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Executive Summary

In accordance with national and local policy guidelines and further to Scottish Government guidance in respect of the development of a CHP Feasibility Study, Forth Energy has investigated the potential for the proposed Grangemouth Renewable Energy Plant to provide various grades of heat for industrial, commercial and for district heating uses near to the development site.

Three potential sources of heat have been identified from the Renewable Energy Plant, two of which have been adopted for initial consideration.

The supply of premium grade heat (bled steam from turbine extraction) and medium grade heat (from the flue gas extraction) have potential to supply renewable heat for the duration of the Renewable Energy Plant's operational lifetime (expected to be at least twenty years).

The use of low grade (low temperature) heat has been discounted at this stage as a viable option for existing potential customers. Further work into future heat opportunities is being undertaken to identify potential users that might be attracted to the area to utilise this grade of heat.

A Heat and Power Plan has been developed, including a Heat Mapping assessment, a phasing and implementation plan, and an indicative district heating pipeline route. This has enabled a realistic assessment of the additional plant elements considered necessary to provide heat supply resilience and operational flexibility. An indicative district heating pipeline route has been developed. The first phase of the proposed heat network will be completed in 2015 following the commissioning of the Renewable Energy Plant.

Preliminary estimates show potential renewable heat supply volumes ranging from between 1,114 GWh/annum to 1,580GWh/annum, the latter being based on a thermal heat use of 200 MWth and giving an associated Quality Index (QI) of 116.35 for the Grangemouth Renewable Energy Plant.

Initial discussions have also been held with the management at the Ineos Refinery whose production facilities are located immediately adjacent to the Port. A letter outlining an expression of support from Ineos has been sent to Forth Energy, a copy of the letter is presented in Appendix C.

This study demonstrates that there is significant potential for a substantial volume of heat to be supplied from the Grangemouth Renewable Energy Plant. As with all project opportunities of this nature however, it will only be possible to undertake detailed feasibility studies and for commercial discussions around contractual terms and conditions to take place, post consent, when there is a confidence that the development of the Grangemouth Renewable Energy Plant will proceed.

1 Introduction

1.1.1 Forth Energy is seeking consent under Section 36 of the Electricity Act 1989 to construct and operate the 100 Megawatt (MWe) biomass-fired Grangemouth Renewable Energy Plant, on a site at the Port of Grangemouth. Sustainably sourced biomass is a recognised source of renewable energy[1].

1.1.2 In addition to the export of electricity, there is the potential for the plant to increase its overall efficiency through the supply of steam and/ or hot water to nearby consumers. The simultaneous generation of usable heat and power (usually electricity) in a single process is known as Combined Heat and Power (CHP). The process puts to use the by-product heat that is normally discharged to the atmosphere and/or to a local surface water body, resulting in a higher thermal efficiency. As a result, CHP schemes have a lower rate of carbon dioxide (CO_2) emissions per MW of useful energy produced, thereby contributing to the national reduction of emissions of CO_2 and contributing to the attainment of national policy objectives which are aimed at the decarbonisation of electricity and heat generation and sustainable economic growth.

1.1.3 To this end, Forth Energy has investigated the potential to utilise various grades of available heat (including steam for process use) from the proposed Renewable Energy Plant for industrial or commercial uses and for district heating (DH) near to the development site. The methodology of this study and the potential for such CHP is discussed below. The methodology follows guidance from the Scottish Ministers[2], SEPA[3] and DECC[4] on the preparation of a Combined Heat and Power Feasibility Study.

1.2 Forth Energy

1.2.1 Forth Energy is a joint venture formed by Scottish and Southern Energy (SSE) and Forth Ports. SSE currently operates combined heat and power plants at the following locations:

- Ninewells Hospital, Dundee: 2.6 MWe gas turbine, 7.0 te/hr composite boiler, 3 x 11.4 te dual fuel boilers.
- Slough Heat and Power, Slough: a CHP plant with six boilers and associated steam turbines with potential generating capacity of 101 MW. The CHP plant is the UK's largest dedicated biomass energy facility and its main sources of fuel are wood chips, biomass and waste paper.
- Koppers UK Ltd, Teesside: including 2.0 MWe gas Engine CHP, 11.0 te/hr composite boiler, 2 x 11.0 te/hr dual fuel boilers.
- Doncaster Dome, Doncaster: 220 kWe gas engine, 3 x 3 MWth low pressure hot water boilers.
- Western General Hospital, Edinburgh: 1.0 MWe gas engine, 800 kg/hr steam boiler, engine cooling heat recovery and ancillary equipment.
- Bromley Hospital, Orpington: 1.0MWe gas engine, 3 x 3.5 MWth Low Temperature Hot Water (LTHW) boilers, 2 x 1.3 MWe diesel generators.

[1] The 'UK Renewable Energy Strategy' (UKRES), Department of Energy and Climate Change (DECC) (July 2009).

[2] Scottish Government Guidance and information on Section 36 of the Electricity Act 1989 under which Scottish Ministers determine consents relating to thermal power stations, March 2010

[3] Annex 2 of SEPA's Thermal Treatment of Waste Guidelines 2009 and also SEPA's Scoping Response dated 12th February 2010

[4] DTI, Guidance on Background Information to Accompany Notifications Under Section 14(1) of the Energy Act 1976 and Application under Section 36 of the Electricity Act 1989, December 2006

- The Warren Development, Woolwich: Energy Centre with associated district heating and electrical networks for 500 residential high specification apartments and some mixed use commercial properties. Consists of 150 kWe gas CHP, 2 x 2 MWth LTHW boilers and pre-insulated district heating scheme.

1.2.2 Forth Energy was formed to develop renewable energy projects at Forth Ports' sites. Port locations with operational berths are ideal as they have existing infrastructure for handling large quantities of biomass. They are also industrial locations, with urban hinterlands, with a strong demand for electricity and potentially heat. Such locations also provide potential access to cooling water for the plant.

1.2.3 Forth Energy has the potential to be Scotland's biggest developer of dedicated renewable power generation facilities.

1.3 Policy Drivers for Combined Heat and Power (CHP) Background

1.3.1 The issue of climate change is recognised as one of the most serious global challenges facing society today. A group of concerned nations, under the stewardship of the United Nations, have agreed targets to reduce greenhouse gas emissions, commonly referred to as the "Kyoto Protocol". At the Copenhagen Climate Change Summit in December 2009, however, leading developed and developing countries did sign the Copenhagen Accord that is backed by a large majority of the world setting out the further need to limit the rise in global temperature to 2 degrees Celsius.

1.3.2 The European Commission has introduced several legislative mechanisms to ensure compliance with the Kyoto Protocol and likely future targets. These include the EU Emissions Trading System (EU ETS) and the Renewable Energy Directive[5], the latter requiring all EU countries to meet specified renewable energy targets.

1.3.3 The Climate Change (Scotland) Act received Royal Assent on 4th August 2009. The Act requires Scotland to reduce its green house gas emissions by at least 80% in 2050 as compared to 1990 levels. The Act also sets an interim target of at least 42 % emissions reductions by 2020, with a power for this to be varied based on expert advice from the UK Committee on Climate Change. In the shorter term, there is a commitment to reduce emissions to 2005 levels in the period to 2011. Scotland is currently committed to achieve a headline target of 20% of total Scottish energy use coming from renewables sources by 2020 and the Renewables Action Plan is in place to ensure that this is achieved. The Climate Change Delivery Plan sets out strategic options for the delivery of the targets.

1.3.4 CHP is seen as an important element in the UK and Scottish Government's energy policy, and has an important role to play in meeting the Energy White Paper's aims[6], specifically with respect to the Government's targets for CO_2 reduction. The UK Government acknowledges that opportunities for CHP are not always technically or economically feasible.[4]

1.3.5 In 2000, the UK Government set a new target to achieve at least 10,000 MW of installed Good Quality CHP capacity by 2010[7]. At the time of writing, this target has not been met, as the most recent figure for installed capacity in the UK (2008) is just 5,469 MWe, generating 27,911 GWhe and 52,197 GWh th[8].

1.3.6 In 2006, there were 87 Good Quality CHP schemes in Scotland generating over 3 GWh of electricity and 8 GWh of heat. This represents 6% of power generated and 8% of heat use in Scotland[9]. These CHP

5 Directive of the European Parliament and of the Council on the promotion of the use of Energy from Renewable Sources , Commission of the European Communities adopted March 2009

6 Energy White Paper - Meeting the Energy Challenge, CM7124, May 2007

7 Strategy for Combined Heat and Power DEFRA, 2004

8 Digest of UK Energy Statistics 2009 http://www.decc.gov.uk/en/content/cms/statistics/source/chp/chp.aspx

9 Combined Heat and Power in Scotland, Wales, Northern Ireland and the region of England in 2006, BERR

schemes mainly serve large process sites in the petrochemicals, chemicals and food sectors, with some smaller installations in the public and service sectors, hospitals, swimming pools, hotels. The most efficient and cost effective use of CHP is where there is a use for the heat either on or near the site of generation.

1.3.7 The UK Government has recently published the draft consultation for the Renewable Heat Incentive (RHI)[10]. The RHI identifies the significance of a new diverse infrastructure to support current and future heat demands. Together with the Renewable Heat Action Plan for Scotland[11], the RHI identifies strategies and programs to help achieve an 11% renewable heat target. The current level of installed renewable heat capacity and output in Scotland is about 1.4% (of the projected 2020 demand), with around 70% of this used in the industrial sector. The RHI is expected to be implemented from April 2011. The Renewable Heat Action Plan notes that "*Renewable heat ... will play a key role in helping to address both climate change and renewable energy ambitions*".

1.3.8 The Scottish Government is currently developing an Energy Efficiency Action Plan for Scotland with the intention of publishing this shortly. The draft Energy Efficiency Action Plan for Scotland[12] and the Scottish Planning Policy (SPP) recognise that maximising energy efficiency is a top priority in tackling climate change.

1.3.9 The new Guidance and Information on Section 36 of the Electricity Act 1989 under which Scottish Ministers determine applications relating to thermal power stations is also positive about the use of waste heat, however it adds a word of caution:

"The use of waste heat could be a way to assist security of supply and reduce overall emissions, although [it is] recognised that many barriers remain to be addressed.'

1.3.10 Further information on the policy background of the proposals is presented in The Need for the Proposed Development Chapter 4 of the Environmental Statement (ES).

1.4 Requirement and Guidance for CHP Feasibility Studies

1.4.1 On 9th November 2009, the Scottish Government stated, in an answer to a parliamentary question, that it had "decided that as part of any future application, either for new or significant retro-fitting for any thermal station, which would cover gas and biomass stations as well as coal, developers will need to demonstrate that they have seriously considered how waste heat from any thermal station could be utilised for use by local households or industry. The application would need to demonstrate that discussions with local authorities have been held"[13].

1.4.2 This requirement was confirmed in the new guidance issued by the Scottish Ministers with respect to Section 36 applications under the Electricity Act[2], published in March 2010. This guidance also stipulates the information required in a CHP Feasibility Study, including information on site selection and that it should be undertaken in a 'manner reflecting' the requirements of Annex 2 of SEPA's Thermal Treatment of Waste Guidelines 2009[14].

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[10] http://www.decc.gov.uk/en/content/cms/consultations/rhi/rhi.aspx

[11] Renewable Heat Action Plan for Scotland: a plan for the promotion of the use of heat from renewable sources, November 2009

[12] Conserve and Save, A Consultation on the Energy Efficiency Plan for Scotland, The Scottish Government, October 2009

[13] www.scotland.gov.uk/News/Releases/2009/11/09170209

[14] http://www.sepa.org.uk/waste/waste_regulation/idoc.ashx?docid=b61dc32b-f2e8-4f65-b237-8e67c5194f08&version=-1

1.4.3 Article 6 of the Large Combustion Plant Directive (LCPD)[15] also requires that new or substantially expanded thermal installations undertake a CHP feasibility study. Where this feasibility is confirmed, bearing in mind the market and the distribution situation, installations should be developed accordingly.

1.4.4 The Scottish Government directed SEPA in the Pollution Prevention and Control (Combustion Plant) (Scotland) Directions 2007 to give effect to relevant provisions of the LCPD (including Article 6) in any permit granted to any such installation. To address this requirement SEPA also expect developers to undertake and submit a Combined Heat and Power (CHP) feasibility study as part of the ES prepared for the development.

1.4.5 SEPA noted in their Scoping Response (See Appendix B of the Environmental Statement) that the CHP feasibility study for the Grangemouth Renewable Energy Plant should include the development of a heat and power plan which 'follows the requirements' as specified in Annex 2 of SEPA's Thermal Treatment of Waste Guidelines 20093. This is also in accordance with the Scottish Government's guidance.

1.4.6 SEPA noted that the Thermal Treatment of Waste Guidelines have been developed for energy from waste installations and the methodology specified is relevant for use in CHP feasibility studies for other fuels including biomass. This guidance has therefore been followed here and Sections 2 to 5 follow the general requirements set out in Annex 2.

[15] Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants

2 Site Selection

2.1.1 The 'Guidance and Information on Section 36 of the Electricity Act 1989 under which Scottish Ministers determine consents relating to thermal power stations'[2] states that a CHP Feasibility Study "*should include information such as site selection. The location of the site will affect whether it is possible to utilise waste heat and this should be taken into consideration with the application*".

2.1.2 A detailed Site Selection Study was undertaken by Forth Energy as described in Chapter 7 Site Selection and Alternatives of the ES and as summarised below.

2.1.3 An initial site selection study was undertaken to consider the suitability of the six Forth Ports' ports in Scotland for the installation of a biomass-fired Renewable Energy Plant with respect to the necessary technical requirements i.e. proximity to an operational berth, land availability, potential for an electrical connection and also opportunities for Combined Heat and Power. This study found that the Ports of Methil and Burntisland did not have sufficient land available in proximity to the wharf for the construction of a Renewable Energy Plant of the appropriate scale at the current time, nor were these ports capable of accepting sufficiently large size vessels.

2.1.4 A number of sites within each of the ports at Grangemouth, Leith, Dundee and Rosyth were identified as meeting the above technical requirements and therefore being potentially suitable as the location of a Renewable Energy Plant. As a result, the decision was made to investigate the environmental and technical feasibility of the various areas available at these ports, with the intention of developing four large-scale biomass plants, one at each of the ports identified.

2.1.5 The sites available at each of the ports were assessed against a number of technical and environmental requirements to identify the preferred site at each location and to identify any that would have an unacceptable environmental impact. A key selection criteria at all four ports was the presence of opportunities for combined heat and power i.e. the site's proximity to existing or proposed heat users or the availability of land for co-locating a possible new heat user.

2.1.6 Five potentially suitable sites were identified at the Port of Grangemouth, as shown on Figure 7.1 of the ES:

- A: Distribution Centre (18.05 ha site) - this is the site proposed and is described in detail in Section 1.4 of the ES;
- B: Areas Q&S (2.6 ha site) - currently used for storage of wind turbine components;
- C: Junction Dock (3.5 ha site) - a dock that would require infilling prior to use;
- D: Deep Water Berth Terminal Area (27.75 ha site) - currently unused; and
- E: Areas P&Q (10.25 ha site) - currently unused.

2.1.7 Two of the above sites were considered to be too small for the development of a Renewable Energy Plant (i.e. B and C). A detailed site selection study was therefore undertaken of the remaining three sites within the port area. The site selection studies indicated the Distribution Centre site (Site A) would be the most suitable for the location of the proposed Renewable Energy Plant. The most significant differentiators identified between this site and the other two sites of sufficient area can be summarised as follows:

- **Transport Issues -** Site D is completely isolated from the existing port infrastructure and significant additional work would be required to cross the Grange Burn between the port and this site or to provide access via the refinery, before it could be considered viable. The selected site (Site A) and also Site E have good road access within the port.
- **Ecology Issues –** Sites D and E are both adjacent to the Firth of Forth Special Protection Area (SPA) and construction at these sites could potentially result in disturbance impacts on the mudflats and a loss of

open habitat and fragmentation of the habitats of the SPA. These sites would also result in removal of habitat adjacent to the Grange Burn and there is also the potential for shading of the Grange Burn habitat. The selected site is located furthest from the SPA in comparison to the other two sites, a significant differentiator.

- **Proximity to Potential Heat Users** – the preferred site (Site A) is located closest to the potential heat users identified in the area, again a significant differentiator.

2.1.8 Site A, the Distribution Centre, was therefore considered to be the most favourable site at Grangemouth. This site is located 250m from the Ineos Oil Refinery, a potential major user of heat. The vicinity of the site has also been identified by Forth Ports for future development to attract further port trade to this area, including the development of additional warehousing, container storage and additional businesses to improve the services available at the port. The development of a Renewable Energy Plant at this site would facilitate the distribution of heat, electricity and cooling (where required). The site was considered to meet all Forth Energy's environmental and technical selection criteria and the decision was made to undertake further detailed studies with the commissioning of the ES. This preliminary assessment has since been confirmed by the EIA.

3 Description of the Facility Technology

A detailed description of the proposed plant and the combustion technology is presented in Section 6 of the ES.

3.1 Types of potential heat capture systems

3.1.1 The proposed Renewable Energy Plant will be designed to incorporate suitable modifications to allow for the export of heat in the event that a suitable user is identified, either pre or post-construction. There are three potential heat sources that exist in a conventional biomass power station:

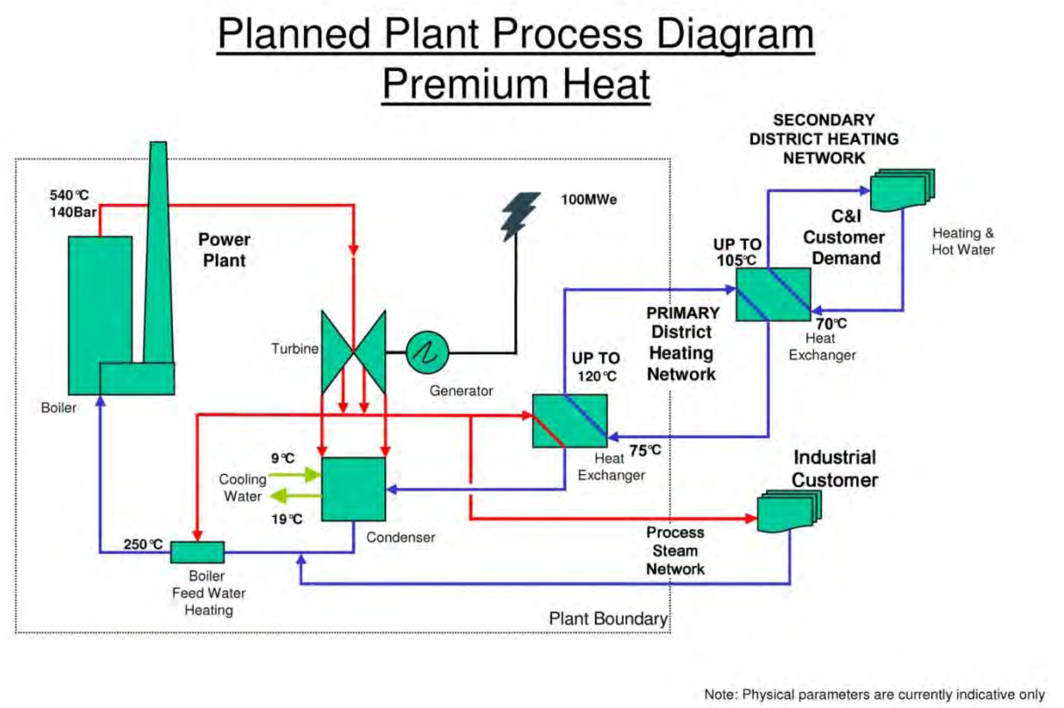
- Turbine Extraction – i.e. Premium Grade Heat. It is possible to design the turbine so that steam can be extracted at one or more points. A turbine extraction can therefore provide heat of any quality between the feed steam temperature and the exhaust steam temperature if required. This heat source is however considered a 'premium' heat source, because extracting steam from the turbine will reduce power generation.
- Flue Gas – i.e. Medium Grade Heat. The flue gas exhausting from the boiler contains heat that can be removed and exported as a hot water stream at a reasonably high temperature. The key issue with flue gas energy recovery is the capital investment required. Any heat produced from this source will have an initial capital expenditure cost and an associated ongoing operational cost. Whilst not affecting the generation capability of the plant, the economics have still to be determined.
- Turbine Exhaust – i.e. Low Grade heat. Turbine exhaust steam exists under vacuum and at reasonably low temperatures (30-50°C). This energy is typically rejected in the condensers and constitutes more than half of the total energy input to the plant. This energy is considered a low grade heat source, so energy recovery from it will not affect the generation capability of the plant or the electrical efficiency, however the use of this low grade heat is not as attractive to potential heat users due to its low temperature and difficulty of handling. Generally this low grade heat is used in horticulture/agriculture for the heating of greenhouses, it is not therefore not considered likely that this heat will be of significant use to existing nearby users at the Port of Grangemouth. It may however be possible to attract a suitable user to set-up its operations adjacent to the site to access the large volumes of low grade heat available.

3.1.2 The potential use of heat from turbine extraction and the flue gas are discussed in more detail in Section 3.2 and 3.3. The plant will be designed to be heat ready with respect to both flue gas and turbine extraction.

3.2 Turbine Extraction

3.2.1 Figure 3.1 illustrates a hot water heat export network that uses steam extracted from the turbine as the energy source.

Figure 3.1: Indicative heat export network using heat recovery from turbine extraction



3.2.2 Turbine extraction points can in theory be taken at any location along a turbine via a bleed point, providing steam at the full range of temperatures and pressures produced by the boiler. Turbine extraction is typically used in processes where high grade heat is required and at a bleed point in the turbine after a significant percentage of the energy has already been extracted for power generation.

3.2.3 The key economic consideration for extracting steam from the turbine is the resultant loss in power generation and the opportunity cost of this. The following table illustrates the typical losses in power that would result from removing steam from the turbine:

Table 3.1 Opportunity cost of heat use from turbine extraction

Extraction Pressure	5 Bar(g)	20 Bar(g)
Power Loss	0.2 MW_e / MW_{th} Steam	0.3 MW_e / MW_{th} Steam

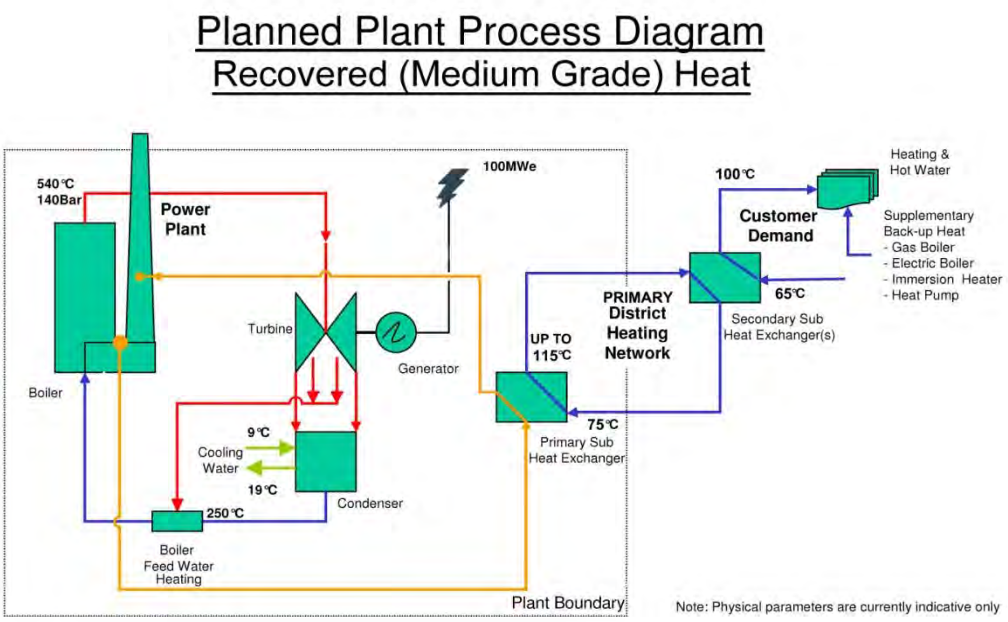
3.2.4 An important observation from this table is that more generation capacity is lost at higher steam extraction pressures; wherever possible, therefore, extractions should be taken at the lowest pressure possible. The commercial implications of this loss in power generation will only be capable of being assessed fully following discussions with potential renewable heat customers.

3.2.5 Another key point is that turbine extraction results in a re-configuration of the power station, the turbine design must be optimised to operate at a particular steam flowrate. The overall electrical efficiency of the turbine will drop and in addition, significant fluctuations away from this design point may also affect the efficiency. This is important to consider when reviewing the short and long term demand profiles of any potential heat off-take.

3.3 Flue Gas Heat Recovery

3.3.1 Figure 3.2 illustrates a heat export network based on recovering energy from the flue gas.

Figure 3.2 Indicative heat export network using heat recovery from the flue gas



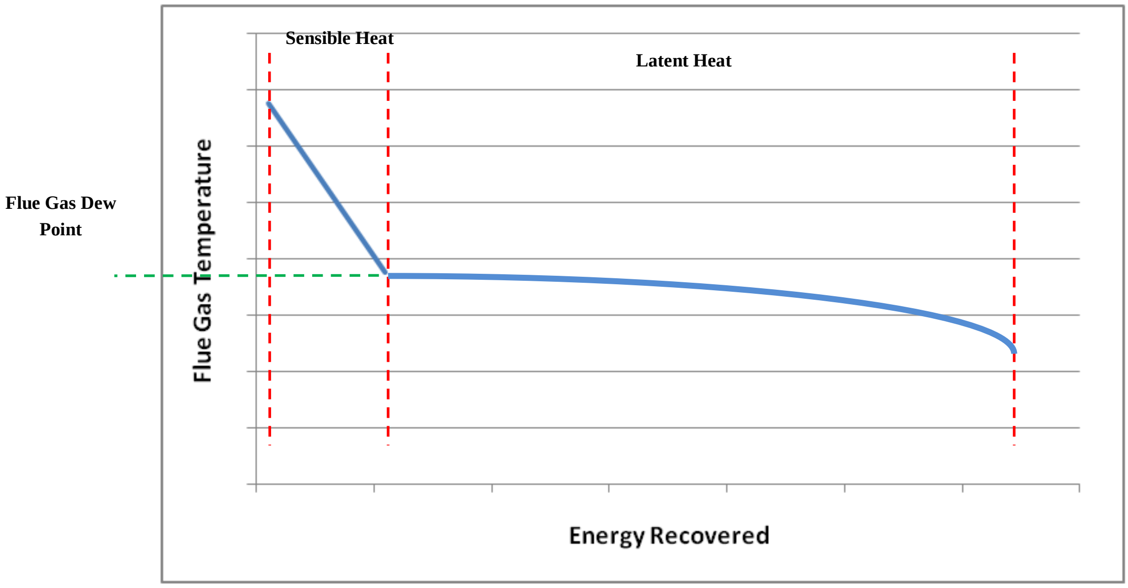
3.3.2 The use of energy recovered from the flue gas is potentially advantageous, because it does not result in a loss in power generation. However to recover heat from the flue gas, a flue gas economiser or flue gas condenser will be required; these constitute a significant capital investment.

3.3.3 The energy available in the flue gas consists of two types of heat:

- Sensible Heat. This is the energy stored in the flue gas that maintains it at a given temperature. Recovering sensible heat will reduce the flue gas temperature linearly, depending on the heat recovery load required.
- Latent Heat. This is the energy stored in the water vapour present in the flue gas; recovery of latent heat occurs at the dew point[16] of the flue gas and involves the condensation of the water vapour.

[16] The 'dew point' is the temperature to which a particular gas must be cooled, at constant barometric pressure, for water vapour to condense into water.

Figure 3.3: Energy recovery from flue gas



3.3.4 The recovery of sensible heat from flue gas is standard practice in power plants for combustion-air preheating.

3.3.5 The following practical implications of flue gas heat recovery need to be considered:

- Recovering the sensible heat available above the dew point requires a flue gas economiser, which is typically a gas to liquid heat exchanger that is used to heat water. The feed water temperature to the economiser can fall below the dew point of the flue gas, meaning that localised condensation occurs on the exchanger tubes. This will be a concern if the flue gas contains hydrochloric acid, which is dependent on fuel type and abatement systems used, as acid gas corrosion could occur. In these cases, the vulnerable tubes will normally be made from resistant material such as stainless steel, polytetrafluoroethylene (PTFE) and Glass Reinforced Plastic (GRP).
- Sensible heat and latent heat can be recovered together in a single unit called a flue gas condensing economiser (FCE). A significant proportion of an FCE's internal surfaces will be in contact with condensate, so they are generally manufactured entirely from the above resistant materials. The downstream ducting and stack will also need to be lined or manufactured from a similarly resistant material, as further condensation will occur.

3.3.6 The moisture content of the flue gas ranges from 9 - 15 % mol, depending on fuel source. The water vapour saturation point (the temperature at which the vapour will start to condense and release latent heat) at this moisture content is only 50-65 °C; sensible heat would therefore only be available for recovery up to this temperature. As most district heating schemes have a return water temperature of 70-75 °C, latent energy would not be of any use. Latent recovery has therefore not been considered any further.

3.3.7 Table 3.2 shows typical heat recovery profiles from the flue gas.

Table 3.2: Example flue gas heat recovery profile

Heat Available in Flue Gas		
	Pellet Fired	Wood chip Fired
Flue Gas Moisture Content	5.27%	11.4%
Dew Point	80-90 °C	80-90 °C
Sensible Heat – Flue Gas Temperature Range	135°C - 80°C	135°C - 80°C
Sensible Heat – Max. Achievable Temperature	115°C	115°C
Sensible Heat – Maximum Heat Recovery	14.50 MWth	19.89 MWth

3.3.8 The flue gas recovery energy figures have been calculated on the basis of a flue gas entrance temperature of 135°C and an exit temperature of 80°C. On the assumption that the flue gas temperature drops by a further 5°C by the time it exits the stack, the exit temperature will be 75°C. This is at least 10°C above the water saturation point and so is considered high enough to prevent condensation at the stack, and potential corrosion as a result.

3.3.9 Depending on the moisture content of the fuel, and hence the flue gas, between 14.5 MWth and 19.89 MWth can be exported with no loss in power generation. To achieve an overall heat export of more than 19.89 MWth, additional heat from a steam bleed will be required.

3.3.10 Following receipt of Section 36 Consent (if granted), Forth Energy will be able to agree commercial terms with potential heat users and the detailed design of the facility can then be progressed. As noted in para 3.1.1, the plant will be designed to incorporate suitable modifications to allow for the export of heat in the event that a suitable user is identified, either pre or post-construction. The phasing of the installation of the CHP technology will be dependent on the heat users identified, however an indicative implementation programme is given in Section 5.6.2.

3.4 Hot Water Storage and Back-up Supply

3.4.1 At times when the plant is off-line due to maintenance, an alternative source of heat is required. Process steam users require steam at particular temperatures and pressures, and loss of either will render the supplied steam ineffective. At Grangemouth it is proposed that the process heat users being supplied by the Renewable Energy Plant retain a substantial element of their existing steam production facilities to provide back-up when the plant is offline and to help meet peak requirements. A heat accumulator (or hot water store) will be provided to enable the Renewable Energy Plant to meet likely peak heat requirements and to provide heat for district heating customers for those times when the main boiler is not in operation.

3.4.2 The heat accumulator will comprise a large hot water tank sized to provide approximately 100 MWh capacity. The sizing of the accumulator assumes the maximum district heating demand is 20 MW and the plant heat export from flue gas heat recovery is around 10 MW. The accumulator will provide peak heat requirements for just over 12 hours and will provide full demand for approximately 6 hours. The accumulator is sized according to the requirements of anticipated district heating customers, as process steam users will utilise their own existing auxiliary supplies of heat at such times.

3.4.3 Two small light fuel oil or biomass alternative, fired auxiliary boilers (2 x 10 MWth) will also be installed to meet the needs of district heating customers at those times when neither the main boiler or the heat accumulator are available. The boilers have been designed to:

- Be large enough to meet maximum district heating demand;
- Have the ability to grow with the system;
- Have the ability to deal with lowest summer load;

- Be located for maximum flexibility; and
- Provide a high level of redundancy, to ensure heat demand can be met at all times.

3.4.4 The advantages of two 10 MWth boilers rather than a single large one would be:

- The boilers can deal with lowest summer district heating load, a 10 MWth boiler can deal with heat demand as low as 2 MWth.
- 10 MWth boilers could be used as a back up if the other is not working. At times of maximum projected district heating demand, should one of the boilers not be available; the other boiler capacity would not be enough to meet the demand. This would be avoided as far as practicable by servicing boilers before the winter season and monitoring closely throughout it.

3.5 Electrical Connection

3.5.1 A preliminary grid connection feasibility study was undertaken on behalf of Forth Energy by the local grid operator, Scottish Power Transmission Ltd (SPTL), in October 2009 and has identified that a connection would be feasible on the local 132 kV network at Bainsford substation. A new onsite 132 kV substation will be built to transform and transmit the electrical output from the plant to the existing substation via a 132 kV underground electrical connection.

3.5.2 The cable installation is expected to be laid using the traditional open-cut method with cables buried directly in the ground. An indicative cable route is shown in Figure 6.5 of the Environmental Statement (ES). The off-site electrical connection is not within the scope of the Section 36 Consent application and the environmental impact assessment. However, wherever possible the known impacts of the cable have been discussed in the ES.

3.5.3 Under the new connect and manage arrangements, generators will be able to connect to the grid on completion of local enabling works, without waiting for the completion of wider network reinforcement. A Grid Connection Application for this project will be submitted to National Grid Electricity Transmission (NGET), once Section 36 consent has been granted, seeking a Connect and Manage Offer with a suitable connection date that fits within the Forth Energy development timescale of commercial operation by the first quarter 2015.

3.5.4 It is not anticipated that any modifications to the local substations will be necessary and that a connection by 2015 would be feasible. The connection between the Renewable Energy Plant and the point of connection will be undertaken by the host network operator SPTL under their permitted development rights. The routing and design of the connection would therefore being undertaken by SPTL.

3.6 Heat export

3.6.1 The Grangemouth Renewable Energy Plant has significant potential to generate heat for potential users. At this stage in the process, heat users cannot be contracted, as it is not until the project has received consent and achieved financial close that contracts can be agreed. In addition, the operation of the proposed plant and the supply of heat is expected to be approximately 4 years away still providing sufficient time for contracts to be agreed. In the meantime however Forth Energy has undertaken an extensive heat mapping and consultation exercise to identify existing and potential users. Information from this is given in Section 5. Recognising however that future market conditions, outside the control of Forth Energy, have the potential to give rise to variations in actual heat demand, heat customers may wish to take more or less heat or new customers may emerge.

3.6.2 The economic viability of a CHP relies on a market for the heat output, with the preferred user being both located close to the facility to minimise pipeline length and having a high constant 24 hour heat or steam demand. Piping steam over long distances (typically more than 5 km) is usually expensive and inefficient, as the steam main has to be oversized and heavily insulated to minimise the loss of pressure and temperature.

3.6.3 Only a limited amount of information has been developed the detail of a potential CHP scheme at this pre-detailed design stage focusing instead on the capability to provide heat. The following text describes the types of potential users and how Forth Energy envisage the heat would be supplied to any users who wish to contract for the heat in the future.

3.6.4 There are two main types of heat use that could be potentially met by the plant:

- As steam or heat for process use in industry, generally with a constant heat demand; and
- As heat for space heating of industrial, commercial, public and domestic buildings, for example District Heating, where demand is seasonal and variable across each day. This can include provision of domestic hot water.

3.6.5 Heat is also used, less frequently, in conjunction with an ammonia cycle in chilling/ refrigeration systems (e.g. for the food processing industry, where again the demand is generally constant) and also in air conditioning. Although the capital cost of this type of air conditioning can be high, the running costs are usually low and this could therefore be an option for a large commercial or public building.

3.6.6 Three possible heat export configurations exist for the Renewable Energy Plant:

- (1) Hot water network, with the heat being provided by energy recovered from the flue gas (medium grade heat);
- (2) Hot water network, with the heat being provided by steam extracted from the turbine (premium grade heat); and
- (3) Steam export, with steam being provided from a turbine extraction point (premium grade heat).

3.6.7 Configurations 1 and 2 both produce hot water for export, so it is possible to combine the use of both heat sources; this would allow all of the energy in the flue gas to be extracted, before using steam to “top up” any outstanding energy requirement.

3.6.8 The following text describes the types of potential users and how Forth Energy envisage the heat would be supplied to any users who wish to contract for the heat in the future.

3.7 Steam for Process Use

3.7.1 Many industrial processes, such as pulp and paper production, food, chemicals and mineral processes, use large volumes of heat or steam in their production processes. This heat or steam can be provided either by an on-site boiler or by an on or off-site CHP Plant, which also generates electricity.

3.7.2 CHP offers greatest benefits where the heat load is large and constant throughout the year, which is typically the case with oil refineries or chemical works which depend on continuous processes and use large amounts of heat energy, usually as steam. The benefits are smaller where the load is intermittent such as the seasonal requirement for the processing of food crops.

3.7.3 Steam for process use is most likely to be required at a particular temperature and pressure and would be provided by turbine extraction. There would therefore be a cost penalty in the form of lost electricity generated and the anticipated annual revenues from the sale of heat must be balanced against reduced electricity sales. The temperature of the water would be supplied at up to 120^{o}C depending on the end user’s requirements.

3.8 Heat for Space Heating

3.8.1 District heating (DH) is a system where buildings and dwellings in an area receive their space heating and domestic hot water requirements from a central energy source, via a network of heat mains. At present the majority of business premises and housing in the UK are reliant upon individual boilers, the majority of which are gas fired, to provide their heating requirements. Where circumstances permit, it may be more cost effective and more energy efficient to supply a large number of consumers, located in a particular area, via a DH scheme. Industrial and commercial sectors with space heating requirements include large hospitals, industrial estates, universities, retail parks, technology parks and leisure centres. Temperatures are typically of the order of 90°C delivery and 50°C return.

3.8.2 The implementation of a DH system will require the involvement of an Energy Supply Company (ESCo). ESCos are typically private sector organisations which specialise in the provision of energy services to the public and private sector. The scope of service provision can range from the maintenance of heating systems, installing building insulation and energy controls, the operation and maintenance of centralised boiler plant on commercial and industrial sites, through to the design, financing, installation, commissioning, operation and ownership of energy assets, selling energy to end users.

3.8.3 An initial feasibility study is required to assess the technical and economic viability of a DH scheme. Account would need to be taken of initial and subsequent project phases and would progress engineering, economic, environmental and commercial issues. The supply and distribution systems would also require detailed consideration.

3.9 CHP Infrastructure

3.9.1 When steam or hot water is supplied off-site to other users, the condensate or cold water may be returned to the Renewable Energy Plant site in a closed cycle or alternatively there may be no condensate return. In some cases there would therefore be flow and return pipes required, however at Grangemouth it is not yet understood if will be possible for condensate to be returned to the plant from process heat users.

3.9.2 All piping would be well insulated and clad to minimise heat losses. It is essential that contamination in the return condensate is avoided, as this would damage the boiler and lead to extensive shut-down and repairs.

3.9.3 Water is pumped continuously around the system. Pumps are operated with 100% standby capacity to maintain heat in the event of a pump fault. The pumps would have variable speed drives to minimise energy usage. Booster pumps can be installed within the distribution pipe network to increase the distance over which the energy can be delivered. Providing the system design pressure is not exceeded then there is no limit as to the distance the water can be pumped. Heat exchangers can be used to provide pressure breaks to enable to the network to be extended.

3.9.4 The distribution pipeline will need to be sized to accommodate the ultimate peak load so as not to preclude future expansion of the system. Therefore the pipeline installed for the initial phases of the CHP development will need to have the capacity to deliver the anticipated final peak load. This has the effect of adversely skewing costs in the early years of the project. In addition heat losses from the system will need to be taken into account when sizing the pipeline.

3.9.5 The high temperature primary network will likely comprise pre-insulated pipe with polyethylene casing and polyurethane foam insulation bonded to steel service pipe to supply pressurised hot water to the customer, and to return cooler water. All primary network pipework would be installed underground. Where pipes are small, two pipes may be integrated within a single insulation sleeve. However, single pipes are likely to be used to meet large heat demands. This technology is well proven and provides an energy distribution system with a design life of up to 30 years. Additional pipe work can be added in the future and it is a straightforward process to add branches to serve new developments.

3.9.6 The typical infrastructure required for a DH scheme would comprise:

- Main heat exchanger station;
- Primary heating network;
- Secondary heat exchanger;
- Secondary heating network; and

- Consumer sited heat termination equipment.

3.9.7 The hot water for the primary heating network will be supplied from the main heat exchanger station. The hot water for space heating or hot water is transferred from the primary heating network into individual buildings through a secondary heat exchanger. In flats, for example, there may just be one heat exchanger for the whole block. Typically, the secondary heat exchanger at the end user is arranged to supply heat to the heating circuit upstream of any boiler plant. The water in the secondary circuit is heated to the temperature required to satisfy the heating needs of the building. Domestic hot water can also be provided by a separate heat exchanger. These heat exchangers can be supplied as prefabricated 'sub-stations' making installation quick and easy.

3.9.8 A range of approaches to heating sub-stations would be considered depending on the following factors:

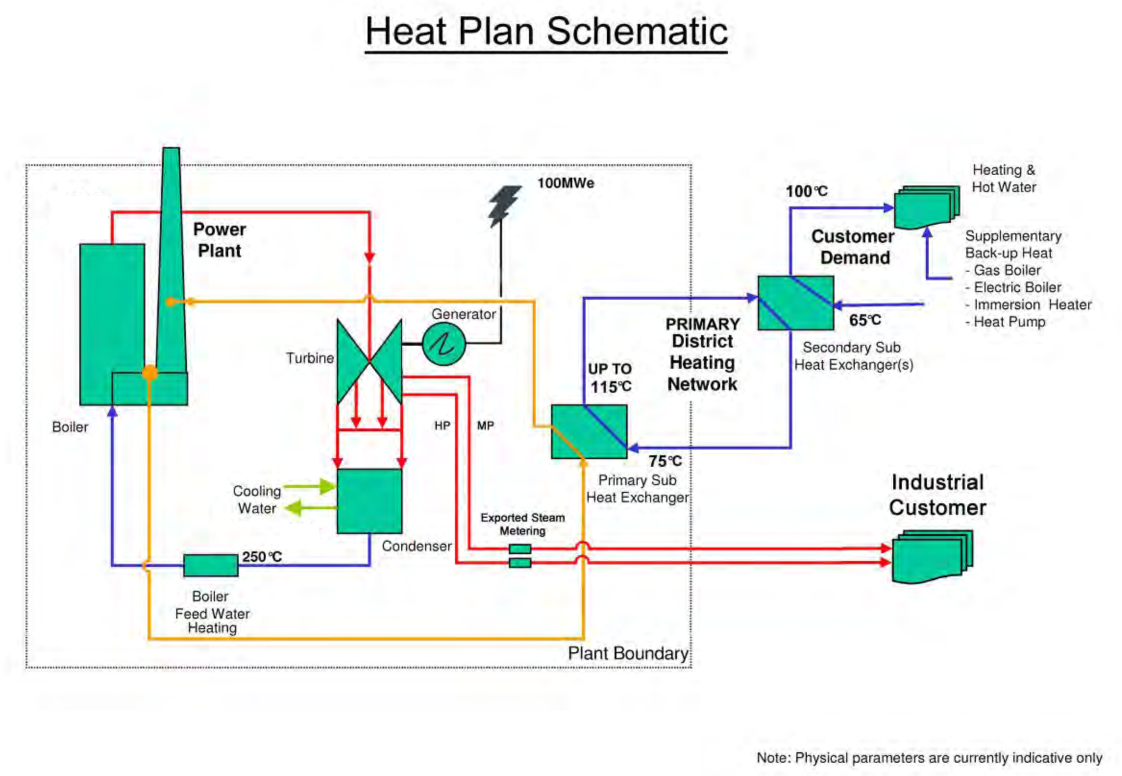
- Heat production characteristics;
- Annual heat consumption;
- Geographical site of the distribution area and the required network length;
- Number and average size of individual District Heating customers;
- Variable operational costs (pumping, water, staff); and
- Viability of the connection of each client.

3.9.9 The development of a heat metering strategy, in terms of specification and location of heat metering equipment, will enable the administration of heat supplies, supply tariffs for which will be developed post consent. Tariff development will reflect the capital and operational costs associated with the provision of heat supplies and will be finalised following a detailed assessment of the route and specific customer load requirements.

3.9.10 The infrastructure required to provide process steam is similar to that described for DH, however steam is supplied directly (without the requirement for a heat exchanger) via a pipeline to the users' receiver point. The steam extracted from the turbine will be at medium and high pressures. The medium and high pressure steam lines will pass through an export steam meters to charge for steam supply and consumption as appropriate.

3.9.11 A typical schematic for the process steam supply and district heating network is shown in Figure 3.4.

Figure 3.4 Indicative heat export network using heat recovery from the flue gas



3.10 Issues Associated with the Supply of Heat

3.10.1 The predominant engineering challenge associated with the supply of heat by hot water relates to the installation of the heat supply pipeline. The pipeline required to supply hot water is likely to be a reasonably large diameter requiring a trench up to 1.5 m wide which, where possible will be routed along public highways. There are a number of European Standards covering the manufacture and installation of pre-insulated district heating pipe networks. There are a number of UK contractors that are experienced in installing this type of pipe in public highways. Determining a feasible route for this pipeline will be carried out during the initial feasibility study.

3.10.2 Easements and Highways Licenses need to be obtained for access, construction, and maintenance of the pipes. There is a significant financial implication for obtaining easements, and these would only be progressed once Section 36 consent has been received and heat supply agreements put in place. There is also a considerable amount of work required to negotiate the traffic management requirements resulting from having to install pipes in large trenches within major access roads within Grangemouth. The traffic management requirements would need to be agreed prior to being able to obtain the necessary Highways Licenses granting permission to install the pipework.

3.10.3 Ideally a DH network would be based on supplying high heat density areas i.e. only a few pipelines going to large users thereby reducing the length of pipeline (and resultant heat loss) and minimising the disruption caused by the installation of the CHP scheme. The presence of a large commercial or industrial heat load can also allow heat to be supplied to other smaller loads along the route of the pipe, which otherwise would have been commercially unattractive due to the comparatively higher capital costs for a low heat use. An indicative heat network has been developed and is shown in Figure 5.4 highlighting the extent that a DH network might be developed, linking up demand clusters of sufficiently large customers. This network shown is approximately 15km in total length (excluding branch networks required to reach customers premises)

3.10.4 The presence of a large industrial heat load can also allow heat to be supplied to other smaller loads along the route of the pipe, which otherwise would have been commercially unattractive due to the comparatively higher capital costs for a low heat use.

3.10.5 There are number of additional factors that have hindered the large scale take up of DH in the UK, in comparison to Scandinavia and Eastern Europe where DH schemes are common. One of these is that British winters are milder and shorter, resulting in a longer return on the capital costs. In addition, in the summer, the only domestic load that could be expected from a residential development is for hot water generation, which may only be required intermittently throughout the day, with peak load being morning and evening. This results in difficulties associated with the lack of reliability and consistency of the load.

3.10.6 Another factor is the current use of the existing natural gas supply network to supply heat to housing and other buildings. The retrospective installation of hot water mains and domestic heat exchangers is expensive when compared to the continued use of this gas. In addition, individual gas consumers have the ability to switch suppliers to find the most economic option which is not the case with DH, where consumers are tied in to a single supplier.

3.10.7 DH schemes in the UK are therefore rare and have generally been associated with new build public funded, often high rise, housing where the heating loads can be readily combined and the heat distribution piping is compact. Other suitable buildings include large office blocks, hotels, hospitals, hotels, leisure centres and higher education establishments. A relatively low number of connections for a high load improves the overall cost of the scheme. Where users only have a small heat use, then a critical mass in terms of the total load of the heat connection must be achieved in a given area prior to development.

3.10.8 For low density housing, such as at Grangemouth, the supply of heat over long distances is challenging, due to the economics of wide-scale/city-wide heat distribution. The combination of high density residential and large commercial users with a large heat load throughout the day can however, give a more constant demand profile.

3.10.9 Both the Carbon Trust and Energy Saving Trust state that DH schemes will generally only be cost effective in the development of new housing estates and only where the development exceeds 300 to 400 dwellings, if no housing association/local community funding is provided. The high capital cost of the infrastructure is known to deter private housing developers. Dwelling density would also have to be in the region of 55 to 75 dwellings per hectare to be cost effective[17].

3.10.10 Retrofitting of DH to existing residential users is extremely expensive and the consumer/residential density, in terms of heat requirements, is generally too low to make it cost effective. The cost of laying the supply and return DH pipework is expected to be in the region of £500 to £1,000 per metre, depending upon the level of land development through which the pipework has to pass, and the additional costs of retrofitting DH equipment could be up to £3,000 per dwelling. The biggest potential for DH to be utilised in the UK is therefore for new, large developments to be constructed with the potential future use of DH in mind (i.e. by laying the required piping systems during construction of the scheme, to avoid the prohibitive costs of retrofitting a DH system in the future).

3.10.11 Despite the above obstacles to DH, Forth Energy are strongly committed to supplying heat to any customers who wish to contract for it.

3.11 Indicative pipework routes

3.11.1 The detailed design and timetable for the development of the heat mains for the proposed plant will be progressed following further discussions with interested parties. Some discussion has been entered into with

[17] Community heating – a guide, Energy Savings Trust (2004)

a number of potential heat users identified by the heat mapping work (described in Section 5). An initial understanding of their possible heat requirements has been factored in to the load and phasing assessments (included in Section 5.6). Further discussions, if successful, would lead into the production of heat supply agreement and designs for the pipework. However, without Section 36 consent, any firm commitment to a supply of heat is difficult to achieve.

3.11.2 It is not therefore possible to provide definitive information at this pre-detailed design stage as to the routes of pipe-work, however an indicative pipeline routing has been developed in order to service the needs of the first phase of potential customers (see Section 5.6) and is shown in Figure 3.5 Appendix D.

3.11.3 Forth Energy's discussions with Falkirk Council have identified considerable potential for the development of a District Heating network to service Grangemouth town centre. Use has been made of a Falkirk District Heating report[18] and its identified public sector loads have been accounted for in the development of an indicative Heat Plan. There is potential to establish a District Heating network with a potential supply capacity of up to 19.89 MW from the flue gases associated with the Renewable Energy Plant.

[18] 'Falkirk Council/BP Grangemouth District Heating Feasibility Study - Grangemouth District Heating Project' Electrowatt-Ekono November 27 2002

4 Description of fuels and calorific value

4.1 Fuel type and calorific value

4.1.1 It is intended that the plant will operate with a range of biomass fuels. All biomass fuels will comply with the requirements and definitions of biomass as defined in the Renewables Obligation Order19. The fuel mix for the Renewable Energy Plant will primarily comprise wood chip or wood pellets with the remainder from other biomass fuels as outlined in Table 4.1 below. All biomass fuels will be sustainably sourced, as set out in the Sustainability Statement that accompanies this application.

Table 4.1: Fuel mix

Wood (70-90%)	Other Fuels (10-30%)
Wood Chip or pellets: Virgin Timber - including short rotation forestry (e.g. eucalyptus) Forest residues	Purpose Grown Energy Crops: Short rotation coppice (e.g. willow) Grasses (e.g. miscanthus) Agricultural residues (e.g. rape seed meal) Recovered Biomass Materials: Timber (including treated timber) Paper Cardboard

4.1.2 Typical calorific values of these fuels are presented in Table 4.2.

Table 4.2: Calorific Values (CV) of Possible Biomass Fuels (MJ/Kg)

Biomass	Net CV	Gross CV	Reference
Virgin wood chip (42% moisture content)	10.6	13.25	Fichtner[20]
Virgin wood chip (dry)	20.05	22.06	Fichtner
Virgin wood pellets (7.6% moisture content)	16.95	21.19	Fichtner
Virgin wood pellets (dry)	18.55	20.41	Fichtner
Miscanthus grass (dry)	17	-	Best Practice Guidelines, July 2007, For Applicants to Defra's Energy Crops Scheme, Link: http://www.naturalengland.org.uk/Images/miscanthus-guide_tcm6-4263.pdf
Straw pellets at 8% moisture and 7% ash content	18.1	-	Link: http://www.widokenergia.pl/en/straw_pellets.html
Recycled wood chip at moisture content 20%	14.6	-	Fichtner

19 Renewable Obligation Order 2009.

20 *Fichtner is one of the world's leading independent consultancies specialising in the field of power generation and transmission and employs 1000 staff in over 30 companies around the world including the UK. With its headquarters in Stuttgart, Germany, the Group has a substantial track record in the development and engineering of power generation and renewable energy projects covering fossil fuels, wind energy (onshore and offshore), thermal solar power, biomass, hydropower and energy from waste. The Group has in-depth capabilities in all aspects of energy conversion including fuel handling, waste derived fuels, combustion, heat transfer and fluid flow, steam and thermal cycle engineering, gas engines and gas turbines, emissions abatement and the engineering of plant mechanical and electrical systems*."

Biomass	Net CV	Gross CV	Reference
Spent Distillers Grain (77.5% moisture content)	2.29	4.53	Fichtner
Spent Distillers Grain (dry)	18.61	20.14	Fichtner
Paper/Card			Based on WRATE Elemental Data (National Household Waste Compositional Study carried out in 1992/93)
Newspapers (25.57% moisture content)	12.01	13.70	Based on WRATE Elemental Data (National Household Waste Compositional Study carried out in 1992/93)
Magazines (11.3% moisture content)	9.97	11.18	Based on WRATE Elemental Data (National Household Waste Compositional Study carried out in 1992/93)
Recyclable paper (27.45% moisture content)	9.73	11.30	Based on WRATE Elemental Data (National Household Waste Compositional Study carried out in 1992/93)
Other paper (27.45% moisture content)	9.73	11.30	Based on WRATE Elemental Data (National Household Waste Compositional Study carried out in 1992/93)
Card packaging (26.73% moisture content)	11.18	12.85	Based on WRATE Elemental Data (National Household Waste Compositional Study carried out in 1992/93)
Other card (24.15% moisture content)	11.61	13.26	Based on WRATE Elemental Data (National Household Waste Compositional Study carried out in 1992/93)
Mixed waste paper	-	14-15.5	Energy Recovery from Mixed Paper Waste, Department of Civil and Environmental Engineering Duke University Durham, North Carolina 27706, Link: http://www.p2pays.org/ref/11/10059.pdf
Waste paper	-	21.3	BIOBIB - A Database for biofuels, Link:http://www.vt.tuwien.ac.at/Biobib/fuel295.html
waste cardboard	-	16-16.1	Energy Recovery from Mixed Paper Waste, Department of Civil and Environmental Engineering Duke University Durham, North Carolina 27706, Link: http://www.p2pays.org/ref/11/10059.pdf
Olive Husks (10% moisture content)	19.4	-	Fichtner
Bark (58% moisture content)	6.5	-	Fichtner
Sawdust (58% moisture content)	6.4	-	Fichtner
Palm kernels (8% moisture content)	18.1	-	Fichtner
Grass (bales) (18% moisture content)	13.7	-	Fichtner
Forest Residues (50% moisture content)	8	-	Fichtner

4.1.3 Although all biomass fuels will fit within the categories described in paragraph 4.1.1, the precise fuels to be used will only be finalised and agreed with SEPA in the forthcoming PPC permit application. The amount of recovered timber, paper and cardboard in the final fuel portfolio will be determined by a range of commercial and technical factors including; availability; price and final plant design.

4.1.4 The use of biomass resources to produce energy has many benefits for Scotland. Not only does the electricity and heat generated from biomass fuels result in significantly less carbon emissions compared with fossil fuel energy alternatives, but the use of these fuels has the potential to increase the security of Scottish energy supply and stimulate economic growth. The development of biomass energy must however go hand in hand with consideration of environmental protection and resource equality issues if the end product is to be considered sustainable. Forth Energy is committed to only using sustainable biomass in its Renewable Energy Plants.

4.1.5 The Sustainability Statement which is submitted with the Section 36 Application sets out Forth Energy's sustainability strategy will be used to guide its procurement of biomass from sustainable sources. Supplier performance will be regularly audited against the emerging national and international standards.

4.1.6 It is Forth Energy's intention to procure as much of the fuel from indigenous suppliers as practicable, if this can be economically sourced. However, it is recognised that there is limited availability of UK sourced biomass currently, therefore the majority of the fuel will, at least initially be procured from overseas.

4.1.7 There will be times during commissioning, and periodically during operation, when the FB boiler needs to be re-started (after being shut-down). Low sulphur light fuel oil (i.e. gasoil or kerosene or a bio-fuel of a similar specification) or natural gas will be used at these times to quickly bring the FB combustion chamber temperature to the correct operating range prior to introducing the biomass fuel. The on-site back-up generator and auxiliary boilers will use low sulphur light fuel oil. The calorific value of this light fuel oil is anticipated to be of the order of 42 MJ/kg.

4.2 Energy Production

4.2.1 The proposed Renewable Energy Plant will export 100 MWe to the local transmission system. It is Forth Energy's intention to provide medium and premium grade heat to local users. The thermal input to the plant will be 522.6 MW. The anticipated overall efficiency will be 60%: electrical efficiency will be in the order of 22% and thermal efficiency in the order of 38%. Table 4.2 indicates the likely heat export capabilities of the project along with associated efficiencies and QI.

Table 4.3: Anticipated efficiencies and QI for various heat loads

Heat Load (MWth)	Heat Load (MWh)	Heat Load (GJ)	QI	Gross Power Efficiency (%)	Gross Heat Efficiency (%)
0	0	0	92.27	29.29	0.00
20	1,576,800	5,676,480	95.42	28.38	5.02
40	3,153,600	11,352,960	98.36	27.53	9.71
60	4,730,400	17,029,440	101.10	26.73	14.09
80	6,307,200	22,705,920	103.68	25.98	18.19
100	7,884,000	28,382,400	106.09	25.19	22.03
120	9,460,800	34,058,880	108.36	24.63	25.65
140	11,037,600	39,735,360	110.49	24.01	29.06
160	12,614,400	45,411,840	112.51	23.42	32.27
180	14,191,200	51,088,320	114.42	22.87	35.31
200	15,768,000	56,764,800	116.00	23.35	38.19
220	17,344,800	62,441,280	117.93	21.85	40.92
Gross power efficiency (%) = gross power production / gross thermal input (based on gross cv) Gross heat efficiency (%)= heat production / gross thermal input (based on gross cv)					

4.2.2 The Renewable Energy Plant is designed to be able to operate for the equivalent of around 7,446 hours per annum (i.e. 85 % availability factor) allowing for 1,314 hours per annum for routine maintenance. The total electrical generation will therefore be of the order of 744,600 MWh (2,680,560 GJ).

4.2.3 Auxiliary power consumption will be 134,000 MWh (18 MW, assumed 85% availability). The parasitic heat load will not be known until the detailed design stage. It is likely that bled steam will be used for feed heating in order to optimise plant efficiency.

4.2.4 The steam export load to the identified process plants is likely to be fairly constant throughout each year. However, for the district heating network, by the nature of the types of services the heat export will be providing, it is possible that there will be a strong seasonal variation in heat load on the plant. An indicative daily heat load curve has been estimated for the scheme for each phase within an 8 year period from 2015 to 2023. For the district heating network, the heat demand for each month has been adjusted based on degree day data for the local area.

4.2.5 Any future sizing of heat infrastructure will need to consider the peak and average heat load requirements. Sizing such infrastructure purely on the basis of a peak requirement which might typically be expected to occur during the winter months, would likely impact on the efficiency of the district heating system during the summer months. Potential over sizing of the system in this manner, in order to accommodate short term peak flows will increase the capital and operating costs of the district heating system. Supply tariffs for heat may be affected as a consequence. It is important that heat supply tariffs are competitively priced in order to maximise subsequent uptake among potential heat users. Detailed design of the heat infrastructure will be such as ensure that the benefits of renewable heat, and associated competitive supply tariffs, are made available to the largest number of interested parties. The heat accumulator will be used to support the main plant at times of peak demand on the district heating system as described in Section 3.1.3. In addition process heat users will be able to use their existing steam production facilities to meet peak demand.

4.3 Renewables Obligation Certificates

4.3.1 All biomass fuels will comply with the requirements and definitions of biomass as defined in the Renewables Obligation Order[21]. All electricity generated will therefore qualify for Renewables Obligation Certificates (ROCs) as follows:

- Without Good Quality CHP 1.5 ROCs
- With Good Quality CHP 2 ROCs

4.3.2 A plant is a Good Quality CHP scheme for the purposes of ROCs if the Quality Index (QI)[22] at the design point is equal to or greater than 105; if the plant operates with a QI over 100, all electricity exported by the plant will qualify for the additional 0.5 ROC/MWh. For any plant with a QI less than 100, the additional 0.5 ROC/MWh will be earned on a proportion of the power exported (e.g. a plant with a QI of 90 will be awarded the extra 0.5 ROC/MWh on a lesser proportion of the power it exports). There is therefore an economic incentive for the plant to achieve a QI of 100 or greater.

4.3.3 It is also worth noting that the CHPQA are unlikely to accept a facility as a CHP plant unless a reasonable proportion of the energy input is exported as heat. The minimum heat export proportion is not defined in the legislation; SEPA are likely to appraise each project individually.

4.3.4 SEPA's Thermal Treatment of Waste Guidelines 2009[23] state that Energy from Waste (EfW) facilities, should progress within the shortest practicable time from the start of operations (i.e. within a period of five to seven

[21] The Renewables Obligation Order 2009

[22] Quality Index (QI) is the basis of the CHPQA scheme and is defined as: QI = X x Power Efficiency + Y x Heat Efficiency, where: X and Y are defined factors. Power Efficiency = Power generated at the generator terminals divided by heat in fuel based on Gross Calorific Value. Heat Efficiency = Useful heat supplied to other users divided by heat in fuel based on Gross Calorific Value. For the purposes of determining ROC eligibility for large wood-fired power stations, the X and Y factors are defined as 315 and 120 respectively.

[23] Annex 2 of SEPA's Thermal Treatment of Waste Guidelines 2009 and also SEPA's Scoping Response dated 12th February 2010

years), towards a QI[24] equal to or in excess of 93 for a plant of a similar size to the proposed Renewable Energy Plant (i.e. > 70,000 tonnes capacity). This is noted by SEPA to be equivalent to indicative gross efficiencies of between 35% and 40%. This is in order to comply with the criteria for the Quality Assurance for Combined Heat and Power (CHPQA) standards as published by Defra and, subsequently, the Directive on Co-generation of Energy[25]. This is not a requirement for the proposed biomass-fired Renewable Energy Plant, which is primarily a base load plant producing electricity rather than a plant for the thermal treatment of waste. As shown within Table 4.3, the QI of the proposed plant will be just less than 93 with no heat export (with project assumptions agreed in the financial model) and would achieve a QI of over a 100 with a heat export of 60 MW. The QI value without heat export is higher than for EfW projects since the design thermal efficiency is significantly higher.

4.3.5 The Government is, however, proposing to divorce heat and electricity generation so that, from 2013, the RO uplift for renewable CHP will no longer apply. Producers would then only be entitled to standard incentivisation for power production under ROCs and will receive incentivisation for heat under the Renewable Heat Incentive (RHI)[26].

[24] Quality Index (QI) is the basis of the CHPQA scheme and is defined as: QI = X x Power Efficiency + Y x Heat Efficiency, where: X and Y are defined factors. Power Efficiency = Power generated at the generator terminals divided by heat in fuel based on Gross Calorific Value. Heat Efficiency = Useful heat supplied to other users divided by heat in fuel based on Gross Calorific Value. For the purposes of determining ROC eligibility for large wood-fired power stations, the X and Y factors are defined as 315 and 120 respectively.

[25] Directive on the promotion of cogeneration based on a useful heat demand in the internal energy market: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:052:0050:0060:EN:PDF which sets minimum requirements for CHP plants which are eligible for subsidies from Member States

[26] Energy Act 2008

5 Heat and Power Potential

5.1 Introduction

5.1.1 An extensive heat mapping and consultation exercise has been undertaken in order to establish the pattern of existing and future heat demand and then to identify potential customers for the use of steam/ heat from the proposed Renewable Energy Plant. This is a complex exercise which can be hindered by the confidential nature of heat load information. A Heat Entrepreneurship study has also been undertaken to identify categories of potential heat users that may be attracted to Grangemouth to take advantage of the renewable heat provided by the Renewable Energy Plant. This information will be made more widely available following further assessment by Forth Energy (see Section 5.7).

5.2 Methodology and Assumptions

Heat Mapping

5.2.1 A Heat Mapping and Spatial Analysis exercise has been undertaken to identify the pattern of the existing demand for heat within the conurbation of Grangemouth and to identify potential heat users. Heat Mapping and Spatial Analysis are relatively new tools and are based on a Geographic Information System (GIS) and the creation of multi layered maps.

5.2.2 Heat load information is available from the DECC Heat Map[27]. This notes the following heat load (Table 5.1) within a 25 km^2 area centred on the site.

Table 5.1: DECC Heat Mapping Data

Type of building	Heat Load kW
Public Buildings	2,764
Commercial Offices	778
Hotel and Catering	1,290
Other Services	315
Retail	2,070
Sport and Leisure	386
Small Scale Industrial	293,146
Domestic	58,422
Education	417
Health	53
Warehouses	2,622
Communication and Transport	179
Sites with small CHP (<5MW)	3,290
Large heat load sites (including CHP sites)	697,054*
* These comprise the Ineos Refinery (687,930 kW) and the Kemfine UK Ltd. & Dalkia Plc facility (9,665 kW)	

5.2.3 Forth Energy has progressed its Heat Mapping exercise in order to augment the high level of aggregated demand data contained within the DECC Heat Map. Heat Maps have therefore been prepared for the Grangemouth Renewable Energy Plant using gas consumption data as a proxy for heat consumption. Energy consumption data has been compiled by Scottish Neighbourhood Statistics, in terms of both 'data zones' and

[27] http://chp.decc.gov.uk/heatmap/index.php

'Intermediate Geography Zones' (IGZs). Data zones are groups of Census output areas which have populations of between 500 and 1,000 household residents, with similar social characteristics, with the extent of each zone taking into account physical boundaries as far as possible. As certain statistics used in data zones are sensitive and confidential, the data is grouped together to give IGZ data, which was used as the basis for the Heat Mapping in this study. The District of Falkirk has 44 IGZs. There are 15 IGZs within a 5 km radius of the proposed Renewable Energy Plant of which 6 Zones are classified as having a medium to high heat demand.

5.2.4 Gas and electricity consumption data for the IGZs across the UK are published by the Department of Energy and Climate Change (DECC)[28] and are compatible with GIS. The data is available for both the domestic and industrial/ commercial sectors. Once integrated within a GIS, this information can be used to prepare Heat Maps with colour coding to distinguish and identify the pattern of energy consumption in detail. Red colour coding has been used here, with high intensity heat IG Zones shown in a dark red colour and low demand zones in a pale pink shade.

5.2.5 The energy consumption statistics, published by DECC, include an 'Unallocated Gas Consumption', which relates to certain IGZs with high gas consumption. Such IGZs cannot be identified due to the sensitivity and confidentiality of data i.e. the information would permit the energy consumption of a particular significant consumer to be identified, which is commercially confidential information. Therefore, once the Spatial Analysis (described in Section 5.1.2) had identified potential heat consumers within an area, it was possible to assign this unallocated gas consumption to particular IGZs on the basis of knowledge of the heat consumers in that zone. Grangemouth has a high percentage of industrial activity including some large scale resource intensive industries located within the Port of Grangemouth. A conservative approach was made that 70% of the unallocated gas consumption data could be assigned in the zonal load assessments. There therefore remains 30% of the unallocated data that could not be assigned as there was no apparent pattern for its distribution that could be identified on the basis of information available in the public domain.

5.2.6 The Heat Maps produced are included in Appendix D. The results of the Heat Mapping exercise of industrial and commercial heat users are shown in Figure 5.1 (Appendix D). Six IGZs were identified for this sector with medium to high Industrial/Commercial gas consumption and the gas consumption of these is shown in Table 5.2.

Table 5.2: Industrial/commercial gas consumption of top six IGZs

IGZ	Industrial/Commercial Gas Consumption in MWh/ annum
Carse & Grangemouth Old Town	42,516
Newlands	134,220
Grangemouth Town Centre	8,221
Bantaskin	28,336
Falkirk Town Centre and Callander Park	304,148 (including High Bonny Bridge and New Hill)
Kinniel	

5.2.7 Figure 5.2 (Appendix D) shows the results of the Heat Mapping exercise with respect to domestic consumers and the gas consumption of the top six of these are shown in Table 5.3.

[28] http://webarchive.nationalarchives.gov.uk/20090703183107/http://www.berr.gov.uk/whatwedo/energy/ statistics/regional/mlsoa-electricity-gas/page50221.html

Table 5.3: Domestic gas consumption of top six IGZs

IGZ	Domestic Gas Consumption in MWh/ annum
Carse & Grangemouth Old Town	21,615
Newlands	34,056
Grangemouth Town Centre	24,595
Bantaskin	32,237
Falkirk Town Centre and Callander Park	25,353
Kinniel	34,570

Assessment Categories for the Spatial Analysis process

5.2.8 The Heat Maps were then used to inform the Spatial Analysis, which was based on a review of OS mapping (1:50,000 and 1:25,000) of the areas of high energy consumption shown on the Heat Maps. The Spatial Analysis was used to identify the key consumers within the high intensity heat zones (i.e. those shown as dark red colour coded areas).

5.2.9 The following building categories were considered and identified for the Spatial Analysis exercise:

- Industrial space;
- Retail parks;
- Public sector – waste water treatment works;
- Chemical works;
- Refineries;
- Hotels;
- Research and development laboratories; and;
- Hospitals.

Information on a number of industries in the area has been sourced from *inter alia* the internet, trade journals and the Scottish Pollution Release Index published by SEPA. For certain companies, where sufficient site data was not accessible, estate teams or general managers were contacted as follows:

- BP LPG UK Ltd;
- Nustar (formerly Ross Chemical and Storage Company Ltd);
- Syngenta UK Ltd;
- Whyte & Mackay Bottling Plant;
- Ineos;
- Kinniel waste water treatment works;
- Dalderse waste water treatment works;
- Kemfine;
- Earlsgate Business Park (utilities operated by Kemfine);
- Grangemouth Football Club;
- MacDonald Inchyra Grange Hotel;
- Falkirk & District Royal Infirmary;
- Polimeri Europa Ltd;
- Firmin Coates;
- Flavell;
- Calor Gas Ltd.;
- Contral Instruments; and
- Alabfoil.

5.2.10 The anticipated heat consumption of the identified buildings was then estimated or identified on the basis of:

- Type of activity and use of heat/steam;
- Building profile: i.e. new build or retrofit;
- Load profiling: seasonal or a regular demand for heat;
- Operational activity: e.g. data centres, hospitals and research laboratories usually have a continuous 24/ 7 heat demand as compared to an office space which has a 10- 12 hr demand period; and
- Industrial heat demand: process heat, demand for steam, high or low grade heat.

5.2.11 A number of methodologies were used to estimate the heat consumption of the identified users. For a number of industrial and commercial sites, the Chartered Institution of Building Services Engineers (CIBSE)[29] Standard benchmark for fossil fuel thermal consumption could be applied on the basis of their floor area. For the domestic sector, the published IGZ gas consumption statistics were used. Guidance on District Heating schemes has also been adopted from the Combined Heat & Power Association and the International Energy Agency[30].

5.2.12 An overview of company profiles in Grangemouth area highlights the need for detailed site evaluations which have not been carried out at this stage. Most of the companies mapped and shown on Figure 5.3 (Appendix D) are engaged in design and manufacturing amongst other industrial activities. Site evaluations would involve both time and close engagement with stakeholders. Further assessment of the expected heat consumer profiles listed in Appendix A will follow at a later stage.

5.2.13 The heat loads for the local hospitals has been assessed on the basis of published NHS energy statistics[31] per hospital bed. A figure of 149 GJ/ bed/ annum has been assumed. This figure includes a factor for the various medical departments in the hospital such as Accident and Emergency wards, laboratories and R&D units.

5.2.14 Apart from individual site heat load estimates, various sources have also been consulted such as the Scottish Pollution Release Index[32], published by SEPA, which includes information on energy consumption of the regulated industries and has been used to identify large energy consumers.

5.2.15 The Spatial Analysis resulted in a total of 33 potential industrial and commercial heat consumers with their estimated heat consumption. Figure 5.3 (Appendix D) indicates the location of the principal potential heat consumers, however detailed information on heat consumption is not reproduced here due to the potentially commercially sensitive nature of the information. Many of these consumers are located within the premises of Industrial Estates. The consumers identified are discussed in Section 5.4.

5.3 Consultation

5.3.1 The industrial and commercial heat consumers identified by the Heat Mapping and Spatial Analysis were then contacted by letter in order to establish formal contact and initiate discussions. In addition, the following organisations were also consulted.

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[29] CIBSE Energy Benchmarks, TM46 2008

[30] Euroheat, 2008- District heating systems management guide; Euroheat, 2008 – District heating systems modernisation guide for energy managers.- key issues for refurbishing networks.; Ecoheatcool, 2006. Guidelines for assessing the efficiency of district heating and district cooling systems

[31] NHS Energy Statistics 2007/2008

[32] http://www.sepa.org.uk/air/process_industry_regulation/pollutant_release_inventory.aspx

Table 5.4: Organisations consulted

Organisation	Contact Details
Scottish Government Renewable Energy Division	Renewable Energy Division Scottish Government 5 Atlantic Quay 150 Broomielaw Glasgow G2 8LU Tel 0141 242 5812
Scottish Enterprise	Laurel House Laurelhill Business Park Stirling FK7 9JQ
Combined Heat and Power Association	Combined Heat and Power Association 35 Grosvenor Gardens London SW1 0BS Tel: 020 7828 4077
CHPQA Administrator	CHPQA Administrator AEA Energy and Environment The Gemini Building Fermi Avenue Harwell International Business Centre Didcot Oxfordshire OX11 0QR Tel: 0870 190 6196
The Energy Saving Trust	2nd Floor Ocean Point 1 94 Ocean Drive Edinburgh EH6 6JH
Carbon Trust (Scotland)	Orion House Bramah Avenue Scottish Enterprise Technology Park East Kilbride G75 0RD
NHS Estates	NHS Forth Valley CSD Buildings Unit 2 Kilhoun Street

Organisation	Contact Details
	Stirling FK7 7PX
HM Prisons Service	Scottish Prison Service Calton House 5 Redheughs Rigg Edinburgh EH12 8HW

5.3.2 Initial responses from those potential customers identified in the Heat Mapping work have enabled further discussion and initial meetings to be co-ordinated. An ongoing dialogue will be progressed with interested parties in order to develop an understanding of the possible commercial arrangements which might be considered for commercial development.

5.4 Existing Heat Users

Commercial, industrial and public buildings

Results of Heat Mapping and Spatial Analysis

5.4.1 The proposed Renewable Energy Plant site is located in the Port of Grangemouth in an area surrounded by highly intensive industrial and commercial activity including an oil refinery, an oil and gas terminal and wide scale chemical design and manufacturing industries. Table 5.1 highlights the industrial and commercial gas demand of Grangemouth and Figure 5.3 (Appendix D) shows the location of the main heat consumers. Potential heat users are identified in Appendix A.

5.4.2 Fifteen IGZs have been identified within a 5 km radius of the proposed site. Six of these have medium to high heat demand and the heat mapping exercise indicated the presence of a number of large energy consumers. These were therefore considered in detail. In addition, Bantaskin IGZ lies within a 5-7 km radius of the site and has been mapped due to the presence of the Falkirk & District Royal Infirmary, Scottish Government buildings and small scale industrial / commercial activity within this zone.

5.4.3 The Newlands IGZ has the highest demand for gas consumption at 168,276 MWh/ annum (both domestic and industrial / commercial). It has been possible to map around 75% of this demand. Other key areas of consumption include Falkirk Town Centre and Callander Park and Kinneil IGZs with a total consumption of 364,071 MWh/ annum (including High Bonny Bridge and New Hill). Around 70 % of this demand has been mapped.

5.4.4 The Earlsgate Business Park is located within the Grangemouth Old Town IGZ at a distance of 1 km from the proposed site. The Park is self sufficient with regards to supply of heat, electricity, steam and nitrogen (via a pipeline operated by BOC). Neighbouring companies in this area include Fujifilm which designs and manufactures high performance colorants for digital printing and may have a high demand for process heat.

5.4.5 Some of the larger occupiers of the Earlsgate Business Park and the immediate area include:

- Kemfine Ltd.;
- Firmin Coates Ltd.;
- Syngenta UK;
- The Whyte & Mackay Bottling Plant;
- Ceetak Engineering Ltd.; and
- Image Polymers Co.

5.4.6 The Grangemouth Ineos refinery and petrochemicals facility is located 250 m to the south east of the proposed Renewable Energy Plant site. This facility manufacturers over 2 million tonnes of chemical products per annum and the refinery has a capacity of 10 million tonnes per annum of petrol, fuel products and a range of olefins and polymer products. The refinery's oil feedstock is principally supplied by the BP operated Kinneil Terminal oil and gas processing plant which is located close to the facility.

5.4.7 Oil and gas arriving at the Kinneil Terminal is passed through a two-stage process of heating and separation to produce stabilised crude oil and raw gas streams. Both the Ineos Refinery and Kinniel Terminal facilities are high intensity energy consumers.

5.4.8 Syngenta's Grangemouth site is also located within a kilometre radius of the Renewable Energy Plant. The site has over 300 employees and manufactures fungicides and herbicides for worldwide export.

5.4.9 The 130 MWe gas-fired CHP facility operated by Fortum O&M (UK) Ltd is located less than 2 km to the south east of the proposed Renewable Energy Plant site and produces 2 x 250 t/h of steam to supply Innovene Manufacturing Scotland (previously BP Grangemouth). Surplus electricity from this facility is exported to the national grid.

5.4.10 Other potential heat consumers within a 3 to 5 km radius of the proposed site include Albafoil, Arinsdale, Bearing Power, CTS grange, Contral Instruments, Exmos Ltd, Flavell, the MacDonald Inchyra Grange Hotel and the smaller Grange Manor Hotel. The location of these can be seen on Figure 5.3 (Appendix D).

5.4.11 An estimated 462,660 MWh/annum potential heat load exists within a 2 to 5 km radius of the proposed Renewable Energy Plant. The potential heat load accounts for 54% of the total gas consumption of the Falkirk area which equates to 899,247 MWh/annum.

5.4.12 The Falkirk & District Royal Infirmary is located approximately 7 km south east of the proposed site, and comprises a newly reopened hospital campus offering 339 acute inpatient beds and a wide range of medical services.

Results of Consultation

5.4.13 Initial discussions have been held with process industry heat customers with regard to identifying the potential for the supply of renewable heat. The proximity of the Ineos Refinery affords considerable opportunity for Forth Energy to supply an element of its process heat needs. Together with the other process heat users the potential for 200 MW of process heat supply potential has been identified.

5.4.14 Discussions between Forth Energy and the companies identified through the heat mapping process are currently ongoing. Further information will be forwarded to the SGECU on the conclusion of these discussions and studies.

Domestic Users

5.4.15 The option of retro-fitting heat connections to domestic customers poses a considerable economic challenge. A high massing density of residential properties would be required in order to support cost-effective development. Further discussions with public and private sector bodies will be progressed should consent be achieved.

5.5 Potential Future Heat Users

On Site Use

5.5.1 Whilst in theory it would be possible to dry the biomass prior to combustion using heat from the facility, in practice this is rarely economically viable. The capital and operational cost of any such system normally outweighs the benefits.

Local Plan Designations

Residential

5.5.2 The Falkirk Council Local Plan Finalised Draft (April 2007) identifies one housing proposal 750 m to the west of the Distribution Centre site (H.GRA6). The proposal is to the west of Carron Dock, outwith the operational port area, and adjacent to proposed mixed use land use allocations. This proposal is for approximately 50 residential units and the applicant is Forth Ports Property Investment Ltd.

5.5.3 Other housing proposals and opportunities in the area include H.GRA5 (25 units) and H.GRA7 (30 units) approximately 1.2 km and 1.5 km to the south of the site. No new schools are being built in the area but Grangemouth High School is being replaced with a new Community High School.

Business / Mixed-Use

5.5.4 There are several economic development proposals and opportunities in the Carron Dock and Western Channel area. The emerging Local Plan identifies the following opportunities on the proposals map:

- A 3.2 ha site classified as residential / class 4 business / leisure within Grangemouth Docks Zone 2 (ED.GRA2) being promoted by Forth Ports;
- A 8.9 ha site classified as marine / water related leisure / residential within Grangemouth Docks Zone 3 (ED.FRA3) being promoted by Forth Ports;
- A 35.3 ha site classified as port related general industrial / storage within Grangemouth Docks Zone 4; and
- A 2.9 ha site classified as general industrial / storage retail at South Bridge Street (ED.GRA5).

5.5.5 The Local Plan identifies an area designated as 'EP 3 Business and Industry Areas with Potential for Redevelopment' to the west of the site, however no specific proposals in relation to this designation are identified.

5.5.6 The site is located within an industrial and general economic development area.

5.5.7 The vicinity of the proposed site has been identified for future development to entice further port trade. The intention is for this to include additional warehousing, container storage and additional business that would improve the future viability of the port and ensure Grangemouth is maintained as a premier port in Scotland. The location of a Renewable Energy Plant capable of providing heat, electricity or cooling could be considered an additional element to attract this further business.

Results of discussions with Planning and Economic Development

5.5.8 Discussions with Falkirk Council have identified considerable potential for the development of a District Heating network to service Grangemouth town centre. Use has been made of a Falkirk Council commissioned District Heating report[33] and its identified public sector loads have been accounted for in the development of an indicative Heat Plan.

5.5.9 A number of other discussions have been held with potential heat users as identified by the heat mapping, foremost amongst these is Ineos, and a letter of support is attached. At the request of other potential heat users to whom Forth Energy has initiated contact, details of initial discussions must remain confidential at this point.

[33] 'Falkirk Council/BP Grangemouth District Heating Feasibility Study - Grangemouth District Heating Project' Electrowatt-Ekono November 27 2002

5.6 Illustrative Implementation Timetable

Heat Plan

5.6.1 It is anticipated that the heat users identified above will be connected in five phases over an 8 year period from 2015 to 2023. The first three phases include the process steam users and the last two phases includes both the process steam users and hot water users. The total potential heat demand for each phase has been predicted based on the individual potential heat consumptions for the identified heat users. Certain assumptions have been made in the heat usage calculations to ensure realistic demands are considered. These assumptions will be revisited at a later stage, following the progression of detailed discussions with heat customers and will be based upon a detailed heating and hot water load assessment of the actual buildings to be connected, taking into account any diversity in load profiles.

5.6.2 Due to the confidentiality requirements of some of the users, the heat demand for each user is kept anonymous but could be supplied separately on request with the express permission of the users. Only the cumulative figures for the phases are shown here.

5.6.3 It has been assumed that the Renewable Energy Plant will supply steam to a process heat user which will be extracted from the turbine. The heat demand for the district heating users will be recovered from the flue gas.

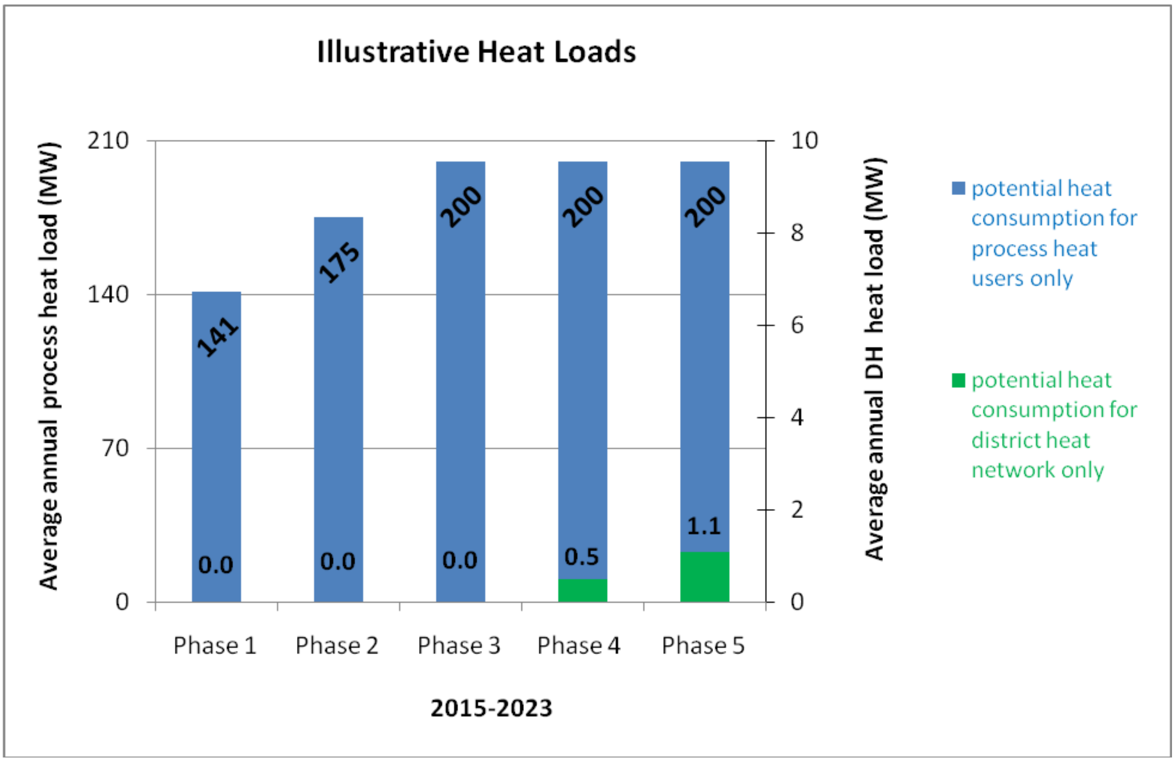
5.6.4 Table 5.5 shows the indicative phasing of the heat load based on the above assumptions.

Table 5.5: Indicative phasing of heat load

Heat Demand					
	Phase 1 (2015)	Phase 2 (2017)	Phase 3 (2019)	Phase 4 (2021) (inc district heating)	Phase 5 (2023) (inc district heating)
Heat available from turbine extraction (MW)	200	200	200	200	200
Heat available from turbine extraction (MWh/annum) **	1,492,100	1,492,100	1,492,100	1,492,100	1,492,100
Potential heat consumption for process heat users only (MWh/annum)	1,052,100	1,302,100	1,492,100	1,492,100	1,492,100
Potential heat consumption for process heat users only (GJ/annum)	3,787,600	4,687,600	5,371,600	5,384,800	5,371,600
Energy use percentage of total annual energy production (%)[1]	70%	87%	99%	100%	100%
Heat available from flue gas extraction (MW)	19	19	19	19	19
Heat available from flue gas extraction (MWh/annum) **	141,500	141,500	141,500	141,500	141,500
Potential heat consumption of district heating network only (MWh/annum)	-	-	-	3,680	8,130
Potential heat consumption of district heating network only (GJ/annum)	-	-	-	13,250	29,270
Energy use percentage of total annual energy production (%)[2]	0%	0%	0%	3%	6%
Total heat consumption (MWh/annum)	1,052,100	1,302,100	1,492,100	1,495,800	1,500,200
Total Heat Consumption (GJ/annum)	3,787,600	4,687,600	5,371,600	5,384,800	5,400,900
Energy use percentage of total annual energy production (%)[3]	70%	87%	99%	100%	100%
[1]: the plant export capacity is based on 200 MW from the turbine extraction					
[2]: the plant export capacity is based on 1.1 MW from recovery of the flue gas					
[3]: the plant export capacity is based on 201 MW from the recovery of the flue gas and the turbine extraction					
Plant availability is assumed to be 85%					

5.6.5 An average annual heat load graph has been estimated for the scheme for each phase within 8 years following the commissioning of the Renewable Energy Plant.

Figure 5.4: Indicative phasing of heat load



Implementation Timetable

5.6.6 The start of the construction of the heat system is highly dependent upon the viability of the system and the location of the heat users. For example, planning and gaining consent for installation of the pipework off the site would take a significant amount of time due to the potential impact on local traffic management. Site restraints at the receiver end, may also play an important role in the project programme. It has been assumed that the first phase of the heat network will be online in 2015 following the commissioning of the Renewable Energy Plant.

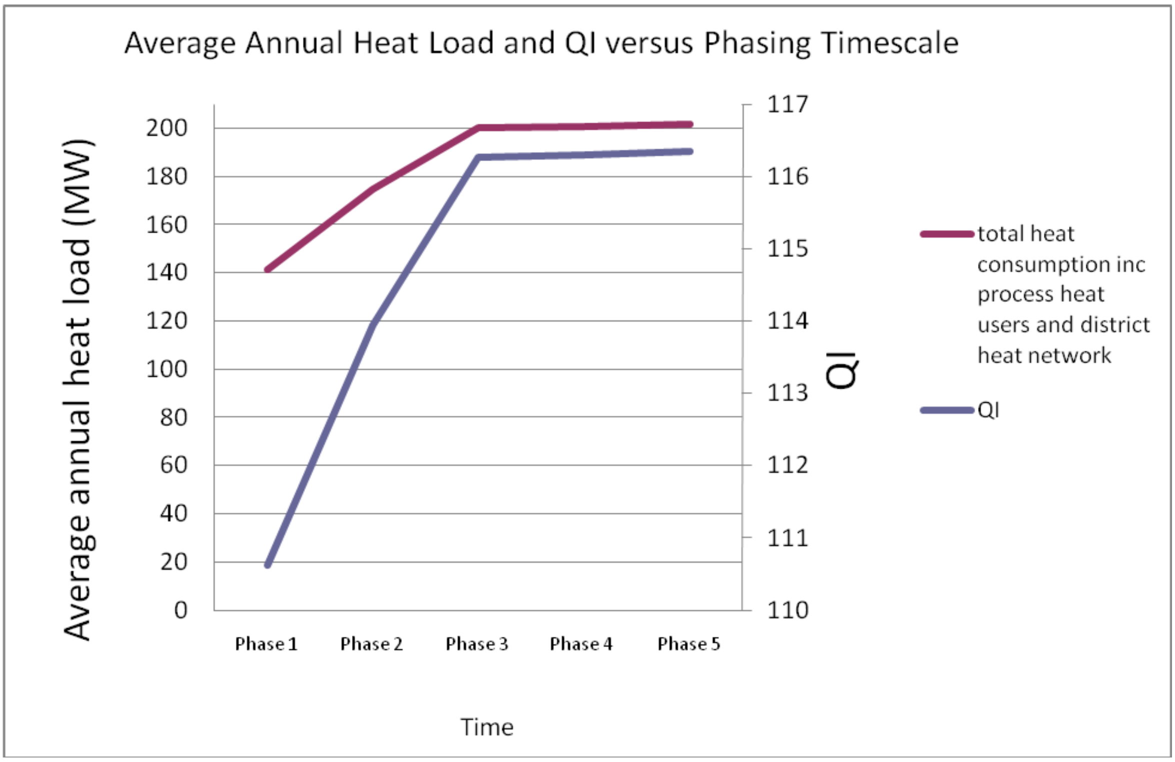
5.6.7 Table 5.6 below shows the expected annual Quality Index (QI) values and power and heat efficiencies for each year of the heat and power plan.

Table 5.6: QI and Efficiency Table

	Phase 1 (2015)	Phase 2 (2017)	Phase 3 (2019)	Phase 4 (2021)	Phase 5 (2023)
QI	111	114	116	116	116
Power Efficiency (%)	24%	23%	22%	22%	22%
Heat efficiency (%)	29%	35%	38%	38%	38%
Overall efficiency (%)	53%	58%	61%	61%	61%

5.6.8 Figure 5.5 shows the estimated average annual heat load and QI for the scheme for each phase within 8 years following the commissioning of the Renewable Energy Plant. More detailed graphs showing the anticipated seasonal changes in the heat load are illustrated in Appendix A.

Figure 5.5: Indicative phasing of annual heat load with respect to QI



5.7 Potential for co-location of heat user

5.7.1 In addition to the procurement of a Heat Mapping exercise and its subsequent use as the basis for informing the proposed Heat and Power Plan, Forth Energy has commissioned the David Livingstone Centre for Sustainability to carry out a Heat Entrepreneurship Study. This has comprised an unconstrained assessment of potential opportunities for renewable heat uses associated with the development of biomass fuelled Renewable Energy Plants.

5.7.2 The assessment is intended to serve to stimulate ideas, affording an insight into a range of possible opportunities which may be attracted by the availability of renewable heat supplies at the proposed locations.

5.7.3 The David Livingstone Centre for Sustainability was commissioned to provide the following information:

- To identify potential business heat entrepreneurship opportunities which arise from having 'heat rich' locations created by the presence of a biomass fuelled Renewable Energy Plant;
- To provide a range of suggestions for potential heat uses that could be located nearby to the proposed Renewable Energy Plant location and to consider the opportunities for heat entrepreneurship and the creation of new ventures, start-up companies and technologies that could co-locate; and
- To outline, where possible, an indication of the potential heat demand that such opportunities may utilise.

5.7.4 An initial range of potential opportunities have been identified, including:

- Hydroponics;
- Gas pressure reduction stations;
- Thermal soil bioremediation;
- Food/beverage industry and food processing;
- Anaerobic digestion;

- Sport/Leisure/Training facilities;
- Manufacturing; and
- Water de-salination and related production facilities.

5.7.5 Forth Energy intend to continue working on these ideas as the project progresses through the consenting process in order to identify the key technical and commercial characteristics that would help facilitate the development of some of these opportunities should the project be granted consent to proceed.

5.7.6 Forth Energy has identified a real opportunity to use the volumes of renewable heat at Grangemouth to meet a substantial element of Scotland's renewable heat targets for 2020 and beyond.

5.7.7 Scoping of commercial terms to describe the framework within which the project will progress will be undertaken by Forth Energy in collaboration with prospective interested parties. The framework will detail the requirements of each of the project specific issues, including (inter alia) the following:

- financing arrangements;
- fuelling arrangements;
- design related issues;
- electricity off-take arrangements;
- plant operational arrangements;
- plant maintenance arrangements; and
- heat supply conditions.

5.7.8 It will be necessary to progress heat specific discussions on the security of supply / resilience expectations of prospective commercial heat customers. Such detailed discussions will focus on technical and commercial supply arrangements and associated plant and equipment.

5.7.9 Forth Energy is committed to the progression of all discussions in a timely and efficient manner. Such discussions will require consent in order to progress the relevant issues and to engage formally with interested parties.

6 Conclusions

6.1.1 In accordance with national and local policy guidelines and further to Scottish Government guidance in respect of the development of a CHP Feasibility Study, Forth Energy has investigated the potential for the proposed Grangemouth Renewable Energy Plant to provide various grades of heat for industrial, commercial and for district heating uses near to the development site.

6.1.2 Three potential sources of heat have been identified from the Renewable Energy Plant, two of which have been adopted for initial consideration.

6.1.3 Premium grade heat (bled steam from turbine extraction) and medium grade heat (from the flue gas extraction) have potential to supply renewable heat for the duration of the Renewable Energy Plant's operational lifetime (expected to be at least twenty years).

6.1.4 The use of 'waste' (low temperature) heat has been discounted at this stage as a viable option for existing potential customers however further work into future heat opportunities is being undertaken to identify potential users that might be attracted to the area to utilise this grade of heat.

6.1.5 A Heat and Power Plan has been developed, in accordance with the requirements of Annex 2 of the SEPA 'Thermal Treatment of Waste Guidelines 2009'.

6.1.6 A Heat Mapping exercise was undertaken which identified a number of potential heat customer opportunities, each with varying range of requirements for heat.

6.1.7 The varying heat requirement for each customer type was used to develop a composite demand profile, taking account of :

- The type of facility;
- The nature of its operation;
- Its location;
- Expected annual heat demand; and
- Anticipated seasonal variation.

6.1.8 This allowed the development of a phasing and implementation plan, an indicative district heating pipeline route and also enabled a realistic assessment of the additional plant elements considered necessary to provide heat supply resilience and operational flexibility.

6.1.9 The proposed phasing of the heat connections together with a developed understanding of the composite load requirements (including heat load diversity captured in the user type profiles) has enabled the derivation of an indicative annual Quality Index for the Renewable Energy Plant.

6.1.10 The initial assessment indicates a multi-phase connection strategy may be capable of delivering useful heat to a number of district heating customers in the vicinity of Grangemouth town centre. In addition, considerable potential exists to provide an element of the process steam requirements at the adjacent Ineos refinery. The first phase of the proposed heat network will be completed in 2015 following the commissioning of the Renewable Energy Plant.

6.1.11 Preliminary estimates show potential renewable heat supply volumes ranging from between 1,114 GWh/annum to 1,580 GWh/annum, giving an associated Quality Index (QI) of 116 for the Grangemouth Renewable Energy Plant.

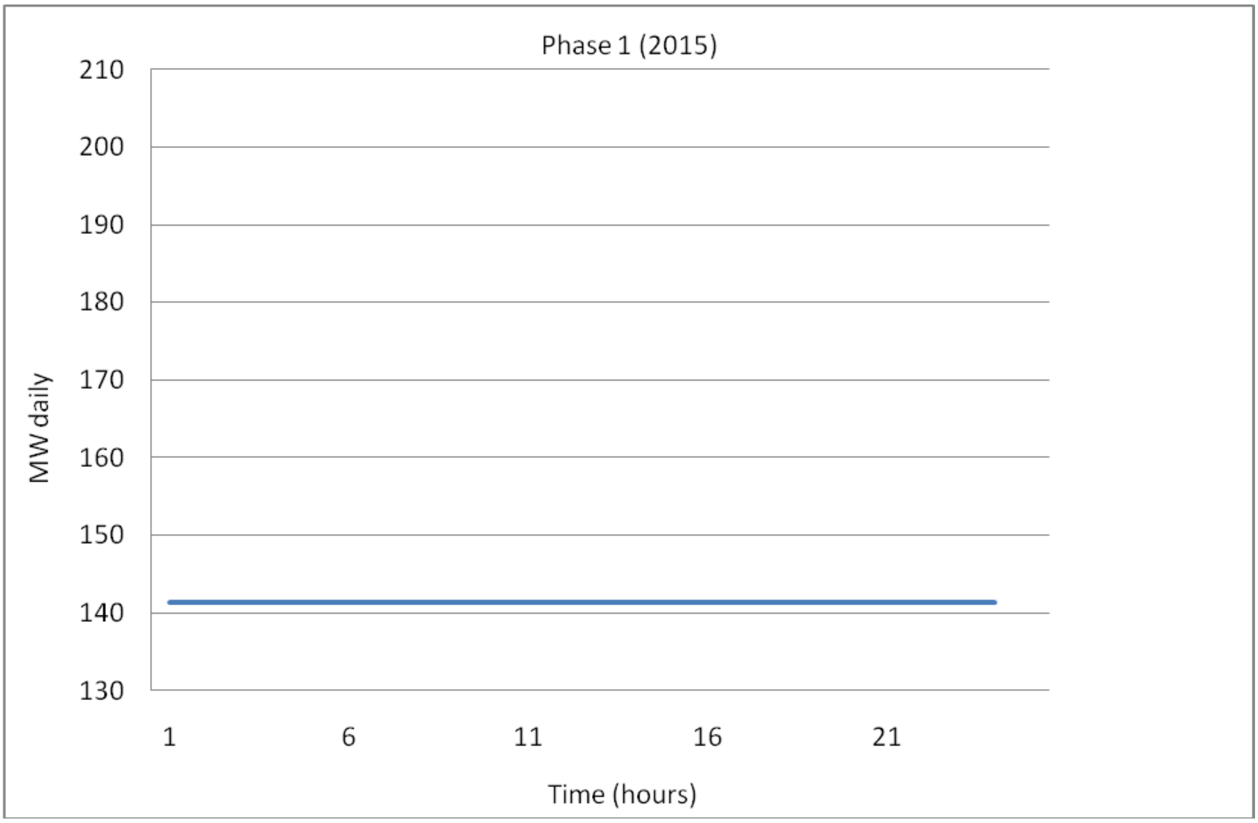
6.1.12 Initial discussions have also been held with the management at the Ineos Refinery whose production facilities are located close to the Port. A letter outlining an expression of support from Ineos has been received by Forth Energy, this is presented in Appendix C.

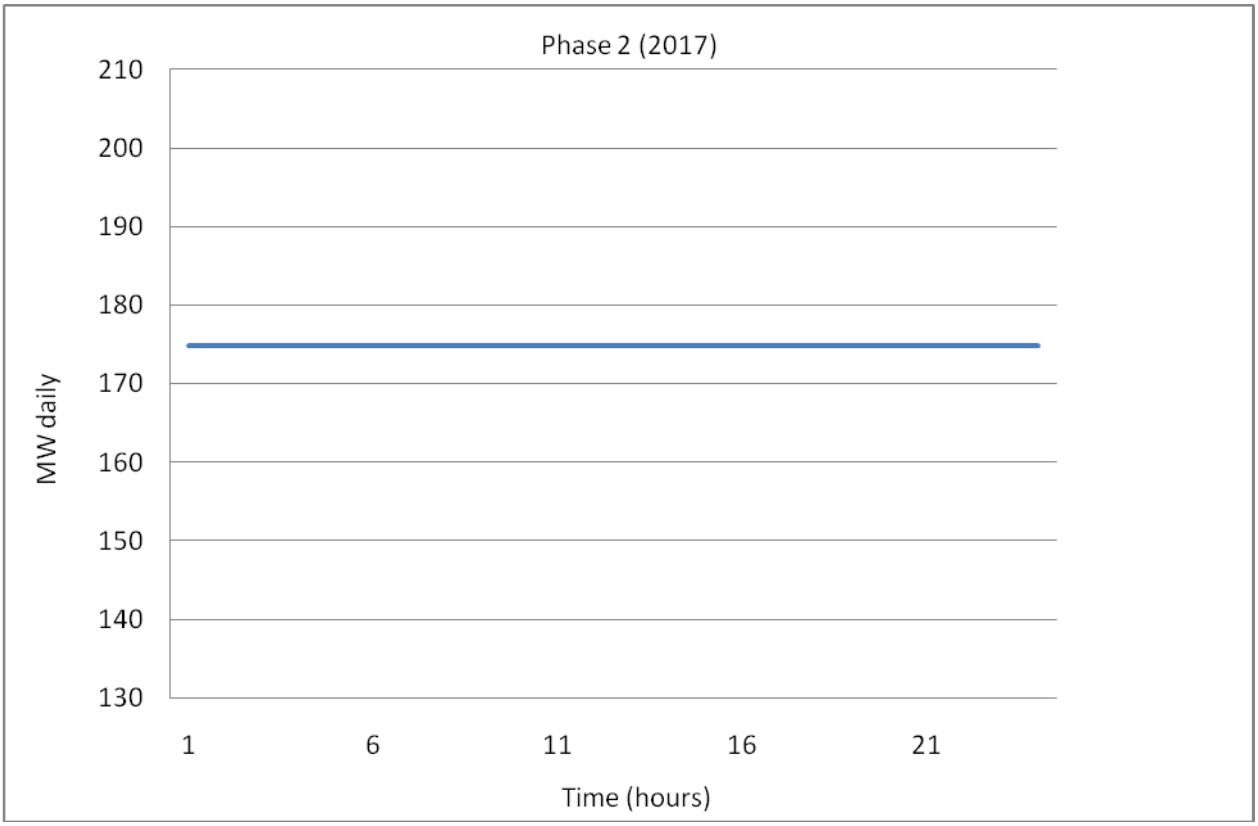
6.1.13 This study demonstrates that there is significant potential for a realistic volume of heat to be supplied from the Grangemouth Renewable Energy Plant. As with all project opportunities of this nature however it will only be possible to undertake detailed feasibility studies and for commercial discussions around contractual terms and conditions to take place, post consent, when there is a confidence that the development of the Grangemouth Renewable Energy Plant will proceed.

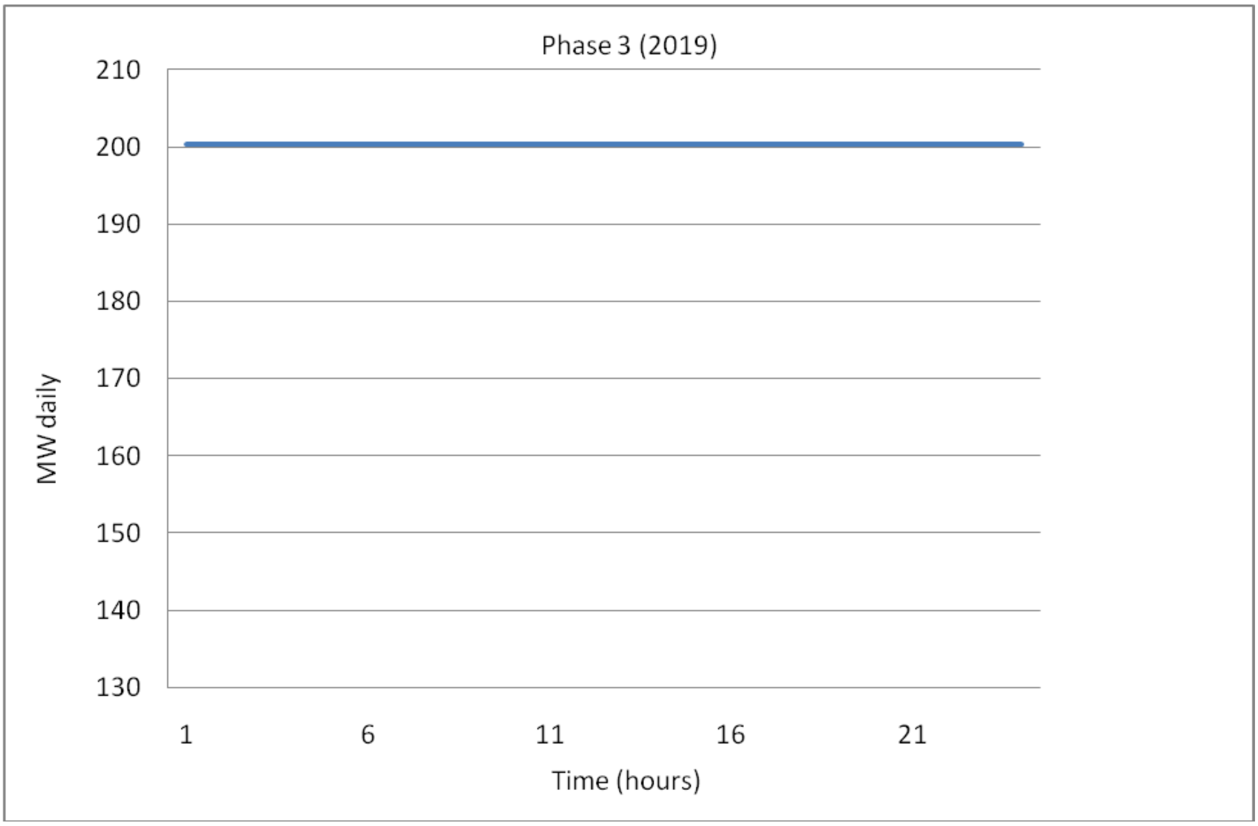
Appendix A Potential Heat Consumers

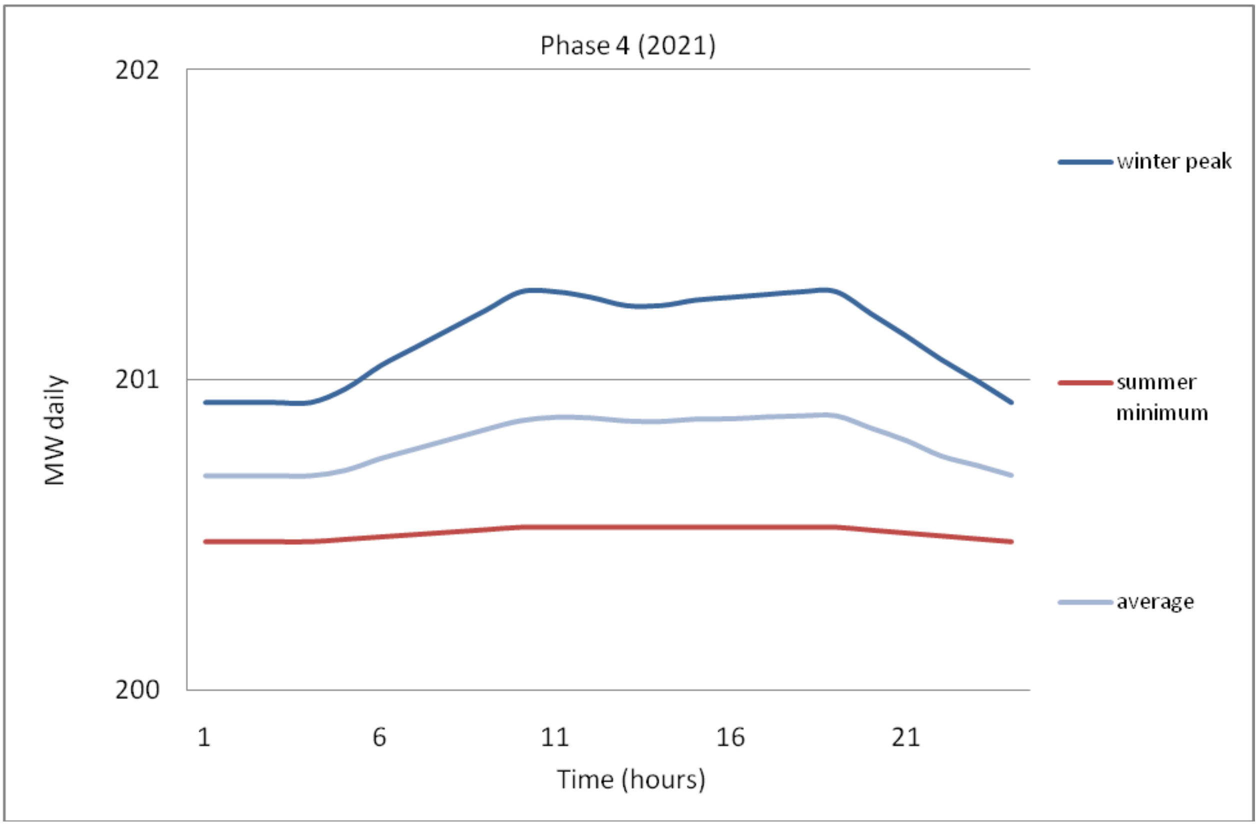
Name of company	Type	Profile	Building profile	Potential energy profile
Syngenta UK Ltd	Industrial	Manufacturing site for fungicide and herbicides 24/7 profile	Retrofit	Potential process heat
Fujifilm UK	Industrial	Manufacturing site for high performance colorants for digital printing. Day operations 9 – 15 hour profile.	Retrofit	Potential process heat
Ceetak Engineering	Commercial	Company specialises in the management and support of pumps and rotating equipment in the chemical, pharmaceutical, food and waste industries. Day operations 9 – 15 hour profile.	Retrofit	Potential process heat
Whyte & Mackay Bottling	Industrial	Bottling Plant. Day operations, 9 – 15 hour profile.	Retrofit	Heating demand unknown
INEOS Petrochemical	Industrial	Refinery including distillation unit, catalytic cracker, hydro cracker, catalytic reformer, hydro desulphurisation unit, gas recovery unit and specialist units for petrochemicals. 24/7 profile	Retrofit	Potential large scale process heat
Kinniel Oil and Gas Terminal	Industrial	Crude oil stabilisation and oil processing and gas processing. 24/7 profile	Retrofit	Potential large scale process heat
Kinniel WWTW	Industrial	Waste water treatment works. 24/7 profile	Retrofit	Potential process heat
Dalderse WWTW	Industrial	Waste water treatment works. 24/7 profile	Retrofit	Potential process heat
Kemfine	Industrial	Manufacturing site for agrochemicals, pharmaceuticals. 24/7 profile	Retrofit	Potential process heat
Grangemouth Football Club	Leisure	Football Club with heated pitch system. Day operations 9 – 12 hour profile when utilised.	Retrofit	Potential heating load
MacDonald Inchyra Grange Hotel	Hospitality	98 rooms, spa and indoor heated swimming pool. 24/7 profile.	Retrofit	Potential heating Load
Grangemouth Ship Repairs	Industrial	Day operations- 9 -15hr profile	Retrofit	Potential process heat
ASDA Distribution	Commercial	Storage facility. 24/7 profile	Retrofit	Potential cooling load
Falkirk & District Royal Infirmary	Hospital	Hospital with 339 inpatient beds. 24/7 profile	Retrofit	Potential heating & cooling load
Polimeri Europa Ltd.	Industrial	Synthetic polymer manufacturer 24/7 profile	Retrofit	Potential process heat
FirminCoates	Commercial	Specialise in warehousing and distribution of packaged chemicals. 24/7 profile	Retrofit	Potential heating load
Flavell	Commercial	Design and printing business. Day operations 9 – 15 hr profile.	Retrofit	Potential heating load
Calor Gas Ltd.	Industrial	LPG Storage. Day operations 9 – 15 hr profile.	Retrofit	Potential heating load
Contral Instruments	Commercial	Specialise in infrared instruments and accessories for instrumentation and measurement. Day operations 9 – 15 hr profile.	Retrofit	Potential heating load
Albafoil	Industrial	Involved in manufacture of Aluminium and Metal Processing	Retrofit	Potential process heat

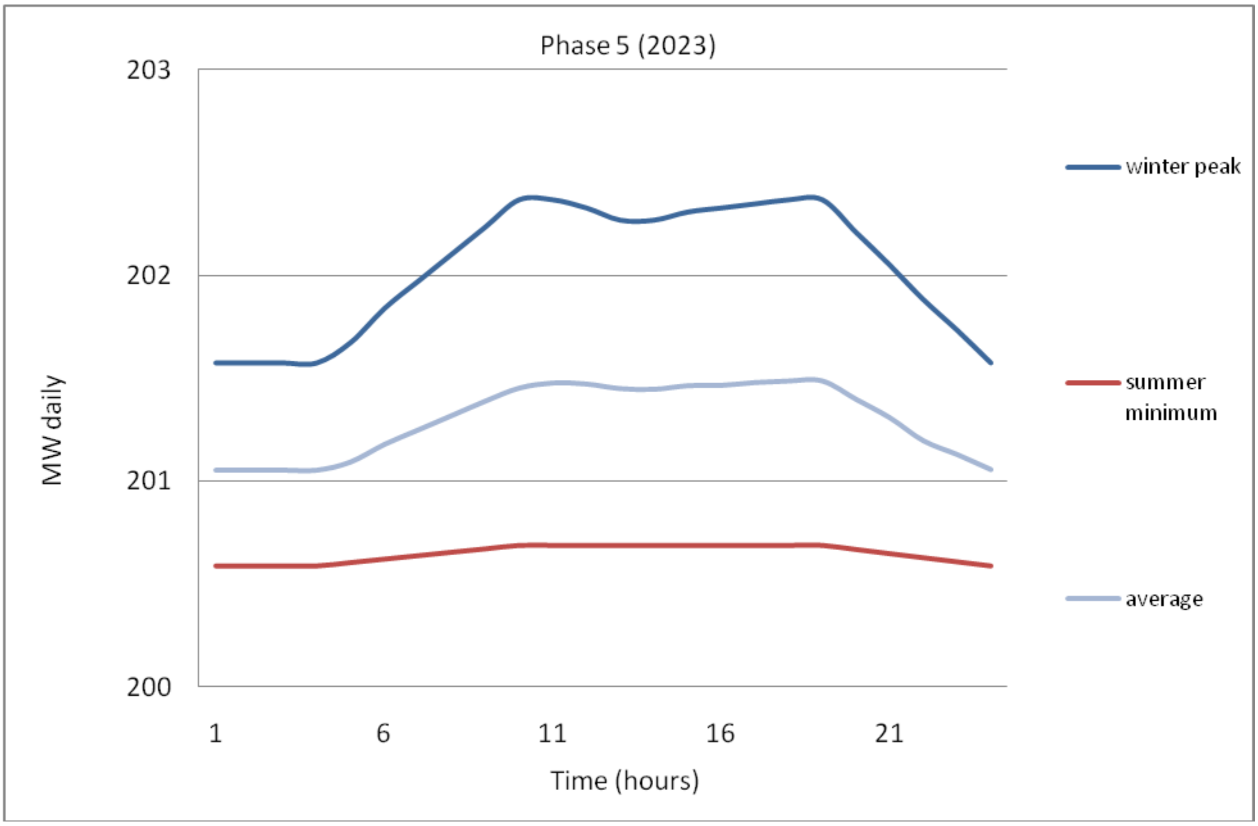
Appendix B Indicative Seasonal Heat Profiles






Phase 3 (2019)
MW daily
210
200
190
180
170
160
150
140
130
1
6
11
16
21
Time (hours)


Phase 4 (2021)
MW daily
202
201
200
1
6
11
16
21
Time (hours)
winter peak
summer minimum
average


Phase 5 (2023)
203
202
201
200
MW daily
1
6
11
16
21
Time (hours)
winter peak
summer minimum
average

Appendix C Letter of interest from Ineos

INEOS

10 JUN 2010

INEOS
PO Box 21
Bo'ness Road
Grangemouth
FK3 9XH

Direct Tel: [redacted]

Email: [redacted]

9th June 2010

Mike Thomas
Project Development Manager
Forth Energy
Imperial House
Albert Dock
Edinburgh EH6 7DX

Ref:

Dear Mike

Forth Energy proposed Biomass CHP Plant Grangemouth

As we discussed I am currently working on the energy strategy for the INEOS Manufacturing Scotland Ltd ("INEOS") manufacturing site at Grangemouth. This is a work stream that I hope to conclude by the end of this year.

As a major user of both steam and electricity our manufacturing assets offer the possibility of a significant step in achieving the Scottish Governments Renewable Energy Action Plan. If achievable this should also deliver a step change in the CO2 emissions within the Grangemouth area. It goes without saying that it does however need to have a sound and sustainable financial case.

I can confirm that INEOS have an active interest in your plans for a Biomass combined heat and power plant at Grangemouth. The proposed generation capacity from your proposal has real potential to meet a significant part of our site needs, and those of our internal customer base, from 2015 and beyond. We are specifically interested in the heat load of your proposal (in the form of steam at the appropriate delivery pressure(s)) but the renewable electricity output also has opportunities.

We would welcome the opportunity to discuss with you how we engage in discussions going forward ranging from straight forward arms length supply and purchase arrangements to operatorship or even owner/ operator potential.

I await the outcome of your planning application with interest

Yours sincerely

Dr Ray Mountford
Grangemouth Site Commercial Manager
INEOS Manufacturing Scotland Ltd

Appendix D Figures