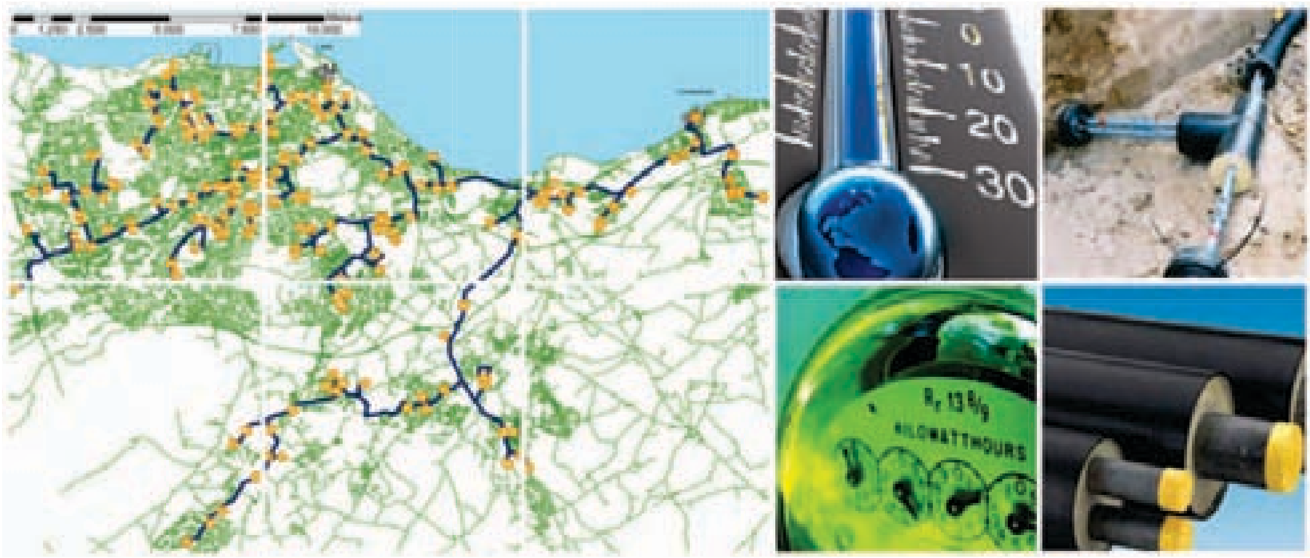

A study into the recovery of heat from power generation in Scotland

Report to the Scottish Government

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AEA Group
Colin McNaught
AEA, Glengarnock Technology Centre
Caledonian Road
Lochshore Business Park
Glengarnock
KA14 3DD

t: 0870 190 6191
f: 0870 190 5151
e. colin.mcnaught@aeat.co.uk

AEA is a business name of AEA Technology plc

AEA is certificated to ISO9001 and ISO14001

Author	Name	Colin McNaught, Evan Williams, Jeremy Stambaugh, Ben Kiff
Approved by	Name	Mahmoud Abu-ebid
	Signature	
	Date	5 September 2011

Executive Summary

Overview

This research project commissioned by the Scottish Government and delivered by AEA, develops an analysis of the financial and technical potential for recovering heat from large scale power stations in Scotland to provide heating through local district heat networks.

The study examines the potential for recovery of heat from four sites used for large scale fossil fuel power generation:

- Longannet;
- Cockenzie;
- Hunterston; and
- Peterhead.

This study then examines the policies that could help make heat recovery a financially viable option.

Heat Supply and Demand

The study considers how four new power stations at each of these sites could provide heat to anchor heat loads within an initial catchment area of 30 km around each site. The types of load considered include:

- Hospitals;
- Schools;
- Swimming pools;
- Industrial sites; and
- New development sites.

Heat loads were mapped and then a screening tool was used to identify which loads would be financially viable for connection for heat supply. With a short list of potential heat loads an outline of the heat network was developed.

Financial Model

A financial model was developed to assess the costs, benefits and CO_2 emissions associated with the recovery of heat. This model used IRR as the main measure of investment returns setting a 9% rate as the target. The following table shows results for each site under two of the scenarios: 75% and 50% of heat load capture.

	Scenario Code	Final heat load % of potential	Timescale of build up	IRR
		%	years	%
Peterhead	P3	75%	15	2.08%
	P4	50%	15	0.68%

Hunterston	H3	75%	15	3.63%
	H4	50%	15	2.17%
Cockenzie	C3	75%	15	2.31%
	C4	50%	15	1.80%
Longannet	L3	75%	15	2.80%
	L4	50%	15	1.63%

Planning

The study included a questionnaire which was sent to planners to search out details of how heat supply and demand were dealt with in current plans.

This showed that many planning authorities were developing policies that encourage co-location of heat supply and demand. However these policies have yet to be implemented. The impact of these policies can only be assessed once implemented and tested against real planning applications.

These policies are a step forward from current practice; however they do not stretch as far as planning law in Denmark. So while these new policies are likely to have a positive effect, it is unlikely that they will create a transformation in the supply of heat.

Detailed Conclusions

Technical

The technical assessment shows that it is possible to develop extensive networks for all four sites, with a range of configurations. The network for Peterhead would only serve very local customers, as the area beyond Peterhead is very rural with limited potential for heat supply. The network for Cockenzie is much bigger, extending well into Edinburgh as this area is urban with many potential heat consumers.

The technical assessment shows that it is possible to recover significant amounts of heat from future power stations that have CCS fitted. This is a key issue because CCS uses a significant amount of heat. CCGT stations are more at risk of this –

because the heat is extracted from the steam turbine. Hence CCGT sites that could serve an extensive network of heat consumers are most sensitive to this issue. In Scotland this is most evident for the Cockenzie site.

Financial

The analysis uses a number of different assumptions on the %age of sites captured as heat customers and the timescale to build up the heat network and heat sales. Some key results are:

- If all 100% of loads (existing and future buildings) connect within 15 years none of these projects would be financially viable (9% IRR). This is not a surprising outcome – if the returns were attractive projects would be under development.
- The funding gap to make projects viable is significant – from £12 million to £92 million.
- If a more accelerated connection rate is assumed the IRR improves significantly and the funding gaps reduce. This scenario is currently unrealistic for Scotland – but is close to the situation in Denmark where heat planning laws require existing and new buildings to connect to the heat supplier's network.

The sensitivity tests show that revenue incentives would be an expensive and impractical route to support schemes. However accelerating the connection of heat loads offers a route towards more cost effective schemes.

Planning

The review of current and future planning policy concludes that:

- Many of current planning policies support heat and co-location of heat supply and demand.
- NFP2 and SPP are recent documents, and the strategic and local development plans are not yet in place, so it is too early to be fully certain of the impact of these policies.
- It is likely that there will be some progress, as developers and planners use the new policies.
- However, the policies were not drafted to deliver a rapid transformation in the uptake of heat recovery and district heating in Scotland. So these new policies are not expected to create a market for district heating as found in countries like Denmark.

Assuming that these conclusions are correct, and that there is a policy requirement to deliver much great uptake of heat recovery and district heating, this suggests that:

- In the short term opportunities for heat recovery and district heating may be missed, as co-location cannot be delivered retrospectively.
- If a transformation in the uptake of heat recovery and district heating is required, further changes in planning policy will be required to accelerate uptake.
- This may require more prescriptive policies, so a review of international planning policies would provide valuable insight into the policy options that have been used and how they could be relevant to the Scottish context.

Policy Options

The model was used to test a selection of policy ideas. The analysis shows that:

- Most policy ideas have a modest impact on the IRR, none of the policies and their assumed impacts led to an increase of IRR to 9%.
- The two policy ideas which had the highest impact co-locate heat supply and heat demand.

These results demonstrate that planning policies are likely to be the most effective way to encourage heat recovery and district heating.

Overall Conclusions

This study shows that it is technically possible to recovery significant amounts of heat from the four large power station sites. However the financial returns are far from attractive for investors.

Direct financial support from the public sector for these investments would need to be very significant to have any impact on IRR and would be very difficult to justify, due to the source of the heat (fossil power stations) and the State Aid requirements.

A range of other policy ideas were tested, these had relatively limited impact on the IRR, but policies that reduced investment costs by co-location of heat supply and demand had the highest impact.

Hence there could be the potential to develop planning policies with mandatory requirements for co-location, drawing on international experience to shape these policies to the Scottish contents and opportunity.

Broader Recommendations

The study also includes a number of broader recommendations, recognising that there is a wider range of opportunities for district heating in Scotland beyond heat recovery from the four power station sites, these recommendations cover:

- Investigation of the wider potential for district heating in Scotland.
- Comparison of district heating with the competing options for low carbon heat.
- A review of international best practice in policies for district heating.
- The potential for a Heat Planning Law in Scotland.
- Heat Mapping.
- District heating Code of Practice.
- Examining the role of regulation in the expansion of district heating.
- How EU Energy Efficiency Action Plans could support policy development.
- Integration of district heating into existing policy and programmes.

These recommendations could be taken up by the proposed Expert Commission on District Heating.

Contributors

The project team would like to thank individuals and organisations who contributed comments:

Bill Lindsay, Team Leader, Local & Community Policy, Fife Council
Michael Westwater, Planner, Strategic Policy & Tourism, Fife Council
Hugh Muschamp, Lead Officer- Sustainable Development, Fife Council
Douglas Evans, Energy Manager, West Lothian Council
Sarah Collings, Planner/ Urban Designer, West Lothian Council
John M Smith, Director, CASA Planning and Development Ltd
Ian Glen, Policy & Projects Manager, East Lothian Council (Planning)
Neil Ferguson, Senior Energy Executive, Scottish Enterprise
David Jennings, Aberdeen City and Shire Strategic Development Planning Authority
John Bury, Head of Planning, City of Edinburgh
Sarah Hartop, Planner, City Development, The City of Edinburgh Council
Graeme Smith- Planner, SESplan
John Esslemont- Acting Manager, Ayrshire Joint Planning Unit
David Hammond, Planning Officer, North Ayrshire Council
Colin Hemfrey- Development Plan Co-ordinator, Falkirk Council
John Angell- Acting Head of Planning and Transportation, Falkirk Council
Niall Urquhart- Team Leader Sustainability, Clackmannanshire
Eric Dodd, Community Energy Scotland
Jon Cape, Renew Services Ltd
Fenella McEwan, Policy Officer, Fife Council
Ian Glen, Policy and Projects Manager, East Lothian Council
John Ferguson, Binn Eco Park
Rufus Ford, Scottish and Southern Energy
Bill Watson, Angus Biofuels
Eric McRory, Sustainable Energy and Resources Unit Manager, SEPA
Maf Smith, Sustainable Development Commission Scotland
Paul O Brien, Scottish Development International
Paul Hindle, Scottish Power

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1 Introduction

This research project commissioned by the Scottish Government and delivered by AEA, develops understanding of the financial and technical potential for recovering heat from large scale power stations in Scotland to provide heating through local district heat networks.

1.1 Background to Study

The Scottish Government recognises the increasing threat of climate change and the issues associated with energy supply (for example rising costs and security of supply). A range of policy initiatives and programmes are in place to address these threats, including:

- A target to generate 100% of gross electricity consumption from renewable sources by 2020.
- A target to reduce greenhouse gas emissions by 80% by 2050.
- An interim target to reduce greenhouse gas emissions by 42% in 2020.
- A target for 11% of Scotland's heat demand to be met by renewable sources by 2020.

These targets are part of the Greener Scotland objective of the Scottish Government's Economic strategy, which has as its central purpose the creation of sustainable economic growth. Hence, the energy and climate change targets are closely linked to wider objectives of job creation and fuel poverty reduction.

The Scottish Government acknowledges that to achieve these ambitious targets Scotland will need to embrace a variety of existing and emerging fuels and technologies. It is anticipated that the bulk of the energy that will contribute to the target for electricity will come from intermittent renewable sources. This will require the presence of back-up base load generating capacity to be installed. For the foreseeable future this will be provided by fossil fuel sources and to a lesser extent biomass. This offers a significant opportunity for the recovery of heat in particular from large scale power stations.

In this context, the purpose of this study is to examine the technical and financial prospects for the recovery of heat from 4 sites used for large scale fossil fuel power generation. This study then examines the policies that could help make recovery of heat a more practical option.

1.2 Energy and Carbon Context

Scotland has adopted a world leading target of reducing greenhouse gas emissions by 42% in 2020 and 80% in 2050. To deliver this, four transformational outcomes have been identified for 2050:

- A largely decarbonised electricity generation sector by 2030, using renewables complemented by fossil fuels with Carbon Capture and Storage.
- Largely decarbonised heating for buildings by 2050, through reduced demand, energy efficiency, and renewable and low carbon heating.

- Almost complete decarbonisation of road transport by 2050, with significant progress by 2030, through wholesale adoption of electric cars and vans; and
- A comprehensive approach to carbon in rural land use.

To deliver these outcomes it is essential to examine all options that could make a material contribution to these objectives.

Previous and on-going activity in Scotland is already examining other contributions to de-carbonise heat supply, examples include:

- The Biomass Action Plan.
- The Scottish Biomass Support Scheme.
- Heat plans for energy from waste plants.
- The Renewable Heat Incentive for biomass, ground source heat pumps etc.
- Use of Section 36 consents to encourage heat recovery from biomass power stations.
- The pilot district heating loan scheme.
- A number of actions set out in the 2020 Routemap for Renewable Energy in Scotland.

This study examines a further opportunity, recovery of heat from large fossil power stations.
Analysis of the energy balance in Scotland for 2002[1] estimated that energy losses in coal and gas fired electricity generation in Scotland at 40 TWh. In the same year natural gas consumption in Scotland was estimated to be 63.5 TWh, most of which will be used for space heating and hot water.

Thus, if only a fraction of these energy losses can be captured and used to displace other heating fuels, significant savings in carbon emissions could be achieved.

Hence this study considers the technical and financial issues associated with recovery of heat from four large power stations sites in Scotland, including the costs and investment returns in the district heating network. This would represent a step change in the scale of district heating in Scotland, adding four large scale schemes to the growing list of smaller community based examples.

The transformation of heat supply from fossil fuel to district heating is not without precedent. The following chart shows the percentage of the population served by district heating in a selected number of countries in the European Economic Area[2].

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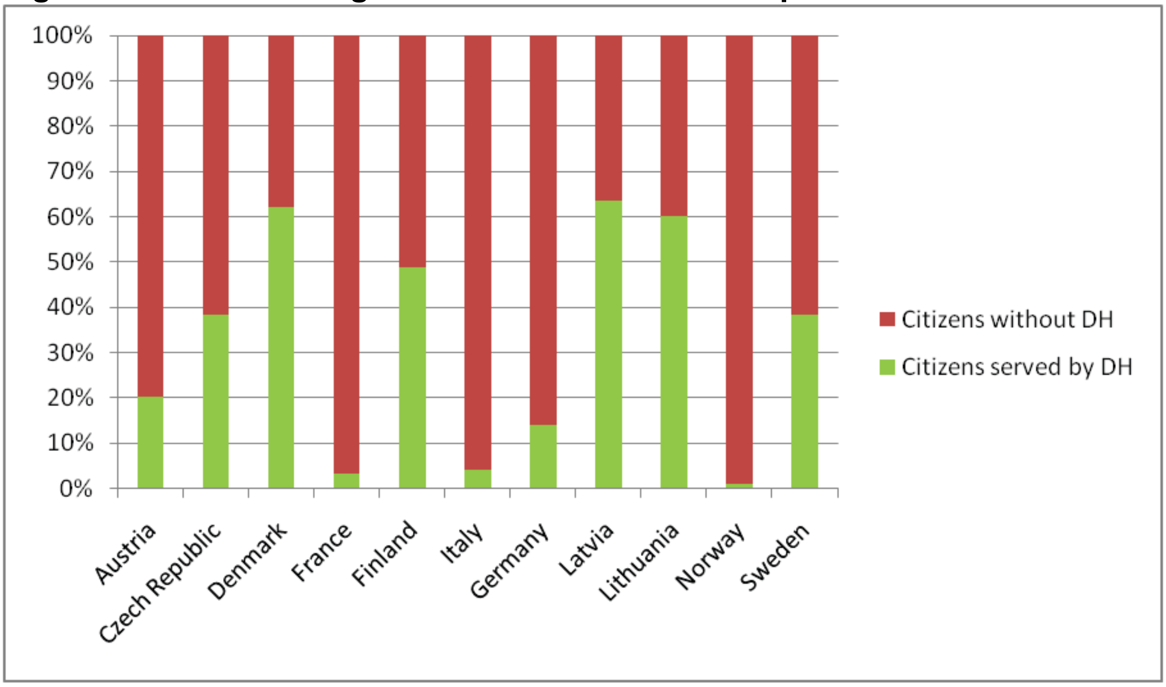
[1] Scottish Energy Study, Volume 1, http://www.scotland.gov.uk/Publications/2006/01/19092748/0
[2] Source: DH Barometer, http://ecoheat4.eu/en/Home/Welcome/

Figure 1 District heating Statistics in Selected European Countries



This shows that several countries in the north of Europe have 40% to 64% of the population connected to district heating. The exception is Norway, where electrical heating dominates, a benefit from Norway's extensive hydro power capacity.

District heating has grown in countries like Denmark as the result of a range of policy measures, particularly planning policies, but also financial support mechanisms. This has supported a range of district heating schemes, from large scale power station based projects to small community scale projects.

Thus it may be possible for Scotland to follow a similar process of transformation, if this is deemed a valuable and viable option for heat supply.

This study will provide insight to support decisions regarding the potential for heat recovery and the case for policies to support the development of this potential.

1.2.1 Report Structure

This report is structured to provide information under the following sections:

Table 1 Report Structure

Section	Summary
2. Introduction to District Heating	This section provides an overview of the main elements of a district heating system and discusses some of the key issues associated with district heating.
3. Network Modelling	This section provides details of the output and operations of the 4 power stations and the assumptions regarding the fuel mix, efficiency and back up heat demands which must be taken into account when modelling the availability of heat from these stations. This section of the report describes how the anchor heat loads are spatially disaggregated within the selected study area. Separate sections consider; Hospitals, Schools, Prisons, Swimming pools, Universities and colleges. The section goes on to discuss the tools and logic used to select routes for pipes.
4. Financial Modelling	This section describes the model used to calculate the annual and whole life cost resulting from bleeding-off steam from discrete power stations to supply heat to surrounding buildings via district heating networks. The model also provides an assessment of carbon dioxide savings
5. Core Results	This section presents the results from modelling each of the 4 power stations.
6. Components of Successful Schemes	Three case studies profile successful implementation of district heat networks. These case studies detail the customer base, drivers, barriers and supportive policies which underpinned this approach.
7. Identification of Current Policies	This section introduces the key energy and planning policies that support and impact on the development of district heating networks This includes a discussion of the Electricity Market Reform as this will have significant impacts on the viability of district heating networks.
8. Review of the Planning Position	This section reviews the status quo. Looking at how councils are responding to the introduction of the new SPP to ensure that the recommendations from this study do not duplicate initiatives that are already underway.
9. Identification of Barriers	This section explores the potential barriers to overcome in delivering a successful district heating network.

10. Ideas for policies and ranking of policy ideas	Policies that overcome the barriers are proposed, categorized, assessed for ease and effect, and ranked. The impacts of the highest ranking policies will then be modelled.
11. Recommendations	The potential impact of key policy ideas is assessed using the model and recommendations are presented.
12. Conclusions	This section presents the conclusions stemming from this work.

2 Introduction to District Heating

2.1 Basic Concepts

District heating can take many forms. The key element is the replacement of individual boilers in each building supplying heat with a network of heat pipes that carry heat to buildings from a central source, or sources, of heat.

The key components of a district heating system are:
- The heat source.
- The heat pipe network.
- The consumer unit in each building.

Looking at each of these in turn:

The heat source can take many forms. Examples include:
- Heat only boilers, burning a wide range of fuels from fossil (gas, oil etc) to renewable (biomass).
- CHP units, typically gas engines which generate power and heat, where the heat is recovered from the exhaust and cooling systems of the engine.
- Power stations, where large amounts of heat can be recovered.
- Energy from waste plants, typically where waste is combusted and heat and/or power is recovered.

In larger systems there can be more than one heat source.

The heat pipe network links the heat sources to the heat consumers. The pipes will be made of steel (main elements) or plastic (final connections to consumers). Pipes are pre-insulated in the factory, to provide a low level of heat loss. The size of pipe required is set by the peak heat flow in the system. So the largest pipes are required close to the heat source, with size gradually decreasing further from the heat source. The final stages of the network are much smaller and may be made of plastic.

District heating systems can carry hot water or steam. If the consumers include industrial sites that require steam then the network will need to be configured to carry steam throughout. Buildings typically require hot water for space heating.

Network configurations depend on the topography of heat sources and heat consumers, simple systems may be radial in nature

The largest element of capital cost is the heat network. The pipe is expensive plus there are high costs to install the pipe. Installation requires a trench to be dug, preparation of the bed of the trench for the pipe, joining the steel and insulating jacket and re-instatement of the trench. In urban areas the pipe route will need to be navigated around existing services (water, sewage and gas pipes and electricity cables).

The cost per metre of the heat pipe ranges from £400/metre for the smallest diameter pipe (20 mm) to almost £3,000/metre for the largest (1,100 mm)[3], a typical cost is around £1,000/metre. A study by Poyry[4] found that the cost of the heat pipes is significantly higher in the UK compared to other markets where district heating is much more widespread. This suggests that there would be potential for cost reduction if the UK market were to be larger in scale.

The final element is the consumer unit, this replaces the boiler in the building. This will normally use a heat exchanger – so that the heat circuit in the building is isolated from the main district heating circuit. This isolates the district heating system from any issues with air or oxidation within the heating systems in the building. The consumer unit will include heat controls, pumps for the buildings heating circuit and heat meters. For homes the consumer unit can be supplied as a compact system that is similar is size and shape to the boiler that would have been used.

There are other supporting elements within a district heating network, including pumps, stand-by heat sources etc.

District heating is used extensively across the world, there are notable examples in New York (serving 100,000 commercial and residential properties) and Paris (serving 5,774 buildings). In Northern Europe, particularly Denmark, Sweden, Finland and Germany, district heating has a very strong presence, from small community to city wide schemes. In Scotland there are a number of small schemes, including:

- The Shetland District Heating scheme. This serves Lerwick taking heat from an energy from waste boiler. Demand has grown, leading to investment in the heat source to supply further customers.
- The Aberdeen Heat and Power schemes. Three projects using gas fired CHP systems to supply tenants in social housing. Expansion plans include development of the Seaton scheme to serve properties in the city centre.

2.2 Security of Heat Supply

District heating systems offer security of heat supply benefits compared to individual boilers in buildings. There are two reasons for this. Firstly many buildings will have only one boiler, whereas a district heating system will normally have several boilers. So one boiler failure would not affect the district heating system. Secondly the focus of the district heating operator is maintaining heat supply, hence reliability of boiler plant, pumps and the heat network are critical to the business. This is not true of ordinary businesses and homes, where boiler maintenance is unlikely to be a priority.

The security of supply aspects are slightly different for the case of heat recovery from a power station. In these cases the main business is power generation. The supply of heat will earn far less income than the supply of power. The availability of heat will

[3] PB Power: http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/publications/resen1a

[4] Poyry: http://www.ilexenergy.com/pages/documents/reports/electricity/A_report_providing_a_technical_analysis_and_costing_of_DH_networks.pdf

be linked to the operation of the power station, which will be linked to the price for power generated. If heat is not available from the power station then back up boilers will be required to provide heat.

In addition there is a possibility that the power station closes – e.g. if the main business of power generation becomes un-profitable.

In this study we have assumed that new stations supply the heat. This assumption assists the security of heat supply in several ways:

- To provide an acceptable return on investment the power station is assumed to operate for 7,000 hours a year. So the system will be generating and producing heat for most of the time, heat will be available all year round.
- The new power station will be designed for a life of many decades – consistent with the life of the district heating network.

2.3 Consumer Lock In

Typically when consumers connect to a district heating system when their existing boiler system requires replacement – or when a new building is developed. Connecting to district heating under these circumstances has a number of advantages:

- The cost of a replacement or new boiler is avoided (both cases).
- Space may be freed up for other uses (both cases).
- The cost of a gas (or other fuel) supply is avoided (new buildings).

The customer will typically remove their existing boiler plant or will not install boiler plant[5]. Hence the district heating system becomes the sole source of heat.

From a security of heat supply perspective this is not significantly different from the conventional situation – customers reply on the reliability of their boiler and the supply of fuel to that boiler.
However from a commercial perspective there is a difference. Firstly, with boilers, consumers can switch suppliers of fuel on a regular basis to obtain the best prices. Secondly they can find different contractors to maintain or service their boiler. This is not the case with district heating, therefore it has elements of a natural monopoly.

There are examples of natural monopolies in the energy sector, principally the owners and operators of the gas and electricity networks. These businesses are regulated to ensure consumer protection, with standards of service and cost controls in place. The investments required by these businesses are scrutinised and approved by the regulator and if approved their costs are allowed to be charged to consumers. These businesses are low risk and often have high dividend yields. The regulatory framework has two sides – consumer protection and low risk for investors. This latter point is very important for businesses that need to invest in large scale, long term, assets.

At present there are no regulatory systems for district heating, nor are there plans to introduce any systems.

The commercial consequences of the monopoly are:

- Potential exposure to higher costs of heat.
- Potential costs to disconnect from the network.

To be able to convince customers to connect a district heating operator will need to offer some form of commercial advantage. This is likely to be cheaper heat. When agreeing to take up district heating consumers should obtain details of long term prices, or agree how prices will be indexed to the prices of other fossil fuels.

Importantly the cost of heat for a customer will include the cost of fuel, the energy losses in the boiler, maintenance and service costs for the boiler and deprecation costs for the boiler. All of these costs are included in the cost of heat – although

[5] Some customers require higher security of heat supply, e.g. hospitals. Hence they main retain some of their own boiler plant.

many consumers may fail to recognise many of these important elements of the cost of heat.

To become connected requires investment in the final connection from the existing district heating network to the client and the installation of the consumer unit – to interface the customers heating system to the district heating system.

These costs can be paid upfront by the customer or can be included in the price paid for heat. In the latter case the district heating operator will require some form of security, either a long term heat supply contract and/or payment if the customer disconnects.

Hence to disconnect, the consumer will need to need to invest in the removal of the district heating connection plus the cost of new boiler plant. These may be significant costs and hence significant barriers to disconnection.

2.4 Fuel Sources

District heating systems can use a wide range of fuels. This study focuses on the potential to recover heat from 4 large scale fossil power stations using coal and gas, with some co-firing of biomass. The study does not include the potential for heat recovery from dedicated biomass power stations. This is intentional.

Scottish Government has already undertaken significant work in the use of biomass. The recent Renewable Energy Roadmap notes the need to use finite biomass resources in the most efficient and beneficial ways. Hence Scottish Government policy supports biomass in heat-only or combined heat and power plants, particularly off gas-grid, and to a scale which maximises heat use and local supply.

Biomass power stations proposed in Scotland (over 50 MWe) require consent under Section 36 of the Electricity Act 1989. The Scottish Government's guidance for Section 36 consent requires a heat plan to accompany the application. There are currently four Section 36 applications for biomass power stations, each of which is assessing the potential for heat recovery. Hence this study would have duplicated effort if it had included biomass power stations.

Finally it is not the purpose of this study to set out an analysis of heat recovery that could be compared with the assessment of the applicants.

While the study does not focus on biomass many of the issues and policy measures are highly relevant to heat recovery from biomass power stations.

2.5 Development Model

The way in which district heating has developed in the UK has taken a number of different forms:

- Systems that serve a new housing or mixed use development – initially owned by the property developer.
- Systems that serve a university, hospital or large military base – initially owned by the main client, sometimes transferred to a third party.

- Systems that serve social housing – typically owned by a local authority or housing association.
- Systems that serve public buildings – initially owned by a local authority, sometimes transferred to a third party.
- Systems associated with energy from waste schemes - initially owned by a local authority, sometimes transferred to a third party.

The focus of this study is the recovery of heat from large power stations. Hence the emphasis is on connection of the power station to heat loads – making early use of the energy and CO_2 savings from heat recovery. As the list above suggests there are many other routes which could lead to the wider uptake of district heating. These could involve recovery of heat from power stations, if clusters of smaller networks can be linked together and connected to a power station. However this development model does not necessarily involve heat recovery from a power station and if it does this element will develop many years in the future.

Accordingly this study uses a development model where heat is recovery from the power station in year one, with heat load building up over time. Using this model means that policies that encourage or require the power station operator to provide heat can be assessed.

2.6 Power Stations

This study considers the potential for heat recovery from new power stations at the four sites. It uses generic assumptions about the scale, performance and costs of these. It does not use the details of the existing or proposed stations at these sites. This is intentional.

Use of generic assumptions has the following advantages:

- It assumes that new power stations are built at these 4 sites. A new power station will have a life of 40 years or more – of a similar timeframe to the life of the district heating network. If the existing stations were assumed to supply the heat, they will close partway through the life of the new district heating network.

- Requirements over planning policy will apply to the new power stations. Hence changes to Section 36 guidance on recovery of heat will apply to these new stations – whereas these policy impacts would have zero impact if the existing stations were assumed to be used.

- The costs and performance details of the existing stations are commercial matters for the operators. Hence assumed costs would need to be used in both cases – existing and typical new plant.

3 Network Modelling

3.1 Energy Supply

Recovery of heat from power stations requires investigation of the heat available along with identification of the potential heat consumers. This section looks at the energy supply and reviews the scale and performance assumptions for the four power station sites.

3.1.1 Site Selection

Conventional power generation produces large amounts of heat which needs to be dispersed into the environment. In Scotland all large conventional power stations are located on the coast, where seawater is used as the cooling medium.

The amount of heat produced is significant; a large coal fired station will be around 40% efficient, a large gas station will be around 50% efficient. Hence, up to 60% of the energy in the fuel will be discharged to sea via the power station's cooling systems or lost through the flue (chimney). The output of the current conventional power stations range from 1,150 MW_e to 2,400 MW_e, so significant quantities of heat are available.

Heat is also produced by smaller biomass stations; several such stations are in operation, whilst several more are proposed. The stations currently in operation all recover some heat. Work is underway to examine the potential for heat recovery as part of the Section 36 planning applications for the proposed stations. All of the biomass stations and proposed stations are significantly smaller (36 MW_e to 200 MW_e) than the conventional fossil fuel stations; as such these will produce less heat.

This study focuses on heat recovery from the four fossil power stations in Scotland – as these offer greater amounts of available heat and little work on heat recovery has been undertaken to date. Three of these fossil stations exist, one is in planning. A high level study has been undertaken to estimate the potential heat loads for the proposed Hunterston plant. This study looks in detail at potential heat loads and the financial attractiveness of connecting some or all of these.

Table 2 Power station operation and capacity

Station	Summary
Cockenzie	Currently a 1,150 MW_e coal fired power station. Due to close prior to 2015 as the station has opted out of the Large Combustion Plant Directive (LCDP). Planning application submitted for a gas fired replacement of 1,200 MW_e. Closest of the 4 sites to a major conurbation.
Longannet	Currently a 2,400 MW_e coal fired power station. Opted in to LCPD.

	Flue Gas Desulphurisation (FGD) being fitted and consent granted to fit Selective Catalytic Reduction (SCR). Expected to operate for some years.
Peterhead	Currently a 2,177MW$_e$ gas fired power station following recent upgrades in 2000 and again in 2007. Transmission system limits the output to 1,550MW$_e$. Hence there are proposals to reduce capacity at Peterhead.
Hunterston	Proposal for a 1,852 MW$_e$ multi fuel (coal and biomass) station. Planning application submitted. Application includes a heat recovery study considering potential use of heat with 20 km.

3.1.2 Assumptions regarding the four power stations

Heat from Power Stations

Power stations are designed to maximise electrical efficiency, making the best use of the fuel purchased. Some heat is rejected into the seawater cooling systems, but this is at a low temperature. This is a lower temperature than used by heat consumers, so is unsuitable for heat recovery.

Instead heat needs to be extracted from a steam turbine. All of the four stations have steam turbines, either as the main prime mover (Longannet & Hunterston) or as part of a combined cycle system (Cockenzie and Peterhead).

Loss of Electricity Generation

In each of the four power stations, heat would be extracted from the steam turbine at a pressure suited to the scale of heat demand. The steam needed for the heat network is extracted before it reaches the final stages of the steam turbine. Therefore, a reduction in electricity generation occurs as the steam extracted does not contribute fully to the electricity output of the turbine.

The amount of electricity generation foregone depends on the amount of steam extracted and the pressure that remains in this steam. This is known as the Z factor.

For these four stations the majority of heat demand will be for hot water based heating, typically generated by conventional boilers at 80°C, returning at 70^C. It is assumed steam would be bled from the power stations between the final two stages of the steam turbines where the steam will be at the lowest useful temperature and pressure. This is typically at 2.4 bar, to feed hot water networks via heat exchangers. The corresponding Z factor at this steam bleed pressure is 6.3[6].

[6] https://www.chpqa.com/guidance_notes/GUIDANCE_NOTE_28.pdf

This means that for every 6.3 units of thermal energy extracted as steam, the electrical output will be reduced by 1 unit. So a 1,000 MWe station operating at full output and extracting 63MW of steam will actually generate 990 MWe.

If heat can be recovered at a lower pressure the Z factor would be lower, with lower reductions in electricity generation. But extracting heat at a lower pressure may limit the efficient transfer of heat into the district heating system. If the district heating system requires higher pressure steam, e.g. for industry, the Z factor will be lower with higher losses of electricity generation.

Power and heat output

As the preceding section shows, there are proposals that could alter the existing or proposed capacity and operating mode of each of these four stations. Therefore we have been conservative in estimating the amount of heat available, we have assumed lower capacity at each site, as shown in the following table:

Table 3 Assumptions regarding the 4 power stations

Station	Modelled Capacity and assumptions regarding fuel mix and efficiency
Cockenzie	1,000 MWe, 100% natural gas input, fully condensing gross electrical efficiency 50% Gross Calorific Value (GCV)
Longannet	1,200 MWe, 100% coal input, fully condensing gross electrical efficiency 40% (GCV)
Peterhead	1,000 MWe, 100% natural gas input, fully condensing gross electrical efficiency 45% (GCV)
Hunterston	1,200 MWe, 90% coal gross energy input, 10% biomass gross energy input, fully condensing gross electrical efficiency 40% (GCV)

These assumptions require some detailed explanation:

Peterhead is a steam turbine driven by both the original steam boilers and a later gas turbine. Hence we have assumed that the efficiency at Peterhead is 45% rather than the 50% assumed for the proposed Cockenzie station which is a modern Combined Cycle Gas turbine (CCGT).

The proposed station for Hunterston is co-fired and will therefore earn income from Renewables Obligation Certificates (ROCs). Extracting steam to recover heat will reduce electricity output – some of which would have earned ROCs. To calculate this requires details of the proportion of input fuels biomass vs. coal. The Hunterston feasibility report states that the plant will be designed to allow up to 14% of input as biomass but currently power stations typically only co-fire around 3%[7] so based on experience to date, a 10% estimate is used, which is conservative in terms of potential loss of ROCs.

Interaction with Carbon Capture and Storage

Carbon Capture and storage (CCS) is likely to play an important role in reducing CO_2 emissions from fossil fuel power generation and industrial plants. Amongst the several methods available for capturing CO_2 from large stationary sources (e.g.

7 http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,41175&_dad=portal&_schema=PORTAL

power plants) amine-based post combustion capture is the leading contender as it can be fitted to existing and new power plants. However, the amine capture process requires significant amounts of heat for regenerating the solvent before it is recycled to absorber for further CO_2 separation.

The heat required could be provided by extracting steam from the steam turbine in the power generation cycle. Hence district heating and amine-based post-combustion capture systems are competing demands for the heat available from the steam turbine. The study undertook a high level review of the compatibility of district heating with CCS – will sufficient heat be available?

This high level review compared the heat available from the steam turbine at each site with the heat demands for CO_2 capture and district heating at that site. It was concluded that there is likely to be sufficient steam available to cover both the district heating and solvent regeneration demands for all sites.

The most challenging example is the Cockenzie. This site has the largest heat load and hence the highest peak heat demand. As the power station is a CCGT, the steam turbine has less heat available than from a coal fired station. The review showed that even with 100% of the heat loads connected, this station should be able to serve both the district heating system and the CO_2 capture process.

Comments from Scottish Power suggest that it could be possible to recover some of the heat that is used in the CO_2 capture process for use in district heating, adding an extra margin to the heat supply available. For example, heat is available from the re-boiler condensate at an ideal temperature for district heating (120-130 °C). Additional heat can also be recovered from the CO_2 compression plant and this can either be used for solvent regeneration or directly in the DH system.

Capital Costs

Although the Longannet and Peterhead plants are in existence and the proposed Cockenzie upgrade will have some of the necessary electrical infrastructure in place, they are modelled as if they are to be built from new. This helps inform policy relevant to new power stations.

The assumed capital costs for the basic power plant are estimated at £1,500/kWe for coal and co-fired fired stations and £720/kWe for gas-fired stations and the estimated additional cost (excluding district heating pipe work) of making these capable of heat recovery is estimated at 1.5% of this basic capital cost.

It is assumed each station will run at full capacity for 7,000 hours/yr i.e. in fully condensing mode the 1GWe stations will generate 7,000GWhe/yr and in heat recovery mode will consume the same amount of fuel but generate less power due to heat extraction. Hence the investment case for the new power station assumes a high utilisation factor.

It is assumed that the power stations will last at least 40 years and the annual operating and maintenance costs over the life of the plant will be 5% of the capital costs throughout the life of the plant for coal stations and 2.5% for CCGT. This may be somewhat conservative for the coal fired power stations but it will not affect the financial assessment of connecting to district heating as this will not affect the maintenance costs.

3.1.3 Backup Heat Supply

Large scale power stations increasingly operate in a flexible manner. This reflects the:

- Dynamic pricing that exists within the GB electricity market, which offers higher income to flexible plant.
- Increasing capacity of wind on the network, which requires other plant to be available to operate.

When not generating energy, large fossil power stations need to be available to operate. The main thermal items of plant are always kept warm, ready to operate when market conditions make this attractive. Hence, fuel will continue to be consumed to ensure that the station is ready.

Keeping the station warm reduces maintenance costs and maintains efficiency as it avoids thermal cycling of key plant items. Thermal cycling reduces plant life as repeated expansion and contraction of steam pipes leads to fatigue and cracking. Cracks in steam pipes reduce efficiency as steam escapes, whilst fixing cracks requires downtime to identify and repair. Both of these aspects add cost. Hence, we assume that sufficient heat will be available from these stations at all times without any significant change to their capital cost. However, they may at times be required to burn more fuel to provide heat, so operating costs may increase slightly.

The proposals for Electricity Market Reform (discussed in section 7.2) include a capacity payment, a new form of revenue to reward stations for being available to run. This proposal further supports the year round availability of heat from large fossil stations.

We have also modelled a separate case where the owner of the power station and the owner of the district heating are different commercial entities. In this case it is assumed that the owner of the district heating system owns and operates a heat only gas boiler to provide back up heat.

3.2 Energy Demand

In order to assess the potential for heat recovery all possible heat loads must be identified. The scale and location of each heat load is important as capital costs are high and so critical to the cost of heat supply and the financial returns. The specification for this study included a 30 km catchment area which would ensure that all possible heat consumers were considered.

The focus of this assessment is on anchor heat loads. These are heat consumers that will be commercially more attractive for heat supply.

3.2.1 Anchor Heat Loads

The factors that make certain heat consumers attractive include:

- **Scale** – customers with high heat loads are more likely to be worth the capital costs.
- **Consistency of heat demand** – heat sales are needed all year round, so customers with significant summer heat demand are valued.
- **Longevity** – district heating is a long term asset which requires customers to be connected over many years. Public sector customers tend to have longer term predictability over the pattern and longevity of site use and site heat demand.
- **Credit risk** – to raise capital for a long term asset, investors in district heating need assurances that potential heat consumers are able to pay for their heat over the long term. Public sector heat consumers have the lowest credit risk.
- **Driving factors** – district heating is not widely known in Scotland. Hence heat customers will need persuasion to connect. Driving factors will include; lower costs of heat, and policy factors such as avoiding Carbon Reduction Commitment (CRC) charges or meeting targets on carbon emissions. These driving factors will be greatest for public sector customers, as all Scottish public bodies are required to act to meet the targets in the Climate Change (Scotland) Act 2009.

The following table shows how these factors are scored against a number of potential heat customers, leading to the selection of key anchor heat loads.

Table 4 Selection of Key Anchor Heat Loads

	Scale of Heat Load	Consistency of heat demand	Longevity	Credit risk	Driving factors
Hospitals	Large	High	Long	Low	CC Act Duties HEAT targets CRC
Schools	Medium to Large	Medium	Long	Low	CC Act Duties CRC
Prisons	Large	High	Long	Low	CC Act Duties CRC
Swimming pools	Medium to Large	High	Long	Low	CC Act Duties CRC

Process Industry	Medium to Large	Medium	Medium	Medium	CRC
Offices, Retail	Small to Medium	Low	Medium	Medium	CRC
Individual Homes	Very Small	Low	Short	High	Minimal
Social Housing	Medium	Low	Short	Medium	Low
New Housing Developments	Medium	Low	Medium	Low	Planning
New Business Developments	Medium	Low	Medium	Medium	Planning

Hence the most attractive consumers will be large public sector buildings with year round heat demand, examples include; hospitals, prisons and publicly owned swimming pools.

The least attractive will be small private-sector buildings with seasonal heat demands. Examples include; offices, retail outlets and individual homes.

Hence, our identification and analysis of heat demand focuses on those anchor heat loads that are more attractive:

- Hospitals;
- Schools;
- Prisons;
- Swimming pools;
- Universities and colleges;
- Industry and commercial sites;
- Large new housing developments; and
- Large new business development sites.

3.2.2 Existing Housing

As explained in the previous section, this study has focused on large new housing developments and has not considered the potential to retrofit district heating to existing housing. There are several reasons for this.

From a technical standpoint individual existing homes are not anchor heat loads:

- They are very small heat loads and hence offer small amounts of heat sales income.
- They have highly seasonal heat demand, adding to the peak heat demand and hence cost of the district heating network.
- They will require existing boiler systems to be removed and replaced with district heating consumer interface units. The space and location of the existing boiler may not be well suited to conversion.
- They may currently use electric heating. Replacing electric heating with recovered heat will offer much higher CO_2 savings. However the capital costs

will also be much higher, to cover removal of the electric system and installation of radiators, pipes and controls. So the added benefit is balanced by a significantly higher cost.

From a financial standpoint:

- When calculating the cost of connecting a new home to district heating we can take into account the costs avoided by not having a boiler. This makes connection of new homes more cost effective than retrofitting existing properties. The study uses an assumed connection cost of £3,800 per dwelling. This is taken from the PB Power study for the Scottish Government which uses data from the International Energy Agency[8]. The assumed cost of a conventional boiler is £2,525, giving a net cost for new dwellings of £1,275. This is clearly much higher than the retrofit cost of £3,800.
- As a long term investment, district heating operators prefer to have long term heat supply contracts. Public sector clients can enter this type of contract, while individual homeowners are not likely to sign up to long term arrangements.
- The cost of extending the main pipe to an individual home will be very high in relation to the income in heat sales from that property. Hence retrofitting would be most cost effective if groups of individual homes were connected at the same time.
- Groups of homes in common ownership, e.g. council or housing association offer better opportunities as the income is greater and the costs of connection will be lower and long term contacts could be arranged.

From a policy standpoint:

- Planning policy and the requirements to co-locate heat supply and demand and to reduce carbon emissions act as lever to connect new housing developments. There is no equivalent lever for existing housing.

Practical considerations:

- Development plans provide a ready source of data on the location and scale of proposed housing developments. To consider existing housing, would require data on individual dwellings or for the social landlords, groups of dwellings under the same tenure. This data is not as readily available.

None of the above precludes the connection of individual existing homes to a district heating scheme. However, the business case for district heating schemes focuses on larger anchor heat loads as the core market. This approach can be seen in most examples of UK district heating scheme development, e.g. Southampton, Nottingham, Citgen in London and a number of schemes designed for new developments e.g. Glenshellach in Oban, the Home Farm Biomass Community Heating on Skye and the Hill of Banchory district heating Scheme in Aberdeenshire.

[8] Parsons Brinkerhoff Heating Supply Options for New Development – An Assessment Method for Designers and Developers http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/publications/resen1a

Once the main system was installed some individual homes have connected, e.g. if the district heating main is already passing the property. A study by Poyry[9] notes that district heating operators in Finland set high connection fees for individual homes, to reflect the high costs and low income for these customers.

There are some exceptions to this, for example the Shetland District Heating Scheme. This includes many individual dwellings as customers. Some of the factors that led to the development of the Lerwick scheme are unique, including:

- The need for a practical and economic solution to deal with waste arisings on Shetland.
- Capital availability from the Shetland Oil Fund.
- Very high heating energy costs for homes.
- Grant support for connection of homes.

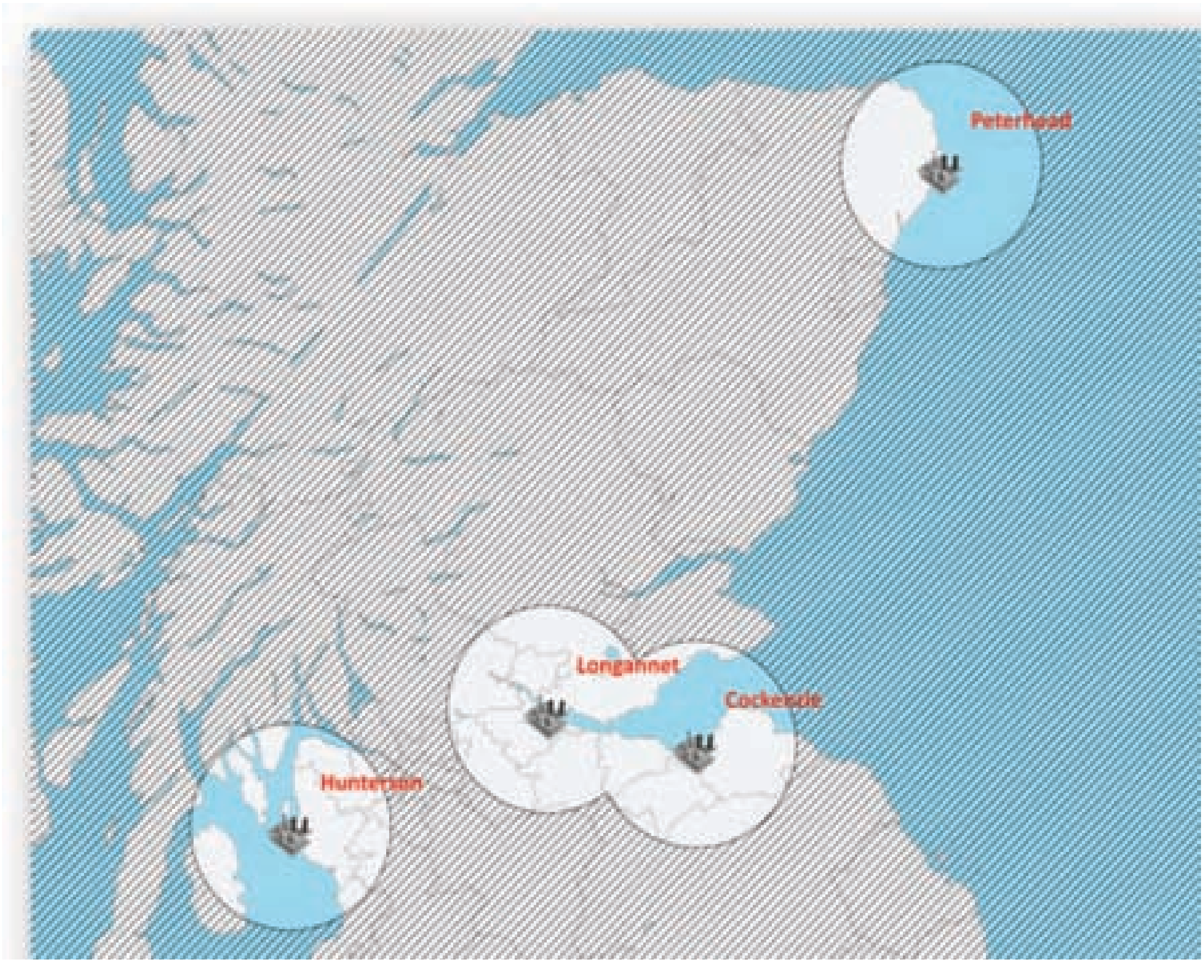
Hence the overall business case, and costs and benefits of connecting individual homes, is very different in this case.

[9] Pöyry Energy, The potential and costs of district heating networks

3.3 Approach to Heat Maps and Anchor Loads

For the purpose of this assessment, the analysis focused on identifying heat loads in locations within the 30km catchment around each station. The following map shows the location of the sites and the 30 km radius around each of these sites.

Figure 2 Study areas



There are areas within the 30 km radius that are impractical for heat recovery, examples include:

- Hunterston; Crossing the Firth of Clyde to serve heat loads on Arran, Bute, Cowal etc.
- Cockenzie: Crossing the Firth of Forth to serve heat loads in Fife.

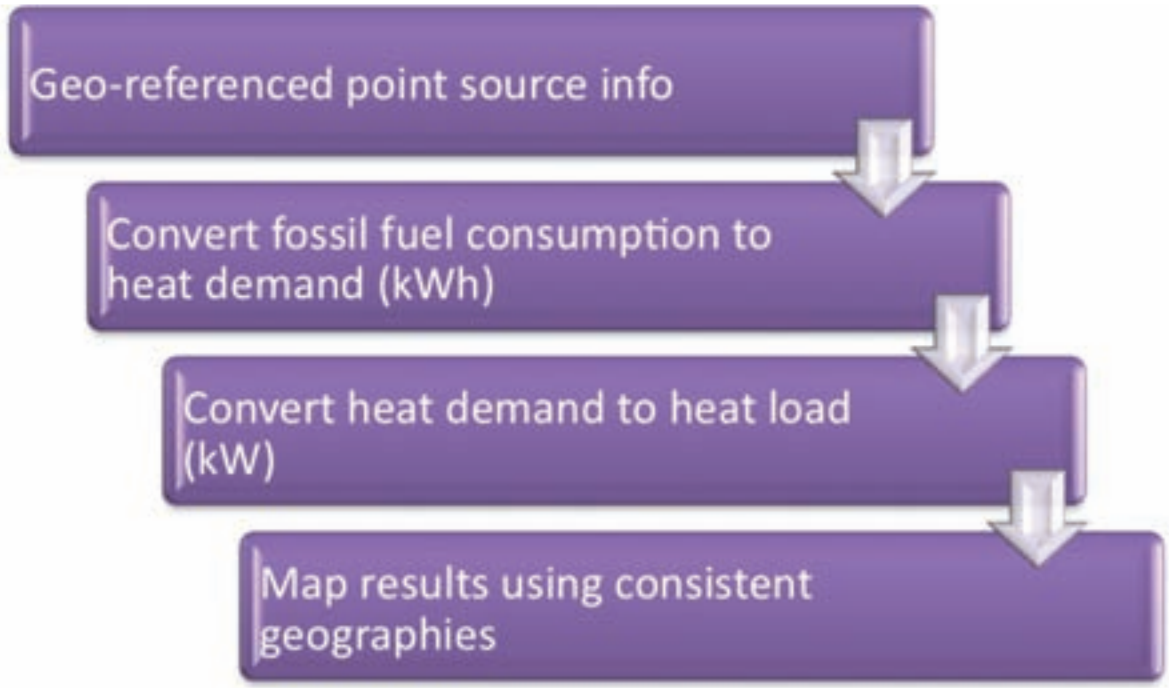
Hence, some areas within the 30 km radius were not searched for suitable anchor heat loads.

GIS maps were developed to show anchor heat loads as separate data layers, with details of peak heat demand (which determines the size of the heat pipe), the annual heat demand (which determines the income from heat sales) and the location (which determines the length of pipe run needed and hence the capital cost).

In most cases, the information about the location of each anchor load has been provided to a full post code resolution. These enable both the geographic location and the magnitude of the heat load to be well characterised. In other cases, the level of evidence was available in a lower resolution (i.e. Local Authority level) and therefore, different assumptions were made.

Figure 3 briefly describes the approach taken to produce the heat maps.

Figure 3 Steps to develop the anchor heat load maps



The mapping methods and data used to develop these distributions are explained in the following sections.

3.4 Data used for Anchor Heat Loads

Individual buildings or groups of buildings (where anchor loads have been estimated) and the distance between these buildings from the power stations was accurately determined using the electronic OS MasterMap[10] data provided by the Scottish Government and our Geographical Information System (GIS). An extension of the OS MasterMap, the OS ITN layer[11] was also used in order to identify the road transport network links to a very high resolution.

[10] http://www.ordnancesurvey.co.uk/oswebsite/products/osmastermap/
[11] http://www.ordnancesurvey.co.uk/oswebsite/products/os-mastermap/itn-layer/index.html

In order to compile the heat load map, assumptions for boiler efficiency and load hours were made; these are presented in Table 5.

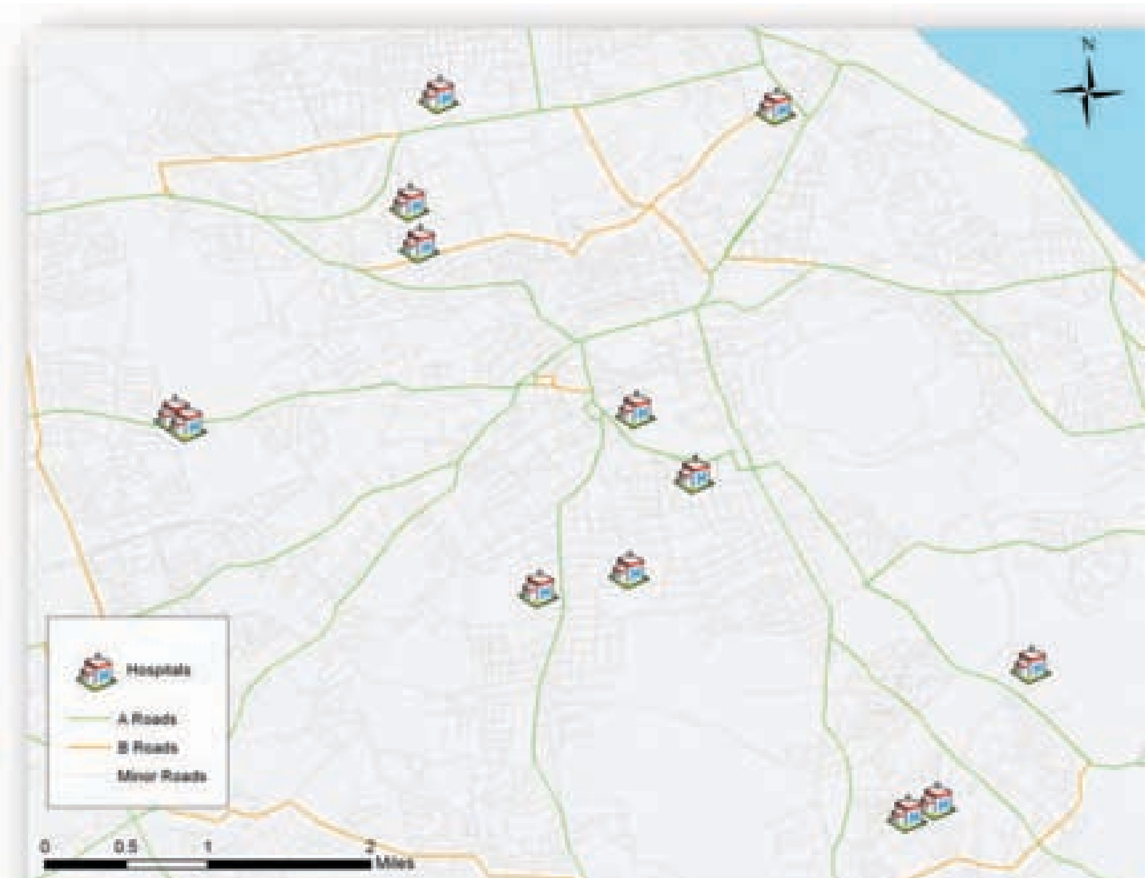
Table 5 Assumptions for boiler efficiency, load hours & heat load

Anchor sectors	Boiler Efficiency	Load Hours
Hospitals	75%	5,700
Schools	75%	1,560
Prisons	75%	2,950
Swimming pools	75%	5,304
Universities and Colleges	75%	2,950

3.4.1 Hospitals

As highlighted earlier, hospitals are a very attractive heat load. The sites are large, use space heating for most of the year and have strong drivers to improve energy efficiency and reduce carbon emissions. A detailed list of hospitals, their actual energy use and locations was provided by Health Facilities Scotland, using data from the NHS eMART system. These have been mapped in detail, as shown below for central Edinburgh:

Figure 4 Hospitals in Edinburgh



3.4.2 Schools

Schools are potentially attractive anchor heat loads, due to the public sector ownership and longevity of site use. The driving factors are also high due to public sector targets and the CRC. However, heat use in schools is seasonal and for smaller primary schools the heat use can be modest in scale. So these are less attractive anchor heat loads than hospitals, but secondary schools and larger primary schools may be important.

Two main sources of data have been used to identify the heat load from schools:

1. List of schools in Scotland in 2007[12].
2. The utility data from the "School Estate Statistics 2010" (published by Scottish Government.

The first source provides a detailed list of secondary and primary schools across Scotland, including post code location. This does not include heat use or the size of the school buildings. However, the data does include numbers of teachers.

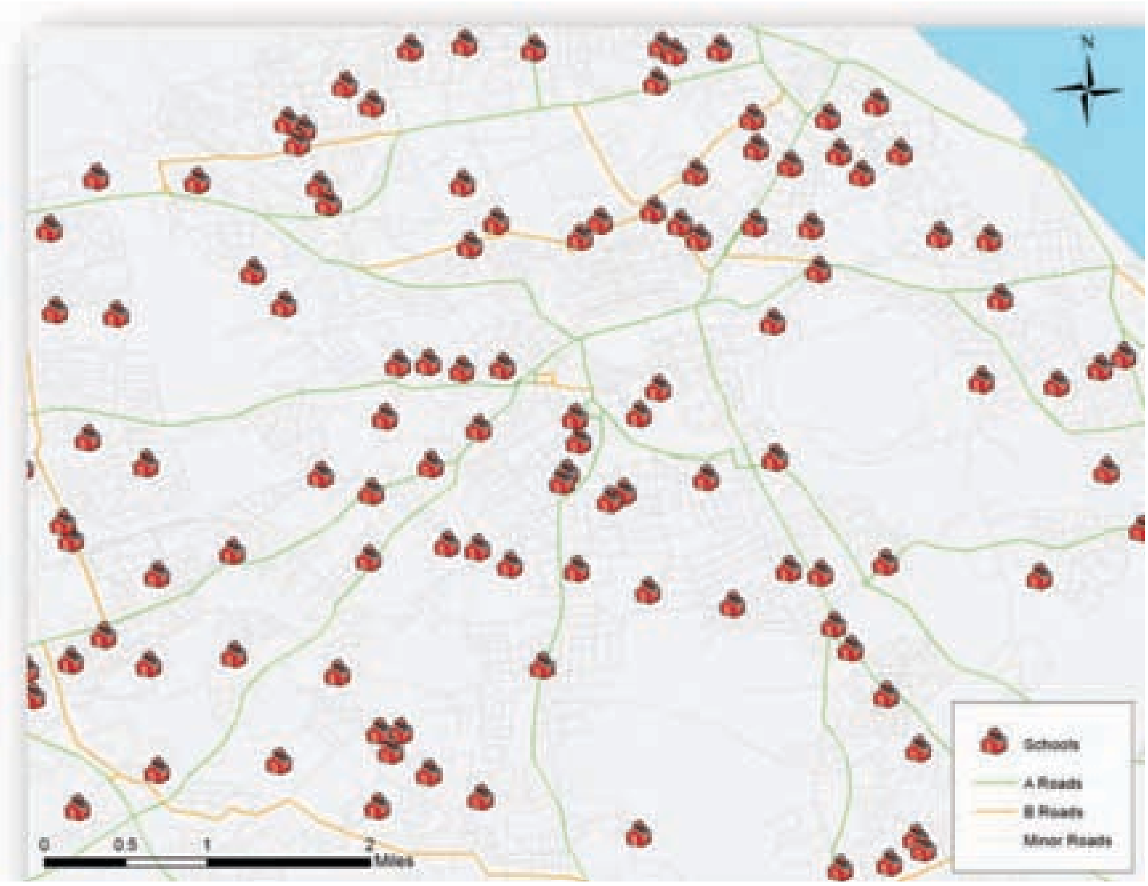
The second source provides estimates for total energy used in schools in each local authority area.

The heat at each school was estimated using a series of modelling processes developed by AEA for the UK heat map. This uses employment statistics as a proxy for heat use at each site, hence using the details of teacher numbers from source one. The total heat use in schools for each local authority was calculated and cross checked with source two.

The following figure, (Figure 5) shows as an example the mapping of schools in central Edinburgh.

[12] http://www.scotland.gov.uk/Topics/Statistics/Browse/School-Education/schoolcontactdetails

Figure 5 Example of the schools mapping (Edinburgh)



3.4.3 Prisons

Prisons are a very attractive heat load. The sites are large, use space heating for most of the year and have strong drivers to improve energy efficiency and reduce carbon emissions. The number of prisons is relatively small; hence these are less likely to be within the 30 km catchment of the four power station sites. However, one example, Peterhead prison is very close to the power station site.

The fossil fuel monthly consumption data, along with daily gas consumption data for prisons within the area of study has been provided by the Scottish Prison Service (SPS)[13]. The postcodes of the prisons were obtained from SPS's web site.

3.4.4 Swimming Pools

Swimming pools are a very attractive heat load. The sites use significant amounts of heat throughout the year. Many large pools are owned and operated by the public hence there are strong drivers to improve energy efficiency and reduce carbon emissions.

Contact was made with Scottish Government and with Swimming Scotland to obtain a list of swimming pools in Scotland. No such list was found during the research. Most large swimming pools are run by local authorities. Hence, a search was made

[13] http://www.sps.gov.uk/ Information

of the web sites of each local authority within the catchment areas of the four stations.

From this a list of swimming pool sites was built, with site name and postcode as the key data, along with information on the size of the pool (if stated on the relevant web site).

The heat use was estimated using UK benchmark data on the energy used in leisure centres with swimming pools. This was cross checked with data on a small sample of pools that was already held by AEA. This showed a conservative agreement between the estimate and the sample.

Hence this method was used across the full list of pools.

This method will not pick up other pools e.g. in hotels or gyms. Most of these will be small with lower levels of heat demand and the drivers for connection will be much weaker.

3.4.5 Universities and Colleges

Universities and colleges are potentially attractive heat loads. However, this sector is very diverse, ranging from colleges with a single building to universities with one or more multi-building campuses. Heat use for some will be significant and in others it will be much more modest. However the driving factors are strong, a range of policy initiatives influence this sector as well as student opinion.

The heat load estimates from universities and colleges, has been obtained from the UK Heat Map[14]. This dataset uses a series of modelling processes which has been developed by AEA, in order to estimate energy used from different sectors. Fossil fuel consumption is estimated using employment statistics in universities and colleges as a proxy for heat use.

3.4.6 Industry & commerce

Industrial sites are potentially attractive heat loads. Some sites are very large consumers of heat and often use heat year round. The drivers for connection can be strong particularly for sites in the European Union Emissions Trading Scheme (EU-ETS) or CRC; however the duties on public sector bodies do not apply. In terms of longevity and credit risk industrial and commercial sites are less attractive than public sector sites.

From a technical standpoint there may be some more complex issues. Industrial sites with large and year round heat demand often already have their own dedicated CHP, e.g. paper mills, food sites etc. Hence the logic for connection will be weaker or absent.

Some industrial sites use steam as a heat carrier to serve the higher temperature processes on site. Hence, a district heating scheme would need to provide these

[14] http://chp.decc.gov.uk/heatmap/

customers with steam not hot water. This would alter some of the characteristics of the part of the district heating network that served these loads.

The large point source heat load sources used within the maps are available in the UK Heat Map. The detailed data on individual large consumers of fuel in the industrial and commercial sector is obtained from several sources:

- The Environment Agency's Pollution Inventory (PI) & EU Emissions Trading Scheme (EU-ETS).
- The Scottish Environmental Protection Agency's (SEPA) European Pollutant Emission Register (EPER) submission.
- National Atmospheric Emission Inventory (NAEI) data.
- Data from the Department for Energy and Climate Change's (DECC's) Combined Heat and Power Quality Assurance Programme (CHPQA).

3.5 Future Anchor Heat Loads

3.5.1 Development Plans

Development plans were examined to identify if any proposed developments would be of a size or geographical location that they could be potential anchor heat loads. As noted previously, the actual heat loads for these sites can only be estimated as the details of the actual development cannot be predicted with certainty.

Business, housing and community development plan allocations (adopted or proposed), within a 30km radius of each power station (Longannet, Hunterston, Cockenzie and Peterhead) were reviewed and thresholds were used to determine relevant sites, these were:

- Housing, over 100 homes (if two adjacent smaller housing sites were found to have an aggregate of 100 homes, these were included).
- Business, over 1 hectare.
- Community and school, all new sites except extensions.

The development plans reviewed were:

- Aberdeenshire;
- Clackmannanshire;
- East Lothian;
- Edinburgh;
- Mid Lothian;
- Fife; and
- North Ayrshire.

Once identified, the list of developments was then verified using information received from the planning officers at each local authority. Some developments were found to differ in size (number of houses, hectares) while others were not within the 30km boundary. In some cases the developments were no longer proposed to go ahead. These developments were removed from the list.

There will also be potential for new developments to be connected to a district heating network. New developments require planning consent and new planning guidance requires developers to consider how to reduce the carbon emissions associated with new housing, new business space and new community buildings. This provides an extra driver for new development sites. In this report, a separate section examines the size and location of new development sites. However, the actual level of heat load for a new development cannot be known with certainly and in some cases the sites identified for development may not actually be developed.

3.5.2 Longer Term Developments

The lifetime of the district heating schemes is assumed to be 40 years. Over this long timeframe there will be many new developments with housing, business and community buildings within each catchment area. This study uses data from the current development plans only, as these provide the location and scale details necessary for the analysis. However it is important to note that current development plans focus on the short to medium term, so it is highly likely that additional development will take place within the 40 years. It is not possible to include these opportunities in the assessment since there is no data on the location or scale of this development to be able to quantify the impact of this on the results. The results will be slightly pessimistic, as long term new development would add heat sales and improve investment returns. This effect may be modest, as the discounting cash flow calculations mean that the net increase in income will be modest.

3.5.3 Social Housing Customers

To attract customers the heat tariff offered by a district heating scheme operator will need to be lower than the cost of conventional suppliers of heat. This logic applies to all types of consumer, public sector, commercial and householders. Reducing heat costs is an advantage in all sectors of the economy. However for householders there is a further policy advantage, reducing the numbers of households in fuel poverty. This is a potentially important advantage, but realising this is likely to require intervention, as households in fuel poverty may not be the target market for district heating developers.

As discussed in 3.2.2 the study focuses on new housing, for a range of technical, financial, policy and practical reasons. However there will be opportunities to connect to social housing within the new housing developments that are included in the study.

Housing developers are encouraged to provide affordable housing within their plans. Scottish Planning Policy states that authorities may seek a percentage of affordable housing contribution from developers of new housing developments where this is justified by the 'Housing Need and Demand Assessment' and included in the 'Local Housing Strategy and Development Plan'. The benchmark figure is that each site should contribute 25% of the total number of housing units as affordable housing.

Housing developers can collaborate with a Registered Social Landlord to administer the affordable housing elements of their development.

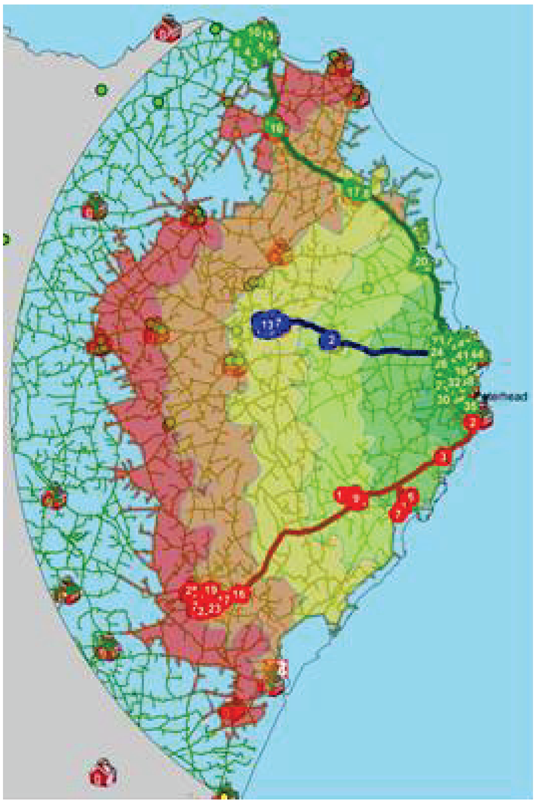
Hence social housing will be included in the properties that are assumed to be connected to each of the four power station networks. However it is not possible to quantify or identify how many and where these homes will be – as this is a site by site issue that is negotiated in each case.

3.6 Logic Used to Select Routes for Pipes

The route mapping tool, Network Analyst (within ArcGIS), was used to create the most financially attractive route connecting heat loads together. This is the shortest distance to the power station along the road network.

The initial analysis included every existing and future anchor heat loads and initially this created some very large district heating networks. Further screening was needed to remove unviable heat loads. The following figure (Figure 6) shows, as an example, the initial main routes identified for Peterhead:

Figure 6 Example map to show the initial network route (Peterhead)



Green Route
This northern route has a total pipe length of 47 km, longest continuous length of about 36 km to Fraserburgh and along the way this section covers a heat load of approximately 70,000 kW (plus several areas of unknown heat load).

Blue Route
This central route has a total pipe length of 16.2 km, longest continuous length of about 12.5km to Mintlaw and along the way this section covers a heat load of approximately 6,000 kW.

Red Route
This southern route has a total pipe length of 29 km, the longest continuous length of about 24km to Ellon and along the way this section covers a heat load of approximately 16,000 kW.

Overall
This would represent a total network of 92 km with a peak load of 92 MWth. Currently the largest network in the UK is 96 km in Nottingham.

3.7 Screening Tool

Details of potential anchor heat loads are included in the GIS map for each site. For each power station site there are many potential anchor heat loads. Many of these are small heat loads, of which some are a considerable distance from the power station site.

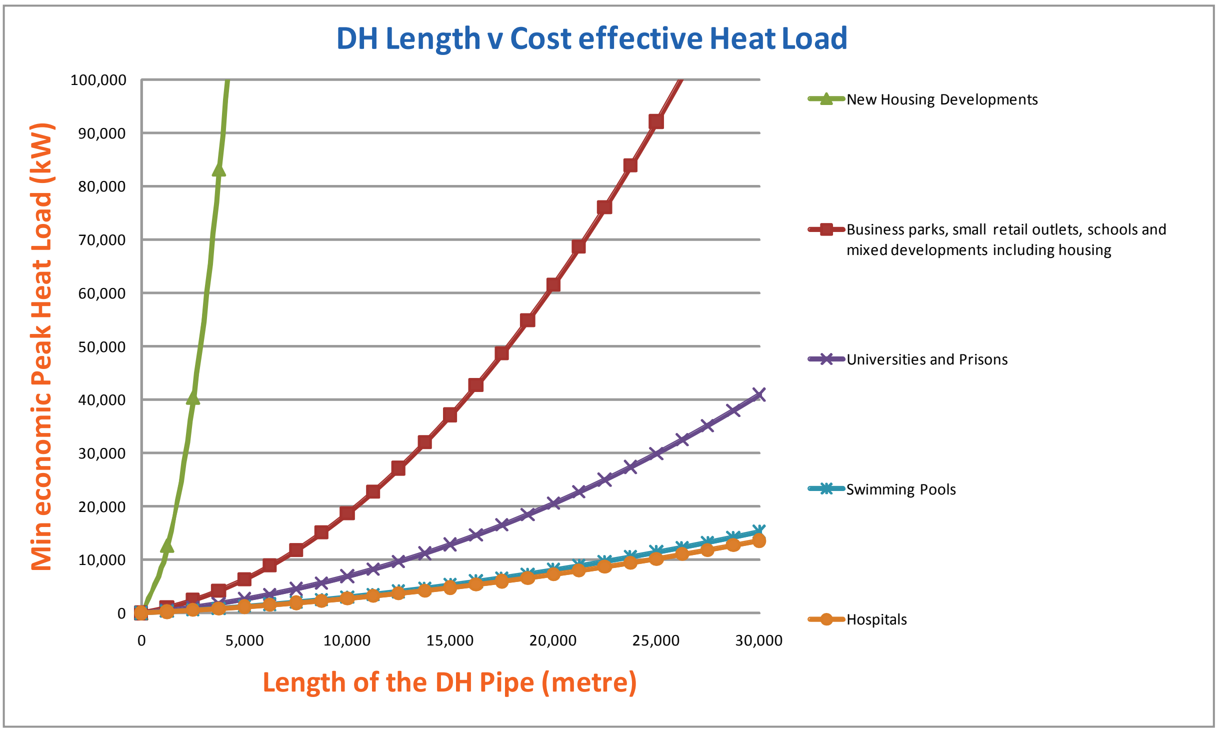
To be financially viable district heating systems should focus on supplying heat to core heat loads, where the high capital costs of the heat pipe are justified by the scale of the heat load served. Hence, many of the loads within the map will not be viable to supply even with policy support measures in place.

A screening tool has been developed to identify those heat loads which are credible for inclusion in the network. This helps to focus the analysis on those heat loads that can make a contribution to the financial returns of each district heating network.

The screening tool takes into account three key parameters:

- Peak heat load (in kW).
- Distance from the power station.
- Type of buildings being served.

Figure 7 Chart to show the screening of heat loads



The lines were calculated using:

- Cost per metre for different district heat pipe sizes from a report by PB Power[15].

[15] http://www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/publications/resen1a

- A discount rate of 9%.
- Projected heat price to end-consumer (e.g. 3.36p/kWh in 2013) derived from DECC gas and oil retail price projections (see section on key financial variables).
- DECC projection of wholesale electricity prices (e.g. 6.63p/kWh in 2013).
- Steam extracted at 2.4 bar.
- Ratio of heat extracted to power loss = 6.3[16].
- Assumed heating load factors i.e. average/peak heat load ratio.
- Additional distribution and connection costs for new housing developments of £1,300 per dwelling (£3,800 per dwelling less avoided £2,500/dwelling cost for conventional boilers).

A screening curve was derived for each building type, the curve shows the minimum required peak heat loads required to justify connection to a network for a given pipe length – given a discount rate of 9%. Heat loads that are above the lines in Figure 7 are screened into the assessment; heat loads below the line are screened out.

The capital cost of a district heat pipe connection is a function of its diameter. This relationship approximates to a quadratic function of peak heat demand. However, the income from heat sales is proportional to the annual quantity of heat supplied. Because the ratio of annual heat demand to peak varies with building type, different curves are required for different building types.

For example hospitals and pools are heated for more hours of the year than commercial buildings and a larger proportion of heat demand is not weather related and so for every kW of peak heat demand, the annual amount of heat in kWh will be much greater. Therefore the return on investment will be higher so a lower peak heat demand is required for a given pipe length.

The screening tool treats new housing developments as one heat load at the end of a primary district heat pipe-leg. So the cost of secondary distribution, connections and meters is then added to the primary cost. This makes the required peak heat load much higher, hence the very steep curve which will tend to screen out all but the largest or nearest developments to the primary network route.

3.8 Potential Heat Pipe Routes and Maps

The methodology outlined above was used to identify all sites with significant heat demands. Thresholds were then applied to ensure that only those sites that were financially viable were taken into account when identifying the optimum pipe routes.

Heat loads that were not viable for connection were identified based on the size of the heat load compared to the building type (Residential, Industrial etc) and pipe length as described in section 3.7.

Any heat load which fell below this threshold was removed and a new network route was calculated. This was repeated until all the financially unviable heat loads were removed and a final smaller more efficient network route for each power station could

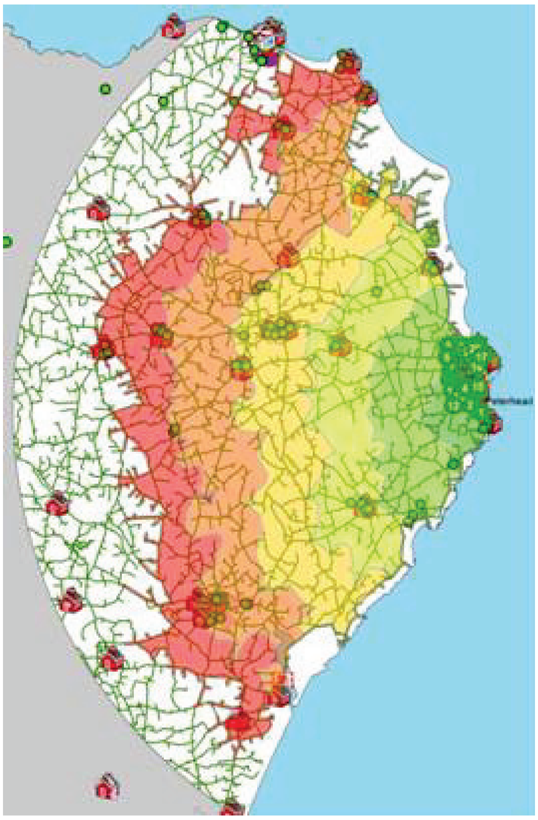
[16] CHPQA Guidance note 28
https://www.chpqa.com/guidance_notes/GUIDANCE_NOTE_28.pdf

be established. For each power station, tight financial conditions were applied to derive the bare minimum core networks and then looser financial conditions were applied to see where the network could extend.

These findings were then analysed in more detail in excel spreadsheets to fully verify and cost the networks. The results of the various network options were then fed into the main financial model to inform the cost and carbon saving impact and quantify how much policy support would be required to extend the network beyond what would be cost effective without support.

The final analysis for Peterhead contracted to the Peterhead urban area around the power station – the red & blue routes and the entire north route to Fraserburgh all proved to be unviable.

Figure 8 Example map to show Peterhead with the application of thresholds to reduce the number of sites



Green Route

All of northern route to Fraserburgh has been removed leaving only the Peterhead urban area.

Blue Route

Completely removed.

Red Route

Completely removed.

Overall

This would represent a total network of 15.5 km with a peak load of 52.5 MWth.

Figure 9 Example map to show a higher resolution of the Peterhead map with thresholds applied

4 Financial Modelling

With the potential district heating networks identified for each of the four power stations, a model was developed to calculate the annual and whole life cost for each of the power stations when supplying heat to surrounding buildings via the district heating networks. The model also provides an assessment of carbon dioxide savings.

The model does not include the wider socio-economic benefits of district heating. Hence the social cost of carbon is not included in the assessment, nor are wider impacts of lower energy costs on the economic and social situation of clients. Hence the assessment is taken from the perspective of the potential investor – who will not be able to realise value from these wider benefits.

The model does not include a detailed comparison of the carbon savings from district heating with other carbon saving measures that could be implemented on the buildings that are provided recovered heat. In the case of new properties it is assumed that they comply with building regulations and that appropriate energy efficiency measures have been included to reach the standards required.

4.1 Summary of Approach Used

The model allows variations on several parameters such as discount rate, energy prices, power station CHP operating mode, operating lifetime, etc. The model includes the following key financial and technical factors:

- The capital cost of modifying each power station to recover heat.
- The heat demand build-up and capital cost of the heat network.
- The operating cost for each heat network.
- Current and projected fuel cost for each power station and any top-up heating fuel.
- Current and projected wholesale value of the power generated at each power station.
- Current and projected value for heat sold to consumers, this depends on their conventional heating costs.
- The impact of current relevant policies (EU-ETS, CCL and ROCs) on the power station.
- Ratio of heat extracted from steam turbine to reduction of power output (Z ratio) and hence the loss of electricity generation (see section 2 for explanation).
- Fuel mix and efficiency of power stations.
- Efficiency of top-up heating boilers; and
- Efficiency of displaced heating boilers and carbon intensity of make-up grid power.

The model also allows the financial performance to be assessed from the perspective of three possible parties:

1) A power station operator if separate.
2) A district heat developer operator if separate; and

3) A power station also developing and operating the district heating.

Flexibility is built into the model, allowing variations on assumptions over:

- The responsibility split for power generation.
- Boiler top up.
- DH transmission (main pipe before branching to multiple loads); and
- DH distribution (pipe work downstream of transmission up to connections in buildings replacing individual boilers).

If the power station and district heat developer are one entity, it compares the performance of:

1. Base Case - power stations generating only electricity and individual conventional boilers supplying heat to the same buildings considered for district heating.

2. CHP Case - power stations supplying heat to surrounding buildings via a district heating network with central back up boilers supplying heat when the power stations are being maintained.

The model calculates the cost and carbon dioxide savings compared to the base case of a new conventional condensing boiler and power from the grid. As costs and carbon factors can vary from year to year, a macro steps through each year of the anticipated life of the power station district heating scheme and calculates the lifetime cost and carbon dioxide savings. The user can vary different parameters, so that different scenarios that might have an impact on uptake rates and carbon dioxide/cost savings can be explored.

Where the power station and district heating operator are separate, the model allows financial modelling from each party's perspective but does not attempt to apportion the carbon savings between parties.

The cost comparison from the power station's perspective is:

1. Base Case - build conventional power station and generate and sell maximum electricity to grid at wholesale price.

2. CHP Case - build CHP ready power station and bleed some steam to generate heat and sell to a district heating operator for an agreed price which will be a share of the price received by the district heating operator from end consumers. Generate a bit less electricity as a result of bleed steam. If responsible, build part of district heating network before branching and provide top up heat via power station's boilers and fuels when heat demand exceeds availability from power generation.

The cost comparison from the district heating operator's perspective is:

1. Base Case - do nothing.

2. CHP Case - build district heating network, buy heat from power station for agreed price and sell to consumers at an agreed price which will be

approximately equivalent to what it would otherwise cost them to generate in conventional boilers.

4.2 Detail of Main Whole Life Cost Model

CHP technical and cost data is input into a CHP database. This includes power station and district heating operation and maintenance costs and availability. The annual energy, cost and carbon analysis is split into 24 time slots. These consist of 6 weekly periods (3 day and 1 night period for weekdays, 1 day and 1 night period for weekends) for each of four different seasons. The timing of these slots can be varied by the user to coincide with significant changes in energy price or demand.

Energy price forecasts from 2013 to 2052 are included for electricity, natural gas, coal, oil and biomass. Energy price forecasts include prices for the power station, the district heating operator or for end consumers as appropriate.

The price values currently entered are derived from the DECC UEP price projections (UEP40). The prices to end consumers are used to estimate the value of heat which could be charged by the district heating operator, a proportion of which might be passed onto the power station if the two are separate parties.

In estimating the carbon savings we have assumed the carbon intensity of natural gas, coal and oil remain constant. We have also looked at two scenarios for the carbon intensity of electricity generated elsewhere. This is included to reflect the extra emissions due to the loss of electricity generated by the power station through heat extraction and electricity used by a district heating operator (if separate from the power station) for pumping.

The two scenarios are:
1. The DECC UEP central generation mix projection out to 2020.
2. The current CO_2 intensity of CCGT.

The model takes account of the following appropriate current policy costs/benefits:

- Climate Change Levy (CCL).
- CCL Levy Exemption Certificates (LECs).
- Renewable Obligation Certificates (ROCs) under current arrangements 2 ROCs for CHP/1.5 for non CHP.
- No Renewable Heat Incentive (RHI); and
- EU Emissions Trading Carbon Charges (EU-ETS) Phase 3 as proposed.

The results of this are captured and the annual model re-run for each year in the CHP's life, which is assumed to be the 40 years, from 2012 to 2052 (with the benefits extended out for the lifetime of the installation). The discounted life costs and lifetime carbon savings are then calculated. A macro then captures key results for all sites in the model.

4.3 Approach to NPV Calculation

For completeness and sense checking, when taking the financial assessment from the power station's point of view, a whole life costing was undertaken on both the base case power only option, and on the CHP option, discounted at a rate and lifetime (up to 40 years) set by the user. The NPV is the whole life cycle cost of the base case less that of the CHP case discounted at 9%.

The difference between these two cases is the key comparison.

However, analysing the NPV of the power station alone allows the user to see if the power station is financially viable in its own right which can also be a good sense check on inputs. If the model shows it to be highly unviable then this suggests the input variables may be incorrect. The model also calculates the IRR of the power station alone and the IRR of then converting to CHP.

4.4 Key Financial Variables

The heat price paid by end consumers assumes a 20% discount on the alternative cost of generating heat from new gas or oil boilers. This calculation assumes that the consumers' boiler systems have an efficiency of 85% (HHV) (95% gas and 5% oil as per current consumption in Scotland excluding electric heating).

Using DECC's latest projection of gas and oil prices (2010 real terms) this gives a price of 3.36p/kWh for heat in 2013. Thereafter heat prices are indexed to DECC Gas and Oil retail price projections[17].

The value paid to the power station by the DH operator (if separate) will be a negotiated fraction of the heat price. The value used is found by iteration in the main WLC model to balance the benefits to both parties.

Electricity wholesale values are assumed to be as per DECC price projections (e.g. 6.63p/kWh in 2013). Carbon prices are assumed at DECC's central traded projection e.g. £14.70/Tonne CO_2 in 2013[18]. ROC prices are assumed to remain at the current price of £45/ROC in real terms.

17
http://www.decc.gov.uk/media/viewfile.ashx?filetype=4&filepath=Statistics/Projections/69-annex-f--fossil-fuel-and-retail-price-assumptions.xlsx

18 http://www.decc.gov.uk/media/viewfile.ashx?filepath=what we do/a low carbon uk/carbon valuation/1_20100610131858_e_@@_carbonvalues.pdf&filetype=4&minwidth=true

4.5 Carbon Saving Assessment Methodology

The CO_2 savings have been calculated taking the following aspects into account:

I. The fuel that would have been used by heat consumers. This assumes gas is the avoided fossil fuel, which will provide a conservative estimate as this has a lower emissions factor than oil, LPG or coal. The assumed boiler efficiency is 85% (GCV).

II. Fuel used by backup boilers at the power station or by a separate DH operator if applicable, these are used when the power station is not generating and hence the main power station boilers cannot provide the heat required. The fuel used is assumed to be the same mix as used for power generation or natural gas if supplied by a separate DH operator and the assumed boiler efficiency is 85 (GCV)%.

III. The additional fuel used in the power generation. Electricity output is reduced slightly when heat is extracted. Hence to maintain the same level of total electricity generation extra fuel is burnt and extra CO_2 emissions occur – at another power station. It is assumed that this additional electricity demand comes from a marginal gas fired CCGT fired power station with a carbon factor of 0.43T CO_2/MWhe. This assumption is made as the power station being used to provide the heat is running to support meet electricity demand when renewable generation is insufficient. Hence the alternative generation is gas fired and not renewable.

IV. The electricity used for pumping in the heat distribution network. Whether this is provided directly by the power station resulting in less power generation or imported by the power station or a separate DH operator, it necessitates make up power which again is assumed to come from marginal CCGT plant so again the emissions factor assumed is 0.43T CO_2/MWhe.

For fossil fuels the emissions factors are taken from annexes for Defra’s guidelines on company reporting of greenhouse gas emissions.

Over time the amount of heat supplied will increase. The study uses a number of assumptions regarding the time period that is needed to reach full heat sales. Hence over the development period all the factors above will change and the annual CO_2 savings will steadily increase. Once the development period is complete, the annual CO_2 savings will plateau.

Hence the annual CO_2 savings depend on what year and which development period is chosen. To make reporting of CO_2 savings simpler the results are quoted as lifetime CO_2 savings, i.e. the calculations described above over each year of the system lifetime of 40 years.

While this makes the CO_2 savings easier to present, the results cannot be compared with annual CO_2 savings in a given year.

5 Core Results

This section sets out the core financial and emissions modelling outputs for each of the four power station sites. The core results assume current policy initiatives are in place.

The model results for each power station fit into five different scenarios:

- **Scenario 1**: An assumed 100% of anchor heat loads are picked up from year 1. In reality this will never be possible, but this result shows the financial returns under the most positive scenario possible, providing a useful yardstick.

- **Scenarios 2 to 5**: The other results use a 15 year built up of heating load, with heat sales increasing by 7% each year. This reflects the fact that most consumers will not consider connecting until their own boilers fall due for replacement. The timescales for this will depend on each site. In the past the period for heat load to build up has been very long, 20 years or more. With new pressures on customers (high energy costs, CRC etc.) we are assuming a typical build up period of 15 years. Scenarios 2 to 5 progressively test the impact of different levels of connection of heat load falling from 100% to 75% then 50% and finally 25%.

The results for each scenario are coded as P1, L4 etc, i.e. Peterhead scenario 1, Longannet scenario 4 etc. The following table shows the scenario assumptions and codes.

Table 6 Scenario Assumptions

	Scenario Code	Final heat load % of potential	Timescale of heat load build up
		%	years
Peterhead	P1	100%	1
	P2	100%	15
	P3	75%	15
	P4	50%	15
	P5	25%	15
Hunterston	H1	100%	1
	H2	100%	15
	H3	75%	15
	H4	50%	15
	H5	25%	15
Cockenzie	C1	100%	1

	C2	100%	15
	C3	75%	15
	C4	50%	15
	C5	25%	15
Longannet	L1	100%	1
	L2	100%	15
	L3	75%	15
	L4	50%	15
	L5	25%	15

5.1 Peterhead

With no additional support the screening process showed that only loads within Peterhead itself would be financially viable to connect to the power station. Around 90%, of the heat load would be non-domestic and it would not be viable to feed most new housing developments. The network would be as follows:

Figure 10 Potential pipe route for Peterhead

This network has two main legs:

- An eastern leg which runs through Peterhead town supplying existing loads.
- A western leg which largely supplies new development sites.

In practice, it may be desirable to complete the loop between the mixed development (M1) to the northwest and business park 1 to the Northeast. This could provide a level of redundancy in the network for sites to the north of the scheme when maintenance was to be carried out, but this option is not modelled below as it would be less cost effective.

Table 7 Peterhead Heat Sales

Scenario Code	Final heat load % of potential	Timescale of build up	Final Peak Load	Lifetime Heat Sales
	%	yrs	MW	MWh
P1	100%	1	51.606	3,341,323
P2	100%	15	51.606	2,756,591
P3	75%	15	38.704	2,067,443
P4	50%	15	25.803	1,378,296
P5	25%	15	12.901	689,148

Table 8 Peterhead Capital Costs

Scenario Code	Power Plant Conversion to CHP Capex	DH Capex Incl. distribution, HCUs and heat meters in dwellings less conventional domestic boilers	Total Capex
	£	£	£
P1	£10,788,177	£10,765,475	£21,553,652
P2	£10,788,177	£10,765,475	£21,553,652
P3	£10,788,177	£9,150,654	£19,938,831
P4	£10,788,177	£6,459,285	£17,247,462
P5	£10,788,177	£3,767,916	£14,556,094

Table 9 Peterhead Scenario Results

Scenario Code	NPV	IRR	Lifetime Carbon Saving
	£	%	Tonnes CO_2
P1	-£2,168,818	7.73%	347,287
P2	-£11,800,368	3.31%	286,512
P3	-£12,623,863	2.08%	214,884
P4	-£12,370,814	0.68%	143,256
P5	-£12,117,768	None	71,628

Probably the most likely scenario above is that 75% of identified heat loads would be connected over a 15 year period (P3). Assuming this is the case and the power station also develops the DH scheme then the NPV at DCR of 9% without subsidy is -£12.6M and the IRR to around 2% so a £12.6M net present value subsidy would be required to achieve an IRR of 9%. The capital cost would be around £19.9M (£10.8M to fit heat extraction capability to the power station and £9.1M for the DH network) and the required whole life subsidy as a percentage of capital cost would be around 63%.

Once the network has reached the peak of its development (75% of all identified potential heat load) it would be delivering 63,000 MWh/Yr of heat to customers and saving 6,500TCO_2/Yr.

The lifetime CO_2 savings would be around 215,000TCO_2 so the lifetime subsidy required to make the scheme cost effective would be around £59/TCO_2.

5.2 Hunterston

Two main pipe routes were initially considered:

- An eastern route, taking in loads in Dalry, Glengarnock and Kilbirnie.
- A southern route, taking in loads in Ardrossan, Saltcoats, Stevenson, Kilwinning, Irvine and the industrial sites south of Irvine.

The eastern route has several long sections without any connected heat loads. The initial logic was driven by the potential industrial anchor heat load in Dalry (Roche). This site already has a CHP system – so there is a high degree of uncertainty over the potential for connecting this load. Without this load the onwards legs to Glengarnock and Kilbirnie would not be financially viable.

As a result the analysis focused on the southern route:

Figure 11 Potential southern pipe route for Hunterston

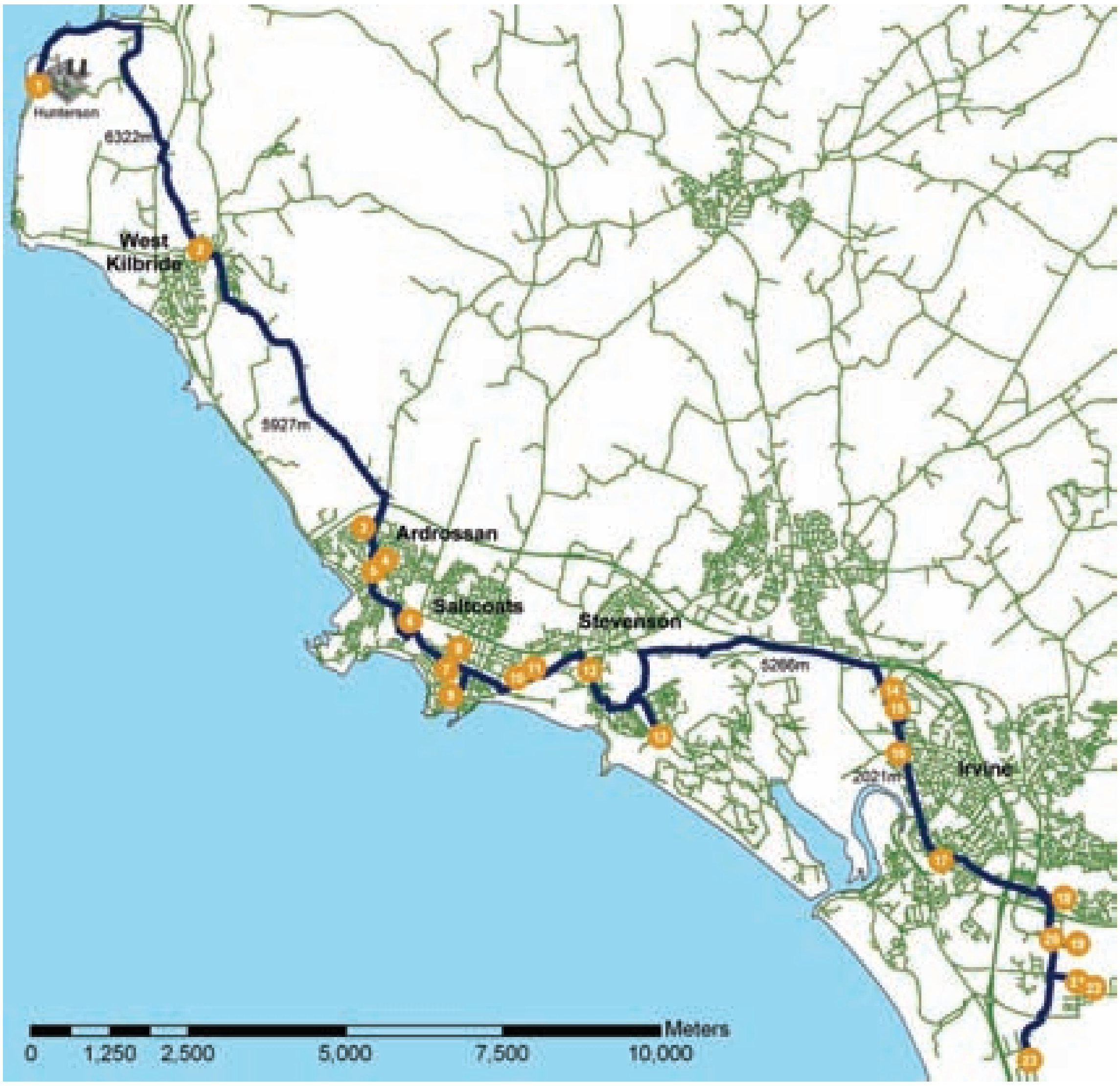


Table 10 Hunterston Heat Sales

Scenario Code	Final heat load % of potential	Timescale of build up	Final Peak Load	Lifetime Heat Sales
	%	yrs	MW	MWh
H1	100%	1	107.453	18,617,060
H2	100%	15	107.453	15,359,074
H3	75%	15	80.590	11,519,306
H4	50%	15	53.726	7,679,537
H5	25%	15	26.863	3,839,769

Table 11 Hunterston Capital Costs

Scenario Code	Power Plant Conversion to CHP Capex	DH Capex Incl. distribution, HCUs and heat meters in dwellings less conventional domestic boilers	Total Capex
	£	£	£
H1	£27,000,000	£44,620,175	£71,620,175
H2	£27,000,000	£44,620,175	£71,620,175
H3	£27,000,000	£37,927,149	£64,927,149
H4	£27,000,000	£26,772,105	£53,772,105
H5	£27,000,000	£15,617,061	£42,617,061

Table 12 Hunterston Scenario Results

Scenario Code	NPV	IRR	Lifetime Carbon Saving
	£	%	Tonnes CO_2
H1	£20,249,722	12.72%	1,092,564
H2	-£27,254,200	5.01%	901,365
H3	-£31,652,504	3.63%	676,024
H4	-£31,588,900	2.17%	450,683
H5	-£31,525,404	-0.58%	225,341

In scenario H3 assuming this is the case and the power station also develops the DH scheme then the NPV at DCR of 9% without subsidy is -£32M and the IRR to around 3.6% so a £32 M net present value subsidy would be required to achieve an IRR of 9%. The capital cost would be around £65M (£27M to fit heat extraction capability to the power station and £38M for the DH network) and the required whole life subsidy as a percentage of capital cost would be around 49%.

Once the network has reached the peak of its development (75% of all identified potential heat load) it would be delivering around 350,000MWh/year of heat to customers and saving around 20,500 TCO_2/Yr.

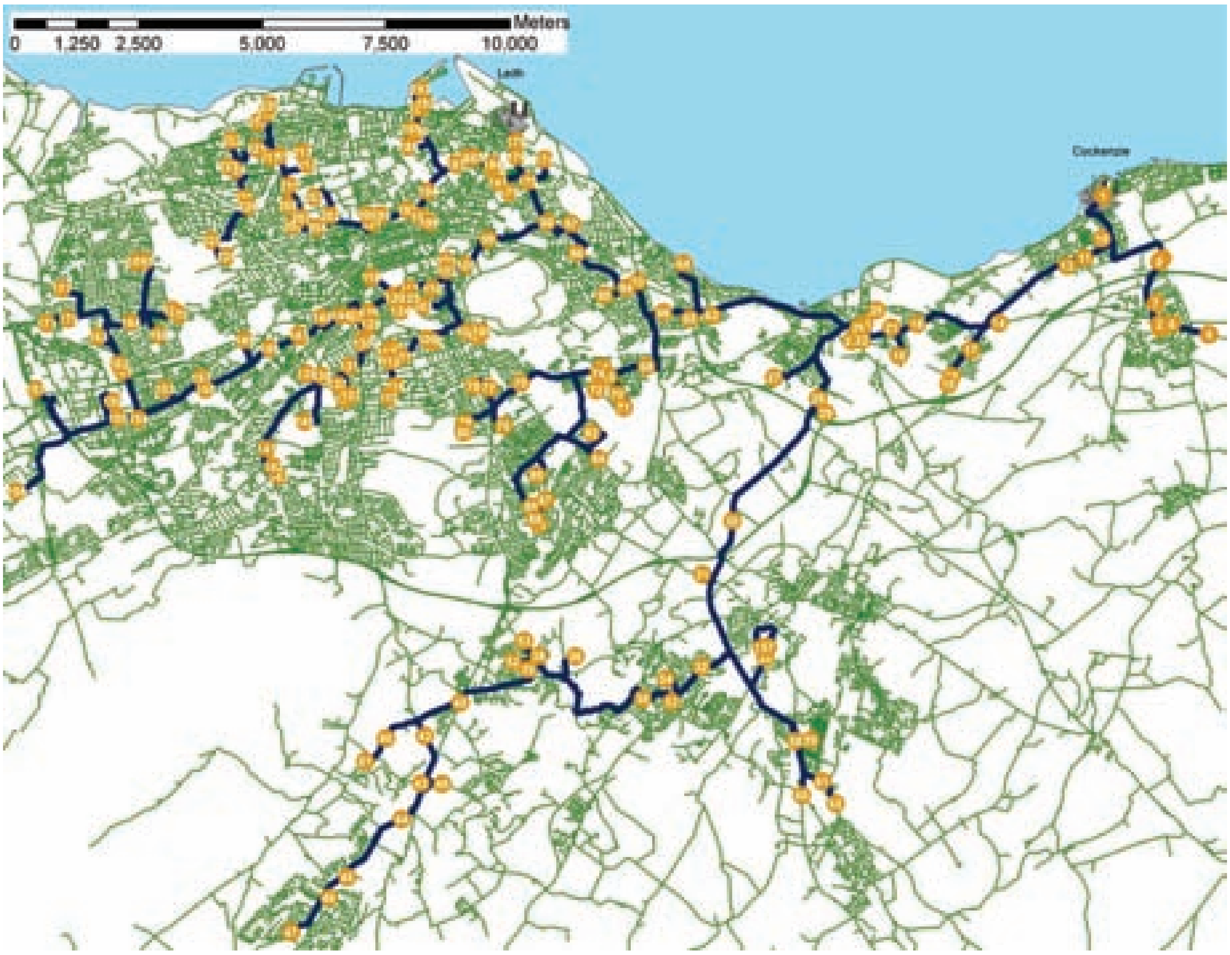
The lifetime CO_2 savings would be around 680,000 TCO_2 so the lifetime subsidy required to make the scheme cost effective would be around £47/TCO_2.

5.3 Cockenzie

This network is significantly larger than the preceding two examples, with 240 anchor heat loads.

Several main pipe routes were considered as shown below:

Figure 12 Potential pipe route for Cockenzie



This network is not only larger, but is likely to be more difficult than the others due to:

- The densely packed urban areas served with extensive networks of pipes and cables already in place.
- The potential competition from the proposed biomass plant at Leith.

It should be noted that the south western most leg extending to Penicuik rises a few hundred metres. This will necessitate high static pressures on most of the DH network but will not increase the pumping energy requirement which is purely due to friction as the static head will be recovered in the return leg.

Table 13 Cockenzie Heat Sales

Scenario Code	Final heat load % of potential	Timescale of build up	Final Peak Load	Lifetime Heat Sales
	%	yrs	MW	MWh
C1	100%	1	222.071	24,049,695
C2	100%	15	222.071	19,840,999
C3	75%	15	166.553	14,880,749
C4	50%	15	111.035	9,920,499
C5	25%	15	55.518	4,960,250

Table 14 Cockenzie Capital Costs

Scenario Code	Power Plant Conversion to CHP Capex	DH Capex Incl distribution, HCUs and heat meters in dwellings less conventional domestic boilers	Total Capex
	£	£	£
C1	£10,788,177	£158,166,950	£168,955,127
C2	£10,788,177	£158,166,950	£168,955,127
C3	£10,788,177	£134,441,908	£145,230,085
C4	£10,788,177	£94,900,170	£105,688,347
C5	£10,788,177	£55,358,433	£66,146,610

Table 15 Cockenzie Scenario Results

Scenario Code	NPV	IRR	Lifetime Carbon Saving
	£	%	Tonnes CO_2
C1	-£11,505,178	8.10%	2,499,655
C2	-£92,596,566	3.14%	2,062,216
C3	-£87,960,720	2.31%	1,546,662
C4	-£67,508,476	1.80%	1,031,108
C5	-£47,056,527	0.57%	515,554

In scenario C3 assuming this is the case and the power station also develops the DH scheme then the NPV at DCR of 9% without subsidy is -£88 M and the IRR to around 2.3% so a £88M net present value subsidy would be required to achieve an IRR of 9%. The capital cost would be around 145M (£11M to fit heat extraction capability to the power station and £134M for the DH network) and the required whole life subsidy as a percentage of capital cost would be around 61%.

Once the network has reached the peak of its development (75% of all identified potential heat load) it would be delivering around 450,000MWh/year of heat to customers and saving around 47,000 TCO_2/Yr.

The lifetime CO_2 savings would be around 1,500,000 TCO_2 so the lifetime subsidy required to make the scheme cost effective would be around £57/TCO_2.

5.4 Longannet

Figure 13 Potential pipe route for Longannet

The network extends westward to Stirling and eastward to Dunfermline and beyond to the Exxon Mobile plant at Mossmorran.

The potential to cross the Kincardine Bridge was discounted due to:

- The heat recovery that could be provided from industrial sites in the Grangemouth area – which would not incur the cost of a pipe network to reach, and then cross the Kincardine Bridge and then cross the south bank of the Forth.
- The potential for additional competition from the proposed biomass plant on Grangemouth docks.

Table 16 Longannet Heat Sales

Scenario Code	Final heat load % of potential	Timescale of build up	Final Peak Load	Lifetime Heat Sales
	%	yrs	MW	MWh
L1	100%	1	162.272	21,999,211
L2	100%	15	162.272	18,149,349
L3	75%	15	121.704	13,612,012
L4	50%	15	81.136	9,074,674
L5	25%	15	40.568	4,537,337

Table 17 Longannet Capital Costs

Scenario Code	Power Plant Conversion to CHP Capex	DH Capex Incl distribution, HCUs and heat meters in dwellings less conventional domestic boilers	Total Capex
	£	£	£
L1	£27,000,000	£72,948,433	£99,948,433
L2	£27,000,000	£72,948,433	£99,948,433
L3	£27,000,000	£62,006,168	£89,006,168
L4	£27,000,000	£43,769,060	£70,769,060
L5	£27,000,000	£25,531,952	£52,531,952

Table 18 Longannet Scenario Results

Scenario Code	NPV	IRR	Lifetime Carbon Saving
	£	%	Tonnes CO_2
L1	£13,732,958	10.85%	1,117,719
L2	-£45,414,355	4.01%	922,118
L3	-£48,104,483	2.80%	691,589
L4	-£43,502,881	1.63%	461,059
L5	-£38,898,930	-0.74%	230,530

In scenario L3 assuming this is the case and the power station also develops the DH scheme then the NPV at DCR of 9% without subsidy is -£48 M and the IRR to around 2.8% so a £48M net present value subsidy would be required to achieve an IRR of 9%. The capital cost would be around 89M (£27M to fit heat extraction capability to the power station and £62M for the DH network) and the required whole life subsidy as a percentage of capital cost would be around 54%.

Once the network has reached the peak of its development (75% of all identified potential heat load) it would be delivering around 410,000MWh/Yr of heat to customers and saving around 21,000 TCO2/Yr.

The lifetime CO_2 savings would be around 690,000 TCO_2 so the lifetime subsidy required to make the scheme cost effective would be around £70/TCO_2.

5.5 Comparison of the Core Results for Each Station

The following table shows the key results for all four power station sites, showing the IRR under each of the five scenarios:

Table 19 Key Results

	Scenario Code	Final heat load % of potential	Timescale of build up	IRR
		%	years	%
Peterhead	P1	100%	1	7.73%
	P2	100%	15	3.31%
	P3	75%	15	2.08%
	P4	50%	15	0.68%
	P5	25%	15	None
Hunterston	H1	100%	1	12.72%
	H2	100%	15	5.01%
	H3	75%	15	3.63%
	H4	50%	15	2.17%
	H5	25%	15	-0.58%
Cockenzie	C1	100%	1	8.10%
	C2	100%	15	3.14%
	C3	75%	15	2.31%
	C4	50%	15	1.80%
	C5	25%	15	0.57%
Longannet	L1	100%	1	10.85%
	L2	100%	15	4.01%
	L3	75%	15	2.80%
	L4	50%	15	1.63%
	L5	25%	15	-0.74%

The key points from this are:

- Only two systems make a commercial rate of return of 9% or more are H1 and L1 – both are under the ideal circumstances of 100% load connected in year 1.
- The best rate of return for scenario 2 is for H2 at 5% - however this is far from financially viability.

- The best rate of return for scenario 3 is for H3 at 3.6% - however this is also far from financially viability.

Hence under current policy conditions none of the more realistic options is close to commercially viable. As there are no schemes of this scale of heat demand connected to any UK power station, this is not an unexpected result. However the model allows a range of policy options to be modelled and the core results give an indication of the key issues.

High capital cost is a well-recognised key issue for district heating. The following table shows the funding required enabling each scenario to reach a 9% IRR.

Table 20 Funding requirement levels

	Scenario Code	Final heat load % of potential	Timescale of build up	Funding required to Reach 9% IRR
		%	years	£ million
Peterhead	P1	100%	1	2.17
	P2	100%	15	11.80
	P3	75%	15	12.62
	P4	50%	15	12.37
	P5	25%	15	12.12
Hunterston	H1	100%	1	none
	H2	100%	15	27.25
	H3	75%	15	31.65
	H4	50%	15	31.59
	H5	25%	15	31.53
Cockenzie	C1	100%	1	11.51
	C2	100%	15	92.60
	C3	75%	15	87.96
	C4	50%	15	67.51
	C5	25%	15	47.06
Longannet	L1	100%	1	none
	L2	100%	15	45.41
	L3	75%	15	48.10
	L4	50%	15	43.50
	L5	25%	15	38.90

This shows that even with 100% load connected (scenario 2); the funding requirements are significant, ranging from £12 million to £92 million.

These are very large sums; however the amount of carbon saved is also significant. Hence the cost effectiveness of the potential funding is key.

The carbon savings are assessed over the 40 year lifetime of each scheme. As heat load builds up over 20 years the carbon savings in year 1 will be small, growing by 5% pa. Because the carbon savings are different in each year it is not possible to give a single figure for annual carbon savings, hence the table below shows the lifetime carbon saving and the funding needed per tonne of lifetime carbon savings.

Table 21 Capital Grant Cost Effectiveness

	Scenario Code	Lifetime Carbon Saved	Funding requirement to Reach 9% IRR	Funding per tonne CO_2
		ktonnes CO_2	£ million	£/tonne CO_2
Peterhead	P1	347	2.17	6.25
	P2	286	11.80	41.19
	P3	214	12.62	58.75
	P4	143	12.37	86.35
	P5	71	12.12	169.18
Hunterston	H1	1	0.00	0.00
	H2	901	27.25	30.24
	H3	676	31.65	46.82
	H4	450	31.59	70.09
	H5	225	31.53	139.90
Cockenzie	C1	2	11.51	4.60
	C2	2	92.60	44.90
	C3	1	87.96	56.87
	C4	1	67.51	65.47
	C5	515	47.06	91.27
Longannet	L1	1	0.00	0.00
	L2	922	45.41	49.25
	L3	691	48.10	69.56
	L4	461	43.50	94.35
	L5	230	38.90	168.74

This shows a range of cost effectiveness for the more realistic scenarios 2 to 5. This ranges from £30/tonne CO_2 to £168/tonne CO_2. Generally the higher the connection level the better the cost effectiveness.

This has an important lesson for the policy ideas, as policies that can increase connection rates will reduce the gap in capital funding needed and offer better cost effectiveness.

5.5.1 Comparison of Heat Loads

5.5.2 Breakdown between existing and proposed heat customers

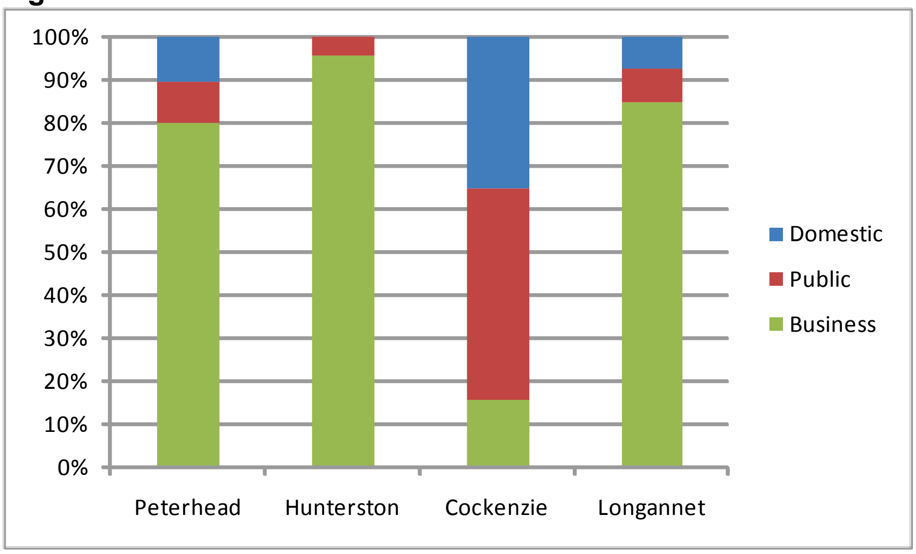
The Peterhead network is dominated by proposed loads, hence this network is the most speculative, as there is significant risk that these heat uses are not developed. The Longannet network is dominated by existing users and as such this network is the least speculative.

Figure 14 the breakdown between existing and proposed heat customers for the four sites

5.5.3 Breakdown between the sectors served

There sectors served by the four stations may be categorised as domestic, public and business. Cockenzie is the closest of the four sites to a large conurbation; hence this has significant heat supply to all three sectors. Hunterston is dominated by heat supply to the business sites around Irvine.

Figure 15 The breakdown between the sectors served for each of the four sites:



5.6 Sensitivity Analysis

This section tests out how sensitive the core results are to changes in key variables and includes some basic assessment of how capital and revenue support might change investment returns.

Where the sensitivity test takes the IRR above 9%, the target rate, the result is in **bold**.

5.6.1 Sensitivity to Build out Rate

Tests have been run to show the impact of a more accelerated growth of the heat load.
With a large capital expenditure, increasing the revenue from heat sales at an earlier period has a potentially important impact. We have modelled three scenarios:

- Accelerated heat load build-up of 10 years.
- Accelerated heat load build-up of 5 years.

Table 22 IRR for the 2 sensitivity tests

	10 Years	5 Years
P2	4.56%	6.13%
P3	2.61%	3.74%
P4	0.23%	0.94%
P5	None	None
H2	6.93%	9.56%
H3	4.46%	6.40%
H4	1.47%	2.72%
H5	None	None
C2	4.45%	6.19%
C3	2.45%	3.70%
C4	0.02%	0.80%
C5	None	None
L2	5.78%	8.14%
L3	3.42%	5.16%
L4	0.53%	1.66%
L5	None	None

In no cases does a 10 year build out reach the 9% target IRR. In only one case, H2, does a 5 year build out reach the 9% IRR, however L2 is close to this rate.

As would be expected the test has the greatest impact on Scenario 2 as this has the highest heat loads and hence the highest revenue from heat sales.

In line with the IRR results the funding gap falls very significantly for the Scenario 2 cases.

Table 23 The funding gap for the 2 sensitivity tests:

Funding gap	10 Years	5 Years
P2	9.01	5.46
P3	12.14	9.48
P4	15.28	13.51
P5	18.42	17.53
H2	13.92	0.00
H3	28.34	15.26
H4	42.77	34.05
H5	57.19	52.83
C2	70.10	40.37
C3	94.81	72.51
C4	119.53	104.66
C5	144.24	136.81
L2	28.89	7.20
L3	46.65	30.39
L4	64.41	53.55
L5	82.18	76.75

5.6.2 Sensitivity to Capital and Revenue Support

The core results emphasis two key financial challenges for district heating:

- The large impact of the high upfront capital costs needed for the heat network. The impact is high as the sums of investment are large and they all occur in year one of the project's financial life.
- The modest impact of the income from heat sales. The impact is modest as the initial heat sales are low and the discounting process reduces the impact of the increasing heat sales in later years.

There are two obvious routes to change the status quo:

- Offer substantial capital funding support

- Offer revenue support on heat sales – a District Heating Incentive

Both of these routes would involve substantial sums of state aid. There are state aid guidelines for environmental support measures – however they tend to focus on renewable energy. The heat from these 4 power stations is predominantly derived from fossil fuel. Hence there will be a significant challenge to gain approval for significant aid. In addition the sums involved are likely to be substantial – raising value for money questions. For the District Heating Incentive this is the type of measure that would probably require UK level primary legislation.

The large scale financial support measures are unlikely to be practical or affordable policy ideas hence they have not been selected for the policy analysis stage of this report. To illustrate the scale of these funding routes and their impact this section provides a sensitivity analysis testing out these ideas.

Capital Funding

The capital costs vary from station to station, depending on the size of the heat network – which depends on the assumption on the level of connections. The following table shows the capital costs under the most extreme scenarios.

Table 24 Summary of Capital Costs

Power Station Site	Capital for Scenario 1 (100% heat load)	Capital for Scenario 5 (25% heat load)
Peterhead	£21,553,652	£14,556,094
Hunterston	£71,620,175	£42,617,061
Cockenzie	£168,955,127	£66,146,610
Longannet	£99,948,433	£52,531,952
Total	**£362,077,387**	**£175,851,717**

Hence 10% capital funding would be between £17 and £36 million for all four sites.

For this idea we propose testing the impact of 20% and 40% capital funding on Scenario 3 – 75% heat load within 15 years.

District Heating Incentive

District heating is a major capital investment. The financial returns are dominated by the value of heat sales vs. the high initial capital costs. In general fiscal support for low carbon technologies are moving towards revenue incentives, e.g. ROCs, FIT and the RHI.

This idea tests the impact of a District Heating Incentive – paid on the sales of heat. This would be similar in concept to the RHI. The proposals for the RHI included a possible uplift for renewable heat supplied via district heating. As currently implemented the RHI does not have this uplift.

This tests the impact of rewarding heat from district heating with the RHI level for biomass boilers over 1 MW, i.e. 2.6 p/kWh and at half this level 1.3 p/kWh.

Capital and Revenue Support Results

The table below shows that with high levels of capital or revenue support that in two cases Scenario 3 can improve from a low IRR of 2.08% to3 3.36% to levels above the 9% threshold.

Table 25 Results of Capital and Revenue Support Ideas

	Longannet		Hunterston		Cockenzie		Peterhead	
Policy	**NPV**	**IRR**	**NPV**	**IRR**	**NPV**	**IRR**	**NPV**	**IRR**
No Support	-£48,104,483	2.80%	-£31,652,504	3.63%	-£87,960,720	2.31%	-£12,623,863	2.08%
Heat Incentive equivalent to RHI	**£17,900,253**	**10.48%**	**£24,204,688**	**11.61%**	-£15,803,867	8.14%	-£2,598,817	7.98%
Heat Incentive equivalent to RHI/2	-£15,102,115	7.55%	-£3,723,908	8.53%	-£51,882,293	5.79%	-£7,611,340	5.60%
40% Capital Grant	-£12,502,016	6.65%	-£5,681,644	7.60%	-£29,868,686	5.65%	-£4,648,331	5.26%
20% Capital Grant	-£30,303,250	4.39%	-£18,667,074	5.26%	-£58,914,703	3.68%	-£8,636,097	3.40%

The table below shows the financial cost of each of these ideas. In the case of capital support this is simply the value of the capital grant. In the case of the District Heating Incentive it is the NPV of the annual support.

The following charts show the impact of these ideas.

Figure 16 Sensitivity Results for Longannet

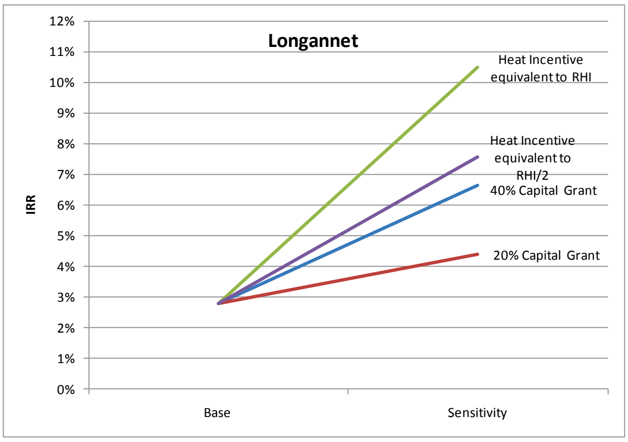


Figure 17 Sensitivity Results for Hunterston

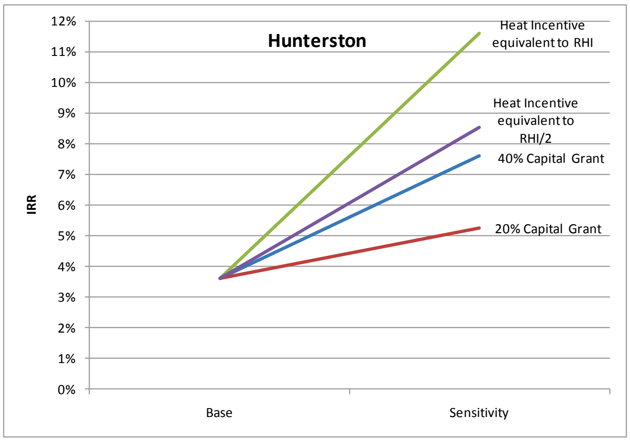


Figure 18 Sensitivity Results for Cockenzie

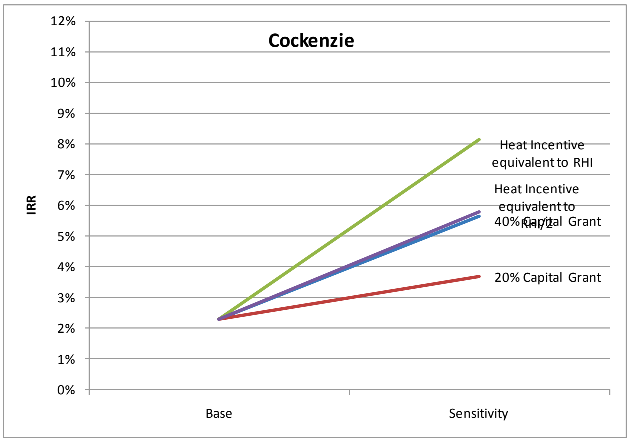
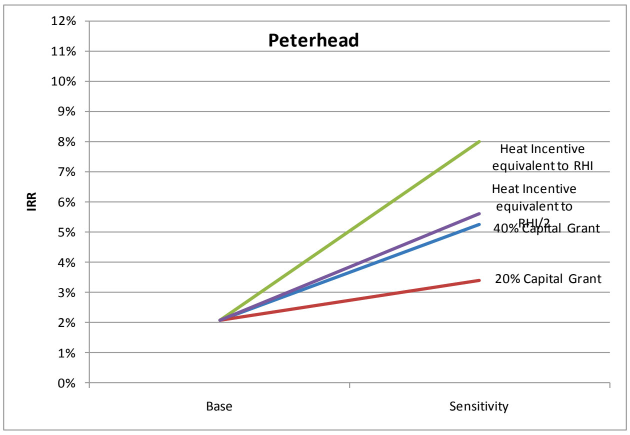


Figure 19 Sensitivity Results for Peterhead



The following table shows the costs of these sensitivity tests.

Table 26 Cost of Capital and Revenue Sensitivity Tests

	Longannet	Hunterston	Cockenzie	Peterhead
	Policy Cost WLC	Policy Cost WLC	Policy Cost WLC	Policy Cost WLC
Heat Incentive equivalent to RHI	£66,004,737	£55,857,192	£72,156,853	£10,025,047
Heat Incentive equivalent to RHI/2	£33,002,368	£27,928,596	£36,078,427	£5,012,523
40% Capital Grant	£35,602,467	£25,970,860	£58,092,034	£7,975,532
20% Capital Grant	£17,801,234	£12,985,430	£29,046,017	£3,987,766

5.6.3 Conclusions on Sensitivity Tests

A small number of the sensitivity tests show that the target rate of a 9% IRR can be met. These are:

- Accelerating the build-up of the heat load from 15 years to 5 years.
- A high level of revenue support, similar in level to the Renewable Heat Incentive.

Of these two the revenue support is not a practical option. The NPV of the revenue support is higher than the funding gap. For Longannet the NPV of the revenue support is £66 million, whereas the funding gap is £45 million. In addition it would be difficult to present a State Aids cased to support heat from a fossil fuel source at the same support level as heat from renewable sources.
This suggests that:

- Policy measures to bring forward heat sales are a more affordable and practical option than revenue incentives.
- Policy measures that can reduce the costs of the heat network, e.g. by co-locating heat demand and heat supply, could play an important role.

Hence planning policy has an important role to play.

6 Components of Successful Schemes

Recovery of heat from large power stations has not been undertaken in the UK in the recent past. However, from a technical and financial standpoint it is possible and is undertaken elsewhere.

6.1 International Lessons

It is useful to consider some of the experience from countries with significant district heating networks. This is drawn from:

- Experience in Denmark
- Details from the Case Studies

6.1.1 Denmark

Around 60% of domestic consumers in Denmark are heated from district heating systems[19]. The growth of district heating started in the 1970's in response to the oil prices shocks. A series of heat laws were passed, which steadily increased the role of district heating. Each version of the Heat Law introduced new features. At the current time the key elements are:

Heat Planning

Denmark passed its first heat supply law in 1979. The law contained regulations on the form and contents of heat planning in Denmark. The heat planning requirements were divided into phases:

- In the first phase, local authorities were to prepare reports on their heat requirements, the heating methods used and the amounts of energy consumed.
- In the second phase they were also asked to assess heat needs and heating possibilities to meet future requirements. This was used to produce regional heat summaries, leading to regional heat plans. The plans were required to show the areas where various forms of heat supply should be prioritised, e.g. district heating or natural gas. The plans also showed where future heat supply systems and pipelines should be located.

Connections

The first law on heat supply gave local authorities the power to oblige new and existing buildings to connect to public supply. Most consumers were obliged to connect to individual natural gas or district heating systems.

A subsequent amendment introduced a ban on installing electric heat in new buildings. This was then extended to include a ban on electric heat installations in existing buildings with water-based central heating systems.

[19] http://www.ens.dk/EN-US/SUPPLY/HEAT/Sider/Forside.aspx

In practice, the ban and obligatory connection made it possible for local authorities to ensure that energy supply companies' earnings were not undermined by an insufficient number of connected consumers, in turn ensuring that investments made were not lost.

Conversion to CHP

The foundations of policy from the 1970's and 1980's was continued in the 1990's with a programme of conversion of district heating schemes to use lower carbon fuels and/or generate electricity as well as heat. The results are shown below, with details of the numbers of CHP and district heating plants in Denmark:

Public-heat supply (cities)

- 16 centralised CHP
- 285 decentralised CHP
- 130 decentralised district heating plants

Private heat supply (enterprises, institutions)

- 380 CHP
- 100 district heating plants

Conclusions

The example of how policy and the market for district heating developed in Denmark show that a long term approach can effect a transformation. The context for the policy in Denmark was a need to move from dependence on imported fossil fuel, prompted by oil price shocks from the 1970's.

The context and policy drivers for district heating in Scotland are different – hence while there are valuable lessons from the Danish example, the results need interpretation and translation into the Scottish context.

A wider range of international experience needs to be examines, the cases studies in the following sections from further insight.

6.2 Case Studies

The following three case studies, one from the UK, one from Germany one from Austria show large scale power stations that supply heat. Important lessons can be learnt from reviewing the policies that contributed to the success of these examples including:

Case Study 1: Isle of Grain LNG terminal

- Under Section 36, power station developers are required to have considered heat loads in the nearby vicinity that could allow the station to be operated as CHP. In the case of Isle of Grain, E.ON worked with the authorities and government advisors to identify heat loads suitable to enable CHP. E.ON subsequently chose to further develop the generating station as a CHP plant rather than a power only generating station.
- As a good quality CHP the scheme electricity output is exempt from Climate Change Levy (CCL) and therefore Levy Exemption Certificates (LEC's) can be claimed for electricity generation.
- CHP benefits under the EU Emissions Trading Scheme from increased carbon allocations compared with power only electricity generation. For a CHP plant of this size the benefit would be likely to be in the order of 25-30% more carbon allowances compared with power only. This reduces the number of allowances that will need to be purchased by the generator under the scheme.

Case Study 2: Mellach (nr. Graz), Austria

- Drivers to reduce particulate emissions in area of higher population density.
- Incentives are in place for end users to connect to the district heating system, in the form of grants of between 500-1000 Euros towards the cost of connection (this is funded by regional government body).

Case Study 3: RDK 8, Germany

- Financial incentive-district heating customers are charged a one-off connection charge to connect to; the district heating system and for the hydraulic interface unit (this is currently subsidised by 50% by Stadtwerke-Karlsruhe).
- Renewable Energies Heat Act (EEWärmeG) (Jan 2009) – German law that introduces the obligation for new buildings to use renewable energy for domestic hot water and space heating. Compliance can include connection to a district heating scheme that has a minimum share of renewable generation or CHP.
- Baden-Württemberg, the Renewable Heat Act (EWärmeG) (2010) – The region of Baden-Württemberg has its own version of the EEWärmeG, this applies to existing buildings not just new buildings.

6.3 Case Study 1: Isle of Grain LNG terminal

Name:	*Isle of Grain LNG terminal*
Country:	*England*
Power output:	*1.3GWe*
Heat output:	*340MWth*
Fuels:	*Natural gas*
Core technology:	*Combined Cycle Gas Turbine (CCGT)*

Background

This £580 million CHP project is currently being developed by E-ON on the Isle of Grain in Kent. The site is an existing oil fired power station which is due to be decommissioned under the Large Combustion Plant Directive (LCPD) in 2015.

The combined cycle gas turbine (CCGT) scheme is expected to achieve an overall plant efficiency of circa.72% and will have an electrical generation capacity of 1,275kWe. The CHP will be able to supply 340MW of heat to a nearby natural gas terminal.

Heat network and customers

The sole customer of the CHP plant is Grain liquefied natural gas terminal (LNG), this is owned by National Grid and was the first UK LNG importation terminal. It will have the capacity to meet 20% of Britain's gas demand by winter 2012.

The E-ON CHP plant will have the capacity to supply up to 340MW of thermal energy to the LNG terminal in the form of (low grade) hot water. It is understood that the heat export is low grade heat recovered from the steam condensation process; this is supplied to the LNG vaporisers at the terminal. The distance of the Grain LNG terminal from the CHP plant is c.2.5km. The LNG terminal has a sufficiently high heat demand that it will be the only customer of the CHP scheme (the low grade of heat exported would also be likely to be restrictive when considering supplying heat to other customers).

Elements key to the proposal

Drivers

- Reduction in gas consumption at the LNG terminal (required to vaporise the LNG), maximising production and reducing operating costs as a result of reduced fuel consumption.
- The scheme will save 350,000 tonnes of carbon dioxide emissions from the LNG Terminal every year (from the natural gas that will be displaced).
- There will be environmental benefits from the scheme due to a reduction in the amount of heat discharged to the River Medway.
- As a good quality CHP the scheme electricity output is exempt from Climate Change Levy (CCL) and therefore Levy Exemption Certificates (LEC's) can be claimed for electricity generation.
- CHP benefits under the EU Emissions Trading Scheme from increased carbon allocations compared with power only electricity generation. For a CHP plant of this size the benefit would be likely to be in the order of 25-30% more carbon allowances compared with power only. This reduces the number of allowances that will need to be purchased by the generator under the scheme.

Barriers

- Cost of district heating connection.

Polices

Under Section 36, power station developers are required to have considered heat loads in the nearby vicinity that could allow the station to be operated as CHP. In the case of Isle of Grain, E.ON worked with the authorities and government advisors to identify heat loads suitable to enable CHP. E.ON subsequently chose to further develop the generating station as a CHP plant rather than a power only generating station.

6.4 Case Study 2: Mellach (nr. Graz), Austria

Name:	*Mellach*
Country:	*Austria*
Power output:	*832MWe*
Heat output:	*400MWth*
Fuels:	*Natural Gas*
Core technology:	*Combined Cycle Gas Turbine*

Background

The €550m Mellach natural gas fired CCGT CHP plant is currently under construction on the outskirts of Graz in Austria by plant owners Verbund. When operational, the system will have an electrical generation capacity of 832MWe and also supply 400MW of heat into the southern part of the Graz district heating system. The overall plant efficiency when fully utilised in CHP mode will be 72.9%. The plant will be installed at site where an existing hard coal power station already provides 230MW of heat into the district heating scheme.

Heat network and customers

The district heating system will serve the Austria's second largest city, Graz with a population of approximately 270,000. The district heating system is owned and operated by Energie Graz (which is largely owned by public companies), it has over 550 MW of heat load connected to it, includes 4,600 heat transfer stations, 300 km of district heating pipes, 977GWh/year of energy generation and is served by 4 existing district heating plants:

- The existing district heat plant Mellach (coal) with a maximum possible heat capacity of 230 MW.
- The district heat plant Graz (gas) with an overall heat capacity of 250 MW.
- The district heat plant Werndorf (oil) with a heat capacity of 230 MW.
- The gas turbine power station in Thondorf with a heat capacity of 30 MW.

In addition to this there has been investment in solar thermal which is operated in combination with the district heating system to provide summer hot water demand on the system.

The new CHP plant is co-located with another of Verbund's existing CHP plant which already supplies heat in to southern part of the Graz district heating system and is located circa 20km from Graz city centre. The maximum heat export from the new Mellach CHP plant is 400MW and it is anticipated that the CHP scheme will export 800 GWh of heat per annum to the district heating scheme.

The flow temperature is a maximum of 120°C in the winter and at max 70°C in the summer with a return flow temperature of approx. 50 °C.

Elements key to the proposal

Drivers

- Existing district heating infrastructure already in place.
- Drivers to reduce particulate emissions in area of higher population density.

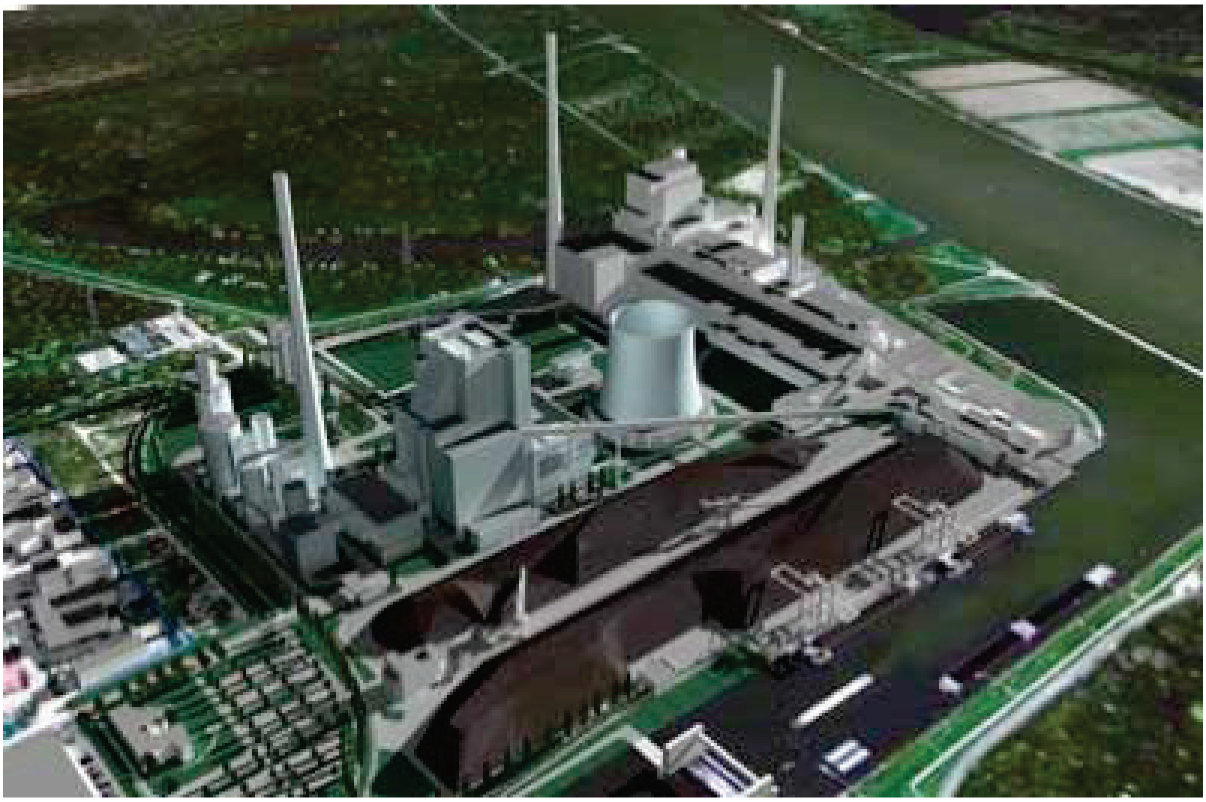
Barriers

- No specific barriers identified.

Polices

- No specific policies have been identified.
- Incentives are in place for end users to connect to the district heating system, in the form of grants of between 500-1000 Euros towards the cost of connection (this is funded by regional government body)

6.5 Case Study 3: RDK 8, Germany



Name:	***RDK 8***
Country:	*Germany*
Power output:	*912MWe*
Heat output:	*220MWth*
Fuels:	*Hard coal*
Core technology:	*Ultra-super critical coal (with steam turbine)*

Background

The RDK 8 CHP plant in Karlsruhe, will cost c. €1b. This will provide 912MWe of electrical generation and supply up to 220MW of heat for district heating. Energie Baden-Württemberg AG (EnBW) will own the plant and is developing it on the same site as a number of existing power generators (some of which have now been decommissioned). The CHP plant will be located around 8km from Karlsruhe city centre. This scheme will utilise an existing pipework connection between the location of the power plants and the municipal district heating system, this is provided by a 4km (800DN) pipe which connects to the site of the power plant to the district heating scheme.

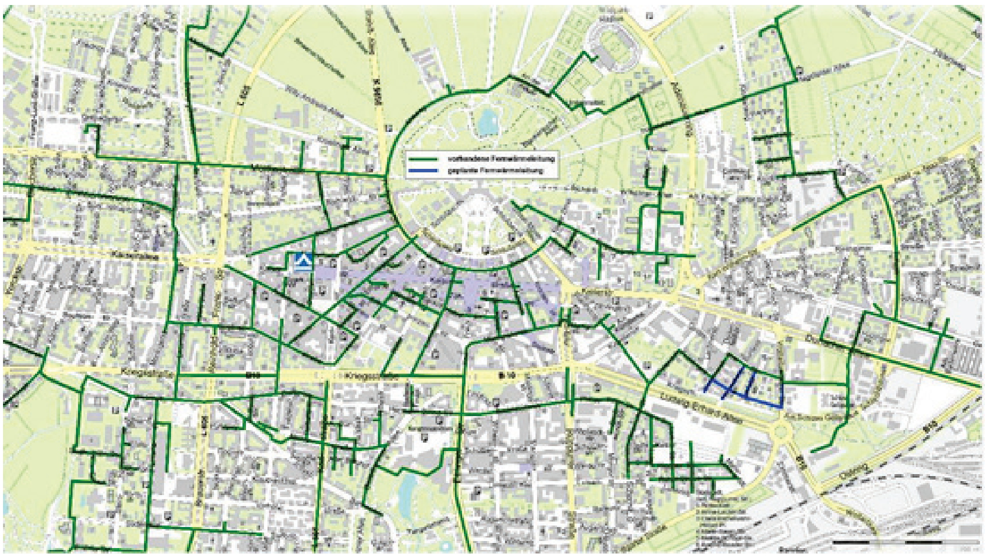
Heat network and customers

The power plant (owned by EnBW) will provide heat to Stadtwerke-Karlsruhe who operates the municipal district heating system. Stadtwerke-Karlsruhe is largely publicly owned company, shared by Karlsruher Versorgungs-, Verkehrs- und Hafen GmbH (KVVH) (70%) it also has private investment from EnBW (20%) and Thuga AG (10%)

Karlsruhe, has a population of circa 300,000, the district heat network is extensive throughout the city and a significant proportion of buildings in the city are served by the scheme. The district heating network is supplied by a range of different heat sources (and includes a waste to energy plant and heat recovery from the MiRO oil refinery in Karlsruhe). The maximum heat load that could be supplied from estimates in 2005, were 500MW.

Heat export from the RDK 8 site, is at 15bar and 130^{o}C, which it the same temperature and pressure as the main heat distribution network. Return water is pumped back to the site at 55^{o}C and 22bar.

District heating customers are charged a one-off connection charge to connect to; the district heating system and for the hydraulic interface unit (this is currently subsidised by 50% by Stadtwerke-Karlsruhe).



Existing network –
Planned network –

Elements key to the proposal

Drivers

- Concerns over long term energy security and estimates from Dena, the German Energy Agency, who predicted a 12GW shortfall of electricity generation in 2020, unless new non-renewable generation was constructed.

- A financial incentive for using the existing district heating infrastructure that is already in place.

Barriers

- There are limited barriers as the heat network is well established and owned and operated by a separate organisation. The heat is only supplied to the district heating company which reduces commercial risks.
- There were some technical challenges when the initial pipeline to connect the RDK site to the district heating scheme was constructed. These included negotiation around existing structures and the utilisation of a combination of above ground and subterranean pipe work.

Polices

- Renewable Energies Heat Act (EEWärmeG) (Jan 2009) – German law that introduces the obligation for new buildings to use renewable energy for domestic hot water and space heating. Compliance can include connection to a district heating scheme that has a minimum share of renewable generation or CHP.
- Baden-Württemberg, the Renewable Heat Act (EWärmeG) (2010) – The region of Baden-Württemberg has its own version of the EEWärmeG, this applies to existing buildings not just new buildings.

7 Identification of Current Policies

A review of existing district heating networks highlights the importance of supportive policy environments as critical to the feasibility of the project. This section therefore reviews the current and proposed, relevant, policy in Scotland. A following separate section examines planning issues – as this is such a key issue it has a separate focus.

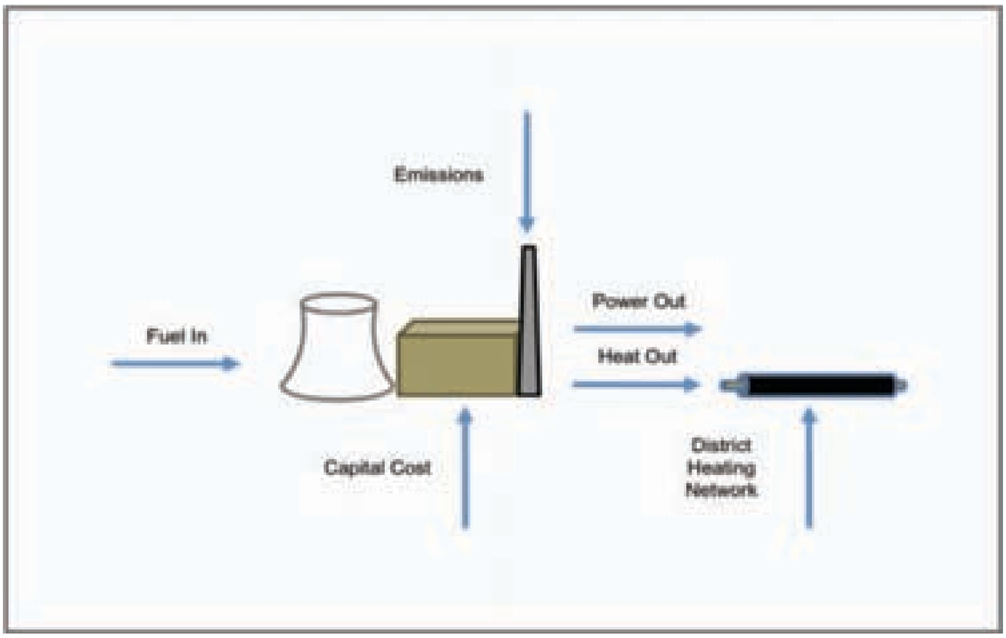
7.1 Existing Energy Policy Support

This study focuses on four conventional power station sites that could recover heat and distribute this to heat consumers via district heating networks. The existing policy measures that would impact on this will include:

- Measures aimed at large power stations, normally with the intent of limiting emissions.
- Measures focused on CHP, normally aimed at supporting the growth of good quality CHP.
- Other general measures that are not specific to power stations or CHP, yet apply to these systems.

A wide range of policy measures apply, for the purpose of this study we have focused on energy and environmental policy. To present these policy measures, these have been grouped, as shown in the figure below:

Figure 20 policy groupings



7.1.1 Fuel In

The review did not identify any policies that currently apply to fuel input. The proposals for a carbon floor price could apply to certain types of scheme – these are described in a separate section on the Electricity Market Reforms.

7.1.2 Emissions

Table 27 The impact of policies applicable to emissions

Policy Measure	Impact
EU Emissions Trading Scheme (EU-ETS)	The EU-ETS is a Europe-wide cap and trade scheme designed to reduce emissions of CO_2. Each EU member state must develop a National Allocation Plan (NAP) approved by the European Commission. This sets an overall cap on the total emissions allowed from all the installations covered by the EU-ETS. All four stations considered in this study will be covered by the EU-ETS and will need to purchase allowances that match the annual emissions of CO_2. The price for EU-ETS allowances used in this study is £14.70/tonne CO_2 in 2013, rising in later years.
Large Combustion Plant Directive (LCPD	The revised LCDP applies to combustion plants with thermal output greater than 50MW. The LCDP controls emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) and dust particulate matter (PM) from power stations running on solid, liquid or gaseous fuel. This requires the fitting of abatement technology on coal fired power plant. Of the four stations considered in this study the LCDP has the most impact on Longannet (which is retrofitted with abatement measures) and Hunterston (which will need to have these fitted from the outset). LCPD abatement adds capital cost and some operating cost. The main operating cost is for SO_2 reduction as this consumes significant amounts of electricity, reducing power station income. Article 6, of the LCPD requires that new or substantially expanded thermal installations undertake a CHP feasibility study. The LCDP is one of the Directives being incorporated into the proposed Industrial Emissions Directive The Commission has proposed the tightening of the maximum emission limit values for SO_X and some other changes reducing the flexibilities available under the present LCPD. The proposals will affect the UK power sector, with possible implications for the development over the next decade of replacement power plants consistent with carbon reduction objectives. There are also proposals to lower the threshold for small combustion plants falling within the scope of IPPC from 50 to 20 MW rated thermal input. In addition, the “aggregation” rules

	would, as now, require consideration of plants below the 20 MW threshold if, in aggregate within an installation, it would exceed the new threshold. Together with the proposed tightening of the emission limit values for large combustion plants the Commission's proposal removes many of the flexibilities that exist in the present LCPD. These include the provision that allows plants to opt out of the terms of the LCPD in return for only being allowed to run for a set amount of limited hours and then closing. This has proved useful for those plants that do not wish to invest in the expensive abatement equipment required to meet ever tighter emission limit values. In addition the present LCPD allowed member states to put in place a national plan within a bubble of total emissions of SO_X, NO_X and dust. Combustion plants are still subject to ELVs, set by the regulator but are able to operate in a more flexible way as long as the overall bubble is not exceeded.
Carbon Capture and Storage Directive	Under this Directive plant receiving development consent are required to undertake a number of assessments related to capturing, transporting and storing its CO_2 emissions. This applies to new combustion plant with a capacity of 300 MWe or more and of a type covered by the EU Large Combustion Plant Directive (LCPD). In Scotland the CCS requirements are incorporated in the guidance for Section 36 consents – see later.
Carbon Floor Price	Under the proposed Electricity Market Reform (EMR) a tax of £16 per tonne of CO_2 produced. This applies from 1 April 2013 rising to £30 by 2020. The EMR is discussed in more detail in a later Section – this new legislation is noted in this report – but as the details are under consultation the impacts have not been assessed.

Capital Plant

Table 28 the impact of policies applicable to capital plant

Policy Measure	Impact
Enhanced Capital Allowances (ECAs)	New good quality CHP schemes can claim ECAs on eligible expenditure. The reduction in corporate tax acts as a reduction in overall capital cost. For schemes that do not fully qualify as good quality the amount of capital expenditure that is eligible for ECA will be scaled back. AEA's interpretation of the ECAs is that does not apply to

	large scale power stations.
Power Station Planning Consent	Power stations over 50 MW of output require planning consent from the Scottish Government under Section 36, of the Electricity Act 1989. The guidance for Section 36 applications, issued in March 2010, includes requirements on heat recovery. This states that: • Scottish Government now expects developers to demonstrate that they have seriously considered how heat from any thermal station could be utilised for use by local households or industry. • Developers should produce a Heat Plan – as set out in SEPA's guidance for energy from waste schemes. • Developers should hold discussions with the local authority • Site selection should consider heat recovery A number of power station proposals have been submitted under this new guidance. The guidance also includes carbon capture readiness (CCR) as required by the EU Directive. This states that no new combustion plant covered by the threshold for CCR would be consented unless the application demonstrated it would be CCR when built. The guidance recognises that CCS plan may have less heat available due to the heat needed within the CCS process.

7.1.3 Power Out

Table 29 the impact of policies applicable to power output

<table>
<tr><th>Policy Measure</th><th colspan="2">Impact</th></tr>
<tr><td>British Electricity Trading Arrangements (BETTA)</td><td colspan="2">BETTA is the electricity market in Great Britain. Large power stations will be full members of this trading system, trading electricity in each half hour period.

A key part of the market design is to reward delivery of generation against predicted output. Failure to generate requires generation shortfall to be bought in the Balancing Market - where prices are intended to be high.

Hence, there is a potential tension between BETTA market requirements and heat supply requirements.</td></tr>
<tr><td rowspan="5">Renewables Obligation (RO)</td><td colspan="2">The RO offers a premium for electricity supplied from a range of renewable technologies.

If a power station fires biomass, the RO could apply to a portion of the electricity generated. Hunterston is planned as a multi-fuel station.

The RO has several bands for biomass; the number of Renewable Obligation Certificates (ROCs) is different for each band. The banding and the number of ROCs per MWh of qualifying electricity are:</td></tr>
<tr><td>Co-firing on non-energy crop (regular) biomass</td><td>0.5</td></tr>
<tr><td>Co-firing of energy crops; co-firing of non-energy crop (regular) biomass with CHP;</td><td>1.0</td></tr>
<tr><td>Co-firing of energy crops with CHP</td><td>1.5</td></tr>
<tr><td colspan="2">In order to qualify for the “co-firing of regular biomass with CHP” and “co-firing of energy crops with CHP” bandings it is required that the regular biomass/energy crops and fossil fuel have been burnt in separate boilers.

As such, power stations converting to CHP operation that co-fire by combusting biomass in the main boilers alongside fossil fuels will not be eligible for the relevant “co-firing...with CHP” banding.

A ROC is worth £45 – in 2013.</td></tr>
</table>

	The Electricity Market Reform proposals include changes to the RO.
Climate Change Levy (CCL)	For large power stations CCL applies to the electricity generated once it is sold through a licensed electricity supplier. CCL is currently charged on electricity at £4.6/MWh. However the qualifying power output from good quality CHP is exempt from the CCL. For each MWh of qualifying power output the operator can obtain a Levy Exemption Certificate (LEC). The generator can redeem a LEC through a licensed electricity supplier, with values around 90% of the face value of £4.7/MWh in 2013.

7.1.4 Heat Out

Table 30 the impact of policies applicable to heat output

Policy Measure	Impact
Climate Change Levy (CCL)	Heat customers in the business and public sectors will normally pay CCL on gas, the main heating fuel. This is charges at a rate of £1.64/MWh of gas. Heat recovery will not attract the CCL, hence this is advantage to some heat customers.
Carbon Reduction Commitment Energy Efficiency (CRC)	More commonly known as the CRC, this is a tax on electricity and gas purchased by medium scale energy users. Initially this will be levied at the rate of £12/tonne of CO_2. Applicable to organisations with total electricity consumption > 6,000MWh/y (based on half hourly meters). Averaging at about 1.0-2.0 MWe electricity demand. Supplies of heat from CHP will be exempt from this and will be classed as zero carbon within the assessment of carbon emissions under the CRC. Hence heat from CHP will have an advantage to some potential heat consumers.
Heat Market	Unlike the markets for electricity and gas, there is very little heat sold in the UK. Thus far there has been no regulatory

	framework to standardise terms or introduce consumer protection. This leaves potential heat consumers with less confidence in switching to a heat supply contact – as the protection available when purchasing gas is no longer available.
Renewable Heat Incentive (RHI)	The RHI offers a premium for heat supplied from a range of renewable technologies. If a power station fires biomass and recovers heat, the RHI could apply to a portion of the heat recovered. Hunterston is planned as a multi-fuel station. However it is assumed that Hunterston opts for the uplift within the RO banding rather than the RHI payment. The RHI is worth £26/MWh of qualifying heat for large scale systems.
Planning Consent for Heat Customers	The new Scottish Planning policy (SPP) recognises the value of co-location of heat demand (new housing, new business development etc.) with potential sources of low carbon heat. Hence future plans could include measures that encourage co-location. The following sub-section looks at this issue in more detail.

7.1.5 District Heating Network

Table 31 the impact of policies applicable to district heating networks

Policy Measure	Impact
Renewable Heat Incentive (RHI)	The RHI applies to heat supplied via district heating but there is no specific treatment or uplift for heat supplied via district heating
Wayleaves & Planning Permission	Installing district heating requires access to roads, pavements etc, to dig trenches and lay the pipes. If the network is to be developed by an organisation able to exercise powers of a Statutory District Heating Undertaking (that is, the city council or a holder of an electricity supply license stipulating district heating) this will permit them to lay mains in the public highway. However, it would not exempt them from the need to apply for planning permission. A street works licence will be needed from the streets authority to dig up roads.

7.1.6 Wider Strategic Support for District Heating

In addition to the policy measures that influence specific aspects of district heating, the Scottish Government's The Energy Efficiency Action Plan for Scotland in includes a programme of activities to support district heating[20].

The Action Plan takes a comprehensive approach, covering all sectors and issues. Hence the Action Plan includes a specific action to:

"We will proactively develop district heating as a discrete policy area within energy efficiency, including by:

I. Appointing a dedicated officer to take forward district heating policy and co-ordinate activity across Scottish Government;
II. Supporting a number of local heat mapping and feasibility projects over 2010/11;
III. Investigating options for training or workshops for planning authority officers;
IV. Pursuing options to finance district heating projects; and
V. SEPA's advice to planning authorities re. water, heat and power"

The Action Plan also notes the wider policy measures that support low carbon district heating e.g. in Scottish Planning policy (SPP) and the National Planning Framework for Scotland 2 (NPF2).

[20] http://www.scotland.gov.uk/Resource/Doc/326979/0105437.pdf

In all the Action Plan notes several supporting initiatives, including:

- The NFP2 which advises that planning authorities 'should take account of the potential for developing heat networks when preparing development plans and considering major development proposals'.

- The Energy Saving Trust planner support pack: "Sustainable Energy in the Built Environment Best practice for Scottish Planners". This includes sections on district heating and heat mapping and provides case studies of how planners can encourage sustainable energy use.

- Funding local projects such as detailed feasibility studies of district heating within phase 2 of the Sustainable Glasgow Initiative.

The Action Plan Also recognises the importance of finance, proposing:

- The use of the European Regional Development Fund (ERDF) programme which has been extended to introduce the possibility of funding energy efficiency and renewable energy measures. This could be used in existing housing in the 13 urban local authority areas targeted by the ERDF. Up to £15 million of ERDF could be accessed to fund low carbon, energy efficiency and district heating projects during the life of the programme.

- Working with partners - as part of work by the Scottish Low Carbon Investment Project - whether appropriate district heating projects can be included in an overall package of opportunities for international investment.

Since the plan was launched, on March 2011 the Scottish Government launched a new £2.5 million loan fund to support district heating networks. This scheme offers loans on a commercial basis for both renewable and low carbon technologies. It is being administered by the Energy Saving Trust with applications now submitted for assessment.

7.1.7 Conclusions

As the preceding tables show, there are many existing policy measures that have an influence on heat recovery from large power stations. However, none of these were developed specifically to support the type of innovative schemes that is the focus of this study.

Hence, a key element of this work is to identify and assess policy measures that apply directly to these stations and the heat that could be recovered.

7.2 Energy Policy Developments

Energy policy is subject to regular change hence the current policy initiatives reviewed in the previous section are likely to change during the 40 year life of a district heating system. The financial assessment has assumed that the current policy frameworks continue. This is the only possible assumption – as detailed policy arrangements cannot be predicted over a 40 year period.

However there are near term policy developments that are under consideration now. In terms of financial impact the most significant of these is the proposed Electricity Market Reform, while the Industrial Emissions Directive (IED) is an important new control on power station emissions, finally the proposed new EU Energy Efficiency Action Plan promotes the use of heat recovery. These new policies are reviewed below.

7.2.1 Electricity Market Reform

In December 2010 DECC released details of proposals that will significant change the electricity market in the UK, the Electricity Market Reform (EMR). These proposals contain four main elements:

- A carbon floor price
- A capacity payment
- A reform of the Renewables Obligation
- An Emissions Performance Standard (EPS)

Because the EMR proposals are not yet finalised, their impact cannot be modelled. Instead, the following sections introduce these proposals and suggest how they may impact on the recovery of waste heat.

The Carbon Price Support Mechanism and CHP

The EMR address one of the perceived barriers to investment in new low-carbon electricity generating capacity. This is stability in the price of carbon faced by electricity generators burning fossil fuels and certainty over the long term about what this price will be.

This proposal is known as the Carbon Floor Price
There are two parts to the proposal:

1. Removal of existing environmental taxes on fuels used to generate electricity. This means the removal of CCL (for gas) and excise duty (for oils) when these fuels are used to generate electricity.

2. The introduction of a new tax called the CCL carbon price support rate (CPS) on each MWh of fuel burned to generate electricity.

The level of the CPS is in proportion to the CO_2 emitted by the fuel burned. This means that the tax per MWh of fuel will be higher for coal and lower for gas fired stations and zero for biomass. The CPS will initially start in April 2013 at £16 per tonne of CO_2, rising to £30 per tonne of CO_2 in 2020.

Overall this will mean increased operating costs for electricity generators using fossil fuels, and these costs will have to be passed on to customers if current levels of profitability are to be preserved.

Under the existing CCL the fuel used and power produced by Good Quality CHP was exempt from the CCL. In respect of CHP, the Government has announced two key intentions:

- The introduction of a specific relief from the CPS for fuel used by Good Quality CHP schemes. This mirrors the current exemption of fuel use from the CCL for Good Quality CHP schemes.
- The removal of Levy Exemption Certificates (LECs) from 2013.

LECs are currently issued in respect of electricity generated from Good Quality CHP schemes that are capable of exporting to the electricity transmission and distribution network. This offers a higher value for electricity to the CHP operator than conventionally generated electricity. This is because CHP electricity accompanied by a LEC entitles the end user to consume that electricity without paying the CCL. As such, it constitutes a valuable revenue stream to the CHP operator, as, in theory, it means that the end user is prepared to pay more for this electricity.

As it stands, the combined effect of the Government's proposals are expected to erode the financial case for exporting electricity from CHP, as LEC income will no longer be available. This also applies to converting existing power only plant to CHP mode – though it is likely that only part of the electricity generated would have qualified for LECs. The table below shows a summary of the impacts.

Table 32 the impact of CPS proposals

	Power Station Only	Power Station with District Heating
Current Arrangements	No CCL on Fuel No LEC on electricity	No CCL on Fuel Potential LEC on electricity
CPS Arrangements	CPS on Fuel No LEC on electricity	No CPS on Fuel No LEC on electricity

The net effect of these changes for a power station with district heating will depend on the fuel used (and hence the impact of the CPS at £16/tonne CO_2) and the amount of electricity that would have qualified for LECs.

Government has told industry that it is their stated aim that changes to the fiscal environment in which CHP must operate should leave CHP no worse off than under the current fiscal environment. If this is to be achieved, amendments will have to be made to the two key intentions mentioned above, and the lobbying process to make this possible is on-going.

However if this lobby is successful it only preserves the status quo – it does not add any additional incentive for heat recovery. The recent EMR White Paper does not include specific proposals on CHP. However it does note that "Legislation relating to specific tax relief for Combined Heat and Power (CHP) will be introduced in the 2012 Finance Bill, to be followed by secondary legislation later in 2012".

Capacity Mechanism

The Electricity Market Reform (EMR) consultation document proposes use of a capacity mechanism to maintain security of supply. With a generation portfolio that will consist increasingly of intermittent renewable plant, such as wind generation, it is important that there is additional capacity available to ensure the optimal capacity margin remains adequate.

A capacity mechanism would pay generators to keep plant available, whether they generate or not. This would mean that, instead of developers receiving all their revenues from electricity sales, generators would receive a payment that attaches value to generating capacity or resource being available. Under such a mechanism the risks associated with underestimating capacity requirements is transferred from generators to the Government. The mechanism would ensure that an adequate safety cushion of capacity is provided as the amount of intermittent and inflexible low-carbon generation increases.

A capacity mechanism helps ensure security of supply in two key ways:

- It reduces the cost of capital by providing a regular revenue stream, thereby helping deliver greater investment in new capacity.
- It can help achieve a higher capacity margin than an energy-only market would deliver.

The recent EMR White Paper proposes a number of ways in which the capacity mechanism could operate and consults on these options. These include:

- A targeted mechanism, with a proposed model of a Strategic Reserve.
- A market-wide mechanism in the form of a Capacity Market, One form of a Capacity Market is a Reliability Market.

Hence the details of mechanism are only in outline form at present.

The volume of standby capacity (and hence the level of payment) is likely to be set and monitored by a central body, expected to be Ofgem, rather than by a decentralised system.

The impact of a capacity payment on the four stations considering in this study cannot be precisely predicted, partly as the proposed capacity mechanism is not fully developed and partly as the response from each power station operator will depend on their commercial objectives.
Some potential impacts are:

- Fossil power stations will wish to be available to run in order to earn the capacity payment. Hence the station will be burning fuel in order to be ready to run. This fuel burn can also provide waste heat.
- Capacity payments may be higher in the winter when electricity demand is the highest. Hence fossil power stations are most likely to be ready to run when heat demand is also at its highest.
- If the station is earning capacity payments, there may be a penalty if the station is found not to ready to run. Hence operators may be wary of connecting heat load – if this is viewed as hindering operational flexibility.

Hence the capacity mechanism may be broadly supportive of heat recovery. However to make this certain it would be valuable to make this an explicit objective for the capacity mechanism. Otherwise the detailed elements of the proposals could have unintended consequences that could harm the prospects for heat recovery.

Given that Section 36 consents encourage power stations to examine and assess the potential for heat recovery, this is consistent with the existing policy framework.

Reform of the Renewables Obligation

The EMR proposes changes to the Renewables Obligation, changing the system of ROC payments for new generators to a new form of Feed in Tariff. The policy aim is to use long-term contracts to provide more certainty on the revenues for low-carbon generation and make clean energy investment more attractive.

For the fossil fuel power station proposals which are the subject of this study, this is only relevant to co-fired plants such as the station considered for Hunterston as this assumed to be a multi fuel station burning coal and biomass.

Under the current RO policy Hunterston would earn ROCs for the qualifying co-fired electricity and could potentially earn an uplift for operating in CHP mode, the CHP uplift. A Scottish Government Consultation on the Renewables Obligation proposed changes to the CHP uplift in 2013, as the Renewable Heat Incentive would provide an alternative means of support.

The EMR proposals discuss several models of potential Feed in Tariff. These include:

- Premium FIT: a static payment which generators receive in addition to their revenues from selling electricity in the wholesale market. This is one of the models of FITs used in Spain.
- Fixed FIT: a static payment which generators receive in place of any revenues from selling electricity in the market. This is the model of FIT used in Germany.
- FIT with a Contract for Difference (CfD): a long term contract set at a fixed level where variable payments are made to ensure the generator receives the agreed tariff (assuming they sell their electricity at the market price). The FIT payment would be made in addition to the generator's revenues from selling electricity in the market. The CfD can be a two-way mechanism that has the potential to see generators return money to consumers if electricity prices are higher than the agreed tariff. This is the model of FIT used in the Netherlands for renewables (though they call it a "sliding premium") and in Denmark for offshore wind. It provides a similar level of revenue certainty to a Fixed FIT, but by setting the level of support according to the average price preserves the efficiencies of the price signal, i.e. generators will have an incentive to sell their output above the average price as they will keep any upside.

On balance, the Government concludes that while a premium payments scheme would be easiest to implement, there are additional benefits of a CfD scheme in terms of cost effectiveness which could outweigh the additional complexities of such a scheme so this is the preferred option. The conclusion of the Electricity Market Reform consultation was to select the FiT CfD as the preferred route.

Generators will be able to opt for the Renewables Obligation (for those projects accredited by March 2017), or the new support mechanism introduced in 2013/2014 (for projects reaching financial close by then). After 2017, the RO will be 'vintaged' until 2037, i.e. support levels will not be reviewed or revised.

The impacts of these proposals on Hunterston are difficult to predict – as the level of the new FiT CfD for a co-firing CHP station is not yet known. As a minimum the proposals create uncertainty, which does not encourage investment, particularly in district heating networks which would not have been considered by developers as a core part of their proposals.

The transformation from the existing RO to the new FiT CfD will inevitably focus on those technologies such as onshore and offshore wind – as these dominate current and future renewable generation potential. Hence it is possible that the final EMR proposals will not consider the impact on emerging opportunities that are driven by heat and not electricity.

The Emissions Performance Standard

The Emissions Performance Standard (EPS) is intended to ensure that fossil fuel power generating stations make a contribution to the UK's objectives on decarbonisation. A Government consultation on these proposals closed in March 2011, with details confirmed in the EMR White Paper in July 2011.

The EPS will set a regulatory limit upon the quantity of CO_2 emissions that are allowed to be released during the generation process. It will be applied to new coal-fired stations only and will not be applied retrospectively or to other technologies. It will operate as an annual emissions limit, enforced at an individual plant level. Following consultation the EMR White Paper sets out the case for the 450g CO_2/kWh_e standard.

The EPS is likely to increase the wholesale price of electricity and therefore improve the cost effectiveness of non-fossil generating technologies. Thus, the EPS policy, as proposed, is likely to discourage unabated coal fired generation and encourage non fossil types of generation. Other policies of course may encourage coal with CCS such as the EU-ETS.

The impacts of the EPS on CHP and heat recovery are potentially complex. Hence the EMR White Paper commits the Government to "look to avoid structuring the EPS in a way which could act as a disincentive to investment in CHP, as far as is practicable. The Government will look to explore the specific complexities and technicalities with stakeholders before bringing forward detailed regulations on this issue."

Developers of new coal fired power stations intend to implement CCS and are therefore likely to be proposing schemes which go some or all of the way to complying with the EPS.

In terms of the impact of the EPS on heat recovery:

- The EPS means that new coal plant is certain to have CCS, at demonstration or full scale. CCS uses heat, extracted as steam from the steam turbine. This is the same method used to extract heat to serve the district heating network. Hence coal plants with CCS will not be able to provide as much heat recovery for district heating as coal plants without CCS. In all four of the cases considered in this study the stations are expected to have sufficient heat capacity to serve the CCS and the district heating network.

- Heat used in the CCS process qualifies as useful heat under the CHP Quality Assurance programme. Hence applicants for Section 36 consents could claim that this is the sufficient to fulfil the heat recovery requirements in the Section 36 consent process. This would significantly reduce the leverage to serve other heat consumers. Hence this Section 36 guidance should clarify this point.

Overall Impact of the EMR

It is difficult to be certain of the overall impact of the EMR, as the proposals are complex, some are still under development and the specific details on how they apply to heat recovery and CHP have yet to be released. In broad terms:

- The CPS should increase the cost of operation conventional fossil plant, which would be beneficial to the case for heat recovery and CHP. However the specific treatment of heat recovery and CHP is not yet known.
- The capacity mechanism should be beneficial, providing additional income that is consistent with operating for longer periods to provide heat as well as power at all four sites.
- The FIT CfD will only affect the site at Hunterston, but the intention is to provide more certainty on the revenues for low-carbon generation and make clean energy investment more attractive. Hence this element of the EMR should support the case for heat recovery at Hunterston.
- The EPS will mean that fossil fuel power generation is less attractive an option, with coal fired generation required to fit CCS.

With the uncertainties discussed above, the net impact of the EMR proposals are very had to judge, as the level of cost or level of incentive cannot be assessed for each element of the proposals. Hence the EMR is not included in the analytical work in this study.

7.2.2 The new Industrial Emissions Directive (IED)

The IED will place a number of requirements on combustion plant with thermal input of 50MW or more. A number of these replicate preconditions already placed on such plant to ensure UK compliance with the existing Integrated Pollution Prevention and Control Directive (IPPCD).

These include the requirement to hold an environmental permit (a Pollution Prevention and Control permit) should the plant wish to continue operating. The permit places conditions on the operation of the installation designed to ensure that all appropriate preventative measures are taken against pollution through the application of best available techniques and that no significant pollution is caused. Conditions within the permits for large power stations will contain controls on the quality of atmospheric emissions. These controls are known as emission limit values (ELV).

The ELV's in place on existing plant will have been derived, where appropriate, with reference to the requirements placed on the UK under the Large Combustion Plant Directive 2001/80/EC (LCPD). All the above requirements are transposed into domestic legislation through the Pollution Prevention and Control (Scotland) Regulations 2000 (PPC)

The IED will retain most of the requirement of IPPCD. It will also replace the LCPD. The main change which IED introduces for power stations is a tightening of emission standards. These new emission standards will apply to existing plant from Jan 2016.

Hence the IED could influence decisions regarding the closure of existing power stations – for example if compliance with the IED is not practical or financially viable for the existing power station. If the power station is replaced the planning consent could require heat recovery and hence lead to the installation of a heat network.

The IED provisions encourage energy efficiency. As heat recovery increases overall energy efficiency compared to electricity-only generation, plants with heat recovery will comply with this element of the IED.

7.2.3 EU Energy Efficiency Action Plan 2011

The European Commission has identified the role of district heating in its recent communication on the Energy Efficiency Action Plan 2011[21.] This plan sets out a series of measures that the Commission has identified in order to reach the EU objective of 20% savings in primary energy use by 2020. Currently the Commission estimates that around half of this target will be met by existing measures, hence the plan sets out a wide ranging series of new initiatives to close this gap.

The Plan includes a focus on improving the efficiency of power and heat generation, with two specific
measures proposed to promote district heating:

- The Commission will therefore propose that, where there is a sufficient potential demand, for example where there is an appropriate concentration of buildings or industry nearby, authorisation for new thermal power generation should be conditional on its being combined with systems allowing the heat to be used – “combined heat and power” (CHP) and that district heating systems are combined with electricity generation wherever possible.
- Addressing heat consumption in buildings will be of prime importance in the coming years. The Commission will further explore the range of available solutions, including possibilities to promote the use of district heating in the context of integrated urban planning.

Each Member State will be required to report back to the Commission on how these measures have been transposed into national law and policy frameworks. Given that the new Plan was published in March 2011, it is too early to know how UK and Scottish policy will be amended.

Both of these issues are devolved, authorisation for thermal power generation in Scotland is set through the Section 36 guidance, while urban planning is also devolved.

[21] http://ec.europa.eu/clima/documentation/roadmap/docs/efficiency_plan_en.pdf

8 Review of the Planning Position

8.1 Introduction

Planning policy is of singular importance for heat recovery. There are several reasons for this:

- The financial importance of the cost of the heat network. If heat loads and heat sources can be co-located, the costs of heat supply falls significantly. The financial modelling shows that high capital costs are a key barrier.
- Local planning for new developments can encourage or even require that new or existing developments connect to existing or future heat networks.
- Development planning and development management for large power stations can influence:
  - The selection of locations, and hence proximity to suitable heat loads.
  - The design of the station to included heat recovery.
  - The funding of district heating networks.
- A number of stakeholders commented that planning was a barrier to district heating; however this may be a perception as limited evidence was provided.
- International experience suggests that planning is a key component in the successful development of district heating.

This section of the report:
- Reviews the relevant parts of current planning policy in Scotland.
- Surveys planners on the inclusion of heat recovery in the new strategic and local development plans.
- Develops conclusions on the impact of current and future planning policies.

8.2 Current Planning Policy

Current planning policy includes:
- National Planning Framework, which sets long term strategic policy.
- Scottish Planning Policy, which sets out the requirements for large scale and small scale developments.

Both of these documents are relevant, as they set out key issues that should be considered in planning level applications and in larger scale developments.

Additional advice is provided for:
- Power stations over 50MW power output, these are significant sources of heat and a specific consent under Section 36 of the Electricity Act 1998 is required.
- Renewable energy.

8.2.1 National Planning Framework 2

The National Planning Framework has a key role in co-ordinating policies with a spatial dimension and aligning strategic investment priorities. It provides the strategic spatial policy context for decisions and actions by the Scottish Government and its agencies.

The Framework can designate certain developments as national developments. National Planning Framework 2 (NPF2)[22] identifies a number of major transport, energy and environmental infrastructure projects. These include the sites of major power stations.

The NFP2 includes climate change and energy as key issues and recognises the low carbon sources of heat have an important role to play, including heat recovery from power stations and local heat and power schemes.

The Framework requires that local authorities: "should take account of the potential for developing heat networks when preparing development plans and considering major development proposals."

NFP2 also includes "heat utilisation" as an issue to be considered in the consents for the power stations designated as national developments.

Hence there is support for heat recovery in the current NFP2. However the details are very broad and are focused on the heat supply side – not heat demand. Hence there is potential for future documents to contain more specific policy and to address the need to co-locate large heat consumers next to large sources of heat.

8.2.2 Scottish Planning Policy

Scottish Government's advice on all planning matters to local authorities was significantly revised when Scottish Planning Policy Guidance (SPP) was issued in February 2010[23]. This replaced previous advice on specific topics e.g. SPP6 on Renewable Energy.

The new SPP encourages spatial planning to bring about co-location. There are several specific references that are relevant to heat recovery:

- *Para 43 "… When designating land for new residential, commercial and industrial development, planning authorities should consider the energy and heat requirements of these new developments. New development should be planned to make use of opportunities for decentralised and local renewable or low carbon sources of heat and power wherever possible."*
- *Para 60 "…consider the potential to reduce impacts on the environment, for example using …combined heat and power systems."*
- *Para 128 "Production of heat and electricity from renewable sources will also make an important contribution both at a domestic scale and through decentralised energy and heat supply systems including district heating and biomass heating plants for businesses, public buildings and community/housing schemes."*

[22] http://www.scotland.gov.uk/Resource/Doc/278232/0083591.pdf

[23] http://www.scotland.gov.uk/Publications/2010/02/03132605/0

- *Para 184 "Development plans should support all scales of development associated with the generation of energy and heat from renewable sources."*
- *Para 255 "The planning system has a significant role in promoting a pattern of development which helps to reduce Scotland's carbon footprint and facilitates adaptation to climate change, in facilitating the generation of power and heat from low carbon sources.*

Local authorities are currently revising their plans in the light of this, hence the impact of the new SPP will depend on:

- How broad advice in the SPP is built into the detailed development plans.
- How developers and local planners interpret and act on the advice and plans.

Hence, the impact of the new advice cannot be judged for several years. In conducting this study, a questionnaire was sent to planning authorities. This asked for details of how heat recovery is covered in existing and future development plans (see section 6.3.2 for details).

8.2.3 Section 36 Consent

All power stations over 50 MW of power output require consent from the Scottish Government under Section 36, of the Electricity Act 1998. This power is executively developed to the Scottish Government and local authorities, SEPA, SNH are statutory consultees in this process. NPF2 and SPP are material for Section 36 applications, but additional guidance is also used for these power station applications.

New advice on Section 36, consents for thermal power stations in Scotland was published in March 2010, following a consultation process[24]. This includes two key paragraphs in a separate section on heat recovery (Paras 3.6 to 3.14):

- *"3.10 Article 6 of the LCPD requires that new or substantially expanded thermal installations undertake a CHP feasibility study. 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."*

- *"3.13 The application would also need to demonstrate that discussions with planning authorities have been held. This should include a CHP feasibility study which should be undertaken in a manner reflecting SEPA's Heat and Power Plan SEPA's Thermal Treatment of Waste Guidelines 2009."*

The SEPA advice requires developers of energy from waste schemes to develop and submit a Heat and Power Plan. This recognises that the level of heat recovery during the period of initial operation may be low. Hence the Heat and Power Plan allows a period of time (typically five to seven years) for heat loads to be connected.

[24] http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Infrastructure/Energy-Consents/Thermal-Guidance/Thermal-2010

At the end of this period the performance of the scheme is tested under the Combined Heat and Power Quality Assurance scheme (CHPQA). CHPQA is used to assess a range of benefits including ROC eligibility and is aligned with the requirements of the EU Cogeneration Directive.

CHP Feasibility studies have been published by:
- Ayrshire Power – Hunterston.
- Forth Energy – Dundee, Rosyth, Grangemouth and Leith.

AEA understands that more detailed design and analysis work is taking place on a number of these projects and that local authorities are being approach to discuss the potential connection of their buildings to the potential heat network.

These investigations and discussions would not have taken place if the new advice had not been in force. So a material change has taken place in the development process. However no power station has been consented under the new system and even if it had, the timetable for power station construction, including a heat network, would take place over several years. Hence, it is too early to judge if this policy will deliver heat recovery from these other sites.

The Forth Energy sites could potentially supply anchor heat loads that are within the catchment areas for the four large conventional stations.

8.2.4 Renewable Energy Planning Advice

Web-based planning advice on renewable energy is now produced by Scottish Government[25]. This has separate sections on a number of different technologies including; Energy from Waste, Anaerobic Digestion etc. A number of these include recovery and use of heat.

This web guidance will be regularly updated and replaces; PAN 45 Renewable Energy Technologies, and Annex 2 Spatial Frameworks and Supplementary Planning Guidance for Wind Farms.

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[25] http://www.scotland.gov.uk/Topics/Built-Environment/planning/National-Planning-Policy/themes/renewables

8.3 Survey of Planners

As a result of the introduction of the new SPP councils are revising their plans[26]. Hence a questionnaire was developed to assess how current and future plans support the recovery of heat. This is relevant as:

- This insight helps establish the status quo, in terms of policy and examples of schemes developed using current guidance and plans.
- The policy recommendations from this study should complement the existing policy frameworks. Hence establishing how existing policy is being interpreted and used is important to ensure that the recommendations do not duplicate initiatives that are already underway.

Accordingly, AEA developed a letter with 3 questions – one of these related to future development sites, the second and third question covered the planning issues – see box below:

Question 2

The planning system can support the decarbonisation of electricity generation in Scotland, the uptake of local district heating schemes and the use of recovered heat in other potential uses.
What action is your authority undertaking to support this?
This typically might include:

- The preparation of a heat demand assessment / heat mapping resource to inform the MIR / development plan? (if you have a heat map, is this published / could you provide a web link)
- Coverage of heat recovery / district heating under an ‘energy efficiency’ main issue in the Main Issues Report?
- Policy support for using heat recovery and /or district heating in development plans?
- Specific proposals for use of heat recovery / district heating?
- Supplementary planning guidance on heat recovery and /or district heating?

Question 3

If there is any other information which you think would assist the Scottish Government in carrying out the study, please provide detail below:

The Scottish Government would be particularly keen to hear your views on any

[26] In the 4 main cities (Aberdeen, Dundee, Edinburgh and Glasgow) and their surrounding areas the development plan is made up of: The strategic development plan, the local development plan and supplementary guidance.

In all other areas, the development plan is made up of: the local development plan and supplementary guidance.

technical, economic or planning barriers to bringing forward the use of waste heat, heat demand assessments, heat mapping and district heating in your area, and if any Scottish Government policy interventions might assist in these areas.

This letter was issued by Jim McKinnon, Chief Planner in the Scottish Government, to the planning authorities within the relevant power station catchment areas.

8.3.1 Survey Results

Question 2: …what action is your authority undertaking….?

The responses to the letter included a wide range of useful information and insight. In general the responses showed that:

- There was a high level of awareness of this aspect of planning policy.
- Some existing plans already have relevant sections on heat.
- The relevant plans are still in development – hence there is an opportunity to influence these.
- The Main Issues Reports (MIR) highlighted heating options as a key issue.
- There were some examples of heat maps and exemplar projects.

The full returns are detailed in Appendix 3: Responses from Planners, the following table sets out a sample of the points raised in the responses, grouped under the headings listed above:

Table 33 Sample plans

Plans detailing heat recovery	
Falkirk Council	In current Falkirk Council Local Plan policy EQ6 supports combined heat and power and community heating schemes as part of new development. Policy ST20 offers general support to utilisation of renewable energy sources in new development. A current proposal, being determined by Sc Govt, for a biomass plant in Grangemouth Docks has a district heating component option to it.
Aberdeen City and Shire Structure Plan	Developers will need to examine the scope for including energy efficient technology, such as combined heat and power schemes when preparing development proposals.
Joint Ayrshire Structure Plan	The Structure Plan identifies a search area in the key diagram and an opportunity to develop a co-fired power plan based on clean coal technology. The coalfield area of East Ayrshire is recognised as having particular opportunities for this type of energy production. Refer Policy ECON 8-Biomass.
The relevant plans are still in development – hence there is an opportunity to influence these.	
SES Plan (South East Scotland)	The MIR recognises that decisions on the location of strategic development sites can assist in contributing to a reduction in the demand for energy through the need to travel and the delivery of options for decentralised energy production, including opportunities for local heat and power schemes energy from waste and micro - generation.

[redacted]	The Preferred Approach as outlined by the MIR recognises that at the Strategic Growth Area level, consideration of alternative heating options for developments such as district heating and combined heat and power, and sustainable construction and development will also contribute towards ensuring the best use of resources.

The Main Issues Reports (MIR) highlighted heating options as a key issue.	
SES Plan (South East Scotland)	The preferred approach as outlined by the MIR recognises that at the Strategic Growth Area level, consideration of alternative heating options for developments such as district heating and combined heat and power, and sustainable construction and development will also contribute towards ensuring the best use of resources.
Clackmannanshire	The MIR consultation ended in March 2011. This placed a strong emphasis on climate change mitigation and one of the main issues identified, and consulted upon, was "How can we reduce our greenhouse gas emissions and adapt to the consequences of climate change". The MIR contained a range of options related to Decentralised Energy, Decarbonised Energy Generation and Low Carbon Development. These can be viewed on the Clackmannanshire Council website. The potential of re-use of heat to significantly reduce energy waste, increase efficiency, reduce costs for energy users and contribute to climate change mitigation is acknowledged in paragraph 4.12 of the MIR. Following recent discussion with Kristen Anderson and Rosie Leven it has been agreed that the Local Development Plan should contain specific proposals relating to waste heat. We also intend to investigate the scope for specific proposals on district heating.
There were some examples of heat maps and exemplar projects.	
Joint Ayrshire Structure Plan	A GIS Heat Map and briefing paper has been produced.
Fife Council	Cited several projects under development that could have potential to supply public buildings and housing: 1. Tullis Russell biomass plant, Glenrothes 2. Lochhead landfill waste treatment scheme 3. Ore Valley Housing Association

Several examples of existing guidance documents (e.g. on renewable energy or general development guidelines) were cited in the responses. Generally these made a broad reference to heat issues.

A key finding is that:

There were no specific targets or tests that a developer would need to meet. Hence there is an opportunity to make plans and guidance more specific and more quantified to strengthen the requirements for development plans to only allocate significant sites where there are available heat loads and to require certain developments to connect to heat sources where these are available.

Question 3: Barriers as identified by the planners

The barriers detailed by planners are detailed in full in the table below. This feedback from the planners was fundamental to the development of section 9 (Identification of Barriers) of this report.

Table 34 the most significant barriers to the recovery of heat from large scale energy generation capacity in Scotland, as identified by planners

Proximity to heat demand	
1	Proximity of heat demand (for existing energy plants)
2	Larger scale power generation facilities which are often located at sites isolated from the major built up areas
3	Proximity to power station of suitable building stock
4	Land use planning difficulties in allowing integration of heat users and heat generators
5	Planning – location of energy plants away from heat demands
6	Existing building plant in suitable buildings may not be inefficient enough to warrant this
7	The distance between the fossil fuel plants and main settlements, which would require an extensive new pipeline network to be created
Financing	
1	Limited financial incentive and uncertainty in appropriate business models for the construction and ongoing maintenance of facilities
2	Financing of heat infrastructure – banks not willing to debt fund
3	Financial considerations/lack of clarity over investment against returns
4	Long term pay back periods are a significant constraint
Fragmentation of ownership	
1	Discontinuity between supplier and customers, fragmentation of ownership – probably works best with large single social housing estates or similar
2	Disparate ownership of land, property, generation, transmission, maintenance responsibilities
3	Responsibility for maintaining infrastructure
Lack of exemplars	
1	Lack of current projects that have undertaken heat recovery schemes from power stations
2	A mindset and culture not tuned to this form of heat source Limited skills and understanding of the technology
3	Mindset and culture not tuned to this form of heat source

Inertia: resistance to change	
1	Inertia: resistance to change
2	Lack of ambition to change tried and tested processes
Lack of community engagement	
1	Making local communities aware such schemes are planned/ installed
2	Providing local residents with simple explanations of benefits when installed

Restrict choice of electricity suppliers	
1	Decentralisation of heat supply could (allegedly) restrict choice of electricity suppliers for householders (an issue raised by house builders with East Lothian Council)
2	Issues around single user use and spreading of risk amongst multiple users
Perception of being dirty	
1	Potential perception of problems of secondary heat and associated industrial processes being “dirty”
Absence of infrastructure	
1	Absence of infrastructure
Lack of willingness to act	
1	Agreement with power station to do this, including pricing
Fiscal policies	
1	Fiscal policies
Risk	
1	Risk averseness of businesses requiring reliable heat supply over long timescale
Heat efficiency in both ends of the equation	
1	Heat efficiency in both ends of the equation
Opposition to biomass	
1	Public opposition to biomass plants
Limited skills and understanding of the technology	
1	Limited skills and understanding of the technology
Commercial sensitivity	
1	Commercial sensitivity regarding industrial estate & processes
Lack of leadership	
1	Lack of lead agency on initiative
Lack of certainly about heat availability	
1.	Lack of long term certainty about excess heat generation
Difficulties in retro-fitting heating systems	
1	Difficulties in retro-fitting heating systems to existing dwellings and business premises, which form the vast bulk of the building stock.

8.3.2 Survey Conclusions

The survey of planners found several examples of new local planning policy ideas that consider heat supply and will encourage the co-location of heat supply and demand.

However these policies are largely under development and have yet to be implemented and tested against real planning applications. Hence it is too early to be certain of their impact.

This said, these policies do not have the wholesale transformation of heat supply as their objective as seen in the case study for Denmark. This was not part of the wider policy framework that informed the development of these planning policies.

Hence it is unlikely that these new strategic and local development plans will deliver a significant and major transformation on the recovery of heat at large scale or in local scale district heating systems. This degree of changes was not a major factor in the development of these new plans, nor is there are significant evidence base to show the location and scale of potential of district heating development. The development and use of heat maps will assist in this, but at present only a small number of planning authorities have this information.

8.4 Planning Conclusions

This section shows that:

- Many of the key planning policy documents have (NFP2 and SPP) or will have (new strategic and local development plans) support for recovery of heat and co-location of heat supply and heat demand.
- NFP2 and SPP are recent documents, while the new strategic and local development plans are not yet in place.
- So while these planning policies include many elements that encourage heat recovery and district heating, it is not possible to be fully certain of the impact of these new policies on spatial planning and actual development.
- It is likely that there will be incremental progress, as project developers start to understand these planning requirements and adapt proposals and as planners test proposals against these new requirements.
- However, the new planning policies were not conceived, or drafted, with the aim of a delivering a rapid transformation in the uptake of heat recovery and district heating in Scotland.
- Hence the impact of these new policies is not expected to mirror the growth of district heating in countries like Denmark – where mandatory polices on spatial planning and co-location of heat demand and supply are in place over a long period.

Assuming that these conclusions are correct, and that there is a policy requirement to deliver much great uptake of heat recovery and district heating, this suggests that:

- In the short term opportunities for heat recovery and district heating may be missed, as co-location cannot be delivered after heat loads and heat sources have been given consent.

- If a transformation in the uptake of heat recovery and district heating is required, further changes in planning policy under SPP will be required to accelerate uptake.
- This may require more prescriptive policies such as the mandatory requirements in place in Denmark to be considered.
- A review of international planning policies would provide valuable insight into the policy options that have been used and how they could be relevant to the Scottish context.
- Testing the impact of planning policy ideas is an important part of the analytical work of this study.

9 Identification of Barriers

There are a number of barriers that must be overcome to implement heat recovery from power generation in Scotland. Understanding these barriers is important in its' own right and is an important input into the development of policy ideas.

This study collected views on the barriers from:

- A questionnaire circulated to members of; the Forum for Renewable Energy Development Scotland, the Renewable Heat Implementation Group and a selection of local planners. This is discussed in detail in section 8 and the detailed returns are consolidated into tables and included in Appendix 3: Responses from Planners.
- A policy workshop held with Scottish Government officials in January 2011.
- AEA knowledge based on contact with district heating operators and developers.

It is important to note that respondents may be commenting on real barriers, or issues that they perceive to be barriers. Perceived barriers may occur through previous experience e.g. difficulties in gaining planning consent, experience that may no longer be as relevant if planning policy has changed.

While perceived barriers can prevent or delay new initiatives in the same way as real barriers, the solution is different, better clarity of information, case studies etc, are the route to deal with perceived barriers.

9.1 Classification of Barriers

Participants and respondents were forthcoming about what they saw as the significant barriers to the recovery of heat from large scale energy generation in Scotland. The range of responses was broad and for ease of presentation these are grouped into 5 types of barrier;

1. Communication or informational barriers.
2. Local or national planning barriers.
3. Funding and Project Capital barriers.
4. Technical barriers.
5. Risk and uncertainty barriers.

Some of the barriers identified overlap or span the boundaries of more than one of these types, however, presentation in broad types is beneficial for clarity and understanding. Each of the barrier types are explored in a little more detail below, the responses are in some cases rephrased and amalgamated as an aid to clarity, but these are all as identified by respondents.

9.1.1 Communication or Informational Barriers

This type of barrier refers to problems that arise due to a general lack of awareness of what is involved in the establishment of a heat recovery network or system.

- Low awareness of / lack of familiarity with potential and opportunity:
  - House builders unfamiliar with systems.
  - Few examples or case study sites from which to draw experience.
- Public concerns about combustion processes:
  - Potentially perceived as being dirty processes.
- Lack of confidence that district heating systems can be effective:
  - Lack of established market or supply models.
- Uncertainty about choice of suppliers and tie in to other services; and
- Lack of basic information such as heat maps.

These informational barriers are thought to result in a number of identifiable impacts including:

- Reduced investor interest.
- Objections lodged during planning processes.
- Low take up of consumers; and
- New developments situated away from potential sources.

9.1.2 Local or National Planning and Regulatory Barriers

These barriers were identified and defined by both planners and non-planners alike, to some extent they might reflect uncertainties or lack of information among respondents in respect to planning arrangements and might therefore be addressed by actions to improve communication and information.

- Planners lack experience of these systems:
  - novelty of systems creates uncertainty for planning officers.
  - lack of presumption in favour of heat recovery systems.
- Lack of clear standards for heat recovery for existing power plant:
  - such as de-minimis efficiency standards.
  - guidance on thermal efficiency requirements unclear.
- Lack of integration of heat systems within existing arrangement for services; and
- Location of existing power stations perceived as being remote from heat users.

These barriers have a number of potential impacts:

- Development time is extended delaying the point at which returns can be achieved; and
- Costs to developers are increased both by delays and a need to undertake work to reassure regulatory agencies.

Planning and regulatory barriers may also increase overall uncertainty about project acceptability and result in potential developers not putting forward proposals or abandoning proposals as such barriers are encountered.

9.1.3 Funding and Project Capital Barriers

These barriers concern the availability of initial capital to establish the infrastructure and the uncertainty around financial models for supply.

- Lack of government incentives for utilising heat from fossil fuel electricity plants;
- Uncertainty over appropriate business models for the construction and ongoing maintenance of facilities:
  - Price relative to gas costs uncertain over time.
  - Lack of established billing system.
- Access to capital to funding network extensions.
- Limited reward for fossil fuel plants to increase efficiency.
- High capital costs and long payback periods for infrastructure:
  - High costs of infrastructure for retrofit.
  - High cost of infrastructure in Scotland relative to Scandinavia.
- Current economic climate and resistance of banks to provide finance; and
- Impact on electricity generation (loss of output).

The impacts of funding and project capital barriers include:
- Weaker business cases for potential development; and
- District heating may be seen as carrying greater risk and therefore higher finance costs, both as a result of potential delays through the planning and regulatory system discussed above, but also uncertainty over income streams.

These barriers also suggest a need for exploration of models of splitting infrastructure (for networks) from supply. These types of barriers also suggest a central role for the public sector.

9.1.4 Technical Barriers

The barriers identified here concern the technical implementation of heat recovery schemes covering the whole technical delivery process from heat recovery, heat transport and use.

- Managing the heat load and heat demand to ensure needs are met and obligations fulfilled.
- Possible need for backup heat supply systems.
- Physical distance from existing sources of heat (heat losses etc).
- Large scale sources require large scale heat users.
- Seasonal nature of heat demand – much less heat wanted in the summer.
- Efficiency of heat exchangers at plant and customer sites; and
- Trading off energy generation losses with heat supply and losses of revenue for generators.

Many district heating schemes exist across Europe, including examples supplied with heat from power stations. Hence the technical barriers can be overcome. However the impact of technical barriers:
- Compound issues of uncertainty.

- Increase the high up front capital costs.
- Make smaller scale proposals more difficult to deliver; and
- Create difficulties for generators in sweating existing assets.

9.1.5 Risk and Uncertainty Barriers

The barriers identified in this section concern risk and uncertainty associated with the development of schemes as a whole, which have not previously been addressed under other sections

- Scheme complexity.
- Long term contracts needed:
  - Long term business uncertainty.
- Risk that alternative technologies supersede district heating (example might be Organic Rankine Cycle or heat pumps).
- Potentially fragmented ownership of system components creating dispute about liability or maintenance.
- Need for landowner agreements potentially covering significant different land managers.
- Attitudes to risk from business users.
- Resistance to change; and
- Users financial stability and longevity uncertain.

The impact of risk and uncertainty barriers might be to:

- Deter potential customers form making connections to a local network.
- Add complexity to business cash-flow management; and
- Impact on costs of finance associated with additional risk.

10 Ideas for Policies and Ranking Policy Ideas

This section of the report details ideas for policies with the potential for overcoming barriers and promoting uptake of heat recovery systems. The policy suggestions are summarised and presented in the following groups:

1. Communication or informational policies.
2. Local or national planning policies.
3. Funding and Project Capital policies.
4. Technical policies; and
5. Risk and uncertainty policies.

As with the barriers there are some overlaps between the policy suggestions but these groupings make reporting on suggestions easier and will be beneficial in framing the multi criteria analysis that follows.

10.1 Communication or Informational Policies

- Provide information / evidence about the benefits to consumers of renewable heat to consumers.
- Training on district heating attributes for planning officials.
- Training on district heating attributes for power plant operators.
- Provide funding for feasibility studies.
- Develop detailed heat maps for Scotland; and
- Establish a large scale demonstration project to illustrate the potential for renewable heat.

10.2 Local or National Planning Policies

- National level policies, supporting renewable heat (the Renewable Energy provisions within SPP, S182-186 may not yet have had time to take effect).
- Apply Heat Plans in S36:
  - Require developers to implement elements of the required heat plan (i.e. strengthen existing policy).
- Connection of adjoining development proposals:
  - Require the co-location of developments and provide support for this.
- Reduce scale of new biomass plant to increase pressure for heat utilisation.
- Introduce Single Outcome Agreement commitments to link planning into the public bodies duties on Climate Change.
- Planning in favour of low carbon heat supplies:
  - Include heat infrastructure within National Planning Framework to ease planning burden on proposed development.
- Use planning system to locate heat producers near to a heat demand within Strategic Development Plans and Local Development Plans.

- Require new electricity generation to be:
  - "Heat ready".
  - Supply hot water; and
  - Increasing requirement for energy efficiency.
- Amendments to building regulations:
  - Require new homes to be capable of receiving heat; and
- Establish a central co-ordinating body.

10.3 Funding and Project Capital Policies

- Financial incentives:
  - Fossil fuel CHP to be rewarded within RHI system.
  - Long term certainty over price and incentive systems (UK Government); and
  - Carbon credit mechanism to reward investors.
- Public sector investment:
  - Loan fund to support connectivity infrastructure.
  - Grants to support Capital investments; and
  - Guarantees over income streams.
- Public private partnership for infrastructure.
- Demand side issues:
  - Favourable tariff regime for domestic customers and commercial scale users.
  - Price stability mechanism (such as the Contracts for Difference mechanism within Feed in Tariffs system); and
  - Fixed ratio of cost of alternative heat supply.
- Support for customers to switch.
- Consumer grant schemes (similar, for example, to boiler replacement incentives).
- Fossil fuel levy (hypothecation) to fund district heating infrastructure.

10.4 Technical Policies

- Minimum efficiency requirement for electricity generation plant.
- Detailed Heat mapping (included above in information).
- System to support infrastructure installation; and
- Explore potential for meta grids (linking local heat networks into broader regional and national grids).

10.5 Risk and Uncertainty Policies

- Policies to increase certainty (included above in 3. Finance and Capital Policies); and
- Use of public sector as anchor heat loads providing certainty over a proportion of the available supply.

10.6 Ranking the Policy Ideas

With a large number of policy ideas a method is needed to select those ideas that have the greatest benefits and these will be taken forward and modelled. Multi-Criteria Decision Analysis (or Weighting and Scoring) is a way of assessing a mix of both monetary and non-monetary benefits. The extent to which each option meets the identified criteria is measured, and explicit weights are given to each of the criteria to reflect their relative importance. Using this technique, options can be ranked and a preferred option identified.

Guidance on how to approach Multi Criteria analysis is provided in Department for Communities and Local Government (2009) Multi Criteria Analysis; A Manual, available at; http://www.communities.gov.uk/documents/corporate/pdf/1132618.pdf

This guidance sets out the following “Steps in Multi Criteria Analysis”

1. Establish the decision context.
2. Identify the options to be appraised.
3. Identify objectives and criteria.
4. ‘Scoring’. Assess the expected performance of each option against the criteria. Then assess the value associated with the consequences of each option for each criterion.
5. ‘Weighting’. Assign weights for each of the criterion to reflect their relative importance to the decision.
6. Combine the weights and scores for each option to derive an overall value.
7. Examine the results.
8. Sensitivity analysis.

10.6.1 Decision Context

In this context we are using multi criteria analysis as a means to highlight the most promising policy areas that will encourage investment in recovery of waste heat from large scale power stations.

Identification of options to be appraised

The list of policy options is derived from the ideas suggested by respondents and in the course of the workshop identified above.

Identify objectives and criteria

In the course of the workshop participants were invited to suggest possible criteria by which these policies could be assessed these were refined s

Central to the idea behind the criteria development is an attempt to identify criteria that would help to distinguish between a good policy option and a poor one. In so far as possible we seek to set criteria that cover a complete spectrum of relevant choices without over analysis. In addition the best criteria are likely to be independent of each other so as to avoid double counting.

Initial criteria suggested are grouped as Quantifiable and Qualitative:

Quantifiable criteria

- Cost to Scottish Government.
- Cost to developer / private sector.
- Potential GVA added.

These criteria have been assessed using a judgement about the scale of the likely quantifiable costs and benefits but without undertaking any detailed cost benefit assessment at this stage. Cost to Scottish Government included policy implementation as well as delivery costs, costs to the developer / private sector focused on capital and ongoing (regulatory burden) costs. Potential GVA added was considered from the point of view of scale of potential GVA within Scotland.

Qualitative criteria

- Public acceptability.
- Meets other policy aims.
- Within devolved powers / competence of the Scottish Government.

These criteria have been assessed using a judgement about the extent to which policies will meet the criteria. Other policy aims have focused largely on climate change and fuel poverty policy aims although where other policy aims were directly relevant these were considered as well. Assessment of policies within the competence of the Scottish Government was considered as a yes or no question with those within the competence of the Scottish Government scoring maximum points and those out-with the Scottish Government scoring minimum points.

Other potentially relevant criteria

- Ease of implementation.
- Effectiveness.

These criteria were assessed by making a judgement with the assumption that the easier or more effective a policy was likely to be the more highly rate it would be. Ease of implementation considered the need for primary legislation, and the need for new administrative arrangements as suggesting implementation would be less easy, small additions to existing arrangements regarded are relatively easy. Effectiveness was considered from the point of view of effectiveness of delivering greater uptake of waste / renewable heat systems on its own. This does not reflect the potential benefits of a combination of measures each supporting one another. Each of the proposed policies have their effect over differing timescales as far as possible each were assessed in the context of the timescale appropriate to the policy.

Scoring and weighting

The methodology adopted is a simple linear additive scale, where each criterion is weighted and scored on a scale 1-6 with the highest numbers being the most beneficial or advantageous and 1 being the least.

Weightings for the scores are 1.0 except for:

- Effectiveness - Weighted at 2.0 – as this is the overall test for each policy.
- Within devolved powers - Weighted at 0.5 – as Scottish Government works with UK Government on many policy issues.

The detailed scores can be found in the annex

Examination of the Results

Communication and information policies generally score well because of their relatively low cost to Scottish Government and low cost burden on business; however they may generally not be particularly effective at overcoming the barriers identified.

Planning policies also generally scored well for similar reasons, while financial and project capital policies were much less likely to achieve high scores.

The following table summarises the gross scores and rankings of the thirty three policies considered:

Table 35 Gross scores and rankings of the thirty three policies considered

		Total Score	Rank
Communication and Information	Provide information / evidence about the benefits of	32	9=
	Training on district heating attributes for Planning officials.	32	9=
	Training on district heating attributes for power plant	31	15=
	Provide funding for feasibility studies.	33	5=
	Develop detailed heat maps for Scotland.	36	1
	Large scale demonstration project to illustrate benefits of	32	9=
Local or National Planning Policies	Apply Heat Plans in S36.	33	5=
	Connection of adjoining development proposals.	32	9=
	Reduce scale of new biomass plant to increase pressure for heat utilisation.	28	23=
	Single Outcome Agreements on renewable heat.	35	2
	Going further on heat recovery in the National Planning	33	5=
	Use planning system to locate heat producers near to heat	32	9=
	New Generation to be "heat ready".	27.5	25=
	New Generation to supply hot water.	27.5	25=
	New Generation to meet increasing energy efficiency	27.5	25=
	Amend building regulations to make new homes capable of receiving heat	29	22
	Establish a national co-ordinating body.	30	19=
Funding and Project Capital Policies	Financial incentives within RHI for fossil heat.	25.5	31
	Long term financial incentives (UK Government).	23.5	32=
	Carbon Credit mechanisms.	23.5	32=
	Public sector loan fund.	31	15=
	Public sector grants.	31	15=
	Public sector Guarantees.	31	15=
	Establish public private partnership mechanism.	30	19=
	Establish favourable tariff regime.	26.5	28=
	Establish price stability mechanism.	26.5	28=
	Establish fixed ratio of heat cost to alternatives (i.e. Gas or	31.5	14
	Support for consumer switching to district heating.	34	3=
	New fossil fuel levy to fund infrastructure.	26.5	28
Technical Policies	Minimum efficiency requirements.	30	19
	System to support infrastructure installation (rights of access to road infrastructure similar to those for other services.	33	5=
	Explore potential for meta grid.	28	23=
Risk and Uncertain	Use of public sector as anchor heat load.	34	3=

The scoring system resulted in a number of projects sharing the same score and these are represented as equal.

The most favourable Information and communication policy was identified as the Development of detailed heat maps of Scotland.

Local and National Planning policies also scored well again largely due to assumptions about relative costs and including Renewable heat obligations within single outcome agreements between the Government and Local Authorities.

Financial and project capital Policies were understandably less favoured under this methodology and therefore scored less well although Support for consumer switching to district heating was ranked third.

10.7 Conclusions on Policy Ideas

The following table summarises the proposed policies ranked up to 9th (15 polices in total covering aimed at the most substantial barriers).

Table 36 Key Policy Ideas

	Proposed Policy	Rank
Communication and Information Policies	Provide information / evidence about the benefits of renewable heat.	9
	Training on district heating attributes for planning officials.	9
	Provide funding for feasibility studies.	5
	Develop detailed heat maps for Scotland.	1
	Large scale demonstration project to illustrate benefits of heat recovery.	9
Local or National Planning Policies	Apply Heat Plans in S36.	5
	Connecting adjoining development proposals.	9
	Single Outcome Agreements on renewable heat.	2
	Going further on heat recovery in the National Planning Framework.	5
	Use planning system to locate heat producers near to heat demand.	9
Funding and Project Capital Policies	Support for consumer switching to district heating.	3
Technical Policies	System to support infrastructure installation (rights of access to road infrastructure similar to those for other services.	5
Risk and Uncertainty Policies	Use of public sector as anchor heat load.	3

10.8 Detailed description of key policies

This section provides further detail on the key policies from the assessment process, in general terms and in terms of how these policy ideas can be represented in the model.

10.8.1 Planning Policies

Apply Heat Plans in S36

Consents required under Section 36 already require developers to submit a heat and power plan. This should show the potential for recovery of heat. This proposed policy would require developers to commit to implement, some, or all, of the heat recovery opportunities in the heat and power plan.

Connecting adjoining development proposals

Co-location of sources of heat demand next to sources of heat is a key issue. This policy proposal envisages affects developments that adjoin a power station. The developer will be required to consider heat supply from the power station. Supporting evidence may include a price for the connection of a heat supply and a price for the heat supply contract.

Single Outcome Agreements on low carbon heat

Single outcome agreements signed with each local authority are based on local circumstances, However they are prescriptive in other respects about what they should contain. A renewable heat clause within the SOA could place a duty or requirement on the Local Authority to explore or promote low carbon heat with in their area, it could also, for example, place a duty on authorities to produce and maintain heat maps.

Use Planning System to locate heat producers near to heat demand

This proposal envisages allocations of land within Strategic and Local Development Plans to indicate the desirability of certain developments going ahead. A clearly marked allocation for proposals that offer low carbon heat would represent a strong signal to developers that such developments can be beneficial in securing consent.

Going further on heat recovery within the National Planning Framework

The current NFP2 sets out clearly national developments, whose that are regarded as strategically important for Scotland. NFP2 also contains broad support for heat recovery and district heating. This policy proposal suggests going further in NFP3 and requiring heat loads to develop closer to the main power station sites.

10.8.2 Funding and Project Capital Policies

Support for consumer switching to district heating

The costs of connecting to district heating will deter potential consumers. Hence there is a role for policies that will support consumers switch to district heating. This is analogous to the logic used to support recent boiler scrappage schemes, helping consumers remove old inefficient boilers and replace them with more modern and more efficient boilers.

Connecting to a district heating scheme offers greater carbon savings that will be maintained over a longer period, compared to swapping to a new boiler. This principle has already been recognised in Scotland as connection to the Lerwick district heating system was eligible for grant support in the past. This policy idea will accelerate the rate of connection to heat networks.

10.8.3 Technical Policies

System to support infrastructure installation (rights of access to road infrastructure)

This proposal was ranked just outside the top 10 but is the highest ranked technical proposal. It is aimed at overcoming some of the barriers associated with the installation of infrastructure and envisages rights of access to the road infrastructure that is similar to that afforded other utility suppliers. The costs of such a policy are likely to be relatively low for the Scottish Government but there may of curse be additional costs imposed on road users through more disruption to road networks. Such a policy would, it is envisaged, substantially reduce costs for infrastructure provision and increase certainty that reasonable access is available for repairs and ongoing maintenance.

10.8.4 Risk and Uncertainty Policies

Use of public sector as anchor heat load

The use of the public sector as an anchor heat load would have a number of benefits where it is practical. It would provide a stable source of income for the heat supplier and ensure that a certain level of demand is likely to be maintained over a number of years. This would have the beneficial effect of overcoming some to the uncertainty and risk and potentially have the effect of reducing the overall cost of finance for a project. It is envisaged that buildings within the Government estate and the wider group of public sector buildings would be the most likely users of heat. It is assumed that this would not require any form of legislation and a direction would be sufficient to ensure implementation. Overall cost to the public sector should be minimal provided that the cost of heat is reasonably comparable with alternatives.

10.9 Policy Ideas Interpreted within the Model

The policy ideas described above need to be expressed in terms that the model can use. In other words, these are the changes in the assumptions or variables that the model uses.

The key variables are:
- Capital costs.
- Heat prices; and
- Connection rates for consumers.

These changes will be applied to a default – which assumes 75% of the potential heat customers are connected within 15 years.

The following table sets out the proposed changes to the model.

Table 37 Model Assumptions for the Policy Ideas

	Policy	Impact on Model
Planning Policies		
1	Apply Heat Plans in S36.	Enforcement of the heat plan will establish the DH network at an early stage and will incentivise the power station operator to win heat customers. The main financial incentive that the operator can offer is a lower price for heat. This is assumed to bring forward connections of all types of customers – which will improve the NPV of the scheme. This will be counterbalanced by the lower income from heat sales which will reduce the NPV of the scheme. The model assumptions are: • A 10% reduction in heat price charged • A 25% reduction in time to connect to the network
2	Connecting adjoining development proposals.	This policy would mean that new development is sited closer to the power station sites, with shorter pipe lengths and lower capital cost. Hence this is modelled as a reduction in the capital cost to serve these heat loads. There is potential flexibility in the location of new development particularly commercial development to be nearer to power station sites. It is assumed that these sites are 50% closer to the power station and hence the capital cost of connecting these is 50% lower.
3	Single Outcome Agreements on low carbon heat.	This would increase the connection rate of public sector buildings. Hence it is modelled as a reduction in the connection time for public sector consumers by 10%. In other words if the site was assumed to connect in 20 years' time, this now happens in 18 years' time.

Policy		Impact on Model
4	Use Planning System to locate heat producers near to heat demand.	This policy would mean that sites for new power stations are closer to sites with heat demand resulting in shorter pipe lengths and lower capital cost. Hence this is modelled as a reduction in the capital cost to serve these heat loads. There will be much less flexibility over the siting of the power station. Hence this will have less impact than policy idea no 2. It is assumed that these sites are 33% closer to the power station and hence the capital cost of connecting these is 5% lower.
5	Going further on heat recovery within the National Planning Framework.	The National Planning Framework identifies major developments that are important for the economic development of Scotland. The current plan covers 14 projects, one of which is a power station (Hunterston). Only one of the 14 would have a significant heat load (Commonwealth games). These two locations are now fixed, hence the current NFP2 cannot have a great deal of influence over locating heat loads. However the next version of the NFP could exert this influence. It is assumed that the power station sites will be fixed by the time NPF3 is produced. However NPF3 could influence the location of a major heat load close to one or more of the power station sites. Hence this policy will add heat loads, assumed to be 5%, within a 5 km radius of the power station site.
Funding and Project Capital Policies		
6	Support for consumer switching to district heating.	This policy will encourage earlier connection of domestic consumers. This will influence the connection of new housing developments. Hence it is modelled as a reduction in the connection time for new housing developments by 33%. In other words if the site was assumed to connect in 15 years' time, this now happens in 10 years' time.

Policy		Impact on Model
Technical Policies		
7	System to support infrastructure installation (rights of access to road infrastructure).	This will have a small impact in reducing the cost of installing the DH network. A 1% reduction in DH capital costs is assumed.
Risk and Uncertainty Policies		
8	Use of public sector as anchor heat load.	This would increase the connection rate of public sector buildings, public buildings they would connected earlier that would have been the case. Hence it is modelled as a reduction in the connection time for public sector customers by 20%. In other words if the site was assumed to connect in 20 years' time, this now happens in 16 years' time.

10.10 Results with the Key Policy Ideas Applied

The initial results from the policy assessments are shown below. The core results are shown in the top section of the table.

Table 38 Results from the policy assessments

	Longannet		Hunterston		Cockenzie		Peterhead	
Policy	**NPV**	**IRR**	**NPV**	**IRR**	**NPV**	**IRR**	**NPV**	**IRR**
None	-£48,104,483	2.80%	-£31,652,504	3.63%	-£87,960,720	2.31%	-£12,623,863	2.08%
1 Apply Heat Plans in S36	-£48,415,687	1.07%	-£32,398,920	2.03%	-£84,975,608	1.59%	-£12,519,219	1.14%
2 Connecting adjoining development proposals	-£43,618,415	3.16%	-£19,424,482	5.15%	-£57,220,334	3.78%	-£8,491,202	3.45%
3 Single Outcome Agreements on low carbon heat	-£47,747,977	2.85%	-£31,508,266	3.66%	-£85,045,106	2.51%	-£12,554,071	2.12%
4 Use Planning System to locate heat producers near to heat demand	-£27,435,761	4.70%	-£19,010,121	5.21%	-£43,146,751	4.65%	-£9,573,646	3.05%
5 Going further on heat recovery in the National Planning Framework	-£27,286,225	4.71%	-£18,602,520	5.27%	-£42,122,071	4.72%	-£9,435,890	3.10%
6 Support for consumer switching to district heating	-£47,194,060	2.91%	-£31,652,504	3.63%	-£82,046,759	2.71%	-£12,416,523	2.18%
7 System to support infrastructure installation (rights of access to road infrastructure)	-£47,484,422	2.85%	-£31,273,232	3.67%	-£86,616,301	2.37%	-£12,532,357	2.11%
8 Use of public sector as anchor heat load	-£47,089,326	2.92%	-£31,244,982	3.70%	-£79,625,844	2.87%	-£12,427,054	2.18%

The following charts show these results graphically with:

- The IRR for the base case of 75% heat load capture in 15 years on the left hand side.
- The IRR for the policy options when applied to the 75% heat load case on the right hand side.

Figure 21 Policy Results for Longannet

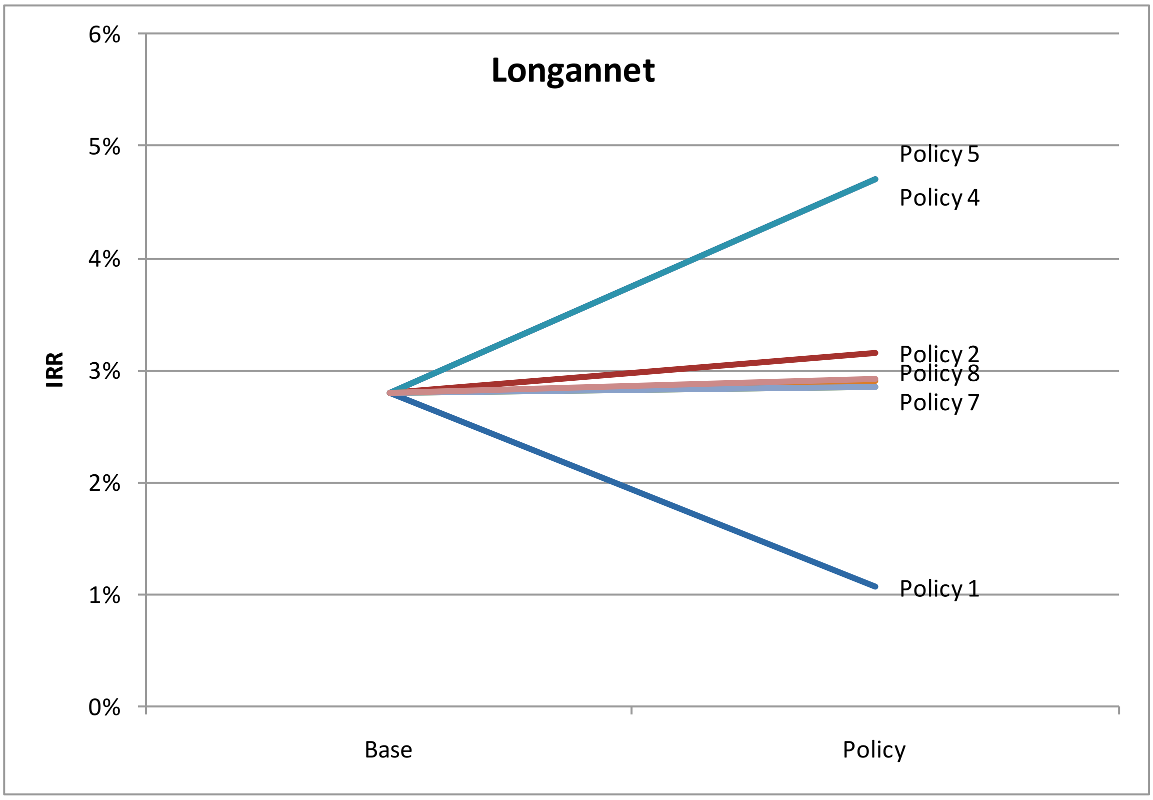


Figure 22 Policy Results for Hunterston

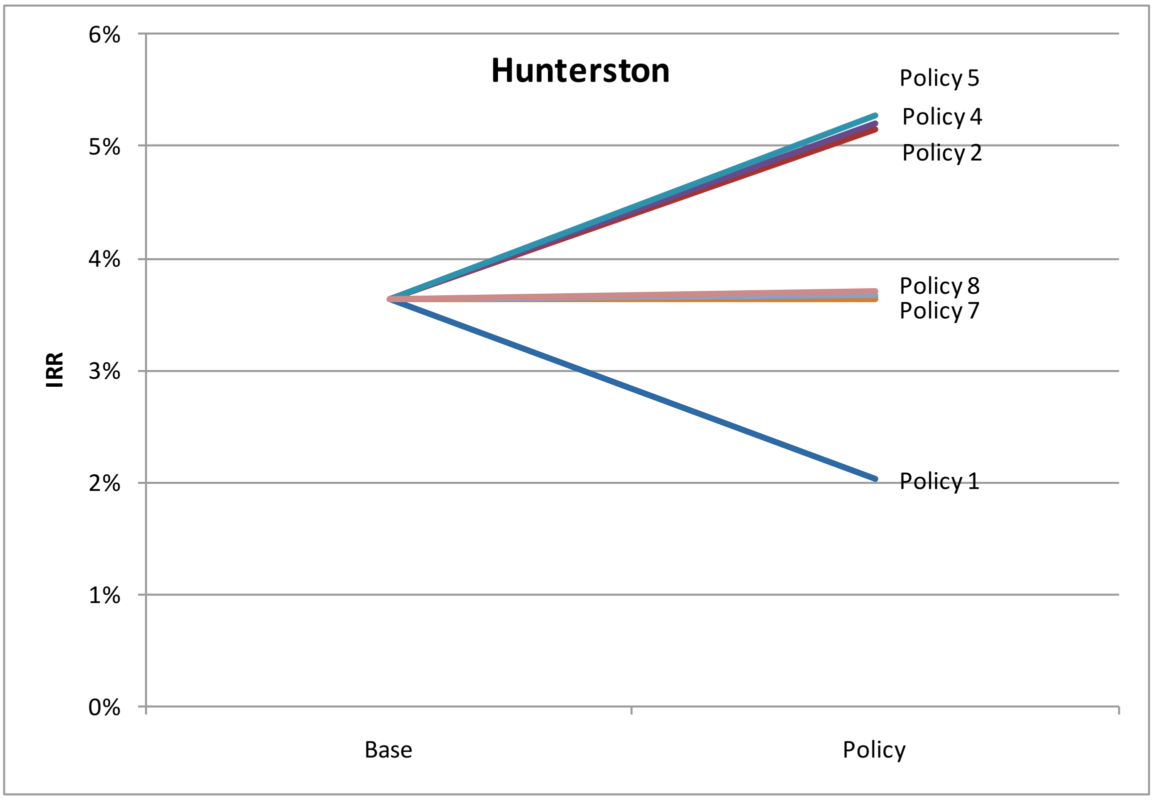


Figure 23 Policy Results for Cockenzie

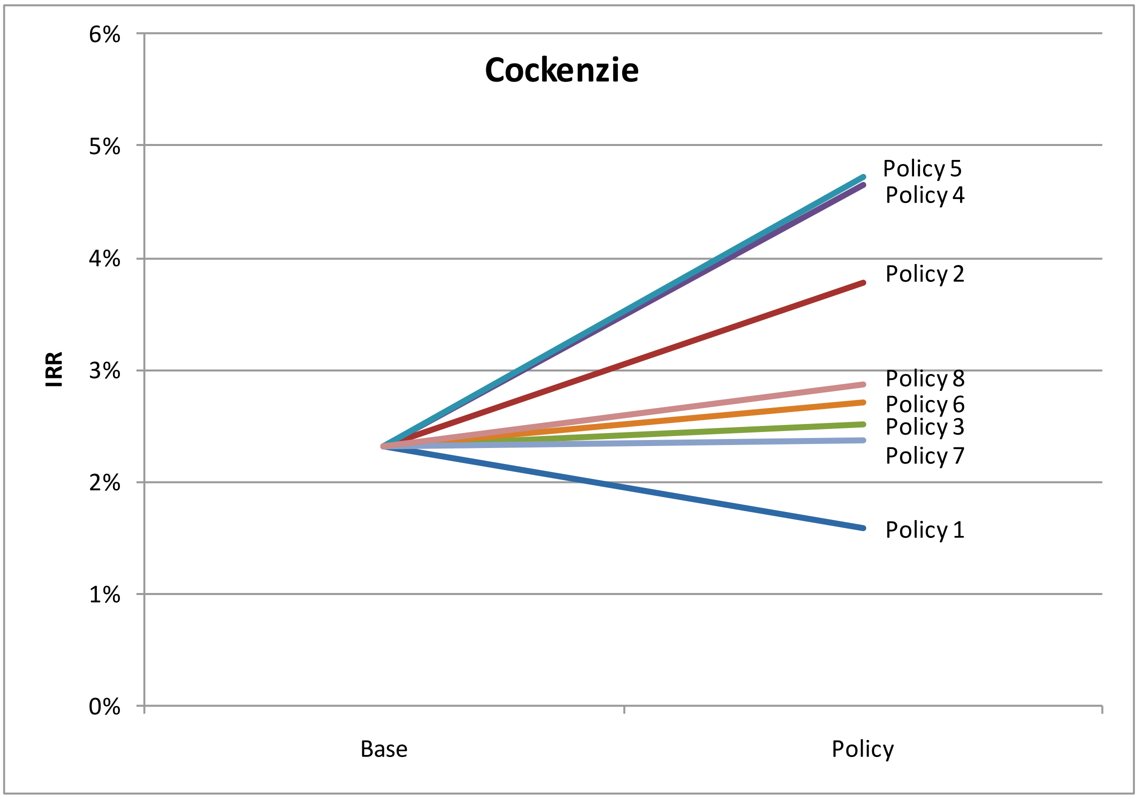
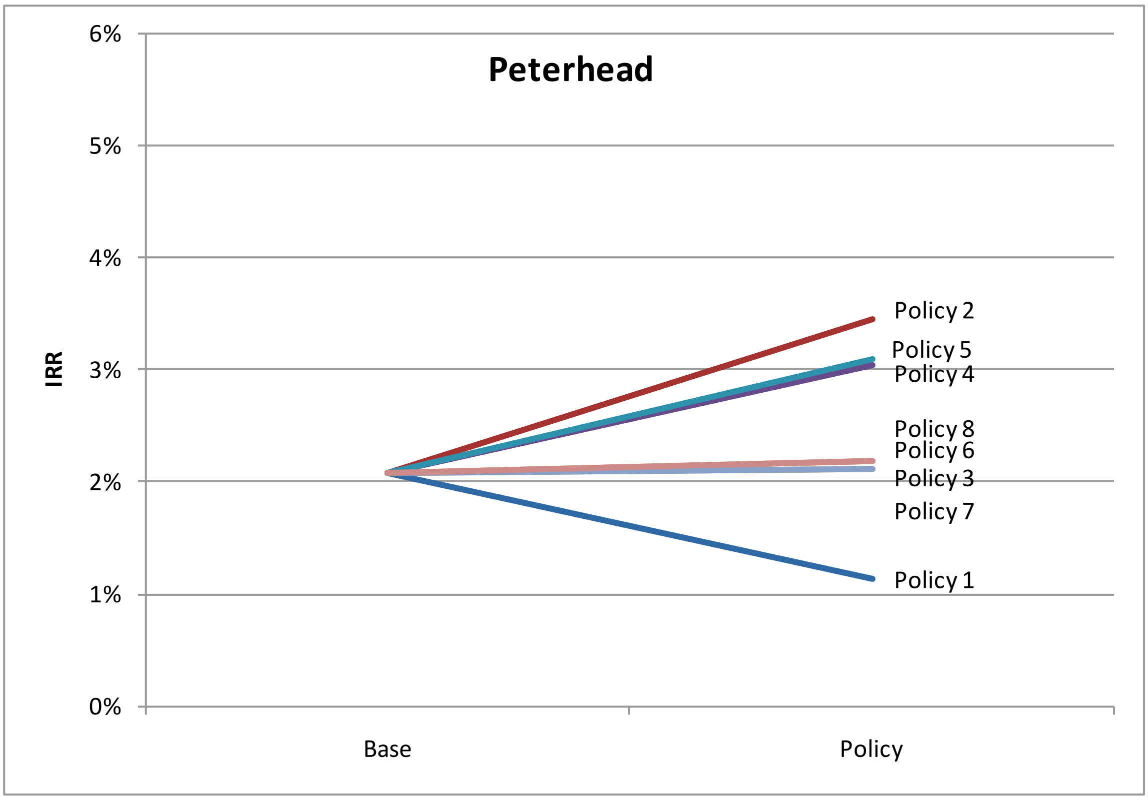


Figure 24 Policy Results for Peterhead



10.11 Conclusions on Which Policies Offer the Best Results

The results from the analysis of the policy options show that none of the ideas tested help the schemes meet the 9% target IRR.

Policy 5, "Going further on heat recovery in the National Planning Framework", has the greatest impact in 3 out of 4 cases. This policy has a high impact because it re-locates all heat loads to be much closer to the power station, making a very significant reduction in the costs of the heat network. There will be practical issues with this policy, for example resistance from hosing developers to have their sites close to a power station. However this test shows the high impact of co-location of heat demand and heat supply.

Policy 4, "Use Planning System to locate heat producers near to heat demand", has a similar level of impact to Policy 5.

For Peterhead Policy 2, "Connecting adjoining development proposals", has the highest impact. Of the 4 sites tested, Peterhead has the highest %age of new development sites within the potential heat load. Hence this policy which only affects connection of new development proposals has a high impact at this site.

Policy 1 reduces the IRR in all cases. This policy was modelled as a 10% reduction in heat price by scheme developers in order to encourage early connection by 25%. This result suggests that developers cannot on their own create an early market from discounted heat sales. So other policy measures will be needed.

The remaining policies have minimal impacts on project IRR.

The two policy ideas with greatest impact co-locate heat supply and demand. This is a strong pointer to the changes that would be needed to bring forward large scale district heating. This is also in line with the experience from Denmark, where the Heat Planning Law is credited with creating Denmark's high use of district heating.

11 Recommendations

During the course of this project a number of issues and questions were raised which were out of the scope of the current work, but would benefit from further consideration by the proposed Expert Commission on district heating.

11.1 Wider Potential for District Heating

This study has examined the potential for district heating using heat from 4 power station sites. This shows the technical and financial potential for these 4 sites. This is a sub set of the overall potential for district heating in Scotland and the results probably represent some of the most challenging cases. In particular the power station sites would have originally been chosen for their proximity to fuel and access to cooling water – not heat loads.

Hence there are many other potential district heating opportunities in Scotland that are not represented in this analysis. These include:

- Small scale district heating schemes. Existing example include the Aberdeen Heat and Power schemes plus new ideas currently being developed as part of the infrastructure of housing developments. There are several examples including, e.g. the Home Farm Biomass Community Heating on Skye and the Hill of Banchory District Heating Scheme in Aberdeenshire.
- The potential for heat recovery from the biomass power station proposals being developed by Forth Energy for Dundee, Grangemouth, Rosyth and Leith.
- The requirement for Energy from Waste schemes to include a heat plan, which encourages the plants to be sited closer to heat loads.
- The opportunities in large urban areas that are not close to the power station sites. The most notable of these is Glasgow – which does not fall into the 30 km catchment area used for the four sites in this study. The Sustainable Glasgow Initiative is currently examining ideas for district heating in several areas of Glasgow. However the current study does not cover Aberdeen, Dundee and other important urban areas that have significant heat loads.

Hence the impact and costs of policies assessed in this study will not represent the impact and costs for all district heating opportunities across Scotland. There are likely to be better opportunities that could deliver carbon savings at lower cost.

11.2 Competing Options for Low Carbon Heat

This study focuses on a single low carbon heat option – heat recovery from power stations. There are many other options, including:

- Biomass;
- Heat pumps;
- Solar thermal; and
- Energy efficiency.

Hence the carbon savings identified by this study could be achieved by alternative low carbon heating technologies. This is an important issue to understand as:

- Owners of buildings will want to choose the most cost effective investment.
- Scottish Government will want to maximise carbon savings vs. support offered.

To assess the competing options would require a more specific study of some of the buildings that could be connected to the district heating network and the competing low carbon heating options that are relevant to each building

11.3 Best Practice in Policies for District Heating

This study has highlighted that there are many EU and non EU countries where the district heating provides a significant share of the heating market. The case studies included with this report suggest that there are very different policies that encourage district heating. As it was not the focus of this study to investigate and review all of the different polices that are used in the EU and beyond, an initial search was undertaken for any recent reviews of policy frameworks for district heating in Europe. As well as general internet searches this included search specific web sites including: Euro Heat and Power, District Heating and Cooling plus (DHC+)Technology Platform, and IEA District Heating and Cooling

This did not find any recent work on this topic. One IEA project will be reporting on “Policies and barriers for District Heating and Cooling outside EU countries”. This may be of relevance when the report is published.

Hence a further investigation into best practice in policies for district heating could be of value. Such a review would provide valuable evidence to shape Scotland’s approach to district heating. A review should collect details of relevant policies and evidence on their impacts (positive and negative). This should also take into account the policy context that is required for these policies to be successful – as background economic, social and political factors are important.

11.4 Heat Planning Law

A specific example of a key policy area for district heating is planning. The international success of district heating is strongly linked to the supportive planning frameworks in place in other countries. This is apparent from the short review of international cases studies and agrees with AEA’s prior experience of working in Europe.

The most progressive of these planning frameworks is the Danish Heat Planning Law. This requires properties in an area served by district heating to connect to that system.

It was not possible to test the potential for this policy as part of this study. An investigation would need to:

a) Establish the location and areas served by existing and proposed district heating schemes in Scotland.
b) Determine the technical potential for additional heat sales from these networks.

c) Assess the technical potential to connect heat loads in the catchment areas of each scheme.
d) Evaluate the potential energy and carbon benefits of a Heat Law.
e) Investigate the potential for a Code of Practice

Step a) is already proposed within the Energy Efficiency Action Plan. Steps b), c) and d) are similar to the assessment in this study, but will cover different parts of Scotland.

Step e) is important as there are existing measures in place that would be in tension with a Heat Planning Law. For example the licence conditions for electricity and gas supply have a focus on consumer protection. This enables consumers to switch suppliers with ease. A Heat Planning Law would create a local monopoly on heat supply – which may raise consumer protection issues. A code of practice, detailing how consumers will be protected could be developed and agreed by all the key players. This would provide clarity and manage consumer expectations.

11.5 Heat Mapping

Knowing where heat consumption is located is extremely valuable when local authorities trying to set local planning priorities and project developers are choosing project locations.
Heat mapping has developed rapidly over recent years, from an initial heat map of Scotland[27], to local authority level heat maps[28]. Scottish Government has encouraged all local authorities to develop a heat map.
Because heat maps are a relatively recent development, there is a need to develop and share understanding on how they can be used, their capabilities and limitations.

For example heat use is not a geographical fixture, it changes. So if a key public building closes the heat demand in that location will change and may no longer be a focus for project development. Hence heat maps need to be used in conjunction with other data – on site closures, new development areas etc.

To ensure that best practice is quickly established there is a need to consolidate and share experience to date in heat mapping. This could take the form of guidance or training in areas such as:

- Integration of heat maps with local and strategic plans.
- Consideration with other carbon assessment tools, e.g. the wider impact of spatial planning and carbon emissions.
- Training in the use and interpretation of heat map data.

[27] See: http://www.scotland.gov.uk/About/FOI/Disclosures/2007/10/AEAHeatMap2007
[28] See: http://www.highland.gov.uk/yourenvironment/planning/energyplanning/renewbleenergy/HighlandHeatMappingProject.htm

11.6 District Heating Code of Practice

In the assessment of barriers a number of respondents cited concerns about heat customers being locked in to take heat from district heating. Unlike choosing a gas supplier, there are no options to obtain prices from several district heating providers. At present there are no regulatory bodies that licence or regulate heat supply. Introducing a voluntary code of practice would help increase consumer confidence. A code could deal with key issues over:

- Connection costs.
- Heat metering.
- Payment terms.
- Price increases.
- Disconnection terms.

The code could also consider the opportunity for multiple sources of heat supply – i.e. can a third party supply heat into a network and pay an access toll to supply customers. This is analogous to the third party access rights that are available for independent electricity distribution networks.

There will be examples of existing good practice in Scotland and the UK as well as useful examples from Europe that could help frame the Code of Practice.

11.7 District Heating Regulation

The operation of a district heating network is a natural monopoly. This is not a case for concern, as all energy networks (gas and electricity) are also natural monopolies. However the business model for this type of operation is very different from businesses that operate in competitive marketplaces.
Aspects of a regulated monopoly business model include:

- Regulation of major capital investment programmes.
- Regulation of prices charged for use of the network.
- Licences and standards of performance to protect customers.

These controls could be seen as a burden on the monopoly business. Instead they are the opposite sides of the same coin, as there are benefits as well as burdens:

- A monopoly business will not have competitors
- Sales will be predictable and low risk and the business does not have to invest in significant sales effort.
- The investments made will have predictable returns.
- The corporate business may be structured round high dividend yields rather than growth in market capitalisation.

Because of the low risk nature of a monopoly business they are able to invest in major infrastructure – i.e. gas pipelines, electricity transmission lines etc.

If district heating is to become a major feature of the UK energy system, the model used to raise money for the other energy networks could be applied in this sector.

This could be an important route to bring the levels of finance needed – however it will also bring the need for regulation.

11.8 EU Energy Efficiency Action Plans

The European Commission is in the process of introducing a new Directive that is aimed at putting Europe on track to meet the 2020 target of a 20% improvement in energy efficiency.
This new Directive will build on and replace existing Directives for Cogeneration and Energy Services and will merge them into one comprehensive legal instrument. Amongst the measures proposed for the new Directive is:

"Efficiency in energy generation: monitoring of efficiency levels of new energy generation capacities, establishment of national heat and cooling plans as a basis for a sound planning of efficient heating and cooling infrastructures, including recovery of waste heat."

The measures in the proposed Directive could be reflected in a future version of the Energy Efficiency Action Plan for Scotland.

11.9 Integration of District Heating into Existing Policy and Programmes

To date district heating has played a minor role in energy supply in Scotland. For district heating to become a more significant element, it will need to be an option that is in the minds of public and private sector investors and be integrated into existing policy frameworks. Examples of this include:

- Building the potential for district heating into the location of key public sector infrastructure. This includes location of key buildings e.g. new hospitals, secondary schools etc so that they can be anchor heat loads, or be the site of the main heating plant.

- Recognition of district heating as a low or zero carbon heat source, e.g. in the calculation of carbon emissions for compliance with building regulations, the Scottish Housing Quality Standard etc.

- Simplifying the access arrangements for laying district heating pipes under public highways.

- Many customers connect to district heating systems when their current boiler is retired. For the domestic sector the Scottish Government has recently offered an incentive for scrappage of older less efficient boilers. Encouraging district heating will need to be incorporated in a wide range of policy ideas – so connection to a district heating system should be eligible for payment under any future scrappage scheme.

- Developing models for roll out of district heating in the building types that are common in Scotland. For example district heating could play a role in reducing the carbon emissions from tenement flats – where many other energy efficiency measures will be impractical or undesirable (e.g. external or internal cladding).

Issues over the shared ownership of common facilities would need to be addressed.

Individually these measures will have a modest impact. Collectively they would show that district heating is a core part of Scotland's plan to reduce carbon emissions and that all of the practical issues are dealt with in regulatory frameworks. This would represent a step change from the current position, where district heating is seen and treated as an unusual occurrence which the relevant bodies were not able to deal with quickly or with certainty.

12 Conclusions

12.1 Technical

The technical assessment shows that it is possible to develop extensive networks for all four sites, with a range of configurations. The network for Peterhead would only serve very local customers, as the area beyond Peterhead is very rural with limited potential for heat supply. The network for Cockenzie is much bigger, extending well into Edinburgh as this area is urban with many potential heat consumers.

The technical assessment shows that it is possible to recover significant amounts of heat from future power stations that have CCS fitted. This is a key issue because CCS uses a significant amount of heat. CCGT stations are more at risk of this because the heat is extracted from the steam turbine. Hence CCGT sites that could serve an extensive network of heat consumers are most sensitive to this issue. In Scotland this is most evident for the Cockenzie site.

12.2 Financial

The analysis uses a number of different assumptions on the percentage of sites captured as heat customers and the timescale to build up the heat network and heat sales. Some key results are:

- If all 100% of heat loads (existing and future buildings) connect within 15 years none of these district heating systems would be financially viable (9% IRR). This is not a surprising outcome – if the returns were attractive projects would be under development.
- The funding gap to make projects viable is significant – from £12 million to £92 million.
- If a more accelerated connection rate is assumed the IRR improves significantly and the funding gaps reduce. This scenario is currently

unrealistic for Scotland however it is close to the situation in Denmark where heat planning laws require existing and new buildings to connect to the heat suppliers network.

The sensitivity tests show that revenue incentives would be an expensive and impractical route to support schemes. However accelerating the connection of heat loads offers a route towards more cost effective schemes.

12.3 Planning

The review of current and future planning policy concludes that:

- Many of current planning policies support heat and co-location of heat supply and demand.
- NFP2 and SPP are recent documents, and the strategic and local development plans are not yet in place, so it is too early to be fully certain of the impact of these policies.
- It is likely that there will be some progress, as developers and planners use the new policies.
- However, the policies were not drafted to deliver a rapid transformation in the uptake of heat recovery and district heating in Scotland. So these new policies are not expected to create a market for district heating as found in countries like Denmark.

Assuming that these conclusions are correct, and that there is a policy requirement to deliver much great uptake of heat recovery and district heating, this suggests that:

- In the short term opportunities for heat recovery and district heating may be missed, as co-location cannot be delivered retrospectively.
- If a transformation in the uptake of heat recovery and district heating is required, further changes in planning policy will be required to accelerate uptake.
- This may require more prescriptive policies, so a review of international planning policies would provide valuable insight into the policy options that have been used and how they could be relevant to the Scottish context.

12.4 Policy Options

The model was used to test a selection of policy ideas. The analysis shows that:

- Most policy ideas have a modest impact on the IRR, none of the policies and their assumed impacts led to an increase of IRR to 9%.
- The two policy ideas which had the highest impact both co-locate heat supply and heat demand.

These results demonstrate that planning policies are likely to be the most effective way to encourage heat recovery and district heating.

12.5 Overall Conclusions

This study shows that it is technically possible to recovery significant amounts of heat from the four large power station sites. However the financial returns are far from attractive for investors.

Direct financial support from the public sector for these investments would need to be very significant to have any impact on IRR and would be very difficult to justify, due to the source of the heat (fossil power stations) and the State Aid requirements.

A range of other policy ideas were tested, these had relatively limited impact on the IRR, but policy ideas that reduced investment costs by co-location of heat supply and demand had the highest impact.

Hence there could be the potential to develop planning policies with mandatory requirements for co-location, drawing on international experience to shape these policies to the Scottish contents and opportunity.

12.6 Broader Recommendations

The study also includes a number of broader recommendations, recognising that there is a wider range of opportunities for district heating in Scotland beyond heat recovery from the four power station sites, these recommendations cover:

- Investigation of the wider potential for district heating in Scotland;
- Comparison of district heating with the competing options for low carbon heat;
- A review of international best practice in policies for district heating;
- The potential for a Heat Planning Law in Scotland;
- Heat Mapping;
- District heating Code of Practice;
- Examining the role of regulation in the expansion of district heating;
- How EU Energy Efficiency Action Plans could support policy development; and
- Integration of district heating into existing policy and programmes.

These recommendations could be taken up by the proposed Expert Commission on District Heating.

Appendices

Appendix 1: Route location/heat load tables

Appendix 2: Multicriteria Analysis

Appendix 3: Responses from planners

Appendix 1: Route location/heat load tables

Peterhead

Node	Site Name	No. Houses	Business Space (ha)	Heat Load (kW)
1	Peterhead Power Station			
2	Business Park 7		12	2,515.4
3	Private Residential School R2			Unknown
4	Business Park 4		47.2	9,893.8
5	Mixed Development of Residential & Commercial M1	1,265	4	4,792.5 Total (3,954 Housing) (838.5 Business)
6	Employment Area EH1		10.7	2,242.9
7	Housing Development EH3	185		578.3
8	Housing Development EH2	130		406.3
9	Business Park 3		26.3	5,512.9
10	Housing Development H1	250		781.4
11	Business Park 5		34.4	7,210.8
12	Employment Area E1		15.9	3,332.9
13	Business Park 6		48.6	10,187.3
14	Burnhaven School			36.9
15	Peterhead Prison			2,658.3
16	Peterhead Community Hospital			179.8
17	Peterhead Academy			614.7
18	Peterhead Swimming Pool			179.5
19	Ugie Hospital			117.0
20	Buchanhaven School			176.1
21	Business Park 1		9.6	2,012.3
22	Business Park 2		Unknown	Unknown

Hunterson

Node	Site Name	No. Houses	Business Space (ha)	Heat Load (kW)
1	Hunterston Power Station			
2	West Kilbride Primary School			407.4
3	St. Peter's Primary School			272.7
4	Stanley Primary School			316.3
5	James McFarlane School			25.8
6	Ardrossan Academy			832.0
7	Caledonia Primary School			306.6
8	St. Matthew's Academy			1,223.2

9	Nobel Enterprises Ltd			10,304
10	Auchenharvie Leisure Centre			304.4
11	Auchenharvie Academy			553.4
12	Glencairn Primary School			205.0
13	Ardeer Industrial Area IND2, Stevenson		66.06	13,847.2
14	Tournament Park Industrial Area IND3, Irvine		27.884	5,844.915
15	Ayrshire Central Hospital			1,258.2
16	Irvine Royal Academy			801.5
17	Glebe Primary School			309.0
18	Greenwood Academy			1,267.6
19	Riverside Industrial Area IND1, Irvine		81.296	17,040.9
20	Riverside Business Park IND2, Irvine		106.918	22,411.7
21	GlaxoSmithKline			22,269.7
22	GlaxoSmithKline Reserve Industrial Site IND12		26.975	5,654.4
23	Caledonian Paper Reserve Industrial Site IND12		9.527	1,997.0

Longannet

Node	Site Name	No. Houses	Business Space (ha)	Heat Load (kW)
1	Longannet Power Station			
2	Eastern link			
3	Culross primary school			36.3
4	Cairnhilly primary school			139.8
5	Carnegie leisure centre			304.4
6	Dunfermline high school			907.6
7	St Leonards primary school			98.1
8	Lynebank hospital			1157
9	St Margaret's RC primary school			182.4
10	Commercial primary school			205
11	Proposed housing (DUN037)	9		28.1
12	Proposed housing (DUN044)	21		65.6
13	Queen Margaret hospital			1,567.7
14	Calais Muir (North), proposed business, general industry & storage/distribution (DUN053)		5.4	1,131.9
15	Carnegie Campus 4, proposed business use (DUN055)		1.1	230.6
16	Carnegie Campus, proposed business use (DUN045)		12	2,515.4
17	South Elliot Street, proposed business, general industry and storage/distribution (DUN056)		1.7	356.4
18	Carnegie Campus 1, proposed business use (DUN046)		9	1,886.5

19	Land east of Inchkeith Drive, proposed business use (DUN052)		0.2	41.9
20	Proposed housing (DUN015)	139		434.5
21	Proposed housing (DUN042)	16		50.0
22	Proposed housing (DUN023)	105		328.2
23	Proposed housing (DUN022)	80		250.1
24	Proposed housing (DUN021)	110		343.8
25	Calais Muir (Central), proposed business use (DUN049)		19	3,982.7
26	Carnegie Campus 2, proposed business use (DUN050)		0.4	83.9
27	Pitreavie Way, proposed business, general industry and storage/distribution (DUN054)		4.4	922.3
28	Axis Point, proposed business, general industry and storage/distribution (DUN048)		5.3	1,110.9
29	Proposed housing (DUN057)	30		93.8
30	Proposed housing (DUN012)	170		531.4
31	Proposed housing (DUN011)	180		562.6
32	Proposed housing (DUN010)	180		562.6
33	Proposed housing (DUN009)	84		262.6
34	Proposed housing (DUN024)	80		250.1
35	Proposed housing (DUN014)	4,200		13,127.9
36	Pitreavie Drive, proposed business use (DUN052)		0.3	62.9
37	St Columba's RC high school			504.8
38	Proposed housing (DUN008)	170		531.4
39	Proposed housing (DUN030)	200		625.1
40	Crossgates primary school			111
41	Exxonmobil chemical ltd			99,393
42	Proposed housing (KCD002)	300		937.7
43	Proposed housing (KCD001)	30		93.8
44	Proposed housing (KCD004)	25		78.1
45	Kincardine Bridge link			
46	Tulliallan primary school			101.7
47	Castlebridge, proposed business area (B23)		12	2,515.4
48	Proposed housing (H42)	81		253.2
49	Proposed housing (H44)	55		171.9
50	Alloa Park, proposed business area (B1)		1.96	410.9
51	Proposed housing (H1)	115		359.5
52	Carebridge Road (North), proposed business area (B4)		5.48	1,148.7
53	Craigbank primary school			140.9
54	New Alloa Business Park, proposed business area (B8)		20.12	4,217.5
55	Proposed housing (H19)	36		112.5

56	Alloa Leisure Bowl			179.5
57	Sunnyside primary school			179.7
58	Proposed housing (H3)	22		68.8
59	Proposed housing (H15)	800		2,500.6
60	Proposed housing (H7)	107		334.5
61	Glenochil Prison			2,576.7
62	Proposed housing (H50)	175		546.9
63	Glenochil Yeast, proposed business area (B19)		4.13	865.7
64	Dumyat, proposed business area (B9/B10)		1.7	356.4
65	Garvel Farm, proposed business area (B12)		22.05	4,622.0
66	Wallace high school			865.7
67	Beaconhurst school			331
68	University			3,667.4
69	Cornton Vale Prison			1,724
70	Cornton primary school			172.7

Cockenzie

Node	Site Name	No. Houses	Business Space (ha)	Heat Load (kW)
1	Cockenzie Power Station			
2	Ross high school			837.9
3	Loch Centre, Tranent			179.5
4	Proposed business park, Kingslaw, Tranent (BUS11)		4.4	922.3
5	Proposed housing (H27)	70		218.8
6	St Martin's primary school			136.5
7	Sanderson's Wynd primary school			226.7
8	East Lothian inclusion service			Unknown
9	Proposed housing (H1)	1,600		5,001.1
10	Preston Lodge high school			791.0
11	Mercat Gait centre			304.0
12	Prestonpans primary school			243.5
13	Proposed business park, Mid Road West, Prestonpans (BUS10)		4.5	943.3
14	Proposed school, Wallyford primary school (ED6)			Unknown
15	Proposed housing (H7)	1,000		3,125.7
16	Proposed business park, Wallyford (BUS12)		4	838.5
17	Wallyford primary school			170.7
18	Proposed housing (H4)	450		1,406.6
19	Edenhall hospital			464.7
20	Pinkie-St. Peter's primary			227.5

21	University			3.8
22	Musselburgh sports centre			304.0
23	Musselburgh grammar school			1,107.5
24	Loretto RC primary school			147.9
25	Loretto school			432.0
26	Musselburgh Burgh primary school			215.6
27	Proposed business park, Craighall Business Park, Musselburgh (BUS1)		21	4,401.9
28	Proposed business park, Old Craighall Junction, Musselburgh(BUS2)		5	1,048.1
29	Proposed business park, Craighall Business Park, Musselburgh(BUS1)		18	3,773.1
30	Proposed economy area for business/industry, Danderhall/Shawfair (E1)		8.5	1,781.7
31	Proposed economy area for business/industry, Dalkeith/Eskbank (E2)		11.5	2,410.6
32	Lasswade primary school			257.7
33	Large Site (might be St Mary's primary school)			185.5
34	St Mary's primary school			122.5
35	Lasswade high school centre			1,023.9
36	Loanhead hospital			89.0
37	St Margaret's primary school			52.8
38	Loanhead primary school			122.6
39	Loanhead Leisure centre			304.0
40	Proposed housing (H14)	130		406.3
41	Proposed economy area for knowledge based industry & manufacturing, Gowkley Moss North (B2)		7.5	1,572.1
42	Proposed housing (H13)	12		37.5
43	Proposed economy area for knowledge based industry & manufacturing, Gowkley Moss South (B3)		2.5	524.0
44	Proposed economy area for knowledge based industry & manufacturing, New Milton (B4)		7.5	1,572.1
45	Beeslack community high school			734.5
46	Strathesk primary school			232.0
47	Penicuik high school			547.0
48	The Penicuik centre			304.0
49	Proposed economy area for business/industry, Oatslie, Roslin (E7)		5	1,048.1
50	Proposed economy area for knowledge based industry & manufacturing, Easter Bush (B1)		7.5	1,572.1
51	University			409.0
52	Paradykes primary school			239.0
53	Proposed economy area for		10	2,096.2

	business/industry, Loanhead (E6)			
54	Bonnyrigg leisure centre			304.0
55	Proposed economy area for economic development, Hardengreen, Eskbank (E3)		6.5	1,362.5
56	Proposed housing (H3)	750		2,344.3
57	University			401.7
58	Newbattle swimming pool			179.5
59	Newtongrange primary school			273.0
60	Proposed economy area for economic development, Redheugh/Prestonholm (E5)		7	1,467.3
61	Proposed economy area for employment land, Stobhill, Newtongrange (E4)		5	1,048.1
62	Support & re-integration services			Unknown
63	University			317.0
64	Portobello swim centre			304.0
65	Brunstane primary school			192.0
66	Portobello high school, proposed school (SCH3)			Unknown
67	Castlebrae community high school			339.0
68	Niddrie Mill primary school			241.0
69	Thistle Foundation, proposed housing (HSG9)	170		531.4
70	Greendykes, proposed housing (HSG6)	900		2,813.1
71	New Greendykes, proposed school (SCH5)			Unknown
72	Castleview primary school			183.0
73	Niddrie Mains, proposed housing (HSG7)	500		1,562.8
75	Prestonfield primary school			222.0
76	Liberton primary school			413.0
77	St. Margaret's school			394.9
78	Royal Blind school			161.0
79	University			3,206.0
80	University			302.5
81	Haden Building Management Ltd, large site			4,067.0
82	University			1,039.0
83	New Royal Infirmary of Edinburgh			3,487.0
84	Edinburgh BioQuarter, Little France, proposed business area (approved) (BUS1)		25	5,240.4
85	Liberton high school			782.0
86	Liberton hospital			567.0
87	Ellen's Glen house			87.6
88	Gracemount high school			644.5
89	Kaimes school			120.6
90	Kingsinch school			81.0

91	University			7.4
92	New Greendykes, proposed housing (HSG5)	1,000		3,125.7
93	St. John's RC primary school			389.0
94	Portobello high school			1,534.7
95	Duddingstone primary school			421.0
96	The Royal High primary school			331.6
97	Craigentinny primary school			207.0
98	St. Ninian's RC primary school			228.7
99	Abbeyhill primary school			201.6
100	Royal Mile primary school			159.9
101	Caltongate, proposed housing (CA2)	1,200		3,750.8
102	University			32.8
103	The University Court of the University of Edinburgh, large site			3,629.0
104	Preston Street primary school			283.8
105	University			1,306.8
106	The University Court of the University of Edinburgh, large site			2,526.0
107	Large site, unknown name			346.6
108	Sciennes primary school			661.8
109	Royal Hospital for Sick Children			1,048.7
110	James Gillespie's high school			1,143.0
111	Warrender swim centre			304.0
112	James Gillespie's primary school			431.0
113	University			52.9
114	Astley Ainslie hospital			1,781.8
115	University			178.5
116	University			7,808.0
117	University			54.7
118	Large site, unknown name			291.8
119	University			89.0
120	University			587.0
121	University			9.2
122	Lauriston complex, hospital			1,075.9
123	Quartermile, proposed housing (CA4)	822		2,569.3
124	St. Thomas of Aquin's high school			1,075.9
125	George Heriot's school			1,723.0
126	Tollcross primary school			238.0
127	Fountainbridge, proposed housing (CA3)	1,129		3,528.9
128	Bonaly primary school			426.7
129	Boroughmuir high school			1,162.0
130	Bruntsfield primary school			423.0
131	University			1,088.0
132	Royal Edinburgh hospital			2,320.0
133	Greenbank centre			48.7
134	William Fraser centre			43.0
135	University			14.5

136	University			70.9
137	George Watson's college			2,406.0
138	Rudolf Steiner school of Edinburgh			257.9
139	Craiglockhart primary school			319.6
140	University			751.0
141	University			878.0
142	Firrhill high school			1,240.0
143	Oxgangs primary school			324.8
144	Dalry swim centre			304.0
145	Dalry primary school			260.0
147	Tynecastle high school			697.0
148	St. Nicholas' school			75.6
149	Balgreen primary school			387.0
150	Edinburgh prison			1,702.0
151	Stenhouse primary school			309.0
152	St. Joseph's RC primary school			192.0
153	Broomhouse primary school			168.8
154	Murrayburn primary school			312.0
155	University			240.8
156	University			774.7
157	Edinburgh Park, proposed business area (granted outline planning permission) (BUS2)		16	3,353.8
158	Heriot Watt University, large site			1,644.7
159	University			2,788.7
160	University			85.7
161	Forrester high school			733.0
162	St. Augustine's high school			839.0
163	Gylemuir primary school			413.8
164	Corstorphine primary school			470.6
165	Fox Covert primary school			145.8
166	Fox Covert RC primary school			155.7
167	University			845.6
168	Carrick Knowe primary school			417.5
169	Corstorphine hospital			238.7
170	Murraypark nursing home			36.7
171	Craigmount high school			1,462.5
172	Large site, unknown name			216.7
173	Large site, unknown name			121.0
174	Leith Eastern Industrial Area, proposed business area (BUS3)		20	4,192.3
175	Prospect Bank school			65.8
176	St. Mary's RC primary school (Leith)			277.0
177	Leith Waterfront (Docks), proposed housing (Wac1b)	18000		56,262.5
178	Leith Waterfront (Salemander Place), proposed housing (Wac1c)	700		2,188.0
179	Hermitage Park primary school			370.7

180	Leith Waterworld			304.0
181	Leith academy			1,008.6
182	University			100.4
183	University			32.8
184	Leith primary school			215.0
185	Leith Victoria swim centre			304.0
186	Leith CTC, hospital			79.7
187	Bonnington primary school			89.8
188	Holy Cross RC primary school			196.8
189	Trinity academy			1,034.0
190	Trinity primary school			342.5
191	Victoria primary school			100.0
192	Leith Waterfront (Western Harbour), proposed housing (WAC1)	2,194		6,857.8
193	Large site, unknown name			195.7
194	Broughton primary school			332.0
195	Drummond community high school			535.9
196	St. Mary's RC primary school (Edinburgh)			318.0
197	Canonmills school			64.9
198	The Edinburgh academy			824.0
199	University			196.8
200	Glenogle swim centre			304.0
201	Stockbridge primary school			197.0
202	Broughton high school			1,011.9
203	Fettes college			722.0
204	Flora Stevenson primary			445.5
205	Royal Victoria Hospital			767.6
206	Royal Victoria Hospital			749.6
207	University			133.2
208	Western General hospital			4,824.6
209	University			599.7
210	Scottish & Southern Energy Generation Ltd, large site			4,896.8
211	Telford College (South), proposed housing (HSG12)	197		615.8
212	City Park, proposed housing (HSG19)	200		625.1
213	Ferryfield House, hospital			99.0
214	Ainslie Park leisure centre			304.0
215	Telford College (North), proposed housing (HSG11)	329		1,028.4
216	St David's RC primary school			158.8
217	Forthview primary			259.0
218	University			1,168.5
219	Granton Waterfront, proposed housing (WAC2)	6,143		19,201.1
220	North of Waterfront Avenue, proposed school (SCH6)			Unknown
221	Pirniehall primary school			190.5

223	Craigroyston primary school			265.0
224	Craigroyston community high school			509.0
225	Ferryhill primary school			314.5
226	Rowanfield special school			69.5
227	Blackhall primary school			393.7
228	Mary Erskine			805.0
229	The Mary Erskine & Stewarts Melville junior school			1,148.7
230	Daniel Stewart's and Melville college			795.0

Appendix 2: Multicriteria Analysis

		Quantified Criteria			Qualitative Criteria						
		Cost to SG lifecycle cost to public *Highest = 1*	Cost to business *least =6*	GVA created *Highest = 6*	public acceptability *Best = 6*	meets other policy aims *Highest = 6*	within devolved powers *no=1 yes =6*	ease of implement ation *easiest =6*	effectiveness *most effective =6*	**Total Score**	**Rank**
	Weighting	1.0	1.0	1.0	1.0	1.0	0.5	1.0	2.0		
Communication and Information Policies	Provide information / evidence about the benefits of renewable heat	5	6	1	6	3	6	6	1	32	9
	Education for Planning officials.	5	6	1	6	3	6	6	1	32	9
	Education for power plant operators	5	5	1	6	3	6	6	1	31	15
	Provide funding for feasibility studies	3	6	2	6	2	6	5	3	33	5
	Develop detailed heat maps for Scotland	4	6	1	6	4	6	6	3	36	1
	Large scale demonstration project to illustrate benefits of waste heat	2	5	3	6	3	6	4	3	32	9
Local or National Planning Policies	Apply Heat Plans in S36	5	5	1	5	3	6	3	4	33	5
	Connection of adjoining development proposals	5	5	2	5	3	6	3	3	32	9
	reduce scale of new biomass plant to increase pressure for heat utilisation	6	4	1	4	2	6	4	2	28	23
	Single Outcome Agreements on renewable heat	6	6	1	6	3	6	6	2	35	2
	Include within National planning framework	5	5	1	6	4	6	5	2	33	5
	Use planning system to locate heat producers near to heat demand	5	5	1	6	4	6	4	2	32	9
	New Generation to be "heat ready"	5	4	1	5	3	3	4	2	27.5	25
	New Generation to supply hot water	5	4	1	5	3	3	4	2	27.5	25
	New Generation to meet increasing energy efficiency requirements	5	4	1	5	3	3	4	2	27.5	25
	Amend building regulations to make new homes capable of receiving heat	5	4	1	5	3	6	4	2	29	22
	Establish a national co-ordinating body	4	6	1	4	3	6	5	2	30	19
Funding and Project Capital Policies	Financial incentives within RHI for fossil heat	3	4	1	4	3	1	2	4	25.5	31
	Long term financial incentives (UK Government)	1	4	1	4	3	1	2	4	23.5	32
	Carbon Credit mechanisms	3	4	1	4	3	1	2	3	23.5	32
	Public sector loan fund	3	6	2	4	3	6	4	3	31	15
	Public sector grants	2	6	2	3	3	6	4	4	31	15
	Public sector Guarantees	4	6	1	4	3	6	4	3	31	15
	Establish public private partnership mechanism	3	6	1	4	3	6	4	3	30	19
	Establish favourable tariff regime	5	4	1	4	3	3	2	3	26.5	28
	Establish price stability mechanism	5	5	1	3	3	3	2	3	26.5	28
	Establish fixed ratio of heat cost to alternatives (i.e. Gas or Oil costs)	5	5	1	5	4	3	4	3	31.5	14
	Support for consumer switching	5	6	1	5	4	6	4	3	34	3
	New fossil fuel levy to fund infrastructure	5	4	1	3	3	1	2	4	26.5	28
Technical Policies	Minimum efficiency requirements	2	4	1	5	4	6	5	3	30	19
	System to support infrastructure installation (rights of access to road infrastructure similar to those for other services	2	5	1	6	3	6	5	4	33	5
	Explore potential for meta grid	2	6	1	6	3	6	5	1	28	23
Risk and Uncertainty Policies	Use of public sector as anchor heat load	3	6	1	6	3	6	4	4	34	3

Appendix 3: Responses from Planners

Feedback from planners

The planning system can support the decarbonisation of electricity generation in Scotland, the uptake of local district heating schemes and the use of recovered heat in other potential uses. A questionnaire was sent to planners to provide information on the status quo, future plans and perceptions of the barriers to heat recovery

Table 39 Local authority action to support the uptake of local district heating and the use of recovered heat

Falkirk Council	
Local Plan	Local Plan policy EQ6 supports combined heat and power and community heating schemes as part of new development and policy ST20 offers general support to utilisation of renewable energy sources in new development. A current proposal, being determined by Sc Govt, for a biomass plant in Grangemouth Docks has a district heating component option to it.
The MIR	The MIR for our new LDP(local development plan) is not due to be published until summer 2011 and we are currently formulating the key issues for the Council which will be raised under the umbrella of Climate Change.
Example	Retrofitting infrastructure for use of waste heat from Grangemouth industrial complex for use in local housing and public buildings – the potential for exploiting this has been explored on a number of occasions but unfortunately has not resulted in proposals or action to date
Ayrshire	
Heat Mapping	Briefing paper & GIS work undertaken. Further work may be undertaken later this year as part of the Joint Ayrshire Waste procurement project. (funding still to be confirmed)
The Structure Plan	The Structure Plan identifies a search area in the key diagram and an opportunity to develop a co-fired power plan based on clean coal technology. The coalfield area of East Ayrshire is recognised as having particular opportunities for this type of energy production. Refer Policy ECON 8-Biomass.
Fife Council	
Development plan	The council supports a variety of renewable technologies in its development plan policies. Whilst there are no specific policies related to waste heat and district heating there is support in principle for the technology where it does not impact negatively on communities and where it can operate safely and efficiently. Options on this are being explored for the development of Fife's Strategic Land Allocations which are allocated in the Approved Structure Plan and the emerging local plans. The Council has planning guidance on renewables which can be accessed at: http://www.fifedirect.org.uk/publications/index.cfm?fuseaction=publication.pop&pubid=A4BF3EC3-9EFC-94DF-DBA00DCB63722D68

	Furthermore the council has a sustainability checklist which is being used to guide future major development to be more sustainable. This can be accessed at: http://www.fife.gov.uk/uploadfiles/publications/c64_SustainabilityChecklist.PDF
Heat mapping	There is recognition of the value of heat demand and supply mapping within Fife council as this facilitates the allocation of land for development use where there would be potential for uptake of these technologies.
Supplementary planning guidance	Supplementary planning guidance is in development for Lochgelly. The community indicated a desire to be more sustainable and reduce carbon emissions. As such consideration is being given to the inclusion of positive encouragement for these technologies at a local level.
Energy Strategy	An energy strategy is being developed for Fife Council, which may consider the potential for utilisation of these technologies.
Example	Tullis Russell biomass plant, Glenrothes-A 49.9MW £200 million state-of-the-art biomass plant development which will be owned and operated by RWE npower renewables. This will provide Tullis Russell Papermakers with steam, which it needs for paper drying, as well as electricity. The plant will also supply significant low carbon renewable power to the national grid. This project helps to safeguard the 540 jobs at the company whilst reducing the papermill's fossil fuel CO2 emissions by around 250,000 tonnes each year. Options are being explored for the creation of a district heating scheme for Glenrothes on the back of the biomass plant development. This is being led by Fife Council who has to date undertaken preliminary work to present an outline economic model enabling the Council to decide on whether to proceed to full feasibility study with the project. Major housing and business allocations in the Glenrothes area, including the 1,000 residential units proposed for the Glenrothes East/ Markinch SLA could feed into this proposal. Major developments and regeneration proposals for the town centre could also potentially benefit from the scheme.
Example	Lochhead landfill waste treatment scheme- 43,000 tonnes of food and garden waste would go to produce renewable power and heat. It is estimated that every year the unit, an anaerobic digestion facility, could save £1.2 million and produce 1.4MW of electricity and heating. It could also reduce carbon emissions of up to 11,000 tonnes a year; produce sufficient renewable electricity to meet the needs of 1500 homes; generate enough heat to meet most of the needs of Queen Margaret Hospital; and produce up to 15,000 litres of liquid fertiliser and 10,000 tonnes of compost per year for use by local farms. There will be an opportunity in the future to produce refined biofuel for injection into the gas main and for use as vehicle fuel.

Example	Ore Valley HA 'Cardenden Heat and Power' (CHAP) is a renewable energy project that aims to deliver affordable heating and hot water to the tenants and residents of Cardenden. The project will be rolled out in stages across the town. Biomass fuel will be used for the scheme and will come from recycled waste wood and sustainably grown crops. In the unlikely event of wood not being available at any stage, such as in times of repair, gas would be used. Ore Valley Housing Association and Fife Council are the primary stakeholders with the project being managed by Energetic Project Management. A power plant would be built in close proximity to Cardenden and a network of hot water pipes will be installed throughout the town. Each connected home would have its boiler replaced with a heat exchanger which would then link in with the existing heating system. Once the heat has been utilised, the colder water would be returned for re-use and re-heating.
Clackmannanshire	
The MIR	The MIR consultation ended in March 2011. This placed a strong emphasis on climate change mitigation and one of the main issues identified, and consulted upon, was "How can we reduce our greenhouse gas emissions and adapt to the consequences of climate change". The MIR contained a range of options related to Decentralised Energy, Decarbonised Energy Generation and Low Carbon Development. These can be viewed on the Clackmannanshire Council website at: http://www.clacksweb.org.uk/site/documents/environment/clackmannanshiredevelopmentplanmainissuesreportenvironmentalreportdecember2010/ The potential of re-use of heat to significantly reduce energy waste, increase efficiency, reduce costs for energy users and contribute to climate change mitigation is acknowledged in the MIR. Following recent discussion with Kristen Anderson and Rosie Leven it has been agreed that the Local Development Plan should contain specific proposals relating to waste heat. We also intend to investigate the scope for specific proposals on district heating.
SEAP	Use of comprehensive energy master planning / sustainable energy action planning
Local Development Plan	Promotion of Local Development Plan (LDP) polices for decentralised energy or use of supplementary planning guidance. LDP policy could outline the scale of development at which the Council expects developments to implement or connect to decentralised energy technologies such as districted heating or combined heat and power. Will allow planning applications to be conditioned to provide pipes or retro fit existing properties.
Grant Funding	Seek additional funding to be made available through the various grant programmes. Additional funding specifically for Council's to enable the set-up of public sector led ESCo's. Continued support for Renewable Heat through the Renewables Obligation.

Table 40 The most significant barriers to the recovery of heat from large scale energy generation capacity in Scotland, as identified by the planners

Proximity to heat demand	
1	Proximity of heat demand (for existing energy plants)
2	Larger scale power generation facilities which are often located at sites isolated from the major built up areas.
3	Proximity to power station of suitable building stock.
4	Land use planning difficulties in allowing integration of heat users and heat generators
5	Planning – location of energy plants away from heat demands
6	Existing building plant in suitable buildings may not be inefficient enough to warrant this.
7	The distance between the fossil fuel plants and main settlements, which would require an extensive new pipeline network to be created
Financing	
1	Limited financial incentive and uncertainty in appropriate business models for the construction and ongoing maintenance of facilities.
2	Financing of heat infrastructure – banks not willing to debt fund.
3	Financial considerations/lack of clarity over investment against returns
4	Long term pay back periods are a significant constraint
Fragmentation of ownership	
1	Discontinuity between supplier and customers, fragmentation of ownership – probably works best with large single social housing estates or similar
2	Disparate ownership of land, property, generation, transmission, maintenance responsibilities.
3	Responsibility for maintaining infrastructure
Lack of exemplars	
1	Lack of current projects that have undertaken heat recovery schemes from power stations.
2	A mindset and culture not tuned to this form of heat source. Limited skills and understanding of the technology.
3	Mindset and culture not tuned to this form of heat source.
Inertia: resistance to change	
1	Inertia: resistance to change
2	Lack of ambition to change tried and tested processes
Lack of community engagement	
1	Making local communities aware such schemes are planned/ installed
2	Providing local residents with simple explanations of benefits when installed
Restrict choice of electricity suppliers	
1	Decentralisation of heat supply could (allegedly) restrict choice of electricity suppliers for householders (an issue raised by house builders with East Lothian Council)
2	Issues around single user use and spreading of risk amongst multiple users.
Perception of being dirty	
1	Potential perception of problems of secondary heat and associated industrial processes being "dirty"
Absence of infrastructure	

1	Absence of infrastructure
Lack of willingness to act	
1	Agreement with power station to do this, including pricing.
Fiscal policies	
1	Fiscal policies
Risk	
1	Risk averseness of businesses requiring reliable heat supply over long timescale
Heat efficiency in both ends of the equation	
1	Heat efficiency in both ends of the equation
Opposition to biomass	
1	Public opposition to biomass plants
Limited skills and understanding of the technology.	
1	Limited skills and understanding of the technology.
Commercial sensitivity	
1	Commercial sensitivity regarding industrial estate & processes
Lack of leadership	
1	Lack of lead agency on initiative
Lack of certainly about heat availability	
1	Lack of long term certainty about excess heat generation
Difficulties in retro-fitting heating systems	
1	Difficulties in retro-fitting heating systems to existing dwellings and business premises, which form the vast bulk of the building stock.

Table 41 The most important policy and support measures to encourage recovery of heat from large scale power generation, as identified by the planners

Funding	
1	Infrastructure funding
2	Price certainty for a period of time.
3	A supportive tariff regime to encourage this form of heat source – *extension of RHI*
4	Resource to carry out feasibility study.
5	A supportive tariff regime to encourage this form of heat source.
6	Provision of funding mechanism to pump prime district heating developments
7	Financial incentives and or pump priming needs to be available to encourage change
8.	Tariffs to support development of approach.
Planning policy	
1	Including this form of heat source in building regulations and planning policy. National Planning Framework and associated Scottish Planning Policy support would assist. Inclusion within planning conditions for refurbished/extended/extended life/new stations.
2	Locating heat producers where there is a market for waste heat recovery
3	Ensuring that large scale power generators are designed to be capable of exporting waste heat at commissioning stage (whether or not there is a current market)
4	National attitudes and supportive policies need to be promoted
5	Planning in favour of low carbon heat supply

6	Support for adjoining development proposals through the planning process (and amended Local plan policies to consider such developments)subject to appropriate use of Surplus heat
7	It is understood that there are some structural issues with the development of district heating schemes that would need to be tackled.
Education of public	
1	Education of public re. benefits and risks of biomass plants
2	Clarity over impact of waste heat on choice of electricity suppliers for residential customers
3	More advice provided on the benefits of using such technology.
4	Improving education on the subject to ensure there are the skills and understanding of the major issues to take projects forward.
Demonstration	
1	Large scale demonstration projects to show potential and explore operational issues.
2	Greater evidence of the advantages of heat recovery, financial and technical feasibility
3	More advice provided on the benefits of using such technology*. Support to developers and communities to enable and gain positive benefit from uptake (Community Energy Scotland).*
4	A government pilot scheme
Framework agreement with the power station	
1	Formal framework agreement with the power stations.
2	It should not be limited to large scale power generation as there is a need to think more efficiently about all development
Energy strategy.	
1	A direct lead by the Scottish Government through an energy strategy.

AEA group
Glengarnock Technology Centre
Caledonian Road
Lochshore Business Park
Glengarnock
KA14 3DD

t: 0870 190 6191
f: 0870 190 5151
e. colin.mcnaught@aeat.co.uk

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