	New district heating and cooling network with a total aggregated net thermal input of more than 20 MW, or a new energy production installation with a total aggregated net thermal input of more than 20 MW in an existing district heating or cooling network, or an existing such installation where the combustion unit is to be substantially refurbished.	CBA of utilising the waste heat from nearby industrial installations (see Diagram 3 below).

Definitions

Aggregated net thermal input means that the value of the rated thermal input of each combustion unit should be expressed according to the lower heating value of the fuel, and added to the values of all the other combustion units on the same site which are capable of operating simultaneously to produce a total value. Where this value exceeds 20 MW, the Article 14 requirements will apply.

Thermal electricity generation installations are power stations and energy from waste plants which generate electricity only.

Cogeneration means the simultaneous generation in one process of thermal energy and electrical or mechanical energy and is also known as combined heat and power (CHP)

High-efficiency co-generation is cogeneration which achieves at least 10% savings in primary energy usage compared to the separate generation of heat and power – see Annex II of the Energy Efficiency Directive for detail on how to calculate this.

Substantially refurbished means a refurbishment whose costs exceed 50% of the investment cost for a new comparable unit (excluding fitting of carbon capture equipment) – see further notes below.

Useful temperature is explained in What is waste heat? below.

Economically justified demand means that, in the absence of the heat linking project, investment in boilers would go ahead to meet this heat demand instead.

Who is the regulator for installations under Article 14 of the Energy Efficiency Directive?

The Environment Agency is the regulator for Part A(1) installations listed in Part 2 of Schedule 1 of EPR, whereas the local authority is the regulator for Part A(2) and Part B installations. This guidance is for operators making applications to the Environment Agency. However, the CBA methodology and template it provides are equally applicable to applications made to local authorities.

Do all installations which meet the description in Table 1 need to do a cost-benefit assessment?

To decide whether you need to do a CBA, follow the decision tree in Diagram 1, 2 or 3 below. If you do not need to do a CBA after following these steps you must agree this with the Environment Agency at the pre-application stage, supplying supporting information as necessary.

Do operators of new or existing combined heat and power plants have to do an assessment?

Operators of new or substantially refurbished combined heat and power (CHP) plants with an aggregated net thermal input of more than 20 MW which serve an industrial process which generates waste heat at a useful temperature are classed as 14,5(c) installations and will need to follow the steps in Diagram 2 below to decide if a CBA will be required for connecting to a district heating and/or cooling network. Operators of new or substantially refurbished CHP plants with an aggregated net thermal input of more than 20 MW which serve a district heating or cooling network are classed as 14,5(d) installations and will need to follow the steps in Diagram 3 below.

When must the cost-benefit assessment be carried out?

You must submit the CBA as part of the application for an environmental permit for new installations, or variation application for existing installations. However, we would expect you to be thinking about the opportunities for combined heat and power at the earliest possible stages of any new proposals, and to agree whether you will need to submit a CBA during pre-application discussions with us.

How must the cost-benefit assessment be carried out?

We strongly advise that you carry out the cost-benefit assessment using the methodology in Section 3 on the Excel template which we provide (which represents the minimum amount of information necessary for us to determine your application). However, you can carry out more detailed assessments and submit further information if you want to.

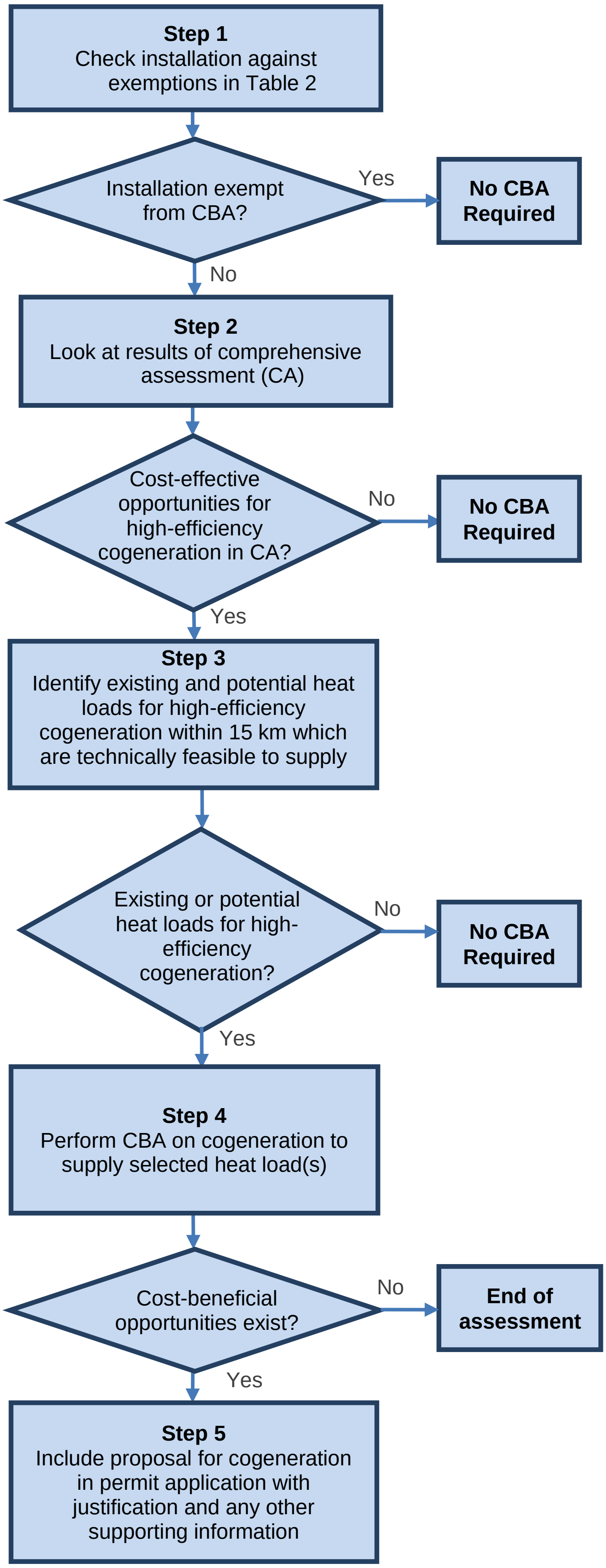
What is waste heat?

For the purposes of 14,5(c) installations, heat is considered to be waste heat at the point at which it is finally rejected from the process. Heat which is “lost” during a process (e.g. from insulated pipework transporting steam or hot water) is not considered to be waste heat. It is assumed that waste heat, once recovered, will be in the form of hot water or steam. Where all the available waste heat is already being recovered for use within the installation, no CBA is required.

In order to determine whether the installation is producing waste heat at a “useful temperature” you should firstly determine whether it is technically feasible to recover the heat in the form of hot water or steam (see section on technical feasibility below) and then see whether there are any heat loads within the appropriate distance which can use the heat at this temperature.

District heating schemes in the UK will generally require waste heat at a temperature of 65 ºC or more which is most likely to arise from high-temperature industries e.g. glass, cement etc.

Diagram 1: CBA assessment methodology for type 14,5(a) and 14,5(b) installations (new and refurbished thermal electricity generation installations)



Notes on Step 2

The comprehensive assessment is a country-wide assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling (see Annex VIII of the Energy Efficiency Directive). Until the results of this are available, omit Step 2 and proceed to Step 3.

Notes on Step 3

Potential heat loads are those where planning consent and investment have been publically announced, but the heat load is not yet in existence, or where the comprehensive assessment identifies clear perspectives, i.e. measures, policies or strategies that the heat load will come to existence. See Annex IX Part II of the Energy Efficiency Directive for more detail.

In order to determine whether a heat load is **technically feasible to supply**, see the guidelines in the section below.

Where the total heat load identified will not be sufficient for high-efficiency cogeneration (i.e. to achieve a minimum of 10% primary energy savings), installations covered by the Industrial Emissions Directive must still consider all possible cogeneration opportunities. See Section X of the H2 guidance for more detail.

Notes on Step 5

Other supporting information could include evidence of discussions with operators of the identified heat load(s) proposed to be supplied.

Diagram 2: CBA assessment methodology for type 14,5(c) installations (industrial plants with waste heat)

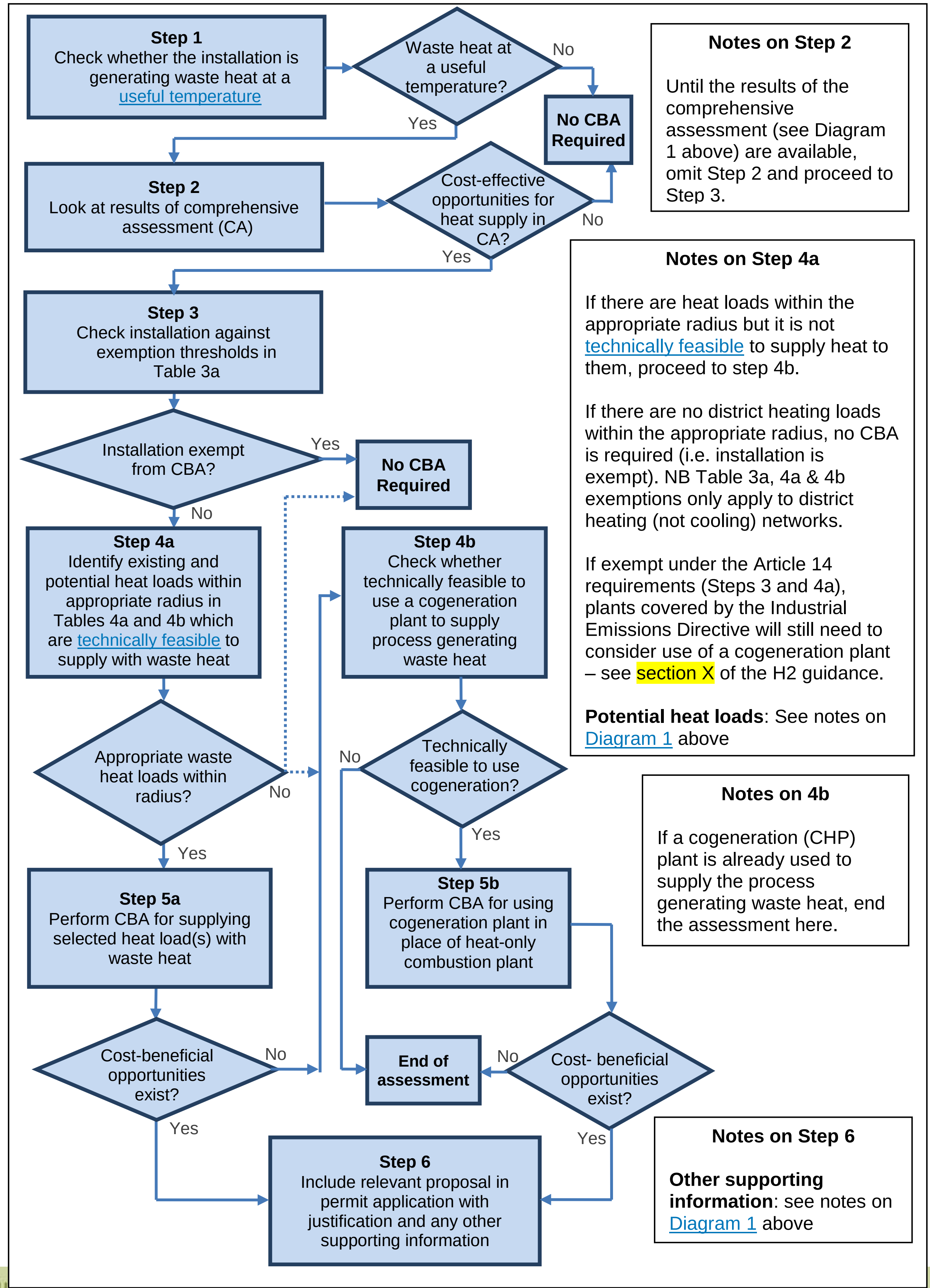
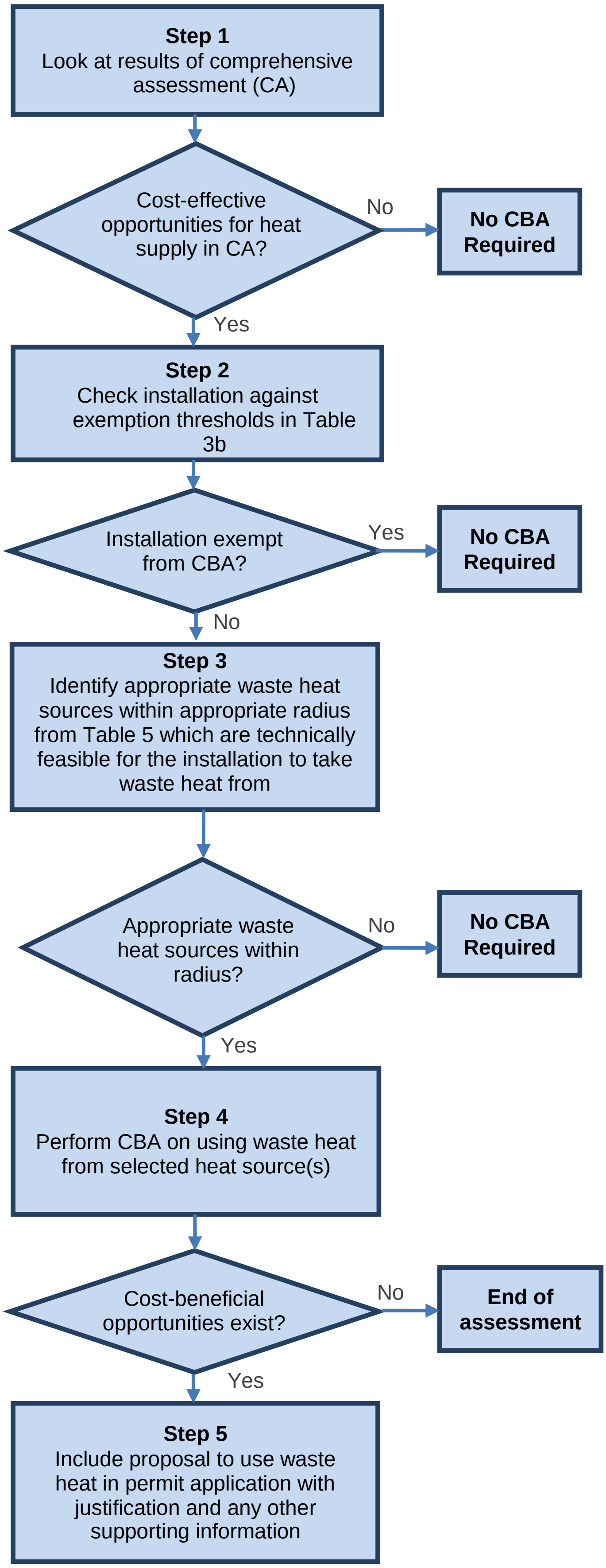


Diagram 3: CBA assessment methodology for type 14,5(d) installations (district heating and cooling networks) that are currently generating their own heat



Notes on Step 1

The comprehensive assessment is a country-wide assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling (see Annex VIII of the Energy Efficiency Directive). Until the results of this are available, omit Step 1

Notes on Step 2

Firstly check the thresholds in Table 3b (minimum amount of heat required), then if above threshold, see Table 5 to determine if any heat sources exist within appropriate radius (according to the amount of heat required).

Note that the exemption thresholds only apply to district heating (not cooling) networks.

Notes on Step 3

In order to identify appropriate waste heat sources, operators will need to consider the temperature and nature of the waste heat source(s), as well as the operating profile.

Where an appropriate waste heat source is identified within the relevant radius which is *less* than the total amount of heat required, refer back to Table 5 to determine whether a CBA is required

Example
Heat required: 2.4 MW hot water = 9.1 km search radius
Waste heat available: 0.7 MW source 8 km away
Refer back to Table 5: max distance for 0.7 MW = 2.7 km
Therefore no CBA required

Note that the Table 5 exemptions only apply to district heating (not cooling) networks.

Notes on Step 5

Other supporting information could include evidence of discussions with operators of the identified waste heat sources(s).

What does “substantially refurbished” mean?

A substantial refurbishment is one whose costs exceed 50% of the investment cost for a new comparable unit. The word “unit” in this context means a single item of combustion plant with a net thermal input of more than 20 MW, or a number of items of combustion plant with a combined net thermal input of more than 20 MW where these are being refurbished simultaneously and are proximate to each other. Some examples are as follows:

- **14,5(b) installations (existing power station or energy from waste plant)** – replacement, refurbishment, upgrade or addition of a gas turbine, steam turbine, heat recovery steam generator, incineration line etc
- **14,5(c) installations (industrial installations with waste heat)** – (industrial installations with waste heat) – replacement, refurbishment, upgrade or addition of a boiler, gas turbine, kiln, furnace, burner etc
- **14,5(d) installations** (existing district heating and cooling network that currently generates its own heat) – replacement, refurbishment, upgrade or addition of a boiler, gas turbine, engine etc

If you are planning any changes to your combustion plant you should agree whether it will constitute a substantial refurbishment with the Environment Agency at the pre-application stage. It is up to you to provide the necessary cost information as (with the exception of CHP plants where further information is provided in Section 4) there are currently no reference costs available, although industry may wish to produce some in the future to make the process easier. If known, original costs adjusted for inflation will provide an acceptable comparison.

Substantial refurbishment in this context should not be confused with “substantial change” which is defined elsewhere in EPR and has a different meaning (covered by separate guidance).

What is the status of an existing combustion installation whose thermal input is increased to above 20 MW?

If an existing combustion installation with an aggregated net thermal input of 20 MW or less is modified by the addition of new combustion plant bringing it above 20 MW, it will be treated as a new installation for the purposes of the Article 14 requirements (as opposed to an existing installation which may have been substantially refurbished).

Should standby plant be included when calculating the aggregated net thermal input?

The aggregated net thermal input of the installation is calculated by adding the rated inputs of the all of the combustion plant on site which is capable of being operated simultaneously (i.e. the maximum possible thermal input at any one time). Therefore where an item of standby plant has the same or lower rated thermal input as the duty plant and cannot physically be operated at the same time as the duty plant (e.g. due to an interlock) it does not need to be included in the calculation.

How should potential heat loads be identified?

Until the results of the comprehensive assessment are available (anticipated early 2016), DECC’s UK CHP Development Map, National Heat Map, CHPA’s District Heating Installation Map and any information available from relevant local authorities will provide a starting point for searches. Once identified, you will then need to contact potential heat customers (or heat sources for Article 14,5 (d) installations) directly.

There is no legal obligation for the operators of potential heat loads/sources to supply information to applicants carrying out CBAs, nor to subsequently enter into a commercial agreement where shown to be cost-beneficial. Therefore if any operators of potential heat loads/sources are unwilling to participate you should exclude them from the CBA/final proposal. However, you will need to demonstrate that you have made a reasonable attempt to secure their cooperation in the first place.

What factors should be considered to determine whether a scheme is technically feasible?

Step 3/4a in diagrams 1, 2 and 3 above require you to determine whether it is technically feasible for the installation to supply (or receive) heat. To help you do this you should take the following factors and principles into account but they are not intended to form an exhaustive list:

- The feasibility of capturing waste heat in order to supply it to the user e.g. use of heat exchangers (14,5 (c) installations)
- The compatibility of the heat source(s) and load(s) in terms of temperature and load profiles
- Whether thermal stores or other techniques can be used to match heat source(s) and load(s) which will otherwise have incompatible load profiles
- Whether there is enough demand for heat to allow high-efficiency cogeneration (14,5(a) and 14,5(b) installations)
- For existing installations which are substantially refurbished, the ability to retrofit heat take-off or waste heat recovery (including space considerations)
- Any adverse effects on the environment of recovering waste heat e.g. reduced dispersion of stack gases (14,5(c) installations)
- Alternative proposals to use waste heat within the installation which the operator is committed to implementing (14,5(c) installations)
- For 14, 5(c) installations where the waste heat cannot be recovered, whether a cogeneration plant could supply the heat requirements instead (see Step 4b in Diagram 2 above)

If a CBA is required, what other information do operators need to provide?

In addition to the completed CBA template, operators need to provide information to support each of the decisions made in Diagrams 1, 2 or 3 above. This information may include:

- Extracts from the results of the Comprehensive Assessment
- Results of the operator’s own search for opportunities for high efficiency cogeneration or district heating
- Evidence of discussions with operators of potential heat loads which could be supplied.
- Technical detail on the amount and type of heat available from/required by the installation
- Technical details on the amount and type of heat required by/available from potential heat loads/sources
- High-efficiency co-generation calculations
- Where the CBA gives a positive result (i.e. where the financial benefits outweigh the costs), a proposal to realise the scheme (or otherwise) with justification and any supporting information, including a commentary on any sensitivity analysis applied.

What about commercially-sensitive information?

Financial information is likely to commercially sensitive. Operators completing a CBA must ensure they clearly mark the relevant sections as confidential and separate them from non-confidential sections. They should also submit a brief justification for why the information needs to be treated as confidential and excluded from the public register – see Defra’s *Environmental permitting guidance: Core guidance* for more detail.

Section 2: Exemptions from the requirement to carry out a cost-benefit analysis

Exemptions for 14,5(a) and 14,5(b) installations

Thermal electricity generation installations shown in Table 2 below are exempt from the need to carry out a cost-benefit analysis:

Table 2 – CBA exempt installations

Type of thermal electricity generating installation
(a) those peak load and back-up electricity generating installations which are planned to operate under 1 500 operating hours per year as a rolling average over a period of five years, based on a verification procedure established by the Member States ensuring that this exemption criterion is met; (N.B. this will be the Environment Agency's verification procedure for limited operating hours for Large Combustion Plants)
(b) nuclear power installations;
(c) installations that need to be located close to a geological storage site approved under Directive 2009/31/EC.

Exemptions for type 14,5(c) and 14,5(d) installations – minimum waste heat available or required

Table 3a below shows the minimum amount of waste heat available from 14,5(c) installations, below which the installation is exempt from the need to carry out a CBA for connecting to a district heating network or for use of a cogeneration plant to supply the process generating waste heat. Note that the exemptions do not apply to opportunities to connect the plant to a district cooling network.

Table 3a – minimum waste heat available (14,5(c) installations)

	Hot water or steam
Minimum amount of waste heat available	$100kW_{th}$

Table 3b below shows the minimum amount of waste heat required for 14,5(d) installations, below which the installation is exempt from the need to carry out a CBA.

Table 3b – minimum waste heat required (14,5(d) installations)

	Hot water	Steam
Minimum amount of waste heat required	$100kW_{th}$	$500kW_{th}$

Exemptions for 14,5(c) installations – maximum search radius

Tables 4a and 4b below show the maximum search radius required for different amounts of waste heat available. If there are no appropriate heat demands within the search radius, then the installations will be exempt from the need to carry out a CBA for connecting to a district heating network or for use of a cogeneration plant to supply the process generating waste heat. Note that the exemptions do not apply to opportunities to connect the plant to a district cooling network.

Table 4a – maximum search radius according to amount of waste heat available (14,5(c) installations)

Grade of heat available	Amount of waste heat available	Search Radius [km] measured from the centre of the installation
Hot water or steam	>100 kW_{th} and <3.9 MW_{th}	0.0038 x H, where H = thermal capacity in kilowatts
	≥3.9 MW_{th}	15

If an appropriate heat load is found within the search radius identified in Table 4a above which requires either less than 100 kW_{th} hot water or 500 kW_{th} steam, or which is further from the installation than the distance specified in Table 4b below (and there are no other appropriate heat loads above the appropriate thresholds/within the appropriate distances) the installation will be exempt from the need to carry out a CBA for connecting to a district heating network.

Table 4b – maximum distance if a heat load is found

Grade of heat required	Amount of waste heat required	Distance [km] measured from the centre of the installation
Hot water	>100 kW_{th} and <3.9 MW_{th}	0.0038 x H, where H = thermal capacity in kilowatts
	≥3.9 MW_{th}	15
Steam	>500 kW_{th} and <12.5 MW_{th}	0.0012 x H, where H = thermal capacity in kilowatts
	≥12.5 MW_{th}	15

Example

- Waste heat available: 1 MW steam = 3.8 km search radius (from Table 4a)
- Heat required by district heating network 3 km from installation = 0.7 MW steam
- Maximum distance which should be considered for load = 0.84 km (from Table 4b)
- Therefore no CBA required for connecting to a district heating network

Exemptions for 14,5(d) installations – maximum search radius

Table 5 below shows the maximum search radius required for different amounts of waste heat required. If the installation is a district heating network and there are no appropriate heat sources within the search radius, the installation will be exempt from the need to carry out a CBA. Note that the exemptions do not apply to district cooling networks.

Table 5 – maximum search radius according to amount of waste heat required (14, 5 (d) installations)

Grade of heat required	Amount of waste heat required	Search Radius [km] measured from the centre of the installation
Hot water	>100 kW_{th} and <3.9 MW_{th}	0.0038 x H, where H = thermal capacity in kilowatts
	≥3.9 MW_{th}	15
Steam	>500 kW_{th} and <12.5 MW_{th}	0.0012 x H, where H = thermal capacity in kilowatts
	≥12.5 MW_{th}	15

Section 3: How to complete the cost-benefit assessment template

Overview

The cost-benefit assessment template is called ‘Environment Agency Article 14 CBA Template.xlsx’. The template includes a key which shows which cells need to be completed.

The model generates a Net Present Value (NPV) which the Environment Agency will use to decide whether to include permit conditions requiring the operator to implement the proposal.

1. Data which you must enter

You will need to enter data into these cells which are shown in the key as “Participant to define” and which look like this:

Scenario Choice (dropdown box) – cell D4 worksheet ‘Inputs and key outputs’

The Operator chooses whether it represents an installation that is:

1. **A power generating installation** (Heat Source) that, by becoming a cogeneration installation, supplies heat but still **uses the same amount of fuel** as it would have done as a power only installation. This means that the power output of the installation as a cogeneration installation is lower than it would have been as a power only installation. However, if the Heat Supply contract cannot be fully met (e.g. there may be times when the power generating installation is working at full power generation capacity, or is off), there is an option for the Operator to specify the percentage of the heat that will be generated in a Standby Boiler. In this case there will also be a need to include the capital and operating costs of building the Standby Boiler and using fuel in the Standby Boiler.

2. **A power generating installation** (Heat Source) that, by becoming a cogeneration installation, supplies heat but **maintains power output at the same level** as it would have had it stayed as a power-only installation. This means that more fuel is consumed as a cogeneration installation than would have been consumed as a power only installation. Again, in this scenario a Standby Boiler may be needed if the current installation does not have the capacity to generate the same level of electricity and the required quantity of heat.

3. **An industrial installation generating waste heat** (Heat Source). In this scenario a Standby Boiler may be needed, for example if the industrial installation operates five days a week, but there is a heat supply contract for seven days a week.

4. **An industrial installation with a demand for heat** (Heat User) that, by becoming an Industrial CHP installation, satisfies its existing heat demand via CHP.

5. **A district heating scheme** (Heat User) that currently generates its own heat.

NB: The capital costs (CAPEX) and operating costs (OPEX) associated with the heat supply infrastructure to carry heat from the Heat Source to the Heat User is assumed in all cases to fall upon the Operator undertaking the CBA.

To assist you in completing the CBA, as well as greyed out cells which are locked, the model has been structured so that once you select the scenario that is appropriate all other cells that do not (or may not) be needed are darkened and look like this:

You should therefore ensure that you do not enter any data in the darkened cells and that there is no existing data in the data entry cells that are darkened cells.. (Data entry cells are light green when applying to the scenario selected.)

Technical Solution Features

Heat carrying medium (hot water, steam or other) (drop down box) – cell D6 worksheet 'Inputs and key outputs'. This value is not used in the calculation of the Net Present Value. It is collected in order for the Environment Agency to validate the Capital Expenditure (CAPEX) of the Heat Supply Infrastructure, which is given by the Operator in Cells H24:H28.

Total length of supply pipework (kms) – cell D7 worksheet 'Inputs and key outputs'. This value is not used in the calculation of the NPV. It is collected in order for the Environment Agency to validate the CAPEX of the Heat Supply Infrastructure, which is given by the Operator in Cells H24:H28.

Peak heat demand from Heat User(s) (MWth) – cell D8 worksheet 'Inputs and key outputs'. This value is not used in the calculation of the NPV. It is collected in order for the Environment Agency to validate the CAPEX of the Heat Supply Infrastructure, which is given by the Operator in Cells H24:H28. It is also used by the Environment Agency to verify the CAPEX for CHP (K24:K28) in the case of an industrial installation (Scenario 4).

Annual quantity of heat supplied from the Heat Source(s) to Heat User(s)(MWh) – cells G49, H49, I49 and K79 of worksheet 'Inputs and key outputs'. The respective value is entered into cells G49, H49 or I49 under the 'Unit Energy Prices, Energy Balance, Fuel related operational costs and Revenue Stream' heading for Heat Sources and into cell K79 for Heat Users.

DCF Parameters

Discount rate (pre-tax financing) (%) – cell D12 worksheet 'Inputs and key outputs'. This is the pre-tax, pre-financing discount rate that the Environment Agency expects to be set at 17%, i.e. the return on net cash flow the Operator would make before it pays tax and any interest and dividend payments.

You should use this value unless there are significant, specific issues of investment risk applying to the opportunity being investigated or specific investment requirements that mean that an alternative rate is more appropriate. Under these circumstances, you must include a strong justification of any alternative rate proposed.

Cost Streams and revenue streams

Construction costs and build-up of operating costs and revenues during construction phase

% operating costs and revenues during construction phase – cells G24:G28 worksheet 'Inputs and key outputs'. In some instances it is possible that construction is phased and that after one or two years part of the investment can start supplying heat to a Heat User, or a Heat User can start to buy heat even though only part of the district heating scheme has been completed. The model allows this flexibility, with percentages being included in cells G24 – G28.

For example, it could be that at the start of the second year 50% of the revenues and operating costs will be incurred and that on the first day of year 3 the plant has reached a steady state with all the construction costs incurred. Therefore a value of 0% would be entered into cell G24 (corresponding to Year 1) and 50%

in cell G25 (corresponding to Year 2). A figure of 100% should not be entered into cell G26 as all the construction costs will have been incurred and the project will have reached a steady state.

CAPEX Year 1 costs (£m), Year 2 costs (£m), Year 3 costs (£m), Year 4 costs (£m), Year 5 costs (£m) – cells H24: K28 in worksheet 'Inputs and key outputs'. Depending on which scenario is being considered, the Operator needs to enter the capital costs for the Heat Supply Infrastructure, the Heat Station, a Standby Boiler (if needed in Scenarios 1, 2 or 3) and, in the case of Scenario 4, the capital costs to build a CHP capable of meeting the installation's heat demand. This needs to be done for each relevant year in which CAPEX is incurred. There is then a counter (row 21 of worksheet 'Inputs and key outputs') that works out how many years the construction will take.

As Scenarios 1, 2 and 3 will include Heat Supply Infrastructure and a Heat Station, the Operator should ensure that the Counters in cells H21 and I21 are the same, and should not enter any zeros (0s) after the last year in which some construction costs in either Heat Supply Infrastructure or the Heat Station take place. If there is a need for a Standby Boiler in Scenarios 1, 2 or 3 the annual capex expenditures should be entered in cells J24 : J28, again with no zeros after the last date of capex expenditure on the last asset to be built (which could the Heat Supply Infrastructure, the Heat Station or the Standby Boilers).

Scenario 4 should only have numbers in cells K24 : K28, with no numbers after the year in which Industrial CHP construction is complete. Section 4 of this document includes guidance on typical CHP CAPEX costs. Scenario 5 should only have numbers in cells H24 : H28, with no numbers after the year in which the district heating Heat Supply Infrastructure construction is complete.

The Environment Agency has constrained the construction period to five years, although it is expected that most proposals will be able to be constructed in one or two years from the date of construction commencement. For simplicity the Environment Agency has also split construction periods into whole years. If the construction period covers part of a year, for example 2½ years it is recommended that the figure in Year 1 covers the first six months of construction, the figure in Year 2 covers the seventh to eighteenth months of construction and the figure in Year 3 covers the nineteenth to thirtieth months of construction.

To alternatively try to utilise the '% operating costs and revenues during construction phase' as a proxy for this is not recommended, for example there could be difficulties if some of the plant is operational earlier and the full plant is operational later in the same year. Figure 1 illustrates three possibilities and gives guidance how to fill in the numbers.

Figure 1: Examples of ways to complete CAPEX figures

	Example 1				Example 2				Example 3			
	Heat Supply Infrastructure	Heat Station	Standby Boilers	Industrial CHP	Heat Supply Infrastructure	Heat Station	Standby Boilers	Industrial CHP	Heat Supply Infrastructure	Heat Station	Standby Boilers	Industrial CHP
Number of years to build	3	3	0	0	3	3	3	0	0	0		2
Year 1 cost (£m)	1.4	0			1.4	1.0	0					6.0
Year 2 cost (£m)	2.5	3.0			2.5	2.0	0.2					5.0
Year 3 cost (£m)	2.7	3.7			0	3.0	0.2					
Year 4 cost (£m)												
Year 5 cost (£m)												

In Example 1 the counters (number of years to build) is the same for the Heat Supply Infrastructure and the Heat Station. In Example 2 with a Standby Boiler the three counters are the same. However, if one capital item is not incurring costs in a particular year, when another capital item is, a zero ('0') must be entered for the former item for the year in question, rather than leaving the cell blank.

Also, in no case is a zero entered after the last year in which some construction costs are incurred.

Non-power related operations

OPEX for full steady state Heat Supply Infrastructure on price basis of first year of operations (partial or steady state) (£m) – cell D31 worksheet 'Inputs and key outputs'. The Operator enters their estimate of the annual operating expenditure (OPEX) to maintain the Heat Supply Infrastructure in the first year of operations (whether this first year of operations is partial or full), but assuming that the operational cost for that year is the full steady state amount. An example is provided in Figure 2.

Figure 2: Guidance on how to work out the steady state OPEX price

If there is no phased build-up of operating costs and revenues the OPEX cost should be the expected in the first year of operations. So if the plant is expected to be opened after two years the Operator should estimate how much the annual non-power related OPEX will be at the start of the third year, taking account of any inflationary increases there may be over the next two years.

If there is a phased build-up of operating costs and revenues, for example with 50% of the operating costs being incurred from the start of the second year and full steady state operations from the start of the third year, the Operator should estimate the steady state OPEX costs at the start of this third year (taking account of inflationary increases there may be over the next two years), and then bring it back to a price basis for the start of the second year, when operations, although partial, began.

Using this example, if OPEX costs if the plant was now fully operational would be £200,000 and OPEX inflation for the following two years is 2%, then the full steady state OPEX in Year 2 would be £204,000 and full steady state OPEX in Year 3 will be £208,080. Even though only 50% of the £204,000 will be spent in Year 2, the number of £204,000 should be entered as this is the '*OPEX for full steady state Heat Supply Infrastructure on price basis of first year of operations*.'

OPEX for full steady state Heat Station on a price basis of first year of operations (partial or steady state) (£m) – cell D32 worksheet 'Inputs and key outputs'. The Operator enters their estimate of the annual cost to maintain the Heat Station in the first year of operations (whether this first year of operations is partial or full), but assuming that the operational cost for that year is the full steady state amount.

OPEX for full steady state Standby Boilers on price basis of first year of operations (partial or steady state) (£m) – cell D33 worksheet 'Inputs and key outputs.' If required in Scenarios 1, 2 or 3 the Operator enters their estimate of the annual cost to maintain the Standby Boilers in the first year of operations (whether this first year of operations is partial or full), but assuming that the operational cost for that year is the full steady state amount.

OPEX for full steady state Industrial CHP on price basis of first year of operations (partial or steady state) (£m) – cell D34 worksheet 'Inputs and key outputs'. The Operator enters their estimate of the annual cost to maintain the Industrial CHP in the first year of operations (whether this first year of operations is partial or full), but assuming that the operational cost for that year is the full steady state. Section 4 includes guidance on OPEX costs for CHP plants.

Additional equivalent OPEX to pay for a major Industrial CHP overall spread over the life of the asset (£m) on price basis of first year of operations (partial or steady state) (£m) – cell D35 worksheet 'Inputs and key outputs'. With Industrial CHP plants there will often be a need for a major refurbishment after a number of years. Where the CHP lifetime is accepted as 20 years the Operator should provide an estimate of these major overhaul costs and express them as an annual equivalent figure for each of the 20 years. This should be priced on the basis of the first year of operations. Section 4 includes guidance on costs for major overhauls of CHP plants.

Other 1 - Operator to define if needed (£m), Other 2 - Operator to define if needed (£m) – cells C36: D37 worksheet 'Inputs and key outputs'. The Operator is free to identify (in cells C36 or C37) and enter an annual value (in cells D36 and D37) for any other non-power related OPEX it considers relevant. Like the other OPEX costs the costs should be entered at a price based on the first year of steady state operations.

Unit Energy Prices, Energy Balance, Fuel related operational costs and Revenue Stream

Scenario					
1	*2*	*3*	*4*	*5*	
√	√	√			*Heat sale price (£/ MWh) at first year of operations (full or partial)* – cells G48, H48 and I48 worksheet 'Inputs and key outputs'. Depending on the scenario the Operator enters its estimate of the price at which it can sell heat in the first year of operations, which should be at steady state or in the case of a phased build-up of heat supply the price in that first phased year.
√	√	√			*Annual quantity of heat supplied from Heat Source(s) to Heat User(s) at steady state (MWh)* – cells G49, H49 and I49 worksheet 'Inputs and key outputs'. Depending on the scenario the Operator enters its estimate of the quantity of heat it will pass to Heat Users via the Heat Supply Infrastructure in the steady state.
√	√	√			*Heat sale price inflation from first year of operations (full or partial) (% per year)* – cells G51, H51 and I51 worksheet 'Inputs and key outputs'. Depending on the scenario the Operator enters its estimate of the annual rate at which it will be able to increase the price at which it sells heat.
√	√	√			*Percentage of heat supplied by Standby Boiler (if relevant)* – cells G52, H52 and I52 worksheet 'Inputs and key outputs'. If relevant to Scenarios 1, 2 and 3 the Operator enters its estimate of percentage of heat that needs to be delivered with a Standby Boiler, with the remaining percentage supplied by the power generating installation (Scenarios 1 and 2) or the industrial installation (Scenario 3).
√					*'Lost' electricity sale price (£/ MWh) at first year of operations* – cell G54 worksheet 'Inputs and key outputs'. Only for Scenario 1 should the Operator enter its estimate of the wholesale price at which it will be able to sell the electricity it generates in the first year of operations, which could be at steady state or in the case of a phased build-up of heat supply the electricity price in that first phased year.
√					*Z-ratio (commonly in the range 3.5 - 8.5)* – cell G55 worksheet 'Inputs and key outputs'. Only in Scenario 1 should the Operator enter the value consistent with the capacity of the steam turbine from which steam is extracted and the conditions of the steam extracted.
√					*Electricity sale price inflation from first year of operations (% per year)* – cell G58 worksheet 'Inputs and key outputs'. Only in Scenario 1 should the Operator should enter its estimate of the annual rate at which it will be able to increase the price at which it sells electricity on the wholesale markets.
			√		*Industrial CHP electricity sale price (£/ MWh) at first year of operations (full or partial)* – cell J60 worksheet 'Inputs and key outputs'. For Scenario 4 the Operator enters its estimate of either: • In the case where the electricity from the CHP is sold the wholesale price at which it will be able to sell the electricity in the first year of operations, which could be at steady state or if there is a phased build-up the price in that first phased year. • In the case where the electricity from the CHP is used by the Operator the retail price at which it buys electricity (which will usually be higher than the wholesale sale price) in the first year of operations, which could be at steady state or if there is a phased build-up of generation the electricity price in that first phased year. If there is a case where part of the electricity is to be used by the Operator and part is to be sold, the Operator should enter a blended electricity price in proportion to the usage and sale percentages.

Scenario					
1	2	3	4	5	
			√		*Industrial CHP electrical generation in steady state (MWh)* – cell J61 worksheet 'Inputs and key outputs'. For Scenario 4 the Operator enters its estimate of the number of MWh of electricity that will be generated in the steady state. Section 4 contains guidance on typical electrical generation resulting from Industrial CHP used to meet a defined heat supply.
			√		*Industrial CHP electricity price inflation from first year of operations (full or partial) (% per year)* – cell J63 worksheet 'Inputs and key outputs'. For Scenario 4 the Operator enters its estimate of the annual inflation rate at which it will be able to sell electricity or the annual inflation rate for the electricity it would otherwise purchase. A blended inflation rate may be appropriate where there is a mix of own use and sale.
	√		√		*Fuel price for larger power generator/ CHP at first year of operations (full or partial) (£ / MWh)* – cell H65 and I65 worksheet 'Inputs and key outputs'. For Scenarios 2 and 4 the Operator enters the price it pays for the fuel it uses to generate power and heat in the installation in the first year of operations, which could be at steady state or, in the case of a phased build-up of heat supply, the price in that first phased year. The fuel price should include any costs of purchasing carbon permits. If some of the heat will be supplied with a Standby Boiler there are other cells for the fuel price for Standby Boilers.
	√				*Z-ratio (commonly in the range 3.5 - 8.5)* – cell H66 worksheet 'Inputs and key outputs'. Only for Scenario 2 should the Operator enter the value consistent with the capacity of the steam turbine from which steam is extracted and the conditions of the steam extracted.
	√				*Power efficiency in cogeneration mode (%)* – cell H67 worksheet 'Inputs and key outputs'. Only for Scenario 2 should the Operator enter the power efficiency of the plant in cogeneration mode.
	√		√		*Additional fuel required per year for larger power generator / CHP in steady state (MWh)* – cell H68 and J68 worksheet 'Inputs and key outputs'. In Scenario 2 this is automatically calculated by multiplying the Annual quantity of heat supplied from the Heat Source(s) to Heat User(s) at steady state (MWh) by the percentage of heat that is generated by the power generating installation (i.e. if Scenario 2 includes a Standby Boiler the percentage of fuel needed for by Standby Boiler is not included here), and then dividing this number by the by the Z-ratio multiplied by the power efficiency in cogeneration mode. For Scenario 4, Section 4 provides separate guidance on typical additional fuel required per year for an Industrial CHP to meet a defined heat supply.
	√		√		*Fuel price inflation from first year of operations (full or partial) (% per year)* – cell H70 and J70 worksheet 'Inputs and key outputs'. For Scenarios 2 and 4 the Operator enters the annual rate at which it expects the price it pays for the fuel it uses to generate the heat and power in the installation to increase.
√	√	√			*Fuel price for Standby Boiler at first year of operations (£ / MWh)* – cell G72, H72 and I72 worksheet 'Inputs and key outputs'. If required in Scenarios 1, 2 or 3 the Operator enters the price it pays for the fuel in the Standby Boiler in the first year of operations, which could be at steady state or, in the case of a phased build-up of heat supply, the price in that first phased year. The fuel price should include any costs of purchasing carbon permits.
√	√	√			*Fuel price inflation for Standby Boiler from first year of operations (full or partial) (% per year)* – cell G76, H76 and I76 worksheet 'Inputs and key outputs'. If required in Scenarios 1, 2 or 3 the Operator enters the annual rate at which it expects the price it pays for the fuel (including any costs of purchasing carbon permits) it uses to generate the heat and power to increase.
				√	*Heat purchase price (£/ MWh) at first year of operations (full or partial)* – cell K78 worksheet 'Inputs and key outputs'. The Operator enters its estimate of the price at which it will purchase heat in the first year of operations which could be at steady state, or in the case of a phased build-up of heat supply, the price in that first phased year.

Scenario 1	2	3	4	5	
				√	*Annual quantity of heat supplied from Heat Source(s) to Heat User(s) at steady state (MWh)* – cell K79 worksheet 'Inputs and key outputs'. The Operator enters its estimate of the quantity of district heating heat it will demand from the Heat Source via the heat link in the steady state.
				√	*Heat purchase price inflation from first year of operations (full or partial) (% per year)* – cell K81 worksheet 'Inputs and key outputs'. The Operator enters its estimate of the annual rate at which it expects heat purchase prices to increase.
				√	*Fuel price (£ / MWh)* – cell K83 worksheet 'Inputs and key outputs'. The Operator enters the price it pays for the fuel it uses to generate heat in the first year of operations, which could be at steady state or in the case of a phased build-up of heat supply the price in that first phased year. The fuel price should also include any avoided costs from not having to purchase carbon permits.
				√	*Fuel price inflation from first year of operations (% per year)* – cell K87 worksheet 'Inputs and key outputs'. The Operator enters its estimate of the annual rate at which it expects the price it would have expected to pay for fuel (including any costs of purchasing carbon permits) to increase.
√	√		√		*Fiscal benefits (£m) and annual inflation rate (%)* – cells G89, H89, J89, G90, H90 and J90 worksheet 'Inputs and key outputs'. Depending on the Scenario these two cells **only** need to be filled out by installations covered by Articles 14(5)(a), 14(5)(b) or the case of Industrial CHP (Article 14(5)(c) if the NPV without the fiscal benefits is negative. If the NPV is negative the Operator enters its estimate of the equivalent fiscal benefit (£m) in the first year of operations and the specific inflation (or deflation) rate to be applied from the first year of operations to the end of the project.

2. Recommended values which you can change if necessary

We recommend that you use the values which are given in the template, but you can enter a different value which you think is more appropriate if you are able to provide a strong justification. These are shown in the key as "Prescribed, but possibility to change if make a case", and they look like this: 2

Exceptional reason for shorter lifespan of Heat Supply Infrastructure, Standby Boiler and/ or Heat Station (yrs) – cells H19, I19 and J19. In Scenarios 1, 2, 3 and 5 there may be exceptional reasons why the assets may not be operated for the period prescribed or required by the Environment Agency. Such exceptional instances could include a planned decommissioning of a coal-fired power generating installation to comply with legislation. If there is an exceptional reason for a shorter lifespan the Operator should make a full case to the Environment Agency about its reasons for the change.

A reason of a lack of a long term contract for the duration of the asset's life is not viewed as an exceptional reason. For the purposes of the model, it is assumed that at the end of the shorter period the asset will still have some value and will be sold. The model assumes the assets will be depreciated to zero over their full project asset lifespan using straight line depreciation. To accommodate the fact that some of the cost of the asset could not be sold (e.g. building foundations) the depreciation is calculated on a nominal basis. Therefore, if for example an asset has a lifespan of 30 years, will cost £100 million, and needs to be decommissioned after 15 years then it is assumed that at the end of the 15th year of operations the asset can be sold for £50 million.

Project asset lifespan for Industrial CHP – cell K18 worksheet 'Inputs and key outputs'. This is the appropriate lifetime for an Industrial CHP (Scenario 4) assumed to be 20 years in line with the Directive's assumption for boilers. In this case, a major refurbishment will be considered necessary. If the Operator's heat is to be supplied by a 3rd party heat supplier, the Operator may petition for an asset lifespan of less than 20 years.

Annual inflation for all non-power related OPEX from first year of operations (full or partial) – cell D41 worksheet 'Inputs and key outputs'. This is set by the Environment Agency at 2.0%, in line with the Bank of England's inflation target.

3. Fixed values

The following values are fixed and cannot be changed. They are shown in the key as "Regulatory prescribed" and they look like this 30

Project Lifespan (yrs) – cells H18, I18 and J18 worksheet 'Inputs and key outputs'. This is fixed at the asset life of the longest serving plant in the project. In Scenarios 1, 2, 3 and 5 this is 30 years consistent with the value given in the Directive. If a Standby Boiler is required, then rather than it lasting for the 20 years as suggested in the Directive a 30 year lifespan is assumed by the Environment Agency.

- Project asset lifespan for Heat Supply Infrastructure – cell H18 worksheet 'Inputs and key outputs'. For scenarios 1, 2, 3 and 5 (where relevant) this is 30 years, consistent with the value given in the Directive.
- Project asset lifespan for Heat Station – cell I18 worksheet 'Inputs and key outputs.' This is 30 years, a value assumed by the Environment Agency.
- Project asset lifespan for Standby Boiler – cell J18 worksheet 'Inputs and key outputs.' This is 30 years, a value assumed by the Environment Agency.

Boiler efficiency of Standby Boiler (%) – cells H73, G73 and I73 worksheet 'Inputs and key outputs'. This entry is only needed in Scenarios 1, 2 and 3 where the Operator will not be able to deliver the required heat supply using its existing equipment and needs to install a Standby Boiler. The Environment Agency's estimate of the efficiency of a typical Standby Boiler is 80%.

Boiler efficiency of district heating plant (%) – cell K84 worksheet 'Inputs and key outputs'. This entry is only required for Scenario 5 and is the Environment Agency's estimate of the efficiency of a typical district heating boiler. This is set at 80%.

4. Outputs

There are two outputs from the CBA shown at the bottom of the template as follows:

Nominal project IRR (before funding and tax) over the project period – cell D98 worksheet 'Inputs and key outputs' which comes from cell K54 in worksheet 'Calculation'. This is the Project's pre-tax pre-finance Internal Rate of Return (IRR) over the life of the project. It is calculated on a nominal basis (i.e. includes the effects of inflation) rather than on a real basis.

An IRR is the discount rate that makes the Net Present Value of all cash flows for a project equal to zero. As a generalisation, if the IRR of pre-tax pre-finance costs is greater than the Operator's pre-tax pre-finance discount rate the project will make the investors more than their hurdle rate of return. If the sum of the cash flows before financing and taxation over the project life is negative (cell K54 worksheet 'Calculation' and cell D98 worksheet 'Inputs and key outputs') then an IRR will not be generated and a

#NUM! symbol will appear. This is because the project would generate a negative return and the IRR formula in Excel cannot deal with negative IRRs.

Nominal Project Net Present Value (NPV) (£m) over the project period – cell D99 worksheet 'Inputs and key outputs' which comes from cell K55 in worksheet 'Calculation'. This is the discounted pre-tax pre-finance cash flow at the Operator's pre-tax pre-finance discount rate. If the NPV is positive the investors will make more than their hurdle rate of return.

The NPV is the more common number used by Government to evaluate projects and will be the one the Environment Agency uses on this project when evaluating proposals.

Where there are uncertainties in the input parameters (e.g. gas, electricity and heat prices), the operator can perform a sensitivity analysis by submitting several versions of the CBA to reflect different scenarios (e.g. central case, best case and worst case). This in turn will give rise to a range of NPVs, in which case the Operator must supply a justification of which NPV is most likely to be representative for the project.

5. Worksheet calculation tab

The Operator cannot alter any of the numbers in this worksheet, which provides all the calculations and is laid out with a number of 'flags' at the top of the worksheet to indicate if the project is in the construction or operations phase. Different inflation indices are also displayed at the top of this worksheet. Lower down the spreadsheet are the annual <u>nominal</u> cash flows. NPVs and IRRs are calculated on the cash flow figures before finance and taxation. At the bottom of the sheet are asset values that are only utilised if there are exceptional reasons why in Scenarios 1, 2, 3 or 5 an asset needs to be decommissioned and sold before the asset life prescribed or fixed by the Environment Agency.

Section 4: Industrial CHP costs

This section provides additional information on how to fill in the CBA template for Scenario 4 and to use the Industrial CHP cost calculation spreadsheet provided by the Environment Agency.

Overview

In Scenario 4 (Industrial CHP) it is assumed that instead of boilers generating heat for industrial processes a new CHP plant is built to meet this heat demand, with the electricity generated by the CHP plant being available for use by the facility or for sale.

Article 14(5) of the Energy Efficiency Directive states that only plants with a total thermal input exceeding 20 MW are covered. Typical standard boiler efficiency is about 80% Gross Calorific Value (GCV), so the thermal output capacity of a 20 MW GCV boiler is about 16 MW.

How to complete the CBA template

To complete the '*Environment Agency Article 14 CBA Template.xlsx*' the Operator is required to enter a number of inputs into the model:

#	Input	Generated by CHP costs template?
1	The Industrial CHP Capital Expenditure (£m) over the build profile which needs to be entered in cells K24 – K28 (where applicable) of worksheet 'Inputs and key outputs'.	X
2	The asset life of the Industrial CHP (cell K18 of worksheet 'Inputs and key outputs') which has been Prescribed by the Environment Agency as 20 years with a major refurbishment during the Industrial CHP's lifespan. If the Operator's heat is to be supplied by a 3rd party heat supplier, the Operator may petition for an asset lifespan of less than 20 years.	
3	Non-fuel operating Cost (OPEX) for full steady state Industrial CHP on price basis of first year of operations (partial or steady state) (£m) which is entered in cell D34 of worksheet 'Inputs and key outputs'.	X
4	Additional equivalent OPEX to pay for a major Industrial CHP overall spread over the life of the asset (£m) on price basis of first year of operations (partial or steady state) (£m) – With Industrial CHP plants there will often be a need for a major refurbishment after a number of years. Where the CHP lifetime is accepted as 20 years or, another period where a major refurbishment is required, the Operator should provide an estimate of these major overhaul costs and express them as an annual equivalent figure for each of the 20 years (or whatever asset life if petitioned for). The figure should be entered in cell D35 of worksheet 'Inputs and key outputs'.	X
5	Industrial CHP electricity sale price (£/ MWh) at first year of operations (full or partial). The figure should be entered in cell J60 of worksheet 'Inputs and key outputs'.	

#	Input	Generated by CHP costs template?
6	Industrial CHP electrical generation in steady state (MWh) which is entered in cell J61 of worksheet 'Inputs and key outputs'.	**X**
7	Industrial CHP electricity price inflation from first year of operations (full or partial) (% per year) which is entered in cell J63 in worksheet 'Inputs and key outputs'.	
8	Fuel price for larger power generator/ CHP at first year of operations (full or partial) (£ / MWh) which is entered in cell J65 of worksheet 'Inputs and key outputs'.	
9	Additional fuel required per year for larger power generator / CHP in steady state (MWh). In cell J68 of worksheet' Inputs and key outputs' the Operator enters the extra fuel that is required to run the CHP plant compared to just running a standard boiler.	**X**
10	Fuel price inflation from first year of operations (full or partial) (% per year) which is entered in cell J70 of worksheet 'Inputs and key outputs'.	
11	Fiscal benefits (£m) in first year of operations assuming it is a steady state is entered in cell J89 of worksheet 'Inputs and key outputs'. This only needs to be entered if the NPV of the CHP project is negative in the first instance, without the cash flow associated with fiscal benefits being included in the analysis.	
12	Fiscal benefits inflation rate from first year of operations (full or partial) (%) is entered in Cell J90 of worksheet 'Inputs and key outputs'. This only needs to be entered if the NPV of the CHP project is negative in the first instance, without the cash flow associated with fiscal benefits being included in the analysis.	

Using the Industrial CHP costs template

The Environment Agency has provided a spreadsheet 'Industrial CHP costs 2014 template' to allow operators to calculate the values of the parameters marked in the table above with a cross in the 'Generated by CHP costs template?' column.

To use the CHP costs spreadsheet, the operator is required to enter the number of hours the plant is expected to run per year in cell C11 of worksheet 'Input', and the average heat load it will have to satisfy in cell D11. The spreadsheet will then display the calculated values for the parameters listed above in bold in 'Output' worksheet, which can then be entered into the CBA template.

The spreadsheet includes further information on how to use it, including how to adjust its outputs for inflation where relevant.

If the operator prefers to calculate their own values for these parameters they can do so, but they are still required to complete the CHP costs template in order for the Environment Agency to audit the figures which the operator has provided.