District Heating for Dublin

Feasibility Study

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GLOSSARY

Carbon Intensity: A measure of the carbon content and hence carbon dioxide production potential of a given fuel or fuel mix when it is consumed. This can be expressed as kg CO_2/GJ.

Combined Cycle Gas Turbine (CCGT): This is the current state-of-the art for commercial electricity production. A CCGT power station combines both gas turbine and steam turbine technology to achieve a high electricity production efficiency.

Combined Heat and Power (CHP): A plant designed to produce both heat and electricity from a single heat source. This is done at the expense of slightly reduced electrical power output, however overall gains in total efficiency can be significant. Heat recovered can be utilised in a district heating system for example.

Climate Change: The global climate system is subject to natural variation. In the context of this report however it refers to the climate change attributable to human activity resulting in the release of greenhouse gases into the atmosphere.

CO_2: Carbon Dioxide. The most abundant greenhouse gas produced from human activities (it is also naturally occurring).

Energy Services Company (ESCO): An Energy Services Company contracted to Dublin City Council will operate and maintain the DH system. The ESCO will also bill and meter individual customers connected to the network.

Fossil Fuel: Peat, coal, fuels derived from crude oil (e.g. petrol and diesel) and natural gas are called fossil fuels because the have been formed over long periods of time from ancient organic matter. All contain varying amounts of carbon, and in the recovery of energy from the fuel through combustion in the presence of air, the carbon combines with the oxygen to form CO_2, which is vented to the atmosphere. In the case of waste to energy carbon emission calculations, plastic based materials are considered to be fossil fuels.

Greenhouse Gas (GHG): A gas in the atmosphere that freely allows radiation from the sun through to the earth's surface, but traps the heat radiated back from the earth's surface towards space and radiates it back to the earth's surface. The heating effect is analogous to the manner in which the glass in a greenhouse traps the sun's radiation to warm the air inside the greenhouse. Most greenhouse gases occur naturally and are a necessary part of the total climate system, but their concentrations can be increased by human action, causing climate change.

Heat Load: The amount of thermal energy required to provide space and water heating for a building types. Retail, residential, etc. will have varying heat demands.

Internal Rate of Return (IRR): Internal Rate of Return is a capital budgeting method used to decide the rate of return on long-term investments. The IRR is the annualised effective compounded return rate which can be earned on the invested capital, i.e. the yield on the investment. A project is a good investment proposition if its IRR is greater than the rate of return that could be earned by alternative investments .Thus, the IRR should be compared to an alternative cost of capital including an appropriate risk premium

Kyoto Protocol: The second largest international agreement (1997) on climate change, setting binding GHG limitation and reduction targets for developed countries. It is a protocol to the UN Framework Convention on Climate Change.

Power Plant Mix: Term used to take account of the various primary energy sources that are used to produce electricity. The carbon intensity of electricity is a function of the power plant mix i.e. the relative proportions of each source (oil, coal, gas, wind etc.)

Tonnes of oil equivalent (Toe): 42 MJ of heat energy are released in the complete combustion of 1,000 kg of oil. Toe is a standard unit used in the energy industry for normalising the energy potential of varying fuels.

Waste to Energy (WTE): Waste treatment process where energy recovery is practised. This term includes landfill gas collection and combustion, and alternative thermal processes such as pyrolysis and gasification. However, WTE in the context of this report - and generally - refers to controlled waste combustion / incineration with energy recovery in the form of electricity and possibly heat.

Simultaneous Load Factor: All consumers will never demand the full load at the same time therefore a "simultaneous load factor" is applied to find the real maximum heat demand from the district heating scheme A simultaneous load factor of 70% is used in this study.

EXECUTIVE SUMMARY

DISTRICT HEATING OVERVIEW

District heating allows the efficient use of thermal energy from combined heat and power plants (CHP), refuse incineration plants, waste heat from industrial processes, natural geothermal heat sources, and fuels which are more easily used centrally including renewables like wood waste and residues, as well as coal and peat.

The proposed district heating (DH) network for Dublin will circulate hot water in an underground, pre-insulated pipe system (with supply and return lines) in accordance with proven and up-to-date design principles. Flow temperatures will be in the range of 80 – 120^0 C with return temperatures designed for 40 – 60^0 C.

Good practice for district heating design is to 'think big' - but the system will often need to 'start small'. This principle has been observed for the Dublin project and it was decided to examine the feasibility of three alternative scenarios of differing scales and at various locations throughout Dublin City.

BACKGROUND

District Heating (DH) and Combined Heat and Power offer advantages in terms of higher energy efficiency, and reduced consumption of energy resources. DH can also offer capital cost savings and reduced operating and maintenance costs.

Every kWh of heat replaced by sustainably fuelled district heating represents a saving of natural resources and a reduction in carbon dioxide (CO_2) emissions. DH can therefore play a significant role in contributing to meeting Ireland's commitments under the Kyoto Protocol, which is set at maintaining Ireland's CO_2 emissions at a level below 113% of 1990 levels by 2012. Worldwide, DH and CHP reduce existing CO_2 emissions from fuel combustion by 3-4%.

DH is a key element of a number of EU Directives and governmental policies. The impending implementation of the Energy Performance of Buildings Directive (EPBD), which specifically refers to district Heating/Block Heating and CHP as heat sources, will also create an added-value to DH customers when their building is being rated.

Increasing energy demand, volatility in world energy market prices and Ireland's vulnerability to security of supply issues accompanied by an increase in concentrated mixed use development in the City Centre have created this opportunity to improve the overall sustainability of Dublin City. Previous consultation identified a real and growing interest among developers in increasing the overall energy efficiency of their developments. Tighter building controls, planning requirements and the EPBD coupled with a growing awareness and demand for higher Energy Efficiency among consumers also mean that developers are now willing to incorporate compatibility with DH in their development designs.

Dublin City has both the quantity and concentration of large buildings to host a large DH system. Despite the mild Irish climate, heating is necessary for several months of the year and domestic hot water is needed year round. In addition, there is a demand for cooling of hotels, offices and shopping centres *inter alia* during the summer season.

The initial development and propagation of a DH scheme in Dublin City could provide an essential more sustainable and energy efficient utility to a wide range of customers in the City and also facilitate:

- The utilisation and installation of CHP by providing a steady and reliable heat demand, allowing constant and optimised heat and electricity production
- Current small and large scale CHP operators to optimise their processes, such as the Guinness Brewery, St. James' Hospital, the Dublin City Council Civic Offices CHP
- The utilisation of waste heat resources from the proposed WTE facility, the Synergen and ESB power stations on the Poolbeg Peninsula

Dublin City Council (DCC) has recognised that it can act as a positive driver to achieve the implementation of a district heating network in the City and to this end it appointed RPS and COWI (Danish engineering consultancy company) in 2003 to examine the potential for district heating in Dublin. A two-fold approach was taken as follows:

- Take the best from Danish technical experience with district heating and apply this to the Irish market. District heating is highly developed and widely used in Denmark.
- Proactively approach developers in the Dublin area with the view to explaining the benefits of district heating to the public, and to encouraging developers to consider district heating for their developments.

As a result of positive interest from energy management companies and developers, Dublin City Council requested that RPS undertake a feasibility study on the potential for the implementation of a Citywide District Heating Network. A funding application was made to Sustainable Energy Ireland in October 2006 seeking support to carry out this work. This application was successful and funding was granted in January, 2007.

FEASIBILITY STUDY

The principal objective of this feasibility study is to assist Dublin City Council to decide on the viability of a citywide district heating network. Three alternative scenarios for the development of a DH scheme were examined including:

- **Scenario 1 - Dublin Docklands**: The development of a DH network that will concentrate on the Dublin Docklands Redevelopment Area. The concentrated nature of this area of new development and its proximity to the eventual CHP heat load provider (proposed Waste-to-Energy facility and power stations) at Poolbeg make it ideal as an initial development area. Significant developments examined under this scenario include Spencer Dock, the Point Village, the Irish Glass Bottle site etc..
- **Scenario 2 – Westgate**: This scenario will see the development of a DH network in the Westgate Area (St. James' Gate – Heuston Area). The base heat load for each DH network will as a start be supplied by peak and reserve load boilers at St. James' Hospital and gas fired boilers at the CHP plant at Guinness Brewery. This will supply heat to the significant developments in the Heuston Station Area.
- **Scenario 3 - Citywide DH Network**: The development of a DH network, which will link the Docklands (as described in Scenario 1) and Westgate (as described in

Scenario 2). The initial foothold development will be followed by the development of a 'spine' following the Liffey allowing the incorporation of the Civic Offices, St. James' Hospital and the Guinness Brewery and supply to significant developments in the Heuston Station Area.

This study is based on an analysis of the operating conditions of a district heating network though a planning period of 20 years. It was assumed that district heating would be offered at a price that is competitive with individual gas heating.

This report builds on previous work and targets a study of district heating supply based on given conditions, including the present plans and respective time schedules for the redevelopment of the areas within Dublin City (e.g. Dublin Docklands Area, Westgate, SoHo in the Liberties) and the potential heat sources that exist and/or are planned within the City area (e.g. establishment of the proposed waste to energy plant in Poolbeg, Guinness and other CHP facilities throughout Dublin). This imposes a certain time schedule for the district heating project and also a number of additional preconditions, which are listed in the report.

POOLBEG POWER STATIONS

Following consultation and meetings with the operators of the ESB Poolbeg and Synergen Power Stations, it was assumed that the power plants at Poolbeg would not provide heat to the district heating network in the short term. This is due to the need for retrofitting of turbines at the plants to make them compatible with the proposed network and the short-term plans already in place for maintenance at the facilities. However it is now our understanding that the development of an extensive DH Network in Dublin would offer these power stations the opportunity to connect to a reliable heat demand, resulting in a cost-effective option to reduce carbon emissions and the requirement for cooling when they will upgrade their facilities. Both facilities have subsequently indicated that they are interested in further examining potential connection into the network in the medium to long-term. In order to provide the operators with the relevant information to carry out their own feasibility study, including a price at which heat from these facilities could be purchased, relevant financial information is provided in the Sensitivity Analyses Chapter.

RESULTS

An overview of the feasibility study findings for the three scenarios is presented in the table overleaf.

	Scenario 1	Scenario 2	Scenario 3
Area	Dublin Docklands	Westgate	Scenario 1 and 2, and area between
Connection Period	2008-2012	2010 -2020	2008 -2024
Total Heat Load (Mw)	79	84	285
Heat consumption (MWh)	111,000	107,000	300,000
Network Size (km)	7.8	4.2	30.5
Total Investment Million €	21.5	14.9	56.9
Payback	8 years	9 years	10 years
Accumulated Result Million €	61.8	10.8	132.8
Internal Rate of Return - 20 years	16.4%	8.4%	17.5%
Internal Rate of Return - 10 years	7.5%	-4.4%	2%
$C0_2$ Savings (tonnes) / year	12,000	-5,000	32,000
Tonnes of oil equivalent saved / year	9,500	-	28,000

Technical

- District heating is a fully controllable and reliable utility service similar to electricity and water supply. District heating customers in Continental Europe appreciate thermal energy being supplied as a commodity. This saves DH customers both the investment and the space for their own boiler equipment (and its operation and maintenance).

- The maximum thermal output from the proposed Waste to Energy (WTE) plant will have the potential to supply the average annual heating requirements of 60,000 homes through the installation of a district heating network. With the propagation of the network, and the potential future increase in thermal output, the number of houses that could be supplied by the WtE facility could be considerably larger. This in turn would see increased environmental and economic benefits for the district heating project.

- The present study describes the first phases of the introduction of a major district heating network which will serve Dublin City with a new utility in an environmentally sound way. This project, if successful, could serve as a flagship development for similar projects nationwide.

- The development of heat demand in district heating networks will also allow the viability of heat supply from existing potential heat sources to be re-examined (e.g. power stations in Poolbeg).

Environmental

- Combined Heat and Power (CHP) can contribute significantly to reductions in CO_2 emissions. The development of a district heating network is essential for the successful harnessing of the large thermal resource which is available from WTE.

- In the wider area under study (Scenario 3), up to 32,000 tonnes per annum of CO_2 could potentially be saved if district heating is implemented as planned. This represents more than 20% of the target a 0.162 Mt reduction in CO_2 emissions resulting from CHP as set out in the National Climate Change Strategy 2007 - 2012. The development of the district heating network can therefore contribute positively to meeting Ireland’s obligations under the Kyoto Protocol.

- The Dublin District Heating Project will help to achieve a low-cost path for CO_2 equivalent emissions reduction and sustainability by providing what will be an innovative service in an Irish context.

- The displacement of conventional heating by the District Heating system will not only reduce cost to consumers but also reduce their exposure to a highly volatile international gas market and reduce Ireland’s dependency on imported gas. It will also increase both the revenue generated by the production of energy in this country and add to the security of supply of the Irish energy market.

- The replacement of conventional fuels for heating with district heating will also improve the local air quality by reducing the number of sources of emissions locally in a development.

- In the context of the implementation of the Energy Performance of Buildings Directive and of Part L Building Regulation the utilisation of Block and District Heating, particularly that derived from a CHP installation, will prove valuable to consumers. This is done by increasing the rating of their home in comparison to conventionally heated buildings of a comparable nature in terms of their construction and energy usage profile.

- District heating can reduce the need for water-cooling for power plants and waste to energy facilities.

- The District Heating network during its construction phase will have traffic impacts in a busy city. The use of public roads to provide distribution pipework to DH customers will be unavoidable. The disruption associated with bringing district heating to any of the developments mentioned above will be similar to any utility works in the City.

Economic

- A District Heating scheme supplied with waste heat from power generation (e.g. from the proposed WTE facility, Gatepower) will be competitive with traditional gas heating.

- The three scenarios examined all show an operational profit and an acceptable payback period for Dublin City Council.

- The project should be attractive to building developers who appreciate the advantage and value of having energy efficiency as a primary performance requirement for their developments.

- The impending implementation of the Energy Performance of Buildings Directive (EPBD), which specifically refers to district Heating/Block Heating and CHP as fuel sources, will also create an added-value to district heating customers when their building is being rated. As the Buildings Directive is implemented and its effects are felt throughout the building sector the value attributable to having a higher rating will create an added attractiveness for potential district heating customers. It is anticipated that this value will also extend to Developers where a new development, which is more energy efficient and has a higher rating will achieve a higher sales figure, thus increasing the attractiveness of incorporating district heating into new build developments.

- Following the commissioning of the WTE facility the project will be attractive as a business venture for Energy Supply Companies.

- Sensitivity analyses show that the two major parameters, which will have an influence on the operational economic performance of the District Heating Scheme, are the price at which heat will be sold to district heating customers and the purchase price at which heat will be bought from the proposed Waste to Energy facility. Scenario 1 is less sensitive to variations in major parameters than Scenario 2.

DH Management Options

In the Dublin District Heating model a key role in the development of DH systems will be played by DCC. The fixed assets of the DH network will be leased by DCC to an energy supply company (ESCO) which will then be responsible for running the business including, for example, investing in maintaining and developing the fixed assets as well as billing.

DCC will be responsible for:

- Providing an organisational framework,
- Financing network development and expansion,
- Selling heat from the WTE,
- Facilitating the network development through planning,
- Price regulation and representing the interests of individual heat consumers.

By its involvement in local energy planning, DCC will optimise energy supply costs to the end users.

RECOMMENDATIONS

Based on this feasibility study, and certain preconditions described within this report, it is recommended that Dublin City Council progress plans to establish a district heating supply serving the Dublin Docklands Area (Scenario 1).

To achieve the successful operation of the network modeled in Scenario 1, the following steps should be taken, as illustrated in the basic roadmap shown below:

	Phases	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	Feasibility										
2	Development of Block Heating Network										
3	Development of first branch from gas boiler station										
4	Establishment of gas boiler station										
5	First customer connections										
6	Development of other branch to WTE										
7	First supply from WTE										
8	Expansion of network to other Docklands customers										

Heat Supply

- An Bord Pleanála issued a decision to grant permission for the thermal waste treatment facility on the 14th of November 2007, with a condition that the detailed design of the facility made provision for the development of a district heating system. On the 22nd of November 2007, the EPA issued a Proposed Decision (PD) for the thermal treatment facility with a condition that, prior to operation, proposals for operation of the facility in Combined Heat and Power mode be made to the agency with a view to providing heat for a district-heating scheme. Therefore, the proposed Waste to Energy plant in Poolbeg must be designed and configured to allow the supply of heat to a district heating network.

- Dublin City Council's utilisation of waste heat from this facility will demonstrate the advantages of CHP that can be achieved from other sources in the same area i.e. from other power plants. This could result in greater gains for a fully developed system. Considering the nearby location of the Poolbeg Peninsula in relation to the high density redevelopment in the city centre and the need to increase the overall efficiency of power production, the feasibility of converting the existing power plants to operate as CHP facilities should be examined. This could be examined as phase two of this feasibility, but will require more detailed investigation of these potential heat suppliers.

- Also, considering that the proposed WTE facility is still in the planning process and that potential heat demand in the Docklands may exceed the supply of heat from the WTE, Dublin City should explore further the availability of other sources of heat (e.g. Gatepower/Guinness CHP and the Synergen and ESB power stations)..

- Dublin City Council should progress the development of a peak load / reserve boiler station. This boiler station will supply all heat needed during the district heating system's first period and will allow the establishment of a customer base prior to the commissioning of the proposed WTE facility. It will also function as a peak-load and reserve boiler station when a separate base-load provider is established.

Network Development

Dublin City Council and the Department of the Environment, Heritage and Local Government should ensure that consideration is given at an early stage to installing heat mains as part of the utility infrastructure. In some instances there may be justification for preserving routes for heat mains in order that the district heating network can be extended. This could be achieved by the creation of a standard for utility routing within new areas.

Dublin City Council should also examine the potential synergies of integrating the district heating network with existing services. In particular

- The development of the district heating network should use information collected for the routing of other services (e.g. Docklands Rising Mains Study and the Dublin Region Watermains Rehabilitation Project).

- The examination of the proposed Dart Underground Interconnector, with stops at Docklands, Pearse, St Stephen's Green, Christchurch and Heuston Stations, presenting opportunities to expand the district heating network main transmission lines to the western part of the City. If the developments were combined this would mitigate some of the impacts of having the two developments progressed separately.

- The identification any abandoned service routes for district heating and examine the possibility of re-routing other services.

Consumers

Dublin City Council should encourage developers to explore the possibility of using sustainable heating in the City and act to coordinate this at the Planning Stage. This is especially relevant where proposed developments are large and located within range of the proposed district heating network. This can be achieved through:

- Incorporation of specific proactive measures in the Dublin Energy Management Plan that support more sustainable energy solutions.
- Development of a Guideline / Guidance Note for Planners in DCC (and other local authorities) that informs them of the availability of district heating solutions and the opportunities presented by CHP and the proposed Dublin WTE Project.
- Development of a 'Model Clause' that DCC planners can incorporate into forthcoming Local Area Plans and Area Action Plans.
- Further development of mapping of the area that can be served by the proposed district heating network for use by planners and inclusion in the next City Development Plan. This will stimulate interest and prioritise the attention of planners into relevant development areas. It will also serve to assist planners in developing more solid requirements for the next City Development Plan.

Marketing

Dublin City Council and SEI should:

- Ensure that information on the potential for District Heating is widely disseminated and assist any existing developer wishing to accommodate the technology into their designs,

- Further explore possibilities for supporting and facilitating the development of district heating in the City in these early stages. Once a primary network is established the system can develop and expand on its own.

- Carry out an information campaign that will introduce new developers and the general public to the concept of DH. Run DH workshops that will give developers a chance to see the potential benefits they can achieve by designing any new developments for DH. Market sounding will be very important for the successful propagation of the DH network.

Funding

- Access to finance is a significant barrier to the development of a district heating network. Dublin City Council should examine potential sources of funding for the development of the Dublin District Heating Network. These could include EU and government funding, commercial banks, leasing companies, ESCO etc.

- The Government and in particular the Department of Communications, Marine and Natural Resources should promote DH by providing grant aid to help cover the large capital costs associated with the construction of a DH network. This will encourage local authorities and developers to consider the inclusion of DH in the initial designs of future developments.

- The introduction of a carbon levy could assist to fund projects, resulting in significant reduction of greenhouse gas emissions.

- Dublin City Council should examine the possibility of looking for financial contribution from developers to towards the provision of District Heating as a part of the public infrastructure as defined in the Planning and Development Act, 2000.

FUTURE EXPANSION OF THE NETWORK

Once a district heating network is established in the Docklands, it is likely that district heating can be propagated further. Other compatible developments will be proposed to join the network. For example, these developments could include:

- Elm Park (located close to Merrion Gates): Elm Park is a large mixed-use development consisting of six large blocks located at Merrion Gates, South East of the Grand Canal Dock. Due to its size, location and the fact that it also incorporates a block-heating network, Elm Park would provide a large heat demand and market for the Dublin district heating network at the southern edge of the city centre. It could also form a stepping-stone to the connection of potential users in Ballsbridge and University College Dublin.

- The Dublin Dockland Development Authority is currently preparing a Planning Scheme for the Poolbeg Peninsula, which is currently characterised by utility and amenity uses. An area detailed Urban Design Framework has yet to be finalised, but once approved by the Minister it will result in the regeneration and redevelopment of this area, with a consequent heat demand.

- Development at the Dublin Port site - A recent publication on the future development of Dublin Port entitled *A Report on Dublin Bay – An Integrated Economic, Cultural and Social Vision for Sustainable Development* outlines a proposal to relocate the existing Dublin Port and develop this 260 hectare area to accommodate up to 55,000 domestic and commercial residents. This high density proposal is targeted for 2050 living with construction over 25 years, encompassing the growing demand for city centre housing and projected greater shipping needs. The close proximity to the Poolbeg Waste to Energy plant and high density of this proposal make it ideal for district heating connection.

- It is likely that older or established developments could also be connected to the district heating network, as opposed to just new buildings and developments availing of the scheme. However, such connections could be made when existing equipment is replaced and when the option of an existing district heating network is available. Older housing in the Ringsend and Irishtown areas of the south city or Eastwall on the north would be typical examples of older housing in close proximity to the waste to energy plant, which could avail of the district heating scheme. This option would provide cheaper heat to the existing community.

Similarly as the number of connected customers grows, the network will require additional heat providers. This heat could be supplied by the power plants at Poolbeg, which are currently generating heat as by-product and requires cooling. This should be taken into consideration when these plants will be upgraded, as this will increase their efficiency and is likely to reduce their carbon dioxide emissions.

1 INTRODUCTION

District heating (DH) and Combined Heat and Power (CHP) offer advantages in terms of higher energy efficiency, significantly reduced CO_2 emissions and reduced consumption of energy resources. DH can also offer capital cost savings and reduced operating and maintenance costs to consumers.

The implementation of the Energy Performance of Buildings Directive (EPBD), which specifically refers to District Heating/Block Heating and CHP as fuel sources, will also create an added-value to DH customers when their building is being rated. District heating is a key driver for a number of EU Directives and governmental policies. This report highlights all external and legislative benefits of DH.

Increasing energy demand, volatility in world energy market prices and Ireland's vulnerability to security of supply issues accompanied by an increase in concentrated mixed use development in the City Centre have created this opportunity to improve the overall sustainability of Dublin City. Previous work conducted identified a real and growing interest among Developers in increasing the overall energy efficiency of their developments. Tighter building controls, planning requirements (Part L, etc..) and the EPBD coupled with a growing awareness and demand for higher Energy Efficiency among consumers is increasingly encouraging developers to incorporate compatibility with DH in their development designs.

The initial development and propagation of a DH scheme in Dublin City could provide an essential sustainable and energy efficient utility to a wide range of customers in the City and also:

- Encourage the utilisation and installation of CHP by providing a steady and reliable heat demand, allowing constant and optimised heat and electricity production

- Allow current small and large scale CHP operators to optimise their processes, such as the Guinness Brewery, St. James' Hospital, the Dublin City Council Civic Offices CHP

- Facilitate the utilisation of potential waste heat resources such as proposed Waste-to-Energy facility and the Synergen and ESB power stations on the Poolbeg Peninsula

Dublin City Council has recognised that it can act as a positive driver to achieve the implementation of a DH network in the City and to this end; it appointed RPS and COWI (Danish engineering consultancy company) in 2003 to examine the potential for DH in Dublin. A two-fold approach was taken as follows:

- Take the best from Danish technical experience with DH and apply this to the Irish market. DH is highly developed and widely used in Denmark.

- Proactively approach developers in the Dublin area with the view to explaining the benefits of DH to the industry, and encouraging developers to consider DH for their developments.

As a result of positive interest from energy management companies and developers, Dublin City Council requested that RPS undertake a feasibility study on the potential for the implementation of a Citywide DH Network. A funding application was made to Sustainable Energy Ireland in October 2006 seeking support to carry out this work. This application was successful and funding was granted in January 2007.

The principal objective of this feasibility study is to assist Dublin City Council to decide on the viability of a citywide DH network.

Three alternative scenarios for the development of a DH scheme will be examined including:

- **Scenario 1 - Dublin Docklands**: The development of a DH network that will concentrate on the Dublin Docklands Redevelopment Area. The concentrated nature of this area of new development and its proximity to the eventual CHP heat load provider at Poolbeg make it ideal as an initial development area. Significant developments examined under this scenario include Spencer Dock, the Point Village, the Irish Glass Bottle site etc.

- **Scenario 2 – Westgate**: This scenario will see the installation of a DH network in the Westgate Area (St. James' Gate – Heuston Area). The base heat load for each DH network will as a start be supplied by peak and reserve load boilers at St. James' Hospital and gas fired boilers at the CHP plant at Guinness Brewery. This will supply heat to the significant developments in the Heuston Station Area.

- **Scenario 3 - Citywide District Heating Network**: The development of a DH network, which will link the Docklands Area System (as described in Scenario 1) and Westgate (as described in Scenario 2). The initial foothold development will be followed by the development of a 'spine' following the Liffey allowing the incorporation of the Civic Offices, St. James' Hospital and the Guinness Brewery and supply to significant developments in the Heuston Station Area.

The proposed DH network scenarios are examined under a number of headings:

- External benefits
- Economic viability
- Future propagation of the network.

This study is based on an analysis of the operating conditions of a DH network though a planning period of 20 years. It was assumed that DH would be offered at a price that is competitive with individual gas heating.

This report builds on previous work and focuses a study of DH supply based on current and projected conditions, including the present plans and respective time schedules for the redevelopment of the areas within Dublin City (e.g. Dublin Docklands Area, Westgate, SoHo in the Liberties) and the potential heat sources that exist and/or planned within the City area (e.g. establishment of the proposed waste to energy plant in Poolbeg, Guinness and other CHP facilities throughout Dublin). This imposes a certain time schedule for the DH project and also a number of additional preconditions, which are listed in the report.

2 DISTRICT HEATING BACKGROUND

District Energy or District Heating systems are thermal energy networks that distribute hot water, chilled water, or steam through insulated dual pipe lines (supply and return) to serve commercial, residential, institutional, and industrial energy needs for space heating, domestic hot water, space cooling, and industrial purposes. DH systems allow heat energy, as distinguished from fuel, to be bought and sold as a commodity. A DH system can start small; when fully developed the utility can serve a whole city. An overview of a DH scheme is presented in **Figure 2.1**.

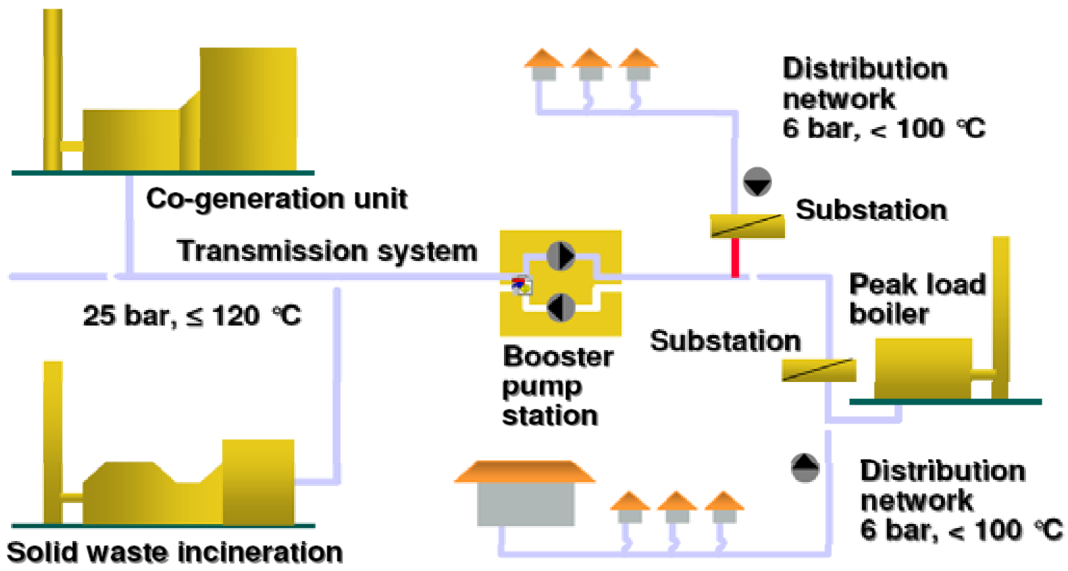


Figure 2.1: Overview of a District Heating Network

DH allows the utilisation of various low-grade energy sources, which would otherwise be wasted. These replace the use of fossil fuels in individual boilers and thus reduce CO_2 emissions. Combined heat and power (CHP) is the principal source of heat for a DH system.

2.1 COMBINED HEAT & POWER

Combined heat and power systems generate electricity and useful heat simultaneously from the same plant. CHP covers a range of technologies but always includes a prime mover (an engine or turbine) driving an electrical generator, plus a heat recovery system.

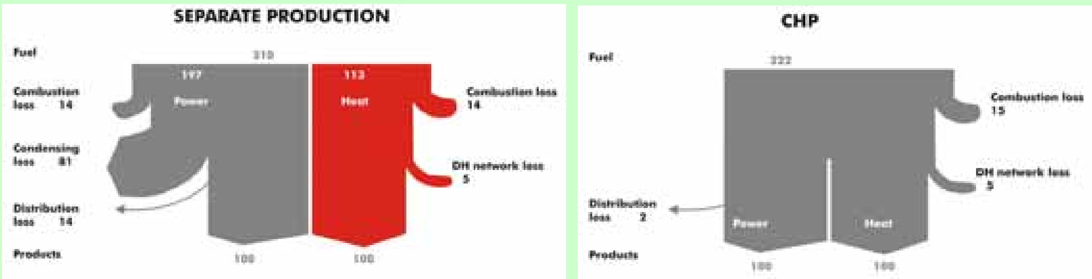
The term ‘useful heat’ refers to heat that meets an economically justifiable demand, or that could be used to generate useful cooling via a secondary process (absorption chillers). District Heating and cooling networks provide one of the best opportunities to utilise the useful heat produced in a CHP plant. DH also allows load matching, thus optimising the heat output of a CHP plant to be matched to a more constant and balanced demand.

In most CHP installations, the heat recovered supplements heat from the site's boilers and the electrical output displaces some (or all) of the electricity bought from the local supply network.
Application of CHP allows generators to recover a much higher proportion of the primary energy source in the form of electricity and heat. In order to optimise the quantity of heat generated, a relatively small amount of net electrical output must be sacrificed, as shown in the box below:

Comparison of Separate Production of Heat and Power Compared to CHP

Typically, a condensing power plant generating 100 units of electric power simultaneously produces up to 200 units of waste heat, which in the absence of a useful heat must be dispersed directly to the atmosphere, seas, lakes or river water.

In the example illustrated below, the separate generation of 100 units of electrical power and 100 units of Heat energy requires 310 units of fuel, resulting in an overall efficiency of 64.5%. by comparison, a combined cycle gas turbine operated in CHP mode will only require 222 units of fuel to produced the same electrical and heat output, giving an overall efficiency of 90%.



Source: Euroheat & Power

Conventional, centralised power generation is normally only 30-40% energy efficient. More recent combined cycle generation gas turbine (CCGT) plants can improve this to 55%, excluding losses for the transmission and distribution of electricity.

By utilising the heat that is always produced in electricity production the efficiency of a CHP plant will typically be 20-25% more efficient than heat-only boilers and conventional power stations. This significantly reduces the amount of CO_2, and to lesser extents Nitrogen Oxides (NOX) and Sulphur Dioxide (SO_2) released into the atmosphere. CHP can offer significant energy savings compared with the supply of electricity and heat from conventional power stations and on-site boilers.

2.2 LEGISLATIVE BACKGROUND

2.2.1 EU and National Environmental Legislation

DH is compatible with the European Union and national objectives in terms of energy security of supply, sustainability and competitiveness. The development of a DH network in Dublin will help achieve a number of environmental targets set out by Dublin City Council and Ireland under a number of different schemes.

Climate Change

A key driver for DH/CHP set out in the **National Climate Change Strategy (2007-2012)** is that Ireland has a policy target to reduce its carbon dioxide emissions by 0.162 Mt by 2010 through the installation of new CHP schemes, which can both support, and benefit from, connection to a DH system. The Government's ambition for CHP is underpinned by a target to achieve an installed capacity of 400 MW_{elec} by 2010 and 800 MW_{elec} by 2020.

The National Climate Change Strategy (2007-2012) states that the current Residential Density Guidelines will be replaced by Guidelines on Sustainable Residential Development, which will encourage the use of efficient energy supply (such as CHP).

The **National Climate Change Strategy (2000)** also states:

> "Increasing the density of residential accommodation, particularly in urban areas, and integration with commercial and other developments, also provides an opportunity to reflect energy planning considerations more explicitly in the provision of new housing. This can occur e.g. through the use of CHP plants for commercial/residential developments (where sufficient heat sinks are available to make this an environmentally suitable option) and the use of DH (e.g. waste heat from power stations will be available in the Dublin Docklands redevelopment area)."

The carbon dioxide reduction targets, security of supply and energy efficiency issues which feature strongly in the **White Paper 'Towards a Sustainable Energy Future for Ireland' (2007)** are all issues that DH, CHP and WTE can make significant contributions to. In the future, these points may be recognised by Government through specific support measures.

In June 2007 a new Government of Fianna Fail, The Green Party and the Progressive Democrats was formed. Their **Programme for Government** states that 'appropriate fiscal instruments, including a carbon levy will be phased in on a revenue neutral basis over the lifetime of the Government'. The Minister for the Environment in his first Carbon Budget speech (2007) pointed out the necessity of a **carbon levy**. When and how this is introduced remains uncertain. While any proposed levy or tax on fossil fuel would not directly favour district heating it is likely that it will encourage the use of CHP (if CHP is exempt) and biomass and waste heat. Revenue raised by the Carbon Tax could also be recycled to support such proven carbon displacement technologies such as CHP and DH. Carbon taxes have been introduced in Denmark, Sweden, Norway, Finland, Italy, the Netherlands, and the United Kingdom.

Combined Heat & Power

The European Union in its **Communication on CHP**, in 1997, recognised the importance of the technology and of DH, which provides a heat load to support its development. The benefits of CHP arise from a higher efficiency, which leads to fuel savings and consequently emission reductions. This efficiency of CHP and the fuel flexibility of DH bring also significant benefits in terms of security of energy supply.

The **Directive 2004/08/EC on 'the promotion of cogeneration based on a useful heat demand in the internal energy market'** provides a framework for Member States to support CHP. The guidelines allow the benefits of expanding CHP in district-heating systems to be made more clearly visible.

The Programme for Government published in 2007 included a commitment to remove any regulatory barriers to CHP and district heating systems. No further details were provided, however it would be reasonable to assume that they would follow from the barriers identified in the SEI report "Assessment of the Barriers and Opportunities Facing the Deployment of District Heating in Ireland".

Energy Efficiency

The Energy Performance in Buildings Directive (EPBD) (2002/91/EC) was adopted in January of 2003. Most EU Member states are obliged to have the necessary mechanisms in place to comply with this Directive by 4th January 2006. However, Ireland availed of an extension that saw implementation of the Directive commence in January 2007.

With households and the tertiary sector attributable for 40% of the EU's total energy consumption, the Directive has attempted to focus on the overall energy demand of these areas. The EPBD focuses on measures to improve energy efficiency within the building, increase energy conservation at the building envelope and on ensuring that the most sustainable and secure sources of energy for the building are utilised. This includes a provision under Article 5 of the Directive, which necessitates the consideration of the following for every building with a useful floor area of over 1,000m^2:

- Decentralised energy supply systems based on renewable energy,
- Combined Heat and Power (CHP),
- District or block heating or cooling, if available.

Under the general framework described in the Annex to the Directive, the positive influence of the above systems will also be taken into account in the calculation of energy performance of buildings. The certificates that will arise from such performance calculations are expected to have an influence on the value of buildings.

By utilising the most energy efficient methods available at this early stage, new developments can avoid costly retrofit and renovation expenses associated with energy efficiency requirements. Therefore, both developers and building owners can benefit now from being EPBD compliant and in seeking more sustainable energy solutions including DH.

The **Directive on Energy End Use Efficiency and Energy Services (2006/32/EC)**, which was agreed in December 2005, requires Member States to develop national action plans for achieving a 1% target for saving energy from end-users. The Directive contains a series of provisions designed to improve energy efficiency.

On meters, the Directive requires that Member States ensure that final customers for electricity, natural gas, district heating/cooling and domestic hot water are provided with competitively priced, individual meters that accurately reflect the customer's actual energy consumption and provide information on actual time of use. This in so far as it is technically possible, financially reasonable and proportionate in relation to the potential energy savings

Different arrangements apply to the provision of DH, where heat is generated in a central boiler or combined heat and power (CHP) plant and provided to residential, business or public sector customers. In the case of CHP, electricity may be supplied to a system's heat customers or exported. The heat supplied may be charged to customers either as part of their rent or as a fixed, average charge additional to their rent. This means that most consumers cannot realise any direct financial benefit from managing their heat consumption. Figures from BRE's UK Nationwide Survey of Community Heating (1998) show that around 400,000 households have heat supplied by DH systems. Of these, it is estimated that 30,000 to 50,000 may have metered heat. These figures do not include non-domestic customers.

Whilst estimates from DH studies suggest the large potential for energy savings from the provision of heat meters, the additional complexity of such meters means that they are expensive in comparison to electricity and gas meters. The additional cost of meter installation has been accounted for in the economic model for the Dublin District Heating project.

Heat Sources

The National Climate Change Strategy (2000-2007) and Ireland's sustainability strategy documents **'Sustainable Development – A Strategy for Ireland' (1997)** and **'Making Ireland's Development Sustainable' (2002)** are supportive of energy production from the biodegradable fraction of MSW. However, there is currently no specific financial support mechanism in Ireland for WTE.

The **EU Renewables Directive (2001/77/EEC)** includes the biodegradable fraction of MSW in its definition of biomass. It therefore qualifies as renewable energy under the Directive. Irish National Policy supports this definition as outlined by Sustainable Energy Ireland (SEI) in its Briefing Note on Biomass (2002) and also in the Government's White Paper 'Towards a Sustainable Energy Future for Ireland' (2006).

The Dublin Waste Management Plan (1999) and its replacement Plan (2005) both recommend the use of thermal waste treatment to meet Dublin's requirements for managing its waste and National targets for diversion of waste from landfill. The proposed Dublin Waste to Energy plant will fulfil this need. Dublin City Council has sought to ensure, that any thermal treatment facility in the Region should maximise its rate of energy recovery in accordance with maximising sustainability. DH is the means for achieving overall plant thermal efficiency rates of 80 – 85%. This compares with 30 – 40 % for a power only facility where heat is not recovered.

EU Emissions Trading Scheme (EU-ETS) and Energy Tax Directive requires the large power generation sector to purchase carbon certificates, which will in the long term increase their operation costs. This will partially address the inequity between large power generators and CHP users (>20MWth) participating in the EU-ETS. However, the small-scale CHP user purchasing gas through for example the industrial and commercial franchise tariff, and not participating in the EU-ETS, receives no such benefit.

2.2.2 Planning

The Planning System can have an important influence on how building developments are conceived and designed. It is through the City Development Plan and Local Area Plans that more sustainable use of energy can be encouraged. CODEMA are currently developing an Energy Action Plan for the City in conjunction with the different departments of Dublin City Council. DCC, through the Environment & Engineering Strategic Policy Committee is also preparing a climate change strategy for the city. These two documents will provide an opportunity to promote more sustainable development and in particular DH solutions.

The current **Dublin City Development Plan, 2005 - 2010 (DCDP)** also includes commitments on renewable and sustainable energy management including:

- The City Council will monitor best practice in energy efficiency and conservation and insist that these standards are followed in all developments.
- The City Council will endeavour to procure 13.4% of its electricity needs from renewable energy sources by 2010.
- Policy U41 of the DCDP states: "It is the policy of Dublin City Council to support a wide range of energy solutions to meet consumption needs, including encouraging

renewable energy sources. In this respect energy recovery could play an increasingly important role".

These commitments along with the new **Part L section of the Building Regulations** and the implementation of the Energy Performance of Buildings Directive will all encourage the development of a more sustainable built environment in Dublin City. They are directly relevant to DH as a more sustainable source of heat where heat energy is provided from CHP and alternative fuels such as biomass / waste.

2007 Part L Building Regulation

The recently published 2007 Building Regulation Part L Guidance Document describes the minimum design and construction guidelines required from July 2008. Compliance with part L of the Building Regulation requires that 10 kWh/m2/annum from renewable energy technologies (e.g. biomass) contributing to energy use for domestic hot water heating, space heating or cooling. As an alternative the use of combined heat and power (CHP) system, which contributes to the space and water heating energy use, would be acceptable.

The main source of heat for the Dublin District Heating System will be the Poolbeg WTE facility which will be operating in CHP mode. The connection to the Dublin District Heating System will help new developments to comply with the Part L Building Regulations.

The **Dublin Docklands Master Plan (2003)** also recognises the contribution to sustainable energy that CHP and the proposed WTE facility at Poolbeg can make. The opportunity to recover waste heat from utilities on the Poolbeg peninsula for meeting local heating needs via a proposed DH network is specifically mentioned. It is also recognised that the network will be relevant as a source of heat to the entire Docklands Area and that developments would be ideally located to benefit from the system if it is built. The Dublin Docklands Development Authority (DDDA) state that all development proposals should "seek to achieve the highest levels of energy efficiency" following "established principles of green design which seek to reduce energy loss". Combined heat and power is also supported by the DDDA who will encourage its provision in the Docklands Area.

The Proposed **Dublin Docklands Master Plan (2008)** supports the proposal to provide a District Heating Network in the Docklands and the wider city area, in co-operation with the ESB and Dublin City Council. It will encourage the major heat producers, including the existing power stations to contribute to this system.

The Master Plan also aims to ensure a co-ordinated approach is taken by utility companies and contractors on the installation of infrastructure, and to encourage the establishment of combined heat & power facilities, as part of an overall energy programme for the Docklands.

The DH system proposed by DCC could realise environmental benefits that will be seen and experienced by all inhabitants of the City. It is in line with National and local policy objectives and is also supported by the DDDA. As the network is expanded, there could be the potential for achieving a wider up-take with associated gains. The incorporation of a specific planning requirement that certain developments be assessed and designed for compatibility with a future DH Network (either planned or in place) could therefore underline local planning policy and assist greatly in the delivery of this infrastructure.

Fingal County Council have already developed an approach to sustainable development that is of interest to Dublin City Council for implementing DH in the City. This initiative uses the **Planning and Development Act (2000)** as its basis and it is supported by a range of high-profile stakeholders including the Minister for the Environment, the President of the Irish Planning Institute, An Taisce and the Labour Party's Spokesperson on the Environment. A number of key developers and builders have also provided their support.

In Fingal, the specific mechanism through which the proposals were included in the Local Action Plan was Section 19 of the Planning and Development Act (2000) which states that Local Area Plans can include objectives set “by the planning authority for the proper planning and sustainable development of the area to which it applies, including detail on (specific) standards for the design of developments and structures”. The Act also gives power to local authorities in terms of “regulating and controlling the design, colour and materials of structures and groups of structures, including streets and townscapes, and structures and groups of structures in rural areas”, and crucially, in terms of “promoting design in structures for the purposes of flexible and sustainable use, including conservation of energy and resources”.

Fingal County Council Experience – Cappagh Local Area Plan

In October 2005 Fingal County Council brought out sustainable building requirements of an unprecedented nature in Ireland, a landmark decision which should prove highly influential in progressing a change towards more energy efficient, healthy, low environmental impact buildings in Ireland. The Local Area Plan for the Cappagh region of Fingal includes a range of sustainable building requirements, with perhaps the most notable being that the annual space and water heating energy requirements for all buildings must now not exceed 50 kWh/m2, and that renewable energy must be used to meet at least 30% of these energy needs.

The Dún Laoghaire-Rathdown County Council have just recently altered their Local Action Plan and are to encourage more sustainable development through energy end use efficiency, increasing the use of renewable energy, and improved energy performance of all new building developments throughout the County. In meeting the CO_2 performance target, the development shall achieve a collective average reduction of at least 40% in energy consumption for space heating, cooling, water heating and lighting within the development, relative to the baseline of existing regulatory and design practice.

2.3 MARKET REGULATION

Currently there is no regulation of DH in Ireland. The Commission for Energy Regulation (CER), which was established in 1999 (as the Commission for Electricity Regulation and subsequently renamed in 2002 with regulation of the gas sector), does not have any specific measures in place that would restrict or encourage DH. Key elements of the CER’s remit are the protection of consumers’ rights to choice, security and value for money in the energy sector.

Regulation of the energy market in Ireland has taken place in response to market needs both here and in Europe. Presently, there is no DH market in Ireland per se and therefore the issue of regulation by the CER has not arisen. As a DH network is developed, it is likely that that certain minimum standards will be expected by the market both for individual consumers and by competitors within the sector. Whether regulation of DH networks by the CER is required remains to be seen, but as stated above, regulation may take place in response to specific issues or problems that require it.

The proposed DH network for Dublin has been conceived and developed in accordance with modern standards for DH in Europe. At the core of reference systems is the facility for individual user control, individual billing and a high standard of service in line with today’s consumer expectations.

2.4 DISTRICT HEATING IN IRELAND AND ABROAD

This section gives an overview of significant developments in Ireland to date and also provides an overview of the development of DH in Denmark and the UK.

In 27 European countries from Greece to Finland and from Portugal to Ukraine district heat is distributed to over 100 million customers, this is 23% of the entire population in these countries. DH is particularly widespread in Northern Europe but remains limited in Ireland.

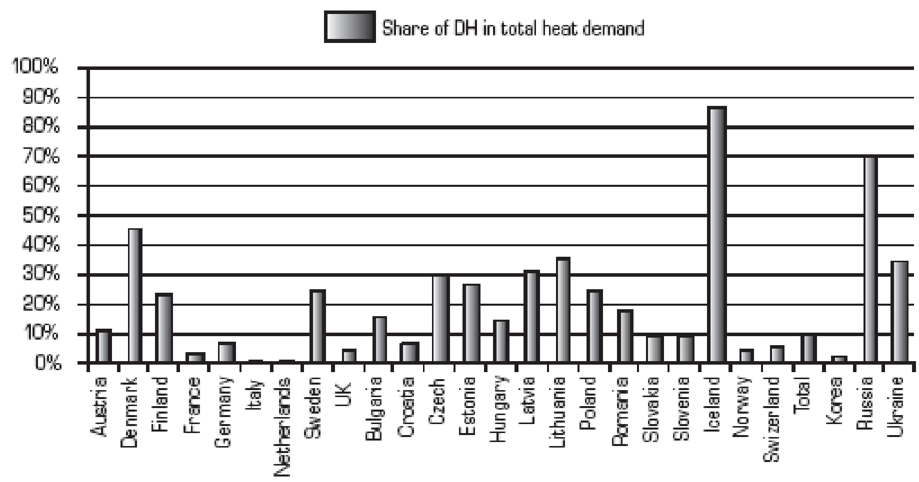


Figure 2.2: Share of District Heating in Total Heat Demand (Euroheat & Power, 2007)

2.4.1 District Heating In Ireland

The potential for DH in Ireland has been present for a long time. Though there is very little DH/CHP (installed thermal capacity = approx 43MW with almost 90% of this at one plant[1]), which poses an interesting institutional challenge. This arises because many stakeholders are involved in the development of a DH network and significant initial investments have to be made without the certainty of a large customer base and adequate energy planning.

The Ballymun Plant

This scheme served seven 13-storey tower blocks (a total of 2,820 flats) that were constructed in the early 1960s and had little or no thermal insulation. Heat was provided by 45 MW light fuel oil and gas boilers. As part of the Ballymun Regeneration Programme, the DH scheme is being decommissioned.

The system was supply orientated, which resulted in very high heat usage in the apartments because of poor temperature control. This was due to its low specifications, operation and

[1] Assessment of the Barriers and Opportunities Facing the Deployment of District Heating in Ireland, SEI (2002)

maintenance rather than a failing of the technology itself. The past performance of many DH plants in central and Eastern Europe was often similar. However, in the European plants, the metering and control problems have been successfully addressed in the various refurbishment projects that have been completed during recent years.

The failure of the DH system and it's consequent bad name and association with Social Housing significantly detracted from the image of DH over the past 20 years.

District Heating and Combined Heat and Power Generation Systems, Dublin and Cork, (ESB, 1982)

The ESB examined the feasibility of DH in the Dublin Area during 1981/1982, the DH alternative was compared to the gas alternative. The heat production from the power plants in the Dublin region was expected to reach 113 MW_{th} in 1991. Areas with a heat density of 120 TJ/yr km^2 were deemed suitable for DH. The barriers to developing a DH network identified at the time were Ireland's shorter and less severe heating season and the high proportion of one-off houses and low density development.

This report described a feasibility study for DH in Dublin and Cork and concluded that the schemes are technically possible and would be very advantageous to the Irish society, the utility and the individual. The report also concluded that DH depends on a co-ordinated approach to energy matters and geographical delineation of fuel preference. Whilst the outcome of this feasibility study did not ultimately result in the development of any DH capacity in the City its findings were positively disposed to DH. However, arguably, at that time, the relatively inexpensive fuel costs meant that there was no compelling reason to implement DH in Ireland. The current energy situation in Dublin differs from that of the early 80s in a number of important aspects which are highlighted further in Section 3.1.

Dublin City Council CHP / DH Scheme

The only current, commercial DH plant that is operating successfully in Ireland is that installed in the centre of Dublin. The plant serves the needs of the Civic Offices, and provides heat to three hotels, a hostel and both private and social housing. The CHP plant is owned and operated by Bord Gáis. The City Council has a five-year contract with Bord Gáis under which the gas price is fixed. The technical and economical data are presented in Table 2.1 below.

Table 2.1: Dublin City Council CHP / DH Scheme Technical and Economical Data

Technical Data	**CHP unit:** Gas fired Jensbacher Engine system generating 922 kW_e and 1132 kW_{th} **Efficiency:** 89.3%
Economic Data	**Capital Cost CHP:** €475,000 **Capital Cost DH network:** €1,450,000 **Financial Support:** €650,000

The hotels get about a 20% saving on the heat price compared to what they would have paid for space heating if they had used their own boilers. The domestic consumers benefit from 10% discount on heat price compared with gas. Social housing tenants have to pay for heat separately as an element of their rent.

Some issues were highlighted as areas for improvement in relation to the operation of the network: payment scheme, procurement of the meters, and responsibility for the installations.

Assessment of the Barriers and Opportunities Facing the Deployment of DH in Ireland, (SEI, 2002)

This high level study of DH in Ireland, followed a report published in 2001 entitled “An Examination of the Future Potential of CHP in Ireland”. It states that a DH network supplied from a heat only boiler is not normally cost-effective. The report identifies several barriers: mild Irish climate, improved insulation standards in modern buildings that limit the heat usage, low price differential between gas and electricity, high capital cost and uncertain consumer uptake. Despite the many barriers a CHP/DH scheme could be cost-effective if there is “free heat” from an appropriately sized and co-located power station, if it serves multi-family apartment blocks and if the customer extends beyond council house tenants. There is a good niche opportunity if the central plant can be fired with a renewable energy source, for example, by using a wood chip fired boiler, or a municipal waste incinerator.

Current District Heating Project in Development in Dublin

Currently, a number of localised DH or block heating networks are being developed across Dublin City with district. An overview of recent developments is presented in Table 2.2.

Table 2.2: District Heating Developments within the Dublin City Area

Development	Type of Development
Spencer Dock, Dublin 1	Mixed used development on a 52 acres site by Treasury Holdings including apartments, offices and conference centre. Gas boilers will serve the DH system until connection to the Dublin City Network.
Elm Park, Dublin 4:	Mixed used development by McNamara with apartments, healthcare, hotel and leisure, office, conference centre and crèche facilities. The DH system will be served by modular gas fired CHP unit and supplementary biomass boilers will help to meet the winter heat load.
New Street, Dublin 8	This is a recent development of 122 units in 3 apartment blocks, where a gas boiler provides space and water heating.
Heuston South Quarter, Dublin 8	Mixed used development by JJ Rhatigan of apartments, offices, hotel and conference centre. A biomass fired CHP unit will serve the DH system and, supplementary gas and oil boilers will help to meet the winter heat load.
The Point Village, Dublin 1	The Point Village will cover a 12 acre site and include a 23,000 square metre Shopping Centre, 13,000m2 of Offices, a 250 bed Hotel and a cinema. The development will have as its signature building "The Watchtower. This 120 metre tower will include 500 m2 of office space and luxury apartments.

2.4.2 District Heating in Denmark

DH, being a cornerstone of Danish Energy Policy, now supplies over 60% of the heated floor area in the country. Over 80% of this heat is generated from CHP. In addition to the cold and long winters, the reasons of the success of DH in Denmark are explained below.

Strong Support from National Authorities

Prior to 1979, there was no law regulating heat supply in Denmark. Most consumers had oil furnaces or other forms of heating. The oil crisies in 1973 / 74 and in 1979 resulted in the formulation of a definitive energy policy in Denmark. The energy policy strongly supported the development of DH through a wide range of measures combining strong regulation and controlled use of the market, including:

- National and urban least cost energy and heat planning,
- Monitoring of strict zoning of DH and other sources for heating,
- Encouragement of local authorities and utilities to implement cost effective projects,
- Implementation of legislative measures which enforce building owners to connect and remain connected to DH,
- A ban on electric heating in new buildings,
- Investment subsidies to utilities, that rehabilitate and complete DH networks and to consumers who install central heating and connect to DH.

Strong Support from Local Authorities

The role of Danish local authorities in the implementation of the national energy policy is very important, as the local authorities have a natural interest in developing a good local DH system for the benefits of its urban area dwellers. The DH network is regarded as a natural part of the urban infrastructure. Similarly, heat planning is an integral part of urban planning. Urban development areas are therefore provided with DH as well as water, sewage and other services.

Democratic Consumer Ownership

Almost all DH companies are owned by the consumers, either directly as consumer co-operatives or indirectly as municipally owned companies. Thus the consumers elect members for the board of directors directly or indirectly through public elections. This gives certain benefits:

- All company profit is given back to the consumers at the end of the year or is transferred to the next year to lower the heat price,
- Management will be encouraged to work for good consumer services at the lowest price possible,
- All budgets and prices are transparent for the consumers.

Efficient Financing

Most companies finance their investments in networks and CHP plants 100% by international credits at the lowest market based interest rate. Banks compete to offer the best conditions so long as they can see that the security is high. Security is high due to the following reasons:

- The national energy policy is stable.
- The municipality guarantees the loans.
- The consumers are obliged to remain connected and to pay at least the fixed tariffs.

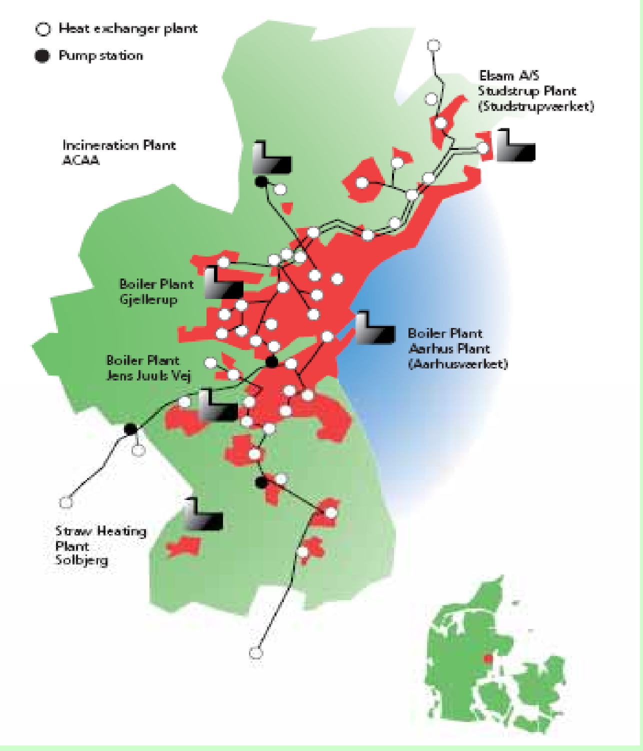
District Heating in Aarhus, Denmark

The DH system covers more than 275,000 of Aarhus 290,000 inhabitants. In addition the plants supply four neighbouring municipalities. The annual heat production in 2004 was 10,963 TJ. The primary production of heat is based on:

- Studstrup CHP plant, heat capacity 910 MW (Coal 92% + biomass 8%)
- WtE plant, heat capacity 60 MW
- Oil fired peak and reserve load boiler stations, total heat capacity 315 MW (Natural gas is not available within the municipality)

Furthermore a number of local heat production units are connected some of the secondary networks, e.g.:

- WtE plant, heat capacity 18 MW
- Several smaller oil and biomass fired boiler stations



The DH network consists of approx. 124 km primary network (125 deg. supply) and approx. 1700 km. secondary network (80 deg. supply). The distance from the power plant to the most remote consumers is approx. 50 km.

2.4.3 District Heating in the United Kingdom

DH in the UK, by contrast with Denmark, has had a turbulent history and its development although greater than in Ireland, has not been extensive.

The busiest period for DH in the UK was during the 1960s and early 1970s, when over 500 district and group (smaller scale) schemes were installed, primarily by local authorities on new housing estates, as part of the boom in council housing construction during that period. By the mid 1970s, over 400,000 users (most of them council house tenants) had DH. From this time the idea began to be incorporated into public policy and the idea of DH as being environmentally as well as socially beneficial emerged, and CHP began to feature more prominently in government policy.

The popularity of DH began to wane following the oil crisis of 1973 because many of the schemes were oil fired; this, combined with the decline in local authority housing construction in the late 1970s and throughout the 1980s, has meant that the hopes for rapid expansion of the original post war era networks have never materialised.

In 1990 the electricity supply industry was privatised and a period of restructuring followed. While this introduced further volatility into energy prices and hence greater risk for DH, a number of schemes went ahead, for examples in Sheffield, London City and Southampton. In this period, a number of subsidy programmes were introduced, such as the Energy Efficiency Demonstration and the Green House Programme, which supported a further nine DH schemes.

It is difficult to say accurately how many DH schemes there are today and how many homes are served, it is estimated that 200,000 homes are served, representing approximately 1 % of the UK housing stock.

District Heating in Sheffield, UK

Sheffield's district energy network is one of the largest in the UK. The complete network consumes 135,000 MWh annually. The DH network in Sheffield, was constructed gradually and now has over 120 customer connections. There are 43km of pipeline installed to deliver heat to buildings in Sheffield.

The production of heat is based on:

- WtE plant utilises 115,000 tonnes of waste to produce 36 MW_{th} of thermal energy and approximately 6.8 MW_e of electric energy.
- The network is supported by back-up facilities with 3 pre-heated stand-by/peaking boiler stations ready to come on line at a moments notice with 84.6 MW of capacity.

Its early development was based around the establishment of Sheffield Heat and Power in 1988. This company was financed by the Ekono company and Sheffield City Council in the ratio 51:49. British Gas were also involved. The involvement of the city council has been a major contributor to the success of the project as a number of large scale buildings such as the Park Hill Flats complex (over 1000 units) were connected at an early stage. In August 2001, Onyx took over the waste management contract from Sheffield City Council. Onyx is also responsible for maintaining and developing the successful DH network which serves homes and businesses across the city.

A reason for the success of the project is the fact that heat customers are actively sought. Onyx agreed that it is difficult to penetrate areas of the market where conventional heating systems are already used. However, by targeting new developments and buildings where heating equipment is due for replacement, the company can offer cost savings to customers who connect to the system. This will naturally depend on proximity to the network. Between 1990 and 2003, approximately £25M has been spent on the system. It is apparently a healthy business in its own right. Energy costs to consumers vary but a typical charge of 2.3p/kWh (2002 , including standing charges etc.) was quoted. Prices are indexed. A typical connection cost of £9,000 was quoted, with civil works accounting for 60% of this cost.

3 DUBLIN HEAT MARKET

3.1 OPPORTUNITY FOR DISTRICT HEATING IN DUBLIN

Recently in Ireland, and particularly in Dublin, the conditions have become more favourable for the development of a DH network. The factors creating this opportunity are explored below.

3.1.1 Dublin City Council District Heating Champion

As a key stakeholder in the City's development, Dublin City Council is in a unique position to promote and coordinate the development of a modern DH system. Discussions with developers, service providers and existing operators of DH Networks and CHP plant are currently underway. Dublin City Council's objective is to establish a new high quality energy utility that can take its place among and compete successfully with existing energy utilities while offering environmental, cost and other advantages to users as presented below.

3.1.2 Contribution to Sustainable Energy Supply

The following strategic goals identified in the "Government White Paper – Delivering A Sustainable Energy Future for Ireland", DCMNR, 2007 will contribute to create conditions favourable to DH:

- Addressing climate change by reducing energy related greenhouse gas emissions
- Delivering an integrated approach to the sustainable development and use of bio energy resources
- Maximising energy efficiency and energy savings across the economy
- Increase the security of energy supply, allowing for the diversity of fuels used to supply heat to DH network.

3.1.3 Inexpensive Source of Heat

Dublin City proposes to develop a waste to energy facility (WtE) at Poolbeg. The Environmental Impact Statement for this facility states that 60 MWe could be exported to the national grid. During waste combustion and power production heat will be generated as a by-product, which would have to be cooled down by releasing water in the Liffey Estuary.

In CHP mode this facility could become a source of inexpensive heat for the DH system. The heat to be supplied by the new WTE plant could be purchased at a price which reflects the production cost. This is explored further in section 6.2.5.

Similarly power plants in Poolbeg are generating heat as by-product, which requires cooling. These plants could also provide 'waste' heat energy to a DH network. This should be taken into consideration when these plants are upgraded and overhauled.

3.1.4 Extended Customer Base in Dublin

DH systems are particularly profitable where they served a wide range of customers. The extended customer base in Dublin will improve the economics of the DH system by providing a variety of commercial customers rather than social housing only schemes. It will also provide a more balanced heat load and level peak demand.

The key costumers to target for DH in Dublin are:

- Local authorities with responsibility for a range of public buildings (Dublin City Council's Civic Offices Woodquay, Marrowbone Lane) and some community and social housing (Saint Teresa's Garden, Fatima Mansions etc.)
- Other public buildings including Leinster House, Dublin Castle, the Modern Art Museum,
- Housing associations, high rise private buildings,
- Universities (Trinity College, DIT, etc..),
- Hospitals (Saint James, St Stevens, The Coombe, The Rotunda, The Mater, Holles Street, Temple Street etc..),
- Industrial heat consumers (Guinness Brewery),
- Hotels (Clarence, Jury's, Davenport, Alexander, The Merrion, Stephen's Green),
- Shopping Centres (Jervis, ILAC, Powerscourt),
- Areas of regeneration (Docklands, SoHo, Grangegorman)

3.1.5 Dublin City Council Development Plan's Recommendations

A central element of Dublin City Council's strategy for establishing a successful DH network is to secure new developments as they occur; in this way the benefits of the system can be maximised.

The current Dublin City Development Plan, 2005 – 2010 identifies 13 key Framework Development Areas shown in **Figure 3.1**. Five of these Framework Plan Areas are very large, each with over 500,000 m2 of new-build residential / commercial development.

These five large schemes together make up about three million square metre of new developments offer significant potential for DH.

Table 3.1: Proposed Framework Plan Areas (in square metres)

Area	Residential	Commercial
Poolbeg	370,000	130,000
Heuston	153,000	352,000
Grangegorman	120,000	274,000
Parkwest	125,000	300,000
North Fringe	952,000	143,000
Total	**1,720,000**	**1,199,000**

Figure 3.1: Dublin Framework Plan Areas (Source Dublin City Development Plan)

The Dublin City Council's report – "Building Height in Dublin: A strategy for Managing Intensification and Change", 2000 – identified the area around Heuston Station and the Docklands area as having the potential to absorb higher buildings. Dublin City Council is currently working on formulating a strategic policy on height that would allow variations to the Dublin City Council Development Plan.

A recent publication on the future development of Dublin Port entitled – "A Report on Dublin Bay – An Integrated Economic, Cultural and Social Vision for Sustainable Development", 2007 – outlines a proposal to relocate the existing Dublin Port and develop this 260 hectare area to accommodate up to 55,000 domestic and commercial residents. This high density proposal is targeted for 2050 living with construction over 25 years, encompassing the growing demand for city centre housing and projected greater shipping needs.

The Dublin Dockland Development Authority is currently preparing a Planning Scheme for over 100 acres in the Poolbeg Peninsula, which is currently characterised by utility and amenity uses. It is planned to develop the area in a way that delivers sustainable mixed use development, while at the same time preserving the natural heritage and developing amenities. It is likely that when approved this Planning Scheme will result in the significant regeneration and redevelopment of this area.

Large new developments are taking place at various locations around the City. In particular several major projects located in the Docklands (U2 Tower, The Point Village, Spencer Dock) and Heuston (Heuston Gate, Heuston North, and Heuston South) are currently in planning or under construction.

The close proximity to the Poolbeg Waste to Energy plant and high density of these proposed developments making them ideal for district heating connection.

3.1.6 Increase in Density of Developments in Dublin

DH becomes a real possibility if there are regeneration or new-build developments in a densely populated area. Heat demand intensity, which is a key criteria for the success of DH schemes, is driven by long-term planning and change in the housing stock.

Dublin City Council is the local authority with the highest density of population in Ireland. A map of the population density per electoral division based on data from the Census 2002 is shown in **Figure 3.2**. High population density already exists in the following electoral divisions:

- Merchants Quay,
- Wood Quay,
- Usher's Quay,
- Arran Quay,
- Rotunda,
- Mountjoy,
- North Docks,
- Royal Exchange.

In 2006, a new census took place; results for Dublin City show an increase in flat/apartments of 28% when compared with data from 1996 Census.

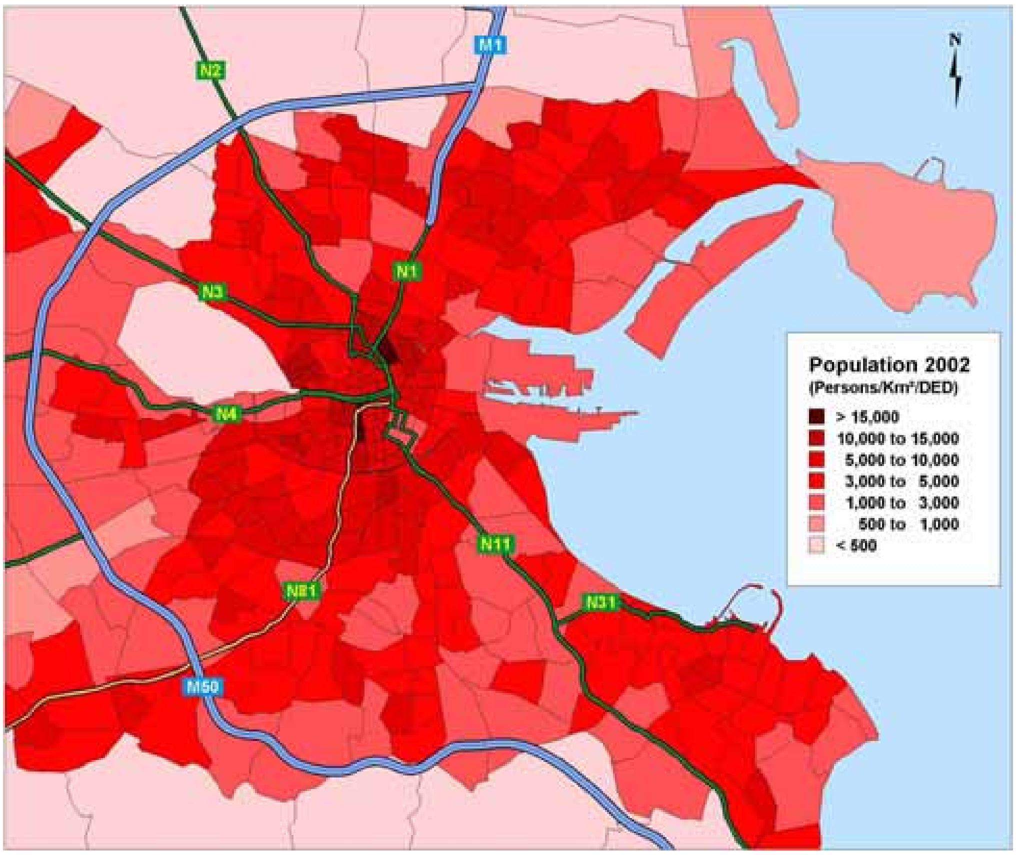


Figure 3.2: Population Density per Electoral Division in the Dublin Region

3.1.7 Renewed Interests from Developers

A further development, which has increased the interest of developers in DH is the implementation of the EPBD and the publication of the updated Part L Building Regulations. According to the Directive, the positive influence of DH and CHP will be taken into account in the calculations of energy performance of buildings. The certificates that will arise from such performance calculations are expected to have an influence on the value of the buildings.

Compliance with Part L requires new developments to be designed with a certain level of sustainability. These Regulations are likely to increase the interest of developers in district heating to provide space and water heating for new developments.

CODEMA assessed how DH will affect the Building Energy Rating of an apartment block using different heating sources. The following section highlights the potential environmental and economical benefits that developers and homeowners will acquire with the construction of a DH network for Dublin.

The Impact of District Heat on Building Energy Ratings[2]

Introduction

This section deals with the impact of District Heating on the Building Energy Rating (BER) for dwellings, particularly apartments. In the period of 1997 to 2006, 80% of new dwellings constructed in Dublin City were apartments. Codema has calculated the BER for 10 apartment schemes both in the public and private sectors.

The results of the BER energy assessment of the apartment blocks show that while they all comply with the Building Regulations TGD Part L 2005 there is a surprisingly large variation in the BER ratings, due in large part, to the effect of the heating system on the rating.

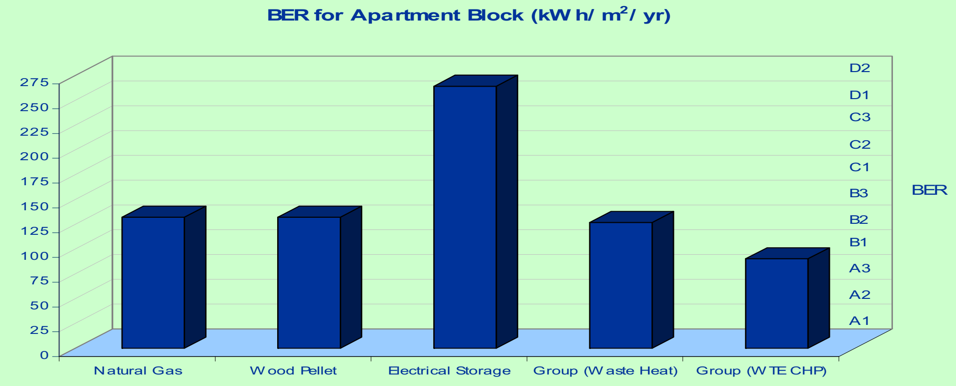
Description of Apartment

It is a four storey building with a basement car park and has an east/west alignment. There are 100 apartments, 20 of which are penthouse apartments and the average floor area is 66.4 m^2. The building was designed as an all electric building with electrical storage heating providing space heating and immersion heaters for domestic hot water.

Results & Discussion

The following analysis shows a comparison between five different heating options and the corresponding Building Energy Rating (BER) for each option. The vertical axis on the left shows the average primary energy consumption in kilo watt hours per meter squared per year (kWh/m^2/yr). The right hand vertical axis shows the corresponding BER category on the A to G scale.

In this analysis, a block of new apartments currently under construction in Dublin and which is representative of current private sector developments in Dublin, has been assessed using the official Dwelling Energy Assessment Procedure (DEAP) methodology. The BER is assessed for individual apartments and the overall average BER (per square meter) for the block was calculated



- The apartments under construction are designed to use electrical storage heating as is common for such developments in Dublin. Apartments with electrical storage heating will have typically D1 rating
- The District Heating system has the potential to recover waste heat from the electricity generation process provided that the station is operated in CHP (combined heat and power) mode. This has the effect of improving the BER rating from D1 to B2 without any change to the fabric or insulation of the building
- By using Waste to Energy (WTE) in CHP mode the energy rating, as assessed by the official DEAP methodology, is B1 for the apartment block analysed.

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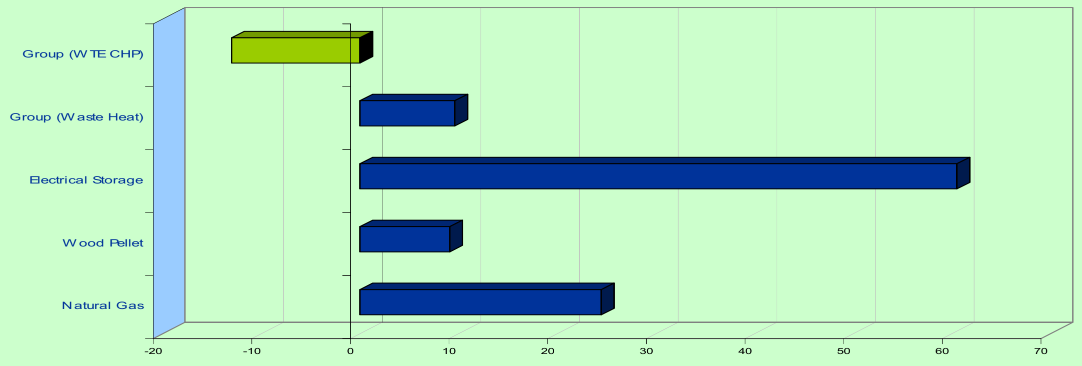
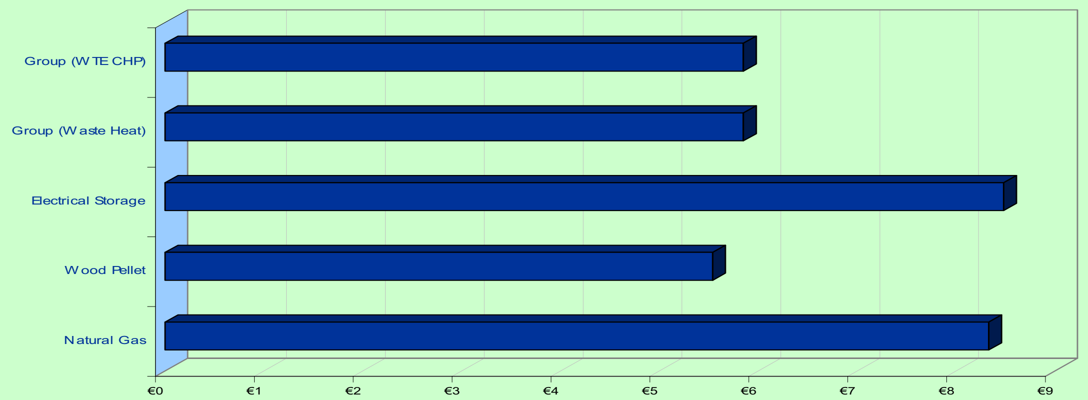
[2] Source CODEMA



- District Heating (WTE/CHP) is the only heating system, of the five considered, that contributes positively to climate change through negative CO_2 emissions. This apparently strange result arises from the fact that the electricity which is produced in the cogeneration process is displacing electrical consumption which would otherwise derive from fossil fuel. The composition of the electrical mix in Ireland is largely from fossil fuels (coal, oil, natural gas) giving a relatively high CO_2 emissions rate of 0.64 kgCO_2/kWh (reducing annually due to the more efficient combined cycle natural gas generation and increased penetration of wind power).



- The DEAP calculation also produces a cost estimate, based on standardised costs produced by SEI, which gives a good general comparison between the different systems considered

- The economic model of Chapter 5 in “District Heating for Dublin - Feasibility Study”, RPS & COWI, develops an overall philosophy with the aim of offering a total annual District Heat cost to the consumers which is 10% cheaper compared with individual natural gas boilers.

Conclusion

1. The impact of District Heating on building energy rating of new Dublin apartments is significant and will be positive. Depending on the source of heat for the District Heating system the building energy rating can improve by up to 68% by comparison with the current design. The best district heating system, of those considered, from the BER perspective, is Group (WTE CHP) with a B1 rating (80 kWh/m^2/yr).

2. The impact of District Heating on CO_2 emissions related to new Dublin apartments is also significant and positive. The best District Heating system, of those considered, from the CO_2 emissions perspective, is Group (WTE CHP) where there is a net minus of 13 kg/m^2 CO_2 due to displacing electricity which would otherwise be generated from fossil fuel. This compares with natural gas individual boilers, emitting 24.5 kg/m^2/yr or electrical heating emitting 60.5 kg/m^2/yr.

3.2 AREA UNDER STUDY / HEAT LOAD

3.2.1 Methodology

A key objective of the study has been to identify large new build developments, which are most suited to the implementation of DH in the City (new developments can be designed for DH from the inception, reducing cost of future connections) and accommodate heat suppliers that could be connected to a DH network. The following approach was taken:

- RPS reviewed the Dublin City Development Plan, 2005 – 2010, the Dublin Docklands Master Plan (2003) and the Framework Area Plans.
- RPS met with Dublin City Planners (North and South) to learn of forthcoming plans and developments in the Dublin Region.
- Recent planning applications were reviewed in order to identify future potential developments suitable to DH.
- RPS also contacted developers, energy management companies, potential existing customers and potential heat sources to determine heat consumptions and heat supply. A list of organisation contacted is provided in **Appendix A**.

For each of the new developments information was obtained about:

- Size of development (m^2) or Estimated heat demand (MW) or consumption (MWh)
- Development type (residential, commercial, etc.)

Where no information on heat demand or consumption was available, they were calculated from the size of development (m^2) using Table 3.2.

Table 3.2: Average Heat Demand for each Development Type

Development Type	Average Heat Demand (kWh/m^2/yr)
Residential	70
Office	95
Hotel	200
Educational	150
Recreational	350
Institutional	200

Source: Heat demand calculations for the Spencer Dock Development (MacArdle McSweeney Associates)

A map of the proposed target areas shown below in **Figure 3.3** was prepared with the main focus being the Dublin Docklands Area and Westgate, where potential heat sources are or may be available in the near future. Other areas have been identified as future target areas (e.g. Grangegorman redevelopment, Elm Park) have not been included in the current report due to their distance from the initial study areas and their far proximity to heat sources, however it is envisaged that these areas will receive their heat from DH. A map of existing potential heat sources was also prepared and is shown in **Figure 3.4**.

Figure 3.3: Areas Suitable for District Heating in this Study

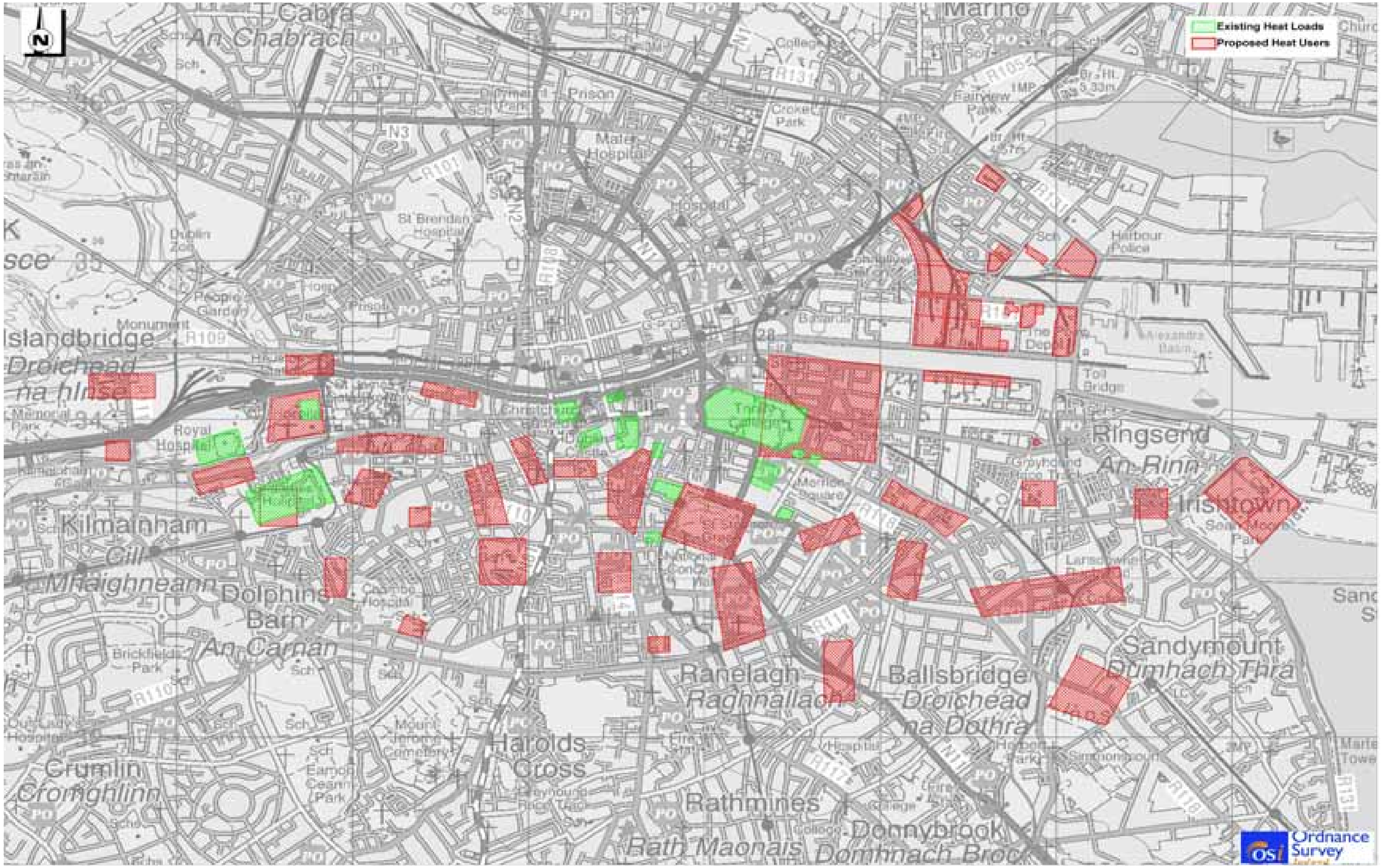


Figure 3.4: Potential Heat Sources in Dublin City

3.2.2 Scenario Selection

Three alternative scenarios for the development of a DH scheme in Dublin are examined.

Dublin Docklands Network (Scenario 1)

The study area in Scenario 1 was chosen due to the fact that the Dublin Docklands Area is close to the initial primary source of DH energy and that it will be mainly high density, mixed use, new build development – this is highly suited to DH development. Presently this area is experiencing intensive urban development and renewal.

The Dublin Docklands Development Authority is undertaking a massive programme of social, economic and physical regeneration in the area. The regeneration and growth of the docklands area will continue for at least another decade. The development is based on a Master Plan launched in 1997 and subsequently updated in 2003. The 15-year project will result in the population of the Docklands increasing by 25,000 to 42,500 by the year 2012 and the construction of more than 11,000 new homes. It will also create up to 40,000 new jobs. This scale of development and the increase in population density provides DH with a large potential heat market and the necessary heat market for the initial phase of a citywide utility. The concentrated nature of this area of new development and its proximity to the proposed WTE facility at Poolbeg make it ideal as an initial development area.

The largest development in the study area (Spencer Dock) is currently being designed to incorporate DH specifications and will be a showcase for this utility in Dublin. It is expected that DH can be propagated further from this foothold and eventually connected with other future DH compatible developments in Dublin. As the development is now under construction, the initial customer connections and a partial network are being installed in the first quarter of 2008 to prepare for the future supply.

Westgate Network (Scenario 2)

Westgate is located in the Heuston Station – St. James' Gate area West of the Docklands area and would see the propagation of the DH network into the western edge of the city centre. There are a number of factors, which make this a target area. Presently this area is experiencing intensive urban development and renewal (part of the 'SoHo' development plan). St. James' Hospital operates its own on-site CHP plant which supplies the hospital's centralised heating system. There is also a large gas fired CHP facility located in the Guinness brewery at St. James' Gate. Both these facilities could potentially provide heat to a DH network. They could both also benefit from having the security of supply that would come from being connected to a wider heating network as opposed to their own supply.

Citywide Network: Connection of Scenario 1 & 2 (Scenario 3)

Scenario 3 will see DH propagated further from Spencer Dock and Westgate and eventually connecting with other future DH compatible developments in Dublin. The development of a network to connect these DH areas will create the demand for and enable the utilisation of alternative existing and future sources of heat in the City (e.g. power stations, Combined Heat and Power (CHP) plants, surplus / waste industrial heat) with considerable environmental and cost advantages.

The initial foothold development will be followed by the development of a 'spine' following the Liffey allowing the incorporation of the Civic Offices, St. James' Hospital and the Guinness Brewery and supply to significant developments in the Heuston Station Area.

3.3 HEAT SOURCES IN DUBLIN

3.3.1 Proposed Waste-to-Energy Facility for Dublin

A thermal waste treatment plant has been proposed for Dublin. It will be one element of the Dublin Waste Management Plan 2005 -2010. In this study, we are assuming that the plant will be completed to programme in 2012. The planned location for the facility is on the Poolbeg peninsula. The plant will most likely use combustion / incineration technology and will be designed to meet the requirements of the European Council Directive on the Incineration of Waste (2000/76/EC).

An Bord Pleanala issued a decision to grant permission for the thermal waste treatment facility on the 14th of November 2007, with a condition that the detailed design of the facility made provision for the development of a district heating system. It also required that within 12 months of the date of this order Dublin City Council shall carry out and publish the results of a feasibility study into the future development of a district heating system to avail of excess heat from the proposed facility and any other waste heat in the Poolbeg Peninsula Area.

On the 22nd of November 2007, the EPA issued a Proposed Decision (PD) for the thermal treatment facility with a condition that, prior to operation, proposals for operation of the facility in Combined Heat and Power mode be made to the agency with a view to providing heat for a district heating scheme.

The recently published National Climate Change Strategy 2007-2012 states: “In the current process of revising the Waste Framework Directive (2006/12/EC), the European Commission is considering mechanisms, which would encourage waste to energy plants to increase efficiency to a level comparable to conventional power plants, thereby allowing the energy within the waste to be transformed into electricity and heat for beneficial use in accordance with Best Available Techniques. The government supports this approach, in the context of the waste hierarchy, which will minimise climate impacts through the sustainable management of waste”.

By supplying heat to DH, the energy recovery rates at the WTE plant could potentially increase to 80-85%, which would be superior to the traditional power plants (30-40%) and even superior to the more efficient Combined Cycle Gas Turbine (55%).

Further, given that the primary source of the heat energy produced will be waste, it would reduce Dublin City’s reliance on imported fuel.

The Environmental Impact Statement for the facility shows that the facility will be designed with two identical lines, each with a capacity of 35 tonnes per hour at a lower calorific value of 10.5 GJ/tonne, equivalent to an annual capacity of 600,000 tonnes per annum.

The burning of waste in the furnace will produce hot gases. The energy in these hot gases will be recovered by passing the gases through a boiler, which will generate steam. The boiler will have a thermal conversion efficiency of at least 90%. It will operate with steam temperature of approximately 400ºC and a pressure of circa 45 bar.

The steam will be expanded across a turbine, which will drive a generator to produce electricity for supply to the national grid. The potential electrical power output of the facility is expected to be up to 60 MW_{elec}. The steam leaving the turbine will then be returned to the boiler feed water via a condenser. The condensate will then be returned to the boiler feed water system.

The design of the turbine will allow for production of heat to a future DH network. In CHP mode, it will be possible to supply 43MW_{elec} of electricity while also supplying a maximum of 150MW_{th} of useful heat.

3.3.2 Dublin Docklands Peak / Reserve Load Boiler Station

The initial phase of development for the DH network in Scenario 1 and 3 will see the construction of a gas fired boiler station located within the Docklands Area with a boiler capacity of 45MW. This boiler station is planned to supply all heat needed during the DH system's first phase of development, i.e. before the proposed waste-to-energy plant is operational. Once the waste-to energy plant is operational, the boiler station will serve as a peak load unit, as well as providing reserve capacity for the future DH system in Dublin.

A suggested location for the boiler station is at the existing pumping station on Pigeon House road, Ringsend. However other potential locations are also under investigation.

3.3.3 Gatepower CHP Facility

In November 1997, Gatepower Ltd. commenced commercial operation of a 14.4 MW gas fired CHP station located at the Guinness Brewery, St. James' Gate, Dublin. The CHP plant is situated outdoors within the brewery site, and incorporates three SOLAR Taurus 60 gas turbines, rated at, 4.8 MW each, along with three 27 tonnes/hr steam boilers. The system is built to operate on either natural gas or diesel fuel, and also includes a standby 27 t/hr boiler and a blackstart generator. In 2003, the plant completed major 5-year overhaul works, during which the gas turbines were replaced with the more advanced model 7301 of the Taurus 60 gas turbine.

Gatepower provides 100% of the Guinness electricity and steam demands, and exports approximately 40% of generated electricity to the national grid. The system is designed to maintain electricity and steam supplies to the site 365 days per year, and can ride through electrical grid outages and any gas fuel supply interruptions.

3.3.4 Small-scale Boilers and CHP

Individual gas boilers supply the majority of built environment heat demand within Dublin City, it is only just in the recent past that developers and policy makers have begun considering the potential of block heating provided by micro CHP.

A number of areas within Dublin have experienced extensive redevelopment throughout the last number of years. The majority of these have been multi storey mixed-use developments, with residential and retail incorporated into the same building. This has lead to a number of developers installing centralised boiler or micro CHP units to provide the heating for the building. There are also about 20 CHP facilities of < 1MW_{th} mainly found in hotels and hospitals.

3.3.5 Poolbeg Power Stations

Poolbeg Generating Station is a power station owned and operated by the ESB. It consists of six units with a total installed capacity of 1020 MW. The plant is located on the Poolbeg peninsula. There are two stations on the site, the older conventional thermal station containing units 1, 2, and 3 and the combined cycle gas station containing units CG14, CG15 and ST16, which is located toward the eastern end of the site.

The identical units 1 and 2 have a design output of 120 MW each. Unit 3 has a design output of 271 MW. All three units in the thermal plant have a plant efficiency of 38% and can currently fire on oil or gas. Gas is supplied to the site by the Bord Gais network. Oil is stored in five tank in the site's oil farm, with a maximum capacity of 140,000 tonnes. The combined cycle gas turbine (CCGT) plant consists of two identical gas turbines producing 155MWe each and a steam turbine producing 271MWe. The CCGT has a plant efficiency of 52%.

ESB did examine the feasibility of DH in the Dublin Area during 1981/1982. This was based on the electricity generation plants at Poolbeg and North Wall and a study area comprising the O’Connell Street, Trinity College, St.Stephen’s Green areas and parts of Ballsbridge.

While the outcome of this feasibility study did not ultimately result in the development of any DH capacity in the City at that time, its findings were positively disposed to DH. ESB proposed that they would be able to supply 113 MW of thermal energy to a DH network, this figure could be viewed as conservative with the increased power capacity of the Poolbeg generating plant.

Synergen operate a 400 MW combined cycle gas-powered generation plant located at Pigeon House Road, Ringsend, Dublin, which came into commercial production in August 2002.

The plant is a single shaft combined cycle unit equipped with a gas turbine, steam turbine, heat recovery steam boiler and electrical generator. This process is very efficient and is designed that all components of the process are interlinked and that all possible waste heat is utilised.

If a DH market was created both Synergen and ESB could become major heat suppliers. The feasibility of connecting the power stations was examined and the findings are highlighted below:

- Connecting the plants to the district heating network would require the plant to be converted to Combined Heat and Power mode. It would not only make use of the thermal energy produced during electricity production and increase the plant efficiency, but it would significantly reduce the volume of water required from the River Liffey in the cooling process and the utilities that go with it such as pumps, fine screens, condenser tubes, scouring and chlorination. It would also reduce the carbon intensity of the energy generated, as the use of the waste heat would increase the total energy output without increasing the greenhouse gas emissions from combustion.

- ESB has approved the closure of the three thermal units plant by 2010, however, the combined cycle gas plant, which opened in 2000, will remain in operation. Currently there are plans to retrofit the ESB plant at Poolbeg in 2010 and after 2015.However the ESB will need to carry out its own detailed feasibility study.

- The Synergen plant is currently optimised for electricity production. Overhaul of the Synergen plant is planned for 2017. During overhaul if the market / regulatory conditions are favourable it would be possible to connect the plant to the district heating system.

- It is likely that once the proposed district heating network is developed by Dublin City Council, it will provide opportunities for these heat suppliers to connect. The feasibility of connecting these power stations should be examined at that time and when more detailed information is available from these potential heat suppliers about their future plans.

3.4 STAKEHOLDERS AND MANAGEMENT OPTIONS

There will be three principal stakeholders involved in the Dublin District Heating System.

Local Authority

A key role in the development of DH systems will be played by DCC. DCC will be responsible for:

- Providing an organisational framework,
- Financing network development and expansion,
- Selling heat from the WTE,
- Facilitating the network development through planning,
- Price regulation and representing the interests of individual heat consumers.

By its involvement in local energy planning, DCC will optimise energy supply costs to the end users.

DH Company / Energy Services Company (ESCO)

DH Companies or ESCO can be divided into the following groups:

- ‘Heat generators’: DH companies operating heating plant (CHP or Heat-only-Boiler plants) and selling heat to the DH network company,
- ‘Heat distributors’: DH companies purchasing heat from ‘heat generators’, operating DH networks (or DH networks and substations) and selling heat to customers,
- ‘Heat generators and distributors’: DH companies operating heat sources and DH networks (or DH networks and substations) and selling heat to customers.

Access to finance is a significant barrier for investment in DH. The concept of the Energy Services Company (ESCO) is an important one for financing energy efficiency and renewable energy projects. It could be a major factor in DH refurbishment and development, ensuring that the most suitable technical solutions are backed up with the necessary financial resources to implement the projects successfully.

Customer

The customer will typically sign a contract with a DH company to purchase heat. The contract should be signed by each owner (of one or more buildings e.g. housing cooperative), house-owner association, company or other customer (but not necessarily by every individual apartment owner). The rights of the customer to receive heat at sufficient quality and at a reasonable price will be stipulated in the contract. The quality of heating services will be defined by means of the following parameters:

- Availability: how many hours a year will heat be available /unavailable for the customer?
- Supply temperature levels: what is the minimum supply temperature at the consumer substation received from the DH network as a function of the outdoor temperature?
- Pressure difference: What is the minimum (and maximum) pressure difference in the network connection available for the consumer substation?

DH Management Options

There are four major alternatives of ownership models for DH utilities, which have been identified:

- Full public control by the state or municipality,
- Full private control,
- Mixed ownership and management – public and private (considered to be most appropriate to Dublin),
- Not-for-profit community-owned cooperatives.

In the Dublin District Heating model, DCC will enter an agreement with an ESCO, which will be responsible for running the business including, for example, investing in maintaining and developing the fixed assets as well as billing. However DCC will retain ownership of the fixed assets of the DH. The contract will stipulate:

- Rules of tariff based on changes in major cost elements, which are mainly fuel prices,
- The value of fixed assets and depreciation rules,
- Information required from the energy company on billing and ongoing performance,
- Governing bodies, their tasks and responsibilities, representative of each party.

The benefits of this option, compared with selling the assets, are that DCC remains the ultimate owner. At the end of the contract, DCC may either take the business back, appoint another company to run the business or continue with a renewed contract with the former ESCO.

At the end of the contract period, the contract can be either renewed or discontinued. In case of discontinuation, DCC will pay for the increased value of the fixed assets to the investor.

An overview of their interaction is presented in **Figure 3.5**.

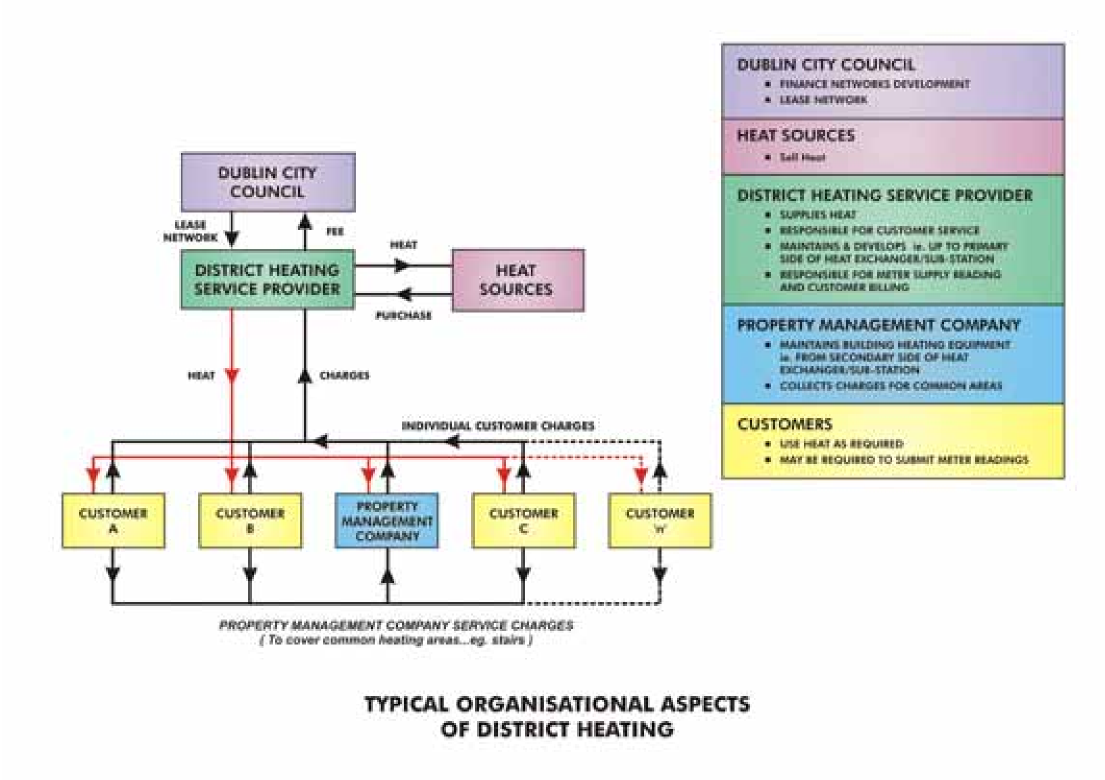


Figure 3.5: Dublin District Heating Typical Organisational Aspects

4 PLANS FOR DUBLIN DISTRICT HEATING SYSTEM

4.1 TECHNICAL ASPECTS OF THE DISTRICT HEATING SYSTEMS

During the first phases, a supply temperature from the production units of 85-90°C will be used for the winter months. During summertime, a lower temperature of no less than 70°C will be used.

The DH system will, however, be designed to accommodate an increase in the supply temperature to 120°C at a later stage. This will increase the transmission capacity and will increase flexibility when establishing connections to older existing buildings, hospitals etc. where boiler equipment and radiators were designed for higher operating temperatures.

The network will be established using pre-insulated DH pipes according to the EN 253 specification. Design temperature will be 120°C and design pressure will be 16 bar, with a hydrostatic test pressure of 25 bar.

The DH network has been dimensioned via hydraulic model calculations according to the estimated maximum heat load for the 3 scenarios. When dimensioning the network a "simultaneous load factor" (a coincidence factor) is applied to find the real maximum heat demand to be supplied via the DH scheme. By experience - and quite conservatively - a factor of 70% has been used.

When dimensioning the network, other conservative assumptions have been made:

- The total Annual Heat Demand (MWh) has been collected for the assumed consumers. Based on this, the maximum heat load (MW) has been calculated using Irish average figures, taking the new building regulations into account for new buildings. This calculation gives a 20 - 30 % higher heat load than it would have been the case for e.g. Scandinavian DH schemes, after taking the different climatic conditions into account.

- The entire system is to be designed for a future increase in the supply temperature, while maintaining the return temperature. This gives a potential for a considerable future expansion of the DH scheme, without having to install larger transmission pipes.

All main buildings or groups of individual buildings will be connected to the DH by a heat exchanger provided by the DH company, in order to separate the distribution system from the house installations. During the further development of the DH system to serve older existing buildings, such heat exchanger stations can also serve local housing areas etc.

In the present study, the heat consumers considered are all large-scale developments, where a main heat exchanger is expected to be installed in each development.

4.2 SCENARIO 1: DUBLIN DOCKLANDS DH NETWORKS

4.2.1 Project Development

The planned development of the Dublin DH system in Scenario 1 will be carried out on a phased basis. These phases are described briefly below:

- **Phase 1 (2007 / 2008**) - Establishment of a local DH network at Spencer Dock to enable connection to the DH system once this is put into operation. This local network is being constructed in parallel with the development to reduce construction costs and to minimise later excavation.

- **Phase 2 (2009/2010)** - Establishment of a gas fired boiler station at Ringsend, followed by the establishment of a DH transmission line from the boiler station, via a new tunnel crossing River Liffey near East Link Bridge and connecting to Spencer Dock and other new developments in the northern parts of the Dockland area.

- **Phase 3 (2010)** - Commissioning of heat supply to all connected buildings from the new boiler station. The existing boiler rooms are converted into heat exchanger rooms, while some of the boiler installations are maintained as reserve load units, as needed. Continued expansion of the network to serve new developments in the Docklands area.

- **Phase 4 (2010)** - Continued expansion of network to serve new developments in the Docklands area

- **Phase 5 (2012)** - Start of heat supply from the WTE plant by June 2012. From this time the WTE plant will serve as the base load unit supplying approx. 98% of the heat energy required over the year. The operation of the boiler station will be reduced, as it will now act as a peak-load and reserve unit only. Continued expansion of network to serve new developments in the Docklands area

4.2.2 Heat Demand

In Scenario 1 a total area of 836,000 m^2 will be connected to the DH network. The connections are assumed to take place from year 2008 till 2012 with a corresponding growth in heat demand as shown in **Figure 4.1**. The network consumes 111,000MWh annually and is shown in **Appendix B1**.

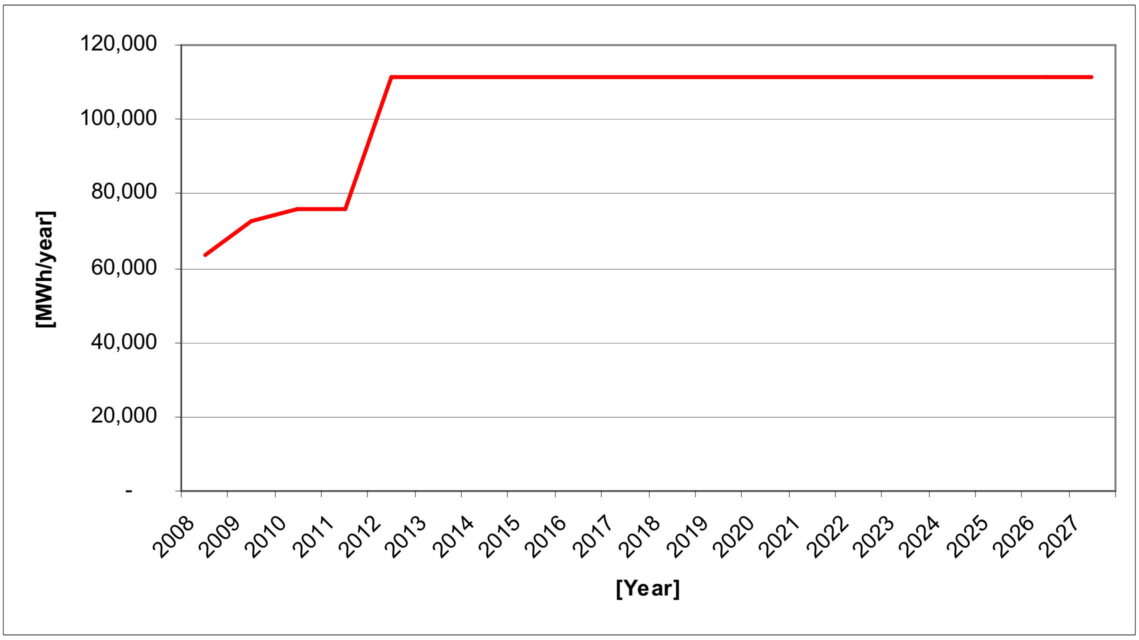


Figure 4.1: Heat demand - Scenario 1

4.2.3 Heat Sources

In Scenario 1 the following heat sources will cover the heat demand:

- **Waste to Energy plant (WtE)** at Poolbeg - Heat recovery at the WtE is assumed to be established with a heat production capacity of 90 MW_{th} including all necessary auxiliary equipment (water treatment, pressure holding, pumps, etc.).

- **A central boiler station** located in the Dockland area will serve as peak and reserve capacity with a capacity of 45 MW_{th}. The boiler station will be constructed in the initial phase of development for the DH network. This boiler station is planned to supply all heat needed during the DH system's first period, i.e. before the waste-to-energy plant is operational. Once the waste-to energy plant is operational it will serve as a peak load unit, and will provide sufficient reserve capacity for the future DH system in Dublin.

- **Boiler stations** at Spencer Dock will serve as peak- and reserve capacity. The boiler stations at Spencer Dock will be connected to the DH system with a total generation capacity of approximately 20 MW. **Appendix B1** indicates the location of the above mentioned heat sources.

- Maximum heat demand in the network relating to Scenario 1 has been estimated on the basis of a total maximum heat demand of approximately 79 MW and a simultaneous load factor of 70%, which gives a maximum heat production demand of approximately 55 MW excluding heat loss in the network.

4.2.4 Transmission line routing and Distribution Network

The DH system serving the Dublin North Dock area, Fabrizia and the Irish Glass Bottle sites is shown on the layout plan in **Appendix B1** and **B2**.

The main transmission line will be established as a DN 600 mm double pipeline from the WTE plant via South Bank Rd., passing the planned boiler station at Ringsend and continuing along Pigeon House Rd. to the East Link Bridge. From this point it will pass through the Liffey tunnel to the North Quay Wall and continue to Spencer Dock and the remaining parts of the Dockland North area.

The DH network can be summarised as follows:

- Length of main pipes - 6.6 km (DN 600 mm - DN 100 mm)
- Length of minor pipes - 1.2 km (≤ DN 80 mm)

The main DN 600 mm transmission line from the WTE plant in the Poolbeg area is designed to carry a normal heat production of approx. 90 MW_{th} at a flow of 2 m/s and a peak capacity of approx. 135 MW_{th} at a flow of 3 m/s from the WTE plant. Further it has a potential to increase heat capacity by lifting the supply temperature to a maximum of 120°C from the WTE plant at a later stage.

4.2.5 Pumping Stations

It has been assumed that a pumping station is established in connection with the central 45 MW boiler station to be established at Ringsend in 2008/2009. Once the WtE plant is operational, the main pumps will be located at the WtE plant, while the pumps at the boiler station will only to be used when the gas boilers are in use.

4.3 SCENARIO 2: WESTGATE DH NETWORK

4.3.1 Project Development

In this scenario the feasibility of a smaller independent DH system in Westgate is evaluated, assuming that the system operates independently from the major CHP sources in the city. In this scenario among others St Patrick Hospital, St James Hospital, Modern Art Museum and Heuston Square are supplied. Heat supply is based on excess heat from Gatepower at Guinness Breweries with peak and reserve boilers at St. James Hospital and Heuston South Quarter.

4.3.2 Heat Demand

In Scenario 2 the network would consume 107,000 MWh annually and is shown in **Appendix C1**. The connections are assumed to take place from year 2010 till 2020 with a corresponding growth in heat demand as shown in **Figure 4.2**.

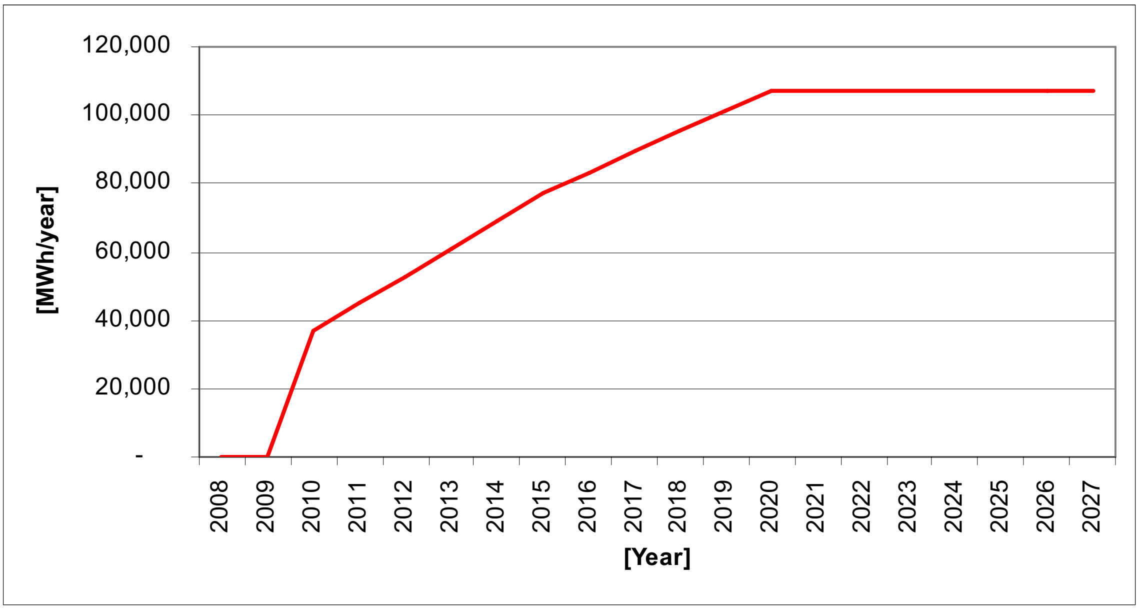


Figure 4.2: Heat demand - Scenario 2

4.3.3 Heat Sources

The heat demand in Scenario 2 will be covered by excess heat from Gatepower/Guinness as base load and with gas fired boiler stations as peak-load and reserve capacity. **Appendix C1** indicates the location of the above mentioned heat sources.

Biomass has also been considered as an alternative to either Gatepower or the gas fired boiler station, but based on the informed fuel price for biomass (150 €/tonne waste wood) equal to 30 €/MWh this option has been eliminated. A biomass-fuelled system with associated high capital investment would not be as attractive compared to natural gas with a fuel price of 36.4 €/MWh, which only leaves a small saving in fuel cost for paying back the additional investment. Additional operational and maintenance costs are also considered in this decision-making process.

The following heat sources are assumed to cover the heat demand:

- **Gatepower CHP** has a total plant capacity of 60 MW_{th} with approximately 20 MW_{th} required by Guinness for the brewing process. For this study we conservatively assumed that there will be 30 MW_{th} available for a DH network. Depending on the basic demand of the factory itself, heat supplied to the DH network will be a combination of excess capacity supplied by the Gatepower CHP plant and additional input from a back- up boiler. The calculation of CO_2 emissions in this case has been based on the conservative assumption that all heat for the DH network in Westgate is produced on gas fired boilers.
- **St. James Hospital Energy Centre gas fired peak and reserve boiler station** with a capacity of 25 MW.
- **Heuston South Quarter gas fired peak and reserve boiler station** is established with a capacity of 30 MW

4.3.4 Transmission line routing and Distribution Network

The DH system serving the Westgate area is shown on the layout plan, inserted as **Appendix C1** and **C2**. The network is designed with a main line of DN 400 ready in the future to be connected to a transmission line coming from the WtE and Ringsend. The DH system is also designed to be served by heat sources at Westgate: Gatepower, St. James Hospital and Heuston South Quarter.

The DH network can be summarised as follows:

- Length of main pipes - 4.1 km (DN 600 mm - DN 100 mm)
- Length of minor pipes - 0.1 km (≤ DN 80 mm)

The maximum heat load in the network relating to Scenario 2 has been estimated on the basis of a total maximum heat load of approximately 84 MW and a coincidence factor of 70%, which gives a maximum heat production load of approximately 59 MW excluding heat loss in the network.

4.3.5 Pumping Stations

The main pumping requirement will be provided by the Gatepower plant, while St. James Hospital Energy Centre and Heuston Square Boiler Station are fitted with pumps which will be run only when these stations are in operation.

4.4 SCENARIO 3: CITYWIDE DH NETWORK

In this scenario the feasibility of a long-term large-scale DH system for Dublin is evaluated.

4.4.1 Project Development

Scenario 3 considers the development of a major DH system supplying the heat consumers covered by the scenario 1 and 2 together with relevant existing and planned heat consumers south of river Liffey in the areas between Dublin Dockland and Westgate. The DH supply is based on a major transmission line along the route from Docklands to Westgate via Pearse Street, College Course, Dame Street, Lord Edward Street, Christ Church Place, High Street, Corn Street, Thomas Street, and James Street.

Recovered heat from the future Dublin WtE plant will be utilised for supplying the base load to the connected DH consumers. Peak and reserve heat loads will be covered by Gatepower as well as by a number of satellite boiler stations located at Docklands and at Westgate.

4.4.2 Heat Demand

In Scenario 3 the network consumes 300,000 MWh annually and is shown in **Appendix D1**. The connections are assumed to take place from 2008 to 2024 with a corresponding growth in heat demand as shown in **Figure 4.3**.

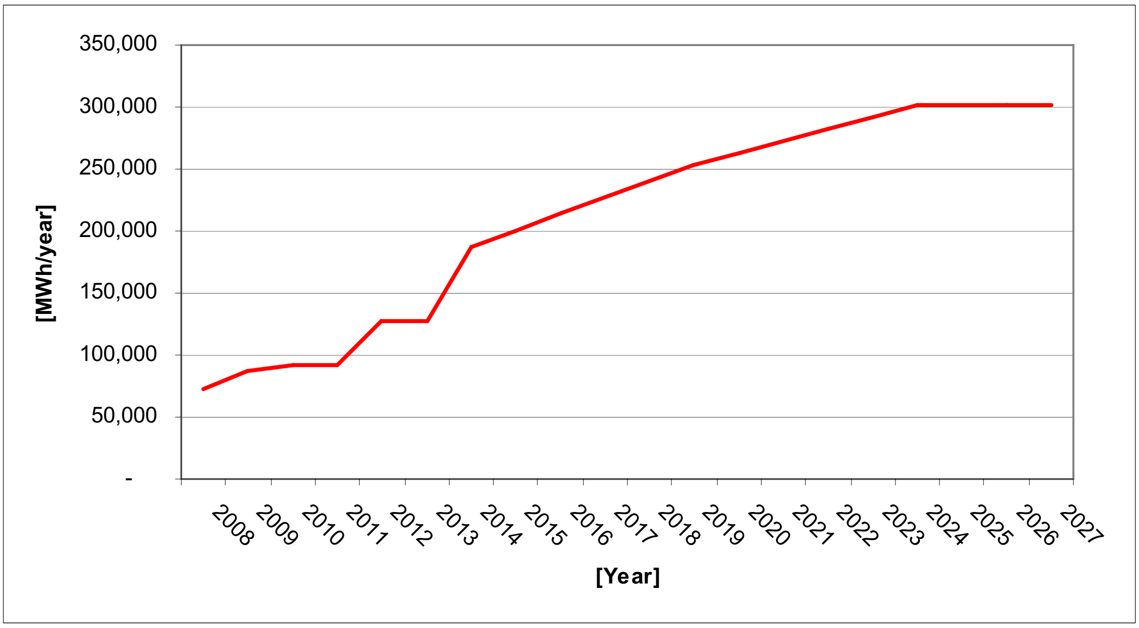


Figure 4.3: Heat demand - Scenario 3

4.4.3 Heat Sources

In Scenario 3 the heat production will be based on heat recovery from WtE and with gas fired boiler stations as peak and reserve capacity. **Appendix D1** indicates the location of these heat sources.

The following heat sources are assumed to cover the heat demand:

- **Waste to Energy plant (WtE)** on Poolbeg - Heat recovery at WTE is assumed to be established with a heat production capacity of 150 MW.
- **A Central boiler station** located in Ringsend will serve as peak and reserve capacity with a capacity of 45 MW.
- **Boiler stations at Spencer Dock** will serve as peak and reserve capacity with a total of approximately 20 MW.
- **Gatepower CHP** is assumed to contribute with a capacity of 30 MW
- **St. James Energy Centre gas fired peak and reserve boiler station** with a capacity of 20 MW.
- **Heuston South Quarter gas fired peak and reserve boiler station** is established with a capacity of 20 MW.
- **DCC's office existing CHP plant** (appr. 1 MW) can be incorporated into the system as well as other smaller plants in the area, but given the small capacity such plants will not play a major role in the system. For this reason they have not been included in the feasibility analysis.

4.4.4 Transmission Line Routing and Distribution Network

Scenario 3 evaluates the option of connecting the Dublin Docklands DH system to Westgate and hereby also connecting a number of the existing and planned heat consumers between the two areas. The areas to be connected can be seen on the layout plan, inserted as **Appendix D1** and **D2**.

When estimating the costs for the DH network in the central city areas between Dublin Docklands and Gatepower, routing and construction constraints have been taken into account. There is a high potential for disruption to traffic and there are many other existing utilities and service lines in these streets. For this reason, the construction costs per meter of DH pipeline in this area have been increased by 50% as compared to the normal construction costs used for other areas in the city.

The DH network can be summarised as follows:

- Length of main pipes - 25.3 km (DN 600 mm - DN 100 mm)
- Length of minor pipes - 5.2 km (≤ DN 80 mm)

The network has been dimensioned on the basis of a total connected heat load of approximately 285 MW and a coincidence factor of 70%, which gives a maximum heat production load of approximately 200 MW excluding heat loss in the network.

4.4.5 Pumping Stations

The entire area to be served is relatively level, with variations from approx -20 meter in the tunnel below the Liffey When and rising to approx +25 meters in the Western parts of the system. For this reason relatively simple pumping systems can be foreseen.

The main pumping will be based on the pumps at the WTE plant plus a major booster pumping station assumed to be constructed in 2012/2013 and placed in a central location in the network between the Docklands and Gatepower. Furthermore, each of the other heat producers comprising the boiler station at Ringsend, existing boiler stations at Spencer Docks, Gatepower, St. James Hospital Energy Centre and Heuston Square Boiler Station are fitted with pumps that are to run when these stations are in operation.

5 ECONOMIC MODEL

5.1 MODEL OVERVIEW AND PARAMETERS

The economic model evaluates the financial consequences of implementing the DH scheme both from a business and consumer point of view. The model is based on an analysis of the operating conditions through a planning period of 20 years. For this purpose, spreadsheets containing information on projected heat demand, use of fuel and economical implications year by year over the project period of 20 years have been set up for each scenario. These spreadsheets can be found in **Appendix B, C** and **D**.

In the study, it is assumed that DH will be offered at a price that is competitive to individual heating based on natural gas supply.

Any profit remaining after an operational year can be reinvested in the network to make the cost of supply more attractive to the consumer and to invest in propagating the system to new consumers and heat sources.

The generation of an operational profit is core to the scheme and will ensure that it exists as an economically robust and self-sustaining example of DH implementation. For this reason, a number of sensitivity analyses have been carried out to examine the impact of external influences on project economy. They are presented in Section 5.4.

All prices used in the study are fixed year 2007 prices for the entire evaluation period of 20 years.

5.1.1 Business economy model

The business economy model calculates following key figures:

- Simple payback time
- Financed accumulated result (20 years)
- Internal rate of return (20 years)

The main prerequisites in the model are:

- Loan interest: 6.0%
- Loan term: 15 years
- Cash account interest, deficit: 6.0%
- Cash account interest, profit: 4.0%
- All prices in the model are stated in fixed prices (price level 2007)

5.1.2 Consumer Economy Model

The consumer economy model calculates annual consumer heating costs for both conventional natural gas heating and DH.

The main assumptions for the consumer economy model are based on a standard consumer defined as a Main Consumer with heat load of 150 kW and specific heat demand of 95 kWh/m^2 and a heat load factor of 68 W/M^2 (based on a 2200 m^2 office building).

5.1.3 CO_2 Emission Model

The emission model calculates the CO_2 emission impacts resuting from each individual scenario as described above. The prerequisite is that 1 MW_{th} heat production costs 0.2 MW_e power production. The model therefore estimates the environmental consequence of heat production at the CHP plant by calculating the impact of the reduced power production, which now will have to be produced at a central power station (based on natural gas).

The heat production produced at peak - and reserve boilers, etc. are taken into account with emissions corresponding to the specific fuel consumptions predicted for those sites.

The results of the emission model are discussed further in Section 6.1

5.2 PRECONDITIONS AND ASSUMPTIONS

5.2.1 Heat demand

Please refer to Section 4 for the calculation of the estimated heat demand for each scenario.

5.2.2 Heat production

The following energy conversion efficiencies have been assumed in the calculations:

- Central boiler station: 92%[3]
- Peak and reserve boilers 92%
- Individual boiler stations: 92%

5.2.3 Emission

The Following carbon intensities have been assumed:

- Natural Gas – 57 kg CO_2/GJ
- Power Station – 57 kg CO_2/GJ

[3] The boiler stations are assumed not to be equipped with flue gas condensers due to the relatively low annual operational hours, which most likely would not justify the relatively high additional investments. Conservatively, the annual average efficiencies for the district heating peak and reserve boilers have been assumed to be similar to individual boilers, i.e. 92%.

5.2.4 Consumer installations

5.2.4.1 District heating

The economy model takes into account the consumer installations, which are to be considered as additional cost, compared with conventional heating systems, i.e. natural gas heating. According to the previous study " District Heating installation costs in Buildings" (2003), the radiator system in the building from the central heating installations (heat exchanger stations or natural gas boiler installations) are cost neutral when comparing the DH option with conventional natural gas heating.

The DH consumer installations are assumed to be separated from the DH main network by heat exchangers, which together with the heat meters are assumed to be provided and owned by the DH company. The DH option includes investments in pipe works, meters (heat meters not included), valves, strainers, expansion systems, pumps and air escape systems. Investment costs have been estimated based on Danish experience.

The main prerequisites related with the consumer economy calculations are:

- Loan interest: 6.0%
- Loan term: 20 years
- DH connection and branch fee, 150 kW: 26 €/kW
- DH consumer installations, 150 kW: 133 €/kW
- Operational and maintenance cost, DH installations: 1.2 €/MWh

5.2.4.2 Conventional natural gas heating

The gas heating consumer installations are assumed to include boiler, pumps, pipes, boiler panels, gas connection and metering system.

- Gas LPHW, boiler, pumps, boiler panels, etc.: 325 €/kW
- Gas connection + metering system: 72 €/kW
- Operational and maintenance cost, boiler installations: 10 €/MWh
- Financing requisites are similar to the DH option.

5.2.5 Energy prices

5.2.5.1 Natural gas

Gas prices used in the economic model are shown in Table 5.1 overleaf.

Table 5.1: Gas Prices March 2007 (Bord Gáis)

Charges	**Domestic** (Standard Rate)	**Commercial / Industrial** **<450 MWh/year** (Standard Commercial Tariff)	**Commercial / Industrial** **450– 2,400 MWh/year** (Demand & Commodity Tariff 1)	**Commercial / Industrial** **> 2,400 MWh/year** (Demand & Commodity Tariff 2)
Standing Charge	€51.43 (bi-monthly)	€12.12 (monthly)	€2,909 (annual*)	€8,726 (annual*)
Unit Prices				
Flat Rate	40.91 €/MWh		36.41 €/MWh	38.90 €/MWh
0 – 3,000 kWh		53.76 €/MWh		
3,001 – 7,500		49.63 €/MWh		
7,501 – 15,000		45.48 €/MWh		
15,001 +		41.36 €/MWh		

*plus €145.47/year/ meter installed

5.2.5.2 Heat purchase price - WTE

The heat purchase price of the heat purchased ‘at the fence’ of a CHP plant (e.g. proposed Waste to Energy Plant) has been calculated through an examination of balanced electricity revenue and capital investment for heat recovery. The following assumptions were made in the calculations:

- $1MW_{th}$ will cost 0.2 MW_{elec}. In CHP mode when heat is produced steam is condensed at a higher temperature (~100^{o}C) compared to approximately 30-40^{o}C for electricity production. This gives a reduced electricity production in a ratio of about 1:5 (however, this is dependent on what condensing media is used). In the case of the proposed Dublin WTE facility, seawater is used as the condensing media giving a greater ratio difference compared to air coolers. The electricity output also depends on how the CHP facility is configured to extract steam from the turbine; the extraction point depends on the quantity of heat required.
- WTE Electricity cost price: 33.5 €/MWh
- DH production investments at the WTE plant (steam extraction, heat exchanger station, pumps, instrumentations, etc.) have been taken into account in the business economy calculations for Scenario 1 and Scenario 3 as follows:
  - Scenario 1 (heat production = 90 MW): 2.10 million €
  - Scenario 3 (heat production = 150 MW): 3.36 million €

Based on the above assumptions the balanced heat production price has been calculated as follows:

Cost of Primary Heat (from proposed WTE Plant): 33.5 x 0.2 + 0.3 = 7 €/MWh

5.2.5.3 Heat purchase price - Gatepower - Scenario 2

In Scenario 2 the base load is assumed to be covered by Gatepower at Guinness Breweries The heat from here is calculated as a "break-even price" coming up with an internal rate of return (10 years) of 4%, which equals the cash account interest assumed in the calculations. The following break-even price has been calculated:

Heat purchase price, Gatepower: 20.6 €/MWh

5.2.5.4 District heating sales price

The overall philosophy of the feasibility calculations is to present economic figures reflecting a DH alternative, which offers cheaper heating compared with conventional natural gas heating. In the basic model the DH price is based on the prerequisite to offer a total annual heating cost to the consumers, which is 10% cheaper compared with individual natural gas. In the basic calculation the DH price has been set to:

District heating charge: 48.5 €/MWh

The standing charge is set to 25% of the total district heating charges[4] giving a standing charge of:

Standing charge, district heating: 1.15 €/m^2/MWh and 50 €/meter/year

5.2.6 Capital Costs

5.2.6.1 DH Network Unit Costs

The costing of the network is based on the pipe dimensions presented in **Appendix B2, C2** and **D2**. DH material costs have increased significantly in recent years due to increases in steel prices (for the carrier pipes) and increases in oil prices (for the PUR insulation and PE jacket pipes). Prices used in this feasibility study are based on experience from similar works, combined with prices collected from suppliers. The main elements of the proposed DH system are shown with prices on Table 5.2 overleaf.

[4] Total District Heating Charge = Heat Price + Operation & Maintenance Cost+ Capital Cost

Table 5.2: Unit costs for construction district heating lines

Dimensions			Price							
Nominal (DN)	Pipe (mm)	Jacket (mm)	€/m	Muffs €/10m	Fittings 10% (€)	Transport 30% (€)	Total Materials (€/m)	Assembly (€)	Excavation (€)	Total (€/m)
20	26	90	12.0	26.9	1.5	4.9	42.1	27.7	109.2	**179.0**
25	33	90	12.9	26.9	1.6	5.1	44.5	27.7	109.2	**181.4**
32	42	110	16.0	30.7	1.9	6.3	54.4	27.7	111.3	**193.5**
40	48	110	16.7	30.6	2.0	6.5	56.6	27.7	111.3	**195.6**
50	60	125	20.4	34.8	2.4	7.9	68.3	30.9	116.5	**215.7**
65	76	140	24.4	36.0	2.8	9.2	80.2	35.0	119.5	**234.7**
80	88	160	29.4	41.3	3.4	11.1	96.0	42.1	121.6	**259.8**
100	114	200	39.4	53.0	4.5	14.7	127.7	47.5	131.7	**306.9**
125	139	225	48.4	56.3	5.4	17.8	154.6	49.4	139.0	**343.0**
150	168	250	60.3	66.2	6.7	22.1	191.3	71.3	163.4	**426.0**
200	219	350	87.0	84.6	9.5	31.5	272.9	74.7	198.9	**546.6**
250	273	400	131.1	138.6	14.5	47.8	414.5	86.6	312.7	**813.8**
300	323	450	165.3	161.0	18.1	59.9	518.7	98.3	365.7	**982.8**
350	355	500	191.5	176.0	20.9	69.0	598.1	111.5	438.1	**1,147.6**
400	406	560	239.1	192.5	25.8	85.3	738.9	133.2	486.8	**1,358.9**
450	457	630	279.6	213.9	30.1	99.3	860.9	159.1	562.5	**1,582.5**
500	508	710	334.7	247.9	35.9	118.6	1,028.1	190.9	675.0	**1,894.1**
600	610	800	407.8	318.8	44.0	145.1	1,257.5	229.1	810.0	**2,296.6**

The development of a DH network including the transmission line results in the investments (million €) shown in Table 5.3.

Table 5.3: Total District Heating Network Cost per Scenario

	Scenario 1	Scenario 2	Scenario 3
Network Cost € million	9.8	3.7	25.5

5.2.6.2 Heat production costs

The heat production capacities shown in Table 5.4 have been assumed to cover the heat demands related with the three scenarios.

Table 5.4: Heat source capacities in MW for each Scenario

Heat Sources	Scenario 1	Scenario 2	Scenario 3
WTE Plant - Heat recovery	90	0	150
Central Boiler Station	45	0	45
Spencer Dock reserve boilers	20	0	20
Gatepower	0	30	30
St. James Energy Centre	0	30	20
Heuston Square	0	25	20
Total	**155**	**85**	**285**

The heat sources at Spencer Dock and Gatepower are existing heat sources and consequently no investments have been accounted to these.

The capital costs related with the heat sources for each scenario are shown in Table 5.5 overleaf.

Table 5.5: Heat Source Investments in Million € for each Scenario

Heat Sources	Scenario 1	Scenario 2	Scenario 3
WTE Plant - Heat recovery	2.1	0.0	3.36
Central Boiler Station	6.9	0	6.9
Spencer Dock reserve boilers	0	0	0
Gatepower	0	0	0
St. James Energy Centre	0	3.8	3.1
Heuston Square	0	4.6	3.1
Pumping station	0.6	0.6	0.6
Booster pumping station	0	0	0.9
Total	**9.6**	**9.0**	**18.0**

5.2.6.3 Schedule of Investment

Figure 5.1 shows the schedules of investment to develop a DH network in million € for each scenario.

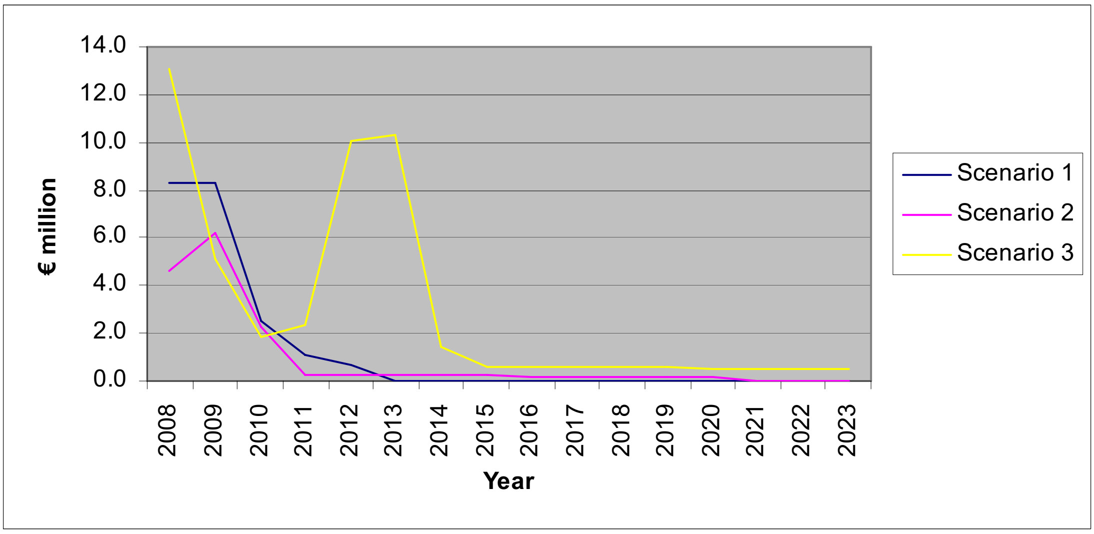


Figure 5.1: Schedule of Investments for each Scenario

5.2.7 Operational and maintenance

The operational costs have been assessed on the basis of experience from similar existing DH systems. The figures used are detailed for the years 2006 - 2025 in **Appendix B4, C4** and **D4**. The operational and maintenance costs are summarised in Table 5.6.

Table 5.6: Operational Costs in €1,000 for each Scenario

	Scenario 1	Scenario 2	Scenario 3
District Heating Network	107	18	259
Heat sources	6	89	83
Electricity cost	42	41	115
Heat purchase	983	1,883	2,439
Fuel Cost	117	1,559	1,464

The following key figures have been used for estimation the operational and maintenance costs in the business economic calculations:

- Central boiler station - 2.1€/MWh-gas
- The district heating network - 0.50 % of investment
- Elec. expenses/aux. Energy - 0.31 €/MWh produced
- The heat sources **-** 2.1 €/MWh-gas
- Heat purchase - See Section 5.2.5.2 & 5.2.5.3
- Fuel cost - See Section 5.2.5.1

5.3 MODEL RESULTS

5.3.1 Business Model

The full economic model for each scenario is included in **Appendix B5, C5** and **D5**. The main results of the calculations are included in **Appendix B3, C3** and **D3**.

5.3.1.1 Scenario 1 - Dublin Dockland North

Investment, total (€ million):	21.5
Simple payback (years):	8
Financed Accumulated result (20 years) (€ million):	61.8
Internal rate of return (20 years):	16.4%
Internal rate of return (10 years):	7.5%

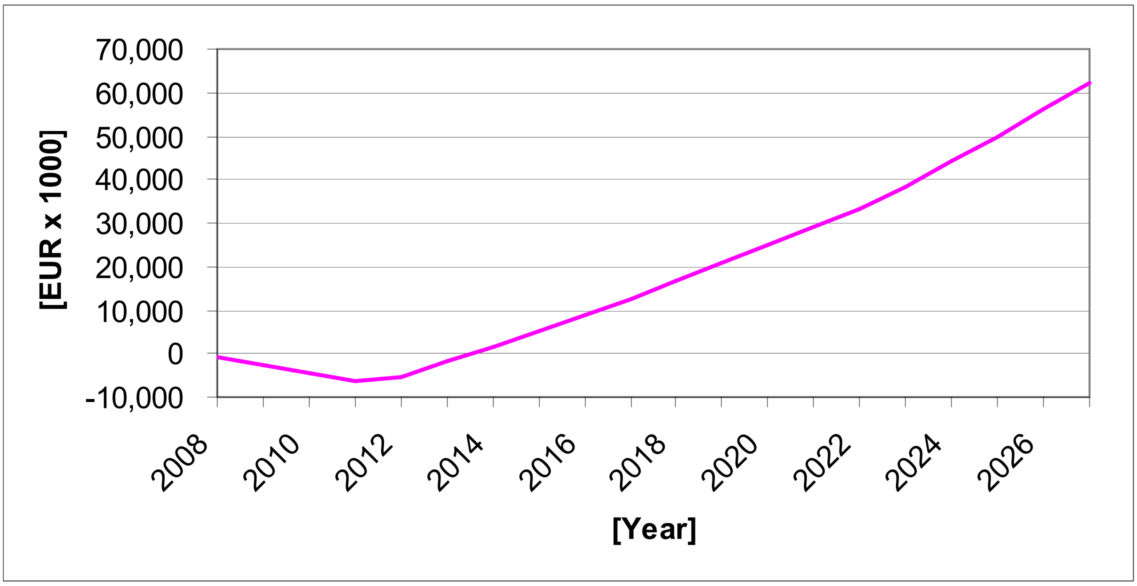


Figure 5.2: Accumulated Financial Result - Scenario 1

5.3.1.2 Scenario 2 - Westgate

The business economy for Scenario 2 has been calculated based on the assumption that the heat purchase price at Gatepower is determined to come up with an internal rate of return (10 years) of 4%.

Heat purchase price at Gatepower (IRR, 10 years = 4%):	20.6 €/MWh
Investment, total:	14.9 million €
Simple payback:	9 years
Financed Accumulated result (20 years):	10.8 million €
Internal rate of return (20 years):	8.4%
Internal rate of return (10 years):	-4.4%

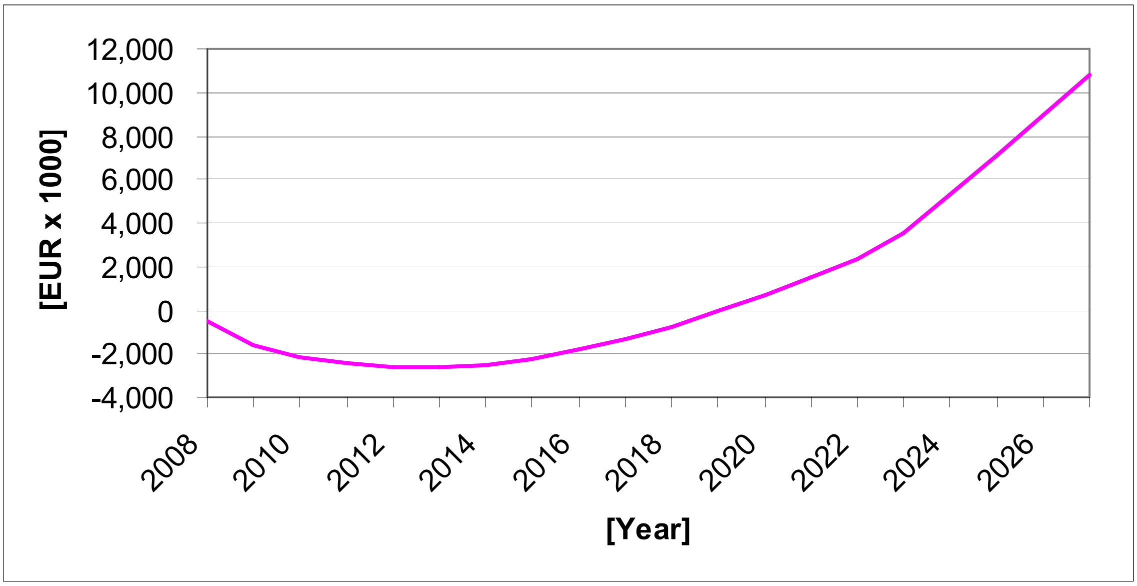


Figure 5.3: Accumulated Financial Result - Scenario 2

5.3.1.3 Scenario 3 – Citywide DH Network

Investment, total:	56.9 million €
Simple payback:	10 years
Financed Accumulated result (20 years):	132.8 million €
Internal rate of return (20 years):	17.5%
Internal rate of return (10 years):	2%

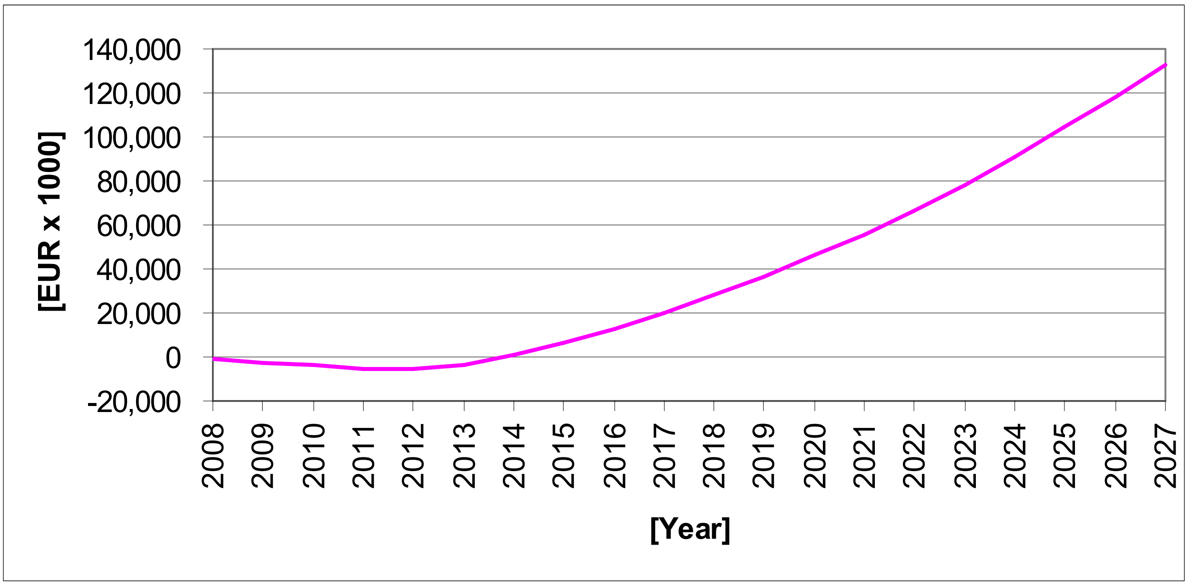


Figure 5.4: Accumulated Financial Result - Scenario 3

5.3.1.4 Conclusion

DH will be competitive with individual heating based on natural gas supply. The economic model showing this assumes that all costs and prices are fixed at 2007 prices. However, DH is capital intensive, so a large part of the customer's DH bill will go to cover fixed costs for the installation of pipes, boiler stations and other plant. The remaining part of the bill is needed to cover operating expenses for staff, maintenance and energy purchase. Because only the operating costs will be subject to inflation, DH is likely to become increasingly competitive in the future. The operation of a profitable DH network is likely to be attractive to Energy Management Companies.

5.3.2 Consumer economy

Annual consumer costs including capital cost related with individual investments have been calculated for a standard main consumer (based on a 2200 m^2 office building) to:

- District heating: 15,078 €/year
- Individual natural gas heating: 16,857 €/year
- Savings: 1,779 €/year

The above savings equal approximately 10% compared with individual gas heating.

The main results of the consumer economy calculations are included in **Appendix B4, C4** and **D4**.

5.4 SENSITIVITY ANALYSES

Sensitivity analyses were carried out for Scenario 1 and 2 only. The major parameters, which will have an influence on the operational economic performance of the District Heating Scheme, are the:

- Purchase price of heat supplied to the DH network,
- Proposed WTE facility is not put into operation and the DH base load will instead be based on power plants at Poolbeg,
- Price at which heat will be sold to DH customers,
- Natural gas price,
- DH Customer penetration rate of district heating (50% - 120%).

5.4.1 Scenario 1

Figure 5.5 shows how sensitive the business economy is to changes in heat sales prices, while keeping the heat purchase price from the WTE plant constant. As an example, a decrease of the heat sales price to the consumers from €48.5/MWh to €40/MWh means that the accumulated result of the district heating company will turn positive approximately four years later than in the base model.

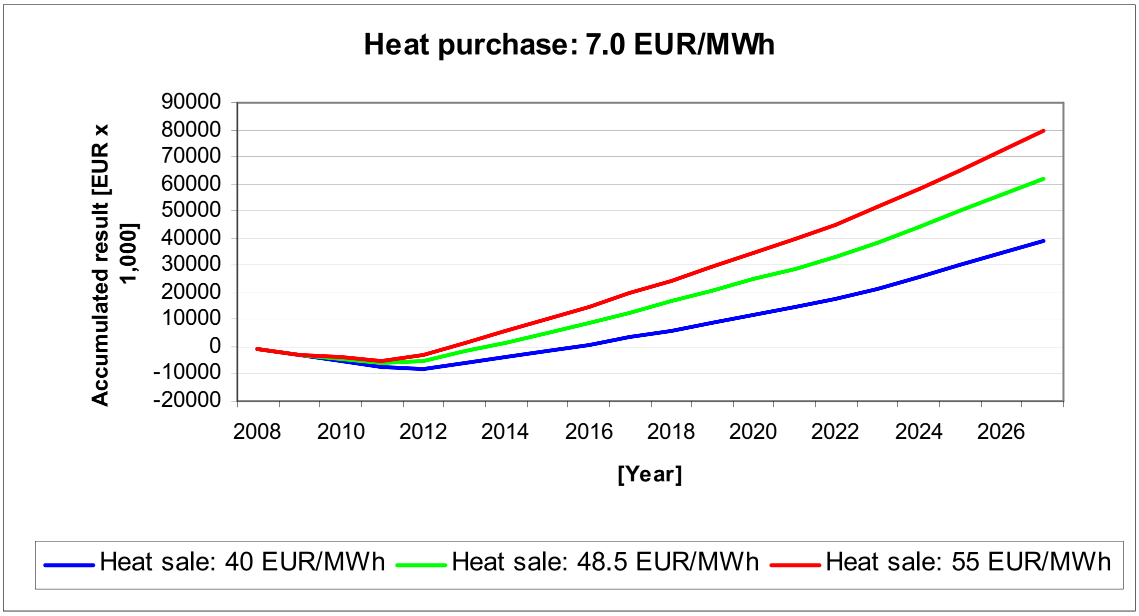


Figure 5.5: Scenario 1 - Accumulated Financial Result for Various Heat Sales Prices

Figures 5.6 below show changes of the expected internal rate of return over a 20 year period, when changing heat sales as shown in Figure 5.5.

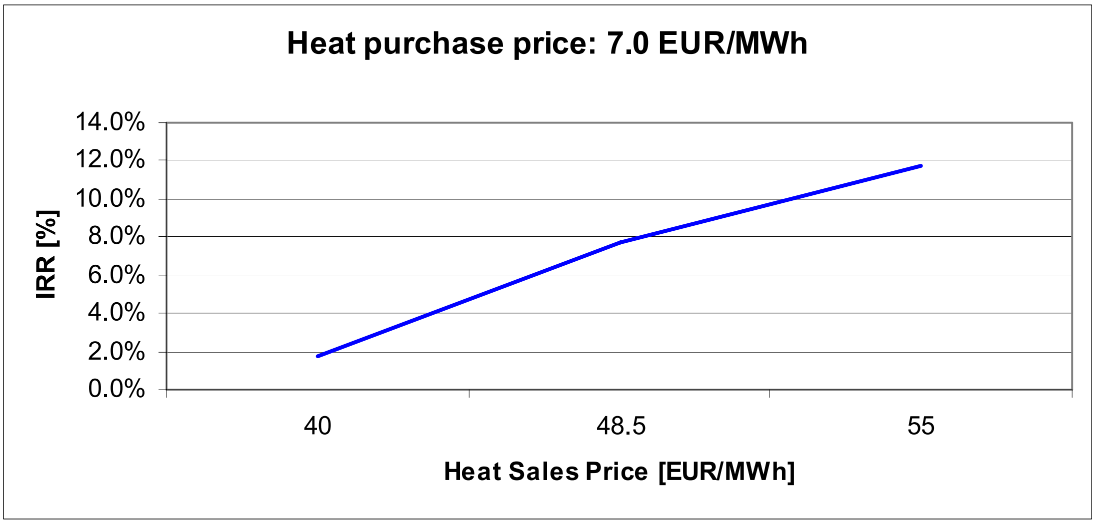


Figure 5.6: Scenario 1 - Internal Rate of Return (10 years) for various heat sales prices

Figure 5.7 shows how sensitive the business economy is to an increase of the heat purchase price from the WTE plant, while keeping the heat sales price to the district heating customers constant. As an example, an increase of the heat purchase price from €7/MWh to €19/MWh means that the accumulated result of the district heating company will turn positive approx. four years later than in the Base Model.

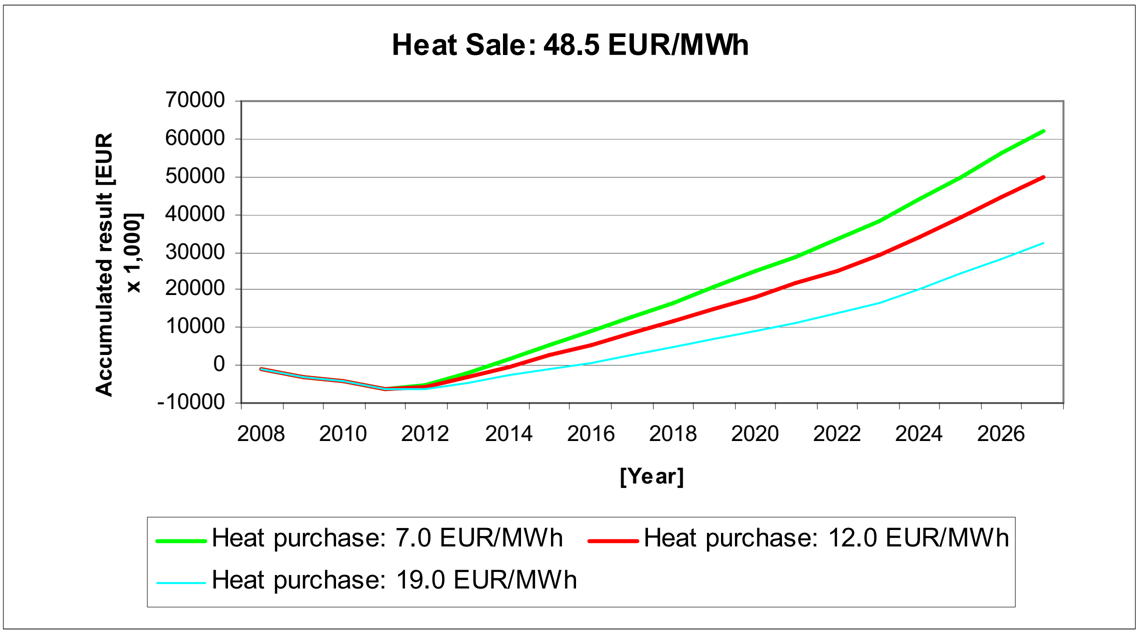


Figure 5.7: Scenario 1 - Accumulated Financial Result for Various Heat Purchase Prices

Figures 5.8 below show changes of the expected internal rate of return over a 20 year period, when changing heat purchase prices as shown in Figure 5.7.

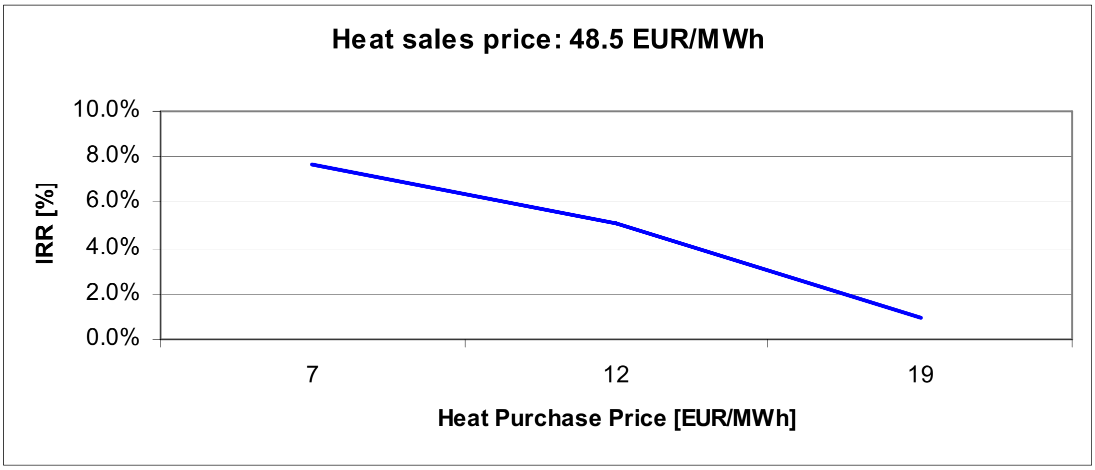


Figure 5.8: Scenario 1 - Internal Rate of Return (10 years) for Various Heat Purchase Prices

If the WTE plant is not put into operation, the DH system will have to be based on alternative heat sources e.g. Poolbeg power plants. This situation is analysed by calculation the maximum heat purchase price for obtaining an internal rate of return of a certain acceptable level. Here an internal rate of return of 4% (10 years) is set as criteria as this equals the cash account interest rate assumed in the business calculations. The required maximum heat purchase price is:

Maximum heat purchase price for obtaining IRR = 4%: 14.0 [€/MWh]

Figure 5.9 shows how sensitive the business economy is to changes in penetration of district heating, while keeping the heat purchase price from the WTE plant constant. As an example, a decrease in penetration of DH from 100% to 80% means that the accumulated result of the district heating company will turn positive approximately one year later than in the base model.

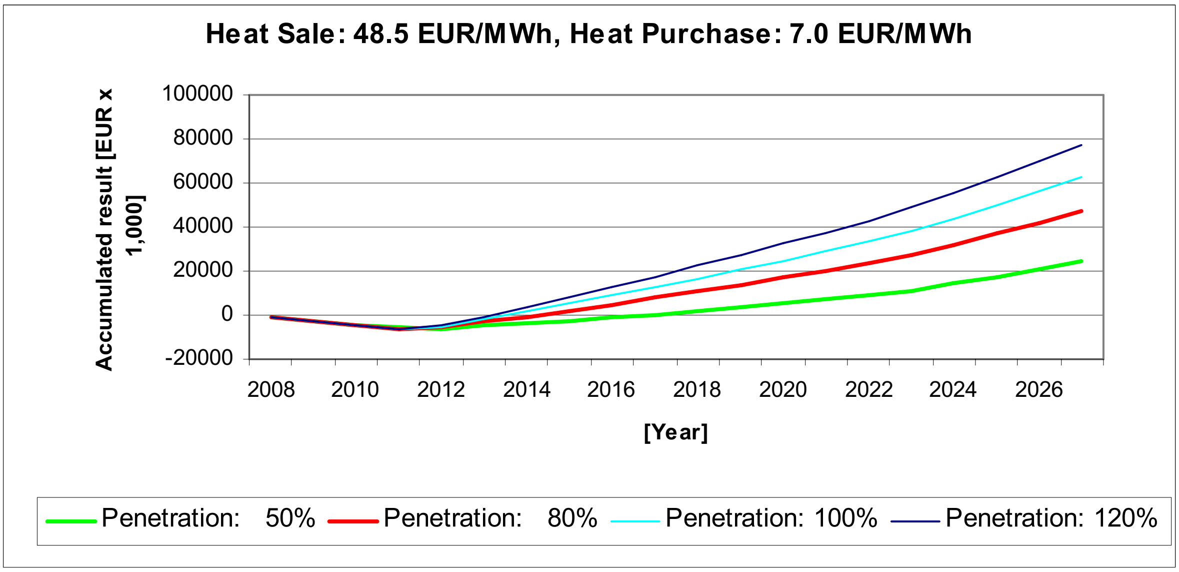


Figure 5.9: Scenario 1 - Accumulated Financial Result for Various Penetration of DH

Figure 5.10 shows the sensitivity of the business economy to changes in gas prices. As an example, an increase in gas prices from 100% to 120% means that the accumulated result of the district heating company will turn positive slightly earlier than in the base model.

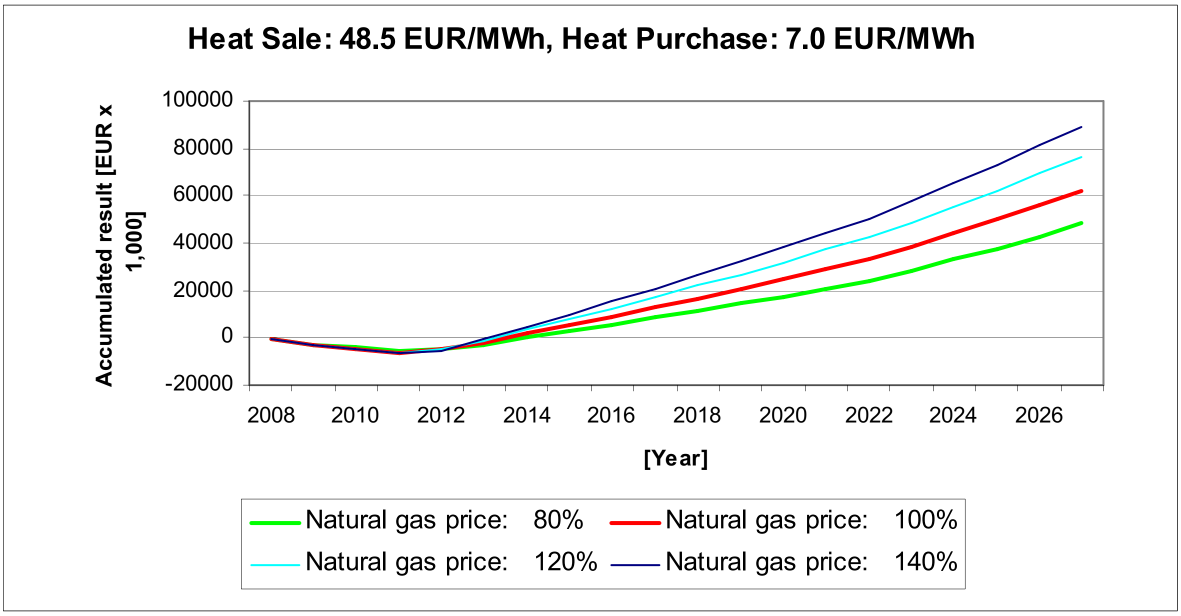


Figure 5.10: Scenario 1 - Accumulated Financial Result for Various Gas Prices

5.4.2 Scenario 2

Figure 5.11 shows how sensitive the business economy is to changes in heat sales prices, while keeping the heat purchase price from the WTE plant constant. As an example, a decrease of the heat sales price to consumers from €48.5/MWh to €40/MWh means that the accumulated result of the district heating company will turn positive approximately five years later than in the base model.

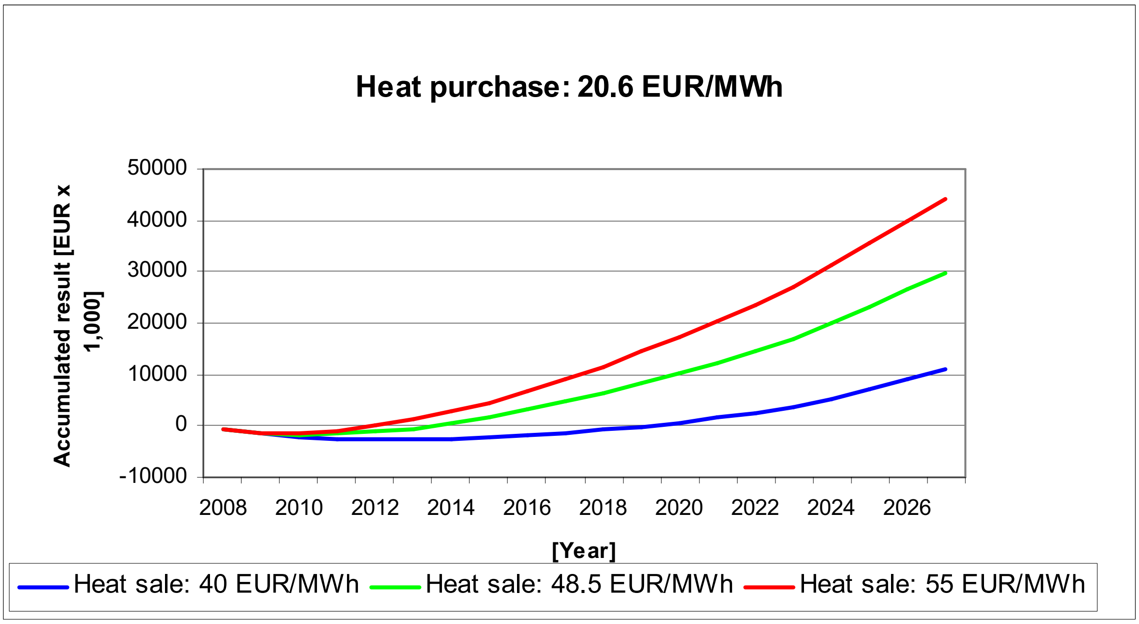


Figure 5.11: Scenario 2 - Accumulated Financial Result for Various Heat Sales Prices

Figures 5.12 below show changes of the expected internal rate of return over a 20 year period, when changing heat sales as shown in Figure 5.11.

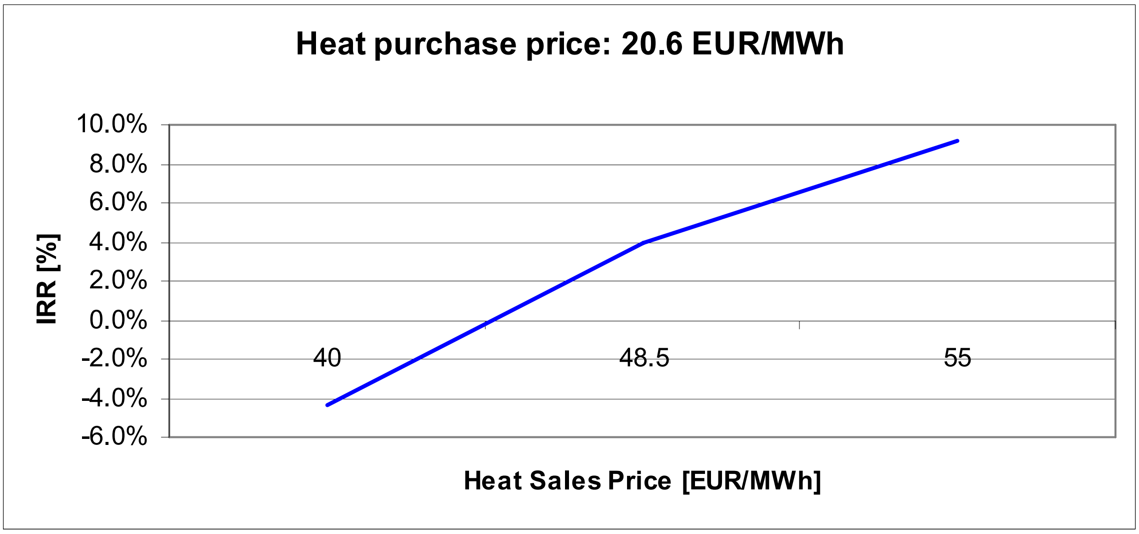


Figure 5.12: Scenario 2 - Internal Rate of Return (10 years) for Various Heat Sales Prices

Figure 5.13 shows how sensitive the business economy is to an increase of the heat purchase price from the WTE plant, while keeping the heat sales price to the district heating customers constant. As an example, an increase of the heat purchase price from €20.6/MWh to €30/MWh means that the accumulated result of the district heating company will turn positive approx. five years later than in the Base Model.

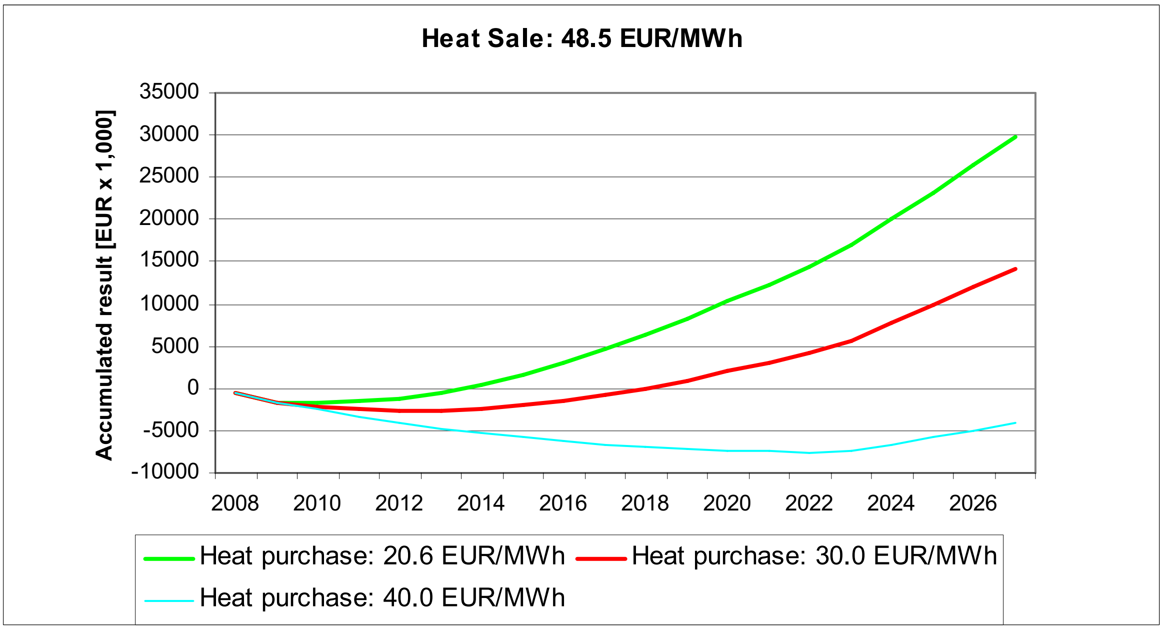


Figure 5.13: Scenario 2 - Accumulated Financial Result for Various Heat Purchase Prices

Figures 5.14 below show changes of the expected internal rate of return over a 20 year period, when changing heat purchase prices as shown in Figure 5.10.

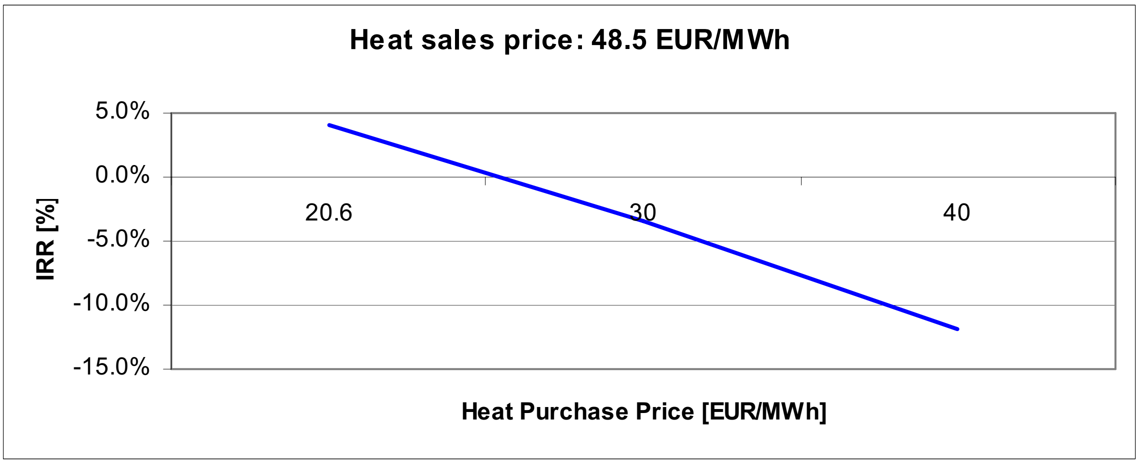


Figure 5.14: Scenario 2 - Internal Rate of Return (10 years) for Various Heat Purchase Prices

Figure 5.15 shows how sensitive the business economy is to changes in penetration of district heating, while keeping the heat purchase price constant. As an example, a decrease in penetration of DH from 100% to 80% means that the accumulated result of the district heating company will turn positive approximately one year later than in the base model. This increases to seven years if penetration falls to 50%.

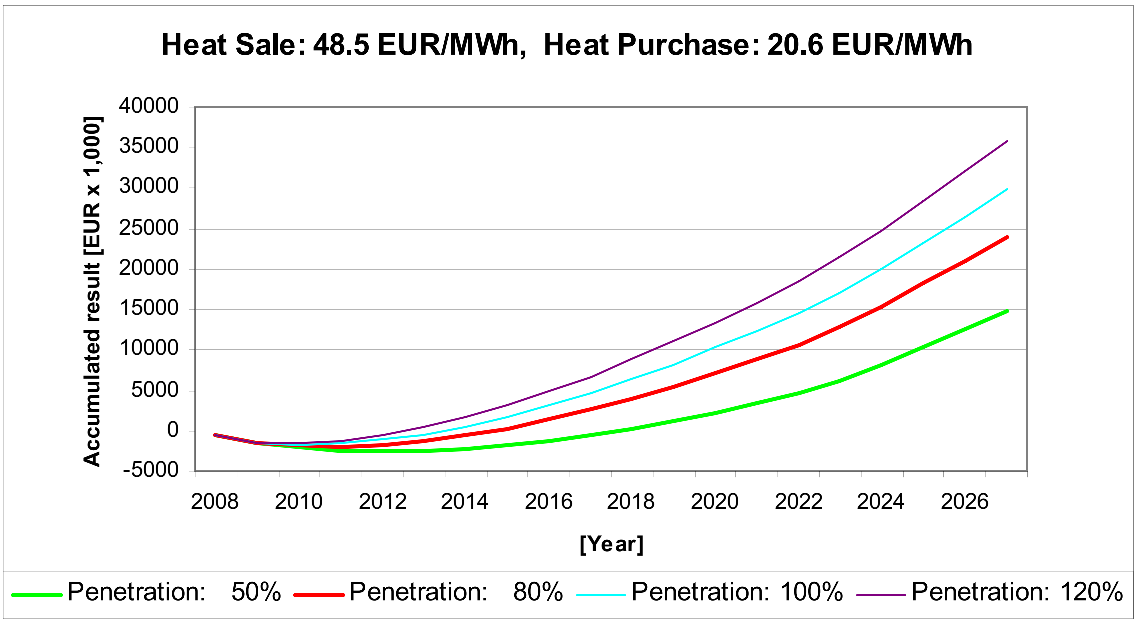


Figure 5.15: Scenario 2 - Accumulated Financial Result for Various Penetration of DH

Figure 5.16 shows the sensitivity of the business economy to changes in gas prices. As an example, a increase in penetration of DH from 100% to 120% means that the accumulated result of the district heating company will turn positive approximately slightly earlier than in the base model.

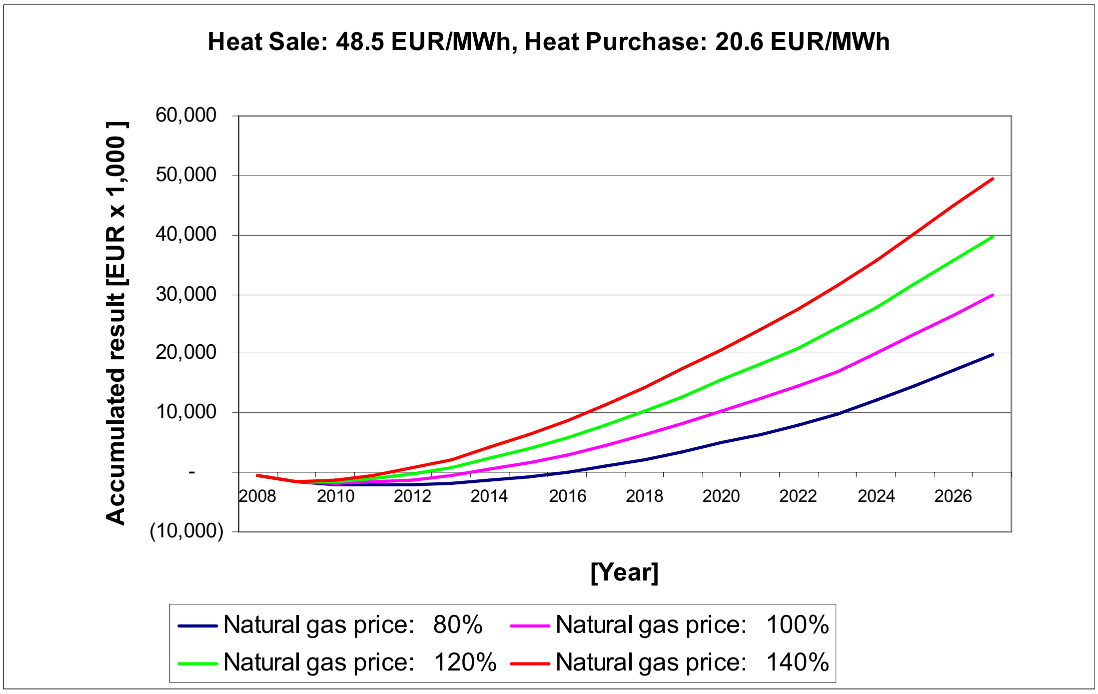


Figure 5.16: Scenario 2 - Business Economy for Various Gas Prices

6 EXTERNAL ASPECTS

In addition to a potentially sound business case, DH schemes can deliver other associated benefits. These benefits can play an important role towards building sustainable communities and development.

The environmental benefits of DH are generally associated with CHP, and result from the fact that the heat from the power generation unit is applied usefully rather than being rejected to the surrounding environment, as it is the case with conventional power stations.

6.1 CARBON DIOXIDE EMISSIONS

6.1.1 Overview

Every kWh of heat replaced by district heating represents a saving of natural resources and a reduction in carbon dioxide (CO_2) emissions. DH can therefore play a significant role in contributing to meeting Ireland's commitments under the Kyoto Protocol, which is set at maintaining Ireland's CO_2 emissions at a level below 113% of 1990 levels by 2012. When practised on a large scale such as in Dublin, the benefits of DH are correspondingly increased.

Euroheat & Power has estimated that worldwide, DH and CHP reduce existing CO_2 emissions from fuel combustion by 3-4%, corresponding to an annual reduction of 670-890 Mtonnes compared to global emission of 22,700 Mtonnes during 1998. The highest carbon reduction occurred in Russia (15%), in the former USSR outside Russia (8%) and in the EU (5%).

CO_2 reductions from DH/CHP will decrease when the CO_2 emissions from alternative generation of electricity and heat are reduced. However this is not a unique situation for DH/CHP; it will apply to all carbon-lean technologies, since the competition will not come from carbon-rich technologies, but from other carbon-lean technologies.

For the future, DH/CHP can make further reductions of global CO_2 emissions. This can be accomplished by:

- Increasing the market penetration of DH through expanding new and existing DH systems,
- Increasing the share of CHP in existing DH generation (e.g. by converting power stations).
- Fuel substitution in existing DH/CHP plants

6.1.2 CO_2 Emissions Model Results

The calculation reflects the substantial reduction in CO_2 emission that can be achieved in Dublin when utilising the combined heat and power production from the WTE plant. It is assumed that the most likely form of heating which DH would replace (for new-build developments especially) is natural gas fired central heating. This is considered one of the 'cleanest' and most widely used heating technologies. The loss in electrical output from the CHP units was assumed to be provided by separate power plants i.e. power from the national grid or on – site power generation.

In Scenario 1, it has been calculated that initially 12,000 tonnes per annum of CO_2 (see **Figure 6.1**) could potentially be saved if DH is implemented. The increase in CO_2 emissions at the start of the scheme is due to the supply of heat by the 45MW gas fired peak and reserve boiler plant. The introduction of the heat supply from the WTE will progressively decrease the amount of CO_2 emissions.

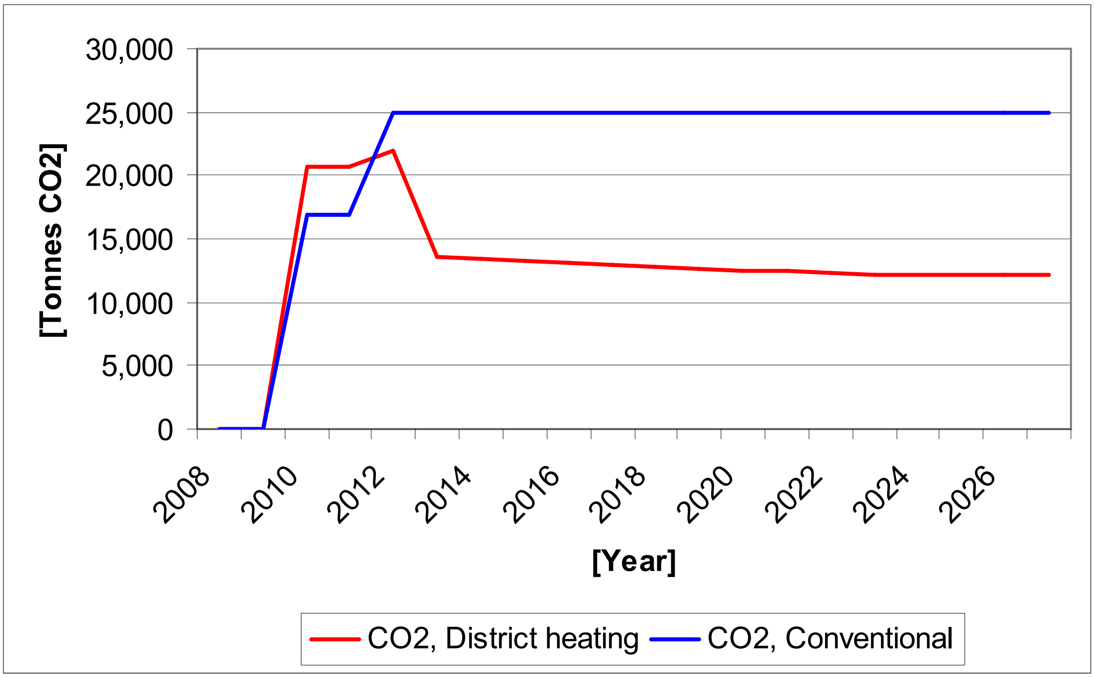


Figure 6.1: Relative CO_2 Emission from DH and Conventional Heating Scenario 1

In Scenario 2, it has been calculated that 5,000 tonnes per annum of extra CO_2 (see **Figure 6.2**) will potentially be emitted if DH is implemented without utilisation of neither CHP production, biomass utilisation nor other environmentally friendly means of heat production. The lack of savings are due to the non availability of the high efficiency of the CHP facility at Guinness Brewery.

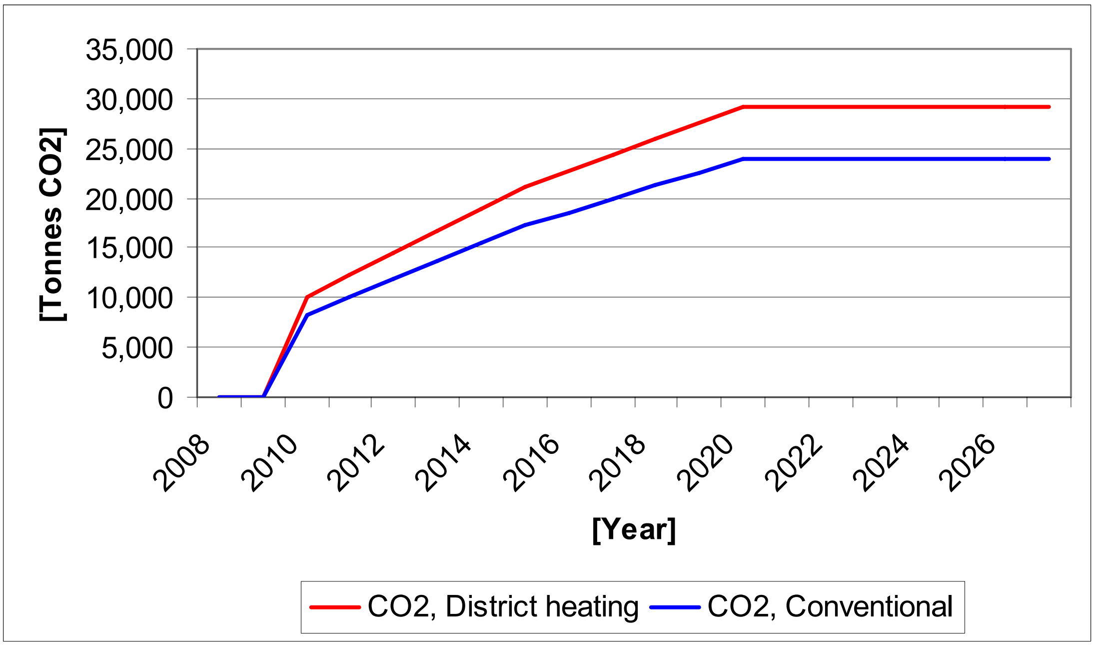


Figure 6.2: Relative CO_2 Emission from DH and Conventional Heating Scenario 2

In Scenario 3, it has been calculated that initially 32,000 tonnes per annum of CO_2 (see **Figure 6.3**) could potentially be saved if DH is implemented.

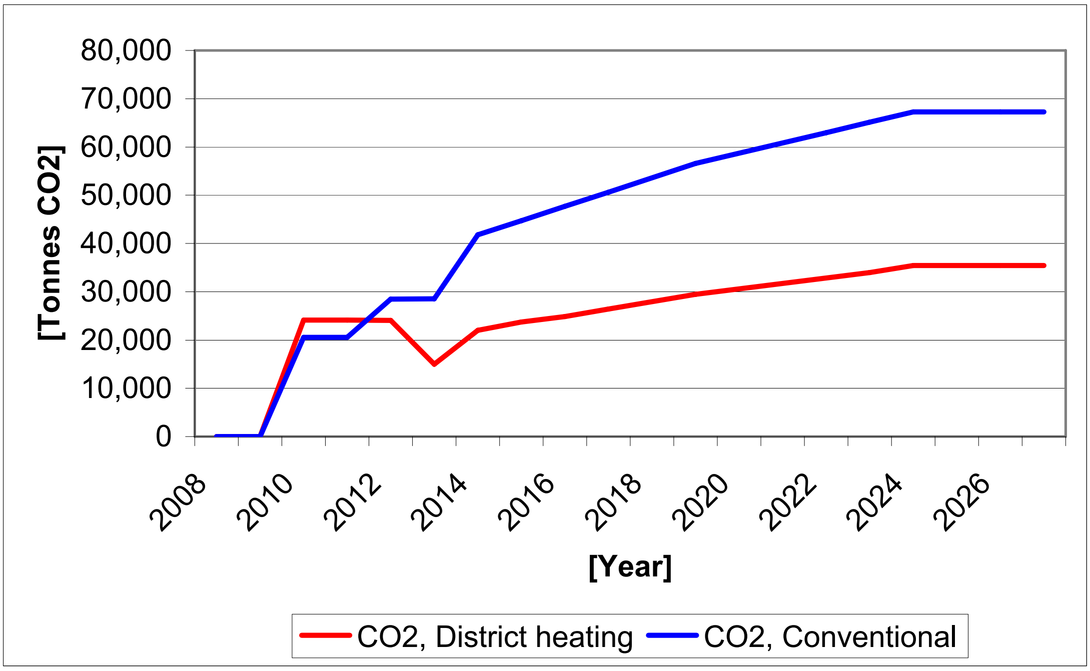


Figure 6.3: Relative CO_2 Emission from DH and Conventional Heating Scenario 3

It is worth noting that the CO_2 savings presented in the results above only relate to the planned developments within the Docklands Areas and Westgate and therefore can be viewed as a conservative estimate of the CO_2 savings potential. With the future propagation of the DH network, the conversion of the Poolbeg power stations to CHP, and the increase in consumer demand the Dublin DH network can become a significant contributor to reducing the national CO_2 emissions and aiding in Ireland's compliance with the Kyoto Protocol. The next section will outline the potential CO_2 savings for a DH network supplied by CHP facility with a thermal output of 90 MW.

6.2 POTENTIAL HEAT LOAD FROM DISTRICT HEATING AND WTE FACILITY

A DH network, fuelled by the proposed WTE plant in CHP mode, could replace the current mode of heating in a given area and thus virtually eliminate the emissions produced by that local heating requirement. Scenario 1 which examines the feasibility of a DH network in the Docklands area highlights the potential heat load provided by the proposed WtE facility. The thermal output from the facility (as illustrated in **Figure 6.4**) will be able to supply the study area's maximum heat load.

Figure 6.4 shows the heat load for the Scenario 1 for a typical year. A purple line indicates the heating load throughout a typical year, with approximately 80 MW of heat being required for a very short period of the year during winter months. The blue line represents the potential output from the proposed WTE facility and the yellow corresponds to an increase in the output from the facility (from 90 MW to 150 MW). The area between the purple and blue indicates the huge heat load potential that 90 MW could supply if the WTE facility was constructed.

In Scenario 1, the feasibility study area considers almost 850,000 m^2 of retail and residential development area that could connect to the DH network. With the propagation of DH and an increase in the consumer uptake for DH the number of housing units that could be potentially connected would increase significantly. If there was a peak heat load of 500 MW, (which would be comparable to the heat load of Dublin City), 90 MW could provide the base heat load throughout the year, increasing the overall efficiency of the DH network and the proposed WTE facility.

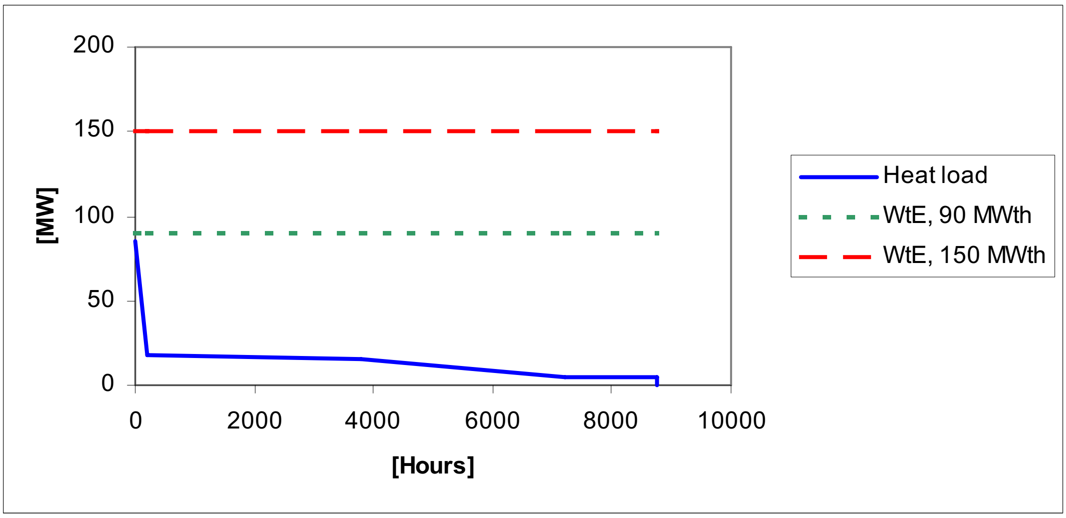


Figure 6.4: Thermal Output of WTE and Estimated Heat Duration Curve for Scenario 1

Scenario 3 envisages the development of a citywide DH network connecting Scenario 1 and 2 and it is hoped that the large potential of excess (relatively cheap) heat from the WtE facility would act as a base heat load for Dublin City and allow for the successful propagation of a DH network for the City of Dublin (see **Figure 6.5**).

Figure 6.5 show that annual peak heating (and also zero heating) are only required for relatively short durations; a much smaller base load is needed for most of the year – this would be comparable to the output of the WTE plant. Maximum efficiency for the proposed WTE plant would be achieved where its output matched a steady base load. This requires the development of an extensive DH network. It would also require additional peak and reserve load capacity.

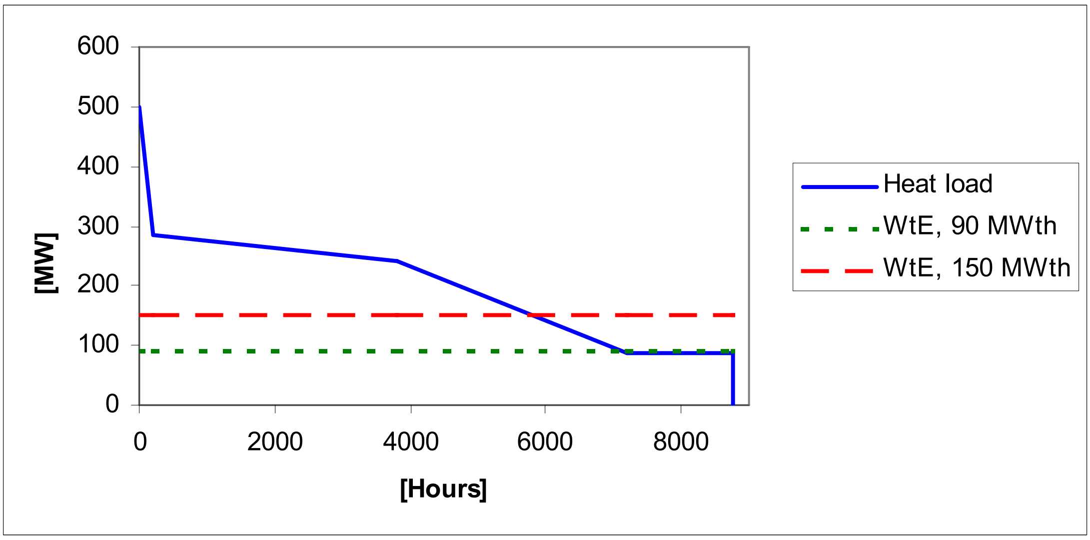


Figure 6.5: Thermal Output of WTE and Heat Duration Curve for a Dublin City District Heating Network

6.3 POTENTIAL CO_2 EMISSIONS SAVINGS BY DISTRICT HEATING AND WTE

As explained in Section 6.2, where the output of the plant can be matched to a constant load, there is considerably more to be gained. Space heating requirements are seasonal, but there is a (relatively small) base heating load year round. Therefore, the potential of DH and the proposed WTE plant for reducing CO_2 emissions is limited by the extent of the DH network i.e. the relative size of the base heating load to the thermal output of the plant.

The total quantity of energy, which could be supplied by the WTE to the DH network, is 1,245 GWh (Maximum thermal output of 150 MW_{th} at 95% availability). Assuming 18% transmission loss from the DH network this would deliver 1,021 GWh of heat energy to costumers.

In 2005 the "average" dwelling consumed a total of 21,755 kWh of energy based on climate corrected data. This was comprised of 16,865 kWh (78%) in the form of direct fossil fuels and the remainder (4,890 kWh) as electricity[5]. The average dwellings was also responsible for emitting 4.5 tonnes of CO_2 from direct fuel use.

Assuming that energy from direct fuels use is used for space heating and water heating, an energy production of 1,021 GWh / annum would be enough to meet the equivalent total heating requirements of approximately 60,000 average homes. The associated potential CO_2 displacement would be approximately 270,000 tonnes / annum.

Another way to show the range of potential CO_2 emissions savings which could be achieved by District heating and WTE is shown below. Table 6.1 compares the CO_2 emissions from various fuels and clearly highlights the fuel sources, which are a bigger source of CO_2 emissions. Using the current power plant mix as a basis for the 'carbon footprint' of electrical heating shows that this form of home heating is by far the biggest emitter of CO_2.

However, it can also be seen from Table 6.1 that if CHP technology is used and the heat generated from the process is utilised in a DH network the CO_2 emissions attributable to the home heated with DH are lower than for natural gas heating – even when 'offset' electrical power (due to operation in CHP mode) is sourced from the power plant mix.

The small, but growing, contribution from renewables in the Irish Energy Market sees the projected carbon intensity of the power plant mix reducing. This in turn will result in a further reduction in CO_2 emissions if CHP technology was used in conjunction with a DH network.

If a DH network is further developed in Dublin, there would be potential CO_2 displacement of approximately 80,000 – 665,000 tonnes / annum. This is based on figures on Table 6.1, which shows the 'cleanest' and 'dirtiest' fuel sources in relation to CO_2 production.

The above range of figures is considered to be a more realistic target for heat related quantities of CO_2 displaced for the Dublin WTE plant. The full development of a DH network in the City as is envisaged by Dublin City Council could allow the plant to achieve its full potential for CO_2 emissions reduction. This is considerably larger than described above

[5] Energy in Ireland 1990 – 2005, SEI, 2006

Table 6.1: Equivalent CO_2 Emissions associated with heating the 'Average Irish Home'

Fuel	Quantity Required	Units	Quantity Required	Units	CO_2 emissions (tonnes CO_2)
Natural Gas	1,960,173	scm	20,891	kWh	4.14
Coal	2.91	tonnes	22,487	kWh	7.31
Wood Pellets	5.62	tonnes	28,108	kWh	Neutral
Electricity (1)	17,753	kWh	17,753	kWh	11.08
Electricity (2)	17,753	kWh	17,753	kWh	10.30
District Heating (3)	17,753	kWh	17,753	kWh	2.22
District Heating (4)	17,753	kWh	17,753	kWh	2.06
District Heating (5)	17,753	kWh	17,753	kWh	1.35
District Heating (6)	17,753	kWh	17,753	kWh	0

Note:
(1) Based on Current Power Plant Mix (SEI, 2004)
(2) Based on Projected Power Plant Mix for 2010 (SEI, 2004)
(3) Based on Current Power Plant Mix and 5:1 ratio of heat gained: reduced electrical output under CHP
(4) Based on Projected Power Plant Mix for 2010 and 5:1 ratio of heat gained : reduced electrical output under CHP
(5) Based on CCGT Power Plant and 5:1 ratio of heat gained : reduced electrical output under CHP
(6) Based on WTE CHP Facility

6.4 EFFECT OF DISTRICT HEATING ON WATER COOLING

DH can reduce the need for water-cooling for power plants and waste to energy facilities.

For example, with respect to the operation of the WTE facility in CHP mode, the connection of the facility to the DH network will also reduce the requirement to discharge cooling water to the Liffey River, as some of the excess heat will be exported by the DH system. It is expected that the quantity of water required for cooling will decrease proportionally with the increased use of heat exported from the WTE in the DH system (e.g. for a heat production of 50MWth, the quantity required for water cooling would be reduced by 33%, this could increase to over 90% if 150 MWth are produced by the WTE).

Connecting the Poolbeg Power Stations to the district heating network will also reduce the requirement to discharge cooling water to the Liffey. The quantity of water required for cooling will decrease proportionally with the export of heat from the Power Stations into the district heating.

6.5 DISTRICT HEATING NETWORK EFFICIENCY

The efficiency of a DH system depends on the effective functioning of each of its components:

- **Production** of heat by DH boilers
- **Distribution** through the network of pipes, and
- **Consumption** in DH-heated buildings

Production

Losses associated with *heat production* can reach 30% - a much higher figure than should be achievable using existing technology. Reducing production losses could improve efficiency by 10% to 12% in newer boilers and up to 35% in older ones.

Depending on the particular DH boilers, the following renovations should be considered to improve heat production efficiency:

- Replacing burners and burning technologies;
- Intensifying furnace heat exchange;
- Converting to gas-fired boilers;
- Introducing technical improvements to increase heat production efficiency.

Distribution

Heat loss during transmission between the point of production and the end-user may range from 8% to 25%, depending on the length of the system. Modern methods of laying and insulating pipe could result in fuel savings of up to 22%, and consequent significant GHG emission reductions.

Factors affecting heat distribution efficiency include pipe insulation and network design. There have been many advances in insulation technology in recent years, and installation of pre-insulated pipe has become an attractive option in many situations. For newer systems, in addition to pipe insulation, important efficiency considerations include pipeline length, type, and installation method.

Consumption

Poorly insulated buildings can lose from 30% to 50% of their heat to the environment.

The main objective is establishing a system that provides incentives for consumers to save energy - the demand side management. There are numerous ways to increase the efficiency at the consumer side, some more cost effective than others, these include:

- Installing of heat meters in buildings and individual apartments
- Installing of heat controls in buildings and individual apartments
- Installing or replacing pipe insulation
- Installing or replacing attic, basement and roof insulation
- Renovating or replacing building exterior doors and staircase windows
- Renovating or replacing doors between apartments and common areas.

Summary

Improving DH systems at the production, distribution, and consumption stages can result in significant energy cost savings and reduced greenhouse gas emissions. The efficiencies for the current study are calculated based on total heat sale and total fuel consumption including fuel consumption at the reference power plant related to the lost power production at the WtE. The results are presented in Table 6.2.

Table 6.2: Dublin DH Network Efficiency

	Units	Scenario 1	Scenario 2	Scenario 3
Heat sale	[MWh/year]	111,640	107,094	301,569
Fuel consumption (Gas)	[MWh/year]	59,138	141,959	179,339
Overall efficiency	[%]	188.8	75.4	168.2

The significant efficiencies for scenario 1 and 3 can be explained by the large share of heat production from WtE, where extraction of heat only affects the overall fuel consumption with a contribution necessary for balancing the reduced power production due to the steam extraction required for producing the heat supply in scenario 1 and scenario 3 respectively.

In the calculations the reduced power production caused by the heat extraction is assumed to be produced at a reference power plant (natural gas), which respective fuel consumption has been included in the calculation of the overall efficiencies. The reduced power production at the WTE caused by the heat extraction has been estimated to be 20 % of the heat extraction (0.2 kWh power per 1 kWh heat extraction).

6.6 IMPACT ON TRAFFIC

The DH network during its construction phase will result in implications on the traffic situation. To approach major consumers public roads are normally the only access. The disruption associated with bringing DH to any of the developments mentioned above will be similar to any utility works in the City.

Much of the proposed outline route for DH transmission mains from Poolbeg to the Docklands Area is not already built upon or is removed from the most busy traffic areas. In the zones to be redeveloped, the pipelines may be installed in parallel with other construction work. This should result in a minimisation of traffic disruption.

The main potential for disruption will be in the area of the North Quays and the major transmission line along the route from Docklands to Westgate via Pearse Street, College Course, Dame Street, Lord Edward Street, Christ Church Place, High Street, Corn Street, Thomas Street and James Street. However, this can be managed as for other services, which have been installed there in recent years.

In order to prevent additional impacts on traffic, synergy with other infrastructure development or renewal should be explored (e.g. water mains renewals, road resurfacing, Construction of the Metro in Dublin etc.)

6.7 FUEL FLEXIBILITY

DH allows the efficient use of surplus heat from “low grade” combined heat and power plants (CHP), refuse incineration plants, waste heat from industrial processes, natural geothermal heat sources, and fuels which are more easily used centrally including renewables like wood waste and residues, as well as coal and peat.

Using indigenous fuels like biomass or waste enhances fuel supply reliability, security and flexibility. Generating power nearer to population centres also increases power grid reliability.

DH networks also provide competition between different heat sources and fuels and can therefore be an important element in liberalised energy markets. In large-scale integrated DH systems, all available heat sources can compete to the benefit of the consumers who are united as a bulk buyer. That way DH ensures a high degree of fuel flexibility, thus increasing the overall security of supply to the actual DH customers.

District Heating and Fuel Flexibility in Copenhagen

By using the different fuels and utilising the different heat sources, the DH system in Copenhagen managed to ensure high security of DH supply to the capital of Denmark, throughout its long history of operation (beginning in 1903).

The first steps in the construction of the Copenhagen DH system – as we know it today – were taken more than 100 years ago. From being a small system based on heat coming from one waste incineration plant, through using coal, lignite and peat during the First and Second World War, today it has developed in a flexible DH system. As a consequence of the energy crisis in the 1970s, increased focus was put on the need for fuel flexibility. Thus natural gas was introduced as an additional fuel. Today the DH system in Copenhagen is an excellent example, showing what the concept ”District Heating” actually is. About 30 % of the annual DH demand is covered with surplus heat from waste incineration, and the remaining production of DH is based on geothermal energy and fuels as wood pellets, straw, natural gas, oil and coal.

6.8 REDUCTION IN FUEL IMPORT DEPENDENCY

The development of DH networks when coupled with the use of indigeneous fuels could lead to a reduction in Ireland's external energy dependency. This will increase both the revenue generated by the production of energy in this country but also increase the security of Ireland's energy supply and decreasing Ireland's dependency on fuel import.

For example, the heat supplied by the proposed WTE facility at Poolbeg can replace conventional energy sources. Every kWh of heat from a DH network supplied by a WTE facility represents a saving of natural resources and a potential reduction of imported fuel.

In the case of Scenario 1 this equals to 10.2 M standard cubic metres (scm) of gas or 9,435 tonnes of oil equivalent (toe). If 150 MW_{th} were exported from the proposed WTE facility at Poolbeg to supply the base load of a DH network, this would replace approximately 94M scm of natural gas or 8.6 M toe.

The displacement of conventional heating by the DH system will not only reduce cost to consumers but also reduce their exposure to a highly volatile international gas market and reduce Ireland's dependency on imported gas.

6.9 COMBATING FUEL POVERTY AND IMPROVING COMPETITIVENESS

By providing heat at a price competitive with gas heating, a DH network should help to combat fuel poverty and improve competitiveness of Irish businesses by reducing their energy bill.

7 CONCLUSIONS

The publication of the report 'The Barriers and Opportunities for District Heating in Ireland', SEI (2002) was an expression of a national strategic interest in developing CHP and district heating capacity in Ireland for reasons (mainly) of energy efficiency and sustainability. Dublin City Council has acted in response to the key findings of this report i.e. without a 'champion' for district heating, it is unlikely to 'take off'. Dublin City Council is in a unique position to act as a catalyst for district heating development in Dublin and has commissioned RPS and COWI the feasibility of installing a district heating network in Dublin.

The findings of the feasibility study are presented below:

- **Scenario 1 - Dublin Docklands**: A DH scheme initially based on the concentrated redevelopment in the Docklands Area, the proximity and the inexpensive heat provided by the proposed WTE has strong technical and economic potential.

- **Scenario 2 - Westgate:** The development of a network at Westgate is possible but will be very sensitive to the price at which heat will be supplied to the DH system.

- **Scenario 3 - Citywide District Heating Network:** The development of a citywide network is possible but will also be very dependent on the price at which heat will be supplied to the DH system. In order for the network to expand it will critical to secure further sources of heat.

7.1 TECHNICAL

- District heating is a fully controllable and reliable utility service similar to electricity and water supply. District heating customers in Continental Europe appreciate thermal energy being supplied as a commodity. This saves DH customers both the investment and the space for their own boiler equipment (and its operation and maintenance).

- The maximum thermal output from the proposed Waste to Energy (WTE) plant will have the potential to supply the average annual heating requirements of 60,000 homes through the installation of a district heating network. With the propagation of the network, and the potential future increase in thermal output, the number of houses that could be supplied by the WtE facility could be considerably larger. This in turn would see increased environmental and economic benefits for the district heating project.

- The present study describes the first phases of the introduction of a major district heating network which will serve Dublin City with a new utility in an environmentally sound way. This project, if successful, could serve as a flagship development for similar projects nationwide.

- The development of heat demand in district heating networks will also allow the viability of heat supply from existing potential heat sources to be re-examined (e.g. power stations in Poolbeg).

7.2 ENVIRONMENTAL

- Combined Heat and Power (CHP) can contribute significantly to reductions in CO_2 emissions. The development of a district heating network is essential for the successful harnessing of the large thermal resource which is available from WTE.

- In the wider area under study (Scenario 3), up to 32,000 tonnes per annum of CO_2 could potentially be saved if district heating is implemented as planned. This represents more than 20% of the target a 0.162 Mt reduction in CO_2 emissions resulting from CHP as set out in the National Climate Change Strategy 2007 - 2012. The development of the district heating network can therefore contribute positively to meeting Ireland's obligations under the Kyoto Protocol.

- The Dublin District Heating Project will help to achieve a low-cost path for CO_2 equivalent emissions reduction and sustainability by providing what will be an innovative service in an Irish context.

- The displacement of conventional heating by the District Heating system will not only reduce cost to consumers but also reduce their exposure to a highly volatile international gas market and reduce Ireland's dependency on imported gas. It will also increase both the revenue generated by the production of energy in this country and add to the security of supply of the Irish energy market.

- The replacement of conventional fuels for heating with district heating will also improve the local air quality by reducing the number of sources of emissions locally in a development.

- In the context of the implementation of the Energy Performance of Buildings Directive and of Part L Building Regulation, the utilisation of Block and District Heating, particularly that derived from a CHP installation, will prove valuable to consumers. This is done by increasing the rating of their home in comparison to conventionally heated buildings of a comparable nature in terms of their construction and energy usage profile.

- District heating can reduce the need for water-cooling for power plants and waste to energy facilities.

- The District Heating network during its construction phase will have traffic impacts in a busy city. Use of public roads to provide distribution pipework to DH customers will be unavoidable. The disruption associated with bringing district heating to any of the developments mentioned above will be similar to any utility works in the City.

7.3 ECONOMIC

- A District Heating scheme supplied with waste heat from power generation (e.g. from the proposed WTE facility, Gatepower) will be competitive with traditional gas heating.

- The three scenarios examined all show an operational profit and an acceptable payback period for Dublin City Council (as illustrated in Table 8.1).

Table 8.1: Economic Results for each Scenario

	Scenario 1	Scenario 2	Scenario 3
Total Investment Million €	21.5	14.9	56.9
Payback	8 years	8 years	10 years
Accumulated Result Million €	61.8	10.8	132.8
Internal Rate of Return 20 years	16.4%	8.4%	17.5%
Internal Rate of Return 10 years	7.8%	-4.4%	2%

- The project should be attractive to building developers who appreciate the advantage and value of having energy efficiency as a primary performance requirement for their developments.

- The impending implementation of the Energy Performance of Buildings Directive (EPBD), which specifically refers to district Heating/Block Heating and CHP as fuel sources, will also create an added-value to district heating customers when their building is being rated. As the Buildings Directive is implemented and its effects are felt throughout the building sector the value attributable to having a higher rating will create an added attractiveness for potential district heating customers. It is anticipated that this value will also extend to Developers where a new development, which is more energy efficient and has a higher rating will achieve a higher sales figure, thus increasing the attractiveness of incorporating district heating into new build developments.

- Following the commissioning of the WTE facility the project will be attractive as a business venture for Energy Supply Companies.

- Sensitivity analyses show that the two major parameters, which will have an influence on the operational economic performance of the District Heating Scheme, are the price at which heat will be sold to district heating customers and the purchase price at which heat will be bought from the proposed Waste to Energy facility. Scenario 1 is less sensitive to variations in major parameters than Scenario 2.

7.4 DH MANAGEMENT OPTIONS

In the Dublin District Heating model a key role in the development of DH systems will be played by DCC. The fixed assets of the DH network will be leased by DCC to an energy supply company (ESCO) which will then be responsible for running the business including, for example, investing in maintaining and developing the fixed assets as well as billing.

DCC will be responsible for:

- Providing an organisational framework,
- Financing network development and expansion,
- Selling heat from the WTE,
- Facilitating the network development through planning,
- Price regulation and representing the interests of individual heat consumers.

By its involvement in local energy planning, DCC will optimise energy supply costs to the end users.

7.5 RECOMMENDATIONS

Based on this feasibility study, and certain preconditions described within, it is recommended that Dublin City Council progress plans to establish a district heating supply serving the Dublin Docklands Area (Scenario 1). To achieve the successful operation of the network modeled in Scenario 1, the following steps should be taken, as illustrated in the basic roadmap shown below:

	Phases	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	Feasibility										
2	Development of Block Heating Network										
3	Development of first branch from gas boiler station										
4	Establishment of gas boiler station										
5	First customer connections										
6	Development of other branch to WTE										
7	First supply from WTE										
8	Expansion of network to other Docklands customers										

Heat Supply

- An Bord Pleanála issued a decision to grant permission for the thermal waste treatment facility on the 14th of November 2007, with a condition that the detailed design of the facility made provision for the development of a district heating system. On the 22nd of November 2007, the EPA issued a Proposed Decision (PD) for the thermal treatment facility with a condition that, prior to operation, proposals for operation of the facility in Combined Heat and Power mode be made to the agency with a view to providing heat for a district-heating scheme. Therefore, the proposed Waste to Energy plant in Poolbeg must be designed and configured to allow the supply of heat to a district heating network.

- Dublin City Council's utilisation of waste heat from this facility will demonstrate the advantages of CHP that can be achieved from other sources in the same area i.e. from other power plants. This could result in greater gains for a fully developed system. Considering the nearby location of the Poolbeg Peninsula in relation to the high density redevelopment in the city centre and the need to increase the overall efficiency of power production, the feasibility of converting the existing power plants to operate as CHP facilities should be examined. This could be examined as phase two of this feasibility, but will require more detailed investigation of these potential heat suppliers.

- Also, considering that the proposed WTE facility is still in the planning process and that potential heat demand in the Docklands may exceed the supply of heat from the WTE, Dublin City should explore further the availability of other sources of heat (e.g. Gatepower/Guinness CHP and the Synergen and ESB power stations)..

- Dublin City Council should progress the development of a peak load / reserve boiler station. This boiler station will supply all heat needed during the district heating system's first period and will allow the establishment of a customer base prior to the commissioning of the proposed WTE facility. It will also function as a peak-load and reserve boiler station when a separate base-load provider is established.

Network Development

Dublin City Council and the Department of the Environment should ensure that consideration is given at an early stage to installing heat mains as part of the utility infrastructure. In some instances there may be justification for preserving routes for heat mains in order that the district heating network can be extended. This could be achieved by the creation of a standard for utility routing within new areas.

Dublin City Council should also examine the potential synergies of integrating the district heating network with existing services. In particular

- The development of the district heating network should use information collected for the routing of other services (e.g. Docklands Rising Mains Study and the Dublin Region Watermains Rehabilitation Project).

- The examination of the proposed Dart Underground Interconnector, with stops at Docklands, Pearse, St Stephen's Green, Christchurch and Heuston Stations, presenting opportunities to expand the district heating network main transmission lines to the western part of the City. If the developments were combined this would mitigate some of the impacts of having the two developments progressed separately.

- The identification any abandoned service routes for district heating and examine the possibility of re-routing other services.

Consumers

Dublin City Council should encourage developers to explore the possibility of using sustainable heating in the City and act to coordinate this at the Planning Stage. This is especially relevant where proposed developments are large and located within range of the proposed district heating network. This can be achieved through:

- Incorporation of specific proactive measures in the Dublin Energy Management Plan that support more sustainable energy solutions.

- Development of a Guideline / Guidance Note for Planners in DCC (and other local authorities) that informs them of the availability of district heating solutions and the opportunities presented by CHP and the proposed Dublin WTE Project.

- Development of a 'Model Clause' that DCC planners can incorporate into forthcoming Local Area Plans and Area Action Plans.
- Further development of mapping of the area that can be served by the proposed district heating network for use by planners and inclusion in the next City Development Plan. This will stimulate interest and prioritise the attention of planners into relevant development areas. It will also serve to assist planners in developing more solid requirements for the next City Development Plan.

Marketing

Dublin City Council and SEI should:

- Ensure that information on the potential for District Heating is widely disseminated and assist any existing developer wishing to accommodate the technology into their designs,

- Further explore possibilities for supporting and facilitating the development of district heating in the City in these early stages. Once a primary network is established the system can develop and expand on its own.

- Carry out an information campaign that will introduce new developers and the general public to the concept of DH. Run DH workshops that will give developers a chance to see the potential benefits they can achieve by designing any new developments for DH. Market sounding will be very important for the successful propagation of the DH network.

Funding

- Access to finance is a significant barrier to the development of a district heating network. Dublin City Council should examine potential sources of funding for the development of the Dublin District Heating Network. These could include EU and government funding, commercial banks, leasing companies, ESCO etc.

- The Government and in particular the Department of Communications, Marine and Natural Resources should promote DH by providing grant aid to help cover the large capital costs associated with the construction of a DH network. This will encourage local authorities and developers to consider the inclusion of DH in the initial designs of future developments.

- The introduction of a carbon levy could assist to fund projects, resulting in significant reduction of greenhouse gas emissions.

    - Dublin City Council should examine the possibility of looking for financial contribution from developers to towards the provision of District Heating as a part of the public infrastructure as defined in the Planning and Development Act, 2000.

7.6 FUTURE EXPANSION OF THE NETWORK

Once a district heating network is established in the Docklands, it is likely that district heating can be propagated further. Other compatible developments will be proposed to join the network. For example, these developments could include:

- Elm Park (located close to Merrion Gates): Elm Park is a large mixed-use development consisting of six large blocks located at Merrion Gates, South East of the Grand Canal Dock. Due to its size, location and the fact that it also incorporates a block-heating network, Elm Park would provide a large heat demand and market for the Dublin district heating network at the southern edge of the city centre. It could also form a stepping-stone to the connection of potential users in Ballsbridge and University College Dublin.

- The Dublin Dockland Development Authority is currently preparing a Planning Scheme for the Poolbeg Peninsula, which is currently characterised by utility and amenity uses. An area detailed Urban Design Framework has yet to be finalised, but once approved by the Minister it will result in the regeneration and redevelopment of this area, with a consequent heat demand.

- Development at the Dublin Port site - A recent publication on the future development of Dublin Port entitled *A Report on Dublin Bay – An Integrated Economic, Cultural and Social Vision for Sustainable Development* outlines a proposal to relocate the existing Dublin Port and develop this 260 hectare area to accommodate up to 55,000 domestic and commercial residents. This high density proposal is targeted for 2050 living with construction over 25 years, encompassing the growing demand for city centre housing and projected greater shipping needs. The close proximity to the Poolbeg Waste to Energy plant and high density of this proposal make it ideal for district heating connection.

- It is likely that older or established developments could also be connected to the district heating network, as opposed to just new buildings and developments availing of the scheme. However, such connections could be made when existing equipment is replaced and when the option of an existing district heating network is available. Older housing in the Ringsend and Irishtown areas of the south city or Eastwall on the north would be typical examples of older housing in close proximity to the waste to energy plant, which could avail of the district heating scheme. This option would provide cheaper heat to the existing community.

Similarly as the number of connected customers grows, the network will require additional heat providers. This heat could be supplied by the power plants at Poolbeg, which are currently generating heat as by-product and requires cooling. This should be taken into consideration when these plants will be upgraded, as this will increase their efficiency and is likely to reduce their carbon dioxide emissions.

APPENDIX A

Organisations Contacted

Organisations Contacted

Buro Happold / The Point Village

CB Richard Ellis

CODEMA

Dalkia

Fingleton & White

Dublin City University

Dublin City Council Engineering

Dublin City Council Facilities Civic Offices

Dublin City Council Planning

Dublin Zoo, Phoenix Park

Edina Ltd

Environmental Protection Agency

ESB

JJ Rhatigan / Heuston South Quarter

LGM Ireland

Logstor

MacArdle MacSweeney / Spencer Docks

Mater Hospital

Saint James Hospital

Sustainable Energy Ireland

Synergen

Temp Technology

Trinity College Dublin

University College Dublin

Varming

APPENDIX B

Scenario 1 - Dublin Docklands District Heating Network

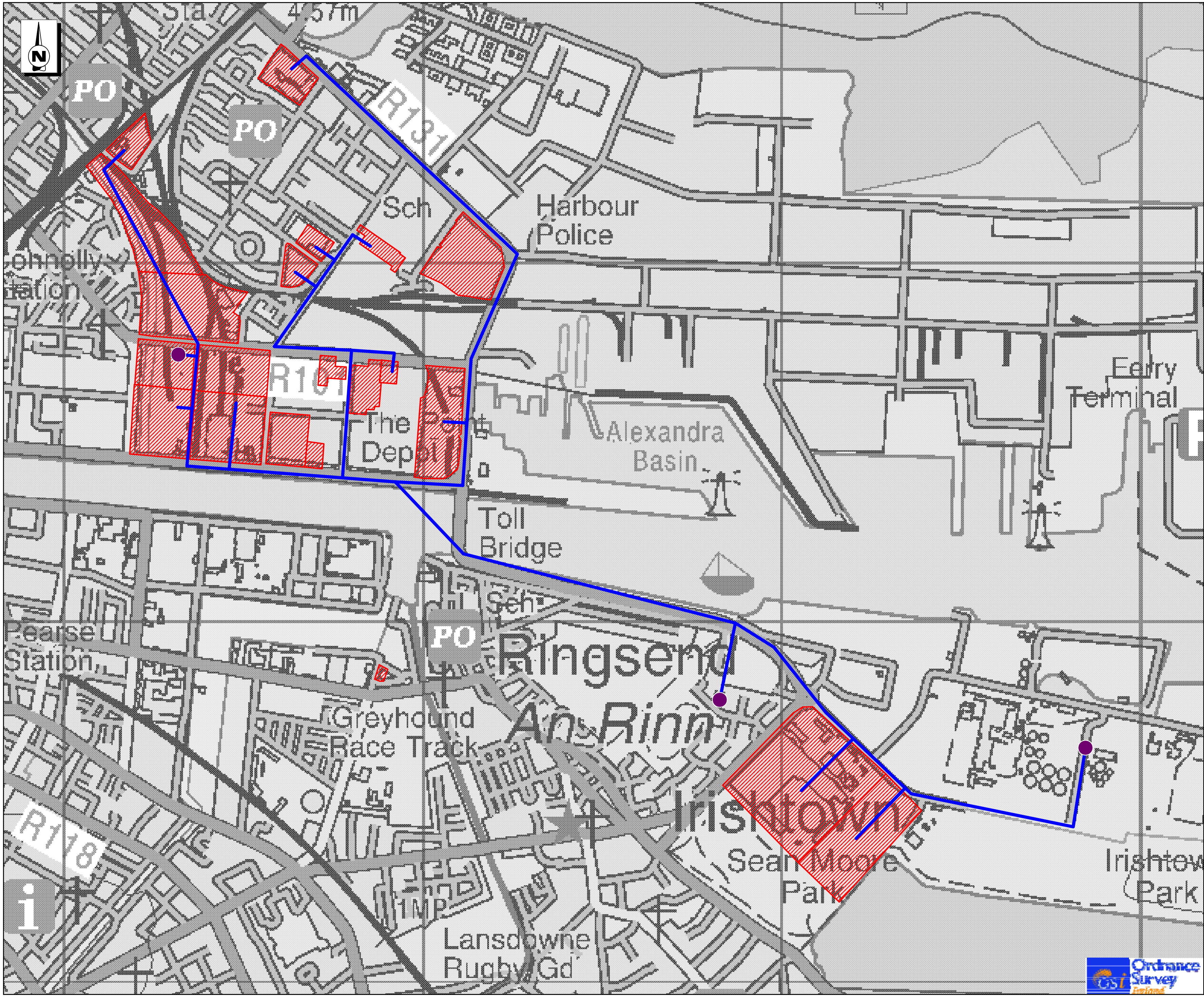
B1 District Heating Network and Connected Heat Consumers

B2 District Heating Network Pipes Size

B3 Business Model

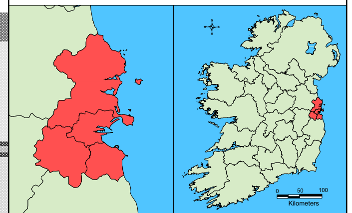
B4 Consumer Model

B5 Results Summary



Legend

- Proposed Heat Users
- District Heating Pipes
- Heat Sources



Dublin City Council
Comhairle Cathrach Bhaile Átha Cliath

Project:

Dublin District Heating Project

Title:

SCENARIO 1
Dublin Docklands District Heating Network

COWI

RPS Consulting Engineers

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Issue Details

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Date: May 2007			

Notes

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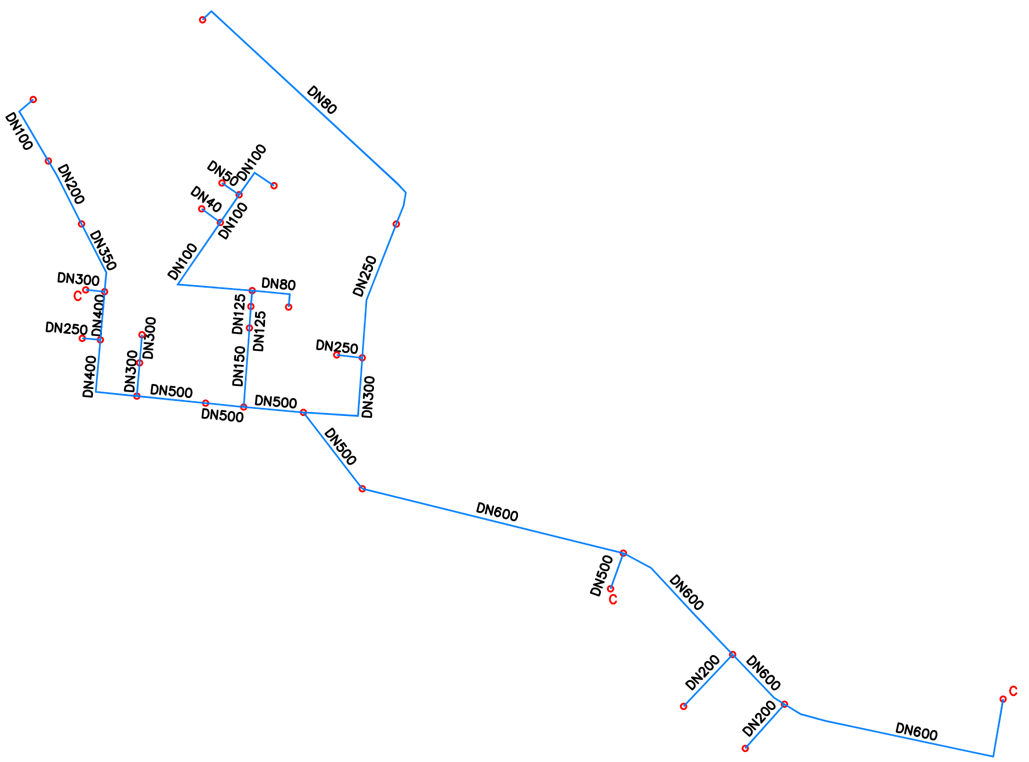


Legend:

District Heating Pipes

Heat Sources

Dublin City Council

Dublin District Heating Project
2007 Feasibility Study

Scenario 1
Dublin Docklands
District Heating Network

COWI District Heating Network Dimensions

Appendix B3: Scenario 1 Business Economic Model for Dublin Docklands District Heating Network

Main Results: District Heating and Natural Gas Heating

Heat Purchase cost ex WTE:	EUR/MWh]	7.0
Heat Charge:	-	48.5

Energy& emissions for 20 years

			District Heating	Individual N-gas	Difference
Fuel Consumption					
	Natural gas	[MWh]	319,872	2,106,790	-1,786,917
	Reference power plant, N-gas	-	912,950		912,950
			1,232,822	2,106,790	-873,967
Reduced emission	CO_2	[ton]	252,975	432,313	-179,338
	NOx	-	666	1,138	-472
	SO_2	-	0	0	0

Economy

Investments, total	21.5 mill. EUR
Loan term	15 years
1. Simple payback time (starting year 2008)	8 years
2. Financed investment with 20-years annuity,	
- result over 20-years evaluation period	Negative till year 2013 - hereafter positive
- accumulated result after 20 years (price level 2007)	61.8 mill. EUR
3. Internal rate of return (20 years)	16.4%
4. Internal rate of return (10 years)	7.5%

Consumer Economy

		Year 2012 Excl. VAT	
1. District heating	[€/Year]	15,078	
2. Individual natural gas heating	-	16,857	
3. Difference	-	-1,779	-10.6%

Appendix B4: Scenario 1 Business Economic Model for Dublin Docklands District Heating Network

Evaluation Period				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
				2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Projection																							
Heat Demand, net at consumer																							
Connected to network			MWh	0	0	76,000	76,000	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640
Heat supply from DH system			MWh	0	0	76,000	76,000	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640
Fuel Consumption																							
District Heating Supply																							
Heat loss in network		18%	MWh	0	0	16,683	16,683	24,506	24,506	24,506	24,506	24,506	24,506	24,506	24,506	24,506	24,506	24,506	24,506	24,506	24,506	24,506	24,506
Heat Production (dh an net)		Sum	MWh	0	0	92,683	92,683	136,147	136,147	136,147	136,147	136,147	136,147	136,147	136,147	136,147	136,147	136,147	136,147	136,147	136,147	136,147	136,147
Division of production	Dublin WTE Plant		[%]	0.0	0.0	0.0	0.0	50.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0
	Central boiler station, 45 MW		[%]	0.0	0.0	100.0	100.0	50.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Division of production	Dublin WTE Plant, net		MWh	0	0	0	0	68,073	133,424	133,424	133,424	133,424	133,424	133,424	133,424	133,424	133,424	133,424	133,424	133,424	133,424	133,424	133,424
	Transmission loss	5%	MWh	0	0	0	0	3,583	7,022	7,022	7,022	7,022	7,022	7,022	7,022	7,022	7,022	7,022	7,022	7,022	7,022	7,022	7,022
	Dublin WTE Plant, gross		MWh	0	0	0	0	71,656	140,446	140,446	140,446	140,446	140,446	140,446	140,446	140,446	140,446	140,446	140,446	140,446	140,446	140,446	140,446
	Central boiler station, 45 MW		MWh	0	0	92,683	92,683	68,073	2,723	2,723	2,723	2,723	2,723	2,723	2,723	2,723	2,723	2,723	2,723	2,723	2,723	2,723	2,723
Fuel consumption	Heat recovery - WTE Plant	100%	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	N-gas - Central boiler station	92%	MWh	0	0	100,742	100,742	73,993	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960
Fuel consumption		Sum	MWh	0	0	100,742	100,742	73,993	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960	2,960
Economy, District Heating																							
Price prerequisite																							
Fuel prices,																							
	N-gas, Central boiler station		[EUR/MWh]	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4
	Standing charge		[EUR/year]	0	0	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871
District Heating																							
	Heat charge		[EUR/MWh]	**48.50**	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50
	Standing charge		[EUR/m²/year]	**1.15**	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
	-		[EUR/meter/year]	**50.00**	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
WtE Plant	Heat purchase		[EUR/MWh]	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***
Investments,																							
WTE Plant - Heat recovery			[EUR x 1000]	0	0	1,050	1,050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumping station			[EUR x 1000]	315	315	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DH boiler station			[EUR x 1000]	3,455	3,455	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DH network			[EUR x 1000]	4,767	4,767	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Liffey tunnel - valves, supports, ets.			[EUR x 1000]	100	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DH connection and branch fee			[EUR x 1000]	0	0	1,392	0	653	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Investment total			[EUR x 1000]	8,637	8,637	2,497	1,050	653	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operation & Maintenance,																							
Central boiler station	[EUR/MWh-gas]	2.1	[EUR x 1000]	0	0	212	212	155	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
District Heating network	[% of investment]	0.5	[EUR x 1000]	43	86	99	104	107	107	107	107	107	107	107	107	107	107	107	107	107	107	107	107
Elec. expenses/aux. Energy	[EUR/MWhprod.]	0.31	[EUR x 1000]	0	0	29	29	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42	42
O&M total			-	43	86	339	345	305	156	156	156	156	156	156	156	156	156	156	156	156	156	156	156
Operational result																							
Heat charge			[EUR x 1000]	0	0	3,686	3,686	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415	5,415
Standing charge			[EUR x 1000]	0	0	712	712	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047	1,047
Income, total			[EUR x 1000]	0	0	4,398	4,398	6,461	6,461	6,461	6,461	6,461	6,461	6,461	6,461	6,461	6,461	6,461	6,461	6,461	6,461	6,461	6,461
Fuel costs			[EUR x 1000]	0	0	-3,677	-3,677	-2,703	-117	-117	-117	-117	-117	-117	-117	-117	-117	-117	-117	-117	-117	-117	-117
Operation & maintenance			[EUR x 1000]	-43	-86	-339	-345	-305	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156	-156
Heat purchase, Waste to Energy Plant			[EUR x 1000]	0	0	0	0	-502	-983	-983	-983	-983	-983	-983	-983	-983	-983	-983	-983	-983	-983	-983	-983
Operational result			[EUR x 1000]	-43	-86	382	377	2,951	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205
Simple payback																							
Investment			[EUR x 1000]	-8,637	-8,637	-2,497	-1,050	-653	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DH connection and branch fee, consumer payments			[EUR x 1000]	0	0	1,392	0	653	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Result, incl. operation			[EUR x 1000]	-8,680	-8,723	-723	-673	2,951	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205	5,205
Result, accumulated			[EUR x 1000]	-8,680	-17,403	-18,126	-18,798	-15,847	-10,642	-5,436	-231	4,975	10,180	15,386	20,591	25,796	31,002	36,207	41,413	46,618	51,824	57,029	62,234
Financing																							
Capital costs (interest and payback)			[EUR x 1000]	-889	-1,757	-1,828	-1,891	-1,845	-1,800	-1,756	-1,713	-1,672	-1,631	-1,591	-1,552	-1,514	-1,477	-1,441	-792	-159	-77	0	0
Cash account			[EUR x 1000]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Result, incl. operation			[EUR x 1000]	-932	-1,843	-1,445	-1,514	1,106	3,405	3,449	3,492	3,534	3,575	3,614	3,653	3,691	3,728	3,764	4,413	5,046	5,129	5,205	5,205
Cash accout, interest			[EUR x 1000]	-28	-113	-217	-315	-350	-250	-52	127	271	420	572	728	888	1,052	1,220	1,404	1,617	1,849	2,087	2,330
Result, accumulated			[EUR x 1000]	-960	-2,893	-4,485	-6,204	-5,297	-2,012	1,435	5,019	8,702	12,484	16,365	20,347	24,429	28,613	32,899	37,914	43,653	49,566	55,649	61,828

Loan		Cash account, interest		Inflation	
Interest	6.00%	deficit	6.00%		2.50% p.a
Term, years	15	profit	4.00%		
Price	100				

Appendix B5: Scenario 1 Business Economic Model for Dublin Docklands District Heating Network

Consumer category: Industry/service

Heat demand	210	[MWh/year]		
Heat load	150	[kW]	Year 2012	Year 2012
Heated area	2,206	[m2]		
Number of meters	1	[pcs.]	Excl. VAT [EUR/year]	Incl. VAT (12.5%) [EUR/year]

District Heating

Heat Charge								54.56
Heat purchase	210	[MWh/year]	at	48.5	[EUR/MWh]	=	10,164	11,434
Standing charge	2,206	[m²]	-	1.15	[EUR/m²]	=	2,541	2,859
	1	[Meters]	-	50.0	EUR/meter/year	=	50	56
Operation & Maintenance	210	[MWh]	-	1.2	[EUR/MWh]	=	242	272
Annual heat cost, total							12,997	14,621
Investment								
DH connection and branch fee	25.9	[EUR/kW]		3,879	[EUR]			
DH consumer installations	133.3	[EUR/kW]		19,995	-			
				23,875	-			
Financing, annuity payment	kurs	100	6%	20	[years]	=>	2,081	2,342
Annual heat costs and financing costs, total							15,078	16,963

Conventional Natural Gas Heating

							Year 2012	Year 2012
Gas boiler efficiency:	92.0%						Excl. VAT [EUR/year]	Incl. VAT (12.5%) [EUR/year]
Natural Gas Tariffs (ex vat)	0.04136	[EUR/kWh]						
Natural Gas Purchase								
Natural Gas Consumption	227,781	[kWh]	at	0.04136	[EUR/kWh]		9,421	10,599
Standing charge	1	[Meters]	-	145.44	[EUR/meter]		145	164
Operation & Maintenance	209,559	[kWh]	-	0.0100	EUR/kWh		2,098	2,361
Annual heat cost, total							11,665	13,123
Investment								
Gas LPHW, boiler, pumps, boiler panels etc.	325	[EUR/kW]		48,720	[EUR]			
Gas connection + metering system	72	-		10,836				
				59,556	-			
Financing, annuity payment	Price	100	6%	20	[years]	=>	5,192	5,841
Annual heat costs and financing costs, total							16,857	18,964
Heat price, natural gas				0.080	EUR/kWh			

Difference

District heating supply - Individual natural gas heating	-1,779	-2,002

APPENDIX C

Scenario 2 - Westgate District Heating Network

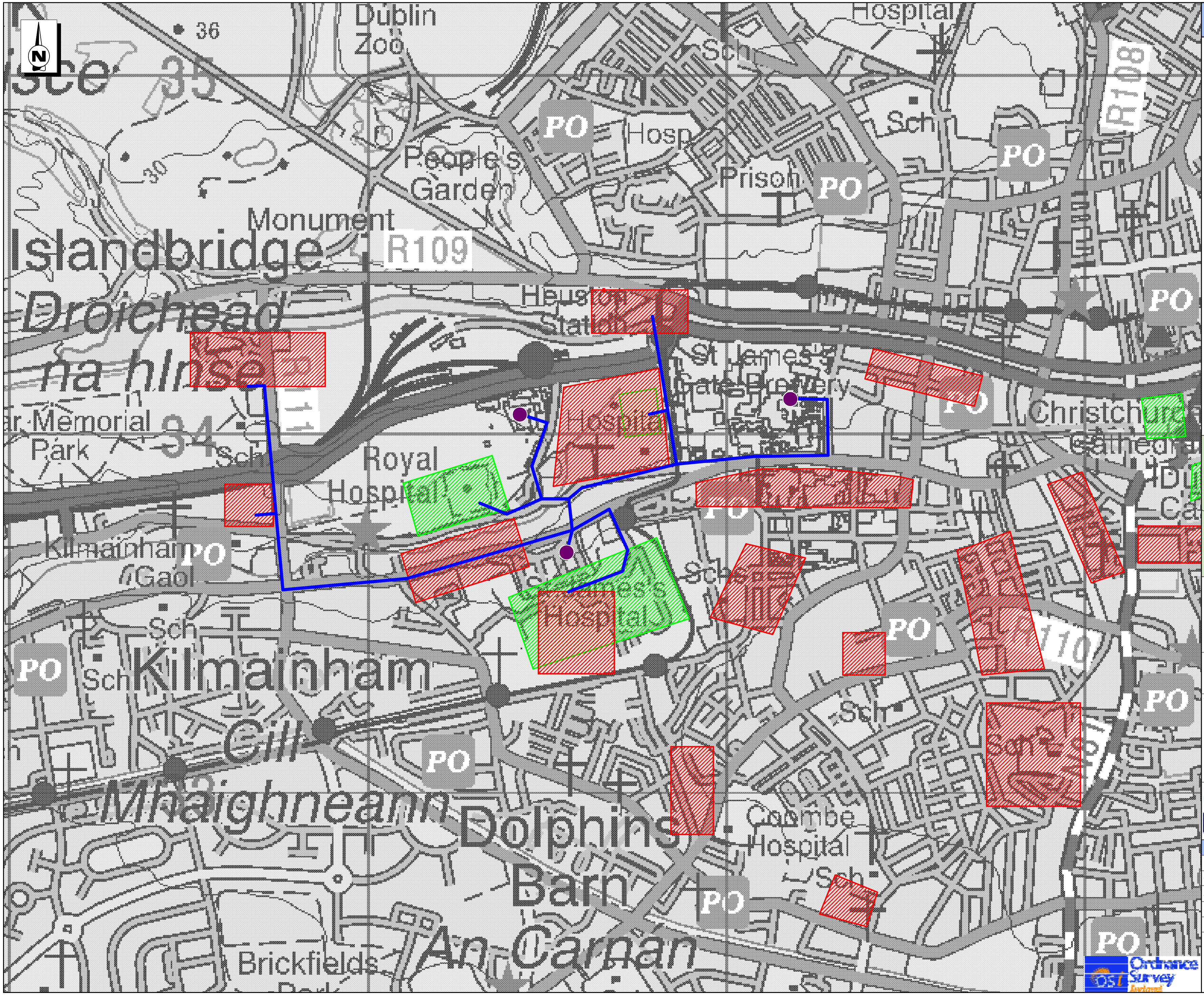
C1 District Heating Network and Connected Heat Consumers

C2 District Heating Network Pipes Size

C3 Business Model

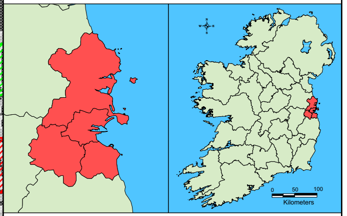
C4 Consumer Model

C5 Results Summary



Legend

- Proposed Heat Users
- Existing Heat Loads
- District Heating Pipes
- Heat Sources



Dublin City Council
Comhairle Cathrach Bhaile Átha Cliath

Project:

Dublin District Heating Project

Title:

SCENARIO 2
Westgate District
Heating Network

COWI
RPS Consulting Engineers

Carnegie House
Dun Laoghaire
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Issue Details

Drawn: RH		**Project No.** MDE0128	
Checked: OG		**File Ref.**	
Approved: OG		MDE0128MI0010D01	
Scale: 1/5,000 @ A1		**Drawing No.**	**Rev.**
Date: May 2007		MI0010	D01

Notes

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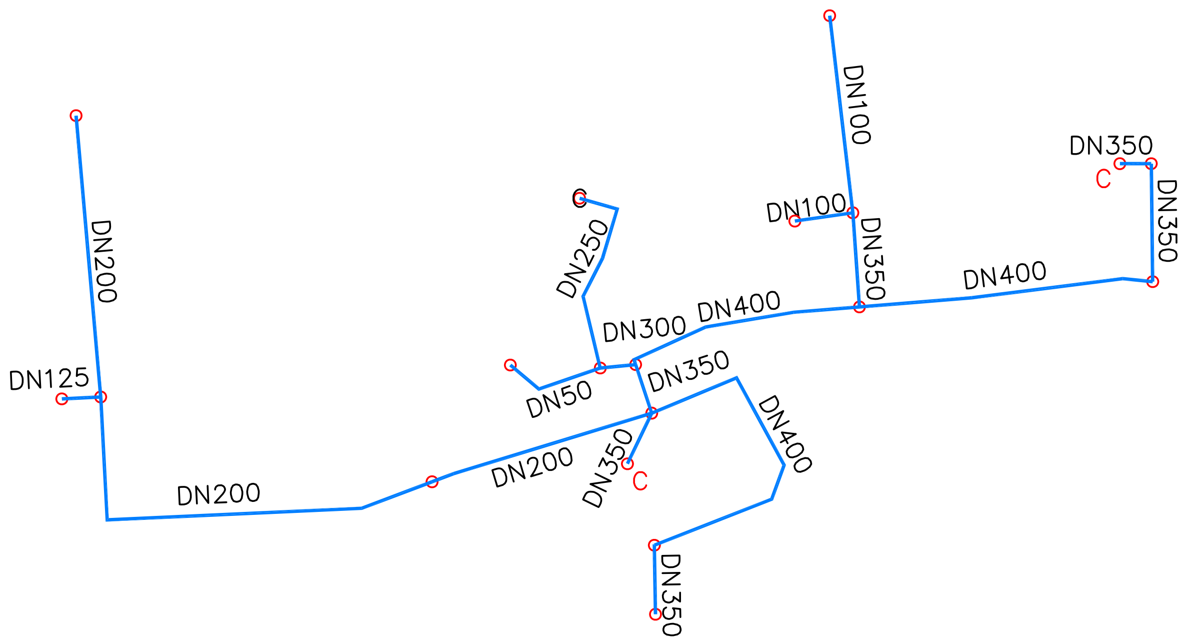


Legend:

District Heating Pipes
Heat Sources

Dublin City Council

Dublin District Heating Project
2007 Feasibility Study

Scenario 2
Westgate
District Heating Network

COWI District Heating Network Dimensions

Appendix C3: Scenario 2 Model Results for a Citywide District Heating Network

Main Results: District Heating and Natural Gas Heating

Specific heat demand	[kWh/m2 per year]	95
Heat Purchase cost ex WTE:	EUR/MWh]	20.6
Heat Charge:	-	40.0

Energy & emissions for 20 years

			District Heating	Individual N-gas	Difference
Fuel Consumption					
	Natural gas	[MWh]	535,664	1,704,536	-1,168,873
	Reference power plant, N-gas	-	0		0
			535,664	1,704,536	-1,168,873
Reduced emission	CO_2	[ton]	426,550	349,771	76,779
	NOx	-	521	920	-400
	SO_2	-	0	0	0

Economy

Investments, total	14.9 mill. EUR
Loan term	20 years
1. Simple payback time (starting year 2006)	8 years
2. Financed investment with 20-years annuity,	
- result over 20-years evaluation period	Negative till year 2014 - hereafter positive
- accumulated result after 20 years (price level 2006)	10.8 mill. EUR
3. Internal rate of return (20 years)	8.4%
4. Internal rate of return (10 years)	-4.4%

Consumer Economy

		Year 2011 Excl. VAT	
District heating	[€/Year]	12,851	
Individual natural gas heating	-	16,857	-
Difference	-	-4,006	-

Appendix C4: Scenario 2 Business Economic Model for a Citywide District Heating Network

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Evaluation Period				2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Projection																							
Heat Demand, net at consumer																							
Westgate			-	0	0	36,621	44,792	52,962	61,133	69,303	77,474	83,398	89,322	95,246	101,170	107,094	107,094	107,094	107,094	107,094	107,094	107,094	107,094
Westgate, total			-	0	0	36,621	44,792	52,962	61,133	69,303	77,474	83,398	89,322	95,246	101,170	107,094	107,094	107,094	107,094	107,094	107,094	107,094	107,094
Heat Demand, connected to DH net																							
Westgate, connected to DH net			MWh	0	0	36,621	44,792	52,962	61,133	69,303	77,474	83,398	89,322	95,246	101,170	107,094	107,094	107,094	107,094	107,094	107,094	107,094	107,094
Fuel Consumption																							
District Heating Supply																							
Heat loss in network		18%	MWh	0	0	8,039	9,832	11,626	13,419	15,213	17,006	18,307	19,607	20,908	22,208	23,508	23,508	23,508	23,508	23,508	23,508	23,508	23,508
Heat Production (dh an net)		Sum	MWh	0	0	44,660	54,624	64,588	74,552	84,516	94,480	101,705	108,929	116,154	123,378	130,603	130,603	130,603	130,603	130,603	130,603	130,603	130,603
Division of production	Gatepower		[%]	0.0	0.0	90.0	88.0	86.0	84.0	82.0	80.0	78.0	76.0	74.0	72.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
	Peak and reserve, natural gas		-	0.0	0.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Division of production	Gatepower		MWh	0	0	40,194	48,069	55,546	62,624	69,303	75,584	79,330	82,786	85,954	88,832	91,422	91,422	91,422	91,422	91,422	91,422	91,422	91,422
	Transmission loss	0%	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gatepower, gross		-	0	0	40,194	48,069	55,546	62,624	69,303	75,584	79,330	82,786	85,954	88,832	91,422	91,422	91,422	91,422	91,422	91,422	91,422	91,422
	Peak and reserve, natural gas		-	0	0	4,466	6,555	9,042	11,928	15,213	18,896	22,375	26,143	30,200	34,546	39,181	39,181	39,181	39,181	39,181	39,181	39,181	39,181
Fuel con-sumption	Gatepower	100%	-	0	0	40,194	48,069	55,546	62,624	69,303	75,584	79,330	82,786	85,954	88,832	91,422	91,422	91,422	91,422	91,422	91,422	91,422	91,422
	Peak and reserve, natural gas	92%	-	0	0	4,854	7,125	9,829	12,966	16,536	20,539	24,321	28,416	32,826	37,550	42,588	42,588	42,588	42,588	42,588	42,588	42,588	42,588
Fuel consumption		Sum	MWh	0	0	45,048	55,194	65,374	75,589	85,839	96,123	103,650	111,202	118,780	126,382	134,010	134,010	134,010	134,010	134,010	134,010	134,010	134,010

Appendix C4: Scenario 2 Business Economic Model for a Citywide District Heating Network

Evaluation Period		1 2008	2 2009	3 2010	4 2011	5 2012	6 2013	7 2014	8 2015	9 2016	10 2017	11 2018	12 2019	13 2020	14 2021	15 2022	16 2023	17 2024	18 2025	19 2026	20 2027
Economy, District Heating		150 dkk/MWH		20																	
Price prerequisite																					
Fuel prices,																					
Biomass	[EUR/MWh]	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
N-gas, Central boiler station	[EUR/MWh]	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4
Standing charge	[EUR/year]	0	0	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871
District Heating																					
Heat charge	[EUR/MWh]	**40.00**	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Standing charge	[EUR/m²/year]	**0.95**	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
-	[EUR/meter/year]	**50.00**	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Gatepower Heat purchase	[EUR/MWh]	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***	***20.60***
Investments,																					
Gatepower, 30 MW	[EUR x 1000]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heuston - Peak and reserve, natural gas	-	2,300	2,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. James - Peak and reserve, natural gas		1,900	1,900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DH pumping station	-	315	315	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DH network		0	1,545	1,545	59	59	59	59	59	59	59	59	59	59	0	0	0	0	0	0	0
DH connection and branch fee	-	0	0	741	165	165	165	165	165	120	120	120	120	120	0	0	0	0	0	0	0
Investment total	-	4,515	6,060	2,286	224	224	224	224	224	179	179	179	179	179	0	0	0	0	0	0	0
Operation & Maintenance,																					
Peak and reserve, natural gas	[EUR/MWh-gas]	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Biomass	[% of investment]	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Elec. expenses/aux. energy	[EUR/MWhprod.]	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
DH Network	[% of investment]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Peak and reserve, natural gas	[EUR x 1000]	0	0	10	15	20	27	34	43	51	59	68	78	89	89	89	89	89	89	89	89
District Heating network	-	0	8	15	16	16	16	17	17	17	18	18	18	18	18	18	18	18	18	18	18
Elec. expenses/aux. energy	-	0	0	14	17	20	23	26	29	32	34	36	38	41	41	41	41	41	41	41	41
O&M total	-	0	8	39	48	57	66	77	89	99	110	122	135	148	148	148	148	148	148	148	148
Operational result																					
Heat charge	[EUR x 1000]	0	0	1,465	1,792	2,118	2,445	2,772	3,099	3,336	3,573	3,810	4,047	4,284	4,284	4,284	4,284	4,284	4,284	4,284	4,284
Standing charge	-	0	0	365	446	528	609	690	772	831	890	949	1,008	1,067	1,067	1,067	1,067	1,067	1,067	1,067	1,067
Income, total	-	0	0	1,830	2,238	2,646	3,054	3,463	3,871	4,167	4,463	4,759	5,055	5,351	5,351	5,351	5,351	5,351	5,351	5,351	5,351
Fuel costs	-	0	0	-186	-268	-367	-481	-611	-757	-894	-1,044	-1,204	-1,376	-1,559	-1,559	-1,559	-1,559	-1,559	-1,559	-1,559	-1,559
Operation & maintenance	-	0	-8	-39	-48	-57	-66	-77	-89	-99	-110	-122	-135	-148	-148	-148	-148	-148	-148	-148	-148
Heat purchase, Gatepower	-	0	0	-828	-990	-1,144	-1,290	-1,428	-1,557	-1,634	-1,705	-1,771	-1,830	-1,883	-1,883	-1,883	-1,883	-1,883	-1,883	-1,883	-1,883
Operational result	[EUR x 1000]	0	-8	777	932	1,079	1,217	1,347	1,468	1,539	1,603	1,662	1,714	1,760	1,760	1,760	1,760	1,760	1,760	1,760	1,760
Simple payback																					
Investment	[EUR x 1000]	-4,515	-6,060	-2,286	-224	-224	-224	-224	-224	-179	-179	-179	-179	-179	0	0	0	0	0	0	0
DH connection and branch fee, consumer payments	-	0	0	741	165	165	165	165	165	120	120	120	120	120	0	0	0	0	0	0	0
Result, incl. operation	-	-4,515	-6,068	-769	873	1,020	1,158	1,288	1,409	1,480	1,544	1,603	1,655	1,701	1,760	1,760	1,760	1,760	1,760	1,760	1,760
Result, accumulated	-	-4,515	-10,583	-11,352	-10,479	-9,459	-8,301	-7,013	-5,604	-4,124	-2,579	-977	679	2,380	4,141	5,901	7,661	9,421	11,182	12,942	14,702
Financing																					
Capital costs (interest and payback)	[EUR x 1000]	-465	-1,078	-1,210	-1,187	-1,164	-1,142	-1,120	-1,099	-1,078	-1,058	-1,038	-1,019	-1,000	-975	-952	-607	-162	-48	-43	-37
Cash account	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Result, incl. operation	-	-465	-1,085	-434	-255	-85	75	227	369	461	546	624	695	760	785	809	1,153	1,598	1,712	1,718	1,723
Cash accout, interest	-	-14	-61	-110	-135	-150	-156	-154	-143	-124	-99	-68	-31	11	44	77	118	175	245	318	393
Result, accumulated	-	-479	-1,614	-2,118	-2,456	-2,631	-2,648	-2,511	-2,224	-1,833	-1,342	-753	-71	702	1,514	2,362	3,575	5,261	7,090	8,953	10,850

Loan		Cash account, interest		Inflation	
Interest	6.00%	deficit	6.00%		2.50% p.a
Term, years	15	profit	4.00%		
Price	100				

Appendix C5: Scenario 2 Consumer Economic Model for a Citywide District Heating Network

Consumer category	Industry/service								
	Heat demand	210	[MWh/year]						
	Heat load	150	[kW]					Year 2012	Year 2012
	Heated area	2,206	[m2]						
	Number of meters	1	[pcs.]					Excl. VAT [EUR/year]	Incl. VAT (12.5%) [EUR/year]
District Heating									
Heat Charge									45.00
Heat purchase		210	[MWh/year]	at	40.0	[EUR/MWh]	=	8,382	9,430
Standing charge		2,206	[m²]	-	0.95	[EUR/m²]	=	2,096	2,358
		1	[Meters]	-	50.0	EUR/meter/year	=	50	56
Operation & Maintenance		210	[MWh]	-	1.2	[EUR/MWh]	=	242	272
Annual heat cost, total								10,770	12,116
Investment									
	DH connection and branch fee	25.9	[EUR/kW]		3,879	[EUR]			
	DH consumer installations	133.3	-		19,995	-			
					23,875	-			
Financing, annuity payment		kurs	100	6%	20	[years]	=>	2,081	2,342
Annual heat costs and financing costs, total								12,851	14,458

Conventional Natural Gas Heating								Year 2012	Year 2012
Gas boiler efficiency:		92.0%						Excl. VAT [EUR/year]	Incl. VAT (12.5%) [EUR/year]
Natural Gas Tariffs (ex vat)		0.04136	[EUR/kWh]						
Natural Gas Purchase									
Natural Gas Consumption		227,781	[kWh]	at	0.04136	[EUR/kWh]		9,421	10,599
Standing charge		1	[Meters]	-	145.44	[EUR/meter]		145	164
Operation & Maintenance		209,559	[kWh]	-	0.0100	EUR/kWh		2,098	2,361
Annual heat cost, total								11,665	13,123
Investment									
	Gas LPHW, boiler, pumps, boiler panels etc.	325	[EUR/kW]		48,720	[EUR]			
	Gas connection + metering system	72	-		10,836				
					59,556	-			
Financing, annuity payment		Price	100	6%	20	[years]	=>	5,192	5,841
Annual heat costs and financing costs, total								16,857	18,964
Heat price, natural gas					0.080	EUR/kWh			
Difference									
District heating supply - Individual natural gas heating								-4,006	-4,507

APPENDIX D

Scenario 3 - Citywide District Heating Network

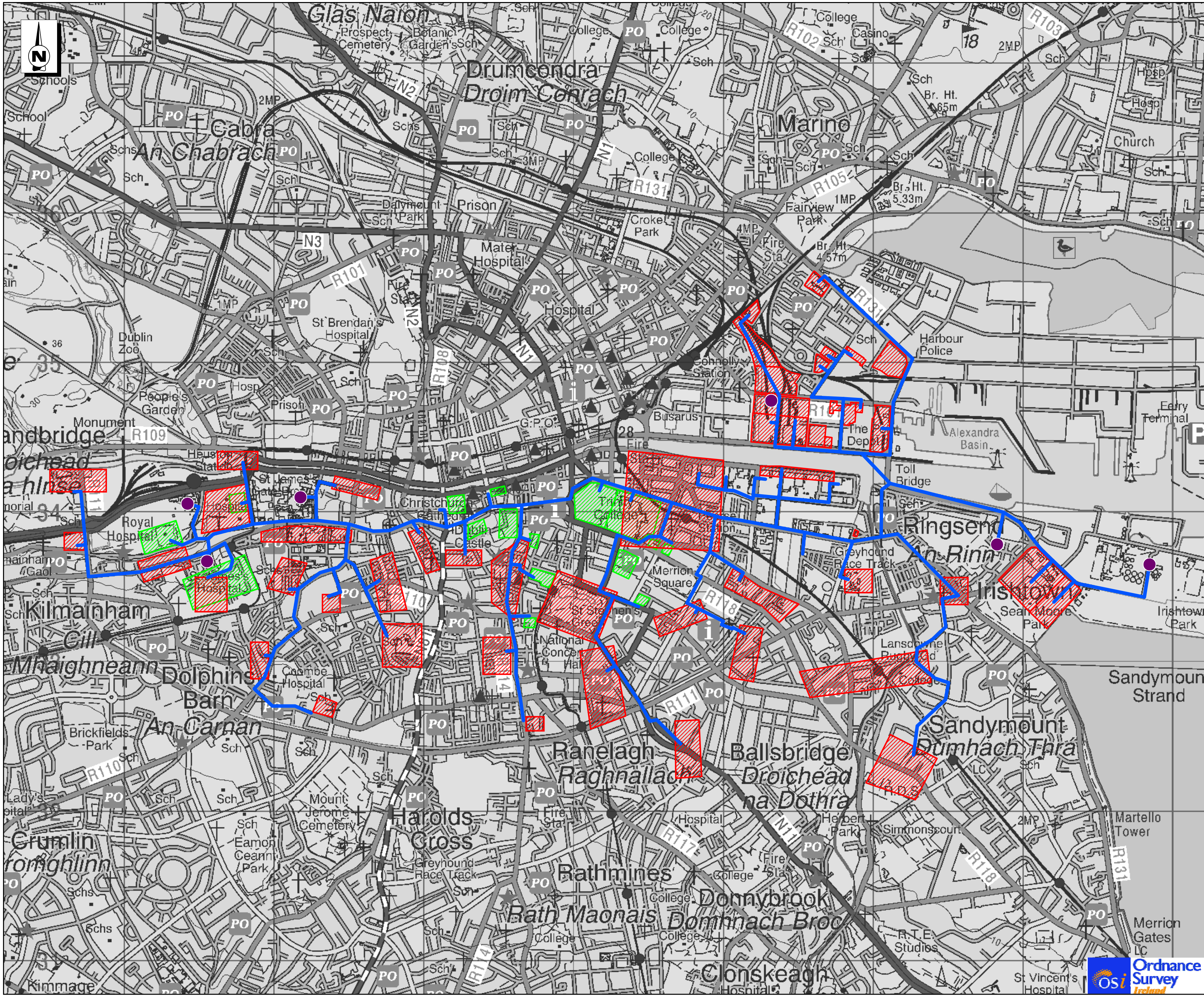
D1 District Heating Network and Connected Heat Consumers

D2 District Heating Network Pipes Size

D3 Business Model

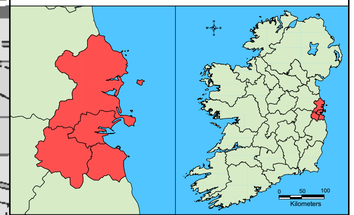
D4 Consumer Model

D5 Results Summary



Legend

- Proposed Heat Users
- Existing Heat Loads
- District Heating Pipes
- Heat Sources



Dublin City Council
Comhairle Cathrach Bhaile Átha Cliath

Project:

Dublin District Heating Project

Title:

SCENARIO 3
Citywide District
Heating Network

COWI
RPS Consulting Engineers

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Issue Details

Drawn: RH		**Project No.**	MDE0128
Checked: OG		**File Ref.**	
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Date: May 2007		MI0008	D01

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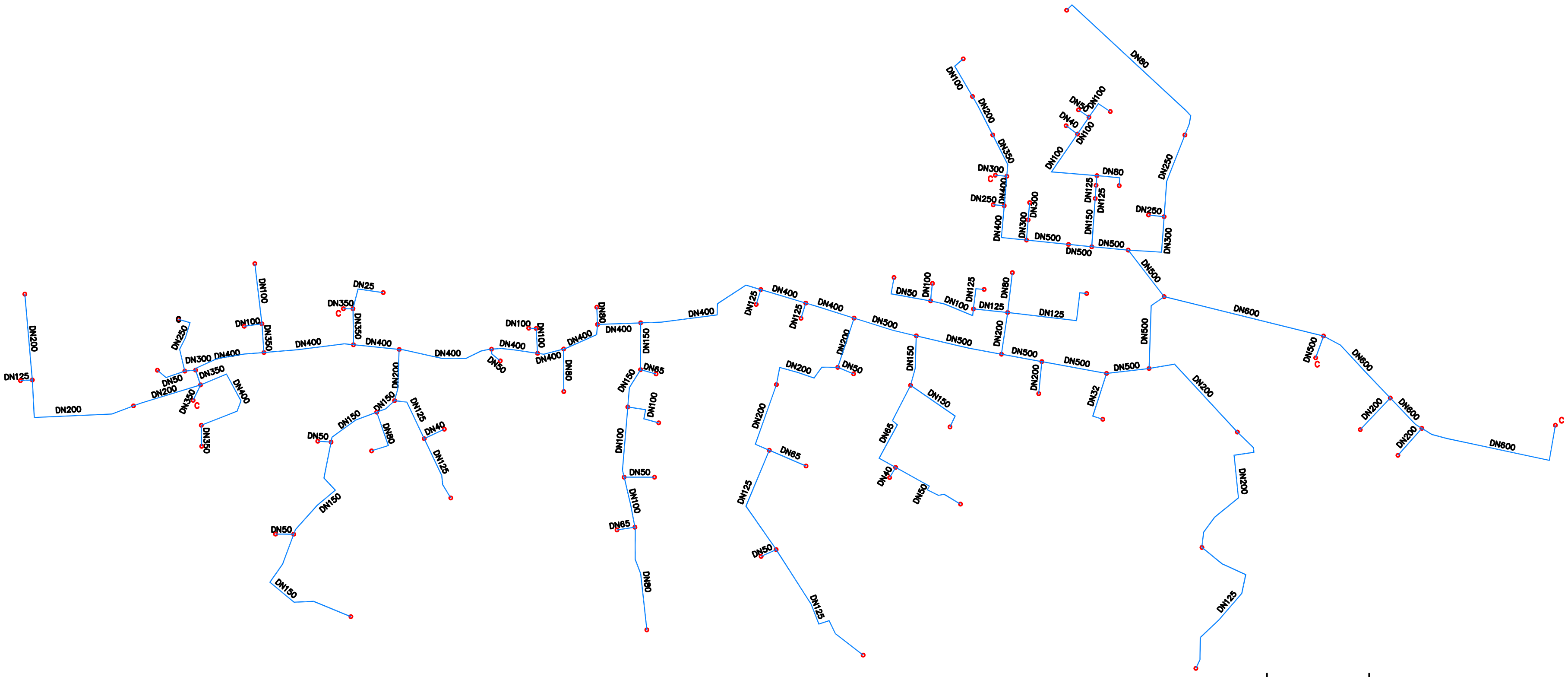

Legend:

District Heating Pipes

Heat Sources

Dublin City Council

Dublin District Heating Project
2007 Feasibility Study

Scenario 3
Citywide
District Heating Network

COWI

District Heating
Network Dimensions

Appendix D3: Scenario 3 Model Results for a Citywide District Heating Network

Main Results: District Heating and Natural Gas Heating

Specific heat demand	[kWh/m2 per year]	95
Heat Purchase cost ex WTE:	EUR/MWh]	7.0
Heat Charge:	-	48.5

Energy & emissions for 20 years

			District Heating	Individual N-gas	Difference
Fuel Consumption					
	Natural gas	[MWh]	694,935	4,433,576	-3,738,641
	Reference power plant, N-gas	-	1,899,022		1,899,022
			2,593,957	4,433,576	-1,839,619
Reduced emission	CO_2	[ton]	512,576	909,770	-397,194
	NOx	-	1,401	2,394	-993
	SO_2	-	0	0	0

Business Economy

Investments, total	56.9 mill. EUR
Loan term	15 years
1. Simple payback time (starting year 2008)	10 years
2. Financed investment with 20-years annuity,	
- result over 20-years evaluation period	Negative till year 2013 - hereafter positive
- accumulated result after 20 years (price level 2007)	132.8 mill. EUR
3. Internal rate of return (20 years)	17.5%
4. Internal rate of return (10 years)	2.0%

Consumer Economy

		Year 2011 Excl. VAT	
District heating	[€/Year]	15,078	
Individual natural gas heating	-	16,857	-
Difference	-	-1,779	-

Appendix D4: Scenario 3 Business Economic Model for a Citywide District Heating Network

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Evaluation Period				2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Projection																							
Heat Demand, net at consumer																							
Dublin Ducklands North Development			MWh	63,475	72,423	76,000	76,000	111,500	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640	111,640
Dublin South,			-	9,221	14,799	16,129	16,129	16,129	16,129	75,622	88,891	102,160	115,429	128,697	141,966	151,559	161,151	170,743	180,336	189,928	189,928	189,928	189,928
Dublin total			-	72,695	87,222	92,129	92,129	127,629	127,770	187,262	200,531	213,800	227,069	240,338	253,607	263,199	272,791	282,384	291,976	301,569	301,569	301,569	301,569
Heat Demand, connected to DH net																							
Dublin total, connected to DH net			MWh	0	0	92,129	92,129	127,629	127,770	187,262	200,531	213,800	227,069	240,338	253,607	263,199	272,791	282,384	291,976	301,569	301,569	301,569	301,569
Fuel Consumption																							
District Heating Supply																							
Heat loss in network		18%	MWh	0	0	20,223	20,223	28,016	28,047	41,106	44,019	46,932	49,844	52,757	55,670	57,775	59,881	61,987	64,092	66,198	66,198	66,198	66,198
Heat Production (dh an net)		Sum	MWh	0	0	112,353	112,353	155,645	155,817	228,369	244,550	260,732	276,913	293,095	309,276	320,974	332,672	344,371	356,069	367,767	367,767	367,767	367,767
Division of production	Dublin WTE Plant		[%]	0.0	0.0	0.0	0.0	50.0	98.0	98.0	98.0	95.8	95.1	94.4	93.6	92.9	92.2	91.5	90.7	90.0	90.0	90.0	90.0
	Peak and reserve, natural gas		-	0.0	0.0	100.0	100.0	50.0	2.0	2.7	3.5	4.2	4.9	5.6	6.4	7.1	7.8	8.5	9.3	10.0	10.0	10.0	10.0
Division of production	Dublin WTE Plant, net		MWh	0	0	0	0	77,823	152,701	223,801	239,659	249,829	263,319	276,575	289,595	298,214	306,664	314,942	323,051	330,990	330,990	330,990	330,990
	Transmission loss	5%	-	0	0	0	0	4,096	8,037	11,779	12,614	13,149	13,859	14,557	15,242	15,695	16,140	16,576	17,003	17,421	17,421	17,421	17,421
	Dublin WTE Plant, gross		-	0	0	0	0	81,919	160,738	235,580	252,273	262,977	277,178	291,132	304,837	313,910	322,804	331,518	340,054	348,410	348,410	348,410	348,410
	Peak and reserve, natural gas		-	0	0	112,353	112,353	77,823	3,116	6,228	8,448	10,903	13,594	16,520	19,681	22,760	26,009	29,428	33,017	36,777	36,777	36,777	36,777
Fuel con-sumption	Heat recovery - WTE Plant	100%	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Peak and reserve, natural gas	92%	-	0	0	122,122	122,122	84,590	3,387	6,770	9,183	11,851	14,776	17,956	21,393	24,739	28,271	31,987	35,888	39,975	39,975	39,975	39,975
Fuel consumption		Sum	MWh	0	0	122,122	122,122	84,590	3,387	6,770	9,183	11,851	14,776	17,956	21,393	24,739	28,271	31,987	35,888	39,975	39,975	39,975	39,975

Appendix D4: Scenario 3 Business Economic Model for a Citywide District Heating Network

Evaluation Period		1 2008	2 2009	3 2010	4 2011	5 2012	6 2013	7 2014	8 2015	9 2016	10 2017	11 2018	12 2019	13 2020	14 2021	15 2022	16 2023	17 2024	18 2025	19 2026	20 2027
Economy, District Heating																					
Price prerequisite																					
Fuel prices,																					
N-gas, Central boiler station	[EUR/MWh]	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4	36.4
Standing charge	[EUR/year]	0	0	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871	8,871
District Heating																					
Heat charge	[EUR/MWh]	**48.50**	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50	48.50
Standing charge	[EUR/m²/year]	**1.15**	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
-	[EUR/meter/year]	**50.00**	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
WtE Plant Heat purchase	[EUR/MWh]	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***	***7.00***
Investments,																					
WTE Plant - Heat recovery, 150 MW	[EUR x 1000]	0	0	1,680	1,680	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Central Boiler Station, 45 MW	-	3,450	3,450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spencer Dock reserve boilers, 20 MW	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gatepower, 30 MW	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
St. James Energy Centre, 20 MW	-	0	0	0	0	1,550	1,550	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heuston Square, 20 MW	-	0	0	0	0	1,550	1,550	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DH network	-	4,767	4,767	55	0	9,425	9,425	474	474	474	474	474	474	474	474	474	474	0	0	0	0
Liffey tunnel - valves, supports, ets.		100	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pumping station	-	315	315	0	0	0	0	0	0												
Booster pump station	-	0	0	0	0	450	450	0	0												
DH connection and branch fee	-	1,340	268	90	0	655	3	1,097	245	245	245	245	245	177	177	177	177	177	0	0	0
Investment total	-	9,972	8,900	1,826	1,680	13,630	12,978	1,570	718	718	718	718	718	650	650	650	650	177	0	0	0
Operation & Maintenance,																					
Peak and reserve, natural gas	[EUR/MWh-gas]	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Elec. expenses/aux. energy	[EUR/MWhprod.]	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
DH Network	[% of investment]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Peak and reserve, natural gas	[EUR x 1000]	0	0	254	254	176	7	14	19	25	31	37	44	51	59	66	75	83	83	83	83
District Heating network	-	24	68	77	86	154	219	227	230	234	238	241	245	248	251	254	258	259	259	259	259
Elec. expenses/aux. energy	-	0	0	35	35	48	49	71	76	81	86	91	96	100	104	107	111	115	115	115	115
O&M total	-	24	68	366	375	378	274	312	326	340	354	370	385	399	414	428	443	456	456	456	456
Operational result																					
Heat charge	[EUR x 1000]	0	0	4,468	4,468	6,190	6,197	9,082	9,726	10,369	11,013	11,656	12,300	12,765	13,230	13,696	14,161	14,626	14,626	14,626	14,626
Standing charge	-	0	0	1,182	1,182	1,638	1,639	2,403	2,573	2,743	2,914	3,084	3,254	3,377	3,500	3,623	3,746	3,870	3,870	3,870	3,870
Income, total	-	0	0	5,650	5,650	7,828	7,836	11,485	12,299	13,113	13,926	14,740	15,554	16,142	16,731	17,319	17,907	18,496	18,496	18,496	18,496
Fuel costs	-	0	0	-4,455	-4,455	-3,089	-132	-255	-343	-440	-547	-663	-788	-910	-1,038	-1,174	-1,316	-1,464	-1,464	-1,464	-1,464
Operation & maintenance	-	-24	-68	-366	-375	-378	-274	-312	-326	-340	-354	-370	-385	-399	-414	-428	-443	-456	-456	-456	-456
Heat purchase, Waste to Energy Plant	-	0	0	0	0	-573	-1,125	-1,649	-1,766	-1,841	-1,940	-2,038	-2,134	-2,197	-2,260	-2,321	-2,380	-2,439	-2,439	-2,439	-2,439
Operational result	[EUR x 1000]	-24	-68	829	820	3,787	6,304	9,269	9,864	10,492	11,085	11,670	12,247	12,636	13,019	13,397	13,768	14,136	14,136	14,136	14,136
Simple payback																					
Investment	[EUR x 1000]	-9,972	-8,900	-1,826	-1,680	-13,630	-12,978	-1,570	-718	-718	-718	-718	-718	-650	-650	-650	-650	-177	0	0	0
DH connection and branch fee, consumer payments	-	1,340	268	90	0	655	3	1,097	245	245	245	245	245	177	177	177	177	177	0	0	0
Result, incl. operation	-	-8,656	-8,700	-906	-860	-9,188	-6,671	8,795	9,391	10,018	10,611	11,196	11,773	12,162	12,546	12,923	13,295	14,136	14,136	14,136	14,136
Result, accumulated	-	-8,656	-17,356	-18,263	-19,122	-28,310	-34,981	-26,186	-16,795	-6,777	3,834	15,031	26,804	38,966	51,512	64,435	77,730	91,866	106,002	120,138	134,275
Finansing																					
Capital costs (interest and payback)	[EUR x 1000]	-889	-1,756	-1,892	-2,019	-3,305	-4,561	-4,498	-4,437	-4,378	-4,320	-4,263	-4,208	-4,154	-4,101	-4,050	-3,338	-2,643	-2,455	-2,276	-1,298
Cash account	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Result, incl. operation	-	-913	-1,824	-1,063	-1,198	482	1,744	4,771	5,427	6,114	6,765	7,407	8,039	8,482	8,918	9,346	10,430	11,494	11,681	11,861	12,839
Cash accout, interest	-	-27	-111	-203	-279	-316	-273	-117	157	393	659	956	1,284	1,638	2,016	2,417	2,855	3,343	3,864	4,401	4,970
Result, accumulated	-	-940	-2,852	-4,049	-5,427	-5,129	-3,533	1,208	6,762	13,104	20,209	28,079	36,717	45,942	55,755	66,159	77,831	90,769	104,101	117,824	132,759

Loan		Cash account, interest		Inflation	
Interest	6.00%	deficit	6.00%		2.50% p.a
Term, years	15	profit	4.00%		
Price	100				

Appendix D5: Scenario 3 Consumer Economic Model for a Citywide District Heating Network

Consumer category	Industry/service								
	Heat demand	210	[MWh/year]						
	Heat load	150	[kW]					Year 2012	Year 2012
	Heated area	2,206	[m2]						
	Number of meters	1	[pcs.]					Excl. VAT [EUR/year]	Incl. VAT (12.5%) [EUR/year]
District Heating									
Heat Charge									54.56
Heat purchase		210	[MWh/year]	at	48.5	[EUR/MWh]	=	10,164	11,434
Standing charge		2,206	[m²]	-	1.15	[EUR/m²]	=	2,541	2,859
		1	[Meters]	-	50.0	EUR/meter/year	=	50	56
Operation & Maintenance		210	[MWh]	-	1.2	[EUR/MWh]	=	242	272
Annual heat cost, total								12,997	14,621
Investment									
	DH connection and branch fee	25.9	[EUR/kW]		3,879	[EUR]			
	DH consumer installations	133.3	-		19,995	-			
					23,875	-			
Financing, annuity payment		kurs	100	6%	20	[years]	=>	2,081	2,342
Annual heat costs and financing costs, total								15,078	16,963
Conventional Natural Gas Heating								Year 2012	Year 2012
Gas boiler efficiency:		92.0%						Excl. VAT [EUR/year]	Incl. VAT (12.5%) [EUR/year]
Natural Gas Tariffs (ex vat)		0.04136	[EUR/kWh]						
Natural Gas Purchase									
Natural Gas Consumption		227,781	[kWh]	at	0.04136	[EUR/kWh]		9,421	10,599
Standing charge		1	[Meters]	-	145.44	[EUR/meter]		145	164
Operation & Maintenance		209,559	[kWh]	-	0.0100	EUR/kWh		2,098	2,361
Annual heat cost, total								11,665	13,123
Investment									
	Gas LPHW, boiler, pumps, boiler panels etc.	325	[EUR/kW]		48,720	[EUR]			
	Gas connection + metering system	72	-		10,836				
					59,556	-			
Financing, annuity payment		Price	100	6%	20	[years]	=>	5,192	5,841
Annual heat costs and financing costs, total								16,857	18,964
Heat price, natural gas					0.080	EUR/kWh			
Difference									
District heating supply - Individual natural gas heating								-1,779	-2,002

APPENDIX E

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