Combined Heat and Power Report

Thurrock Flexible Generation Plant

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Quality Management

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Executive Summary

This report provides evidence and justification for why the proposed Thurrock Flexible Generation Plant development does not include provision for CHP and should be excluded from the requirement for CHP Readiness.

Thurrock Power Ltd proposes to develop a flexible generation plant to provide up to 600 megawatts (MW) of electrical generation capacity on a fast response basis, together with up to 150 MW of battery storage capacity.

The potential heat loads within a 15 km radius of the proposed development were assessed, in line with the relevant guidance. The largest potential heat users are large industrial developments and domestic users. There are nine large heat load sites recorded within the search area, comprising approximately 30% of the potential heat demand.

Much of the potential heat demand located within the search area is on the other side of the River Thames from the proposed development. As a heat pipeline crossing the River Thames would have substantial construction and financial challenges, possible heat loads on that side of the Thames are not considered to be relevant to the proposed development.

The technical, logistical and financial feasibility of provision of CHP for the proposed development has been assessed in this report. Fundamentally, the intermittent nature and hence the unpredictability of peaking plant operation makes this mode of operation unlikely to be capable of providing for the expected demands of heat users. Gas reciprocating engines are only able to make low-medium grade heat available as they do not include the necessary steam-raising equipment for higher grade heat.

The distance to the large heat load sites identified on the same side of the River Thames as the proposed development is at least 5 km and these are separated from the site by a railway line and residential settlements, which would present a physical barrier to the installation of a potential pipeline route. Other more diffuse heat loads are generally at more than 1 km distance from the proposed development and these are also separated from the proposed development site by existing and potential future physical barriers including the railway line, a major port expansion and a proposed motorway construction project.

It is considered that CHP would not be technically, logistically or financially viable for the proposed development. This report has concluded that the project does not need to undertake further investigation of CHP for the proposed peaking plant and provides evidence as to why the proposed development should be excluded from being CHP-Ready.

Contents

1 Introduction

1.1 Requirements for Consideration of CHP in UK Policy and Guidance

1.1.1 Consideration of CHP is a requirement detailed within Section 4.6 of the 'Overarching National Policy Statement for Energy (EN-1)'[1].

1.1.2 Paragraph 4.6.6 of EN-1 states that:

"Under guidelines issued by DECC (then DTI) in 2006 [the CHP Guidance[2]]*, any application to develop a thermal generating station under Section 36 of the Electricity Act 1989 must either include CHP or contain evidence that the possibilities for CHP have been fully explored to inform the [Secretary of State]'s consideration of the application."*

1.1.3 Paragraph 4.6.6 continues:

"The same principle applies to any thermal power station which is the subject of an application for development consent under the Planning Act 2008."

1.1.4 EN-1 goes on to state:

"The [Secretary of State] should have regard to DECC's Guidance, or any successor to it, when considering the CHP aspects of applications for thermal generating stations."

1.1.5 Paragraph 4.6.12 of EN-1 states that when potential future CHP opportunities are identified:

"…the IPC [Infrastructure Planning Commission, now part of the Planning Inspectorate] *may wish to impose requirements to ensure that the generating station is CHP-ready unless the IPC is 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."*

1.1.6 Paragraph 24 of the CHP Guidance acknowledges:

"...that decisions on major new power station investments, including the location and anticipated load duty of the station (e.g. base load, mid-merit, peak-lopping, support to local industry, etc.), will primarily be driven by the market..."

1.1.7 EN-1 requires that developers consider the opportunities for CHP when considering locations for their project. It emphasises the value of early consultation with bodies such as Local Enterprise Partnerships (LEPs) and Local Authorities in order to identify potential heat users (i.e. customers). The Environment Agency (EA) will also be consulted on the application (including its consideration of CHP) as part of the DCO examination process.

1.1.8 The EA has published its own 'CHP Ready Guidance for Combustion and Energy from Waste Plants'[3] (2014) (CHP-R Guidance) since the CHP Guidance was published. Section 3.3 of the CHP-R Guidance states that:

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

1.1.9 A CHP Assessment submitted with a DCO application should contain the following details, as set out in the CHP-R Guidance (based on Section 4.6 of EN-1):

- *"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."*

1.1.10 For plants with a DCO granted for "generation without CHP", the Environmental Permit application should build on the CHP Assessment to demonstrate CHP readiness, with the submission of a CHP-R Assessment in line with the CHP-R Guidance.

1.1.11 The considerations of paragraph 24 of the CHP Guidance as shown in paragraph 1.1.5 of this report are further developed in the CHP-R Guidance:

"...it is recognised that in some cases (such as peaking plant [...]*) the provision of CHP would not be compatible with the original operating regimes / intentions. Therefore, in such cases, applicants for Environmental Permits should provide evidence as to why their plant should be excluded from being CHP-R."*

1.1.12 Paragraph 4.6.8 of EN-1 also states:

"If the proposal is for thermal generation without CHP, the applicant should:

- *Explain why CHP is not economically or practically feasible for example if there is a more efficient means of satisfying a nearby domestic heat demand;*
- *Provide details of any potential future heat requirements in the area that the station could meet; and*
- *Detail the provisions in the proposed scheme for ensuring any potential heat demand in the future can be exploited."*

1.1.13 This document addresses the requirements for the provision of information identified in the above policy and guidance.

1.2 Purpose of this Report

1.2.14 This Combined Heat and Power (CHP) report has been prepared by RPS on behalf of Thurrock Power Limited (the Applicant) to support an application for a Development Consent Order (DCO). This report provides evidence and justification for why the proposed Thurrock Flexible Generation Plant development does not include provision for CHP and should be excluded from the requirement for CHP Readiness.

1.2.15 This report is structured as follows:

- Section 1 sets out the need for consideration of CHP and provides descriptions of CHP technology and of the proposed development.
- Section 2 provides the results of the assessment of possible heat demand in the area around the proposed development.
- Section 3 assesses the compatibility of the proposed development with CHP provision, with regard to the technical, logistical and financial feasibility and prospective heat requirements.
- Section 4 sets out the conclusions of this CHP report.

1.3 Combined Heat and Power

1.3.16 CHP technology involves the use of both the electrical power and waste heat produced by the electricity generation process. Available heat sources from a gas engine occur in five key areas: engine jacket cooling water; engine lubrication oil cooling; first stage air intake intercooler; engine exhaust gases; and second stage intercooler. The first three are available in the form of hot water, requiring heat exchangers to recover the waste heat if there is no nearby consumer for the hot water. Heat can be recovered from the engine exhaust gases through direct use in drying processes, in a waste heat boiler to generate steam, or via an exhaust gas heat exchanger. The heat from the second stage intercooler is also available for recovery as a lower grade heat. The heat may also be used to provide cooling through driving absorption chillers.

1.3.17 CHP can be a highly fuel-efficient technology, providing environmental benefits from the reduction in greenhouse gas and air pollutant emissions and primary energy (fuel) consumption per unit useful energy generated.

1.4 Project Description

1.4.18 Thurrock Power Ltd proposes to develop a flexible generation plant on land north of Tilbury Substation in Thurrock. The flexible generation plant will provide up to 600 megawatts (MW) of electrical generation capacity on a fast response basis, together with up to 150 MW of battery storage capacity.

1.4.19 The proposed development is located on land south west of Station Road near Tilbury, Essex. The British National Grid coordinates are TQ662766 and the

nearest existing postcode is RM18 8UL. It is within the administrative area of Thurrock Borough Council (TBC) and lies in the Thurrock Green Belt.

1.4.20 The application boundary and location of the proposed development are shown in the Location and Order Limits Plans, Application Document A2.1.

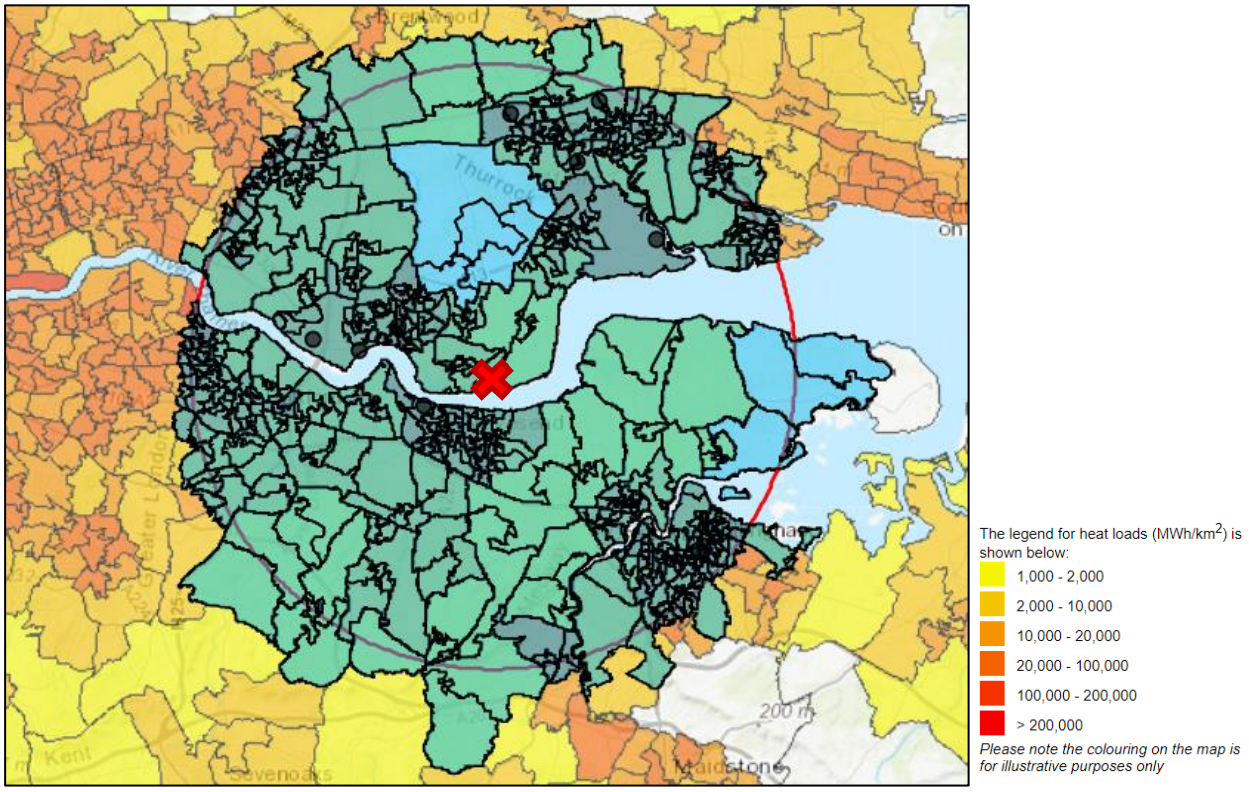
1.4.21 The proposed development will comprise gas reciprocating engines, which will be used intermittently, firing up when energy market signals the operator to do so for some or all of the engines. The engine sets will comprise the engine itself, electrical generator, air cooling system and exhaust flue. The gas engines are also proposed to include a system to generate electricity from the engine exhaust gases, options for which an exhaust gas turbine (EGT) or an organic Rankine cycle engine (ORC, i.e. using a non-water working fluid that is efficient at lower temperatures).

1.4.22 The proposed development is a Nationally Significant Infrastructure Project (NSIP) for which Thurrock Power is submitting an application to the Planning Inspectorate (PINS) for an order granting development consent (a DCO).

2 Possible Heat Demand

2.1.1 To understand the potential for heat demands in the area local to the proposed development site, information has been drawn from the DECC online CHP development map[4]. The EA guidance proposes a search radius of 15 km for plants greater than 300 MW. Figure 2.1 and Figure 2.2 show the results of that search.

Figure 2.1. Map of potential heat loads within a 15 km radius of the proposed development, marked with a cross on the map



2.1.2 Figure 2.2 shows the potential heat loads within the 15 km search radius. It shows that the largest potential heat users are large industrial developments, with an approximate requirement of 2,515,086 MWh, and domestic, with an approximate requirement of 3,649,181 MWh. There are nine large heat load sites recorded within the search area, comprising 2,136,891 MWh of the demand, but all listed as unknown operators.

2.1.3 Much of the potential heat demand mapped is located on the other side of the River Thames from the proposed development. As set out in Section 3, a heat pipeline crossing the River Thames would have substantial logistical and

financial challenges and hence theoretical heat loads south of the Thames, including the industrial loads in the Swanscombe area, are in practice not considered to be relevant.

Figure 2.2. Potential heat loads within a 15 km radius of the proposed development by sector

Sector Name	Share	Total MWh
Communications and Transport	0.1%	7,130 MWh
Commercial Offices	5.37%	379,397 MWh
Domestic	51.6%	3,649,181 MWh
Education	1.45%	102,316 MWh
Government Buildings	0.28%	20,139 MWh
Hotels	0.3%	21,425 MWh
Large Industrial	35.57%	2,515,086 MWh
Health	1.05%	74,414 MWh
Other	0.18%	12,889 MWh
Small Industrial	2.96%	209,420 MWh
Prisons	0%	0 MWh
Retail	0.77%	54,516 MWh
Sport and Leisure	0.12%	8,774 MWh
Warehouses	0.24%	16,866 MWh
District Heating	0%	0 MWh
Total heat load in Area		**7,071,554 MWh**

3 Compatibility with Provision of CHP

3.1 Feasibility

3.1.1 A feasible CHP scheme should be able to meet the heat demand of any user connected to and reliant on the scheme.

Technical Feasibility

3.1.2 The proposed development will use gas reciprocating engine power plant. The operating intention of the proposed development is to deliver power at times of peak demand. This requires plant that can start up quickly, usually within minutes, and that will operate for short periods of time (typically 1-2 hours) in order to meet the intermittent demand without unnecessary losses in efficiency.

3.1.3 Plants using gas reciprocating engine technology do not produce steam as part of the electricity generating process. The provision of CHP capability would require additional heat exchangers or steam-raising plant, which would mean an increase in capital expenditure, additional space requirements and additional technical challenges.

3.1.4 As stated in paragraph 1.3.16, there are five areas from which heat is available to be recovered when utilising gas reciprocating engine technology. Three of these comprise low-grade heat in the form of hot water, typically on a 70-80 °C flow return basis[5]; the heat from these can be recovered with the use of a plate heat exchanger if there is no feasible local demand for hot water. The use of a hot water circuit to recover the low-grade heat restricts the potential users to only those requiring low-grade hot water, and limits the distance it could be transmitted while retaining a useful temperature.

3.1.5 The engine exhaust gases are typically at a higher temperature of between 300 and 400 °C when they leave the engine, which is considered medium-grade heat. The heat from these gases can be used directly for drying where CHP engines form part of an industrial facility (which is not the case for the proposed development), or more typically can be recovered with the use of additional plant to generate steam in a waste heat boiler or via an exhaust gas heat exchanger, which can sometimes be joined to the engine cooling circuit. The additional

equipment required would be steam-raising plant to recover the exhaust heat from the engines and heat exchange equipment to use the steam duty, whether that is a hot water district heating network or steam piping to consumers.

3.1.6 The need for additional equipment also clashes with the requirements to be carbon capture (CC) ready. The standard configuration of gas reciprocating engine technology does not include heat recovery steam generator (HRSG) equipment. The gas reciprocating engine is also fundamentally a cooled cycle compared to the adiabatic simple gas turbine cycle. As a consequence, there is less exhaust heat energy in the reciprocating engine and less capability to recover heat for either CC or CHP. The CC readiness studies in the Carbon Capture Readiness Report (Application Document A7.6) suggest that the gas reciprocating engine does not deliver adequate heat to the CC cycle and so will require supplementary firing. This leaves no excess capacity to provide exhaust-derived heating for CHP – however does not preclude the use of 'water' side heat. And vice versa, if the CHP is already delivering exhaust-derived heat then this depletes the amount available for the CC cycle and will require supplementary firing, thus negating the benefits. In order to manage differing patterns for heat and electrical power, it will be necessary to study the demand profiles for both – this raises additional operational constraints compared to a simple behind-the-meter system which is able to economise on the import from the grid.

3.1.7 Utilising waste heat using additional equipment as described above also involves a delay (e.g. four hours for a conventional boiler HRSG) before full heat load can be achieved. There is little likelihood that the heat demand profile of a potential consumer will be met by the electrical energy generation profile from the facility when it is required. For this reason, the peaking operating regime is also not compatible with the time delay from steam-raising equipment. As the facility's purpose is to support the national electricity transmission system at times of peak demand, and to balance the intermittency of renewable energy generation, it would be difficult, if not impossible, to predict the times of heat available from the peaking plant with the certainty or notice that customers would require in order to rely on it. An additional time delay due to the steam-

raising plant would introduce further issues of meeting the required short time periods of peak demand.

3.1.8 In contrast to the intermittent and short-run operating times of the peaking plant, the local heat demands will generally be steadier and more consistent over at least half of the year for domestic heating or for the full year for industrial or commercial uses, and will be driven by their demand rather than being able to respond flexibly when heat is available.

3.1.9 Therefore, backup heat-only boilers would likely be required to continue to meet heat demands when the proposed development is not generating electricity. It is noted that generating heat using packaged boilers would not be expected to provide a reduction in primary energy usage or carbon emissions (expected to be the majority of the time per the operating regime).

3.1.10 The intended operating regime of the proposed development is therefore not compatible with CHP and the proposed development should not be CHP ready.

Logistical Feasibility

3.1.11 The logistical feasibility of applying CHP technology to the proposed development is considered low due to the following issues.

3.1.12 The distance to the main theoretical heat load areas identified in Section 2 (i.e. the town of Tilbury, which ranges from 0.75 km to 2.5 km west of the development, for domestic demand or the port and surrounding industry, which lie approximately 2.3 km to the west, for industrial demand) may be too great for much, if any, useful heat to be transmitted. Average distribution losses of 6–28% of the heat generated by facilities serving distribution networks ranging from 1 km to greater than 10 km in length were found in DECC's 'Assessment of the Costs, Performance, and Characteristics of UK Heat Networks'[6]. The assessment identified maximum distribution losses of up to 43% of the heat generated; the report suggested that higher distribution losses are due to thermal losses in internal pipework within buildings, such as in communal heating systems serving apartment blocks. If the heat is not all being distributed to the same place, these losses would be incurred for each different distribution network involved.

3.1.13 Additionally, some of the smaller heat loads identified (i.e. the village of West Tilbury located 1.25 km north, East Tilbury village 2.1 km east and scattered individual properties, the closest of which are located 600 m north east) are diffuse in nature and present the challenge of matching the demand profile with the intermittent generation of the plant.

3.1.14 There are several existing and potential future physical barriers to heat network pipework from the main development site to potential areas of heat loads. To the north and west, the railway line lies between the development and the largest nearby urban areas of Tilbury and Chadwell St Mary. The Port of Tilbury is currently constructing a major expansion on land to the west of the main development (Tilbury2 project) including new link road and railway; this construction would lie between the development and any heat loads at the existing port and industrial area. Furthermore, the Tilbury2 expansion, which is primarily for an aggregates terminal and for ro-ro freight, is not anticipated to have a significant heat demand itself.

3.1.15 To the east, the proposed Lower Thames Crossing motorway scheme would be a significant physical barrier during construction or once built for a pipe network between the development site and the villages of East Tilbury and Linford.

3.1.16 As identified in Section 2, a substantial proportion of the hypothetical mapped heat loads are located on the opposite (southern) side of the River Thames from the proposed development. Installing a pipeline to transmit available heat across the River Thames would have substantial logistical and financial challenges. It is considered that the theoretical heat loads south of the Thames can therefore be effectively ruled out of the feasible potential consumers.

3.1.17 The distance to potential areas of significant heat demand (i.e. large heat load sites) is at least 3.9 km, the closest of which lies across the River Thames. As set out in paragraph 3.1.16, the heat loads identified on the southern bank of the Thames can be ruled out as potential customers. The closest large heat load site on the same side of the River Thames as the proposed development is approximately 5 km to the north west and lies on the other side of a railway line and residential settlements including Tilbury and Grays, which are in the way of a potential pipeline route.

Financial Feasibility

3.1.18 The proposed development will be a peaking plant which will operate intermittently, for short periods of time (typically 1-2 hours). Applying CHP to a peaking plant is not considered to be financially feasible because there is little likelihood in this case that the heat demand profile of a potential consumer will be met by the intermittent electrical energy generation profile from the facility when it is required.

3.1.19 Normally, an agreement drawn up between the operator and local customers for the supply of heat from the peaking plant would guarantee that heat would be available for specified periods of the year and in sufficient quantities to satisfy the agreed demand – financial penalties would be in place to mitigate any scenario when heat was not able to be supplied when contracted to do so. The difference between the relatively constant demands for heat from domestic and industrial users and the inherently unpredictable supply from a peaking plant such as the proposed development means that the CHP concept is not financially feasible in this case.

3.2 Prospective Heat Requirements

3.2.20 Potential users of CHP include industry, commerce, and public services and residential demand where a district heating network is feasible. From an economic perspective, the largest opportunities are in industry, where large heat demands are often found for their processes. CHP may also be used to deliver cooling services for various consumers.

3.2.21 An efficient CHP plant will be designed to meet a specified heat demand and the electrical power will be used by local plant if possible, with the additional power to be exported to the grid. As mentioned in Section 3.1, the proposed development could only serve an intermittent heat source.

3.2.22 The size of a CHP scheme is determined by the local heat load which can be supplied at a common point. As a result of this, many CHP schemes are small (< 5 MWe); comprising units which can offer high utilisation of fuel when supplying heat at full load. At times when there is low or no heat load, the efficiency of these units is much lower than that of conventional power stations.

Although there appears to be a large heat load in the area for domestic heat users, as shown in Figure 2.2, this is unlikely to represent a viable CHP opportunity based on the intermittency of the peaking plant operation and the distance from the site.

3.2.23 Due to the high cost involved in transporting heat in insulated pipes, it is not usually feasible for consumers to be spaced far apart from each other or from the heat source itself. Additionally, since the heat is generally carried as hot water, the efficiency of CHP reduces with increasing distance from the buildings the plant would be serving.

3.2.24 The unpredictability of peaking plant operation required to support the national grid demand means that the feasibility of supplying occasional heat loads to future local demands is very low.

4 Conclusions

4.1.1 It can be concluded that the following factors inhibit the current and future application of CHP at the site.

- Fundamentally, the intermittent and peaking modes of operation of gas reciprocating engines are incompatible with the likely demands of heat users.
- The reciprocating gas engines, unlike a combined cycle gas turbine power station, do not incorporate steam-raising equipment and only low- to medium-grade heat would be available.
- The distance to mapped large heat load sites on the same side of the River Thames as the proposed development is at least 5 km and a railway line and residential settlements (i.e. Tilbury and Grays) are in the way of a potential pipeline route.
- Other more diffuse heat loads are generally at more than 1 km distance and there are a number of existing and potential future physical barriers including railway line and major port and motorway construction projects.

4.1.2 As such, it is considered that CHP would not be technically, logistically or financially viable for the proposed development. This report has concluded that the project does not need to undertake further investigation of CHP for the proposed peaking plant, and provides evidence as to why the proposed development should be excluded from being CHP-Ready.

Glossary

CCGT	Combined Cycle Gas Turbine
CCR	Carbon Capture Readiness
CHP	Combined Heat and Power
CHP-R	Combined Heat and Power Ready
DCO	Development Consent Order
DECC	Department of Energy and Climate change
DTI	Department of Trade and Industry
EA	Environment Agency
EN-1	Overarching National Policy Statement for Energy (EN-1)
LEP	Local Enterprise Partnership
MW	Megawatt
NSIP	Nationally Significant Infrastructure Project
ORC	Organic Rankine Cycle
PINS	Planning Inspectorate
TBC	Thurrock Borough Council

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