CHP Ready Guidance for Combustion and Energy from Waste Power Plants

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Within EN-1 Overarching Energy NPS, Section 4.6 details the requirements for consideration of CHP. This states (at Paragraph 4.6.12) that in the event that future CHP opportunities have been identified "the IPC [Infrastructure Planning Commission, now integrated with the Planning Inspectorate] may wish to impose requirements to ensure that the generating station is CHP-Ready unless ... [they are] satisfied that the applicant has demonstrated that the need to comply with the requirement to be Carbon Capture Ready will preclude any provision for CHP"[1].

For new plants less than 50 MW, the NPS are likely to be a material consideration.

[1] It should be noted here that this CHP-R Guidance assumes that the requirement to be Carbon Capture Ready (CCR) has not precluded any provision to be CHP-R.

1.1 Development Consent Orders

In England, as part of any application for a Development Consent Order (DCO) under the Planning Act 2008 (previously Section 36 Consent under the Electricity Act 1989), applications for new plants (greater than 50 MW) must show that they have fully considered the opportunities for CHP. Typically, this is undertaken by submitting a CHP Assessment with the application (in line with Section 4.6 of EN-1 Overarching Energy NPS) which contains details on:

- "An explanation of their choice of location, including the potential viability of the site for CHP;
- A report on the exploration carried out to identify and consider the economic feasibility of local heat opportunities and how to maximise the benefits from CHP;
- The results of that exploration; and
- A list of organisations contacted.
- And, if the proposal is for generation without CHP:
- The basis for the developer's conclusion that it is not economically feasible to exploit existing regional heat markets;
- A description of potential future heat requirements in the area; and
- The provisions in the proposed scheme for exploiting any potential heat demand in the future"[2].

For DCO granted for new plants for "generation without CHP", the subsequent application for an Environmental Permit should build on the conclusions of the CHP Assessment and contain sufficient information to demonstrate the new plant will be built CHP-R (for the chosen location and design). This CHP-R Guidance is to be used in these instances.

Additionally, whilst CHP Assessments may only require waste heat[3] to be made available, being CHP-R may require both process heat and waste heat to be made available according to the likely future CHP opportunities identified.

1.2 Natural Resources Wales's Role as a Consultee to the Planning Process

The primary focus of this CHP-R Guidance is on the demonstrations required in an application for an Environmental Permit for new plants under the Environmental Permitting (England and Wales) Regulations 2010. However, the principles contained within this CHP-R Guidance may also have implications on consent applications (i.e. Planning Permission (under the Town and Country Planning Act 1990) or a DCO (under the Planning Act 2008)) for the new plant. Indeed, Natural Resources Wales will be consulted on these applications, as well as applications for extensions of / variations to existing plants.

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[2] Department of Trade and Industry's (DTI) (now DECC) Document "Guidance on Background Information to Accompany Notifications under Section 14 (1) of the Energy Act 1976 and Applications under Section 36 of the Electricity Act 1989, December 2006"

[3] One example of 'waste heat' is hot water from the cooling system which could be used as a heat source for Liquefied Natural Gas Plant Vaporisers or Greenhouses.

Natural Resources Wales Document "Guidelines for Developments requiring Planning Permission and Environmental Permits" sets out Natural Resources Wales's role in the planning process and its approach to responding to applications for developments which will also require an Environmental Permit. In particular, these Guidelines recognise that there may be some interdependencies between planning and permitting requirements. In the case of such interdependencies, the Guidelines recommend early engagement with Natural Resources Wales via their planning pre-application service and, in some cases, a "parallel-tracking" approach is recommended whereby the preparation and submission of the planning and permitting applications is carried out at the same time.

Therefore, it is recommended that this CHP-R Guidance (and the requirements for CHP-R) is considered prior to making a consent application for a new plant, in particular because the first and second BAT tests may affect the layout, space requirements and building design for the implementation of CHP. Accordingly, Natural Resources Wales recommends that the requirement for new plants to be CHP or CHP-R is discussed at the earliest possible stage, ideally during planning preapplication. In any case, where a DCO is required the applicant will have to make similar demonstrations under both the planning and permitting applications in terms of suitability of the location for CHP, potential opportunities for heat supply and CHP-R.

When consulted by the Planning Authorities on relevant consent applications for new plants, Natural Resources Wales will highlight the need for the plant to be CHP or CHPR and will make reference to this CHP-R Guidance. Where a DCO is required, Natural Resources Wales will additionally comment on the results of the CHP Assessment.

Where a DCO is not required, Natural Resources Wales will recommend to the Planning Authorities that the location of the plant with respect to potential opportunities for heat supply is considered as part of the planning process. Where Natural Resources Wales is aware of potential heat loads in the area, they will provide details of these to the Planning Authorities.

Natural Resources Wales will not object to applications for new plants where they are located in areas where there are no opportunities for heat supply. However, where relevant, Natural Resources Wales will highlight the lack of opportunities to the Planning Authorities and this may influence the Planning Authority in its consideration of the suitability of the proposed location. When consulted on applications for modifications to existing plants (which will also require a variation to the Environmental Permit), Natural Resources Wales will highlight the need for the plant to be CHP or CHP-R (where relevant), but is unlikely to provide comments in the suitability of the location of the plant for CHP.

Additionally, the Planning Authority may take into account the ability of the new plant to supply heat as part of its assessment on whether the development constitutes an appropriate use of land. In this regard, Natural Resources Wales may also provide comments to the Planning Authority on the suitability of the location for the plant with respect to potential heat loads, with an emphasis on co-locating heat sources and loads wherever possible. In this respect, Natural Resources Wales anticipates that new EfW plants are likely to have greater flexibility in terms of their location than new combustion power plants, while new combustion power plants will generally be able to apply a wider search radius for economic opportunities for the supply of heat by virtue of their far greater potential heat output.

2 CHP-R Assessment

This Section should be read in conjunction with the CHP-R Assessment Form which is provided in Appendix A. Additional Guidance Notes on the use of the CHP-R Assessment Form are also provided in Appendix A.

The CHP-R Assessment should demonstrate that the new plant is designed to be ready, with minimum modification, to supply heat in the future. The term 'minimum modification' represents an ability to supply heat in the future without significant modification of the original plant / equipment. For example, a CHP-R plant will not be required to replace major items of original plant / equipment, but should retain the capability for additional plant / equipment to be installed at a later date.

In this regard, the CHP-R Assessment allows for the provision of supporting information regarding any appropriate technical provisions which demonstrate that the new plant is ready to supply heat in the future. As these technical provisions are provided alongside a justification of the chosen location and selected heat loads, it is noted that the degree to which any new plant will be CHP-R will be location-specific. Therefore, BAT (under the Environmental Permitting (England and Wales) Regulations 2010) is assessed on a site-specific basis.

The requirements for the CHP-R Assessment are listed in this Section. Supporting information is provided in the Appendices:

- Appendix B provides five Case Studies / Worked Examples using the CHP-R Assessment Form.
- Appendix C provides Additional Economic Supporting Information.
- Appendix D provides Additional Technical Supporting Information.

2.1 Requirement 1: Plant, Plant Location and Potential Heat Loads

EN-1 - Overarching Energy NPS states that "a 2009 Report for DECC on district heating networks suggested that ... a district heating network using waste heat from a generating station would be cost-effective where there was a demand for 200 MWth of heat within 15 km".

As such, it is noted that to be commercially viable for CHP, new plants should ideally be sited close to potential heat loads / heat customers with the actual distance varying with the size of the plant and the nature of the demand for heat. With this in mind, it is likely that the search radius for CHP opportunities for large combustion power plants is likely to be greater than that for a typical EfW plant. However, there is likely to be greater location flexibility for EfW plants than for large combustion power plants, potentially making it easier to co-locate EfW plants with suitable heat loads. Accordingly, wherever possible, the location criteria for selection of new plant must include the potential for immediate CHP opportunities in balance with other factors.

However, it is recognised that there are often other important factors which dictate a plant's location which may take precedence over immediate CHP opportunities. In these cases, where there are no immediate CHP opportunities, BAT is to build the power or EfW plant to be CHP-R to a degree which is dictated by the likely future opportunities which are technically viable and which may, in time, become economically viable. As such, in these cases, determining CHP-R requires consideration to be given to the likely extent and nature of future opportunities in the chosen location.

This is addressed under this Requirement.

Demonstrations under Requirement 1:

- A description of the plant;
- A description of plant location;
- A description of the factors influencing the selection of the plant location;
- A description of the likely extent and nature of CHP opportunities (i.e. potential heat loads) in the area (an indicative search radius of 10 km should be used for plants less than 300 MW, and 15 km for plants greater than 300 MW);
- The appropriate selection of heat loads (which must be agreed with Natural Resources Wales at the Environmental Permit Pre-Application Stage, or (preferably) at the pre-planning application stage) to take forwards in the CHP-R Assessment;
- A justification for the appropriate selection of heat loads; and,
- Identification of the expected supply and return requirements for the selected heat load / heat loads.

In terms of the 'appropriate selection of heat loads', regard should be given to the role that CHP can play in meeting the UK's Energy Policy priorities, particularly in terms of Good Quality CHP. As noted in Section 1.3 (Potential for Good Quality CHP), Good Quality CHP is that which achieves at least 10% primary energy savings. Therefore, the selection of heat loads should be such that, wherever possible, 10% primary energy savings could be achieved in the future. However, where this is not possible, the selection of heat loads should be such that maximum primary energy savings could eventually be achieved in the future whilst not necessarily meeting the criteria for Good Quality CHP. Accordingly, the appropriate selection of heat loads will likely include a discussion with Natural Resources Wales and potential heat load recipient(s), and / or a degree of qualitative economic screening. It should be noted that the heat loads for assessment must be agreed with Natural Resources Wales.

For further information, please see Additional Economic Supporting Information in Appendix C.

It should be noted that the subsequent Requirements, listed below, discuss a methodology for one selected heat load. However, if the appropriate selection of heat loads requires that more than one heat load is taken forward, then the CHP-R Assessment should be undertaken for all selected heat loads.

2.2 Requirement 2: Identification of 'CHP Envelope'

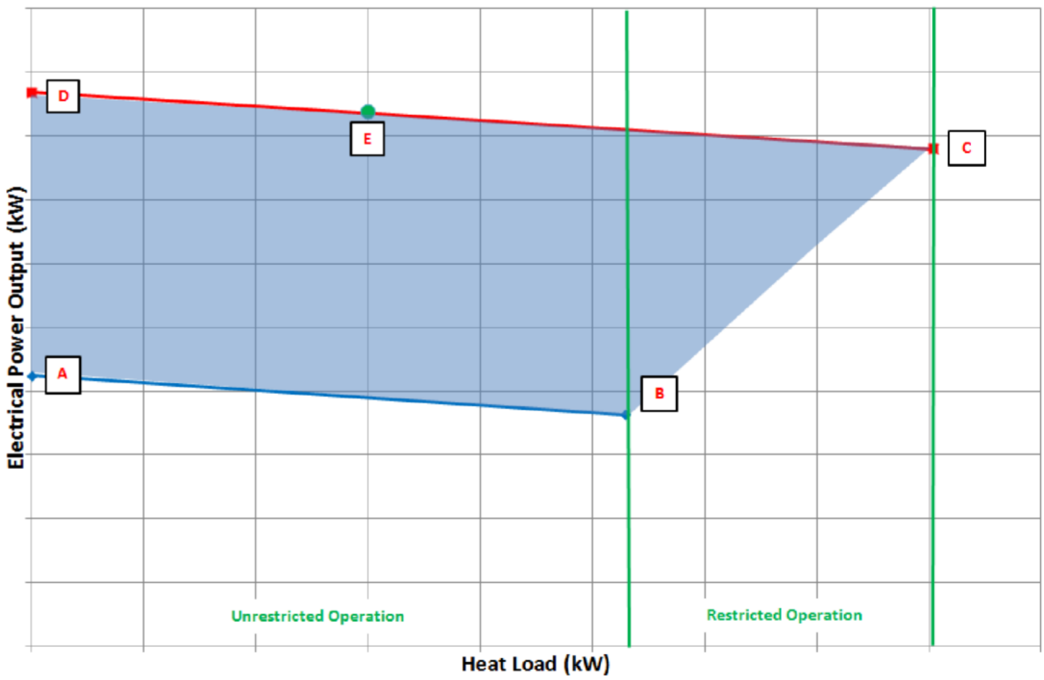
Obtaining a supply of heat from a plant is most likely to be achieved by extracting steam from the steam cycle. Alternatively (or additionally), for some types of applications where only low grade heat is required (such as Liquefied Natural Gas

Plants and Greenhouses), a supply of heat from a plant can be achieved by extracting hot water from the cooling system.

A plant which is CHP will have a known heat load size and profile at the outset, and therefore an optimal design for electrical power generation with heat generation can be achieved, including optimised extraction points. A plant which is CHP-R will not have a known heat load size or profile at the outset, and therefore an optimal design for electrical power generation only should be achieved. Indeed, given the uncertainty of future heat loads, the initial electrical efficiency of a CHP-R plant (before any opportunities for the supply of heat are realised) should be no less than that of a nonCHP-R plant.

Therefore, in demonstrating CHP-R, consideration needs to be given to the ability of the new plant to meet future heat loads within its likely operational profile. This consideration allows for the identification of a 'CHP Envelope'. The CHP Envelope represents the potential operational ranges of the new plant where it could be technically feasible to operate electrical power generation with heat generation. A graphical representation of the CHP Envelope is provided in Insert 3.

INSERT 1: GRAPHICAL REPRESENTATION OF THE CHP ENVELOPE



The following explanations are given for the points on Insert 3:

- A: The minimum electrical power output with no heat load (corresponds to the minimum stable plant load, also known as Minimum Stable Generation).
- B The minimum electrical power output at the maximum heat load (corresponds to the minimum stable plant load).
- Line A to B: The minimum electrical power output for any given heat load (corresponds to the minimum stable plant load).
- C: The maximum electrical power output at the maximum heat load (corresponds to 100% plant load).

- D: The maximum electrical power output with no heat load (corresponds to 100% plant load).
- Line D to C: The maximum electrical power output for any given heat load (corresponds to 100% plant load).
- E: Proposed operational point of the plant.
- Unrestricted Operation: If a selected heat load is located in this region, the plant will have the ability to operate at any load between minimum stable plant load and 100% plant load (i.e. is not load restricted).
- Restricted Operation: If a selected heat load is located in this region, the plant will not have the ability to operate over its full operational range (i.e. is load restricted).

This is addressed under this Requirement.

Demonstrations under Requirement 2:

Identification of:

- The potential heat extraction at 100% Plant Load, and the effects on the plant;
- The potential heat extraction at Minimum Stable Plant Load, and effects on the plant; and,
- Whether the plant can supply the selected heat load.

2.3 Requirement 3: Operation of Plant with the Identified Heat Load

Within the identified CHP Envelope, the effect of the selected heat load on the proposed operation of the plant should be determined.

This is addressed under this Requirement.

Demonstrations under Requirement 3:

Identification of:

- The likely effects of the selected heat load on the plant.

2.4 Requirement 4: Technical Provisions and Space Requirements

Determination of the effect of the selected heat load on the operation of the plant (under Requirement 3) will have required suitable extraction points to be identified.

These extraction points should be described under this Requirement.

Furthermore, determination of the CHP Envelope (under Requirement 2) will allow for consideration to be given to potential options which could be incorporated into the plant (either within the initial design or at a later stage) should a CHP opportunity be realised outside the identified CHP Envelope (i.e. outside the potential operating ranges of the plant).

The potential options should be described under this Requirement.

In addition, within the demonstration of CHP-R for all opportunities, it is important that consideration is given to the provision of additional space which may be needed.

This is addressed under this Requirement.

Demonstrations under Requirement 4:

- Identification of likely suitable extraction points in the plant for the identified heat load. Additional Technical Supporting Information is provided in Appendix D;
- Identification of the potential options which could be incorporated in the plant, should the CHP opportunity be realised outside the identified CHP Envelope;
- Description of how the future costs and burdens associated with supplying the identified heat load / potential CHP opportunity have been minimised through the implementation of an appropriate CHP-R design; and,
- Provision of site layout plan of the plant, indicating available space which could be made available for CHP.

2.5 Requirement 5: Integration of CHP and Carbon Capture

Through the EU Directive on the geological storage of carbon dioxide (Directive 2009/31/EC) (the Carbon Capture and Storage (CCS) Directive), it is now required that developers of new plants with an electrical power output of 300 MW or more carry out an assessment to determine whether the plant is Carbon Capture Ready (CCR). Based on this requirement, current UK Policy now stipulates that "no power station at or over 300 MW ... would be consented unless it could demonstrate it would be CCR"[4]. Therefore, for plants with an electrical power output at or over 300 MW, consideration should be given to the ability of the plant to satisfy the requirements of CCR in conjunction with CHP-R[5].

This consideration allows for the identification of a 'CHP and Carbon Capture Envelope'. The CHP and Carbon Capture Envelope represents the likely range for the operation of the new plant with carbon capture where it could be technically feasible to operate electrical power generation with carbon capture and heat generation at a later date. Determination of the CHP and Carbon Capture Envelope will allow for consideration to be given (either within the initial design or at a later stage) to: options for useful integration of the two systems; or, potential options which could be incorporated into the plant with carbon capture should a CHP opportunity be realised outside the identified CHP and Carbon Capture Envelope (i.e. outside the operating capability of the plant with carbon capture).

This is addressed under this Requirement.

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[4] Carbon Capture Readiness (CCR): A Guidance Note for Section 36 Electricity Act, 1989 Consent Applications. Crown Copyright URN 09D/819.

[5] For power plants with an electrical power output of less than 300 MW, no demonstrations under this Requirement are necessary.

Demonstrations under Requirement 5:

Identification of:

- The expected supply and return requirements identified for carbon capture[6];
- The effects of carbon capture on the operation of the plant;
- The CHP and Carbon Capture Envelope including:
  - The potential heat extraction at 100% Plant Load, and the effects on the plant.
  - The potential heat extraction at Minimum Stable Plant Load, and effects on the plant.
  - Identification of whether the plant with carbon capture can supply the selected identified heat load.
  - Identification of the potential options which could be incorporated into the plant for useful integration of any realised CHP system and carbon capture system.

2.6 Requirement 6: Economics of CHP-R

An integral part of any BAT test is a consideration of the economic viability of the chosen option. With regard to the second BAT test, the economic viability is dictated by the potential future opportunities for heat supply and the:

- Associated potential future revenues / benefits; and,
- Likely additional initial costs of making the new plant CHP-R for the selected potential future opportunities for heat supply.

Therefore, in addition to the technical assessments of CHP-R (Requirement 2 to Requirement 5), applications for an Environmental Permit for a CHP-R plant should also conduct a high level economic assessment. The high level economic assessment may build on the results of the qualitative economic screening (if completed under Requirement 1) and demonstrate, for the selected potential future opportunity for heat supply, the associated potential future revenues / benefits and likely additional initial

[F]or the majority of new power plants which are required to demonstrate CCR, post-combustion carbon capture technology is referenced. For this carbon capture technology is it likely that a supply of low pressure steam will be required.

costs for the plant to be CHP-R. For further information, please see Additional Economic Supporting Information in Appendix C

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3 BAT Assessment

In cases where there are no immediate opportunities for the supply of heat from the outset, Natural Resources Wales considers that BAT is to build a new plant to be CHPR to a degree which is dictated by the foreseeable future opportunities which are technically viable and which may, in time, become economically viable.

Therefore, based on the CHP-R Assessment, there should be an identification of the extent to which the new plant will be CHP-R and thus whether the proposals represent BAT.

Within this CHP-R Guidance, the term BAT is considered to have the same definition at that under the IED (given at Article 3 (Definitions), Item 10).

This definition is:

"'Best available techniques' means the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impacts on the environment as a whole:

> (a) 'techniques' includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned;
>
> (b) available techniques' means those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced in the Member State in question, as long as they are reasonably accessible to the operator;
>
> (c) 'best' means most effective in achieving a high general level of protection of the environment as a whole".

The BAT Assessment (including consideration of the economic viability[7]) should include:

- A basic description of the proposed plant;
- A description of the potential heat loads (including their appropriate selection) which have been used in the CHP-R Assessment; and,
- A justification of the degree to which the new plant will be CHP-R based on the results of the CHP-R Assessment including:
    - The CHP Envelope (i.e. the likely range for the operation of the new plant where it could be technical feasible to operate electrical power generation with heat generation at a later date);
    - Whether the selected heat loads are within the CHP Envelope

[7] This is considered to represent the Cost-Benefit Analysis.

(i.e. whether they are within the operating capability of the plant);

What the effect of the selected heat load(s) will be on the proposed operation of the new plant;

- What technical provisions and space requirements are envisaged;
- (If the plant is required to be CCR), the CHP and Carbon Capture Envelope (i.e. the likely range for the operation of the plant with carbon capture where it could be technical feasible to operate electrical power generation with carbon capture and heat generation at a later date);
- (If the plant is required to be CCR), whether the heat loads are within the ‘CHP and Carbon Capture Envelope’ (i.e. whether they are within the operating capability of the plant with carbon capture); and,
- The results of the high level economic assessment (or the Cost-Benefit Analysis) establishing the economic viability of CHP-R.

Appendix A: CHP-R Assessment Form

#	Description	Units	Notes / Instructions
Requirement 1: Plant, Plant Location and Potential Heat Loads			
1.1	Plant Name		The plant name.
1.2	Plant Description		To include a basic description of the plant, considering (as a minimum): • The type of plant; • The rated gross thermal input (based on the Higher Heating Value (HHV)) of the plant • The maximum continuous electrical power rating; • The proposed fuel(s); • The proposed combustion technology; and • High-level discussion of the anticipated plant design (e.g. number of combustion units / number of steam turbines / cooling technology)
1.3	Plant Location (Postcode / Grid Ref)		The location of the plant. This should include a plan showing the proposed plant site boundary, and the land in its vicinity.

1.4	Factors Influencing Selection of Plant Location		This should include a description of the factors that have been used to select the location of the plant. The description should make reference to the following factors as appropriate: • Likely potential for CHP opportunities*; • Availability of sufficient land capacity; • Current land use*; • Compatibility with the policies of the relevant Local Plan(s) and the NPPF together with other relevant planning considerations; • CHP provisions contained within the relevant Planning documents*; • Environmental considerations (such as proximity to sensitive receptors including: Air Quality Management Areas (AQMAs); and Statutory Designated Sites (and the likely presence of Protected Species)); • Proximity of suitable connection point to the National Grid Electricity Transmission System, and available capacity for export to the Electricity Transmission System; • Proximity to / availability of fuel source; • Proximity to / availability of cooling water; • Likely suitability for CCS (if applicable)*; and • Any other relevant considerations. * For the purposes of demonstrating CHP-R the items marked (*) must be included.

1.5	Operation of Plant		
a)	Proposed Operational Plant Load	%	This should clearly describe the proposed operating load point of the plant. For example: • For gas turbine plant, this should comprise the number of gas turbines in operation and the load as % of gas turbine base load. • For steam plant, this should comprise the main steam flow as a percentage of maximum turbine continuous rating (%TMCR).
b)	Thermal Input at Proposed Operational Plant Load	MW	The plant thermal input (based on the Lower Heating Value (LHV)) at proposed operational plant load. Identified from modelling.
c)	Net Electrical Output at Proposed Operational Plant Load	MW	The plant net electrical output at proposed operational plant load. Identified from modelling.
d)	Net Electrical Efficiency at Proposed Operational Plant Load	%	The plant net electrical efficiency at proposed operational plant load based on the LHV. Identified from modelling.
e)	Maximum Plant Load	%	This is the maximum possible plant load. The value to be used is 100%.
f)	Thermal Input at Maximum Plant Load	MW	The plant thermal input (based on the LHV) at 100% plant load. Identified from modelling.
g)	Net Electrical Output at Maximum Plant Load	MW	The plant net electrical output at 100% plant load. Identified from modelling. This is represented by Point D on Insert 3.
h)	Net Electrical Efficiency at Maximum Plant Load	%	The plant net electrical efficiency at 100% plant load based on the LHV. Identified from modelling. This is represented by Point D on Insert 3.

i)	Minimum Stable Plant Load	%	This is the minimum stable plant load. This will vary with type of plant, and may be governed by the combustion stability or capability to meet emissions limits at low plant loads.
j)	Thermal Input at Minimum Stable Plant Load	MW	The plant thermal input (based on the LHV) at minimum stable plant load.
k)	Net Electrical Output at Minimum Stable Plant Load	MW	The plant net electrical output at minimum stable plant load. Identified from modelling. This is represented by Point A on Insert 3.
l)	Net Electrical Efficiency at Minimum Stable Plant Load	%	The plant net electrical efficiency at minimum stable plant load based on the LHV. Identified from modelling. This is represented by Point A on Insert 3.
1.6	Identified Potential Heat Loads		

			This should include a description of the identified potential heat loads in the vicinity of the plant. A plan showing all identified potential heat loads in the vicinity should be provided. For each potential heat load the following information should be provided: • Name of identified heat load / recipient; • Size of heat load (MW) • Location of identified heat load / recipient including distance from the plant(where the identified heat load / recipient is a District Heating Network, the primary service location(s) should be provided); • Nature of use of potential heat load; and • Typical export and return requirements of the potential heat load.

1.7	Selected Heat Load(s)		
a)	Category (e.g. Industrial / District Heating)		Of the identified potential heat loads under Requirement 1.6, appropriate selection of heat loads should be undertaken in discussion with the Potential Heat Load Recipient / Natural Resources Wales. It should be noted that the heat loads for assessment must be agreed with the Natural Resources Wales **If more than one heat load is taken forward, then an assessment should be undertaken for all selected heat loads.**

b)	Maximum Heat Load Extraction Required	MW	Of the identified potential heat loads under Requirement 1.6, appropriate selection of heat loads should be undertaken in discussion with the Potential Heat Load Recipient / Natural Resources Wales. It should be noted that the heat loads for assessment must be agreed with the Natural Resources Wales **If more than one heat load is taken forward, then an assessment should be undertaken for all selected heat loads. .**
1.8	Export and Return Requirements of Heat Load		
a)	Description of Heat Load Extraction		To complete, based on potential heat load extraction for CHP (e.g. steam / hot water)
b)	Description of Heat Load Profile		To complete, based on potential heat load profile (e.g. constant or intermittent / fixed or variable load)
c)	Export Pressure	bar a	To complete, based on the requirements at the terminal point with the heat load customer.
d)	Export Temperature	°C	To complete, based on the requirements at the terminal point with the heat load customer.
e)	Export Flow	t/h	To complete, based on the requirements at the terminal point with the heat load customer.
f)	Return Pressure	bar a	To complete, if applicable, based on the requirements at the terminal point with the heat load customer.
g)	Return Temperature	°C	To complete, if applicable, based on the requirements at the terminal point with the heat load customer.
h)	Return Flow	t/h	To complete, if applicable, based on the requirements at the terminal point with the heat load customer.
Requirement 2: Identification of CHP Envelope			
2.0	Comparative Efficiency of a Standalone Boiler for supplying the Heat Load	90 % LHV	This is used only to calculate the primary energy savings (or reduction in primary energy usage) as a comparative guide.

2.1	Heat Extraction at 100% Plant Load		
a)	Maximum Heat Load Extraction at 100% Plant Load	MW	This is the maximum possible heat load extraction within the technical limitations of the plant at 100% plant load (i.e. heat load extraction beyond which major plant modification would be required). This will vary with type of plant. This is represented by Point C on Insert 3.
b)	Maximum Heat Extraction Export Flow at 100% Plant Load	t/h	This should be consistent with the: • Steam conditions given in 1.8; and • The figure given in 2.1(a).
c)	CHP Mode Net Electrical Output at 100% Plant Load	MW	The plant with CHP net electrical output at 100% plant load. Identified from modelling. This is represented by Point C on Insert 3.
d)	CHP Mode Net Electrical Efficiency at 100% Plant Load	%	The plant with CHP net electrical efficiency at 100% plant load based on the LHV. Identified from modelling. This is represented by Point C on Insert 3.
e)	CHP Mode Net CHP Efficiency at 100% Plant Load	%	The plant with CHP net CHP efficiency at 100% plant load based on the LHV. Identified from modelling. This is represented by Point C on Insert 3.

f)	Reduction in Primary Energy Usage for CHP Mode at 100% Plant Load	%	The reduction in primary energy usage (i.e. measure of primary energy savings) is based on the EED and is given by: $\left[1 - \frac{1}{\frac{CHP\ H_\eta}{Ref\ H_\eta} + \frac{CHP\ E_\eta}{Ref\ E_\eta}}\right] \cdot 100$ Or (with reference to the values calculated in this CHP-R Assessment) this can also be given by: $\left[1 - \frac{1}{\frac{CHP_\eta}{H + E}\left(\frac{H}{Ref\ H_n} + \frac{E}{Ref\ E_n}\right)}\right] \cdot 100$ Where: CHP Hη : CHP Heat Efficiency CHP Eη : CHP Electrical Efficiency CHPη : CHP Efficiency Ref Hη : Reference Heat Efficiency[8] Ref Eη : Reference Electrical Efficiency[9] H : Heat Load Extraction E : CHP Mode Net Electrical Output
2.2	Heat Extraction at Minimum Stable Plant Load		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load	MW	This is the maximum possible heat load extraction within the technical limitations of the plant at minimum stable plant load (i.e. heat load extraction beyond which major plant modification would be required). This will vary with type of plant. This is represented by Point B on Insert 3.

[8] This is the Comparative Efficiency of a Standalone Boiler for supplying the Heat Load [2.0].

[9] This is the power plant net electrical efficiency without heat extraction.

b)	Maximum Heat Extraction Export Flow at Minimum Stable Plant Load	t/h	This should be consistent with the: • Steam conditions given in 1.8; and • The figure given in 2.2(a).
c)	CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	The plant with CHP net electrical output at minimum stable plant load. Identified from modelling. This is represented by Point B on Insert 3.
d)	CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	The plant with CHP net electrical efficiency at minimum stable plant load based on the LHV. Identified from modelling. This is represented by Point B on Insert 3.
e)	CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	The plant with CHP net CHP efficiency at minimum stable plant load based on the LHV. Identified from modelling. This is represented by Point B on Insert 3.
f)	Reduction in Primary Energy Usage for CHP Mode at Minimum Stable Plant Load	%	The reduction in primary energy usage (i.e. measure of primary energy savings) is based on the EED. This is given by 2.1(f).
2.3	Can the Plant supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the 'CHP Envelope')?		Should be identified: Yes or No
Requirement 3: Operation of the Plant with the Selected Identified Heat Load			
3.1	Proposed Operation of Plant with CHP		

a)	CHP Mode Net Electrical Output at Proposed Operational Plant Load	MW	The plant with CHP net electrical output at proposed operational plant load. Identified from modelling. This is represented by Point E on Insert 3.
b)	CHP Mode Net Electrical Efficiency at Proposed Operational Plant Load	%	The plant with CHP net electrical efficiency at proposed operational plant load based on the LHV. Identified from modelling. This is represented by Point E on Insert 3.
c)	CHP Mode Net CHP Efficiency at Proposed Operational Plant Load	%	The plant with CHP net CHP efficiency at proposed operational plant load based on the LHV. Identified from modelling. This is represented by Point E on Insert 3.
d)	Reduction in Net Electrical Output for CHP Mode at Proposed Operational Plant Load	MW	The extraction of heat from the plant will cause a corresponding loss in electrical power. Typically, the higher the quality of the extracted heat, the greater the corresponding loss in electrical power. The reduction in electrical power output due to the heat load extraction at proposed operational plant load is given by: (Net Electrical Output at Proposed Operational Plant Load) – (CHP Mode Net Electrical Output at Proposed Operational Plant Load).
e)	Reduction in Net Electrical Efficiency for CHP Mode at Proposed Operational Plant Load	%	The reduction in net electrical efficiency (based on the LHV due to the heat load extraction at proposed operational plant load is given by: (Net Electrical Efficiency at Proposed Operational Plant Load) – (CHP Mode Net Electrical Efficiency at Proposed Operational Plant Load).
f)	Reduction in Primary Energy Usage for CHP Mode at Proposed Operational Plant Load	%	The reduction in primary energy usage (i.e. measure of primary energy savings) is based on the EED. This is given by 2.1(f).

g)	Z Ratio		The Z-Ratio compares the heat exported to the reduction in electrical power. A higher Z-Ratio indicates a more efficient method of heat supply. This is given by: (Maximum Heat Load Extraction Required) / (Reduction in Net Electrical Output for CHP Mode at Proposed Operational Plant Load)

Requirement 4: Technical Provisions and Space Requirements			
4.1	Description of Likely Suitable Extraction Points		Demonstration of CHP-R does not require that suitable extraction points are fitted from the outset, but rather it is technically feasible to retrofit at a later date. Therefore, based on the likely heat load, a suitable method (or suitable methods) of extraction should be identified, along with the associated technical requirements of such extraction. For example, for heat load extraction from a CCGT power plant for a District Heating Scheme, a quantity of low pressure steam would be required. A suitable method of extraction would involve extracting a quantity of low pressure steam from the Intermediate Pressure / Low Pressure Turbine Crossover (if present). If this is not possible, but steam can be extracted from the Cold Reheat Pipe, a suitable method of extraction would involve extracting the steam and passing it through a let-down station or back pressure steam turbine. Additional information is presented in Appendix D.

4.2	Description of Potential Options which could be incorporated in the Plant, should a CHP Opportunity be realised outside the 'CHP Envelope'		If heat load extraction in sufficient quantities is not possible, consideration should be given to potential options which could be incorporated into the plant should the realised CHP opportunity be outside the identified 'CHP Envelope'. For example: • Back-up boilers operated by the plant operator / head load recipient; and • The use of heat storage equipment.
4.3	Description of how the future Costs and Burdens associated with supplying the Identified Heat Load / Potential CHP Opportunity have been minimised through the implementation of an appropriate CHP-R design		A description of how the future costs and burdens of CHP have been minimised. This may include discussions with major plant or component manufactures to investigate modifications to design which could allow for the maximum heat supply without compromising the initial performance, flexibility and reliability of the plant.

4.4	Provision of Site Layout of the Plant, indicating Available Space which could be made available for CHPR		Following identification of suitable extraction points and potential options which could be incorporated into the design of the plant should a CHP opportunity be realised outside the 'CHP Envelope', demonstration of CHP-R comprises indication of the available space for the extraction points / potential options. For example: • When operating within the 'CHP Envelope', in addition to the extraction points, there may be a need for space to be provided for: - Supply and return pipes within the plant site, for steam and / or hot water; - The Water Treatment Plant / Demineralisation Plant, which may need to be increased in size if steam is to be piped offsite without condensate return; - A let-down station or back pressure steam turbine; and, - Back-up boilers, which could supply heat in the event that the plant is offline. • When operating outside the 'CHP Envelope', there may be a need for space to be provided for: - Back-up boilers; and - Heat storage equipment. It is noted that the available space for the provision of additional balance of plant systems / control and instrumentation systems should be in the most suitable location, and therefore may not always be on the plant site itself.

Requirement 5: Integration of CHP and Carbon Capture			
5.1	Is the Plant required to be CCR?		Should be identified: Yes or No
5.2	Export and Return Requirements Identified for Carbon Capture		
	100% Plant Load		
a)	Heat Load Extraction for Carbon Capture at 100% Plant Load	MW	This is the heat load extraction required for carbon capture at 100% Plant Load. This does not include the heat available for export.
b)	Description of Heat Export (e.g. Steam / Hot Water)		To complete, based on the likely heat load extraction for carbon capture at 100% Plant Load.
c)	Export Pressure	bar a	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at 100% Plant Load.
d)	Export Temperature	°C	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at 100% Plant Load.
e)	Export Flow	t/h	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at 100% Plant Load.
f)	Return Pressure	bar a	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at 100% Plant Load.
g)	Return Temperature	°C	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at 100% Plant Load.
h)	Return Flow	t/h	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at 100% Plant Load.
i)	Likely Suitable Extraction Points		Based on the likely heat load extraction for carbon capture a suitable method (or suitable methods) of extraction should be identified.
	Minimum Stable Plant Load		

j)	Heat Load Extraction for Carbon Capture at Minimum Stable Plant Load	MW	This is the heat load extraction required for carbon capture at Minimum Stable Plant Load. This does not include the heat available for export.
k)	Description of Heat Export (e.g. Steam / Hot Water)		To complete, based on the likely heat load extraction for carbon capture at Minimum Stable Plant Load.
l)	Export Pressure	bar a	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at Minimum Stable Plant Load.
m)	Export Temperature	°C	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at Minimum Stable Plant Load.
n)	Export Flow	t/h	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at Minimum Stable Plant Load.
o)	Return Pressure	bar a	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at Minimum Stable Plant Load.
p)	Return Temperature	°C	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at Minimum Stable Plant Load.
q)	Return Flow	t/h	To complete, based on the likely requirements at the terminal point with the Carbon Capture Plant at Minimum Stable Plant Load.
r)	Likely Suitable Extraction Points		Based on the likely heat load extraction for carbon capture, a suitable method (or suitable methods) of extraction should be identified.
5.3	Operation of Plant with Carbon Capture (without CHP)		
a)	Maximum Plant Load with Carbon Capture	%	This is the maximum possible plant load with carbon capture. The value to be used is 100%.
b)	Carbon Capture Mode Thermal Input at Maximum Plant Load	MW	The plant with carbon capture thermal input (based on the LHV) at 100% plant load. Identified from modelling.

c)	Carbon Capture Mode Net Electrical Output at Maximum Plant Load	MW	The plant with carbon capture net electrical output at 100% plant load. Identified from modelling.
d)	Carbon Capture Mode Net Electrical Efficiency at Maximum Plant Load	%	The plant with carbon capture net electrical efficiency at 100% plant load based on the LHV. Identified from modelling.
e)	Minimum Stable Plant Load with CCS	%	This is the minimum stable plant load with carbon capture. This will vary with type of plant.
f)	Carbon Capture Mode CCS Thermal Input at Minimum Stable Plant Load	MW	The plant with carbon capture thermal input (based on the LHV) at minimum stable plant load.
g)	Carbon Capture Mode Net Electrical Output at Minimum Stable Plant Load	MW	The plant with carbon capture net electrical output at minimum stable plant load. Identified from modelling.
h)	Carbon Capture Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	The plant with carbon capture net electrical efficiency at minimum stable plant load based on the LHV. Identified from modelling.
5.4	Heat Extraction for CHP at 100% Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at 100% Plant Load with Carbon Capture [H]	MW	This is the maximum possible heat load extraction within the technical limitations of the plant with carbon capture at 100% plant load (i.e. heat load extraction beyond which major plant modification would be required). This will vary with type of plant, and Carbon Capture Plant requirement.
b)	Maximum Heat Extraction Export Flow at 100% Plant Load with Carbon Capture	t/h	This should be consistent with the: • Steam conditions given in 1.8; and • The figure given in 5.4(a).
c)	Carbon Capture and CHP Mode Net Electrical Output at 100% Plant Load	MW	The plant with carbon capture and CHP net electrical output at 100% plant load. Identified from modelling.

d)	Carbon Capture and CHP Mode Net Electrical Efficiency at 100% Plant Load	%	The plant with carbon capture and CHP net electrical efficiency at 100% plant load based on the LHV. Identified from modelling.
e)	Carbon Capture and CHP Mode Net CHP Efficiency at 100% Plant Load	%	The plant with carbon capture and CHP net CHP efficiency at 100% plant load based on the LHV. Identified from modelling.
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at 100% Plant Load	%	The reduction in primary energy usage (i.e. measure of primary energy savings) is based on the EED. This is given by 2.1(f).

5.5	Heat Extraction at Minimum Stable Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load with Carbon Capture	MW	This is the maximum possible heat load extraction within the technical limitations of the plant with carbon capture at minimum stable plant load (i.e. heat load extraction beyond which major plant modification would be required). This will vary with type of plant, and Carbon Capture Plant requirement.
b)	Maximum Heat Extraction Export Flow at Minimum Stable Plant Load with Carbon Capture	t/h	This should be consistent with the: • Steam conditions given in 1.8; and • The limit given in 5.5(a).
c)	Carbon Capture and CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	The plant with carbon capture and CHP net electrical output at minimum stable plant load. Identified from modelling.
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	The plant with carbon capture and CHP net electrical efficiency at minimum stable plant load based on the LHV. Identified from modelling.
e)	Carbon Capture and CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	The plant with carbon capture and CHP net CHP efficiency at minimum stable plant load based on the LHV. Identified from modelling.
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at Minimum Stable Plant Load	%	The reduction in primary energy usage (i.e. measure of primary energy savings) is based on the EED. This is given by 2.1(f).

5.6	Can the Plant with Carbon Capture supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the 'CHP and Carbon Capture Envelope')?		Should be identified: Yes or No
5.7	Description of Potential Options which could be incorporated in the Plant for useful integration of any realised CHP System and Carbon Capture System		The Carbon Capture Plant will reject large quantities of heat. A description of potential uses of this heat should be provided with regard to how it could be used in any CHP System. If this is not possible, consideration should be given to potential options which could be incorporated into the plant with carbon capture should the realised CHP opportunity be outside the identified 'CHP and Carbon Capture Envelope'.
Requirement 6: Economics of CHP-R			
6.1	Economic Assessment of CHP-R		A clear summary of the high level economic assessment (or Cost-Benefit Analysis) should be provided, stating for the selected potential future opportunity for heat supply, the associated potential future revenues / benefits and likely additional initial costs for the plant to be CHP-R. Unless it can be demonstrated that the additional initial costs for the plant to be CHP-R would be excessive (and outweigh the associated potential future revenues / benefits), it is considered that the economic viability of CHP-R is demonstrated.
BAT Assessment			
	Is the new plant a CHP plant at the outset (i.e. are there economically viable CHP opportunities at the outset)?		Should be identified: Yes or No. If yes, then the new plant is considered BAT.
	If not, is the new plant a CHP-R plant at the outset?		Should be identified: Yes or No

			If no, applicants should provide evidence as to why their plant should be excluded from being CHP-R.
	Once the new plant is CHPR, is it BAT?		Should be identified: Yes or No (as a result of periodic reviews of opportunities for heat supply once the CHP-R plant becomes operational).

Appendix B: Case Studies / Worked Examples

This Appendix provides a number of Case Studies / Worked Examples using the CHPR Assessment Form.

The Case Studies / Worked Examples are summarised below:

	Description
Case Study 1	Case Study 1 is based on a large multi-shaft CCGT power plant, which incorporates an IP / LP crossover pipe. Two selected heat loads are considered simultaneously. These are a heat load associated with an industrial use, and a heat load associated with district heating.
Case Study 2	Case Study 2 is based on a large multi-shaft CCGT power plant, which incorporates an IP / LP crossover pipe. One selected heat load is considered, which is associated with an industrial use.
Case Study 3	Case Study 3 is based on a biomass plant. One selected heat load is considered, which is associated with district heating.
Case Study 4	Case Study 4 is based on an EfW plant. One selected heat load is considered, which is associated with district heating.
Case Study 5a	Case Study 5a is based on a small single-shaft CCGT power plant, which does not incorporate an IP / LP crossover pipe. One selected heat load is considered, which is associated with district heating. Within Case Study 5a, although the selected heat load lies inside the CHP Envelope, the steam cannot be extracted from the IP turbine exhaust. Therefore, the steam is extracted from the cold reheat pipe, passed through a let-down station and supplied to the District Heating System.

Case Study 5b	Case Study 5b provides further assessment of Case Study 5a. Accordingly, Case Study 5b is also based on a small single shaft CCGT power plant, which does not incorporate an IP / LP crossover pipe. One selected heat load is considered, which is associated with district heating. Similar to Case Study 5a, although the selected heat load lies inside the CHP Envelope, the steam cannot be extracted from the IP turbine exhaust. Therefore, the steam is extracted from the cold reheat pipe, passed through a back pressure steam turbine and supplied to the District Heating System.

Case Study / Worked Example 1

#	Description	Units	Notes / Instructions
Requirement 1: Plant, Plant Location and Potential Heat Loads			
1.1	Plant Name		Case Study 1
1.2	Plant Description		Plant comprises: • Multi-shaft (1 + 1) Configuration; • IP / LP crossover pipe available as an extraction point; • Hybrid Cooling; and • UK ambient conditions.
1.3	Plant Location (Postcode / GridRef)		Not required for the Case Study
1.4	Factors Influencing Selection of Plant Location		Not required for the Case Study
1.5	Operation of Plant		
a)	Proposed Operational Plant Load	%	100
b)	Thermal Input at Proposed Operational Plant Load	MW	764.5
c)	Net Electrical Output at Proposed Operational Plant Load	MW	434.1
d)	Net Electrical Efficiency at Proposed Operational Plant Load	%	56.8
e)	Maximum Plant Load	%	100
f)	Thermal Input at Maximum Plant Load	MW	764.5
g)	Net Electrical Output at Maximum Plant Load	MW	434.1

h)	Net Electrical Efficiency at Maximum Plant Load	%	56.8
i)	Minimum Stable Plant Load	%	40
j)	Thermal Input at Minimum Stable Plant Load	MW	432.1
k)	Net Electrical Output at Minimum Stable Plant Load	MW	212.4
l)	Net Electrical Efficiency at Minimum Stable Plant Load	%	49.2
1.6	Identified Potential Heat Loads		
			30 MW of District Heating and 30 MW of Industrial Steam
1.7	Selected Heat Load(s)		
a)	Category (e.g. Industrial / District Heating)		District Heating (DH) / Industrial (I)
b)	Maximum Heat Load Extraction Required	MW	60
1.8	Export and Return Requirements of Heat Load		
a)	Description of Heat Load Extraction		Hot water (DH) / Superheated steam (I)
b)	Description of Heat Load Profile		Constant
c)	Export Pressure	bar a	5 (DH) / 20 (I)
d)	Export Temperature	°C	95 (DH) / 300 (I)
e)	Export Flow	t/h	645 (DH) / 40 (I)
f)	Return Pressure	bar a	3 (DH) / 5 (I)
g)	Return Temperature	°C	55 (DH) / 82.2 (I)
h)	Return Flow	t/h	645 (DH) / 36 (I) (Note: Only 90% of the industrial steam is returned)
Requirement 2: Identification of CHP Envelope			
2.0	Comparative Efficiency of a Standalone Boiler for supplying the Heat Load	90 % LHV	90
2.1	Heat Extraction at 100% Plant Load		
a)	Maximum Heat Load Extraction at 100% Plant Load	MW	161 (42.5 (DH) / 118.5 (I))
b)	Maximum Heat Extraction Export Flow at 100% Plant Load	t/h	910 (DH) / 157 (I)
c)	CHP Mode Net Electrical	MW	389

	Output at 100% Plant Load		
d)	CHP Mode Net Electrical Efficiency at 100% Plant Load	%	51.0
e)	CHP Mode Net CHP Efficiency at 100% Plant Load	%	72.0
f)	Reduction in Primary Energy Usage for CHP Mode at 100% Plant Load	%	11.6
2.2	Heat Extraction at Minimum Stable Plant Load		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load	MW	106
b)	Heat Extraction Export Flow at Minimum Stable Plant Load	t/h	620 (DH) / 102 (I)
c)	CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	182
d)	CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	42.0
e)	CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	66.5
f)	Reduction in Primary Energy Usage for CHP Mode at Minimum Stable Plant Load	%	11.2
2.3	Can the Plant supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the ‘CHP Envelope’)?		Yes
Requirement 3: Operation of the Plant with the Selected Identified Heat Load			
3.1	Proposed Operation of Plant with CHP		
a)	CHP Mode Net Electrical Output at Proposed Operational Plant Load	MW	419
b)	CHP Mode Net Electrical Efficiency at Proposed Operational Plant Load	%	54.8

c)	CHP Mode Net CHP Efficiency at Proposed Operational Plant Load	%	62.7
d)	Reduction in Net Electrical Output for CHP Mode at Proposed Operational Plant Load	MW	15.1
e)	Reduction in Net Electrical Efficiency for CHP Mode at Proposed Operational Plant Load	%	3.5
f)	Reduction in Primary Energy Usage for CHP Mode at Proposed Operational Plant Load	%	5.0
g)	Z Ratio		4.0
Requirement 4: Technical Provisions and Space Requirements			
4.1	Description of Likely Suitable Extraction Points		Steam for the District Heating System is extracted from the Low Pressure (LP) cross over pipe, (which supplies steam to the LP turbine from the exhaust of the Intermediate Pressure (IP) turbine). Steam for the Industrial Process is extracted from the cold reheat line. To facilitate this, a cold reheat header would be required.
4.2	Description of Potential Options which could be incorporated in the Plant, should a CHP Opportunity be realised outside the 'CHP Envelope'		N / A (CHP opportunity lies within the CHP Envelope)
4.3	Description of how the future Costs and Burdens associated with supplying the Identified Heat Load / Potential CHP Opportunity have been minimised through the implementation of an appropriate CHP-R design		Not required for the Case Study

4.4	Provision of Site Layout of the Plant, indicating Available Space which could be made available for CHPR		Please see Layout CS 01. The District Heating System will (likely) include: extraction piping; control and shut-off valves, and actuators; a Pressure Reduction and Desuperheating Station; District Heaters; District Heating supply and return lines; condensate return piping (to the condensate header); interconnecting piping; drains; pipe bridges / supports; and Control and Instrumentation / electrical connections. The Industrial Process will (likely) include: the installation of a cold reheat header; extraction piping; control and shut-off valves, and actuators; a Pressure Reduction and De-Superheating Station; condensate return piping; interconnecting pipeline; drains pipe bridges / supports; and Control and Instrumentation / electrical connections. A Stand-by Boiler is also included. Provision is also made for possible extension of the Water Treatment Plant.
Requirement 5: Integration of CHP and Carbon Capture			

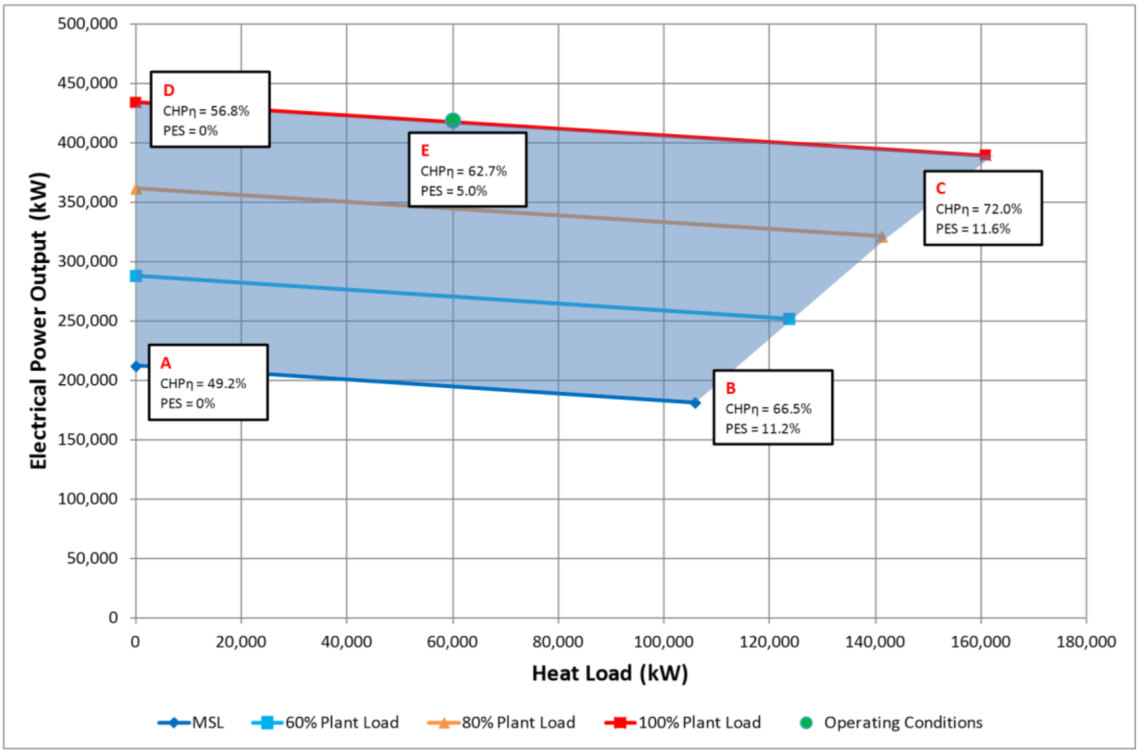
5.1	Is the Plant required to be CCR?		Yes
5.2	Export and Return Requirements Identified for Carbon Capture		
	100% Plant Load		
a)	Heat Load Extraction for Carbon Capture at 100% Plant Load	MW	128.9
b)	Description of Heat Export (e.g. Steam / Hot Water)		Low pressure steam
c)	Export Pressure	bar a	3.4
d)	Export Temperature	°C	150
e)	Export Flow	t/h	212.8
f)	Return Pressure	bar a	3.4
g)	Return Temperature	°C	137.4
h)	Return Flow	t/h	212.8
i)	Likely Suitable Extraction Points		LP superheated steam / HP water desuperheating
	Minimum Stable Plant Load		

j)	Heat Load Extraction for Carbon Capture at Minimum Stable Plant Load	MW	71.5
k)	Description of Heat Export (e.g. Steam / Hot Water)		Low pressure steam
l)	Export Pressure	bar a	2.7
m)	Export Temperature	°C	150
n)	Export Flow	t/h	116
o)	Return Pressure	bar a	2.7
p)	Return Temperature	°C	130
q)	Return Flow	t/h	116
r)	Likely Suitable Extraction Points		LP superheated steam / HP water desuperheating
5.3	Operation of Plant with Carbon Capture (without CHP)		
a)	Maximum Plant Load with Carbon Capture	%	100
b)	Carbon Capture Mode Thermal Input at Maximum Plant Load	MW	764.7
c)	Carbon Capture Mode Net Electrical Output at Maximum Plant Load	MW	400.4
d)	Carbon Capture Mode Net Electrical Efficiency at Maximum Plant Load	%	52.4
e)	Minimum Stable Plant Load with CCS	%	40
f)	Carbon Capture Mode CCS Thermal Input at Minimum Stable Plant Load	MW	432
g)	Carbon Capture Mode Net Electrical Output at Minimum Stable Plant Load	MW	192
h)	Carbon Capture Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	44.5
5.4	Heat Extraction for CHP at 100% Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at 100% Plant Load with Carbon Capture [H]	MW	35
b)	Maximum Heat Extraction Export Flow at 100% Plant Load with Carbon Capture	t/h	185 (DH) / 35 (I)

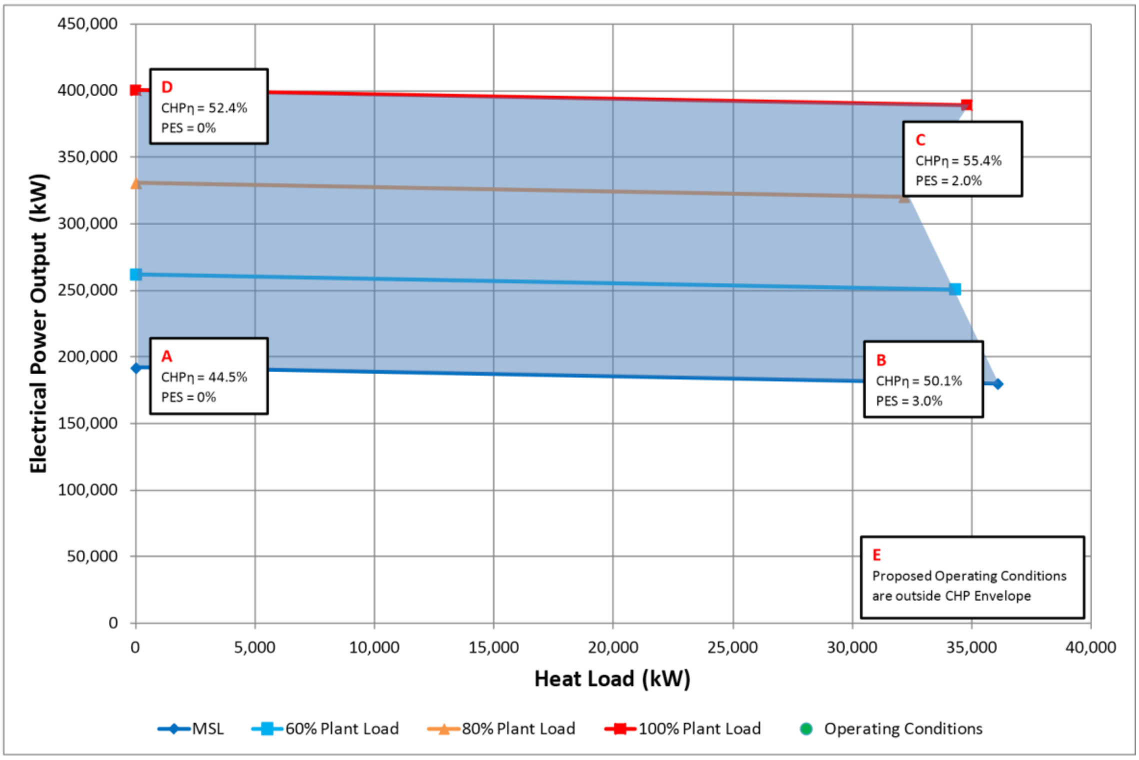
c)	Carbon Capture and CHP Mode Net Electrical Output at 100% Plant Load	MW	389.2
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at 100% Plant Load	%	50.9
e)	Carbon Capture and CHP Mode Net CHP Efficiency at 100% Plant Load	%	55.4
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at 100% Plant Load	%	2.0
5.5	Heat Extraction at Minimum Stable Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load with Carbon Capture	MW	36
b)	Maximum Heat Extraction Export Flow at Minimum Stable Plant Load with Carbon Capture	t/h	191 (DH) / 36 (I)
c)	Carbon Capture and CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	180.1
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	41.7
e)	Carbon Capture and CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	50.1
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at Minimum Stable Plant Load	%	3.0
5.6	Can the Plant with Carbon Capture supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the ‘CHP and Carbon Capture Envelope’)?		No

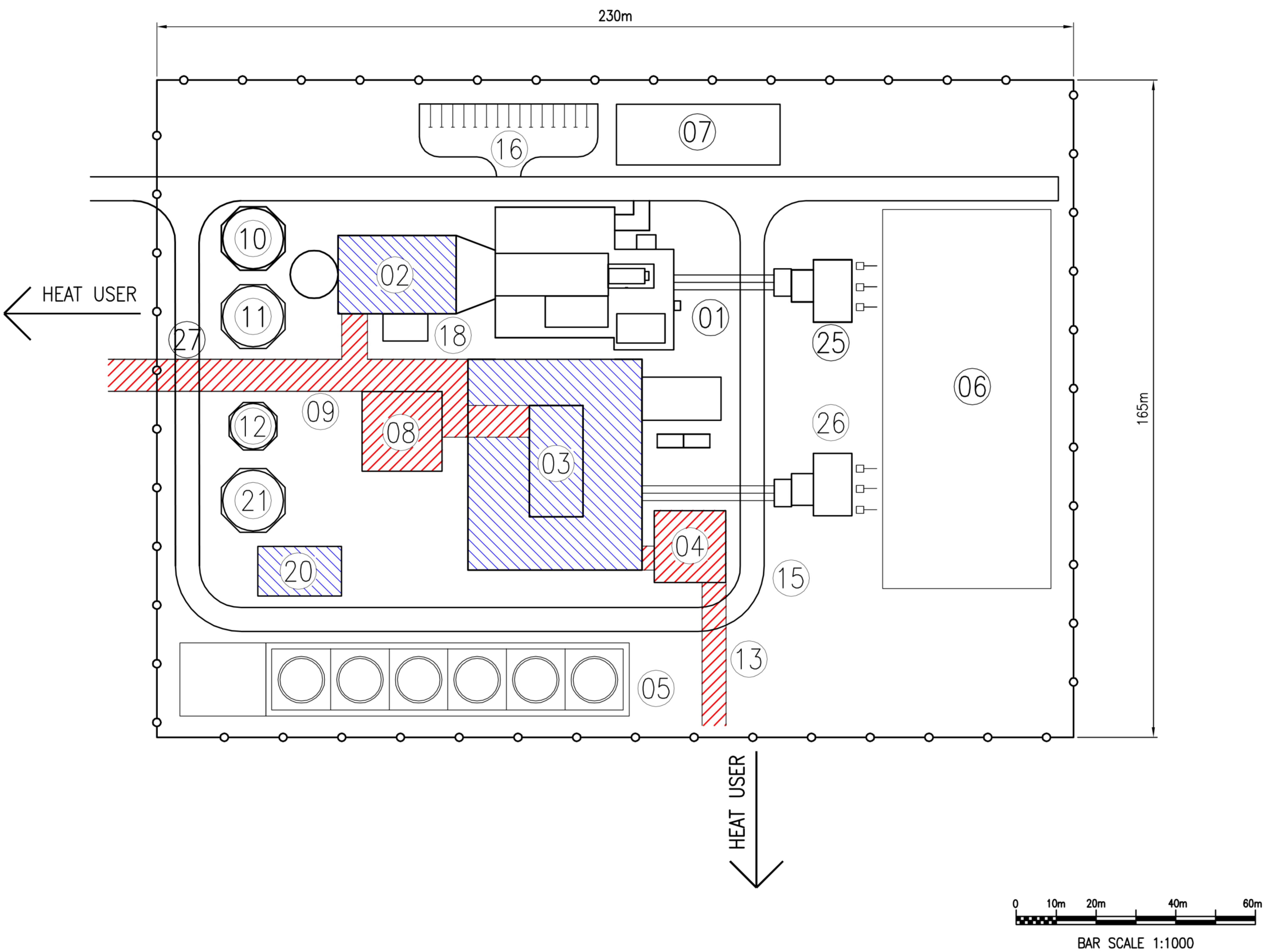
5.7	Description of Potential Options which could be incorporated in the Plant for useful integration of any realised CHP System and Carbon Capture System		The plant has sufficient capacity to simultaneously meet the CCS requirements and produce steam from one of the two identified heat loads (either Industrial or District Heating). However, in the case where the plant is required to simultaneously meet the carbon capture requirement and both identified heat loads (Industrial and District Heating), a dedicated auxiliary boiler may form part of the CHP Plant. Therefore, the plant would produce heat for the Carbon Capture Plant requirement and one of the identified heat loads, and the auxiliary boiler would produce heat for the remaining heat load.
Requirement 6: Economics of CHP-R			
6.1	Economic Assessment of CHP-R		Not required for the Case Study
BAT Assessment			
	Is the new plant a CHP plant at the outset (i.e. are there economically viable CHP opportunities at the outset)?		Not required for the Case Study
	If not, is the new plant a CHP-R plant at the outset?		Not required for the Case Study
	Once the new plant is CHPR, is it BAT?		Not required for the Case Study

CHP Envelope for Case Study 1



CHP and Carbon Capture Envelope for Case Study 1





LEGEND

CCGT PLANT

- (01) GAS TURBINE
- (02) HEAT RECOVERY STEAM GENERATOR
- (03) STEAM TURBINE
- (05) COOLING TOWERS
- (06) A.I SWITCHYARD
- (07) ADMINISTRATION, SHOP & WAREHOUSE
- (10) DEMINERALISED WATER TANK
- (11) RAW WATER TANK
- (12) NEUTRALIZED WATER TANK
- (15) ROAD
- (16) PARKING
- (18) FEED PUMPS
- (20) WATER TREATMENT PLANT
- (21) FIRE PROTECTION TANK
- (25) GAS TURBINE TRANSFORMER
- (26) STEAM TURBINE TRANSFORMER

CHP–R PROVISIONS

- (02) HRSG WITH PROVISIONS FOR IDENTIFIED SUITABLE RETURN POINTS
- (03) STEAM TURBINE WITH PROVISIONS FOR IDENTIFIED SUITABLE EXTRACTION POINTS
- (04) ON SITE SPACE FOR DISTRICT HEATING HEAT EXCHANGERS
- (08) ON SITE SPACE FOR STANDBY BOILER
- (09) ON SITE SPACE FOR INDUSTRIAL STEAM AND CONDENSATE RETURN PIPEWORK (PIPE CORRIDOR)
- (13) ON SITE SPACE FOR DISTRICT HEATING WATER PIPEWORK (PIPE CORRIDOR) INCLUDES SPACE FOR PUMPS AND EXPANSION LOOPS ETC (PIPE CORRIDOR)
- (20) POSSIBLE EXPANSION TO WATER TREATMENT PLANT
- (27) PIPEBRIDGE

Rev	Date	Description	By	Chk	App	Notes:

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Tel: 44-(0)191-226-2000
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Client: ENVIRONMENT AGENCY

Project: CHP-R GUIDANCE

Title: SITE LAYOUT PLAN FOR CASE STUDY 1 CCGT POWER PLANT WITH 30MW DISTRICT HEATING & 30MW INDUSTRIAL CHP USE

Drawn: ALM		Checked:	
Designed: EB		Approved:	
Date: 30/07/2012	Scale: 1:1000	A3	Sheet:
Project Number: 3511829A		Drawing Number: CS 01	Revision:

Case Study / Worked Example 2

#	Description	Units	Notes / Instructions
Requirement 1: Plant, Plant Location and Potential Heat Loads			
1.1	Plant Name		Case Study 2
1.2	Plant Description		Plant comprises: • Multi-shaft (2 + 1) Configuration; • IP / LP crossover pipe available as an extraction point; • Hybrid Cooling; and • UK ambient conditions.
1.3	Plant Location (Postcode / GridRef)		Not required for the Case Study
1.4	Factors Influencing Selection of Plant Location		Not required for the Case Study
1.5	Operation of Plant		
a)	Proposed Operational Plant Load	%	100
b)	Thermal Input at Proposed Operational Plant Load	MW	1543
c)	Net Electrical Output at Proposed Operational Plant Load	MW	889
d)	Net Electrical Efficiency at Proposed Operational Plant Load	%	57.6
e)	Maximum Plant Load	%	100
f)	Thermal Input at Maximum Plant Load	MW	1543
g)	Net Electrical Output at Maximum Plant Load	MW	889
h)	Net Electrical Efficiency at Maximum Plant Load	%	57.6
i)	Minimum Stable Plant Load	%	40
j)	Thermal Input at Minimum Stable Plant Load	MW	854.6
k)	Net Electrical Output at Minimum Stable Plant Load	MW	429
l)	Net Electrical Efficiency at Minimum Stable Plant Load	%	50.2
1.6	Identified Potential Heat Loads		
			200 MW Industrial

1.7	Selected Heat Load(s)		

a)	Category (e.g. Industrial / District Heating)		Industrial
b)	Maximum Heat Load Extraction Required	MW	200
1.8	Export and Return Requirements of Heat Load		
a)	Description of Heat Load Extraction		Superheated steam
b)	Description of Heat Load Profile		Constant
c)	Export Pressure	bar a	20
d)	Export Temperature	°C	300
e)	Export Flow	t/h	273
f)	Return Pressure	bar a	5
g)	Return Temperature	°C	82.2
h)	Return Flow	t/h	273
Requirement 2: Identification of CHP Envelope			
2.0	Comparative Efficiency of a Standalone Boiler for supplying the Heat Load	90 % LHV	90
2.1	Heat Extraction at 100% Plant Load		
a)	Maximum Heat Load Extraction at 100% Plant Load	MW	251
b)	Maximum Heat Extraction Export Flow at 100% Plant Load	t/h	337
c)	CHP Mode Net Electrical Output at 100% Plant Load	MW	807
d)	CHP Mode Net Electrical Efficiency at 100% Plant Load	%	52.3
e)	CHP Mode Net CHP Efficiency at 100% Plant Load	%	68.5
f)	Reduction in Primary Energy Usage for CHP Mode at 100% Plant Load	%	8.1
2.2	Heat Extraction at Minimum Stable Plant Load		

a)	Maximum Heat Load Extraction at Minimum Stable Plant Load	MW	164
b)	Heat Extraction Export Flow at Minimum Stable Plant Load	t/h	220
c)	CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	376
d)	CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	44.0
e)	CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	63.1
f)	Reduction in Primary Energy Usage for CHP Mode at Minimum Stable Plant Load	%	8.1
2.3	Can the Plant supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the 'CHP Envelope')?		Yes
Requirement 3: Operation of the Plant with the Selected Identified Heat Load			
3.1	Proposed Operation of Plant with CHP		
a)	CHP Mode Net Electrical Output at Proposed Operational Plant Load	MW	823
b)	CHP Mode Net Electrical Efficiency at Proposed Operational Plant Load	%	53.3
c)	CHP Mode Net CHP Efficiency at Proposed Operational Plant Load	%	66.3
d)	Reduction in Net Electrical Output for CHP Mode at Proposed Operational Plant Load	MW	66
e)	Reduction in Net Electrical Efficiency for CHP Mode at Proposed Operational Plant Load	%	7.5
f)	Reduction in Primary Energy Usage for CHP Mode at Proposed Operational Plant Load	%	6.5

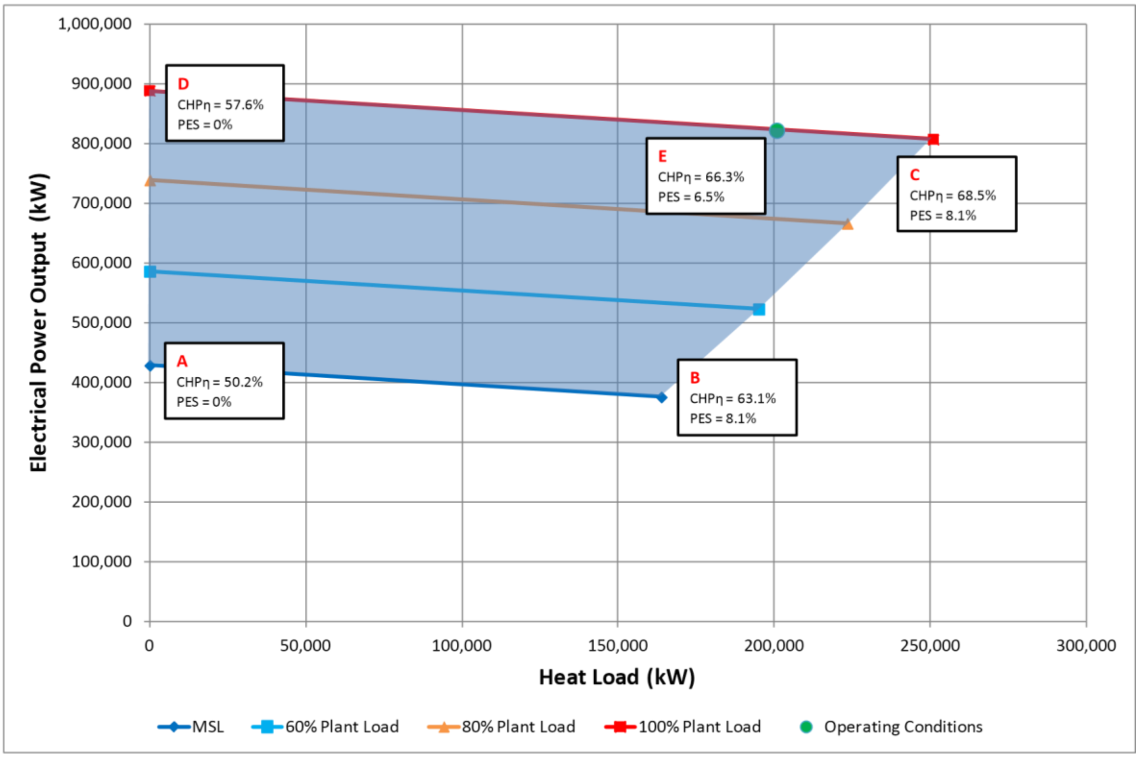
g)	Z Ratio		3.0
Requirement 4: Technical Provisions and Space Requirements			
4.1	Description of Likely Suitable Extraction Points		Steam for the Industrial Process is extracted from the cold reheat line. To facilitate this, a cold reheat header would be required.
4.2	Description of Potential Options which could be incorporated in the Plant, should a CHP Opportunity be realised outside the 'CHP Envelope'		N / A (CHP opportunity lies within the CHP Envelope)
4.3	Description of how the future Costs and Burdens associated with supplying the Identified Heat Load / Potential CHP Opportunity have been minimised through the implementation of an appropriate CHP-R design		Not required for the Case Study
4.4	Provision of Site Layout of the Plant, indicating Available Space which could be made available for CHPR		Please see Layout CS 02. The Industrial Process will (likely) include: the installation of a cold reheat header; extraction piping; control and shut-off valves, and actuators; a Pressure Reduction and De-Superheating Station; condensate return piping; interconnecting pipeline; drains pipe bridges / supports; and Control and Instrumentation / electrical connections. A Stand-by Boiler is also included. Provision is also made for possible extension of the Water Treatment Plant.
Requirement 5: Integration of CHP and Carbon Capture			
5.1	Is the Plant required to be CCR?		Yes
5.2	Export and Return Requirements Identified for Carbon Capture		
	100% Plant Load		

a)	Heat Load Extraction for Carbon Capture at 100% Plant Load	MW	258
b)	Description of Heat Export (e.g. Steam / Hot Water)		Low pressure steam
c)	Export Pressure	bar a	3.4
d)	Export Temperature	°C	150
e)	Export Flow	t/h	425.7
f)	Return Pressure	bar a	3.4
g)	Return Temperature	°C	137
h)	Return Flow	t/h	425.7
i)	Likely Suitable Extraction Points		LP superheated steam / HP water desuperheating
	Minimum Stable Plant Load		
j)	Heat Load Extraction for Carbon Capture at Minimum Stable Plant Load	MW	142.5
k)	Description of Heat Export (e.g. Steam / Hot Water)		Low pressure steam
l)	Export Pressure	bar a	2.7
m)	Export Temperature	°C	150
n)	Export Flow	t/h	232
o)	Return Pressure	bar a	2.7
p)	Return Temperature	°C	130
q)	Return Flow	t/h	232
r)	Likely Suitable Extraction Points		LP superheated steam / HP water desuperheating
5.3	Operation of Plant with Carbon Capture (without CHP)		
a)	Maximum Plant Load with Carbon Capture	%	100
b)	Carbon Capture Mode Thermal Input at Maximum Plant Load	MW	1542
c)	Carbon Capture Mode Net Electrical Output at Maximum Plant Load	MW	822
d)	Carbon Capture Mode Net Electrical Efficiency at Maximum Plant Load	%	53.3
e)	Minimum Stable Plant Load with CCS	%	40
f)	Carbon Capture Mode CCS Thermal Input at Minimum Stable Plant Load	MW	856
g)	Carbon Capture Mode Net Electrical Output at Minimum	MW	389

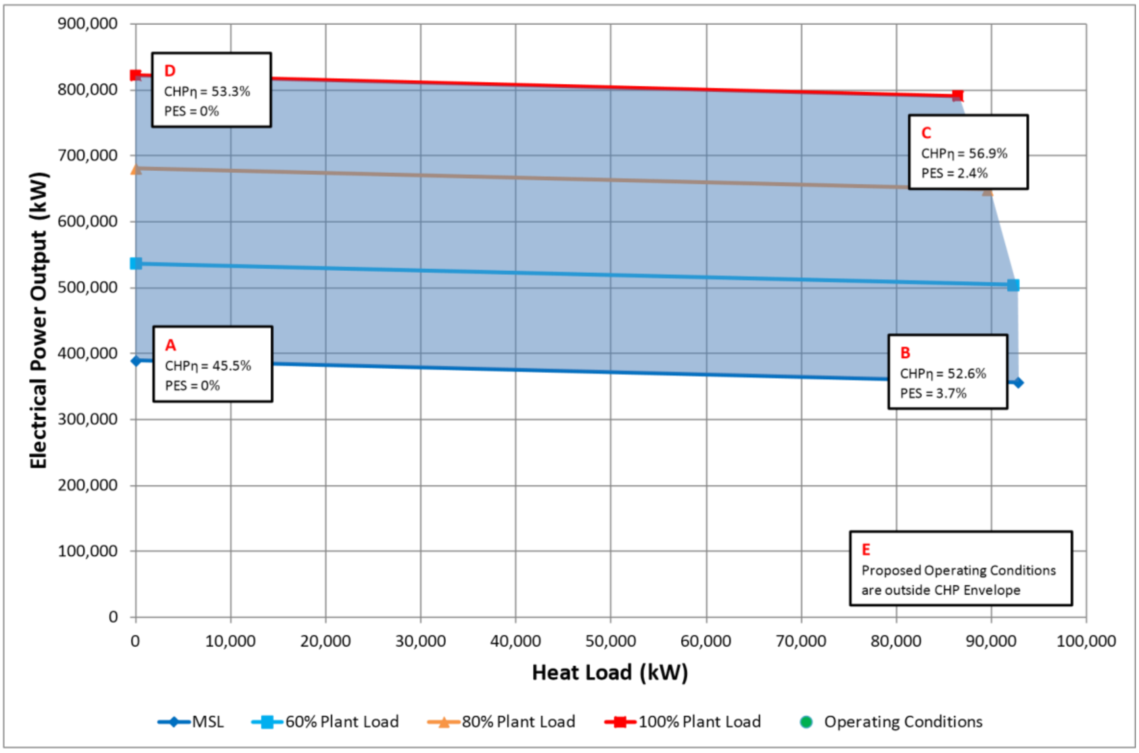
	Stable Plant Load		
h)	Carbon Capture Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	45.5
5.4	Heat Extraction for CHP at 100% Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at 100% Plant Load with Carbon Capture [H]	MW	86.5
b)	Maximum Heat Extraction Export Flow at 100% Plant Load with Carbon Capture	t/h	117
c)	Carbon Capture and CHP Mode Net Electrical Output at 100% Plant Load	MW	791
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at 100% Plant Load	%	51.3
e)	Carbon Capture and CHP Mode Net CHP Efficiency at 100% Plant Load	%	56.9
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at 100% Plant Load	%	2.4
5.5	Heat Extraction at Minimum Stable Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load with Carbon Capture	MW	93
b)	Maximum Heat Extraction Export Flow at Minimum Stable Plant Load with Carbon Capture	t/h	125
c)	Carbon Capture and CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	357
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	41.7

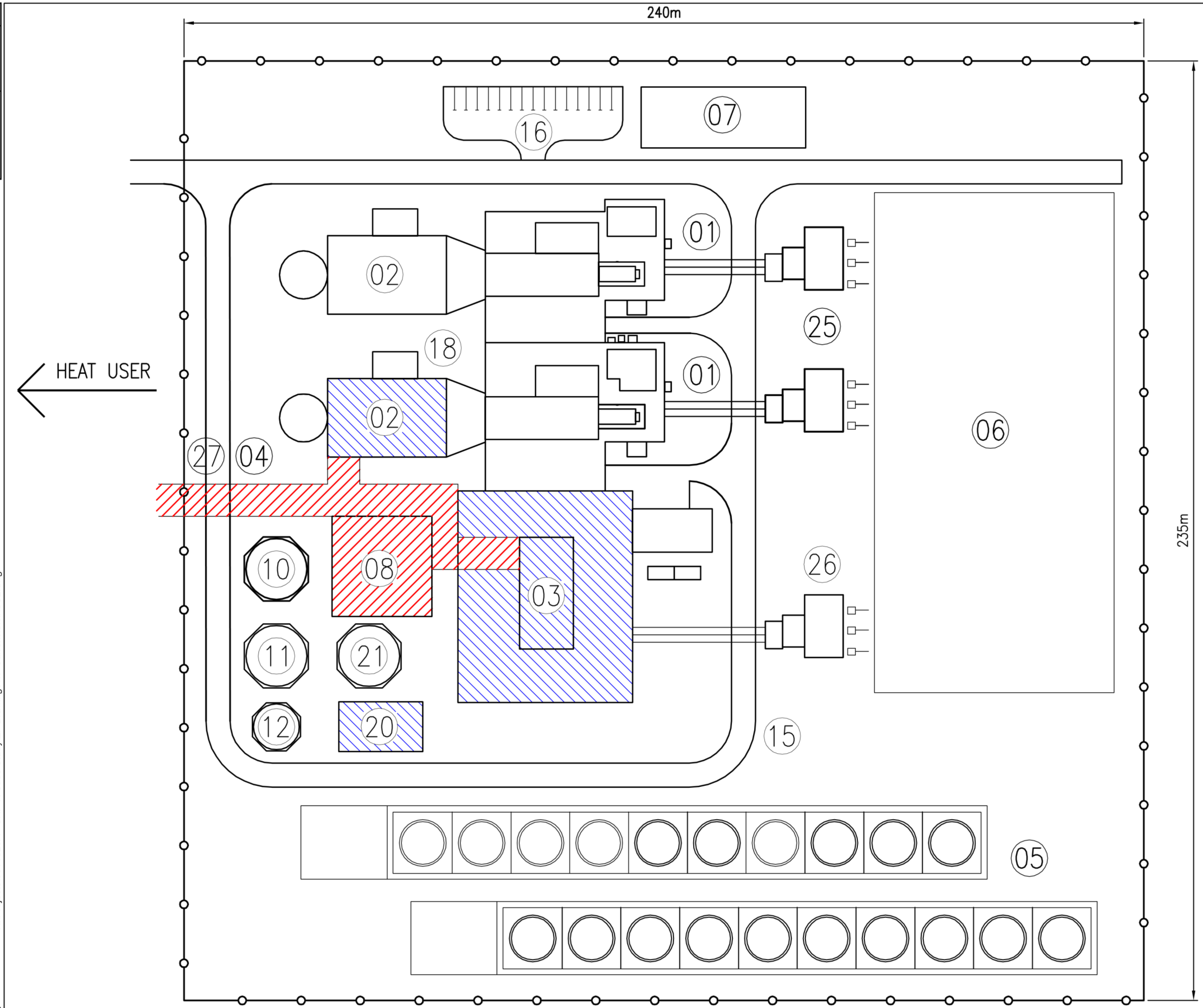
e)	Carbon Capture and CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	52.6
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at Minimum Stable Plant Load	%	3.7
5.6	Can the Plant with Carbon Capture supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the 'CHP and Carbon Capture Envelope')?		No
5.7	Description of Potential Options which could be incorporated in the Plant for useful integration of any realised CHP System and Carbon Capture System		In the case where the plant is required to simultaneously meet the carbon capture requirement and the identified heat load, a dedicated auxiliary boiler may form part of the CHP Plant.
Requirement 6: Economics of C P-R			
6.1	Economic Assessment of CHP-R		Not required for the Case Study
BAT Assessment			
	Is the new plant a CHP plant at the outset (i.e. are there economically viable CHP opportunities at the outset)?		Not required for the Case Study
	If not, is the new plant a CHP-R plant at the outset?		Not required for the Case Study
	Once the new plant is CHPR, is it BAT?		Not required for the Case Study

CHP Envelope for Case Study 2



CHP and Carbon Capture Envelope for Case Study 2





LEGEND

CCGT PLANT

- (01) GAS TURBINE
- (02) HEAT RECOVERY STEAM GENERATOR
- (03) STEAM TURBINE
- (05) COOLING TOWERS
- (06) A.I. SWITCHYARD
- (07) ADMINISTRATION, SHOP & WAREHOUSE
- (10) DEMINERALISED WATER TANK
- (11) RAW WATER TANK
- (12) NEUTRALIZED WATER TANK
- (15) ROAD
- (16) PARKING
- (18) FEED PUMPS
- (20) WATER TREATMENT PLANT
- (21) FIRE PROTECTION TANK
- (25) GAS TURBINE TRANSFORMER
- (26) STEAM TURBINE TRANSFORMER

CHP–R PROVISIONS

- (02) HRSG WITH PROVISIONS FOR IDENTIFIED SUITABLE RETURN POINTS
- (03) STEAM TURBINE WITH PROVISIONS FOR IDENTIFIED SUITABLE EXTRACTION POINTS
- (04) ON SITE SPACE FOR INDUSTRIAL STEAM PIPEWORK (PIPE CORRIDOR)
- (08) ON SITE SPACE FOR STANDBY BOILER
- (20) POSSIBLE EXPANSION TO WATER TREATMENT PLANT
- (27) PIPEBRIDGE

0 10m 20m 40m 60m

BAR SCALE 1:1000

Rev	Date	Description	By	Chk	App	Notes:

PARSONS BRINCKERHOFF

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Newcastle upon Tyne NE4 7YQ
Tel: 44-(0)191-226-2000
Fax: 44-(0)191-226-2104

Client: ENVIRONMENT AGENCY

Project: CHP-R GUIDANCE

Title: SITE LAYOUT PLAN FOR CASE STUDY 2 CCGT POWER PLANT WITH 200MW INDUSTRIAL CHP USE

Drawn: ALM		Checked:	
Designed: EB		Approved:	
Date: 25/07/2012	Scale: 1:1000	A3	Sheet:
Project Number: 3511829A		Drawing Number: CS 02	Revision:

Project Number 3511829A | Drawing Number CS 02 | Revision

Login: Minikin, Sandra
Plot Date: 09/08/2012 11:41:26
File Name: K:\Projects\3511829A - CHP-R Case Study\Z. Drawings\1. Current\Civil\CS2.dwg

Case Study / Worked Example 3

#	Description	Units	Notes / Instructions
Requirement 1: Plant, Plant Location and Potential Heat Loads			
1.1	Plant Name		Case Study 3
1.2	Plant Description		Biomass Plant
1.3	Plant Location (Postcode / GridRef)		Not required for the Case Study
1.4	Factors Influencing Selection of Plant Location		Not required for the Case Study
1.5	Operation of Plant		
a)	Proposed Operational Plant Load	%	100
b)	Thermal Input at Proposed Operational Plant Load	MW	210
c)	Net Electrical Output at Proposed Operational Plant Load	MW	75
d)	Net Electrical Efficiency at Proposed Operational Plant Load	%	35.8
e)	Maximum Plant Load	%	100
f)	Thermal Input at Maximum Plant Load	MW	210
g)	Net Electrical Output at Maximum Plant Load	MW	75
h)	Net Electrical Efficiency at Maximum Plant Load	%	35.8
i)	Minimum Stable Plant Load	%	60
j)	Thermal Input at Minimum Stable Plant Load	MW	126
k)	Net Electrical Output at Minimum Stable Plant Load	MW	42
l)	Net Electrical Efficiency at Minimum Stable Plant Load	%	33.4
1.6	Identified Potential Heat Loads		
			45 MW District Heating
1.7	Selected Heat Load(s)		
a)	Category (e.g. Industrial / District Heating)		District Heating
b)	Maximum Heat Load Extraction Required	MW	45
1.8	Export and Return Requirements of Heat Load		

a)	Description of Heat Load Extraction		Hot water
b)	Description of Heat Load Profile		Variable
c)	Export Pressure	bar a	5
d)	Export Temperature	°C	95
e)	Export Flow	t/h	970
f)	Return Pressure	bar a	3
g)	Return Temperature	°C	55
h)	Return Flow	t/h	970
Requirement 2: Identification of CHP Envelope			
2.0	Comparative Efficiency of a Standalone Boiler for supplying the Heat Load	90 % LHV	90
2.1	Heat Extraction at 100% Plant Load		
a)	Maximum Heat Load Extraction at 100% Plant Load	MW	40
b)	Maximum Heat Extraction Export Flow at 100% Plant Load	t/h	859
c)	CHP Mode Net Electrical Output at 100% Plant Load	MW	69.7
d)	CHP Mode Net Electrical Efficiency at 100% Plant Load	%	33.2
e)	CHP Mode Net CHP Efficiency at 100% Plant Load	%	52.3
f)	Reduction in Primary Energy Usage for CHP Mode at 100% Plant Load	%	12.3
2.2	Heat Extraction at Minimum Stable Plant Load		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load	MW	18
b)	Heat Extraction Export Flow at Minimum Stable Plant Load	t/h	387
c)	CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	39.3

d)	CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	31.3
e)	CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	45.6
f)	Reduction in Primary Energy Usage for CHP Mode at Minimum Stable Plant Load	%	8.7

2.3	Can the Plant supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the 'CHP Envelope')?		No (Go to Requirement 4)
Requirement 3: Operation of the Plant with the Selected Identified Heat Load			
3.1	Proposed Operation of Plant with CHP		
a)	CHP Mode Net Electrical Output at Proposed Operational Plant Load	MW	N / A
b)	CHP Mode Net Electrical Efficiency at Proposed Operational Plant Load	%	N / A
c)	CHP Mode Net CHP Efficiency at Proposed Operational Plant Load	%	N / A
d)	Reduction in Net Electrical Output for CHP Mode at Proposed Operational Plant Load	MW	N / A
e)	Reduction in Net Electrical Efficiency for CHP Mode at Proposed Operational Plant Load	%	N / A
f)	Reduction in Primary Energy Usage for CHP Mode at Proposed Operational Plant Load	%	N / A
g)	Z Ratio		N / A
Requirement 4: Technical Provisions and Space Requirements			
4.1	Description of Likely Suitable Extraction Points		An amount of steam for the District Heating System could be supplied from the bleed steam lines for the LP feedwater heaters, downstream of the non return valves.

4.2	Description of Potential Options which could be incorporated in the Plant, should a CHP Opportunity be realised outside the 'CHP Envelope'		Additional amounts of steam could be generated from a stand-by boiler.

4.3	Description of how the future Costs and Burdens associated with supplying the Identified Heat Load / Potential CHP Opportunity have been minimised through the implementation of an appropriate CHP-R design		Not required for the Case Study
4.4	Provision of Site Layout of the Plant, indicating Available Space which could be made available for CHPR		Please see Layout CS 03. The District Heating System will (likely) include: extraction piping; control and shut-off valves, and actuators; a Pressure Reduction and Desuperheating Station; District Heaters; District Heating supply and return lines; condensate return piping (to the condensate header); interconnecting piping; drains; pipe bridges / supports; and Control and Instrumentation / electrical connections. A Stand-by Boiler is also included. Provision is also made for possible extension of the Water Treatment Plant.
Requirement 5: Integration of CHP and Carbon Capture			
5.1	Is the Plant required to be CCR?		No
5.2	Export and Return Requirements Identified for Carbon Capture		
	100% Plant Load		
a)	Heat Load Extraction for Carbon Capture at 100% Plant Load	MW	N / A
b)	Description of Heat Export (e.g. Steam / Hot Water)		N / A
c)	Export Pressure	bar a	N / A
d)	Export Temperature	°C	N / A
e)	Export Flow	t/h	N / A
f)	Return Pressure	bar a	N / A

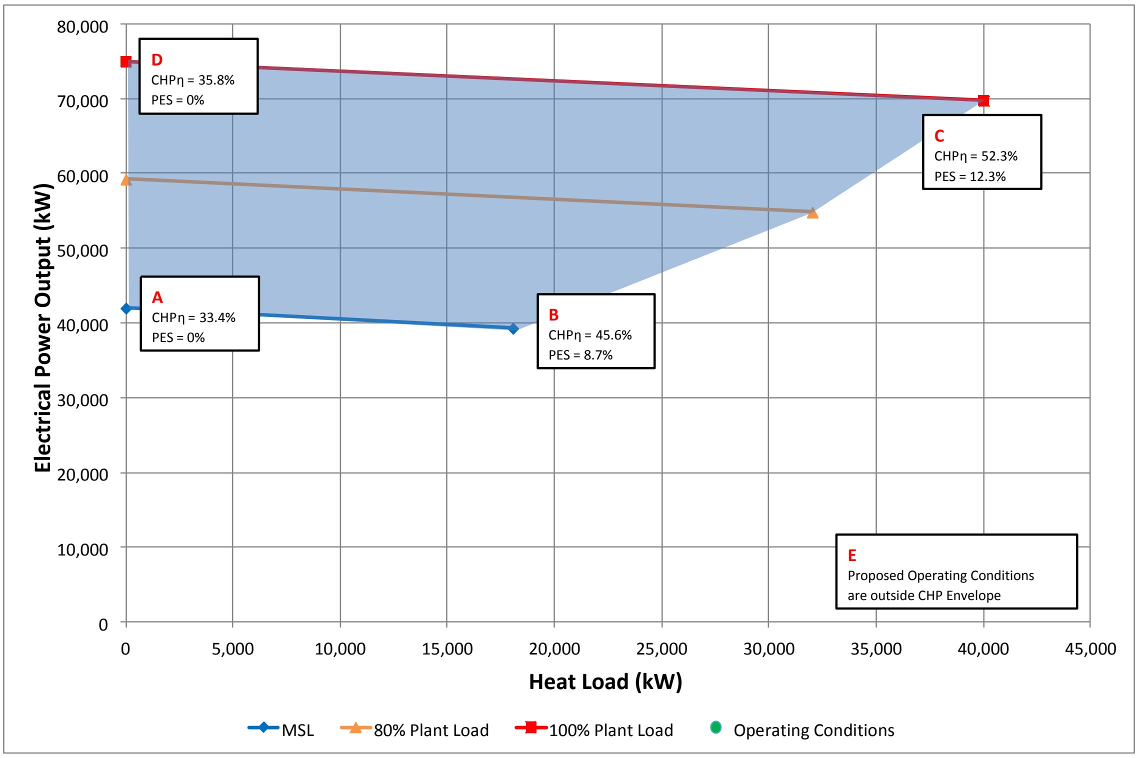
g)	Return Temperature	°C	N / A
h)	Return Flow	t/h	N / A
i)	Likely Suitable Extraction Points		N / A
	Minimum Stable Plant Load		
j)	Heat Load Extraction for Carbon Capture at Minimum Stable Plant Load	MW	N / A
k)	Description of Heat Export (e.g. Steam / Hot Water)		N / A
l)	Export Pressure	bar a	N / A
m)	Export Temperature	°C	N / A
n)	Export Flow	t/h	N / A
o)	Return Pressure	bar a	N / A
p)	Return Temperature	°C	N / A
q)	Return Flow	t/h	N / A
r)	Likely Suitable Extraction Points		N / A
5.3	Operation of Plant with Carbon Capture (without CHP)		
a)	Maximum Plant Load with Carbon Capture	%	N / A
b)	Carbon Capture Mode Thermal Input at Maximum Plant Load	MW	N / A
c)	Carbon Capture Mode Net Electrical Output at Maximum Plant Load	MW	N / A
d)	Carbon Capture Mode Net Electrical Efficiency at Maximum Plant Load	%	N / A
e)	Minimum Stable Plant Load with CCS	%	N / A
f)	Carbon Capture Mode CCS Thermal Input at Minimum Stable Plant Load	MW	N / A
g)	Carbon Capture Mode Net Electrical Output at Minimum Stable Plant Load	MW	N / A
h)	Carbon Capture Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	N / A
5.4	Heat Extraction for CHP at 100% Plant Load with Carbon Capture		

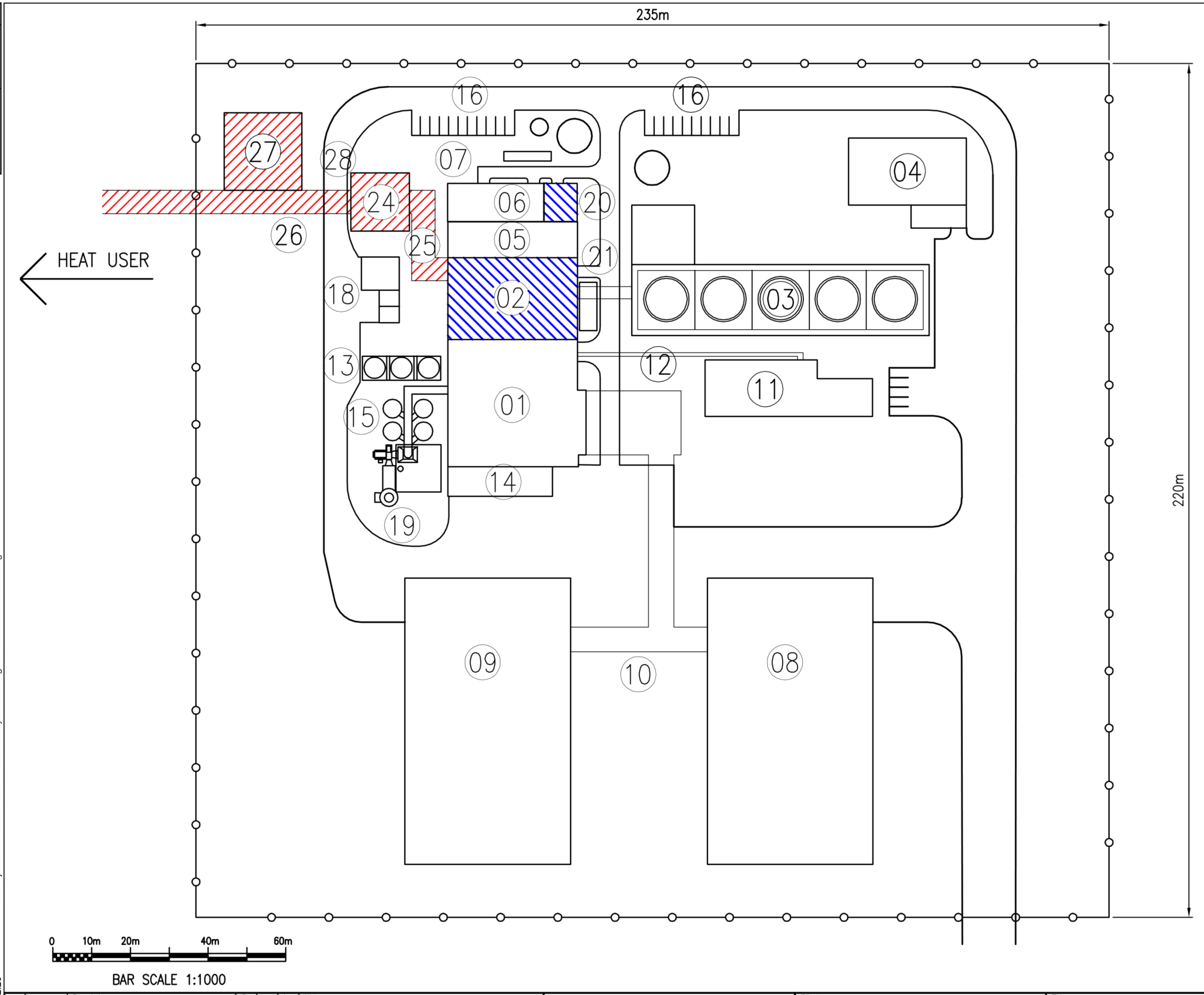
a)	Maximum Heat Load Extraction at 100% Plant Load with Carbon Capture [H]	MW	N / A
b)	Maximum Heat Extraction Export Flow at 100% Plant Load with Carbon Capture	t/h	N / A
c)	Carbon Capture and CHP Mode Net Electrical Output at 100% Plant Load	MW	N / A
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at 100% Plant Load	%	N / A

e)	Carbon Capture and CHP Mode Net CHP Efficiency at 100% Plant Load	%	N / A
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at 100% Plant Load	%	N / A
5.5	Heat Extraction at Minimum Stable Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load with Carbon Capture	MW	N / A
b)	Maximum Heat Extraction Export Flow at Minimum Stable Plant Load with Carbon Capture	t/h	N / A
c)	Carbon Capture and CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	N / A
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	N / A
e)	Carbon Capture and CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	N / A
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at Minimum Stable Plant Load	%	N / A

5.6	Can the Plant with Carbon Capture supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the 'CHP and Carbon Capture Envelope')?		N / A
5.7	Description of Potential Options which could be incorporated in the Plant for useful integration of any realised CHP System and Carbon Capture System		N / A
Requirement 6: Economics of CHP-R			
6.1	Economic Assessment of CHP-R		Not required for the Case Study
BAT Assessment			
	Is the new plant a CHP plant at the outset (i.e. are there economically viable CHP opportunities at the outset)?		Not required for the Case Study
	If not, is the new plant a CHP-R plant at the outset?		Not required for the Case Study
	Once the new plant is CHPR, is it BAT?		Not required for the Case Study

CHP Envelope for Case Study 3





LEGEND

BIOMASS PLANT

- 01 BOILER BUILDING
- 02 STEAM TURBINE
- 03 COOLING TOWERS
- 04 A.I SWITCHYARD
- 05 CONTROL BUILDING
- 06 ADMINISTRATION, SHOP & WAREHOUSE
- 07 FIRE PUMP EQUIPMENT AREA
- 08 STRAW BARN 1
- 09 STRAW BARN 2
- 10 STRAW CONVEYORS
- 11 WOOD STORAGE BUILDING
- 12 WOOD CHIP CONVEYOR
- 13 FLY ASH AND REAGENT STORAGE
- 14 SLAG STORAGE
- 15 FLUE GAS TREATMENT AREA
- 16 PARKING
- 18 TRANSFORMER
- 19 STACK
- 20 WATER TREATMENT PLANT
- 21 SEDIMENTATIONS BASIN

CHP-R PROVISIONS

- 02 STEAM TURBINE WITH PROVISIONS FOR IDENTIFIED SUITABLE EXTRACTION POINTS
- 24 ON SITE SPACE FOR DISTRICT HEATING HEAT EXCHANGERS
- 25 ON SITE SPACE FOR DISTRICT HEATING STEAM AND CONDENSATE RETURN PIPEWORK (PIPE CORRIDOR)
- 26 ON SITE SPACE FOR DISTRICT HEAT WATER PIPEWORK (PIPE CORRIDOR) INCLUDES SPACE FOR PUMPS
- 27 ON SITE SPACE FOR STANDBY BOILER
- 28 PIPEBRIDGE
- 20 POSSIBLE EXPANSION TO WATER TREATMENT PLANT

Project Number	Drawing Number	Revision
3511829A	CS 03	

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Login: Minikin, Sandra
Plot Date: 09/08/2012 11:42:20

Rev	Date	Description	By	Chk	App	Notes:

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Client: ENVIRONMENT AGENCY

Project: CHP-R GUIDANCE

Title: SITE LAYOUT PLAN FOR CASE STUDY 3 BIOMASS POWER PLANT WITH 45MW OF DISTRICT HEATING

Drawn: ALM		Checked:	
Designed: EB		Approved:	
Date: 01/08/2012	Scale: 1:1000	A3	Sheet:
Project Number: 3511829A	Drawing Number: CS 03	Revision:	

Case Study / Worked Example 4

#	Description	Units	Notes / Instructions
Requirement 1: Plant, Plant Location and Potential Heat Loads			
1.1	Plant Name		Case Study 4
1.2	Plant Description		Energy from Waste Plant
1.3	Plant Location (Postcode / GridRef)		Not required for the Case Study
1.4	Factors Influencing Selection of Plant Location		Not required for the Case Study
1.5	Operation of Plant		
a)	Proposed Operational Plant Load	%	100
b)	Thermal Input at Proposed Operational Plant Load	MW	84
c)	Net Electrical Output at Proposed Operational Plant Load	MW	25
d)	Net Electrical Efficiency at Proposed Operational Plant Load	%	29.7
e)	Maximum Plant Load	%	100
f)	Thermal Input at Maximum Plant Load	MW	84
g)	Net Electrical Output at Maximum Plant Load	MW	25
h)	Net Electrical Efficiency at Maximum Plant Load	%	29.7
i)	Minimum Stable Plant Load	%	60
j)	Thermal Input at Minimum Stable Plant Load	MW	50.5
k)	Net Electrical Output at Minimum Stable Plant Load	MW	13.6
l)	Net Electrical Efficiency at Minimum Stable Plant Load	%	26.9
1.6	Identified Potential Heat Loads		
			5 MW District Heating
1.7	Selected Heat Load(s)		
a)	Category (e.g. Industrial / District Heating)		District Heating
b)	Maximum Heat Load Extraction Required	MW	5
1.8	Export and Return Requirements of Heat Load		

a)	Description of Heat Load Extraction		Hot water
b)	Description of Heat Load Profile		Constant
c)	Export Pressure	bar a	5
d)	Export Temperature	°C	95
e)	Export Flow	t/h	110
f)	Return Pressure	bar a	3
g)	Return Temperature	°C	55
h)	Return Flow	t/h	110
Requirement 2: Identification of CHP Envelope			
2.0	Comparative Efficiency of a Standalone Boiler for supplying the Heat Load	90 % LHV	90
2.1	Heat Extraction at 100% Plant Load		
a)	Maximum Heat Load Extraction at 100% Plant Load	MW	20
b)	Maximum Heat Extraction Export Flow at 100% Plant Load	t/h	430
c)	CHP Mode Net Electrical Output at 100% Plant Load	MW	22
d)	CHP Mode Net Electrical Efficiency at 100% Plant Load	%	26.1
e)	CHP Mode Net CHP Efficiency at 100% Plant Load	%	49.9
f)	Reduction in Primary Energy Usage for CHP Mode at 100% Plant Load	%	12.6
2.2	Heat Extraction at Minimum Stable Plant Load		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load	MW	10
b)	Heat Extraction Export Flow at Minimum Stable Plant Load	t/h	220
c)	CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	11.9

d)	CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	23.5
e)	CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	43.8
f)	Reduction in Primary Energy Usage for CHP Mode at Minimum Stable Plant Load	%	9.7

2.3	Can the Plant supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the 'CHP Envelope')?		Yes
Requirement 3: Operation of the Plant with the Selected Identified Heat Load			
3.1	Proposed Operation of Plant with CHP		
a)	CHP Mode Net Electrical Output at Proposed Operational Plant Load	MW	24
b)	CHP Mode Net Electrical Efficiency at Proposed Operational Plant Load	%	28.8
c)	CHP Mode Net CHP Efficiency at Proposed Operational Plant Load	%	34.8
d)	Reduction in Net Electrical Output for CHP Mode at Proposed Operational Plant Load	MW	1
e)	Reduction in Net Electrical Efficiency for CHP Mode at Proposed Operational Plant Load	%	3.0
f)	Reduction in Primary Energy Usage for CHP Mode at Proposed Operational Plant Load	%	3.5
g)	Z Ratio		5.0
Requirement 4: Technical Provisions and Space Requirements			
4.1	Description of Likely Suitable Extraction Points		Steam for the District Heating System could be supplied from the bleed steam lines for the LP feedwater heaters, downstream of the non return valves.

4.2	Description of Potential Options which could be incorporated in the Plant, should a CHP Opportunity be realised outside the 'CHP Envelope'		N / A (CHP opportunity lies within the CHP Envelope)
4.3	Description of how the future Costs and Burdens associated with supplying the Identified Heat Load / Potential CHP Opportunity have been minimised through the implementation of an appropriate CHP-R design		Not required for the Case Study

4.4	Provision of Site Layout of the Plant, indicating Available Space which could be made available for CHPR		Please see Layout CS 04. The District Heating System will (likely) include: extraction piping; control and shut-off valves, and actuators; a Pressure Reduction and Desuperheating Station; District Heaters; District Heating supply and return lines; condensate return piping (to the condensate header); interconnecting piping; drains; pipe bridges / supports; and Control and Instrumentation / electrical connections. A Stand-by Boiler is also included. Provision is also made for possible extension of the Water Treatment Plant.
Requirement 5: Integration of CHP and Carbon Capture			
5.1	Is the Plant required to be CCR?		No
5.2	Export and Return Requirements Identified for Carbon Capture		
	100% Plant Load		
a)	Heat Load Extraction for Carbon Capture at 100% Plant Load	MW	N / A
b)	Description of Heat Export (e.g. Steam / Hot Water)		N / A
c)	Export Pressure	bar a	N / A
d)	Export Temperature	°C	N / A
e)	Export Flow	t/h	N / A
f)	Return Pressure	bar a	N / A

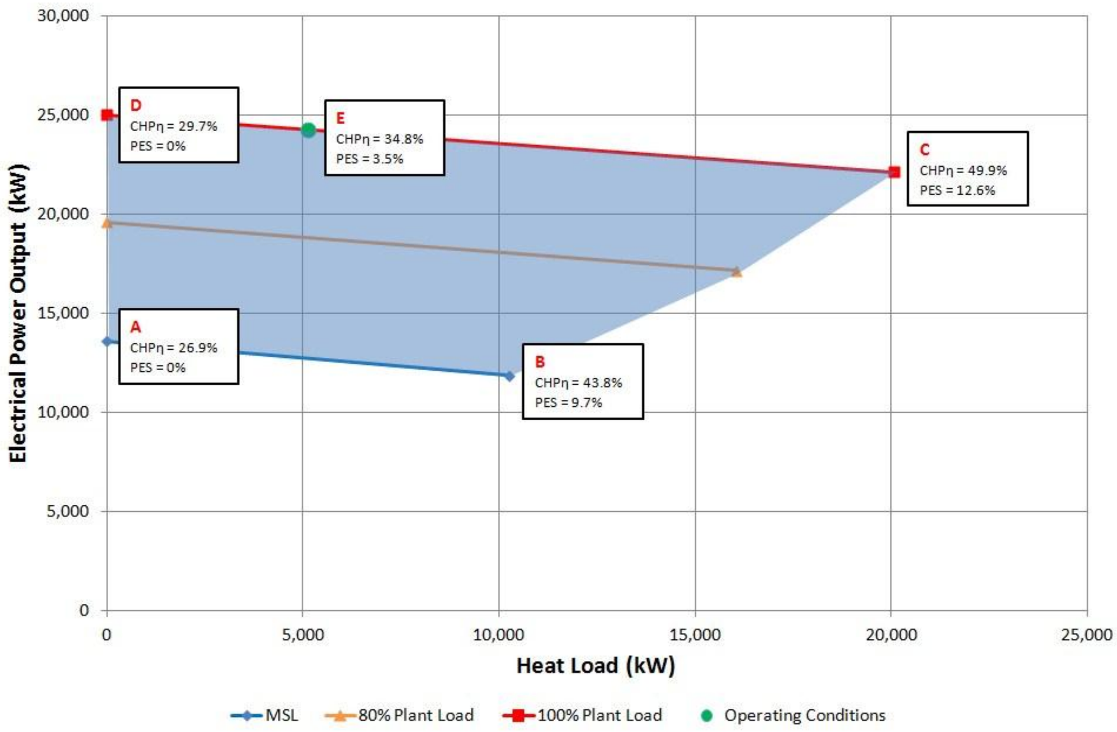
g)	Return Temperature	°C	N / A
h)	Return Flow	t/h	N / A
i)	Likely Suitable Extraction Points		N / A
	Minimum Stable Plant Load		
j)	Heat Load Extraction for Carbon Capture at Minimum Stable Plant Load	MW	N / A
k)	Description of Heat Export (e.g. Steam / Hot Water)		N / A
l)	Export Pressure	bar a	N / A
m)	Export Temperature	°C	N / A
n)	Export Flow	t/h	N / A
o)	Return Pressure	bar a	N / A
p)	Return Temperature	°C	N / A
q)	Return Flow	t/h	N / A
r)	Likely Suitable Extraction Points		N / A
5.3	Operation of Plant with Carbon Capture (without CHP)		
a)	Maximum Plant Load with Carbon Capture	%	N / A
b)	Carbon Capture Mode Thermal Input at Maximum Plant Load	MW	N / A
c)	Carbon Capture Mode Net Electrical Output at Maximum Plant Load	MW	N / A
d)	Carbon Capture Mode Net Electrical Efficiency at Maximum Plant Load	%	N / A
e)	Minimum Stable Plant Load with CCS	%	N / A
f)	Carbon Capture Mode CCS Thermal Input at Minimum Stable Plant Load	MW	N / A
g)	Carbon Capture Mode Net Electrical Output at Minimum Stable Plant Load	MW	N / A
h)	Carbon Capture Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	N / A
5.4	Heat Extraction for CHP at 100% Plant Load with Carbon Capture		

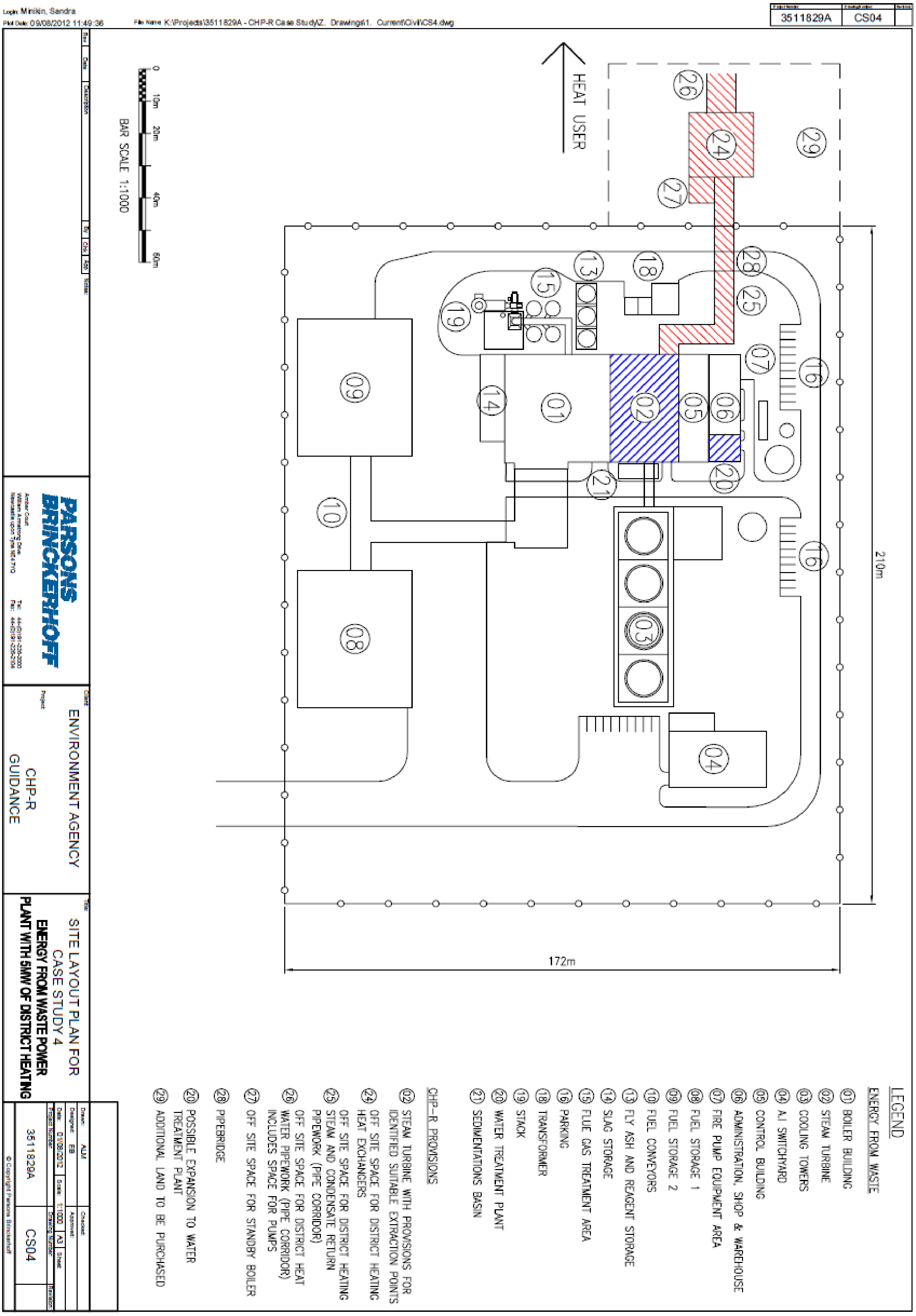
a)	Maximum Heat Load Extraction at 100% Plant Load with Carbon Capture [H]	MW	N / A
b)	Maximum Heat Extraction Export Flow at 100% Plant Load with Carbon Capture	t/h	N / A
c)	Carbon Capture and CHP Mode Net Electrical Output at 100% Plant Load	MW	N / A
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at 100% Plant Load	%	N / A
e)	Carbon Capture and CHP Mode Net CHP Efficiency at 100% Plant Load	%	N / A
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at 100% Plant Load	%	N / A

5.5	Heat Extraction at Minimum Stable Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load with Carbon Capture	MW	N / A
b)	Maximum Heat Extraction Export Flow at Minimum Stable Plant Load with Carbon Capture	t/h	N / A
c)	Carbon Capture and CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	N / A
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	N / A
e)	Carbon Capture and CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	N / A
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at Minimum Stable Plant Load	%	N / A

5.6	Can the Plant with Carbon Capture supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the ‘CHP and Carbon Capture Envelope’)?		N / A
5.7	Description of Potential Options which could be incorporated in the Plant for useful integration of any realised CHP System and Carbon Capture System		N / A
Requirement 6: Economics of CHP-R			
6.1	Economic Assessment of CHP-R		Not required for the Case Study
BAT Assessment			
	Is the new plant a CHP plant at the outset (i.e. are there economically viable CHP opportunities at the outset)?		Not required for the Case Study
	If not, is the new plant a CHP-R plant at the outset?		Not required for the Case Study
	Once the new plant is CHPR, is it BAT?		Not required for the Case Study

CHP Envelope for Case Study 4




LEGEND
ENERGY FROM WASTE
01 BOILER BUILDING
02 STEAM TURBINE
03 COOLING TOWERS
04 A.I SWITCHYARD
05 CONTROL BUILDING
06 ADMINISTRATION, SHOP & WAREHOUSE
07 FIRE PUMP EQUIPMENT AREA
08 FUEL STORAGE 1
09 FUEL STORAGE 2
10 FUEL CONVEYORS
13 FLY ASH AND REAGENT STORAGE
14 SLAG STORAGE
15 FLUE GAS TREATMENT AREA
16 PARKING
18 TRANSFORMER
19 STACK
20 WATER TREATMENT PLANT
21 SEDIMENTATIONS BASIN
CHP-R PROVISIONS
02 STEAM TURBINE WITH PROVISIONS FOR IDENTIFIED SUITABLE EXTRACTION POINTS
24 OFF SITE SPACE FOR DISTRICT HEATING HEAT EXCHANGERS
25 OFF SITE SPACE FOR DISTRICT HEATING STEAM AND CONDENSATE RETURN PIPEWORK (PIPE CORRIDOR)
26 OFF SITE SPACE FOR DISTRICT HEAT WATER PIPEWORK (PIPE CORRIDOR) INCLUDES SPACE FOR PUMPS
27 OFF SITE SPACE FOR STANDBY BOILER
28 PIPEBRIDGE
20 POSSIBLE EXPANSION TO WATER TREATMENT PLANT
29 ADDITIONAL LAND TO BE PURCHASED
210m
172m
HEAT USER
0 10m 20m 40m 60m
BAR SCALE 1:1000
PARSONS BRINCKERHOFF
Client: ENVIRONMENT AGENCY
Project: CHP-R GUIDANCE
Title: SITE LAYOUT PLAN FOR CASE STUDY 4
ENERGY FROM WASTE POWER PLANT WITH 5MW OF DISTRICT HEATING
Drawn: ALM
Designed: EB
Date: 01/08/2012
Scale: 1:1000 A3
Project Number: 3511829A
Drawing Number: CS04
© Copyright Parsons Brinckerhoff
Login: Minikin, Sandra
Plot Date: 09/08/2012 11:49:36

Case Study / Worked Example 5a

#	Description	Units	Notes / Instructions
Requirement 1: Plant, Plant Location and Potential Heat Loads			
1.1	Plant Name		Case Study 5a
1.2	Plant Description		Plant comprises: • Single-shaft (1 + 1) Configuration; • No IP / LP crossover pipe present; • Hybrid Cooling; and • UK ambient conditions.
1.3	Plant Location (Postcode / GridRef)		Not required for the Case Study
1.4	Factors Influencing Selection of Plant Location		Not required for the Case Study
1.5	Operation of Plant		
a)	Proposed Operational Plant Load	%	100
b)	Thermal Input at Proposed Operational Plant Load	MW	771
c)	Net Electrical Output at Proposed Operational Plant Load	MW	446.5
d)	Net Electrical Efficiency at Proposed Operational Plant Load	%	57.9
e)	Maximum Plant Load	%	100
f)	Thermal Input at Maximum Plant Load	MW	771
g)	Net Electrical Output at Maximum Plant Load	MW	446.5
h)	Net Electrical Efficiency at Maximum Plant Load	%	57.9
i)	Minimum Stable Plant Load	%	40
j)	Thermal Input at Minimum Stable Plant Load	MW	427
k)	Net Electrical Output at Minimum Stable Plant Load	MW	215
l)	Net Electrical Efficiency at Minimum Stable Plant Load	%	50.4
1.6	Identified Potential Heat Loads		
			50 MW District Heating

1.7	Selected Heat Load(s)		
a)	Category (e.g. Industrial / District Heating)		District Heating
b)	Maximum Heat Load Extraction Required	MW	50
1.8	Export and Return Requirements of Heat Load		
a)	Description of Heat Load Extraction		Hot water
b)	Description of Heat Load Profile		Constant
c)	Export Pressure	bar a	5
d)	Export Temperature	°C	95
e)	Export Flow	t/h	1075
f)	Return Pressure	bar a	3
g)	Return Temperature	°C	55
h)	Return Flow	t/h	1075
Requirement 2: Identification of CHP Envelope			
2.0	Comparative Efficiency of a Standalone Boiler for supplying the Heat Load	90 % LHV	90
2.1	Heat Extraction at 100% Plant Load		
a)	Maximum Heat Load Extraction at 100% Plant Load	MW	151
b)	Maximum Heat Extraction Export Flow at 100% Plant Load	t/h	3249
c)	CHP Mode Net Electrical Output at 100% Plant Load	MW	386
d)	CHP Mode Net Electrical Efficiency at 100% Plant Load	%	50.1
e)	CHP Mode Net CHP Efficiency at 100% Plant Load	%	69.7
f)	Reduction in Primary Energy Usage for CHP Mode at 100% Plant Load	%	7.7
2.2	Heat Extraction at Minimum Stable Plant Load		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load	MW	77

b)	Heat Extraction Export Flow at Minimum Stable Plant Load	t/h	1651
c)	CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	184
d)	CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	43.2
e)	CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	61.2
f)	Reduction in Primary Energy Usage for CHP Mode at Minimum Stable Plant Load	%	5.4
2.3	Can the Plant supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the 'CHP Envelope')?		Yes
Requirement 3: Operation of the Plant with the Selected Identified Heat Load			
3.1	Proposed Operation of Plant with CHP		
a)	CHP Mode Net Electrical Output at Proposed Operational Plant Load	MW	424
b)	CHP Mode Net Electrical Efficiency at Proposed Operational Plant Load	%	55.0
c)	CHP Mode Net CHP Efficiency at Proposed Operational Plant Load	%	61.5
d)	Reduction in Net Electrical Output for CHP Mode at Proposed Operational Plant Load	MW	22.7
e)	Reduction in Net Electrical Efficiency for CHP Mode at Proposed Operational Plant Load	%	5.1
f)	Reduction in Primary Energy Usage for CHP Mode at Proposed Operational Plant Load	%	2.1
g)	Z Ratio		2.2

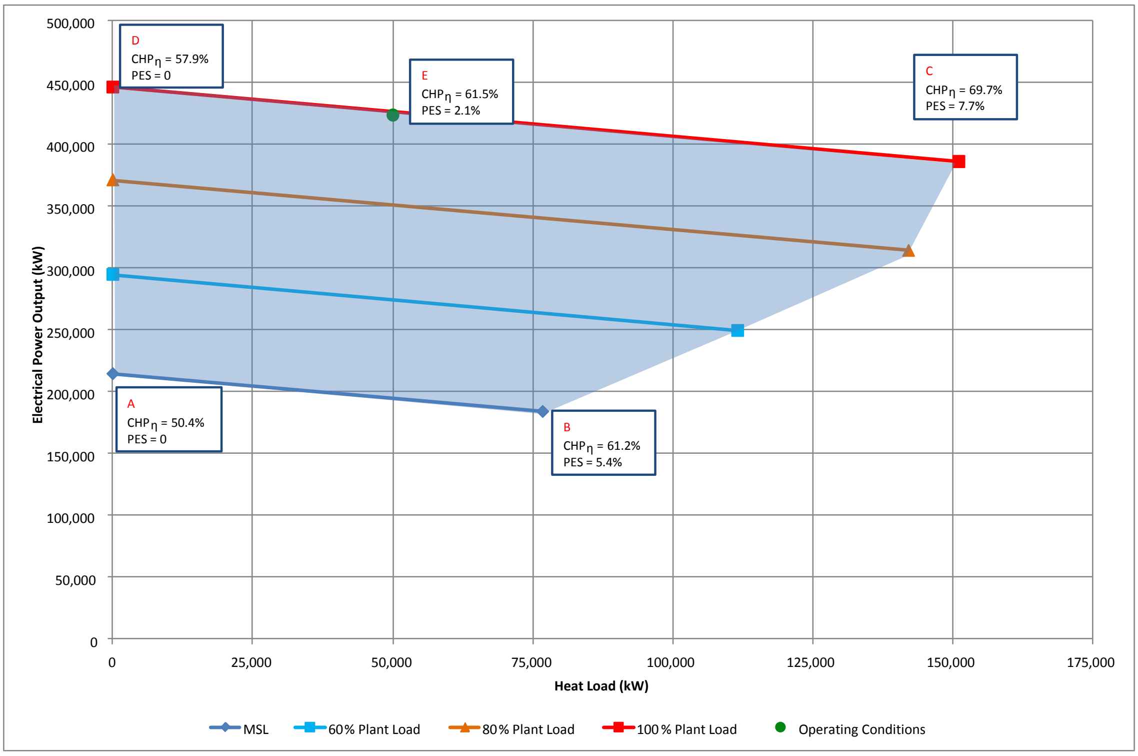
Requirement 4: Technical Provisions and Space Requirements			
4.1	Description of Likely Suitable Extraction Points		Steam cannot be readily extracted from the IP turbine exit. Therefore, steam is extracted from the cold reheat pipe, passed through a letdown station and supplied to the District Heating System.
4.2	Description of Potential Options which could be incorporated in the Plant, should a CHP Opportunity be realised outside the 'CHP Envelope'		N / A (CHP opportunity lies within the CHP Envelope)
4.3	Description of how the future Costs and Burdens associated with supplying the Identified Heat Load / Potential CHP Opportunity have been minimised through the implementation of an appropriate CHP-R design		Not required for the Case Study
4.4	Provision of Site Layout of the Plant, indicating Available Space which could be made available for CHPR		No Site Layout is provided for Case Study 5a. However, a number of points are noted. The District Heating System would (likely) include: extraction piping; control and shut-off valves, and actuators; a Pressure Reduction and Desuperheating Station; District Heaters; District Heating supply and return lines; condensate return piping (to the condensate header); interconnecting piping; drains; pipe bridges / supports; and Control and Instrumentation / electrical connections. A Stand-by Boiler would also be included. Provision would also be made for possible extension of the Water Treatment Plant.
Requirement 5: Integration of CHP and Carbon Capture			
5.1	Is the Plant required to be CCR?		Yes

5.2	Export and Return Requirements Identified for Carbon Capture		
	100% Plant Load		
a)	Heat Load Extraction for Carbon Capture at 100% Plant Load	MW	117
b)	Description of Heat Export (e.g. Steam / Hot Water)		Low pressure steam
c)	Export Pressure	bar a	3.4
d)	Export Temperature	°C	150
e)	Export Flow	t/h	193
f)	Return Pressure	bar a	3.4
g)	Return Temperature	°C	137
h)	Return Flow	t/h	193
i)	Likely Suitable Extraction Points		Steam cannot be readily extracted from the IP turbine exit. Therefore, steam is extracted from the cold reheat pipe, passed through a letdown station.
	Minimum Stable Plant Load		
j)	Heat Load Extraction for Carbon Capture at Minimum Stable Plant Load	MW	65
k)	Description of Heat Export (e.g. Steam / Hot Water)		Low pressure steam
l)	Export Pressure	bar a	2.7
m)	Export Temperature	°C	150
n)	Export Flow	t/h	105
o)	Return Pressure	bar a	2.7
p)	Return Temperature	°C	130
q)	Return Flow	t/h	105
r)	Likely Suitable Extraction Points		Steam cannot be readily extracted from the IP turbine exit. Therefore, steam is extracted from the cold reheat pipe, passed through a letdown station.
5.3	Operation of Plant with Carbon Capture (without CHP)		
a)	Maximum Plant Load with Carbon Capture	%	100
b)	Carbon Capture Mode Thermal Input at Maximum Plant Load	MW	771
c)	Carbon Capture Mode Net Electrical Output at Maximum Plant Load	MW	380

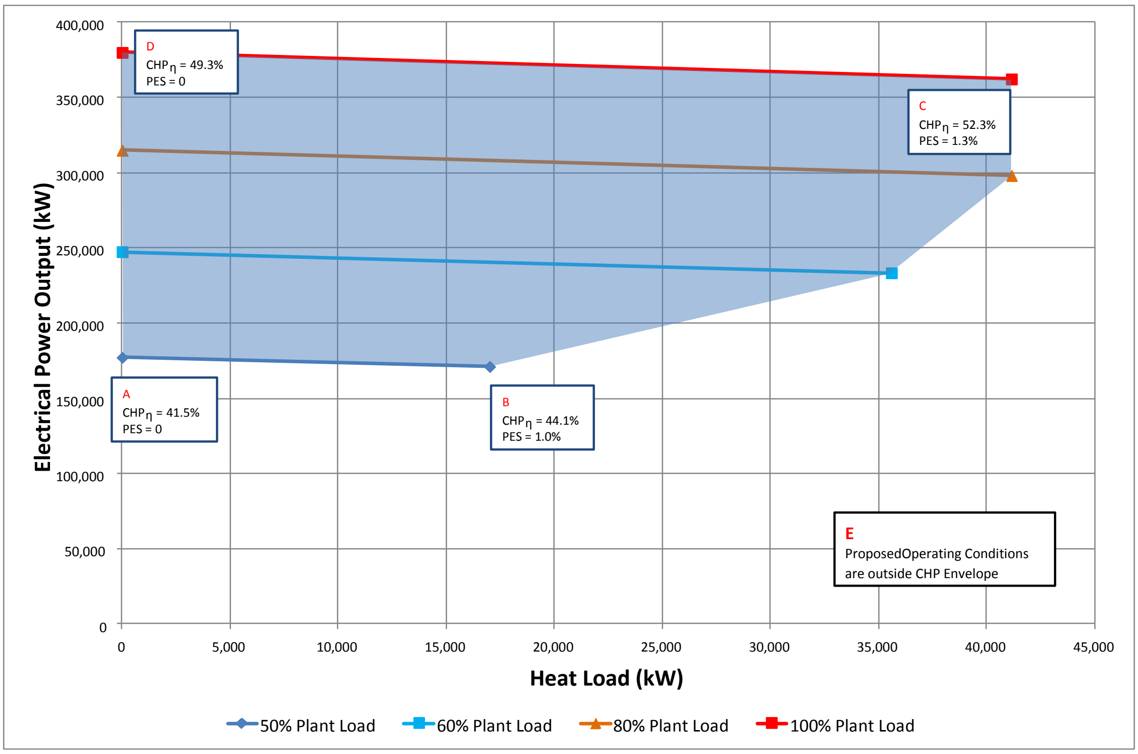
d)	Carbon Capture Mode Net Electrical Efficiency at Maximum Plant Load	%	49.3
e)	Minimum Stable Plant Load with CCS	%	40
f)	Carbon Capture Mode CCS Thermal Input at Minimum Stable Plant Load	MW	427
g)	Carbon Capture Mode Net Electrical Output at Minimum Stable Plant Load	MW	177
h)	Carbon Capture Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	41.5
5.4	Heat Extraction for CHP at 100% Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at 100% Plant Load with Carbon Capture [H]	MW	41
b)	Maximum Heat Extraction Export Flow at 100% Plant Load with Carbon Capture	t/h	879
c)	Carbon Capture and CHP Mode Net Electrical Output at 100% Plant Load	MW	362
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at 100% Plant Load	%	47.0
e)	Carbon Capture and CHP Mode Net CHP Efficiency at 100% Plant Load	%	52.3
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at 100% Plant Load	%	1.3
5.5	Heat Extraction at Minimum Stable Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load with Carbon Capture	MW	17
b)	Maximum Heat Extraction Export Flow at Minimum	t/h	366

	Stable Plant Load with Carbon Capture		
c)	Carbon Capture and CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	171
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	40.1
e)	Carbon Capture and CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	44.1
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at Minimum Stable Plant Load	%	1.0
5.6	Can the Plant with Carbon Capture supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the 'CHP and Carbon Capture Envelope')?		No
5.7	Description of Potential Options which could be incorporated in the Plant for useful integration of any realised CHP System and Carbon Capture System		In the case where the plant is required to simultaneously meet the carbon capture requirement and the identified heat load, a dedicated auxiliary boiler may form part of the CHP Plant.
Requirement 6: Economics of CHP-R			
6.1	Economic Assessment of CHP-R		Not required for the Case Study
BAT Assessment			
	Is the new plant a CHP plant at the outset (i.e. are there economically viable CHP opportunities at the outset)?		Not required for the Case Study
	If not, is the new plant a CHP-R plant at the outset?		Not required for the Case Study
	Once the new plant is CHPR, is it BAT?		Not required for the Case Study

CHP Envelope for Case Study 5a



CHP and Carbon Capture Envelope for Case Study 5a



Case Study / Worked Example 5b

#	Description	Units	Notes / Instructions
Requirement 1: Plant, Plant Location and Potential Heat Loads			
1.1	Plant Name		Case Study 5b
1.2	Plant Description		Plant comprises: • Single-shaft (1 + 1) Configuration; • Hybrid Cooling; and • UK ambient conditions.
1.3	Plant Location (Postcode / GridRef)		Not required for the Case Study
1.4	Factors Influencing Selection of Plant Location		Not required for the Case Study
1.5	Operation of Plant		
a)	Proposed Operational Plant Load	%	100
b)	Thermal Input at Proposed Operational Plant Load	MW	771
c)	Net Electrical Output at Proposed Operational Plant Load	MW	446.5
d)	Net Electrical Efficiency at Proposed Operational Plant Load	%	57.9
e)	Maximum Plant Load	%	100
f)	Thermal Input at Maximum Plant Load	MW	771
g)	Net Electrical Output at Maximum Plant Load	MW	446.5
h)	Net Electrical Efficiency at Maximum Plant Load	%	57.9
i)	Minimum Stable Plant Load	%	40
j)	Thermal Input at Minimum Stable Plant Load	MW	427
k)	Net Electrical Output at Minimum Stable Plant Load	MW	215
l)	Net Electrical Efficiency at Minimum Stable Plant Load	%	50.4
1.6	Identified Potential Heat Loads		
			50 MW District Heating
1.7	Selected Heat Load(s)		

a)	Category (e.g. Industrial / District Heating)		District Heating
b)	Maximum Heat Load Extraction Required	MW	50

1.8	Export and Return Requirements of Heat Load		
a)	Description of Heat Load Extraction		Hot water
b)	Description of Heat Load Profile		Constant
c)	Export Pressure	bar a	5
d)	Export Temperature	°C	95
e)	Export Flow	t/h	1075
f)	Return Pressure	bar a	3
g)	Return Temperature	°C	55
h)	Return Flow	t/h	1075
Requirement 2: Identification of CHP Envelope			
2.0	Comparative Efficiency of a Standalone Boiler for supplying the Heat Load	90 % LHV	90
2.1	Heat Extraction at 100% Plant Load		
a)	Maximum Heat Load Extraction at 100% Plant Load	MW	145
b)	Maximum Heat Extraction Export Flow at 100% Plant Load	t/h	3111
c)	CHP Mode Net Electrical Output at 100% Plant Load	MW	409
d)	CHP Mode Net Electrical Efficiency at 100% Plant Load	%	53.1
e)	CHP Mode Net CHP Efficiency at 100% Plant Load	%	71.8
f)	Reduction in Primary Energy Usage for CHP Mode at 100% Plant Load	%	11.1
2.2	Heat Extraction at Minimum Stable Plant Load		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load	MW	68

b)	Heat Extraction Export Flow at Minimum Stable Plant Load	t/h	1456
c)	CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	195
d)	CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	45.6
e)	CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	61.5
f)	Reduction in Primary Energy Usage for CHP Mode at Minimum Stable Plant Load	%	13.3
2.3	Can the Plant supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the 'CHP Envelope')?		Yes
Requirement 3: Operation of the Plant with the Selected Identified Heat Load			
3.1	Proposed Operation of Plant with CHP		
a)	CHP Mode Net Electrical Output at Proposed Operational Plant Load	MW	433
b)	CHP Mode Net Electrical Efficiency at Proposed Operational Plant Load	%	56.3
c)	CHP Mode Net CHP Efficiency at Proposed Operational Plant Load	%	62.8
d)	Reduction in Net Electrical Output for CHP Mode at Proposed Operational Plant Load	MW	13.6
e)	Reduction in Net Electrical Efficiency for CHP Mode at Proposed Operational Plant Load	%	2.8
f)	Reduction in Primary Energy Usage for CHP Mode at Proposed Operational Plant Load	%	4.2
g)	Z Ratio		3.7

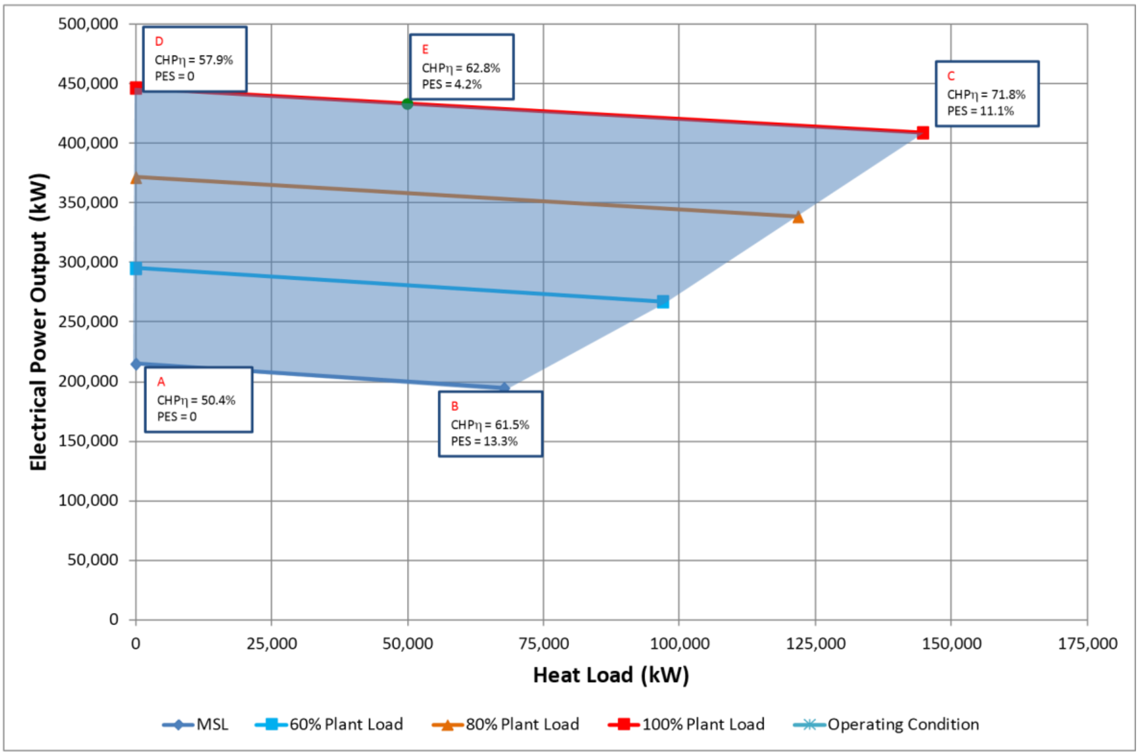
Requirement 4: Technical Provisions and Space Requirements			
4.1	Description of Likely Suitable Extraction Points		Steam cannot be readily extracted from the IP turbine exit. Therefore, steam is extracted from the cold reheat pipe, passed through a back pressure steam turbine and supplied to the District Heating System.
4.2	Description of Potential Options which could be incorporated in the Plant, should a CHP Opportunity be realised outside the 'CHP Envelope'		N / A (CHP opportunity lies within the CHP Envelope)
4.3	Description of how the future Costs and Burdens associated with supplying the Identified Heat Load / Potential CHP Opportunity have been minimised through the implementation of an appropriate CHP-R design		Not required for the Case Study
4.4	Provision of Site Layout of the Plant, indicating Available Space which could be made available for CHPR		Please see Layout CS 05b. A back pressure steam turbine generator (with associated transformer) is included. The District Heating System will (likely) include: extraction piping; control and shut-off valves, and actuators; a Pressure Reduction and Desuperheating Station; District Heaters; District Heating supply and return lines; condensate return piping (to the condensate header); interconnecting piping; drains; pipe bridges / supports; and Control and Instrumentation / electrical connections. A Stand-by Boiler is also included. Provision is also made for possible extension of the Water Treatment Plant.
Requirement 5: Integration of CHP and Carbon Capture			
5.1	Is the Plant required to be CCR?		Yes

5.2	Export and Return Requirements Identified for Carbon Capture		
	100% Plant Load		
a)	Heat Load Extraction for Carbon Capture at 100% Plant Load	MW	34.6
b)	Description of Heat Export (e.g. Steam / Hot Water)		Low pressure steam
c)	Export Pressure	bar a	3.4
d)	Export Temperature	°C	150
e)	Export Flow	t/h	57
f)	Return Pressure	bar a	3.4
g)	Return Temperature	°C	137
h)	Return Flow	t/h	57
i)	Likely Suitable Extraction Points		Steam is taken from the exit of the new back pressure steam turbine.
	Minimum Stable Plant Load		
j)	Heat Load Extraction for Carbon Capture at Minimum Stable Plant Load	MW	5.2
k)	Description of Heat Export (e.g. Steam / Hot Water)		Low pressure steam
l)	Export Pressure	bar a	2.7
m)	Export Temperature	°C	150
n)	Export Flow	t/h	8
o)	Return Pressure	bar a	2.7
p)	Return Temperature	°C	130
q)	Return Flow	t/h	8
r)	Likely Suitable Extraction Points		Steam is taken from the exit of the new back pressure steam turbine.
5.3	Operation of Plant with Carbon Capture (without CHP)		
a)	Maximum Plant Load with Carbon Capture	%	100
b)	Carbon Capture Mode Thermal Input at Maximum Plant Load	MW	771
c)	Carbon Capture Mode Net Electrical Output at Maximum Plant Load	MW	385
d)	Carbon Capture Mode Net Electrical Efficiency at Maximum Plant Load	%	49.9
e)	Minimum Stable Plant Load with CCS	%	40

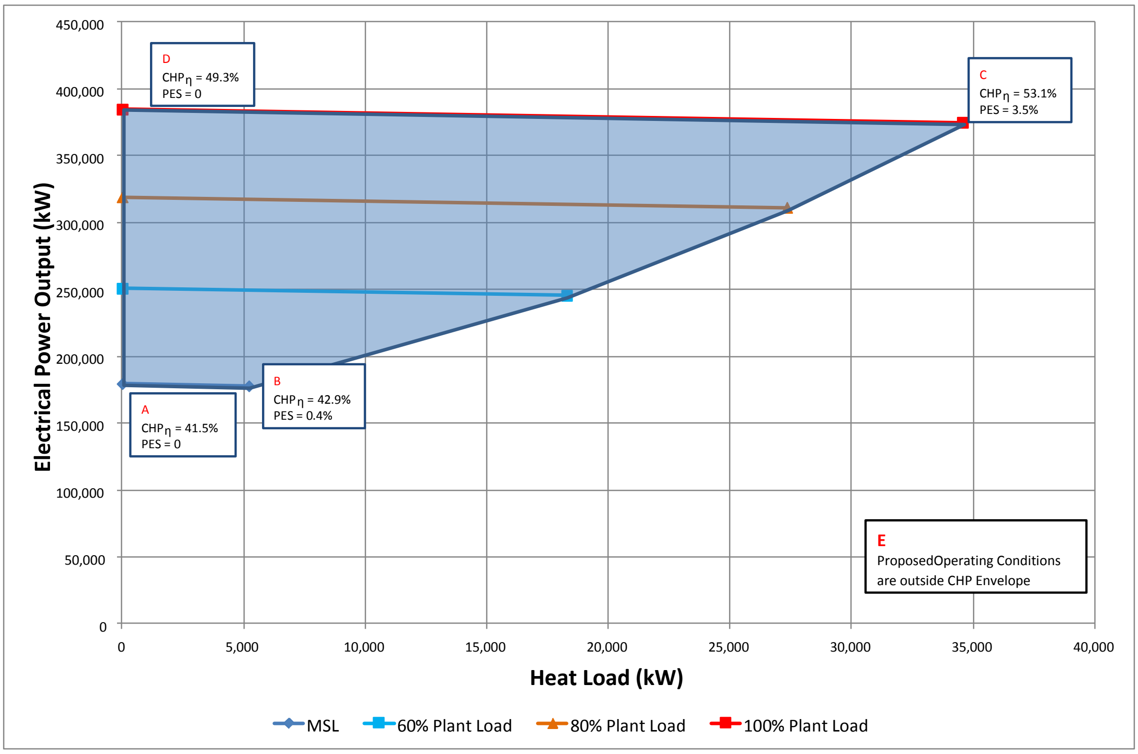
f)	Carbon Capture Mode CCS Thermal Input at Minimum Stable Plant Load	MW	427
g)	Carbon Capture Mode Net Electrical Output at Minimum Stable Plant Load	MW	180
h)	Carbon Capture Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	42.1
5.4	Heat Extraction for CHP at 100% Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at 100% Plant Load with Carbon Capture [H]	MW	35
b)	Maximum Heat Extraction Export Flow at 100% Plant Load with Carbon Capture	t/h	739
c)	Carbon Capture and CHP Mode Net Electrical Output at 100% Plant Load	MW	375
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at 100% Plant Load	%	48.6
e)	Carbon Capture and CHP Mode Net CHP Efficiency at 100% Plant Load	%	53.1
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at 100% Plant Load	%	3.5
5.5	Heat Extraction at Minimum Stable Plant Load with Carbon Capture		
a)	Maximum Heat Load Extraction at Minimum Stable Plant Load with Carbon Capture	MW	5
b)	Maximum Heat Extraction Export Flow at Minimum Stable Plant Load with Carbon Capture	t/h	112
c)	Carbon Capture and CHP Mode Net Electrical Output at Minimum Stable Plant Load	MW	178

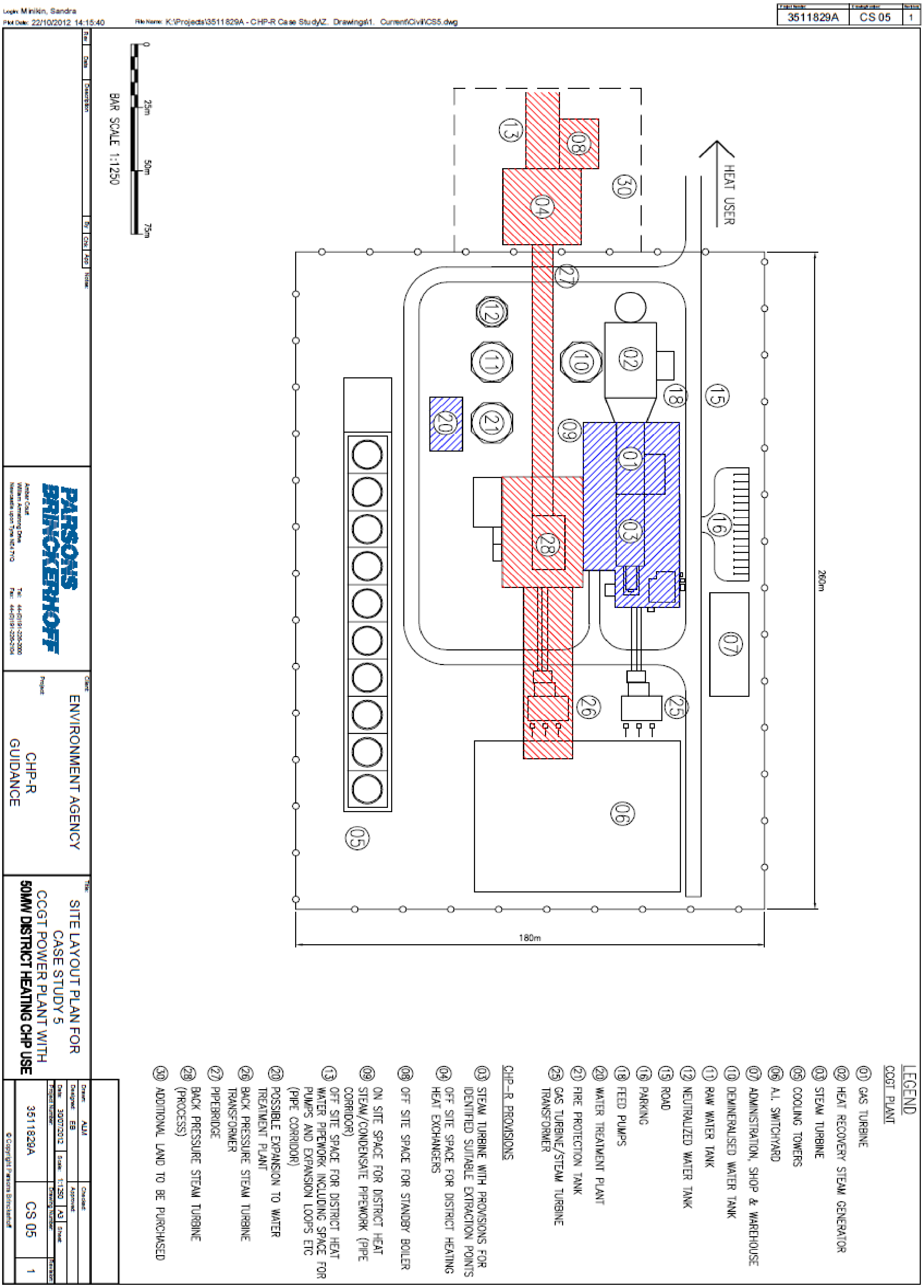
d)	Carbon Capture and CHP Mode Net Electrical Efficiency at Minimum Stable Plant Load	%	41.7
e)	Carbon Capture and CHP Mode Net CHP Efficiency at Minimum Stable Plant Load	%	42.9
f)	Reduction in Primary Energy Usage for Carbon Capture and CHP Mode at Minimum Stable Plant Load	%	0.4
5.6	Can the Plant with Carbon Capture supply the Selected Identified Potential Heat Load (i.e. is the Identified Potential Heat Load within the 'CHP and Carbon Capture Envelope')?		No
5.7	Description of Potential Options which could be incorporated in the Plant for useful integration of any realised CHP System and Carbon Capture System		In the case where the plant is required to simultaneously meet the carbon capture requirement and the identified heat load, a dedicated auxiliary boiler may form part of the CHP Plant.
Requirement 6: Economics of C P-R			
6.1	Economic Assessment of CHP-R		Not required for the Case Study
BAT Assessment			
	Is the new plant a CHP plant at the outset (i.e. are there economically viable CHP opportunities at the outset)?		Not required for the Case Study
	If not, is the new plant a CHP-R plant at the outset?		Not required for the Case Study
	Once the new plant is CHPR, is it BAT?		Not required for the Case Study

CHP Envelope for Case Study 5b



CHP and Carbon Capture Envelope for Case Study 5b




3511829A
CS 05
1
HEAT USER
BAR SCALE 1:1250
0
25m
50m
75m
180m
260m
LEGEND
CCGT PLANT
01 GAS TURBINE
02 HEAT RECOVERY STEAM GENERATOR
03 STEAM TURBINE
05 COOLING TOWERS
06 A.I. SWITCHYARD
07 ADMINISTRATION, SHOP & WAREHOUSE
10 DEMINERALISED WATER TANK
11 RAW WATER TANK
12 NEUTRALIZED WATER TANK
15 ROAD
16 PARKING
18 FEED PUMPS
20 WATER TREATMENT PLANT
21 FIRE PROTECTION TANK
25 GAS TURBINE/STEAM TURBINE TRANSFORMER
CHP-R PROVISIONS
03 STEAM TURBINE WITH PROVISIONS FOR IDENTIFIED SUITABLE EXTRACTION POINTS
04 OFF SITE SPACE FOR DISTRICT HEATING HEAT EXCHANGERS
08 OFF SITE SPACE FOR STANDBY BOILER
09 ON SITE SPACE FOR DISTRICT HEAT STEAM/CONDENSATE PIPEWORK (PIPE CORRIDOR)
13 OFF SITE SPACE FOR DISTRICT HEAT WATER PIPEWORK INCLUDING SPACE FOR PUMPS AND EXPANSION LOOPS ETC (PIPE CORRIDOR)
20 POSSIBLE EXPANSION TO WATER TREATMENT PLANT
26 BACK PRESSURE STEAM TURBINE TRANSFORMER
27 PIPEBRIDGE
28 BACK PRESSURE STEAM TURBINE (PROCESS)
30 ADDITIONAL LAND TO BE PURCHASED
PARSONS BRINCKERHOFF
ENVIRONMENT AGENCY
CHP-R GUIDANCE
SITE LAYOUT PLAN FOR CASE STUDY 5 CCGT POWER PLANT WITH 50MW DISTRICT HEATING CHP USE
3511829A
CS 05
1

Appendix C: Additional Economic Supporting Information

An integral part of any BAT test is a consideration of the economic viability of the chosen option.

Qualitative Economic Screening

Under Requirement 1, the CHP-R Assessment requires that there is a description of and search for the likely extent and nature of CHP opportunities (i.e. potential heat loads) in the area of the new plant. Following this, the CHP-R Assessment requires that there is an appropriate selection of heat loads to take forwards to the CHP-R Assessment.

In terms of the 'appropriate selection of heat loads', this should be such that, wherever possible, 10% primary energy savings could be achieved in the future. However, where this is not possible, the selection of heat loads should be such that maximum primary energy savings could eventually be achieved whilst not necessarily meeting the criteria for Good Quality CHP. Accordingly, the appropriate selection of heat loads may include a discussion with Natural Resources Wales, potential heat load recipient(s), and / or a degree of qualitative economic screening.

An example of a qualitative economic screening process is given here. However, it should be noted that this should not be considered to be the only way in which a qualitative economic screening can be undertaken, and therefore it would be the responsibility of the applicant / operator to justify the basis for their qualitative economic screening.

Step 1: High Level Analysis of Likely Extent and Nature of CHP Opportunities in the Area

The high level analysis of the likely extent and nature of CHP opportunities in the area should comprise a description of:

- Size / type of heat load and initial estimation of primary energy savings;
- Likelihood of CHP opportunity being realised;
- Likely requirement for on site works (giving consideration to additional land / space requirements); and
- Likely requirement for off site works (giving consideration to: additional land / space requirements; distance of CHP Load from Plant; and, terrain between CHP Load and Plant).

Step 2: Ranking of CHP Opportunities in the Area

In terms of the factors listed under Step 1, a ranking of CHP opportunities in the area should be undertaken.

The ranking (and subsequent) selection of heat loads should be such that, wherever possible, 10% primary energy savings could be achieved in the future. Therefore, where the initial estimation of primary energy savings is greater than 10%, this heat load (or heat loads) should automatically be taken forwards. However, it is accepted that this may not always be possible. In these cases, the selection of heat load (or heat loads) should be such that maximum primary energy savings could eventually be achieved whilst not necessarily meeting the criteria for Good Quality CHP.

In terms of the remaining factors, an example of additional ranking criteria which can be used is provided in Table C.1.

TABLE C.1: DESCRIPTION OF ADDITIONAL RANKING CRITERIA

	Likely High Level of Economic Viability	**Likely Medium Level of Economic Viability**	**Likely Low Level of Economic Viability**
Likelihood of CHP Opportunity being Raised	Within 5 Years	Between 5 to 10 Years	Over 10 Years
Ranking	1	2	3
Requirement for On Site Works	Minimal	Moderate	Complex
Ranking	1	2	3
Requirement for Off Site Works	Minimal	Moderate	Complex
Ranking	1	2	3

Step3: Appropriate Selection of Heat Loads

Based on Step 2, an appropriate selection of heat loads should be undertaken. A justification of this appropriate selection should be provided, which could be based on the analysis / ranking undertaken in Step 1 and Step 2.

Also, the appropriate selection of heat loads may include a discussion with Natural Resources Wales and potential heat load recipient, and must be agreed with Natural Resources Wales.

Economics of CHP-R and CHP

Further to the requirement for the new plant being CHP-R, the economic viability of actually realising a CHP scheme is an important consideration for:

- The first BAT test (i.e. when realising a CHP scheme at the outset); and
- The third BAT test (i.e. when carrying out periodic reviews of opportunities to realise CHP (both existing and new)).

For this reason, this CHP-R Guidance provides some suggestions on assessing and presenting the potential revenues and costs of the wider economics of CHP-R and CHP schemes. Accordingly, within the context of this CHP-R Guidance, the potential revenues and costs of being a CHP-R plant, converting a CHP-R plant to a CHP plant or a CHP plant are considered to include (but not necessarily be limited to):

- Revenues / benefits associated with incentives and support measures for CHP, including[10],[11]:
    - Up to 1 April 2013, exemption (via Levy Exemption Certificates) from the Climate Change Levy of all fuel inputs to (and electricity outputs from) Good Quality CHP;
    - Enhanced Capital Allowances for Good Quality CHP equipment / machinery in Non-Utility Sectors;
    - Business Rates exemption for embedded CHP equipment / machinery; and,
    - Support under the Renewables Obligation and / or Renewables Heat Incentive[12] for some types of plant that incorporate CHP. .
- Costs associated with being a CHP-R plant, including:
    - Upfront Studies;
    - Modifications to 'standard' design (i.e. providing suitable extraction points); and,
    - Additional land / space requirements.
- Costs associated with the modification / conversion to CHP plant, including:
    - Modifications to CHP-R plant (e.g. implementing suitable extraction points);
    - Modifications to existing plant items (e.g. pipe runs);
    - Expansion of existing plant items (e.g. water treatment plant);
    - Structural / civil works; and,
    - Control and Instrumentation / Electrical works.
- Costs associated with new on site CHP equipment / plant, including:
    - Additional equipment items (e.g. supply and return pipes, back-up boilers); and
    - Additional plant items (e.g. valves, pumps, heat exchangers).
- Costs associated with the new off-site CHP equipment / plant, including:
    - Additional equipment items (e.g. supply and return pipes);
    - Additional plant items (e.g. valves, pumps);
    - Structural / civil works;
    - Control and Instrumentation / Electrical works; and - Additional land / space requirements.

[10] Adapted from Digest of UK Energy Statistics (DUKES) 2011 – Chapter 6 (Combined Heat and Power).

[11] However, it should be noted that these measures may be subject to change as a results of changes in Government Policy. There is may be that additional incentives and support measures for plant which incorporate CHP may be available in the future.

[12] At the time of writing, DECC are intending to consult on amendments to the Renewable Heat Incentive (RHI) tariff arrangements for renewable CHP plants which are not eligible for the "half Renewable Obligation Certificates uplift" which applies to plant accredited before 1 April 2013.

It is noted that the EED contains guidance on conducting an economic assessment (i.e. a cost-benefit analysis). This is included at Part 2 of Annex IX.

Furthermore, it is noted that there are a number of Documents available which contain guidance on conducting economic assessments. These Documents include:

- Annex K (Cost Benefit Analysis) of Natural Resources Wales H1 Guidance (Environmental Risk Assessment Framework);
- Appendix 4 (Appraisal of Energy Efficiency Techniques) of Natural Resources Wales H2 Guidance (Energy Efficiency); and,
- Paragraphs 62 to 69 of Carbon Capture Readiness (CCR): A Guidance Note for Section 36 Electricity Act, 1989 Consent Applications[13].

The following suggested proposed structure incorporates elements from the above Documents. However, it should be noted that this should not be considered to be the only way in which an economic assessment can be undertaken, and therefore it would be the responsibility of the applicant / operator to justify the basis for their economic assessment.

- **Outline**

The economic assessment should be based on the parameters provided in the technical assessments of CHP-R (i.e. those in Requirement 2 to Requirement 5).

- **Parameters taken into Account**

The parameters for the economic assessment should be described.

For the economic assessment, including the subsequent revenues and costs of the CHP scheme, the following parameters may be required: discount rate; assumed lifetime; fuel price; carbon price; heat price; amount of heat supplied; plant net electrical power output with and without CHP; proposed plant load factor; likely incentives and support measures for CHP; initial costs for the plant to be CHP-R (i.e. similar to those estimated in the second BAT test, as described in this CHP-R Guidance); subsequent costs to modify / convert the CHP-R plant to a CHP plant (including all associated on site and off site costs) (i.e. similar to those estimated in the second BAT test, as described in this CHP-R Guidance); and, reasonable estimates of when the revenues / costs would occur.

- **Estimated Costs**

Based on the above parameters, Table A4.3 (Template for the Presentation of Capital Costs) and Table A4.4 (Template for the Presentation of Operating Costs) of Appendix 4 (Appraisal of Energy Efficiency Techniques) of Natural Resources Wales H2 Guidance (Energy Efficiency) could be used as a template to estimate (for each identified option): the capital costs; the likely annual operating revenues; and, the average change in annual operating and maintenance costs.

[13] Carbon Capture Readiness (CCR): A Guidance Note for Section 36 Electricity Act, 1989 Consent Applications. Crown Copyright URN 09D/819.

In using these Tables, the capital costs / operating revenues and costs are broken down into sufficient details to allow the major influences of each option to be clearly demonstrated.

- ### Methodology / Determining Economic Viability

The principles in use within the modelling should be described, and a comparison could be provided between costs of generation for the various options. Table A4.2 (CostBenefit Appraisal Summary) of Appendix 4 (Appraisal of Energy Efficiency Techniques) of Natural Resources Wales H2 Guidance (Energy Efficiency) could be used as a template.

For example:

	Non CHP Plant	CHP Plant (Option 1)	CHP Plant (Option 2)
Capital Costs (£)			
Potential Operating Revenues (£/year)			
Operating Costs (£/year)			
Life of Option			
Annual Costs / Savings with CHP[14]	N /A		
Price of Electricity			
Annual Carbon Dioxide savings with CHP	N / A		

A sensitivity analysis could then be undertaken (i.e. by varying the parameters which influence the annual costs / savings) to determine likely ranges which would ultimately allow an option to be economically viable. This could be used to give a measure of uncertainty within the modelling.

- ### Economic Assessment Summary

Based on the above, a clear summary of the economic assessment could be provided, indicating the likely ranges (in terms of costs of generation) which would ultimately allow an option for a CHP scheme to be economically viable

[14] Based on one of the support measures to incentivise CHP.

Appendix D: Additional Technical Supporting Information

Based on the CHP-R Assessment Form Point 4.1 (Description of Likely Suitable Extraction Points), it is required that likely suitable extraction points are described and a suitable method (or methods) or extraction are identified.

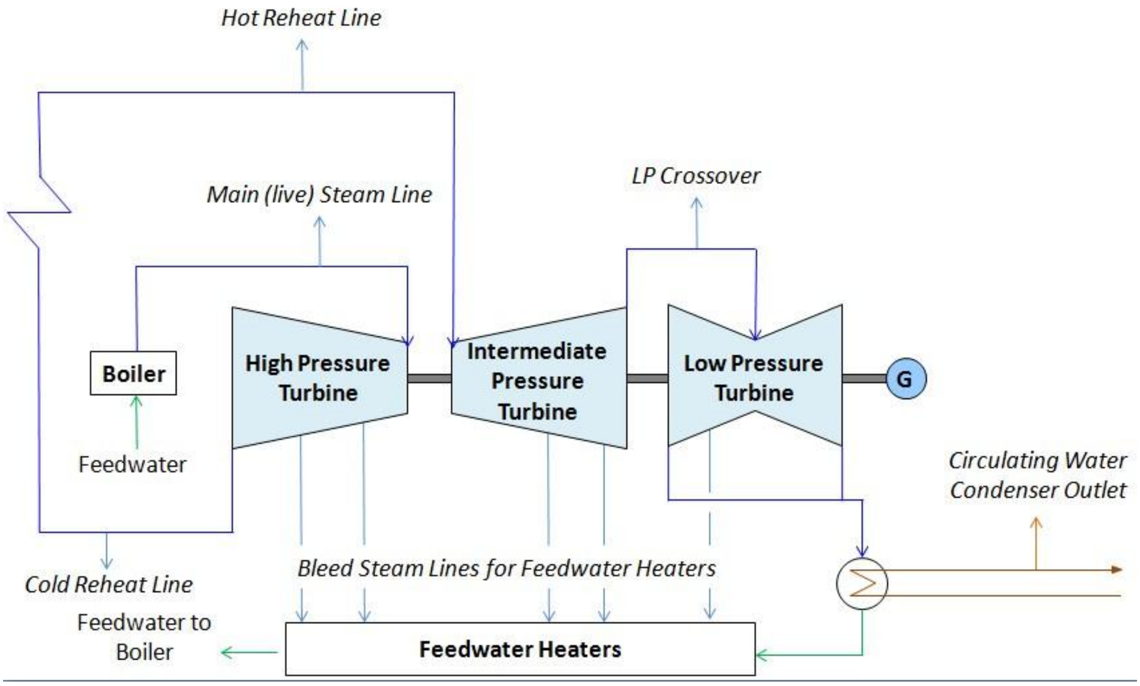
The potential for a plant to be converted to supply heat in the future (whether it is to either a district heat network or an industrial process) depends upon: the type of plant being considered (i.e. whether it is conventional steam or a CCGT); the steam cycle configuration; and, the steam turbine configuration.
For example:

- The steam cycle can be:
  - With or without reheat; and,
  - (For CCGT) it can be one, two or three pressure.
- The steam turbine can:
  - Have a lateral exhaust (side or down), or an axial exhaust;
  - Have different casing arrangements (i.e. single and multi).

The following information contains a range of examples which represent a range of configurations for illustrative purposes. However, it should be noted that this range of examples is not intended to be exhaustive.

Additionally, the potential steam sources shown are based on typical arrangements without consideration of CHP (i.e. they are representative of plants which are initially required to generate electrical power). However, the future extraction points are described for the purposes of demonstrating CHP-R.

Large Scale Conventional Steam Plant with Reheat (Water Cooled Surface Condenser)

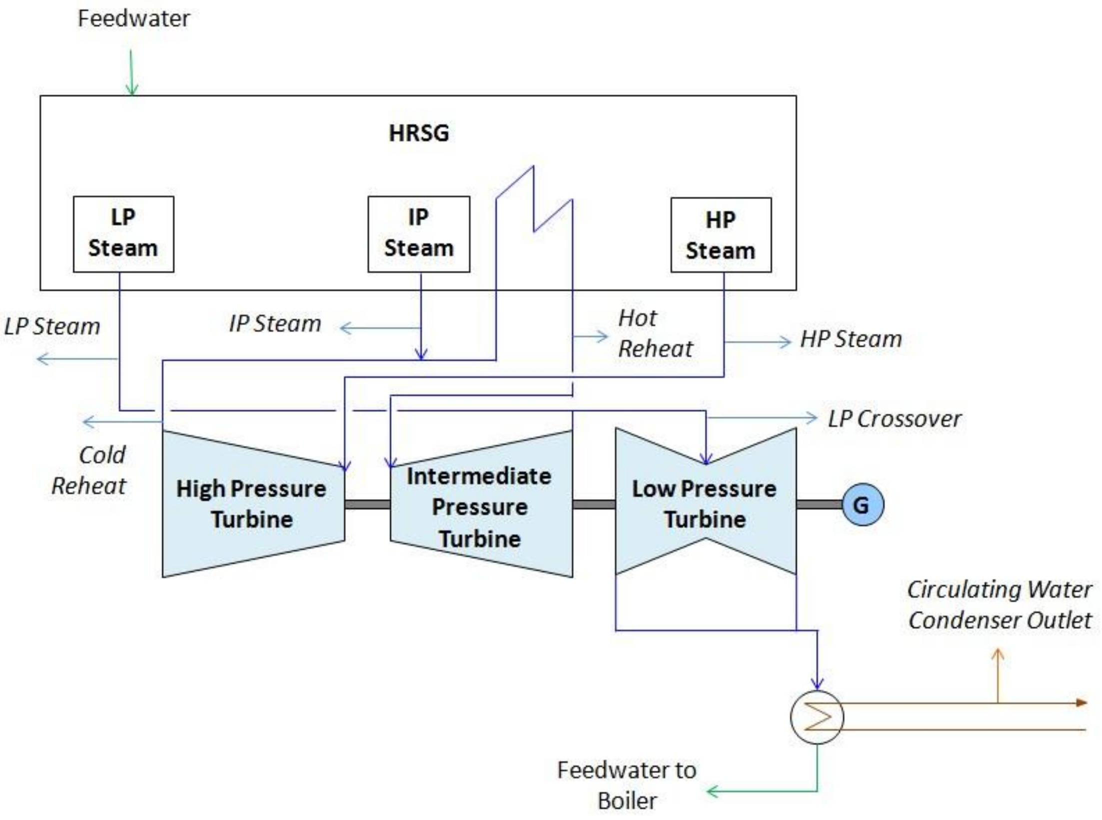


This example considers a typical large scale conventional steam plant with reheat, and a water cooled surface condenser. This is based on separate HP, IP and LP steam turbines. The LP steam turbine(s) have down exhausts, and the steam is delivered from the exhaust of the IP steam turbine to the LP steam turbine by large crossover pipes.

Potential sources of heat are:

- Main (live) steam (high pressure);
- Hot reheat (intermediate pressure);
- Cold reheat (intermediate pressure);
- LP cross over (low pressure);
- Bleed steam for feedwater heaters (high pressure / intermediate pressure / low pressure); and
- Circulating water condenser outlet (hot water).

Large Scale CCGT Plant with Reheat (Water Cooled Surface Condenser)



This example considers a typical large scale CCGT plant with a three pressure reheat, and a water cooled surface condenser. This is also based on separate HP, IP and LP steam turbines. The LP steam turbine(s) have down exhausts[15], and the steam is delivered from the exhaust of the IP steam turbine to the LP steam turbine by large crossover pipes. There are usually no feedheaters, but multiple pressures are generated in the Heat Recovery Steam Generator (HRSG).

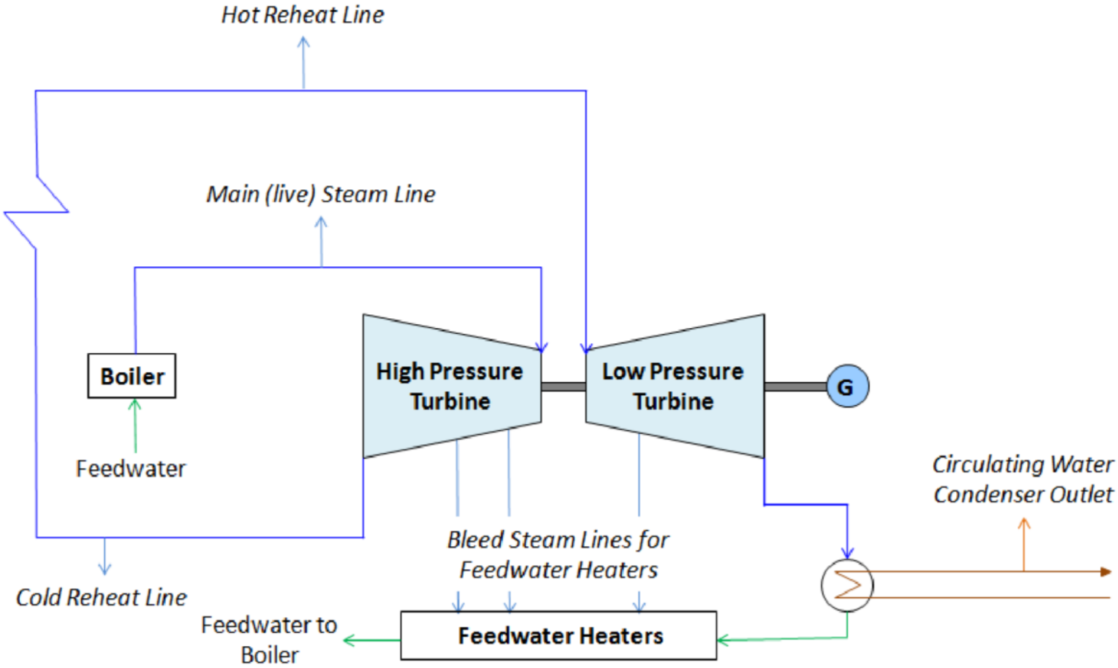
Potential sources of heat are:

- HP steam (high pressure);
- Cold reheat (intermediate pressure);
- IP steam (intermediate pressure);
- Hot reheat (intermediate pressure);
- LP steam (low pressure);
- LP cross over (low pressure); and,
- Circulating water condenser outlet (hot water).

This is considered to represent the configuration in Case Study 1 and Case Study 2.

[15] Depending on the cooling system and condenser pressure selected, steam turbines for single shaft may have a single LP turbine without a full IP / LP crossover pipe and an axial exhaust. This is considered to represent the configuration in Case Study 5.

Small Scale Conventional Steam Plant with Reheat (Water Cooled Surface Condenser)

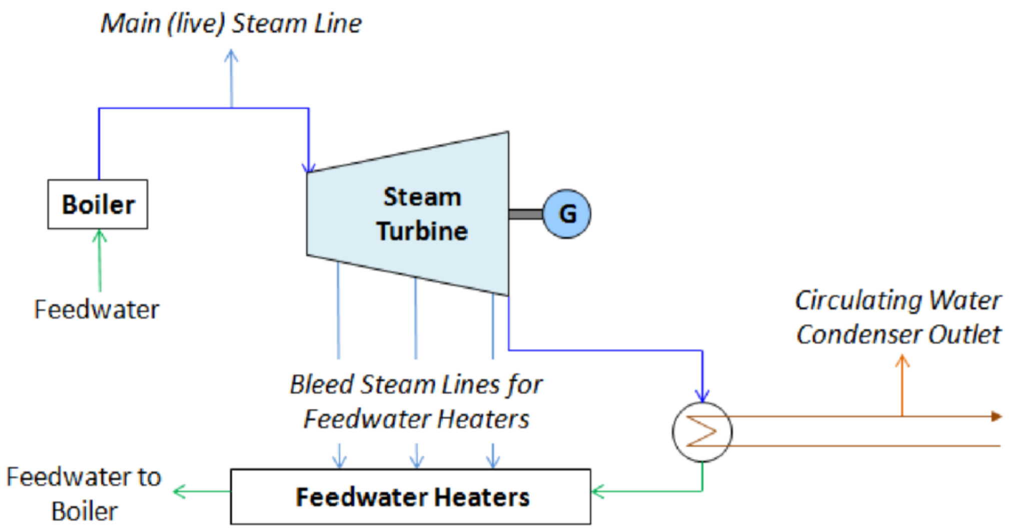


This example considers a typical small scale conventional steam plant with reheat, and a water cooled surface condenser. This is based on separate HP and LP steam turbines. The LP steam turbine could have a lateral or axial exhaust. There is no crossover pipe.

Potential sources of heat are:

- Main (live) steam (high pressure);
- Hot reheat (intermediate pressure);
- Cold reheat (intermediate pressure);
- Bleed steam for feedwater heaters (high pressure / intermediate pressure / low pressure); and
- Circulating water condenser outlet (hot water).

Small Scale Conventional Steam Plant without Reheat (Water Cooled Surface Condenser)



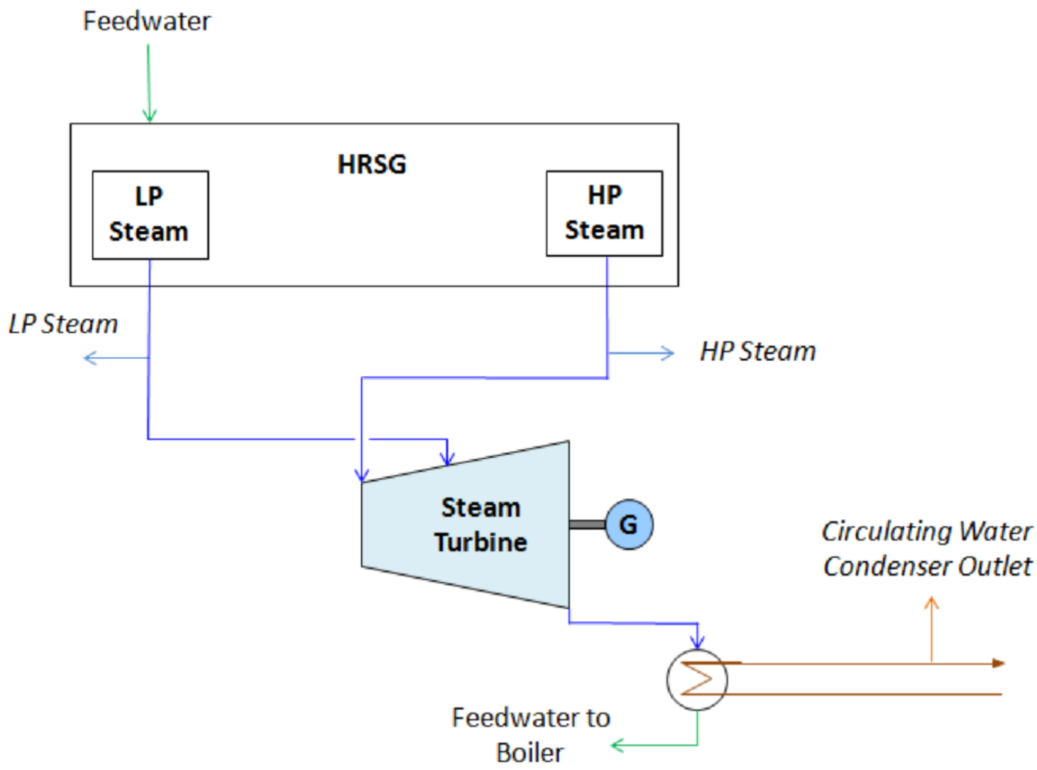
This example considers a typical small scale conventional steam plant without re-heat, and a water cooled surface condenser. This is based a single casing Steam Turbine. The Steam Turbine could have a lateral or axial exhaust. There is no crossover pipe.

Potential sources of heat are:

- Main (live) steam (high pressure);
- Bleed steam for feedwater heaters (high pressure / intermediate pressure / low pressure); and
- Circulating water condenser outlet (hot water).

This is considered to represent the configuration in Case Study 3 and Case Study 4.

Small Scale CCGT Plant without Reheat (Water Cooled Surface Condenser)



This example shows a typical small scale CCGT plant without reheat, and a water cooled surface condenser. This is based on a single case steam turbine with two pressures. The steam turbine could have a lateral or axial exhaust. There is no crossover pipe.

Potential sources of heat are:

- HP steam (high pressure);
- LP steam (low pressure); and
- Circulating water condenser outlet (hot water).