A comparative case study of non technical barriers for combined heat and power and district heating diffusion in Sweden and the United Kingdom

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A comparative case study of non technical barriers for combined heat and power and district heating diffusion in Sweden and the United Kingdom

En jämförande fallstudie mellan Sverige och Storbritannien av icke tekniska barriärer för spridningen av kraftvärme och fjärrvärme

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Uppsala 2007

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ABSTRACT

The subject of this thesis is the non technical drivers and barriers which are observed for the two energy saving technologies Combined Heat and Power (CHP) and District Heating (DH) in the United Kingdom and in Sweden. Due to lack of specific theory applicable to the specific technologies a general theory based in market failure, institutional and technologic diffusion theory has been used for understanding and analysing the market phenomena and for making policy recommendations.

The thesis has been written as a comparative case study comparing two individual market case studies of the UK and Swedish CHP and DH markets. Qualitative data has been collected through a series of interviews which have been analysed using the coding and clustering method developed in Miles and Huberman (1994)

The results from the research show that the formal as well as informal institutional environment on the respective market is of significant importance for the uptake of CHP and DH presently and historically. The current and past policy as well as the information available on a market is important to avoid market failures for CHP and DH. This thesis recommends the use of more mandatory regulations, institutional innovation and stronger financial incentives in the United Kingdom to increase the uptake of CHP and DH.

Key words: *Combined Heat and Power (CHP), District Heating (DH), Institutions, Market failures.*

SAMMANFATTNING

Denna D-uppsats behandlar de icke tekniska drivkrafter och barriärer som har observerats i Storbritannien och Sverige för de energibesparande teknikerna Kraftvärme och Fjärvärme. Uppsatsen är på grund av brist på specifik teori baserad på generisk marknadsmisslyckande, institutionell och teknisk spridnings teori. Denna teori har tillämpats för analys av marknads fenomen och för att göra rekommendationer angående marknadsstyrningar och energi politik.

Uppsatsen är skriven som en jämförande fallstudie av två individuella fallstudier av Sverige respektive Storbritannien. Kvantitativ data har insamlats genom intervjuer i båda länderna vilka senare har blivit analyserade enligt en ”Coding and Clustering” metod utvecklad av Miles and Huberman (1994)

Uppsatsens resultat och slutsats visar att den formella så väl som den informella institutionella miljön är viktig för spridningen av både kraft och fjärrvärme i nutid och historiskt. Nuvarande och dåtida energipolitik och styrmedel tillsammans med den tillgängliga marknadsinformationen är viktiga för att undvika marknadsmisslyckanden för fjärrvärme och kraftvärme. Denna uppsats rekommenderar mer obligatoriska bestämmelser tillsammans med starkare finansiella incitament i Storbritannien för att öka spridningsgraden av kräftvärme och fjärrvärme.

Nyckelord: *Kraftvärme, Fjärrvärme, Institutioner, Marknadsmisslyckanden*

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND TO THE RESEARCH

Different countries have different solutions to energy supply, energy markets and energy production. Some countries are heavily reliant on fossil fuels others on nuclear energy while some have natural endowments allowing them to practise hydro- or wind power. If there where no environmental and resource problems with different approaches to production and consumption of useful energy this thesis would never have been written. Energy which in all cases is a limited resource and by so being needs economizing and to be made into best use suits the definition of the concept of economics: “how to allocate limited resources”. That is why this thesis has been written and why it is based in economic theory and is applying economic theory in an analysis of the UK and Swedish solutions to energy production and delivery systems. Two technologies Combined Heat and Power (CHP) and District Heating (DH) which both are offering great energy savings potential are the main focus of this thesis. The comparatively high Swedish diffusion rate and low UK diffusion rate are what is discussed below.

1.2 THE RESEARCH PROBLEM

Combined Heat and Power (CHP) and District heating (DH) technologies are both technologies which enable a more efficient use of energy by utilising more of the energy content of the fuel used. The two technologies which are interdependent seems because of the high efficiency and relatively low environmental impact to be desirable when they use less resources per useful energy unit produced and are decreasing the negative impact energy consumption has on the environment. The technologies have the ability to use fossil, renewal or waste fuels for generation of useful energy in the form of heat and electricity. Because of CHP’s and DH’s superiority in efficiency and environmental aspects the major research problem, for this thesis, is why the diffusion rate is low in the UK and relatively high in Sweden? If the benefits from the technologies are considerable there is no reason to believe that they should be smaller in the UK than in Sweden, both countries located in the northern part of Europe and both with industrial and domestic demand for heat and electricity. CHP and DH which have been mature for a long time do not have any technical barriers in terms of design and reliability; they are ready and available on the market.

In the study of CHP and DH diffusion a lack of theoretical knowledge has been identified, no theory of CHP and DH diffusion exist presently which is why this thesis is relying on the neoclassical, institutional and technological diffusion theory in appendix I. The research problem has been approached by the use of this theory combined with a literature review of the UK and Swedish CHP and DH markets which together enable the development of a conceptual framework and research questions.

1.3 RESEARCH AIMS OBJECTIVES AND QUESTIONS

The above research problem has been translated in to a specific aim and specific objectives. Because of the maturity of CHP and DH systems non technical barriers have been what the research has been focused on when the technical aspects of the technologies are well understood and can be managed in a cost efficient way. More specific research questions where developed after the literature review. Table 1.1 is stating the aim, objectives and the research questions.

General Aim

- To identify non technical drivers and barriers to the diffusion of Combined Heat and Power (CHP) and District Heating (DH): a comparative case study of the United Kingdom and Sweden.

Specific Objectives

- To identify Economic Theory applicable to energy savings technology in general and CHP and DH technology in particular.
- To identify country specific market characteristics for the CHP and DH markets in the UK and Sweden.
- To understand and identify the institutional and policy environment for CHP and DH in the UK and Sweden.
- To understand and identify the prevailing drivers and barriers for CHP and DH diffusion in the UK and Sweden.

Research Questions (derived form the literature review, chapter two)

- What market failure characteristics characterise the UK and the Swedish CHP and DH markers respectively?
- What are the formal/informal institutional drivers and barriers for CHP and DH in the UK and Sweden?
- How developed is the market for Heat in the UK and Sweden?

Table 1.1 Thesis aim, objective and research question

1.4 SCOPE OF THE RESERCH

This thesis is about how society has through perceptions, organisation, institutions and governance managed to promote the two energy savings technologies CHP and DH. CHP is the technology for simultaneous production of useful heat and power and DH is the technology for providing heat (generally low grade) to buildings connected to a heat distribution system supplied from a central boiler or power station. (STEM 2005) The research has covered economic theory and technological diffusion theory in the lack of specific research related to the technologies. The theory, in appendix I, is the base for the interpretation of the market study carried out in the literature review and the case study of non technical barrier for CHP diffusion. Aspects of economic policy and different institutions are studied in both countries and from the results the conclusion is drawn.

1.5 THESIS STRUCTURE

Table 1.2 is describing the structure of this thesis.

Chapter	Title	Content
1	Introduction	The background to the research and the research problem where the major issues concerning CHP and DH diffusion is presented. The specific aim, objectives and research questions are defined.
2	Literature review	Provides information on CHP and DH technology and the environmental benefits associated. Presents the UK and the Swedish CHP and DH markets including historical development, present state, current policy and the role of institutions. The first conceptual framework is formalised in the end of the chapter. The framework has later been used for formalising and analysing the interviews. A summary of economic theory from appendix I is present in the end of the chapter.
3	Methodology	Details the research methodology and describes how the study has been carried out. The method of data collection and the data analysis is outlined.
4	Results from Case Study Primary Research	Reports the results from the analysed data obtained from the case study interviews. The chapter is ended with the second modified conceptual framework which has been altered according to the research findings.
5	Discussion	Interprets the results and compare the Swedish and the UK markets. Makes policy recommendations for increased CHP and DH diffusion in the UK
6	Conclusion	Presents the main study outcome and looks for fulfilment of the initial aim and objectives.
7	References	The reference list of printed and internet sources.
Appen.	Appendices	A1. Market failure and institutional economic theory is presented together with theory of technological diffusion. A2. Interview transcript A3. Coding and clustering analysis matrix.

Table 1.2 Thesis structure.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is reporting the findings from the literature review. This collected knowledge has been important since it contributes to fulfilling the aim and objectives and provides the based for the research. The main purposes have been to provide the primary research phase with a solid theoretical foundation, to give the reader an overview of CHP technology and to provide a market description of the present market conditions in the UK and Sweden. Relevant economic theory and innovation theory is summarised before the conceptual framework. The theories are outlined in detail in appendix I and are in the framework used to provide structure and connections. The findings from this chapter are providing the research questions for the primary research phase and are also feeding in to the conclusion of this thesis.

2.2 COMBINED HEAT AND POWER, DEFINITION

Combined Heat and Power (CHP) plants produce electricity and recover the waste heat in the same process. CHP technology can use the recovered heat for a wide variety of thermal needs such as hot water, industrial steam and space heating and cooling. Because of the cogeneration of heat and power CHP systems achieve high fuel efficiency (Žižka 2005). The European Commission have in their directive 2004/8/EC "On the promotion of cogeneration based on a useful heat demand in the internal energy market" stated that CHP technologies should have an annual fuel efficiency of a minimum 75-80% (depending on the type of technology) (EU 2006). The directive short tem objectives is to ensure a level playing field for all producers of good quality CHP in Europe, good quality is the definition for CHP with a fuel efficiency at or above the 75-80%. On a medium to long term basis the directive is made to ensure that good quality CHP is considered when new generating capacity is planned in Europe and to promote the technology in markets where it has been relative unsuccessful. (OPET 2006). Below technical and environmental aspects of CHP is covered as well as the relation between CHP and District Heating. The different types of fuels used are also studied.

CHP Technology • Technology for cogeneration of heat and power. • Used in Residential, commercial and industrial buildings as well as in DH • Achieves typically 75-80 efficiency compare to conventional power plants 47% • CHP engines divided in to three different size groups, Micro CHP, Small Scale CHP and Large Scale (DH) CHP.

Table 2.1 CHP technology summery (CHP-Club, DEFRA 2006a, DTI 2005, Carbon Trust 2004)

Figure 2.1 below illustrates the increased energy efficiency of CHP systems.

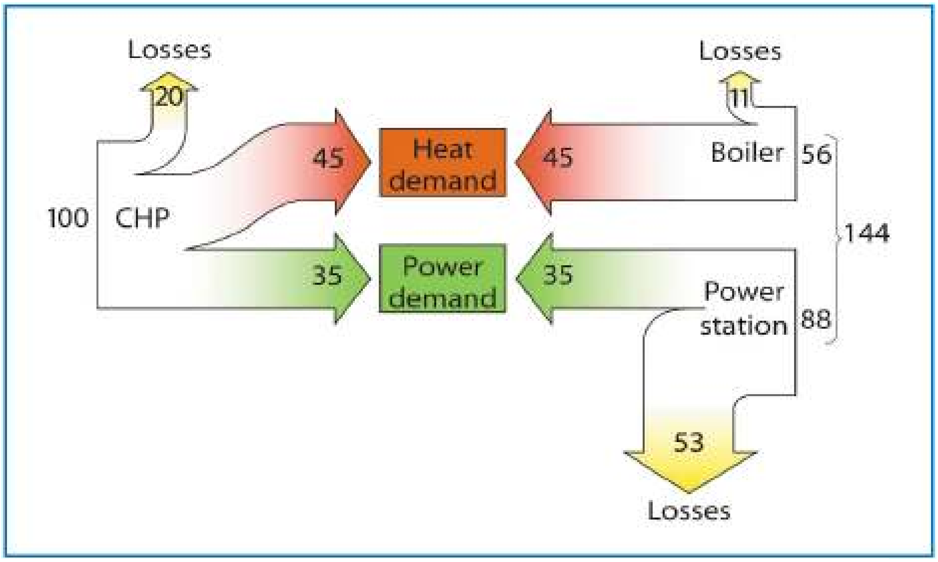


Figure 2.1 energy balance for a typical gas fired CHP engine (Carbon Trust 2004)

2.2.1 THE DIFFERENT FUELS USED IN CHP GENERATION

CHP generators can be run on a large variety of fuels including solids, liquids and gaseous. (Svensk Fjärrvärme 2006). The production utilities on the Swedish CHP market, dominated by large scale district heating networks for heat utilisation are manly using local and non fossil fuels in the production process (STEM 2005). This feature of having rather large and centralised plants have made it possible for utilities to use low grade fuels as waste, wood chips, peat instead of fossil fuels which are dominating the UK market (DTI 2005). This is a general trend, if a system is comprised of a large distribution system or a large single user of the heat produced in a central production facility the ability to use low grade fuels increase (ibid). The UK CHP plants are almost exclusively run on fossil fuels with Natural Gas in a dominant position (DTI 2005). This trend can be seen in all countries using CHP without having large DH systems (Euroheat 2006). Figure 2.2 and 2.3 below is illustrating the fuel mix in the UK and Sweden, it is noticeable that Swedish CHP by 50-55% is run on renewables while renewals comprise of a marginal 2% in the UK.

Natural gas is the most common fuel in CHP plants in mainland Europe, but other fossil fuels as coal and oil are not uncommon (Euroheat 2006). In the former communist countries in the eastern part of Europe coal have been the most important fuel, those systems have however mostly been used for district heating and only in rear cases for CHP production (ibid).

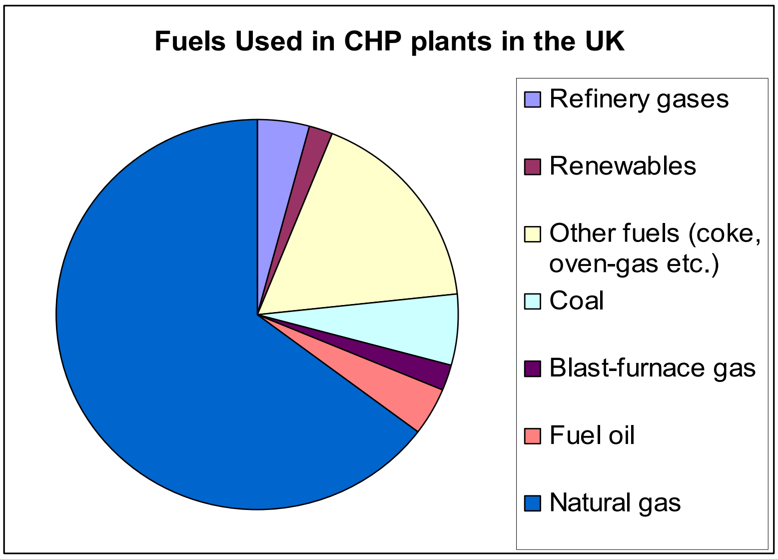


Figure 2.2 The Fuels used in the UK CHP sector. (DTI 2005)

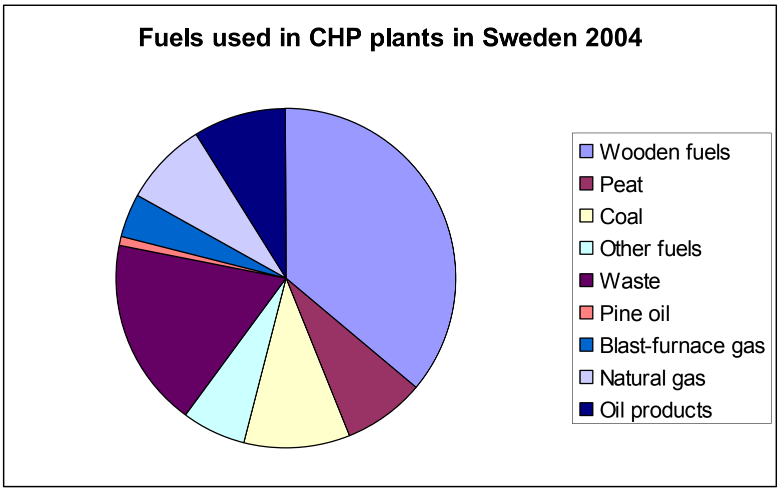


Figure 2.3 Fuels used in the Swedish CHP sector (SCB 2005)

2.2.2 THE ENVIRONMENTAL BENEFITS OF CHP AND DH

Considering that every kilowatt hour (kWh) of electricity generated in an average fossil fuel power utility result in emissions of more than 0.5 kg of CO2 of which 53 % is lost in the cooling towers heat recovery can make environmental improvements. (Carbon Trust 2004 and DTI 2005) If the heat was recovered from the utility and used for heating purposes individual boilers would become unnecessary. The heat demand the average gas fired boiler is catering for by emitting 0.25 kg of CO2 per kWh could be made redundant. If more co-generation where introduced the emissions of sulphur dioxide could be reduced by the closure of the most polluting power plants (Carbon trust 2004).

The construction of a centralised district hearing system where the excess heat from power production can be utilised have benefits compared to individual heating. Local air pollution can avoided by having stringent pollution control on the few production facilities needed which easily can be upgraded with the most resent technical developments and renewal fuels when accessible. (Svensk Fjärrvärme 2006) The opposite can be said about a micro and small scale CHP generation where emissions redistribute from large production facilities in remote regions to urban areas. This can cause some concern for local air quality measures (Thomas 2003). The distribution of heat from a central supply facility is however subjected to losses, if the networks are neglected and poorly maintained they can quickly become highly inefficient. Modern and well maintained networks as the network in Linköping, a very progressive CHP and District Heating city in southern Sweden still experience losses of 12% of heat input (Tekniska Verken 2004ab).

2.2.3 CHP IN RELATION TO DISTRICT HEATING

The growth in CHP capacity has been substantial in the EU over the last years. The trend has been strongest in the countries, which had the strongest growth in District Heating (DH). This suggests that operators which construct new district heating schemes consider application of CHP as a rational and viable solution to enhance energy production and reduce overall costs. (Euroheat 2006) In markets where the existence of heat distribution networks is limited or non existent, small and micro CHP are the most feasible option however. (DEFRA 2004) There are exceptions to the rule of DH as a pre requirement for CHP, the Dutch market where the CHP share of all heat production is 53% only have a 3% DH share. (Euroheat 2006)

An example of a comprehensive national CHP program which has worked is the Finnish where almost 80% of DH heat is produced in combined production. The Finnish example shows that this can be reached by a balanced fuel input and a good viability of the DH and the CHP industry. (Euroheat 2006) The importance of a balanced fuel input has also been pointed out by Swedish authorities where the ability to use waste as a fuel has been emphasised when this solves two problems, less need for fossil fuels and less waste to landfill (KTH 2006). There must however be a balanced approach when some types of waste should rather be reused or recycled than converted in to energy (ibid).

2.2.3.1 MIXED USED DEVELOPMENT

Research has shown that the most important and significant variable for making a CHP development profitable is the mix of users involved in the development. If a CHP scheme is built in an area with a single or very dominating end user it is likely to result in poor over all financial and energy efficiency for the project because of the periodical demand and consequently low running hours of the CHP generator (Žižka 2005). The net present value of the project is likely to be negative due to low running times of the CHP plant because of the periodical demand for heat and power (ibid). If a CHP scheme on the other hand is built in an area where there is a good mix of different developments the heat demand is less periodical and more even through out the day. This crates a better base load of heat demand for which the CHP generator can be designed and is making uptake of the technology feasible. (Ibid)

2.3 THE CHP AND DH MARKET IN THE UNITED KINGDOM

This section of the thesis is about the past and present market situation of CHP and DH in the United Kingdom. In the UK today around 19% of the annual energy consumption is in the form of space heating. The need for space heating is greatest from the residential and service sectors of the economy which in total demands 40% of the annual energy supply (99 million toe or 1148 TWh). (Brown, Maryan and Rudd 2005 and DTI 2005) Only 8 % of this heat is currently supplied by CHP systems using mainly gas or other fossil fuels. (DTI 2005) The average CHP size is comparatively small and 80% of CHP schemes are less than 1 MWe in capacity (DTI 2005). The larger systems with a capacity over 10 MWe are however producing 83% of the electric output. Some industrial sectors have experience of CHP and the technology is commonly used in chemical and paper industries. The use of CHP in industry is however competing on the same basis as other investments and has to date not been overly successful in investment priorities. (DEFRA 2004) Because of the lack of DH Systems in the UK, less than 1 % of the dwellings are connected to a scheme (Brown, Maryan and Rudd 2005 and ibid).

The government has set out goals for CHP development in the Energy White Paper (2003) where 10000 MWe of high quality CHP capacity is to be achieved by 2010. The status of installed capacity was as the end of 2004 5.606 MWe and is predicted to increase to between 8-9000 MWe depending on the market conditions and support mechanisms by 2010. (Brown, Maryan and Rudd 2005)

2.3.1 HISTORICAL DEVELOPMENT

CHP technology is a relatively new invention in the UK markets for heat and power. The technology was comparatively unknown until the 1990s when installed capacity more than doubled. Installed capacity was in 1988 1900 MWe which rose in 10 years to just over 4400 MWe. (DEFRA 2004)

Some of the explanation for this fast expansion of the technology can be given to the 1990 Government White Paper "This Common Inheritance" which set a target for CHP of 4,000 MW, of installed capacity in the year 2000. Early progress was encouraging, and consequently in 1993 the Secretary of State for the Environment announced an increase in the target to 5,000 MWe as part of UK's Climate Change programme. (Rochester 2006a) The combination of the government initiative, privatisation and favourable market conditions with high electricity prices and low gas prises sparked the development. (ibid)

The major players on the UK CHP market have been and still are the major energy companies. They have been involved with the energy intensive industry to develop schemes to recover heat for use in industrial processes. (CHPA 2006) The chemical industrial sector and paper manufacturers have traditionally been the major customers of CHP in the UK. They have real incentives for developing CHP schemes because of the demand of both process heat and power. (Brown, Maryan and Rudd 2005) The development of small scale residential and commercial CHP is a recent occurrence which grew significantly through the 1990s. (Rochester 2006a)

2.3.1.1 HISTORY OF COMMUNITY HEATING IN THE UK

The development of CHP is as seen in this chapter, many times closely linked to district heating development. (Euroheat 2006). The UK market for District Heating is very small. 2005 less than 1% of UK dwellings was connected to a DH scheme. (DEFRA 2004) It is therefore important to look in to the historical reasons for the lack of DH development.

The UK history of DH dates from the 1900s, when schemes were established in several cities including Glasgow, Manchester, Dundee and Chesterfield. (Rochester 2006b) Following the Second World War, a number of reports on district heating were published, which stimulated renewed action on developing such schemes. The busiest period was during the 1960s and early 1970s, when over 500 large and medium district schemes were installed, primarily by local authorities in 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 district heating. (ibid)

The popularity of district heating 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 has meant that the hopes for rapid expansion of the post war era have never materialised. (Rochester 2006b) The poor design of many systems, as the lack of indoor temperature control and the poor insulation of DH estates made tenets to become unsatisfied with the heating practise and the popularity of the systems to vain further. (ibid) These factors, expensive oil, poor design and poor management created perceptions among tenets and house owners in the UK of DH as a highly inefficient and communist style heating practise. (SOU 2004:136) The UK home owner has also been shown to be very individualistic when choosing how to heat his/her home and the early failures of DH have created perceptions of an unreliable, risky and expensive technology. (ibid)

2.3.1.2 THE (LACK OF) ENERGY PLANNING IN THE UK

When looking at the planning guidance set out by The Department for Communities and Local Authorities no current legislation is forcing local councils or regions to have a specific energy allocation plan. This is a major difference from the Swedish municipal act 1977 which is forcing all local councils to have a plan for the local energy demand and energy distribution systems (Stenlund 2006). CHP is suggested as a possible technology for reducing carbon emissions for homes and standards for DH systems are set out in section (L) in the building regulations, but there are no regulations which make adoption of CHP mandatory under any specific conditions. (2006) Because energy efficiency issues not is covered and included in the planning guidance no measures are taken there for initiating the creation of DH schemes with CHP generation (ibid). This can be perceived as a major barrier for DH and large scale CHP in the UK, DH needs a systems perspective from planners and developers to be realised. (Svensk Fjärrvärme 2004)

2.3.2 PRESENT MARKET SITUATION

Because of the heavy reliance on natural gas as the primary fuel in UK CHP generation the trend of increasing CHP capacity seen through the 1990s stopped when the gas price increased in early 2001. (DTI 2005) Figure 2.4 below is illustrating the sudden stop in CHP capacity increase. The increase seen in 2004 is due to one single scheme which Conaco Philips had to complete because of contractual reasons. The heavy investment in CHP capacity prior 2000 can be explained by the gap between electricity prices and gas prices (the spark spread), where gas being cheaper than electricity (DTI 2006). Figure 2.5 below is illustrating the fuel prices faced by industry over the last decades. The situation of gas being cheaper than electricity was new for the market in the 1990's, except a brief period in the 1970s. This lead to an increased interest in cogeneration technology. The situation helped the UK to expand generation assets and improve the economy's carbon performance. The current market situation of a low spark spread have led all developers to suspended further CHP investment because of the great uncertainties of future gas and electricity prices, government policy is also a concern and the impact it might have on the viability of CHP and DH (CHPA 2006).

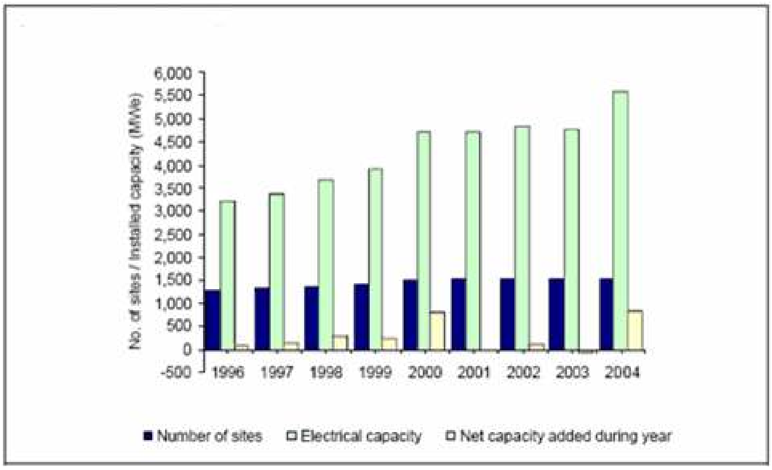


Figure 2.4 The Installed CHP Capacity in the UK 1996-2004 (DTI 2005)

The lack of District Heating in the UK has made the CHP market very reliant on gas as the primary fuel. Countries with more developed DH systems have a wider fuel range comprising of both fossil and renewable. (Euroheat 2006) If CHP generation to a larger extent was connected to a DH grid for the excess heat produced; it would most likely result in a situation more similar Sweden and Denmark where the CHP and DH production have a lower reliance on natural gas (ibid and Brown, Maryan and Rudd 2005). The impacts of fuel prices are further discussed in 2.3.3.3.

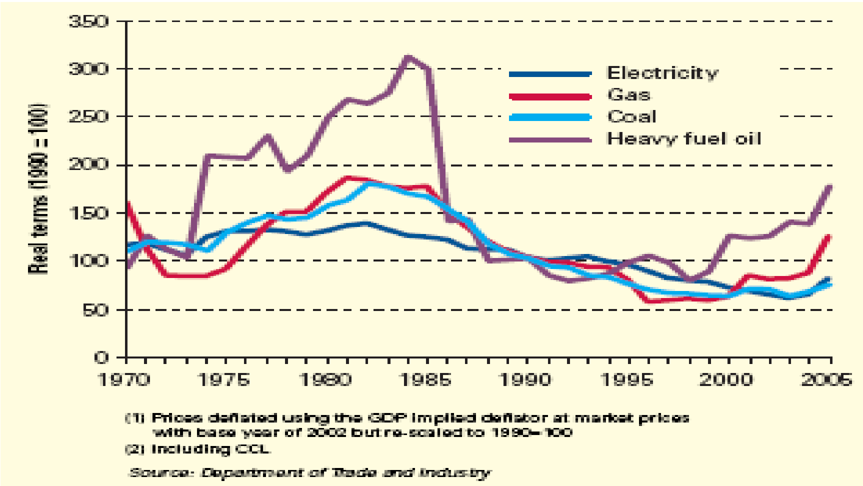


Figure 2.5 The Fuel prices faced by industry in the UK 1970-2005. (DTI 2006)

2.3.2.1 THE ACTORS ON THE UK CHP MARKET

The actors on the UK markets for CHP and DH are according to the member's directory of the CHP Association manly private companies undertaking ether contracts for industry or the public sector. It is common for Public Private Partnerships (PPP) to be formed when a DH network with CHP features is set up. The scheme operated by Eon in the City of London and the energy from waste scheme in Sheffield operated by ONYX are both examples of this PPP trend (ONYX 2006 and City of London 2006) Big power companies as Eon and RWE (Npower Cogen in the UK) control large parts of the CHP capacity in the UK, both companies have specialised in supplying CHP to industry by signing long term contracts with mostly energy intensive customers as chemical plants and paper mills. Actors other than the large power companies are mainly smaller CHP and DH equipment suppliers not active in the running of the systems. (CHPA 2006)

2.3.3 DRIVERS AND BARRIERS TO CHP AND DH DIFFUSION

The drivers and barriers to CHP development in the UK can generally be diverted in to three different categories policy, fuel and electricity prices and technical barriers to CHP development. Government policy is both a driver and barrier for CHP as well as fuel and fuel prices which, as seen from the historical development and the present market situation has been driving and stopping CHP diffusion. The technical aspects of CHP are almost exclusively barriers to further increase of the generation capacity.

2.3.3.1 GOVERNMENT POLICY

CHP development in the UK is generally promoted by the Sustainability branch of the Department for Environment, Food and Rural Affairs (DEFRA). (DEFRA 2006b) The Department of Trade and Industry (DTI) is also having responsibilities for energy issues and are concerned with development of CHP in the UK. (DTI 2006b) Both departments have produced comprehensive frameworks to promote and regulate CHP activities. In table 2.2 below the major policy and regulatory frameworks present in the UK are summarised.

2.3.3.2 THE NEED FOR MORE PROMOTION OF CHP

The government has earlier this year reviewed the policy for promotion of CHP. The main problem identified was the high gas price compared to the electricity price. (DEFRA 2006c) This situation has lead to the current market situation where CHP projects which have been given consent not are taken forward and to that some existing capacity has been mothballed. DEFRA is well aware of how to proceed the promotion of CHP but because of concerns for public expenditure and an unwillingness to intervene in energy markets none of the four proposed policies, table 2.3 below, have been taken forward

Fiscal Incentives:

- Climate Change Levy Exemption on fuel inputs to good quality CHP and on all good quality CHP electricity outputs.
- Eligibility for Enhanced Capital Allowance to stimulate investment. Business are able to write of the full cost of their CHP investment against their taxable profit over the period when the investment is made.
- Business Rate Exemption for CHP power generating plants and machinery if the unit is free standing from other buildings.
- Reduction in VAT for all domestic CHP appliances.
- Climate Change Agreements which can provide financial incentives for CO2 emissions reductions.

Capital Grant Support

- £50m Community Energy Programme which purpose is to encourage CHP in DH schemes.
- The Bio energy Capital Grants Scheme which provides funding from DTI and the New Opportunities Fund. The Funds are available for new projects using biomass, and particularly energy crops in energy production.

Regulatory Framework

- The EU Emissions Trading Scheme (EUETS) from which CHP should benefit because of the marketability of the emission permits. When CHP decreases the overall emissions of an organisation it can because of that generate revenue.
- The EU directive on the Promotion of Cogeneration which seeks to promote CHP in all new generating capacity and makes it mandatory for power companies to explore the option of installing CHP. (EU 2006)
- Changes to the Licensing regime, which seeks to benefit smaller generators by addressing the administrative burden placed on those.
- Futher work to ensure a level playing field on the electricity markets. The New Electricity Trading Arrangements (NETA) governed by Ofgem have been found to have a tendency to promote large generators which can ensure delivery at specific times.
- Continued emphasis of the benefits of CHP and DH when Planning Policy, Regional Planning Guidance and Sustainability Development Planning Guidance is made or renewed.
- Explore the opportunities to incentivise CHP technologies in the Expanded Household Energy Efficiency Commitment
- Promote CHP uptake through the Building regulations.

Promotion of innovation

- Promotion and support by the Carbon Trust (non domestic markets) and the Energy Savings Trust (domestic markets) for the development of energy efficiency and low carbon technologies, including CHP.
- Review of Carbon Trust's and Energy Savings Trust's current and future programs to achieve coherence with the government's CHP target.
- Improvement of existing CHP schemes through development of a Quality Improvement Program

Government Leadership in CHP development

- The adoption of a 15% target for Government Departments to use CHP electricity by 2010 and the encouragement of other parts of the public sector to consider a target for CHP.

Table 2.2 Policy in the UK.

Policy not taken forward by Defra

- A CHP Obligation, which would force power utilities to have a certain percentage of CHP electricity in their power mix.
- A guarantee of a minimum spark spread for CHP, which would reduce the uncertainty which have inhibited the growth of generation capacity.
- An exemption of CHP generation from the Renewals obligation. Power utilities would not have to hold renewal certificates for their CHP electricity.
- Adding a 15% target for heat to come from CHP generation in government owned properties.

Table 2.3 Policy not taken forward by Defra (DEFRA 2006c)

2.3.3.3 FUELS AND FUEL PRICES

As seen is the spark spread (the difference between gas and electricity price) of uttermost importance for the viability of CHP in the UK. The difference between gas and electricity prises has to be large enough to provide an adequate return on investment. A low disparity between gas and electricity have been the prevailing market condition in recent years, which means that there is still need for different support mechanisms to promote CHP if the 10000 MWe government goal is to be fulfilled. (DEFRA 2006c) Modelling by Cambridge Econometrics estimates a 2010 capacity figure of 7.5-7.7 GWe excluding the impact of the EU ETS. With the EU ETS, Cambridge Econometrics estimates an increased capacity of 9.3-9.6 GWe with a medium allowance price. (Brown, Maryan and Rudd 2005). A medium allowance price would imply some kind of subsidy given to promote CHP or to stabilise the market, this would be in the range of £10/MWh to make a real difference (ibid). This has however as seen in 2.3.3.2 been ruled out as too expensive and market distorting.

There are some CHP installations in the UK using other fuels than Natural Gas. UK is the market leader of producing and using Landfill gas for production of heat and power. This combined with an emerging interest in waste incineration with energy recovery might stimulate a new development of CHP plants. (DTI 2004)

2.3.3.4 TECHNICAL BARRIERS

There are two major technical barriers to increased CHP development in the UK, pure technical characteristics of the systems and more technical policy related barriers. Current government policy creates what is perceived as technical barriers (Žižka 2005). The NETA trading arrangements (which is mentioned in table 2.2) is currently punishing small generators and generators who are finding it hard to guarantee supply at fixed times. CHP generators often have both of those characteristics. (DEFRA 2004) Small generators were in 2004 found to get a 17% lower average price for their electricity than larger producers (ibid). There are other policy arrangements which work in an unfavourable way for CHP; this is outlined below in Box 4.3. The other types of technical barrier which retain CHP development is the high cost of building a market for heat. The cost of retrofitting a DH scheme in houses not fitter with a piping system and building a distribution network in a city without heat pipes is very expensive and time consuming. (Brown, Maryan and Rudd 2005). The design of the current national grid is not optimal for CHP generation because the grid is build for one-way electricity supply which is causing technical limitations in dealing with dispersed generation (ICCEPT 2002).This is outlined in table

Technical Barriers Due to the Design of current technical systems

- Access to the gas and electricity grid for small and medium CHP operators. The original design might not have intended large increases in gas or electricity load. (ICCEPT 2002)
- Problems of feeding back electricity in to local grids; the original grid was never intended as a two way system, only for supply from major central power stations. (ICCEPT 2002)
- Problems of retrofitting DH systems in the current built environment due to the high costs and problematic installations. (Brown, Maryan and Rudd 2005)

Technical Barriers Related to Government Policy

- The NETA electricity trading arrangement which is bad in handling electricity from unlicensed small generators, resulting in lower prices for small scale production.
- Government approval of the existence of unlicensed electricity producers, which has not been coordinated and properly communicated with the NETA trading system.
- Un-proportional high costs of accessing the electricity grid for small generators, partly caused by the NETA regulator Ofgem. (All above DEFRA 2004)

Table 2.4 Technical barriers to CHP diffusion in the UK

2.4 THE CHP AND DISTRICT HEATING MARKET IN SWEDEN

The energy use in the Swedish service and residential sector was in 2003 153,7 TWh which was 38% of the total energy use. Approximately 60% of the energy use in the sector was due to demand for space heating and hot water in residential homes, commercial buildings and other services, which makes space heating and hot water consume 22.8% of the total energy consumption. (STEM 2005b) The energy carriers used by the residential and service sectors in Sweden, seen in figure 2.6, has undergone a distinct shift away from oil towards electricity and DH. 1970 the sector used 118,6 TWh of fossil fuels compared to 27.3 TWh 2003. (SCB 2005) This will be further outlined in section 2.4.2. The market share of DH in space heating and hot water for the residential and service sector in Sweden is 50% and is predicted to grow in the future. DH systems are in place in 570 out of 1900 population centres in

Sweden. All major cities and towns today have DH systems. (Svensk Fjärrvärme 2004)

The Swedish industrial sector is a relatively small consumer of DH, the sector is heavily abundant on electricity. (STEM 2005) The paper, pulp and steel industries have experience of CHP production and are currently the major users of CHP in industry. Investments in CHP technology is however competing with other investments and must be as profitable or show higher yields to become realised. (IVA 2002) The historically low electricity price in Sweden has repeatedly made CHP investments in industry, as well as in DH production, unviable. (SOU 2005:33)

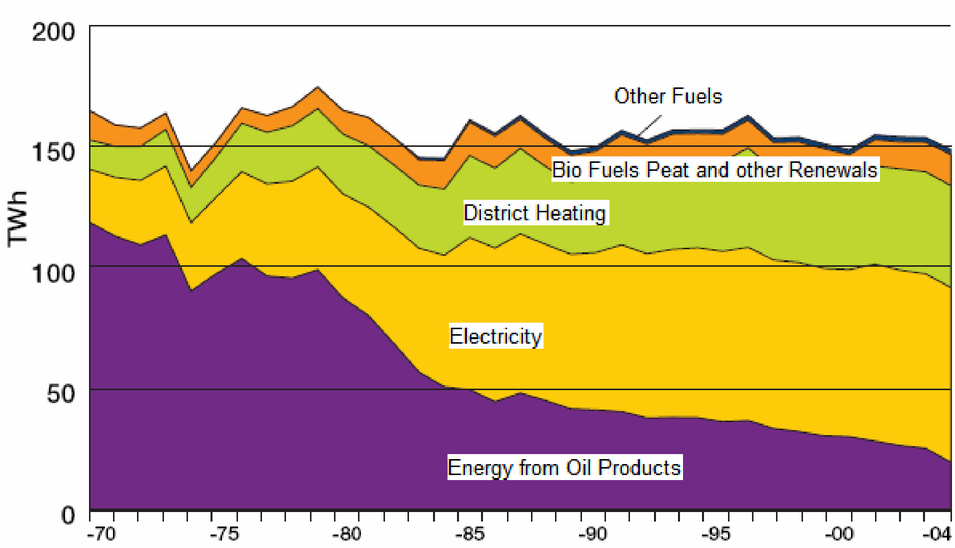


Figure 2.6 The energy carriers in the Swedish residential and service sector, it is noticeable how rapidly the oil consumption has decreased in favour of electricity and DH. (SCB 2005)

2.4.1 HISTORICAL DEVELOPMENT OF DH AND CHP IN SWEDEN

District heating was introduced in Sweden after the Second World War when it seemed likely that, the hydropower resources of the north would not be enough to supply both the expanding energy intensive industries (paper, pulp and steel) and the rapidly increasing use of domestic electricity. (Westin and Lagergren 2001) CHP technology was after the war viewed as an economic and efficient way of combining the build up of electric generation and at the same solving the problem of heating for new housing developments. The first Swedish district heating system was put into operation in Karlstad (1948) followed by Malmö, Gothenburg, Stockholm, Linköping and others through out the 50s. (Werner 1989 and Tekniskaverken 2004b). Because of the rapid urbanisation through out the 1960s large public and private housing programs where built, with them followed new DH systems. The operation of district heating was then conceived as a task for the local council. Local authorities were also heavily involved in the housing programs as the planning authority and the owner of public housing companies and the energy infrastructure. (Westin and Lagergren 2001)

After the oil price shocks of 1973 and 1979 district heating was found by Swedish policy makers to play an important part of the energy policy. In order to reduce oil dependency in heating of homes and commercial buildings, 90% at the time, the large-scale production facilities for DH systems were found well suited for conversion to other fuels, as peat, municipal waste and biomass. The Swedish economy which had been growing rapidly through the 60's slowed down during the 70's and industry restructuring took place. Electricity intensive industries such as the steel sector, mines and wharfs were closed while qualified services, production of complex industrial products and the telecommunication industry gained importance. (Westin and Lagergren 2001) Sweden had in the growth years of the 60's planned a large nuclear power build up in 70's and 80's, this was kept on track even though electricity demand fell. The nuclear development was also supported by government owned power company Vattenfall. (ibid) The government programs for energy efficiency introduced at the same time as industry closure led to lower per capita final consumption of energy, especially in the housing sector and for heating (STEM, 2005).

2.4.1.1 THE PROBLEM OF EXCESS ELECTRICITY

Because of the new 12 nuclear reactors in addition to the great hydropower resources, a surplus capacity for electricity generation was created in 1980s and 1990s. In order to ‘‘get rid’’ of the produced electricity, two new developments were seen. Dwellings built in the 80's were equipped with electrical heating, and DH companies were encouraged to invest in electric boilers and large heat pumps for the use of electricity for heat production. In chemical, paper and pulp industries as well as the steel sector, conversion from fossil fuel driven processes to electricity driven could be observed. (Westin and Lagergren 2001) This time period also saw the introduction of district heating in many small population centres. In 1990, the dependence on oil in district heating had been dramatically reduced and was now less than 10% of total energy use (STEM 2005).

This situation with a low electricity price and over capacity lead to an underinvestment in CHP technology, Sweden is the only country in Europe with an extensive DH system with a low CHP ratio. Only 30% of the Swedish DH production capacity has cogeneration installed. (SOU 2005:33)

2.4.1.2 THE SYSTEM VIEW IN LOCAL AUTHORITIES

The act on municipal energy planning was established in 1977. It has since been revised and complemented with additional legislation several times. Figure 2.7 illustrates the planning approach taken by the authorities. The plans were initially a reaction to increasing energy consumption and high oil prises and an emphasis was made to reduce oil use in general and for heating in particular. The energy planning approach has been quite efficient in terms of fulfilment of goals and has contributed to a systems view of the issues. (Stenlund 2006) The most positive developments have been observed for goals on a relatively low systems level when the local authority owns the infrastructure and productions facilities, for example district heating expansion and energy efficiency measures in public buildings. The Swedish local authorities have due to traditions and the requirements under the plans formed energy companies which have built, maintained and run the local energy networks under a own cost pricing regime. This has as made it relatively easy for the local political assembly in a local council to control and make sure that the requirements in the energy planes have been meet. (ibid) This is a major difference to the UK situation where the energy issues not have been incorporated in the planning system. (SOU 2005:33)

The systems view in local authorities has also contributed to the use of waste as fuel for DH and CHP. Because of the early realisation of the synergy effects, waste and energy issues where integrated in a number of local councils and waste incinerators connected to the local DH grids where built. (KTH 2006) This solved two major problems, less dependency on imported fuels as oil and provided a safe and efficient way of disposing house hold and industrial waste (ibid).

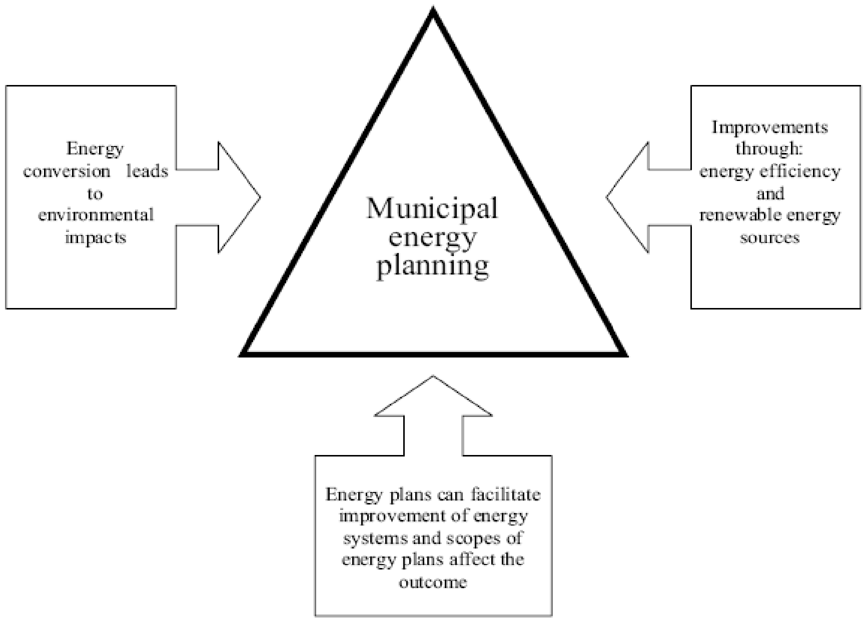


Figure 2.7 Framework applied to describe energy plans and components of the system view behind them (Stenlund 2006)

2.4.2 PRESENT MARKET SITUATION

Sweden is as earlier mentioned the only county in the EU with an extensive DH system and a low share of CHP. (SOU 2005:33) This can be explained by the market conditions of excess electricity production capacity which prevailed throughout the 80's and 90's (Westin and Lagergren 2001). The present situation is however changing in favour of CHP, with new incentives as the renewal obligation to stimulate renewal energy production. (Svensk fjärrvärme 2005)

In a report from Swe Bio and The Swedish District Heating Association the current state of the market has been revised. From now and until 2010 around 40 different CHP production units are predicted to be built. The investments are a mixture of new plants and rebuilding of older installations due to presently favourable conditions for bio fuelled CHP production. The total installed capacity is predicted to increase from 2.3 GW to approx 3.7 GW which is a 60% increase or an increase of 1.4 GW. (Svensk Fjarrvarme 2005) This is illustrated in figure 2.8. The production of electricity from CHP installations is illustrated in figure 2.9 together with a forecast made by the consultancy Örlings PricewaterhouseCoopers (SOU 2005:33)

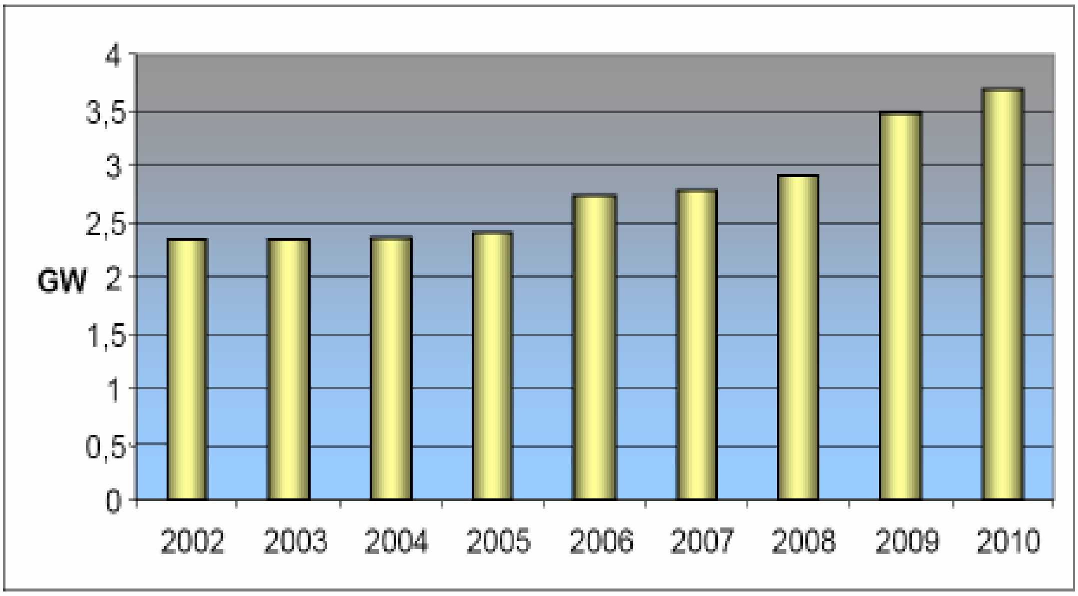


Figure 2.8 Installed CHP capacity in Sweden presently and future forecast. (Svensk Fjarrvarme 2005)

According to Svensk Fjärrvärmes *(The Swedish District Heating Association's)* report "CHP and District Heating in the Future" (2004) the expansion potential is dependent on two major factors: first the need for new boilers and production facilities in the present DH system and second the future expansion of the networks. It is not likely that boilers will be replaced before their predicted end of life and therefore it is unlikely to see a rapid expansion of CHP capacity in the current DH grids, exceptions are however possible. When DH networks are expanded, with the increased demand for heat implied, it is likely to se new wood fired CHP capacity being built. Presently this is the most profitable option for new electricity generation capacity in Sweden. (Svensk Fjärrvärme 2004) The technical potential for DH in Sweden is about 75% of the countries demand for space heating, compared to the 50% supplied presently. (SOU 2005:33) When financial considerations have been taken the actual new potential is lower. (ibid)

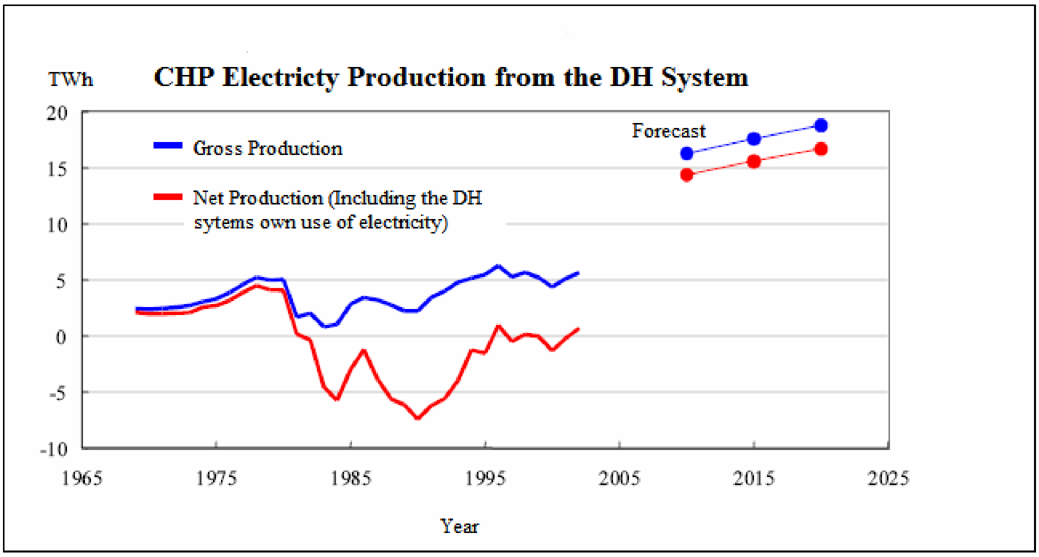


Figure 2.9 Electricity generated from CHP generation in Sweden. The gap between the lines is the electricity used by DH providers for heating purposes. The forecast is made by Örlings PricewaterhouseCoopers 2005. (SOU 2005:33)

2.4.2.1 ACTORS ON THE SWEDISH DH AND CHP MARKET

DH in Sweden has originally been delivered by the local council energy department, but with the privatisation of the energy market in 1996 structural changes has taken place. Private actors have since penetrated the market by buying council owned companies and integrated them with their other private businesses. (SOU 2004:136) The share of local council owned DH production has decreased significantly during the last years as seen in figure 2.10. The new "private" actors are government owned energy company Vattenfall, German energy company Eon and the Finnish energy company Fortum. They are all major electricity producers on the Swedish market with large nuclear and hydroelectric assets. (Svensk Energi 2005) In 2002 222 different companies were producing DH mainly owned by the local councils, of the 222, 28 where owning and operating CHP plants for combined production. The new entrants "private" on the market have focused on buying DH networks in larger population centres which have made their share of district heating delivered larger than the number of companies they own. Local council companies where in 2002 supplying 43% of the heat while the "private" actors had a 57% market share.

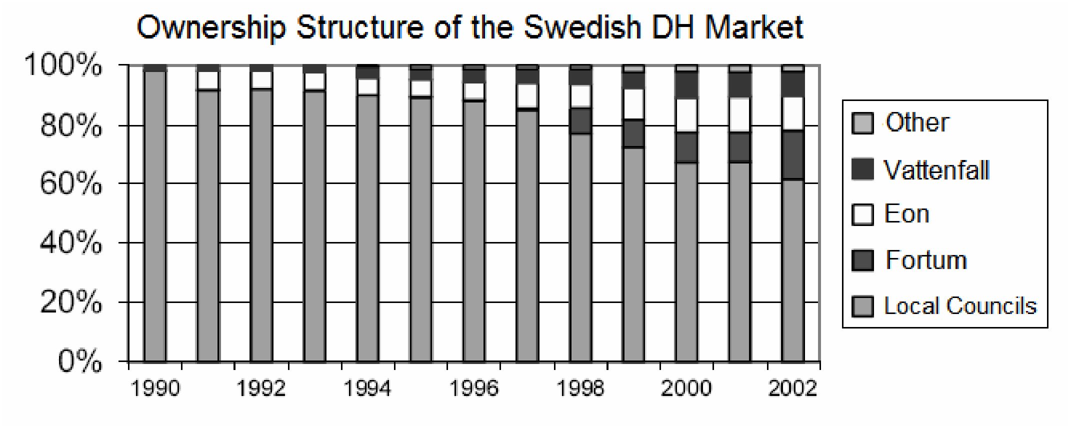


Figure 2.10 The Change in ownership of Swedish DH production 1990-2002 (SOU 2004:136)

2.4.3 DRIVERS AND BARRIERS TO CHP AND DH DIFFUSION

The drivers and barriers on the Swedish CHP market are quite diverse ranging from a historically low electricity price to changing government policy. Below in this section are the different drivers and barriers as government policy, fuels and technical issues presented.

2.4.3.1 GOVERNMENT POLICY

Present Swedish energy policy is based on the 1997 "energy act". The energy act and other more resent legislative acts have set up the establishment of support schemes for promotion of local sustainable investments. The funds have lead to promotion of DH when the subsidies to a large extent have been used for extensions of current networks and the establishment of new DH. (Naturvårdsverket 2006) The expansion of DH together with promotion of bio-fuels made wood and waste fired DH profitable during the 1990's. (Wang) CHP was fitted in some of the new wood and waste boilers built but the growth of wood fired CHP capacity did not take place until the introduction of the renewables certificates in 2003. The policy is guaranteeing the owner of renewable electricity generation capacity, excluding large scale hydropower, a premium price for produced electricity. (STEM 2004). The certificates have made wood and waste CHP attractive on the market. (Wang 2004).

The regulation which had an adverse effect on CHP development in Sweden until 1 Jan 2004 when changed, was the carbon tax on fossil fuels introduced in the early 90's (SOU 2005:33). The tax made heat produced from fossil fuels expensive but excluded fossil electricity production (ibid and Wang 2004). The decrease of the CO2 tax for CHP generation increased the incentive especially for new gas fired capacity in Sweden. (STEM 2005) A new large gas CHP plant is currently under construction in Gothenburg on the Swedish west coast (Göteborgs Energi 2006)

There are three major policy drivers, identified by the Swedish Energy Agency (2005) affecting CHP in Sweden, table 2.11 below. The policies together with the funds available for investments subsidies are important for Swedish CHP and DH development. (STEM 2005 and Naturvårdsverket)

Important Swedish Policy
• The decreased taxation of CO2 in CHP production. This has made more fuels available for CHP investments. With the high tax regime only bio-fuels and waste where feasible to use, now gas where available is an option. The widening of available fuel choices have also resulted in a more favourable pricing situation of bio-fuels because of the more competitive market. • The Renewables Obligation. Before the introduction of the obligation the revenue from heat was similar to the revenue from electricity made from bio-fuels and waste. The certificates have made cogeneration more profitable by introducing the premium pricing mechanism for bio-fuel CHP electricity. • The Emission Trading Scheme EUETS. CHP is favourable treated under the Scheme when new generation capacity get free allocation of emission rights compared with electricity only production. This stimulates new good quality CHP capacity to be built. (All above STEM 2005)

Table 2.5 Important Swedish Policies

2.4.3.2 FUELS AND FUEL PRICES

The prices of fuels which are unpredictable are of great concern for investments in CHP capacity. Because of the great diversity of fuels used in Swedish CHP production, as seen in section 2.2 , the impact of fuel price changes are not as big as in Sweden as in the UK. (SCB 2005)

Most Swedish CHP producers can choose between at least two fuels, which imply an option of using a fuel if it becomes cheaper for a period and then changing to an alternative if the prices increases. (STEM 2005) This reduces the sensitivity in the sector, but increases the administrative burden and the investment costs when more than one production facility needs to be maintained. (ibid) The ban of putting combustible waste on landfill has increased the fuel availability for incineration and in that way promoted energy from waste and CHP schemes. (KTH 2005) New CHP capacity in Sweden today only has three real fuel options bio-fuels, waste or natural gas. (STEM 2005) The fuel flexibility and the ability to use low cost fuels as waste is making Swedish CHP a viable industry.

2.4.3.4 TECHNICAL DRIVERS AND BARRIERS

The combined production of heat and power is dependent on the simultaneous demand for heat and power. This is the major technical driver as well as barrier in Swedish CHP production as for all CHP. (Svensk Fjärrvärme 2004) The extensions of the DH networks will provide an increased demand for heat production and because wood ands waste fired CHP is the most revenue maximising option for new investments, CHP has a great technical potential in Sweden. (IVA 2005) The obvious barrier for CHP is that no new CHP capacity can be added in an existing network without extending the heat demand or replacing the current boiler. (SOU 2005:33)

2.5 CHAPTER SUMMARY

The main findings from the literature review is summarised below:

Summary of CHP technology

- CHP is cogeneration of electricity and heat which makes the thermal efficiency substantially higher then independent production
- CHP technology is contributing to lower emissions of greenhouse gases
- CHP connected to a DH grid is more fuel flexible then independent CHP production.
- Growth in DH leads to growth in CHP generation because of the importance of mixed used developments for a large base load.

Table 2.6 Summary of CHP technology

Summary of the UK CHP and DH market

- 30% of UK energy consumption, excluding traffic is consumed by space heating of which 8% of supplied by CHP
- Less than 1% of UK dwellings is connected to a DH network
- DH became a popular way of heating council estates in the 60s and 70s, because of mismanagement, poor constructions and negative customer perceptions it is now unpopular
- No mandatory regulations in the building code and no energy planning requirements set for the local authorities in the current planning system is a major barrier for CHP and DH in the UK.
- There are mostly private actors on the UK CHP market working with industry and most DH schemes are run under PPP partnerships.
- The UK government has a goal of 10000 MW of high quality CHP installed generation by 2010 which currently is going to be missed.
- Both Defra and DTI are responsible for CHP issues in the UK
- There is an extensive promotion and regulating framework for CHP in the UK which is having only a minor impact on the viability of the technology Defra is aware of the non functionality but is currently doing nothing to correct the shortcomings.
- The single most important barrier in the UK CHP market is the low spark spread which is so critical because of the sectors high reliance on natural gas as fuel.
- Electricity trading arrangement, the construction of the national grid and the high construction costs of DH networks are all barriers for CHP development in the UK

Table 2.7 Summery of the UK CHP and DH market

Summary of the Swedish CHP and DH market
➢ 22.8% of the total energy consumption in Sweden is coming from the demand for space heating and hot water. ➢ 50% of space heating and hot water demand is met by DH and all major Swedish towns have DH networks. ➢ DH and energy issues became an integrated part in local authorities planning after the Second World War which made most local councils set up an energy provision organisation under their own management. ➢ In 1977 the municipal energy planning act came which made local authorities adapt a systems view of energy issues resulting in more DH and waste incineration. ➢ Deregulation of the energy sector has led to more private actors on the Swedish DH market. ➢ Excess electricity production from the nuclear build-up in Sweden in the 70s-90s made CHP unviable and unflavoured resulting in the lowest CHP share of DH production in Europe (30%). ➢ Favourable conditions for CHP in Sweden since the late 1990s with a major breakthrough with the introduction of the renewable certificates. ➢ Wood fired CHP is presently the most profitable option for new generation capacity in Sweden with waste and gas fired CHP generation as the only other options.

Table 2.8 Summery of the Swedish CHP and DH market

2.6 CONCLUSION OF THE LITERATURE REVIEW

CHP and DH technology have been found to have benefits for society when they decrease the negative impacts of power and heat production. The technologies can be run on a diverse range of fuels which highlights the difference in fuel use in the two countries.

The CHP market in the UK is very abundant on natural gas which is making the technology and the industry vulnerable for price variations. There also seems to be a lack in marketing opportunities for heat produced in the UK. The lack of DH as a heat sink is one likely source of the un-viability of UK CHP presently. There seems to be a lack of energy planning in local authorities in the UK, this is most probably a major barrier for DH and in turn CHP development. The policy aspects of CHP and DH on the UK market are mostly acting as barriers for CHP, there is policy for promotion of CHP and DH but it seem to have little impact. The UK heating market is characterised by small scale private heating solutions.

The Swedish DH and CHP plants have a diverse fuel range and are less sensitive to fuel price changes than UK plants. There is a developed market for heat in Sweden with distribution systems in all major cities and towns. The heating markets have been promoted by energy planning of local authorities and local energy utilities. The excess supply of electricity during the 80s and mid 90s made CHP investments unviable in Sweden. Swedish policy seems to promote CHP presently making wood fired CHP the most revenue maximising new generation investment for the energy companies. Sweden is characterised by large scale private and public heating solutions.

2.7 FINDINGS FROM ECONOMIC AND TECHNOLOGICAL DIFFUSION THEORY

In table 2.9 is the findings from theory in appendix summarised. This theory has been used in the conceptual framework (2.8 below), where it has been needed for understanding and theorising the information form the above literature review. The research questions have been derived by using the information form the literature review, the conceptual framework and the summarised theory.

- When a market is characterised by goods with public goods characteristics the likelihood of a market failure increases.
- Externalities are caused by over and under production/consumption compared to the optimum usually of public good.
- Externalities can make markets fail because of their negative attributes for which no one is accountable.
- Asymmetric information and high transaction costs can lead to a market failure, lack of information can make markets never form.
- Policy to battle market failure includes taxation and assigning and policing property rights, the initial allocation of property rights are important.

- Institutions make up what we perceive is the world around us
- The local culture have formed a set of informal institutions which are making boundaries for individuals behaviour, they can provide a high degree of trust to a society and reduce transaction cost
- Formal institutions are characterised by a strict hierarchy with different degrees of policing and are originally formed from informal cultural institutions.
- Institutional change is initiated due to institutional inefficiency and firms benefit maximisation. Technological change can be the reason for institutional change.

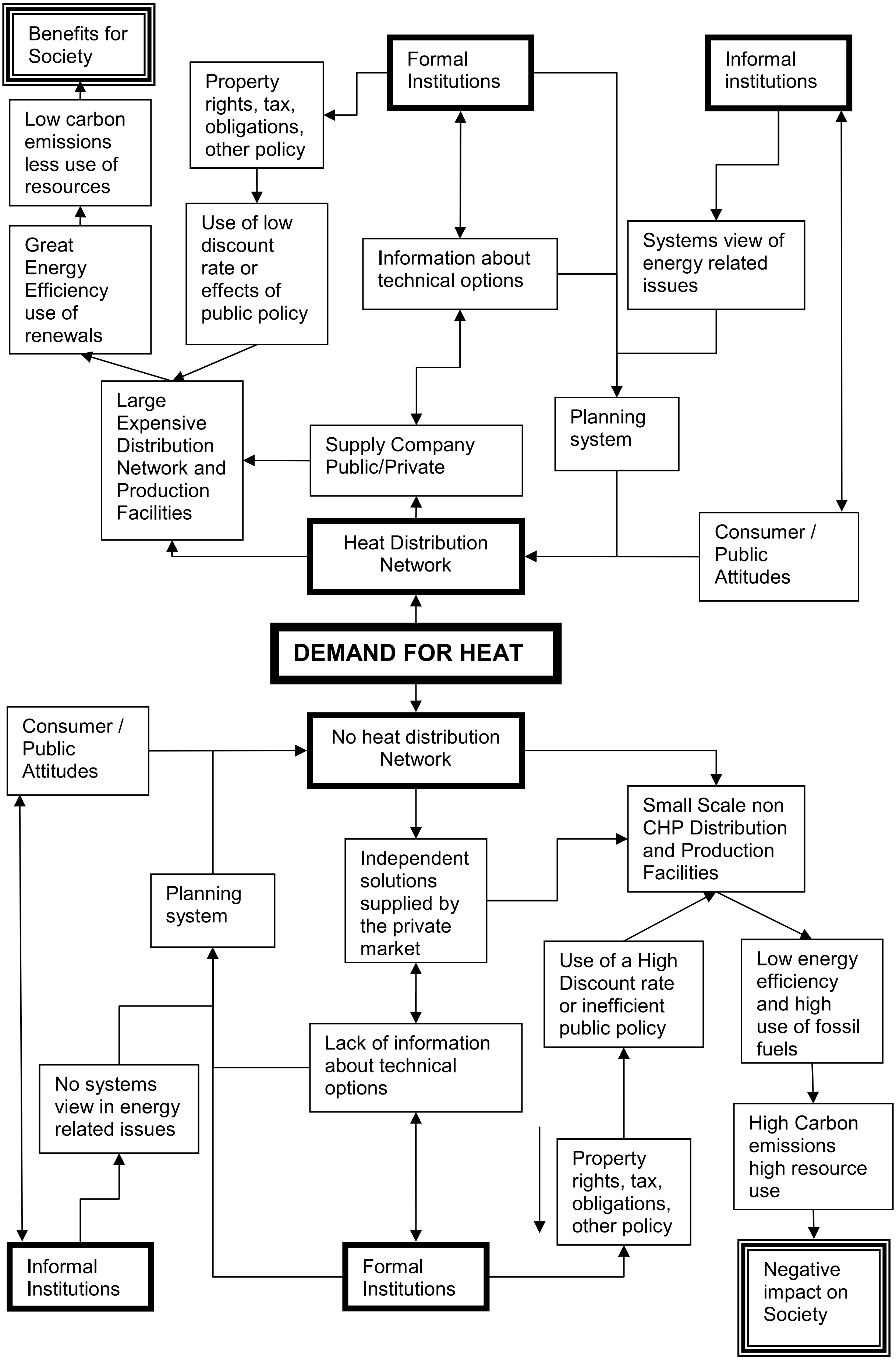
- CHP development in the 1990s was pushed and pulled in accordance with the induced innovation theory
- Technological lock-ins are experienced when technological diffusion starts to gain from economises of scale, this can result in a lock-in of inferior technology.
- The system of innovation is combining neoclassical and institutional economics as well as different theories of technical innovation in a systems view of the matter.
- Large and medium scale CHP is fully commercial while micro generation is under development.

Table 2.9 Summary of theoretical findings

2.8 CONCEPTUAL FRAMEWORK

The conceptual framework originates from the demand for space heating and heat in industrial processes. Economic theory from appendix I (summery above) and market observations from the literature review has been combined to make up the below framework. The framework has been used in the process of formalising research and interview questions and for making the coding and clustering system.

CONCEPTUAL FRAMEWORK



2.8.1 EXPLANATION TO THE CONCEPTUAL FRAMEWORK

The conceptual framework shows the relation between different market characteristics. The framework starts with the demand for heat, the box in the centre. This demand can be supplied in two ways, with or without a heat distribution system. As seen in the framework formal and informal institutions are important for the development of a heat distribution system. They both input in the emergence / non emergence of a market for heat through the planning system, consumer attitudes, systems view, information provision and policy. If the formal and informal institutions make the market conditions right for the formation of a heat market this will result in benefits for society due to less resource depletion and lower CO2 emissions. With an unfavourable institutional environment no heat market will be formed, which will result in a negative impact on society due to lower energy efficacy, greater resource depletion and higher CO2 emissions.

2.9 RESEARCH QUESTIONS

The research questions have been derived from the literature review, the conceptual framework and the theory in appendix I. The research questions have been used for formalising relevant interview questions to be answered by the respondent through out the primary research phase.

Research Questions

1. What market failure characteristics, characterise the UK and the Swedish CHP and DH markets respectively

2. What are formal/informal institutional drivers and barriers of CHP and DH in the UK and Sweden?

3. How has the market for heat developed in the UK and Sweden?

Table 2.10 Research Questions

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

This part of the thesis is concerned with the methodology used for addressing the aims, objectives and research questions. A comparative case study approach where taken in this thesis when a separate study of the UK and a separate study of Sweden was carried out and compared. Qualitative data where collected in an open design study because it in a satisfying way made the fulfilment the aims and objectives possible.

3.2 THE PURPOSE OF THE STUDY

This thesis which is a comparative case study, looking at non technical barriers for CHP and DH diffusion in UK and Sweden is of Exploratory nature with some Explanatory instruments. These classifications is taken form Robson (2002) and are explained below.

Exploratory Research

- To find out what is happening, particularly in little understood situations
- To seek new insights
- To ask questions
- To assess phenomena in new light
- To generate ideas and hypotheses for future research
- Almost exclusively of flexible design

Descriptive Research

- To portray an accurate profile of persons, events or situations.
- Requires extensive previous knowledge of the situation etc. to be researched or described, so that you appropriate aspects on which to gather information.
- May be flexible and/or fixed design

Explanatory

- Seeks an explanation of a situation or problem, traditionally but not necessarily in the form of casual relationships.
- To explain patterns relating to the phenomenon being researched
- To identify relationships between aspects of the phenomenon
- May be of flexible and/or fixed design.

Table 3.1 The three main research strategies developed in Robson (2004)

The reason for the research being of explanatory nature is that a sector specific comparison between the two countries CHP and DH sectors never has been carried out before. But some parts will according to Robson's (2004) definition be of a more explanatory nature. It is not the aim and intention to prove the theoretical body in appendix I right or wrong, it is more a case of using the theory to make a proper analysis of the market condition in the two countries.

3.3 RESEARCH STRATEGY

Robson (2002) referrers to research strategy as the general approach taken during an enquiry. In table 3.2 and 3.3 it is outlined that a study can be of fixed or flexible design. This thesis has been written as a flexible design study, the researcher had not sufficient information in the beginning of the process to assess the final outcome which was why a flexible design where chosen.

The study has been carried out as a comparative case study comparing the case of Swedish CHP and DH to the case of UK CHP and DH. This approach has been chosen because of the case study designs ability to incorporate multiple methods and to elicit data from multiple sources (Yin 1994). No other of the below suggested study designs where viewed as appropriate for this thesis.

Studies are often intimately related to the data the study relies on, Quantitative (numbers) or Qualitative (words and sentences). (Robson 2002) The research in this thesis has been collecting qualitative data because of the nature of the study. It is very difficult to quantify formal and informal institutional drivers and barriers by collecting numbers when they are expressed as opinions, legislation and policy statements. Robson (2002) suggests that qualitative data is better then quantitative when conducting a study which is likely to change as more data becomes available. This process of respondents contributing with more information through out the interview series was experienced through out the research process.

Fixed design studies	
Experiment strategy:	The researcher actively and deliberately introduces some form of change in the situation, circumstances or experience of participants with a purpose of getting a change in behaviour.
Non- Experimental:	The overall approach is the same as an experimental strategy but the researcher does not actively introduce any change in the situation. The research does typically involve collection/selection of samples and hypotheses testing.

Table 3.2 Characteristics of fixed design studies (Robson 2002)

Flexible design studies	
Case study: “	Development of detailed intensive knowledge about a single case”, or a small number of related “cases”. This usually involves collecting data from observations, interviews and literature studies.
Ethnographic study:	Seeks to capture, interpret and explain how a group, organisation or communities live, experience and make sense of their lives and he world. Use of participant observation.
Grounded theory study:	The central aim is to generate theory from data collected during the study. Commonly interview based.

Table 3.3 Characteristics of flexible design studies (Robson 2002)

3.4 DATA COLLECTION

Data collection can be divided in two parts, secondary data collection and primary data collection. They are both outlined below.

3.4.1 SECONDARY DATA COLLECTION

The secondary data collection has mainly been focused on the use of printed and internet sources. The data can be divided in to:

- The use of publications manly from libraries and private collections.
- The use of databases and the information available in those.
- The use of serious internet websites manly from governmental organisations, well renowned firms and industry organisations.

The major secondary sources chosen have been websites and reports form government organisations and well established private companies. Academic journals have also been of great help as well as economic literature in general. The sources used have all been chosen on the basis of reliability and source recognition.

3.4.2 PRIMARY DATA COLLECTION

Robson (2002) suggests that data collection in case studies can include interviews, observations and documentary review. Interviews have been used for this thesis secondary research phase. Gillham (2005) has reviewed a number of techniques for “face to face” methods of data collection in table 3.4. The semi structured interview approach was selected for the data collection in this thesis since it gave the right combination of structure and flexibility the researcher needed.

Unstructured interviews

- As an initial technique where the researcher is casting around for those things that need to be investigated in a subsequent, more structured stage of the research.
- Where the person being interviewed might be inhibited or constrained by a more structured approach.
- Where the interest is in some dimension of an individual's life experience, and where the significant themes can only be elicited by allowing the individual to give their account in their own way.

Semi-structured interviews

- The same questions, with some minor variations are asked to all those involved.
- The kind and form of questions go through a process of development to ensure their topic focus.
- To ensure equivalent topic coverage with some variations for spontaneous questions.
- Approximately equivalent interview time is allowed in each case.
- Questions are usually open and it is up to the interviewee to interpret.

Fully-structured interviews

- Fixed questions in a face to face setting.
- Three type of questions
    - Subject descriptors: information about the person you are interviewing which can be used to sub divide the group – age, occupation and so on.
    - Behavioural: what people do. Example: Which of the following newspapers do you reed?
    - Attitudes and opinions: Example: How do you rate the government's policy on asylum? Followed by a rating scale.

Table 3.4 Different methods for ”Face to Face” data collection (Gillham 2005)

The research conducted have been focused on getting a deep understanding of the drivers and barriers present on the CHP and DH markets in Sweden and the UK and to give insights in historical events leading to the present. The respondents where selected to archive this, but the research has been constrained by factors as availability, willingness to participate and accessibility. The diverse range of organisations and participants show however that the constraints have to some extent been overcome. A short description of the respondents is presented in table 3.5.

Participant	Description
Respondent A (Swe)	Head of District Heating, Large regional District Heating, Water and Waste Company.
Respondent B (Swe)	Environmental consultant, working with EIA, ISO 14001 and other issues within the energy sector.
Respondent C (Swe)	Energy Consultant with experience from the incineration, CHP and district heating sectors in Sweden and Europe.
Respondent D (Swe)	Expert in CHP and DH, Swedenergy.
Respondent E (Swe)	Member of energy group, Swedish Ministry of Sustainable Development.
Respondent F (Swe)	Head of Strategic Planning Group, Swedish Ministry of Finance.
Respondent G (Swe)	Responsible for energy issues, Swedish Ministry of Industry, Employment and Communication
Respondent H (Swe)	Responsible for energy policy, Swedish District Heating Association
Respondent I (UK)	Responsible for CHP issues, City of London.
Respondent J (UK)	Director of Sustainable Innovations, Sustainable Technology Consultancy
Respondent K (UK)	Technical consultant, Sustainable Technology Consultancy
Respondent L (UK)	Research assistant, Combined Heat and Power Association
Respondent M (UK)	Sustainable energy policy division, Defra
Respondent N (UK)	Director, UK CHP Energy Company.

Table 3.5 The respondents professions and the descriptions of the organisation they are representing.

HISTORIC BARRIERS HBa

Code	Meaning
HBa-man	Poor management
HBa-ris	Lack of public risk taking
Hba-sys	Lack of systems view
HBa-pre	Customer perceptions
HBa-ava	Unavailable

TECHNICAL BARRIER - TBa

Code	Meaning
TBa-des	Poor design
TBa-unr	Unreliable
TBa-neg	Negative experience
TBa-sin	Heat Sink
TBa-acc	Poor accessibility
TBa-lab	Lack of skilled labour

POLICY BARRIERS - PBa

Code	Meaning
PBa-eur	EU Regulation
PBa-nat	National Policy
PBa-loc	Local Policy
PBa-com	Lack of long term commitment
PBa-sta	Lack of long term stability

INSTITUTIONAL BARRIERS - IBa

Code	Meaning
IBa-gov	Government bodies
IBa-loc	Local authorities
IBa-pub bodies	Perceptions public
IBa-cus	Customer perceptions
IBa-pla	Planning system building code
IBa-sys	Lack of Systems view
IBa-pri	Private companies

INFORMATION BARRIERS - InB

Code	Meaning
InB-inf	Lack of information
InB-acc	Hard access information
InB-gov	Lack of government info.

FINANCIAL BARRIERS - FBa

Code	Meaning
FBa-los	Low profits/losses
FBa-ret	Low returns on investment
FBa-dis	Use of high discount rate
FBa-fue	Expensive fuel
FBa-pol	Policy measures
Fba-ele	Elecrircity price

Table 3.7 Codes used for identifying drivers in collected data

HISTORIC DRIVERS - HDr

Code	Meaning
HDr-inv	Public investment
HDr-uti	Public utilities
HDr-com	Public commitment
HDr-pla	Planning integration
HDr-ava	Availability
HDr-oil	Oil crisis

TECHNICAL DRIVERS - TDr

Code	Meaning
TDr-eff	High Efficiency
TDr-pro	Technical Progress
TDr-pos	Positive experience
TDr-acc	Accessibility
TDr-lab	Skilled labour
TDr-hea	Demand for heat

POLICY DRIVERS - PDr

Code	Meaning
PDr-eur	EU regulation
PDr-nat	National Policy
PDr-loc	Local Policy
PDr-com	Long term commitment
PDr-sta	Long term stability

INSTITUTIONAL DRIVERS - IDr

Code	Meaning
IDr-eui	EU institutions
IDr-gov	Government bodies
IDr-loc	Local authorities
IDr-pub	Perceptions public bodies
IDr-cus	Customer Perceptions
IDr-pla	Planning systems building code
IDr-sys	Systems view
IDr-tra	Trade association

INFORMATION DRIVERS - InD

Code	Meaning
InD-acc	Good access to information
InD-gov	Government sponsored information

FINANCIAL DRIVERS - FDr

Code	Meaning
FDr-pro	Profitable
FDr-ret	Adequate returns
FDr-dis	Use of low discount rate
FDr-fue	Cheap fuel
FDr-tax	Taxation
FDr-ele	Electricity price
FDr-gra	Grant

Table 3.6 Codes used for identifying barriers in collected data.

3.5 DATA ANALYSIS

3.5.1 PRIMARY DATA ANALYSIS

The data analysis approach which has been used for analysing the primary data was the coding and clustering method developed by Miles and Huberman (1994). Codes where developed for finding common patterns in the data in line with the guidelines given. The coding system enabled the identification of drivers and barriers for CHP and DH in Sweden and the UK when it was focused on six areas identified as important from the literature review and the initial case study work, se table 3.6 and 3.7 above. The results from the analysis can be found in appendix three.

3.6 THE APPLICATION OF THE METHOD

How the above method has been applied in this thesis has been summarised in table 3.8. The theoretical parts of the methodology together with the description of how it has been applied shall provide the reader with a good understanding of the reasons for the chosen method of data collection and how it has been carried out in practise.

- The secondary data collection phase was mainly relying on printed sources and research in data bases and from official web sites. Energy Policy, DTI, Defra, The Swedish Energy Agency, Euroheat and Power, the Swedish District Heating Association and textbooks in economic theory and other economic literature have been of great value as sources of information. The sources where chosen on basis if reliability and information content. Previous experience and knowledge of the researcher have influenced the source selection.
- The secondary data collected has been written in chapter two and the theoretical background to the study was established in appendix one. The results form the primary data has been presented in chapter four.
- The first conceptual framework was developed on the basis of the theory in appendix one and the market study in chapter two. This framework was later used when formalising the interview questions.
- The respondents in the interviews were selected to achieve a wide range of opinions from both the private and the public sector. Personal contacts of the authors family and the Swedish and the English supervisors where used as well as information from the CHPA web site. Communication was mostly established by email and in some cases by phone. The major weakness in the selection of respondents has been the lack of connections within the UK government from where only email correspondence could be obtained. The respondents where in general very enthusiastic after they had participated in the interviews.

Table 3.8 The application of the method

• The interview questions where formalised from the knowledge acquired from the writing of the literature review and the conceptual framework. The theory in appendix I have also been very important when formulating the interview questions. • The data from the interviews where analysed by using the coding system suggested by Miles and Huberman which was very useful in visualising trends in the data which otherwise would have been easy to oversee. The codes where developed on the basis of the conceptual framework and the information in appendix one and chapter two. • The analysed data presented in chapter four was later combined with the theory from appendix one and the market study from chapter two. The combination resulted in the modified conceptual framework in the end of the chapter four and the policy recommendations in the discussion. In the new framework some parts are emphasised since they where found to be of a great importance for explaining the differences between state the markets in the two countries. • In the discussion the countries where compared and policy recommended on the basis of the market differences and the economic theory in chapter two. • The conclusion was written to emphasise the main findings of the thesis and to ensure the fulfilment of the aim and objective.

Table 3.8 (cont.) The application of the method

CHAPTER FOUR

RESULTS FROM CASE STUDY PRIMARY RESEARCH

4.1 INTRODUCTION

This chapter presents the findings from the interviews. The results where derived by using the data collection techniques described in chapter 3 including the coding and clustering analysis method which have been useful in providing a framework and structure for the results from the interviews (a short description of the respondents can be found in box 3.5). The respondents views and opinions is substantiated by the use of illustrative quotas, Swedish quotas have been translated to English by the author.

The interviews have been structured around six areas on which information have been collected, se table 4.1 below. The areas have been derived from the research questions and conceptual framework. The reporting of the research findings is consequently based on the same structure as the interviews and interview analysis matrix.

Areas of interest covered in the interviews

- **Historic Drivers and Barriers** – how CHP and DH emerged and important past events and social settings for the present market situation.
- **Technical Drivers and Barriers** – technical aspects of CHP and DH systems that have contributed to the present market situation
- **Policy Drivers and Barriers** – how the policy environment is affecting the present CHP and DH market
- **Institutional Drivers and Barriers** – how formal and informal institutions are affecting the CHP and DH market
- **Information Drivers and Barriers** – if the information available on the market is sufficient for the market players.
- **Financial Drivers and Barriers** – how the profitability, returns on investment and use of discount rate are affecting CHP and DH including taxes and subsidies.

Table 4.1 The six areas of interest covered in the primary research interviews.

4.2 RESEARCH FINDINGS FROM INTERVIEWS WITH UK RESPONDENTS

This section is reporting the research findings from interviews and correspondence with UK respondents, when Swedish respondents are commenting UK conditions this is stated explicitly. All respondents below imply UK respondents only.

4.2.1 HISTORICAL DERIVATIONS FOR THE PRESENT CHP AND DH MARKET IN THE UK

The UK market seem to have little historical drivers for CHP, three respondents (I), (L) and (N) have mentioned historical developments which they believe are reasons for positive deployment of CHP technology. The fact that CHP and DH have been available as options might have been to some value for the promotion of the technology according to (L) and (N).
The privatisation of the UK energy markets have according to respondent (N) worked as a diver for CHP when it made the technology more accessible for new entrepreneurs and companies.

The historical development seems rather to be a barrier than a driver for UK CHP. All UK respondents point out that there are historical reasons for the lack of CHP and DH today. Respondent (I) and (M) are pointing at the lack of public risk taking and respondent (J), (K) and (L) are emphasising the lack of a systems view in local authorities to be reasons for present CHP difficulties. The low willingness of public authorities to take on the financial responsibility of DH schemes is still a major barrier for CHP development in the city of London according to (I).

“The management of the installed schemes during the 70s made many tenets unhappy with the practise and when they where allowed to buy their flats they started to look for other types of heating practices” (respondent I)

Poor management of the installed schemes and rapidly rising costs during the oil crises in the 70s made many tenets unhappy with DH. The initial design had not been adequate and the maintenance unsatisfactory respondent (I) argues. The fact that to a great extent only council housing had DH installed created the perception that DH was only for the “poor people”. (H and C Swe)

“In England DH is viewed as the poor mans heating. –Are you having DH at home, then you must live in one of THOSE areas… “(Respondent H Swe)

4.2.2 TECHNICAL REASONS FOR THE PRESENT STATE OF THE CHP MARKET IN THE UK

Respondent (I) has in his market description of the CHP market in general and the London market in particular argued that the higher efficiency of CHP generation and the accessibility of the technology both are driver for CHP in the UK. Respondents (J) and (K) also agrees that the efficiency of the technology is a driver for CHP but they ad that this has been known for years and that efficiency clearly not is enough to promote the technology.

The technical barriers are pointed out by (I), (L), (J) and (K). The lack of a heat sink is a major problem, not even obvious buildings as leisure centres (swimming pools) and local council owned properties are connected into a grid and which according to (J) and (K) would be a cost efficient and easy way to get a demand for heat. Respondents (I) and (L) are both pointing at technical unreliability in the past and that some schemes have chosen a poor design which has given the technology a bad reputation among engineers.

"I mean in Aylesbury they built a pool a couple of years ago, a bran new swimming pool and I talked to a friend who worked for the local council at the time about energy efficiency. He had asked the council – why don't you have CHP here. They simply answered "too expensive" end of story." (respondent J)

Respondent (N) points at the lack of skilled labour on the CHP market, there are according to the respondent presently a skill shortage in the UK.

4.2.2.1 TECHNOLOGICAL LOCK-IN

Respondent (L) exposes the difficulty of getting CHP technology to work with the current national grid. A more decentralised production network would need investments in new power distribution to allow for a two way flow of electricity. New investments are needed anyway according to the respondent, if the government is to proceed with its nuclear plans. This would imply new power lines and other new infrastructure. It is only a matter of choosing which route to take.

The cost of retrofitting a DH system in existing housing estates and dwellings have been pointed at as a technological lock in by respondent (N)

4.2.3 UK POLICY AND ITS IMPACTS ON CHP AND DH

The impact of policy on CHP and DH is what makes the technology viable or not. All respondents express this as a fundamental fact. All but respondent (M) also agrees that current UK policy is acting more as a barrier than a driver for the technology. Below some of the most important drivers and barriers are outlined.

4.2.3.1 POLICY DRIVERS IN THE UK

The EU Emissions Trading Scheme (EUETS) is by most respondents pointed out to be a driver for CHP technology in the UK by promoting superior carbon ratio per unit of energy produced. The some respondents also like the EU backing which make all players act on a level playing field and they see the EU as a guarantee for stability and long term commitment. The CHP directive is mentioned by (L), (M) and (N) as a driver for CHP in the UK when it is supposed to guarantee a favourable treatment of the technology by government.

The UK national efforts for supporting CHP is expressed as something which could be very efficient if the government implemented one or more of what they them self identified as efficient policies in promoting CHP in the report “Climate Change the UK Program 2006” according to respondent (L). The exemption of Climate Change Levy (CCL) is expressed to be an important driver but only if the actors on the market would be guaranteed a long term exemption, presently the exemption only lasts until 2012. Respondent (M) is expressing the commitment from the government to promote CHP and is expressing the various initiatives taken for promoting the technology.

“Through the CHP Quality Assurance programme CHP is assessed for efficiency. Qualifying CHP becomes eligible for exemption from CCL on fuel inputs and power outputs. New CHP plant is also eligible for Enhanced Capital Allowances. VAT on domestic CHP was reduced to 5% as announced in budget 2005, which will provide a signal to developers of the Government's initial support for the development of the technology.” (respondent M)

Respondent (N) agrees to some extent to that the CCL exemption has provided a driver for CHP but only to enhance existing CHP not to provide incentives for new capacity. The increased capital allowances for CHP are also making a small contribution to CHP viability according to the respondent.

“The government have done a little bit in promoting CHP, but not as much as they would like you to think.” (respondent N)

4.2.3.2 POLICY BARRIERS IN THE UK

The policy environment was described by all respondents except (M) as an inefficient and inadequate system of measures to make CHP more attractive for industry; developers, local councils and private homeowners. An often encountered comment is “it looks good on paper but not in practise” and “it is a lot of talk but little action”. In The “Climate Change the UK Program 2006” report the government has identified what policy measures to take forward to promote CHP, but in next paragraph the government states that no of the identified promoting policies is going to be realised. This has frustrated all but respondent (M). Respondent (I) is expressing a feeling of hopelessness for the future of CHP in the UK.

The New Electricity Trading Arrangements (NETA) introduced in 2001 is according to respondent (L) working in an unfavourable way for CHP and renewals in the UK. When renewals have been compensated for the shortcomings of NETA by the introduction of the renewal obligation, nothing has been done to correct for the harm made to CHP.

"NETA is a big barrier for small power producers in this country; the policy is causing a huge lowering of electricity prices when our members want to sell excess electricity to the grid" (respondent L)

Respondent (L) is in general very critical to the government's way of handling CHP issues and is claming the government to cause most of the present CHP problems. The goal of 10.000 MW of installed capacity by 2010 which according to the governments own reports is going to be missed is viewed as unrealistic by all respondents. Respondent (J and K) is pointing at a statement where the government has clamed CHP to be a major part of their energy strategy, but the respondents have not yet seen any real results.

4.2.3.3 THE LACK OF A LONG TERM COMMITMENT

The government was supporting the development of DH between 2001-March 2006 by the introduction of the community energy program which was a result of industry lobbing according to (L) This was suddenly stopped without previous warning in march this year which has caused major problems for the DH developers and shows a lack of long term commitment. This view that the government is lacking a strong commitment is shared among most respondents but (M) and is believed to be a major problem for CHP.

"The community energy program was cut in March, a hellish month, without any previous warning. The only explanation we get from the government is that it wasn't cost efficient enough, they refuse to show us the calculations even when we ask for them." (respondent L)

Respondent (N) agrees that the major policy barrier for CHP in the UK presently is the lack of long term commitment from UK and EU government. Both the EUETS and the CCL exemption are running out in 2012 with no future guarantees for industry.

"The problems we have are time scales if you are looking to build a CHP plant now it will take a couple of years. This means that you can only bank the benefits of policy for maximum five years." (respondent N)

4.2.4 THE UK INSTITUTIONAL ENVIRONMENT AND IMPACTS ON THE VIABILITY OF CHP AND DH

When conducting the interviews the institutional arrangements concerned with CHP and DH emerged as an important factor for the viability of the technology. All respondents but (M) emphasised that the present arrangements are not working efficiently and are in most cases acting as barriers to CHP and DH diffusion. The local authorities and the planning system were repeatedly pointed at as a source of problems for the technologies. Below this is outlined further.

4.2.4.1 INSTITUTIONAL DRIVERS FOR CHP DIFFUSION IN THE UK

There where two respondents (M) and (N) which expressed the institutional environment in the UK to have a positive impact on CHP. Respondent (M) referred to the planning guidance given to local authorities by central government and the positive promotion it is suppose to have on CHP and DH diffusion.

"Planning Statements are intended for use by local planning authorities in their preparation of regional spatial strategies and by local planning authorities in the preparation of local development documents. CHP is included in PPS 22 and planning authorities are instructed to encourage renewable and CHP schemes through positively expressed policies in local planning documents." (respondent M)

Respondent (I) also comments on this guidance but the respondent's focus on the lack of fixed targets and mandatory requirements. The respondent strongly believes that local authorities and the government can be a strong force in CHP and DH promotion but only if the requirements in planning regulations and other guidance became of a more mandatory nature. Respondents (J) and (K) have the same opinion on this issue.

Respondent (N) is however optimistic on future development in local authorities, the respondent believes that the current discussion about increased sustainability planning will slowly make local councils become more integrated with energy issues.

"I think sustainability is much more on the agenda now than 10-15 years ago in local authorities." (respondent N)

4.2.4.2 INSTITUTIONAL BARRIERS FOR CHP AND DH DIFFUSION IN THE UK

There seems to be different layers of institutional problems on the UK CHP and DH market according to all UK respondents and some Swedish respondents with UK experience. There are problems with customer perceptions, problems with perceptions of public organisations, problems with local authorities, problems with the planning system and problems with the national government. The problems with local authorities and the planning system seems to be a very serious barrier for CHP and especially DH in the UK.

4.2.4.3 CUSTOMER AND PUBLIC PERCEPTIONS

Negative customer perceptions to connect their buildings to a DH grid is according to respondent (I) a major problem for expansion of CHP and DH in the UK. The explanation for this is divided in two according to the respondent. Fist there are the historic reasons of poor design, poor management and a will to be independent and not rely on other organisations for essential services as heating and cooling. Second there are contracting problems when the companies providing the DH service not are able to give the appropriate guarantees to the customers. This could according to the respondent be solved if local authorities guaranteed the heat supply, but the respondent have no knowledge of any local authority which have been willing to take on the risk of such an arrangement.

“Bad customer perceptions of failures in the past and an increase in a cheap gas supply replaced poorly designed DH systems when tenants where allowed to by their flats from the councils.” (respondent I)

Swedish respondents (D), (H) and (C) have through there involvement with European CHP and DH organisations understood that a major barrier of DH and CHP in the UK is customer perceptions. DH is according to (C) and (H) alleged by some UK customers to be something for “poor people” and a socialist and communist heating practise.

Public attitudes are according to (L), (J) and (K) characterised by as mentioned in 5.2.3.2 “allot of talk but little action” this is resulting in a distrust of public statements and policy.

4.2.4.3 LOCAL AUTHORITIES AND THE PLANNING SYSTEM

There are problems in how CHP, DH and energy issues in general are handled within local authorities in the UK. All respondents but (M) agree to this. (M) vaguely hints that there might be some problems in how energy issues are handled at local levels. The lack of energy/carbon plans in which the issues would be integrated is pointed out by respondent (J) and (K) they believe such a tool could create a better integration of energy issues to promote savings.

“There are problems with joint up issues in local authorities” (respondent L)

There is a general opinion that the cooperation between different parts of local authorities are not working and that there is a lack of systems view within the organisations. Respondents (J) and (K) have a clear opinion that the waste section of local authorities not is taking to the energy section which not is taking to the planning section creating an inefficient institutional environment resulting in independent solutions to systems problems. (I) and (L) have similar opinions. Respondents (J) and (K) are also pointing at contractual problems in dealing with local authorities, it is believed to be difficult to make commercial agreements with the public sector because of the large number of decision makers involved.

"Local authorities are terrible they don't do any new innovations without a push from central government." (respondent J)

The innovative capacity and entrepreneur ship of local authorities are questioned by respondent (J) and (K) and they are not putting any faith in them being able to create good conditions for energy saving technique as CHP and DH without forcing central government legislation. They are proposing some kind of mandatory requirement to deal with the issue.

"You want to provide guidance to local authorities and make it very difficult for them not to use CHP." (respondent K)

The planning system for which the local authorities are responsible is another important barrier for CHP and DH. According to all respondents but (M) the planning system does not incorporate incentives for technologies as CHP and DH. It is on the contrary the major reason for not using certain energy sources as energy from waste when planning permissions for incinerators are practically impossible to get according to (J) and (K).

"The major problem for energy from waste is the local planning authorities; they want to live the quiet life, not go to war" (Respondent J)

The planning system does not provide any incentive for new housing developments to install DH grids which could work as heat sinks for CHP. This is according to both (I) and (L) because of the lack of mandatory requirements in the regulations and the lack of a systems view within the local planning organisations.

"It is easy to build individual heating. It is more convenient for a developer to stick a gas pipe in and make individual boilers then to install DH with the difficult contracting setup it would mean. I think there is a lack of authority helping to combine the issues" (respondent J)

4.2.4.4 NATIONAL GOVERNMENT AND BUILDING REGULATIONS

Respondent (L) and (N) think there is an institutional failure in how the government is handling CHP issues when both DEFRA and the DTI are responsible for different issues affecting the technology and often have different opinions about how to promote the technology. The technology falls between two chairs according to (L). Respondent (N) thinks there might be some personal or cultural issues between the two parts of government hence the bad cooperation.

"A big problem we have with CHP is that we are stuck between two departments DEFRA and DTI, when we arrange meetings the people from the two often have hmm very different opinions." (respondent L)

The unwillingness of the UK government to make the building regulations stricter is a barrier which (L) and (I) independently are pointing at. The regulations have a tendency to "pick the low hanging fruit first" which is putting the more complex DH and CHP down in priority to increased insulation and low energy light bulbs. With regulations which have no mandatory requirements it is impossible to get a DH system started with the high initial costs implied and to get people to install CHP with its high upfront costs. Respondent (L) refers to a Danish regulation where all new electricity utilities over 1 MW now is forced to be CHP, which has forced companies to create markets for heat. The respondent never thinks the same would happen in the UK because of the government's reluctance of market interventions and the lack of commitment to energy savings.

4.2.5 THE INFORMATION SITUATION ON THE UK CHP AND DH MARKETS

Information is believed to be a major reason for the present problems of low CHP diffusion by respondent (N) The largest market players are believed to have adequate information about technical options and possibilities the technology implies but most industrial sector and local councils have no CHP and DH experience at all according to the respondent.

"I think the political climate is right, I think the economics are right the only major barrier for CHP presently is marketing. Marketing is the key which without any government initiatives is the decisive factor." (respondent N)

Respondent (L) concur to this when the respondent doesn't think there is enough DH information available for local planners and for individual homeowners. This is believed to cause the DH option to be overlooked in the planning process and might be a reason for no consumer demand for the heating practise.

Respondent (M) calls attention to the government's efforts in promoting information about CHP and DH to the market players. Some respondents seems to think that the government's intention has been successful because respondent (I) and (J) think that the information is readily available and of high quality and respondents (K) and to some extent (L) can partly agree to this.

4.2.6 THE FINANCIAL VIABILITY OF CHP ON THE UK MARKET

The CHP market in the UK is by all respondents described as a thriving market during the 1990s and around the millennium because of the large spark spread, the difference between the electricity and gas prices. When the gas price started to increase and electricity prices to decrease around 2001 CHP technology became less attractive. The price of gas is by most respondents described as the major financial driver/barrier for further CHP development. This and other drivers/barriers are outlined below.

4.2.6.1 FINANCIAL DRIVERS FOR CHP AND DH IN THE UK

All respondents agree to the importance of the spark spread as one of the primary drivers for CHP in the UK. Respondent (L) emphasis this when the historic drivers are discussed and (I) is very determined that this is the primary driver for the technology. High electricity and energy prises are mentioned by respondent (L) and (N) as important; if the prices received by small generators where higher the respondent believes this could provide a large incentive for more small scale decentralised production.

Respondent (M) mentions the CCL exemption as an important financial driver for CHP when it provides companies a lower over all tax expenditure. The respondent also mentions decreased VAT on domestic CHP as another financial driver for CHP installations. The grant scheme for subsidising DH installations is also pointed at as a financial driver; the sudden abandonment of the scheme is as stated above stressed by respondent (L). Respondent (N) emphasises the importance of grants or other subsidies for making DH a viable option in the UK, if no such incentives are in place the economics of DH are unfavourable.

4.2.6.2 FINANCIAL BARRIERS FOR CHP AND DH IN THE UK

Large losses for companies involved in the CHP and DH sector is pointed at by respondent (I) and (L) as a major barrier for increased investments in the technologies. The CHP and DH scheme in the city of London running since the min 1990s has according to (I) never made money and the company responsible for the scheme has been reconstructed several times. The unfavourable situation is according to the respondents caused by the low spark spread which has prevailed since 2001 and for some schemes because of poor design choices.

The losses the companies are making are closely linked to another barrier identified by respondent (L) which is low returns on investment in CHP and DH technology. It is according to the respondent difficult tot get companies to invest in projects with long payback periods as many CHP installations and DH schemes require. Private companies seem to be using a higher discount rate than public organisations when choosing how to invest, according to most of the respondents. The use of a lower discount rate should make public organisations more willing to make long term commitments than private. This trend has however not been very visible and respondent (I) do not think that the public sector is more willing to invest in CHP and DH than the private sector.

4.3 RESEARCH FINDINGS FROM INTERVIEWS WITH SWEDISH RESPONDENTS

This section is reporting the research findings from interviews with Swedish respondents, the structure used is the same used above and expressed in box 5.1. All respondents below refers to Swedish respondents only.

4.3.1 HISTORICAL DERIVATIONS FOR THE PRESENT CHP AND DH MARKET IN SWEDEN

When interviewing the Swedish respondents a common theme of many historical drivers for DH and the price of electricity as the prevailing historical barrier for CHP were seen. All respondents have positive opinions of the past in conjunction with DH and to some extent CHP development. The Swedish decision makers and players on the market seem to have embraced the DH technology and made it in to common practise and a low cost heating option. CHP has not been used to its full potential because of the historically low price of electricity.

4.3.1.1 HISTORICAL DRIVERS ON THE SWEDISH CHP AND DH MARKET

There seems to be a general consensus among the Swedish respondents of the importance of the oil crises in the 1970s and 80s as a driver for making Swedish decision makers realise the harm high oil dependence can have on an economy relying on oil imports. This combined with a growing concern of environmental issues (respondent E) made the government start pushing for lower oil dependence.

"When the oil crisis started to affect the county in the 70s there was a commission set up for looking at what to do. Olof Johansson (later leader of the liberal Center Party, author's remark) was actually using climate change as an argument for using less oil." (respondent E)

This push made according to respondents (E), (F) and (D) investment in DH and non oil fuels more attractive, because of government subsidies for change to DH instead of individual heating and because of the signal sent which made utility companies and private homeowners realise that oil was going to become very expensive in the future. The subsidies were according to respondent (F) successful in promoting DH and managed to decrease the number of oil heated homes substantially.

4.3.1.2 HISTORICAL ROLE OF LOCAL AUTHORITIES

The role of the local authorities as creators of local utility and energy departments within the authorities are deemed as very important drivers by respondents (A), (D) and (H). These departments later made in to local energy companies, were in most places given multiple responsibilities of providing heating, electricity, water and waste management. This created a systems view of looking at the issues which resulted in DH solutions with CHP features in several Swedish cities in the later 50s and early 60s. It was the local politicians and the members of the board of directors of the local energy company which were the major driving force for DH, CHP and energy from waste in the Swedish city of Linköping according to (A).

"After the Second World War a need for more electricity was identified, a DH grid was seen as a good heat sink for the CHP unit which helped reduce local air pollution and provide cheep heating. The other option was to use river water and just dump the heat in there. Progressive local politicians got involved with the thing and made the energy department not just dump the heat. This was all done without any government involvement." (respondent A)

The local planning systems with energy plans which made it easy for the local utility companies to connect new development to DH provided a substantial driver for DH and used as a heat sink for CHP according to respondents (A) and (H). The large public investments in housing during the 60s and 70s helped to expand the DH systems and work as a driver for technological development and learning by doing. The new deregulated energy market regulations which came in to force in 1996 removed the option of designating areas to DH and is according to the respondents a barrier for further DH development.

4.3.1.3 THE LOW ELECTRICITY PRICE AS CHP BARRIER

The major reason for the lack of CHP capacity installed in DH systems is the historically low price of electricity in Sweden according to the respondents. Respondent (A), (D) and (H) comments on the excess electricity which was the prevailing market condition during the 80s and 90s. Respondent (H) remember that the large power companies installed heat pumps and electric boilers in DH plants only to get rid of the excess electricity in the power grid. All respondents concur that such a situation did not provide any incentive for installing a turbine for electricity production in DH production with the extra investment costs it would have brought.

4.3.2 TECHNICAL ISSUES –CHP AND DH DEVELOPMENT IN SWEDEN

The high rate of efficiency CHP generates is the overriding technical reason for installation of CHP in Sweden according to the respondents. The technology is seen as a good way of utilising the energy inputs in a resource efficient way. Respondent

(A), (B), (C) and (E) are expressing positive experience as good reliability, well known and easy to work with as other drivers. This positive technical experience has been built up because CHP has been used for years in industrial sectors, mainly the paper, pulp and steel industries and in local power utilities own plants. This has according to the respondents created learning by doing scenarios where the staff and the companies now know how to handle CHP and how to run the technology efficiently. There are sufficient skills on the market which is making all companies able to access CHP and DH competencies.

The demand for heat from DH grids is a driver for CHP according to respondents (A) and (H). The existence of accessible and well working heat sinks which are making use of the heat instead of just loosing it, as in a cooling tower, is making CHP installations easier to fit. The same reasoning but in reverse is made by respondents (D) and (H) who are pointing at the lack of heat sinks for a further expansion of CHP in Sweden. (D) and (H) look at technical problems as a barrier for further Swedish CHP expansion.

4.3.3 SWEDISH POLICY AND ITS IMPACTS ON THE VIABILITY OF CHP AND DH

There are mixed opinions about whether policy has been a driver or barrier for CHP and DH in Sweden. Most respondents seem to agree on that the policy signals to reduce oil and other fossil fuels have been communicated efficiently and that the government's commitment to the task has been firm. The policy promotion of DH is also commonly agreed on as a driver for the technology. For CHP there are more divergent views, the respondents from government departments generally think that the energy policies lately have been in favour of CHP and the industry representatives disagree. The CHP and DH industry generally have an opinion that Swedish environmental policy is too strict and is making investment in gas fired CHP too difficult.

4.3.3.1 POLICY DRIVER FOR CHP AND DH IN SWEDEN

The EU carbon trading scheme is according to all respondents a driver for further CHP investments because it is rewarding high efficiency production. Respondents (A), (D) and (H) is however critical to the Swedish national allocation plan since it has given less emission rights to Swedish fossil fuel CHP than fossil CHP on other European countries. The government respondents agree to this but emphasise that the mistake has been corrected and that new fossil CHP shall be treated in line with the favourable guidelines set out in the CHP directive.

The renewal obligation is according to all respondents the prime driver for CHP in Sweden. The policy is stimulating the market by providing a premium price for renewal electricity. This policy is so powerful that according to respondent (G) all potential wood fired CHP is being explored. Respondent (H) have the same opinion, the renewal obligation is according to the respondent a very powerful policy. The respondent points out that the utilisation rate of the wood fired CHP units increased substantially when the policy was introduced 2003.

"All CHP which is potentially viable is currently being explored and built; wood fired CHP might be too profitable. It's a threat when it is competing for the raw materials with the paper and pulp industry". (respondent G)

The obligation is being heavily criticised by respondent (F) and (H). They think too much incentive is provided to the CHP market and that it is resulting in a higher electricity price for the consumer and might jeopardise the supply of raw materials to the paper and pulp industry. Respondent (L) think that it is inefficient for the government to provide more incentives for carbon reductions in Sweden since the marginal abatement cost is very high compared to Europe as a whole.

"The Green Certificates are in principal a plan economic system. It is a political product, an order which is not environmentally optimal or optimal for the economy as a whole." (respondent F)

The Swedish carbon tax have according to all respondents made it less attractive to burn fossil fuels then waste and wood in Swedish heat and power production. The taxes on carbon emissions are according to respondents (E) and (F) high enough to internalise the external costs associated, which respondent (F) is basing on "scientific research in the area". Respondents (D) and (H) are questioning the present carbon tax rate and think is more of a revenue maker for the government that an environmental policy. They agree however that the carbon tax have been successful in making coal and oil being faced out form the DH and CHP market.

"It is easy to see that the shift away from fossil fuels happened when the tax was at half the rate it is today. It is obvious that the present emissions are very expensive to reduce which why our opinion is that the present tax only is a revenue maker for the government." (respondent H)

The system for subsidising homeowners to connect to a DH system and to make local utilities expand their DH girds have according to (F) and (G) been successful and made DH expand rapidly. The optimal size of the networks is now reached according to (F). Respondent (A) don't think that the government has helped expand the networks to a large extent, the respondent agree to a little help the last few years but argues that all the major expansions which happened before the 90s where locally financed.

"Sweden has already expanded DH to social optimum. More incentives are inefficient for society. The trade with emission right will make sure that the reductions will happen somewhere else where it is cheaper." (respondent F)

4.3.3.2 POLICY BARRIERS IN FOR CHP AND DH IN SWEDEN

The major complaint about the policy environment from the industry respondents in Sweden are what they perceive is a lack of stability in the current system.

"According to me and The Swedish DH Association is the policy environment for increased CHP development in Sweden very favourable presently, there are no specific policy barriers since the taxation on heat for CHP production was decreased." (respondent E)

The energy tax system and the taxation of fuels are perceived as the major barrier, not because of the tax levels as such but because of the inconsistency in them. Energy taxation is according to respondent (E) a technical issue which needs to be worked through by experts and not by politicians. Respondent (D)'s opinion is that the government have managed to communicate its commitment to reduce fossil fuels but "when it comes down to business" they have failed to make a policy system with a clear path to follow for the industry.

"There is no way that I could have predicted the current energy policy 10 years ago" (respondent G)

Respondents (F) and (E) do not agree with the industry's view and their opinion is that the industry don't want to understand the information they are given. Respondent (G) understand the industry and agrees to the lack of a "clear path". The respondent doesn't think that anyone can predict the energy policy environment more then a few years in advance.

"It must be inefficient to force the industry to build power plants for many different fuels only to optimise the current energy tax policy." (respondent G)

The carbon tax on heat produced in CHP plants was until 2004 a major policy barrier for CHP in Sweden according to most respondents. The reduction of the carbon tax to the same level as for industrial heat made investment in gas fired CHP a viable option on the Swedish market both industry and government representatives concur.

4.3.4 THE SWEDISH INSTITUTIONAL ENVIRONMENT AND ITS IMPACT ON THE VIABILITY CHP AND DH

The Swedish institutional environment which is covering CHP and DH technology seems according to the respondents to be almost exclusively in favour of the technology. The informal institutions as customer and public perceptions are positive to the technology and formal institutions as local authorities where the ones which initiated the systems in the first place. The heavy involvement of local authorities has according to many respondents created a positive systems view where different issues are connected and an integration of DH and lately CHP in to the planning system has been achieved.

4.3.4.1 INFORMAL INSTITUTIONAL DRIVERS FOR CHP AND DH DEVELOPMENT IN SWEDEN

When the respondents where asked to comment on customer and public perceptions of DH and CHP a distinction between attitudes to the technology and attitudes to the companies running the systems could be found. According to respondent (B), (C), (H) and (G) there are almost exclusively positive perceptions of DH as practise but in some instances negative experience of local DH company’s pricing policies. Customers in general seem to be satisfied with the green image of DH and the convenience of being connected to the grid according to respondent (A).

Many respondents don’t think CHP is well known by DH customers because CHP is more an investment decision for DH companies which not make a difference for the heat customers. Respondents (C), (F) and (D) perceive the government and other public organisations perceptions of CHP and DH as very positive and think that the technology is well treated formally as informally by the government and local councils.

“Göran Persson (the Swedish prime minister, author’s remark) held a speech some time ago; I think it had something to do with the oil commission where he called the Swedish District Heating Association’s director for a hero in the change away from Swedish oil dependence towards a more sustainable society” (respondent D)

4.3.4.2 LOCAL AUTHORITIES, ENERGY COMPANIES AND THE PLANNING SYSTEM

As expressed by the respondents above in section 5.3.1 local authorities and their energy companies has been acting as important historical drivers for the development of DH and CHP. The local authorities are according to all respondents but (F) still acting as drivers for the technology by initiating network expansions and introduction of new local networks in smaller towns.

"All cities and towns above 10.000 inhabitants have a DH network." (Respondent H)

Respondent (C) thinks that the ability of connecting different issues together to come up with common solutions is a very important driver for the DH and large scale CHP. According to the respondents international experience is this ability usually present in those countries and regions with large networks and heat sinks and the respondent believes that the local authorities have a key roll to play as the initiator and planner of the systems. The ability to use waste as a fuel is a combination of acceptance from both formal and informal institutions according to the respondent.

"In Sweden the local councils have had a common approach to development. They have through organising all decisions through one organisation managed to get an efficient whole" (respondent C)

"Important with acceptance for the technology, there can be a need to reform perceptions to get a driver for technologies as energy from waste" (respondent C)

According to respondent (H) is the acceptance of especially wood and to some extent waste fired CHP good in local councils and private energy companies. Energy companies are many times reluctant to propose fossil fuel developments in Sweden because of the negative perceptions fossil fuels have in local and national authorities. It would according to the respondent be very difficult to get planning permission for a coal or oil plant.

"If you came to a local authority and wanted to build a coal fired power plant you would face allot of resistance. If you on the other hand want to build a wood fired CHP plant you would be welcomed with open arms. An energy from waste plant is something in-between". (respondent H)

The planning system is identified by respondents (E), (A), (D) and (H) as a driver for DH in Sweden. The integration of multiple issues and the existence of energy planning is said to be important for DH and lately for CHP. Respondent (H) do not think it is possible to get planning permission for an apartment block in a city/town with DH if the building not is connected to the DH system.

4.3.4.3 THE NATIONAL GOVERNMENT

Respondent (B) have a clear view that the only real driver for development of environmental friendly technology and implementation of such is dependent on national and presently EU legislation. The respondent thinks that the Swedish government has been successful in its development of policy for promoting DH and lately CHP. The major problem the respondent together with respondent (C) has identified is the lack of stability from the government's side. The respondents think that the government in committed to reduce carbon emissions and fossil fuels but there have been to many shifts in the tax levels and other policy which have made some industries reluctant to invest further. They believe however that this only is a minor part of the market actors.

Respondents (E), (F) and (G) think that the government's involvement in DH and CHP development has been very important for the progress made.

"My opinion is that no DH expansion the last 10 years would have happened if it would not have been for the government support to the local councils and companies" (respondent G)

Respondent (F) in particular think that the government has contributed substantially to get the current market situation. The respondent's opinion is that the government has done enough and that all further incentives provided will be inefficient from a society perspective.

"We do not need to expand the renewal sector any more, we have already done enough. Any further incentives will be political choices and will not be based on social efficiency." (respondent F)

4.3.4.4 INSTITUTIONAL BARRIERS FOR CHP AND DH DEVELOPMENT IN SWEDEN

Four out of the seven Swedish respondents think that there are institutional barriers for CHP development in Sweden, hardly any think that there are barriers for DH. Respondent (E) is pointing at the big private and public energy companies as barriers for CHP. They have sometimes acted to discourage small regional companies to invest in generation capacity to keep their oligopoly.

The other barrier put forward by respondents (G) and (H) is the inconstancy in tax levels, mentioned above, which have made some companies reluctant to invest. Respondent (H) is emphasising that a technology as DH with CHP are dependent on high initial investments because it is capturing low grade heat and fuel sources. If there is a risk that the government suddenly change the market conditions companies might find them self in a position of owning a very expensive unprofitable CHP plant. This has happened according to the respondent and has had a discouraging effect on the market.

4.3.5 INFORMATION AS A DRIVER OR BARRIER FOR SWEDISH CHP AND DH

When asking the respondents about the information available for actors on the DH and CHP market the answerers where very straight forward. There is no lack of information and it is not hard to gain access to information about CHP and DH in Sweden. No respondent could think of any information constraint on the market. The access to skills is not a barrier in Sweden, skills on CHP and DH is readily available on the market and can be purchased by anyone. No respondent thought that smaller actors on the market where constrained because a lack of skills when deciding to make CHP investments.

4.3.6 THE FINANCIAL VIABILITY OF CHP AND DH ON THE SWEDISH MARKET

The historically low price of electricity is the major reason for the low rate of CHP in the Swedish DH systems according to the respondents. The large amounts of cheap hydropower from the north and the surge of nuclear power connected to the grid in the 70s and 80s stopped all aspirations of building new CHP plants. The situation have changed however and the present market conditions look more promising for making CHP economically viable in Sweden. This will be outlined in further detail below.

4.3.6.1 FINANCIAL DRIVERS FOR CHP AND DH IN SWEDEN

Respondents (A), (D), (H), (C) and (B) give a very straight forward answer when asked for financial drivers for DH and CHP investments; it is simply profitable. The systems are making money and are giving relatively good returns on investment. A difference can be seen when the respondents are asked for what discount rate they use. Local council owned utilities seem generally to use o lower rate then private or government owned. Respondents (J) and (C) think that this might be because they are viewing DH and CHP investments more as energy services than purely business investments.

“DH must be built without thinking of profitability; this can not be done on a purely private market.” (respondent G)

According to respondents (E), (A), (G), (H) and (B) are low discounts rates a driver for DH and CHP. The use of a low rate or subsidies is necessary during the start up phase of the technology according to respondent (J). The respondent does not think that any investments would have happened if a pure private market had made the decisions. The role of the local authorities and the low discount rate public ownership implies is according respondents (A) and (C) crucial for DH and CHP today.

"We are usually using a 20 year payback period for our major DH and CHP investments." (respondent A)

The current policy of renewable obligation is clearly providing a good financial driver for CHP investment since it is providing a premium price for electricity made from bio fuels. All respondents agree that there are increased incentives for CHP production because of the present premium prices. The carbon tax has provided a financial driver for non fossil fuels according to the respondents; it has made investments in renewable and more efficient energy production more financially viable. It is however very difficult to now presently how efficient the tax has been because of the general price increase of fossil fuels, according to respondent (F) and (E).

4.3.6.2 FINANCIAL BARRIERS FOR CHP AND DH IN SWEDEN

All the respondents give the low prices of electricity as the major barrier for CHP production in Sweden. The situation with overcapacity of electricity generation was according to respondent (A) a situation which made all CHP investments disappear for almost three decades.

"It was a major decline in the profitability of our CHP turbine when the nuclear plants came online. The excess electricity provided no incentive for CHP." (respondent A)

Respondent (H) points out that this situation more or less prevailed until the introduction of the renewable obligation 2003. Before that, it was according to the respondent difficult to attract investments to CHP because of the low returns due to low incomes from electricity sales.

The use of high discount rates and short payback periods by private actors on the market are seen as barriers by respondents (E), (G), (H), (C) and (B). Respondent (C) has experienced when council owned DH companies has made investments which would have been ruled out by the private market. The private actors are generally using between 8-13% while council owned companies can use rates as low as 2-3% according to the respondent.

"When I have been working for the big private "dragons" I've seen rates of 12-13% used. This is very different from working in council owned enterprises." (respondent C)

4.4 CHAPTER SUMMARY

Summary of UK Respondents

- More historical barrier than driver for CHP and DH, the lack of public risk taking and lack of systems view in authorities are barriers and the privatisation of the UK energy markets provided a driver for CHP
- Poor management and poor design of DH created bad customer perceptions.
- The lack of a heat sink is acting as a barrier and the lock in of the national grid and the lock of heat distribution are barriers for DH and CHP
- EUETS is a driver for CHP and UK policy could be a driver if more efficient policies where implemented.
- There seems to be a disparity between the government and industry about policy and institutions.
- The lack of long term policy commitment is a barrier for CHP and DH in the UK.
- The role of local authorities might act as a future driver for CHP and DH because of more sustainable planning
- Present role of local authorities is perceived as a major barrier for CHP and DH because of the lack of a systems view and the lack of energy and carbon planning integration.
- CHP and DH is a responsibility of Defra while other energy is under the DTI which makes the technology to be unfavourable treated du to lack of cooperation.
- Lack of marketing and lack of information is believed to be a major barrier for CHP and DH.
- The spark spread (difference between gas and electricity price) is the prevailing driver and barrier for CHP in the UK.
- Losses and low returns on investment and the use of a high discount rate are other barriers for UK CHP and DH.

Table 4.2 Summary of UK Respondents

Summary of Swedish Respondents

- The oil crisis acted as an important driver for Swedish DH
- Local authorities have acted as drivers for CHP and DH in the past when they set up energy companies with multiple responsibilities which created a systems view and integrated energy issues in the planning system.
- Low electricity prices made CHP unprofitable between the 1970s and the late 1990s
- The demand for heat is both a driver and a barrier for Swedish CHP.
- EUETS is a driver for CHP in Sweden and the Swedish renewal obligation is presently making all potential wood fired CHP being built.
- The renewal obligation is so powerful that there are fears of over stimulation of the renewal CHP market.
- The Swedish carbon tax has made fossil fuels to be pushed out of CHP and DH and subsidies and grants have helped expand DH.
- The lack of long term stability of the taxation levels and system is perceived at the major policy barrier for DH and CHP in Sweden.
- There are very positive customer perceptions of DH and the government is positive to both CHP and DH
- The local authorities are good in connecting different issues and come up with joint solutions; they are good in integrating DH and to some extent CHP in the planning system.
- There are no problems with CHP and DH information and skilled labour in Sweden.
- DH and especially renewal CHP is presently profitable on the Swedish energy market this and use of low discount rates are acting as financial drivers for the technology.
- The low price and excess production of electricity have been and to some extent still is acting as CHP barriers.

Table 4.3 Summary of Swedish respondents

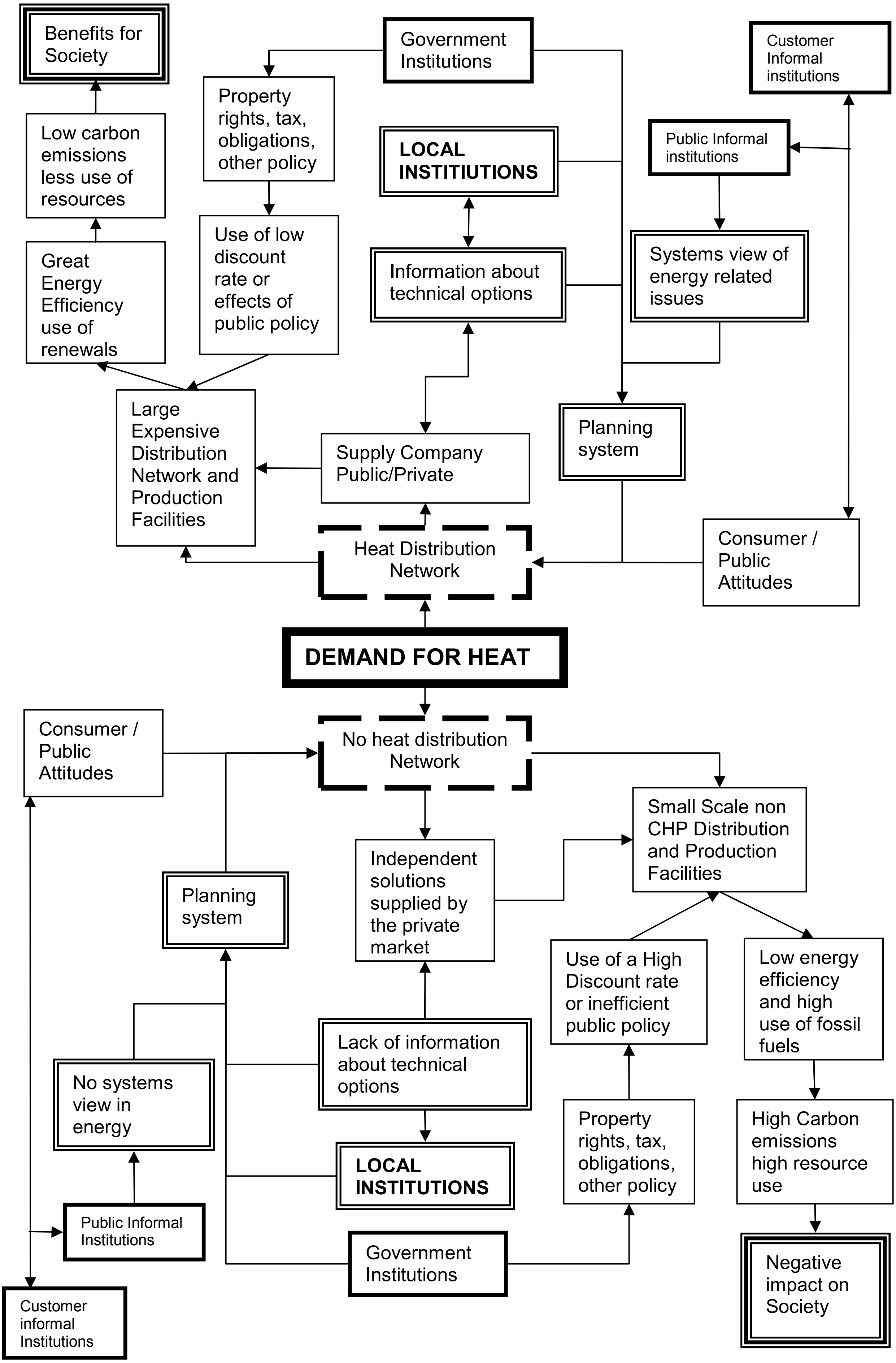
4.5 CONCLUSION FORM CASE STUDY PRIMARY RESEARCH

The major differences between the two countries observed from the interviews are the difference in information load on the respective market, the function of government and local authorities and the way the public sector is formulating policy and is handling the technologies. Customer perceptions, interlinked with the difference in information, are also an important difference as well as the use of a lower discount rate for energy investment in council owned energy companies in Sweden compared to the private actors in the UK.

4.6 MODIFIED CONCEPTUAL FRAMEWORK

The conceptual framework from chapter two has after the findings from the interviews been modified for making a better representation of the concepts in this thesis and to emphasise some important findings. The major differences between the UK and Sweden seem to be lying in the information situation and in the formal and informal institutional environment. This is show below by changes in the frames of those boxes. The mandatory planning requirements, the systems view of energy issues and the good information situation is making Sweden avoid the negative externalities associated with individual heating market which the UK is characterised by.

CONCEPTUAL FRAMEWORK



CHAPTER FIVE

DISCUSSION

5.1 INTRODUCTION

This chapter is discussing the research findings from the market study in chapter two and research results in chapter four in light of the neoclassical and institutional economic theory from appendix one. The discussion is focusing on the differences found on the two markets and is, by using economic and innovation theory, suggesting policy recommendations for increased CHP and DH diffusion.

5.2 THE DIFFERENCES BETWEEN THE UK AND SWEDISH CHP AND DH MARKETS

Chapter two and four have both made important findings, chapter two by providing market descriptions from secondary sources and chapter four by presenting the findings from the respondents. The below boxes are identifying the major differences found on the two markets. The most significant differences which are going to be discussed further in this chapter are the institutional arrangements, government policy/commitment and the information situation. These three plus the fuel and electricity supply have been identified s to be significant for explaining the CHP and DH diffusion (or lack of).

CHP Diffusion

- UK: Installed CHP capacity in the UK is presently about 5500 MW, mainly gas fired. This is concentrated to industrial sites and large single users of both heat and power. There are very five if any new CHP projects planned.

- SWE: Installed CHP capacity in Sweden is presently about 2700 MW, fired by a diverse range of fuels mainly renewal. The CHP is concentrated to DH systems and to some large industrial heat and power users. The CHP sector is predicted to grow over the coming years.

DH Diffusion

- UK: Less than 1% of UK Dwellings are connected to a DH network, bad customer perceptions and difficult financial viability are hampering the practise

- SWE: 50% of Swedish residential heat demand and some industrial demand are supplied by DH and all cities and town with over 10.000 inhabitants have a DH system.

Ownership Structure of DH and CHP

- UK: Mostly large private energy companies in the CHP business working predominantly with industrial clients. The DH that exists is to a large extent run under PPP partnerships.

- SWE: Many local council owned energy utilities with a recent move towards privatisation of the industry, still a large extent of the DH and CHP assets are publicly owned

Table 5.1 Differences found in chapter two

Planning Requirements for DH and CHP

- UK: No mandatory requirements for energy planning under the planning law for local councils. The building regulations only have recommendations to use CHP and DH no forcing requirements

- SWE: Mandatory energy planning law for local councils since 1977 which has resulted in a systems view in local authorities and their planning departments.

Government Policy

- UK: An extensive government policy framework promoting CHP which according to a recent government report only is having little effect on the viability of CHP. CHP is handled by both Defra and the DTI.

- SWE: Favourable conditions for renewal CHP since the late 1990s in Sweden with a major breakthrough whit the introduction of the renewal obligation 2003. Gas CHP became a viable option with the adjustment of the carbon tax 2004, before that date low viability.

Fuel and Electricity Prices

- UK: The spark spread identified as the most important factor for viability of CHP in the UK. The NETA electricity trading arrangement has lowered prices for independent CHP producers.

- SWE: Historically low electricity prices which made CHP unviable especially between the 70s-90s. The renewal obligation has provided a major turning point.

Table 5.1(cont.) Differences found in chapter two

Historic Drivers and Barriers

- UK: The respondents thought there where more historical barriers than drivers in the UK, the lack of ability to join issues together in local authorities was perceived as an important barrier.

- SWE: The oil crises and local authorities set up of local energy companies where perceived as important historical drivers. The systems view which arose was seen as significant driver for the development of DH and energy from waste schemes.

Technical Drivers and Barriers

- UK: The lack of heat sinks where perceived as a technical barrier for CHP in the UK. The technological lock in of the national gird and the high cost of retrofitting heat distribution networks where stated as barriers.

- SWE: Demand for heat both a driver and barrier for CHP in Sweden.

Policy Drivers and Barriers

- UK: EU policy is a driver for CHP and government policy has potential to be if it was more long term and made more to address the present low viability of CHP and DH. The industry and the government have diverging views on CHP policy in the UK

- SWE: EU policy is to some extent a driver for CHP in Sweden. Government policy (the renewals obligation) has made renewal CHP the most profitable power generation investment possible on the Swedish market. Externalities are internalised in power production according to government respondents.

Table 5.2 Differences found in Chapter four

Institutional Drivers and Barriers

- UK: The role of local authorities on the UK market is perceived as a major barrier for CHP and DH development because of the lack of joint issues and energy planning. The planning system is not providing any mandatory incentives for CHP and DH presently. There seems to be an institutional failure of CHP when responsibility is divided between Defra and DTI.

- SWE: Local authorities are good in connecting issues together and come up with joint solutions. They have fully integrated DH and to some extent CHP in to the planning system which makes it very difficult for new large housing developments to receive planning consent if not connected to DH systems.

Information Drivers and Barriers

- UK: The lack of marketing and information about options and benefits is belived to be a major barrier for CHP and DH in the UK

- SWE: There are no information problems with CHP and DH in Sweden.

Financial Drivers and Barriers

- UK: The spark spread is stated as the major driver and barrier to CHP in the UK. The use of high discount rates and general low profits/high losses and low returns on investment are all financial barriers for CHP and DH in the UK

- CHP and DH are presently profitable in Sweden, the use of low discount rates have and are acting as a driver for CHP and DH. Low electricity prices have been the major financial barrier for CHP investments.

Table 5.2 (cont.) Differences found in Chapter four

5.3 THE COUNTRY DISPARITIES IN LIGHT OF ECONOMIC AND INNOVATION THEORY

Below are the major differences from table 5.2 and 5.3 discussed using the neoclassical and institutional theories summarised in the literature review and described in detail in appendix I. Market failure theory including public goods and externalities theory together with asymmetric or lack of information assumptions is applied on the research findings and analysed. The institutional models provided manly by North (1990) is applied on the findings as well as the innovation theory developed in Ruttan (2001) and Foxon (2004)

5.3.1 THE DISPARITY OF THE INSTITUTIONAL ARRANGEMENTS

The institutional arrangements both the formal and the informal seem to work in favour of CHP and DH in Sweden and are working as a barrier for the diffusion in the UK. The institutional administration of DH seems to be fundamentally different and be the prevailing reason for Swedish success and UK underdevelopment.

5.3.1.1 THE MARKET FAILURE OF THE HEATING MARKET IN THE UK

Institutional theory would claim that the informational institutional environment among customers and public officials in the UK has created boundaries within which the market currently is acting. The distrust of DH and lack of systems view for providing joint solutions seems to increase the transaction costs (defined by North (1990) as search costs, negotiation cost and enforcement cost). High transaction costs in institutions do according to Papandreou (1994) result in a market failure because of an underlying institutional failure. Respondents have mentioned that there are contractual difficulties with DH especially when working with local councils; this is an indication of high transaction costs when this fits North's (1990) definition well and this could lead to a market failure. Transaction costs seem to be high within government as well as within local authorities when both Defra and the DTI are sharing responsibility for CHP and DH policy. This is close to Papandreou's (1994) definition of an undefined institutional structure which can give rise to undefined property rights and make markets fail and externalities arise.

UK government has provided little or no pressure and mandatory regulations to encourage energy savings in the country; this has lead to local authorities having no incentive through formal institutions to make planners and developers change behaviour. Energy savings have large benefits for society as a whole because of the reduced carbon emissions but small or negative benefits for the private customer, a classical definition of a public good. This situation with no pressure from formal high level institutions to make difficult and unpopular decisions and fossil fuels in plenty supplies most likely made and are making local authorities to do nothing to correct for the inefficiencies and arising externalities. Use of high discount rates by private market actors combined with no mandatory regulations from central or local governments are making externalities arise in the UK since short pay back periods are promoting inefficient low cost technologies which are cheaper for the individual but not for society. The tradition of a strong belief in independent and free markets coming up with "efficient" market solutions in the UK is most likely a reason for the non interventionistic UK policies. Sweden with no fossil fuels on its own was forced on a redaction path by the oil crisis in the 70s, something that the UK with plentiful oil and gas resources never had to do but could rely on the "efficiency of markets".

5.3.1.2 THE SUCCESS OF INSTITUTIONAL PROMOTION OF DH IN SWEDEN

The high diffusion rate of DH in Sweden seems to be driven by the local and national institutional environment. The institutions seem to have provided incentives for DH and to some extent CHP diffusion and managed to decrease the transaction costs for diffusion by creating DH and CHP companies and organisations. This is inline with Coase arguments for the existence of the firm which is agued to subsist because it significantly decreases transaction costs. This development has similarities with the theory of institutional innovation which suggest that leaders of firms can change the institutional environment to maximise benefits. This is what happened in Sweden where the leaders of DH companies where closely connected to the political assemblies in local councils and could change formal and informal constraints to benefit DH. Benefit maximisation in Swedish DH seems to have been a combination of creating revenue and building up a large distribution network where the later seems to have been the more important. The creation of the large networks would not have been possible if only “efficient market forces” would have been involved in the decisions. This institutional environment have made many if not most DH companies to use low discount rates which benefit the common good and result in low carbon emissions.

5.3.2 THE POLICY ENVIRONMENT

The policy environment in the UK and Sweden have in common that respondents in both countries complain about short time horizons. The renewals obligation has in both countries been successful in promoting renewal electricity because of its long term commitment. Swedish CHP has been able to explore this policy because of Sweden’s natural endowments.

Property rights The EUETS is mentioned by both UK and Swedish respondents as an important principal driver for CHP when CHP is an efficient technology with lower CO2 emissions per produced energy unit. This is showing that allocating property rights to environmental assets is a solution to external problems and market failures as agued by Coase (in Kim 2005) and by Nicholson (2005). The distribution of the rights seem to be important as predicted by Mishan, respondents in both Sweden and the UK are unhappy of the present allocation model when it is unfavourable for fossil CHP production. **Externalities** The carbon tax introduced in Sweden in the early 1990's seems to have managed to internalise most of the externalities in the Swedish DH and CHP sector arising from fossil fuels. It has been that efficient that hardly any fossil fuels are used presently in Swedish CHP and DH. The tax is likely to have been too high when it has prevented efficient fossil fuel CHP to penetrate the market. The same signals of a complete internalisation of CO2 externalities have not been given by UK respondents and from UK literature. The policy in the UK is not committed enough to bear the consequences of paying a true price of carbon when the abatement cost are high and renewal fuel supply short. **Public goods** The public good characteristics of delivering heat in a distribution system are pointed out by UK respondents when they are finding many contractual difficulties with DH schemes. It seems that excludability have been a problem with DH in the past in UK when poorly designed schemes made heat control impossible. This problem have however been solved in Swedish DH which have more metering and there for have more private goods characteristics when the customers are billed for the heat they are using. The use of metering in Sweden is avoiding what is perceived as a market failure in the UK.

Table 5.3 Different aspects of the policy environment

5.3.3 INFORMATION AND RELLATION TO MARKET FALIURES

The information situation on the two markets is very different, plenty of information in Sweden shortage in the UK. The benefits CHP and DH are bringing seem to be unknown by the general public and most companies as well as by local councils in the UK. Jaffe and Stavins (1994) perceived lack of information as a major barrier for diffusion of energy efficient technology. This theory seems to fit the UK situation well when industry respondents think that the lack of marketing is one of the major barriers for CHP and DH diffusion. This lack of information signals that there are transaction costs in obtaining information and staying informed. Pindyck and Rubinfeld (2001) has also showed that markets can fail because of asymmetric information and high information transaction cost.

The major reason for the difference in information penetration of the two markets are likely to be the long historical diffusion of DH and CHP in Sweden and that CHP was an almost new UK occurrence in the early 1990s. CHP and DH have also been given substantial public backing by the institutional environment in Sweden.

5.3.4 FUEL SUPPLY SITUATION

The oil crisis which was a very important driver for DH and renewals in Sweden seems to have promoted gas in the UK. The fuel supply situation of the two countries is very different; Sweden is having a good supply of renewal fuels and the UK have fossil fuels. The supply situation is likely to be an explanation to the large difference in the fuel use of the CHP sector on the two markets. This combined with the colder climate in Sweden is probably a part of the explanation why the Swedish institutional environment has promoted an efficient form of heating as DH and lately CHP. The lack of energy from waste in the UK can however not be explained by this reasoning when both countries have the same problem of disposing the waste produced. The high institutional barriers present in the UK and institutional drivers in Sweden are the most likely explanations for the difference in use of energy from waste technology.

5.4 POLICY RECOMMENDATIONS

The policy recommendations which has been made to improve the UK market conditions is not simply to copy the Swedish situation, Sweden and Swedish institutions have succeeded in promoting DH and lately CHP under Swedish country specific conditions as access to renewal fuels and progressive local authorities. To succeed in the UK, positive UK trends must be used and strengthened and more incentives need to be provided to the market. The UK mentality seems to be more to encourage people to take up low carbon technology than through requirements and regulations. The renewals obligation is however a step aside form the market liberal thinking in the UK and is an institutional innovation which presently is having and is going to have a large influence on UK power production in the future. Changes in favour of a more mandatory nature of regulations would be in favour of CHP and DH.

5.4.1 MORE MANDATORY REGULATIONS IN UK PLANNING POLICY

If UK planning policy and building regulations were more demanding and had more ambitious targets for energy efficiency, changes in favour of DH and CHP are likely. If there would be requirements which had to be met DH and CHP could easily become a low cost alternatives when more insulation and low energy light bulbs no longer would be sufficient to reach the energy savings targets. If strict energy efficiency requirements where imposed on new housing developments in the UK, especially in those instances where large new continuous areas are developed (as in the London growth corridors) this could lead developers choosing to implement DH produced in a CHP plant. Moves in this direction could stimulate the markets for technologies as energy from waste when large heat sinks would be created and planners would be forced to be innovative in there search for new energy efficiency improvements. Micro and small scale CHP could be a good option for improved energy efficiency for new smaller projects affected by more stringent requirements.

5.4.2 A HEAT OBLIGATION IN THE UK

This policy option would work along the same basis as the renewals obligation which is the major incentive for CHP in Sweden. Because of the limited access to renewal fuels in the UK it is unlikely to se large scale renewal CHP. This is making an obligation for heat recovery and delivery a very powerful and favourable instrument for CHP promotion. CHP would with an obligation become a low cost alternative for the power utilities and would create a strong incentive for utilities to find suitable heat markets. The likelihood of this happening is however low when Defra earlier this year decided to not take a heat obligation and the possibilities it implies further.

5.4.3 A PUBLIC COMPANY TO PROVIDE DH AND CHP

This option is about institutional innovation. If the government decided to form a company in which all different competencies needed for successful creation of DH with (or without) CHP the transaction costs for the technology would be significantly decreased. The organisation would most likely have access to capital with long payback periods and could start by targeting “easy wins” as recovering waste heat form existing industries or power stations and direct it to DH or single users. The initial phase would raise the awareness of heat recovery and the associated benefits. After successful completion of “easy” projects it is likely that industry and the public sector would become aware of existing opportunities. The initial phase would later be followed by more ambitious DH and CHP projects to raise the information level further. This is all in accordance with Coase basic theory for the existence of the firm as it intends to decrease transaction coat and make markets more efficient.

The Carbon Trust has by the creation of the new enterprise “Connective Energy” in July 2006 actually done what is advised above. The new organisation main objective is to create markets for waste heat from power stations and industry by combining excess heat producers with existing clients with a large heat demand. (The Carbon Trust 2006)

5.4.4 PROVISION OF LOW INTEREST LOANS TO DH AND CHP PROJECTS

Because of the high initial costs of DH and some CHP production, as energy form waste, a grant or subsidised capital scheme could be used as a catalyst for development. The private cost faced by DH companies and organisations is outweighed by the large benefits the technologies have for society, this signals that the government should subsidise CHP and DH to avoid a market failure which exist due to the arising externalities from standard electricity and heat production. A practical solution is to subsidise companies by offering low interest loans or investment grants. To drive the technology further grants, assistance or technical equipment can be offered to individual homeowners and businesses to ease the change from individual to DH. Increased assistance for micro and small scale CHP would likely improve the technologies market penetration.

5.4.5 DEMAND PULL / SUPPLY PUSH APPROACH

The combined approach of creating a demand pull and at the same time a supply push for DH and CHP as described in theory by Ruttan (2001) can be achieved by applying different policy mixes for increased diffusion. A practical example would be to extend the CCL to the domestic sector, create a grant scheme for DH networks and enforce a heat obligation for power utilities. This would provide an incentive for individual homeowners to install DH since it would be exempt form the CCL if produced in a high quality CHP plant. The policy mix would also provide power utilities to look for heat markets because of the obligation, the grants given would make it comparatively cheap for the utilities to invest in DH (closer to its real cost for society). If policy makers are serious about CHP and DH diffusion no single policy is enough; it needs to be a joint approach of incentives and information combined with a genuine commitment form the central government, the local governments and the countries institutions.

CHAPTER SIX

CONCLUSION

6.1 REVIEW OF AIMS, OBJECTIVES AND RESEARCH QUESTIONS

The below box, box 6.1 is stating the aim, objectives and the research questions

General Aim

- To identify non technical drivers and barriers to the diffusion of Combined Heat and Power (CHP) and District Heating (DH): a comparative case study of the United Kingdom and Sweden.

Specific Objectives

- To identify Economic Theory applicable to energy savings technology in general and CHP and DH technology in particular.
- To identify country specific market characteristics for the CHP and DH markets in the UK and Sweden.
- To understand and identify the institutional and policy environment for CHP and DH in the UK and Sweden.
- To understand and identify the prevailing drivers and barriers for CHP and DH diffusion in the UK and Sweden.

Research Questions (derived form the literature review, chapter two)

- What market failure characteristics characterise the UK and the Swedish CHP and DH markers respectively?
- What are the formal/informal institutional drivers and barriers for CHP and DH in the UK and Sweden?
- How developed is the market for Heat in the UK and Sweden?

Table 6.1 The aim, objectives and research questions

The general aim of this thesis is believed o have been met when non technical drivers and barriers have been identified in the UK and Sweden. The nature of the research, research about technological diffusion, has made some parts of the thesis more technical than others but all the major identified drivers and barriers in both countries are of a non technical nature. The drivers and barriers identified are as from above concerned with formal as well as informal institutional environments, information constraints and the current policy instruments. It is believed that the specific objectives have been covered and that the research questions have been fully answered.

6.2 THESIS CONCLUSION

The concept of the energy savings paradox, when there is no or marginal diffusion of technologies which offer substantial energy savings and which are available to no excess cost in the long run is the main theme of this thesis. The theory suggested that where the paradox is present there might be a market failure due to externalities, public goods or information constraints. Moreover there might be institutions, which are adding transaction cost and could make markets fail or never form. These characteristics seems from the research to be a part of the CHP and DH market in the United Kingdom, where the market for heat in the domestic sector in particular, is very underdeveloped and where local and national institutions have failed to promote large scale energy efficiency. The comparatively high development of the Swedish heat market seemed to have happened because of institutional innovation, by formation of local energy companies and planning integration and use of different policies to decrease the disparity between public and private cost.

The explanation for the differences between Sweden and the UK seems mostly to be due to cultural aspects, historical development, organisational tradition in different layers of government and the strong UK belief of the ability of a free market to allocate resources in the most efficient way. Sweden seems to have created more favourable conditions for DH and lately CHP diffusion through the unique mix of the above mentioned characteristics combined with favourable natural endowments. The UK has with market oriented policies and institutions not to the same extent made the private cost close or similar to the benefits for society. If CHP and DH diffusion is to takeoff in the United Kingdom the cost disparity between public and private cost needs to be decreased, more information needs to be supplied to the market and new institutional arrangements needs to be put in place.

6.3 RESEARCH LIMITATIONS

This thesis shall not be seen as a completed research study, there is more research to be conducted to make the findings from both literature and interviews more comprehensive. Collection of quantitative data and the set up of a model in which hypothesises could be tested would give the conclusions in this thesis more weighting. Time and word limitations have not allowed the research and the researcher to explore all options and to collect all data desired. Difficulties in getting in contact with respondent, especially within the UK government have also limited the research. The findings from the two markets are country specific and the researcher is not encouraging generalisations from the conclusions and recommendations made in this thesis.

The researcher believes however that the research conducted is of sufficient quality to be used for further research and to be published in a journal publication.

6.4 RECOMMENDATIONS FOR FUTURE RESEARCH

What the author perceives as the most interesting areas for future research is practical focused research in policy design for promotion of DH and CHP in the UK or a further deepening of quantitative data collection and modelling of non technical barriers mentioned above. There is on the basis of the research in this thesis a possibility to focusing on different areas of identified UK weaknesses and by practical real world policy design try to address the problems. This would imply working closely with government institutions, local authorities and private market actors to design desirable policy which would work under UK conditions.

CHAPTER SEVEN

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APPENDICES

A1 ECONOMIC AND TECHNOLOGICAL DIFFUSION THEORY

A1.1 THE NEOCLASSICAL SCHOOL OF ECONOMIC ANALYSIS

This part of appendix I am providing the thesis with a theoretical background of neoclassical economic theory. In neoclassical economic theory most if not all environmental problems can be identified as a market failure. Reasons for failures are studied below and their implications on environmental issues.

A1.1.1 MARKET FAILURES

The notion of market failure is commonly referred to in economic literature is many times blamed for non functional markets and consequently for the rise of economic inefficiencies. Markets can fail for different reasons, where externalities often are an important component of the failure. Literature has shown markets to be unwilling to capture environmental values and services. This is in most cases because of the public features of the services provided. Section A1.1.2 will look at different reasons for market failures and section A1.1.3 will look at policy to make markets work.

A1.1.1.1 PUBLIC GOODS

Public goods are goods which can be consumed by one person without restricting any other persons consumption possibilities (Nicholson 2005). In the illustrative example below is the national defence force exemplified as a pure public good to which all tax payers must contribute. The same level of defence service will be provided to all citizens and there are no possibilities to trade or give away any defence certificates. (Perman 2003) The opposite is the pure private good which only can be consumed by the buyer and easily can be kept away from non buyers exemplified by an ice cream in figure A1. (ibid)

	Excludable	**Non-Excludable**
Rivalrous	Pure Private Good *Ice Cream*	Open Access Resource *Ocean Fishery (outside territorial waters)*
Non-Rivalrous	Congestible Resource *Wilderness Area*	Pure Public Good *National Defence Force*

Figure A1. Characteristics of public and private goods, with typical examples (Perlman 2003)

The major problems with all kinds of public goods but especially with pure public goods are that they easily end up in market failures because of over consumption and under production of the good. There is no price signal to tell whiter the consumption is causing any problems and no producer is receiving any revenue from sales. The demand curves for public goods (pure in particular) can be illustrated by adding all consumers demand curves on top of each other and only summing up the total amount. If no restrictions are put on the consumptions it is likely for the good to run out, which happened with ocean fish stocks and clean air in some regions. (Nicholson 2005 and Papandreou 1994)

A1.1.1.2 EXTERNALITIES

Externalities will arise when the polluter/user do not pay the full cost of the activities/purchases they are taking part in, se figure 2.5. (Perman 2003) The major issue is that externalities may cause a misallocation of resources because of a divergence between private marginal cost and social marginal cost. (Nicholson 2005) Externalities are frequently but not always caused by over consumption of public goods; the emission of CO_2 to the atmosphere is a suitable environmental public goods example. (Perman 2003) This can be viewed as an over consumption of the carbon sink the atmosphere is acting as and because of poor prise signals can continue.

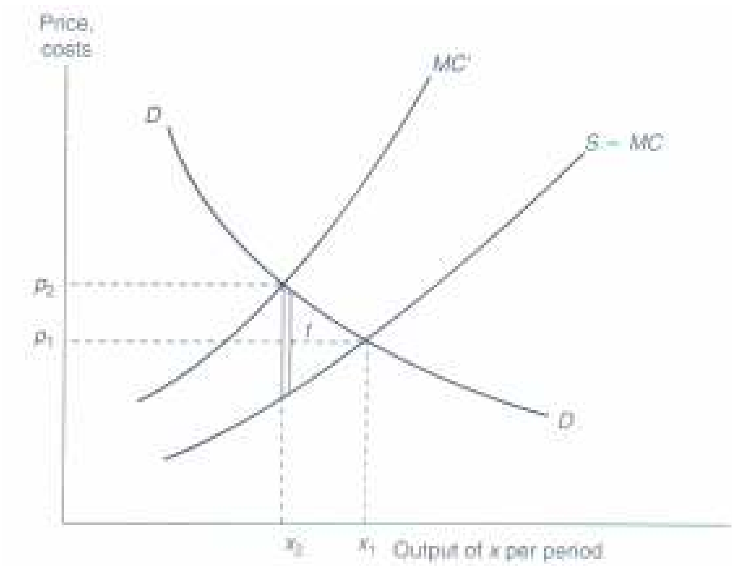

Figure A2 The demand curve for goods x is given by curve DD. The supply for x is the MC curve (the private marginal cost curve). If production of x imposes external costs for sociality as Pigou states the MC´will exceed MC by the extent of these costs. Market equilibrium occurs at x_1, at this level will the costs for sociality exceed those paid by the privae actor. A tax of amount t on goods x would archive a efficient output of goods x and internalise the externalities resulting in output level x_2
(Papandreou 1994)

Externalities can be divided in to different groupings; three important groups are explained in figure 2.6 below. If externalities not are addressed by adequate policy measures market failures are likely to happen because of the associated negative attributes.

The Consumption-Consumption Externality can be derived from the utility function below. Utility for person a is in this equation derived from consumption of goods X and Y. Person b can however influence the utility level of person a by consuming good X. In this way person b will act as an externality because b's own actions can influence the utility level of person a.

$$U^a = U^a(X^a, Y^a, X^b)$$

The Production-Production Externality can de explained by the production function below. The production of good X in a firm is dependent on inputs K, L, and Y. Y is a factor on which the production depends, which might by raw materials as water, air or something else who can be affected by others actions. If other firms can affect this factor by their own activities this will act as an externality on the production of X.

$$X = X(K^x, L^x, Y)$$

The Production-Consumption Externality is derived from the two equations below. In the production of good X some kind of emission or other attribute is affecting the utility of person a. Y is arising from the production of X, for example water discharges this is then affecting the utility of person a who puts a value on not having dirty water.

$$U^a = U^a(X^a, Y^a, Y)$$
$$X = X(X^x, Y^x, Y)$$

Figure A3 Different classifications of externalities (Perman 2003)

A1.1.1.3 IMPERFECT INFORMATION AND TRANSACTION COST

Most neoclassical theory is built on the assumption of perfect information; this implies that all actors on the market have the same and complete information at any given time. (Pindyck and Rubinfeld 2001) When this criteria fails markets can fail. A Nobel price winning example is the study of the used car market in the United States. It was shown in the study that the asymmetric information implied in a used car sale (seller knows more than buyer) made the buyer unwilling to pay a fair price for the vehicle. All used cars were assumed to be “lemons”, why would the seller want to sell a fit and working car? (ibid) The presence of asymmetric information may affect a variety of market outcomes which can be exemplified by the insurance and property markets. (ibid)

The lack of information is a reason for the slow adoption rate of new technology, if the actors are not aware of possibilities new technology no new market will be formed (Jaffe and Stavins 1994) It is also costly for market players to keep up to date with technical developments on the market. This fact is according to Jaffe and Stavins (1994) proving that there are transaction costs in obtaining information. Because of the public goods attributes of information (problems with excludability and non rivalrousness) information is likely to be underprovided by the market (ibid)

A1.1.2 MEASURES TO DEAL WITH MARKET FAILURE

In the following section will different neoclassical, which to some extent are overlapping with the institutional school of economics, measures to battle market failures be studied and outlined.

A1.1.2.1 TAX

Incentive based solutions to battle the allocation harm externalities causes was developed by Pigou in the 1920s. In his analysis is the introduction of a tax or subsidy (Pigouvian tax) the solution to the externality problem. (Nicholson 2005) The optimal tax level should make the social marginal cost equal the private marginal cost, as seen in figure A3 above. This terminology can be used when battling environmental problems, in those instances it is used to make the marginal damage function (MD) of the emission to equal the marginal benefit function (MB) of the emitted substance for society (Perman 2003) If figure A4 below this reasoning be can seen when the tax is shifting the MB from its private optimum to the social optimum. (Ibid)

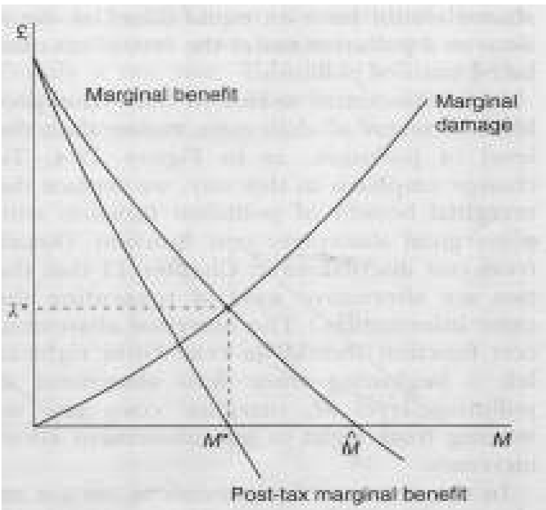

Figure A4 The optimal pollution level reached by an introduction of an emission tax at level λ*. (Perlman 2003)

A1.1.2.2 PROPERTY RIGHTS

This basic Pigouvian theory was in the 1950s elaborated by Coase who published a classic paper in 1960 where the environmental problems are conceived as a classic case of market failure caused by the Marshall Pigou externalities. (Kim 2005) What Coase showed in his publication was that if property rights were assigned to environmental problems the environmental degradation is likely to be decreased. Interestingly he showed when transaction costs are zero the level of pollution and environmental degradation will be the same no matter who owns the “right to pollute” (the coase theorem). (Nicholson 2005) Arrow took Coase work further when he tried to incorporate transaction cost in to the theorem. He showed that the efficient allocation of rights to pollute is only a theoretical solution; in the real world the high costs of assigning the property rights and enforcing them will imply non optimal outcomes. Arrow described this outcome as a relative market failure (Papandreou 1994)

If the rights to certain environmental assets, such as the oceans, the atmosphere or other environmental public goods would be clarified some if not all of the associated problems would be significantly decreased. (Nicholson 2005). The unimportance in the Coase theorem of the initial allocation of property rights for the final outcome of the optimal market solution is interesting. It did not matter for Coase´s theorem if the rights, for continuing on the previous example of spill over noise from aircrafts, where assigned to the noise makers as the rights to make noise or to the neighbours as the rights to a noise free environment. (Papandreou 1994) In the study by Mishan which added the transaction cost showed on the contrary the importance of the initial allocation of rights for the final outcome. This can be seen in figure A5 and A6 below. The transaction costs are being carried by the two different parties depending on to whom the allocation was assigned and the compensatory payment demanded by the potential victims where substantially different depending on the initial allocation. (ibid) A recent real world example of assigning property rights is EUETS where the initial allocation is an important issue of the scheme. This is pointing at Mishan to be right in his objections to the Coase theorem.

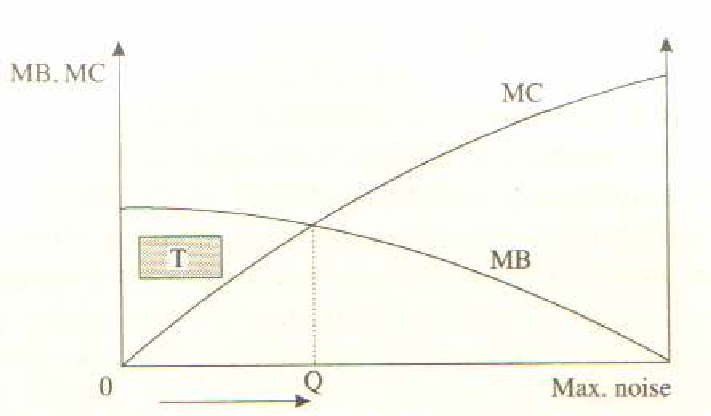

Figure A5 The initial allocation of rights are in favour of a noise free environment. This makes the potential victims demand a relative large compensation for accepting noise. The transaction costs are visualised as the T-box which indicates that there are more benefits than transaction costs.

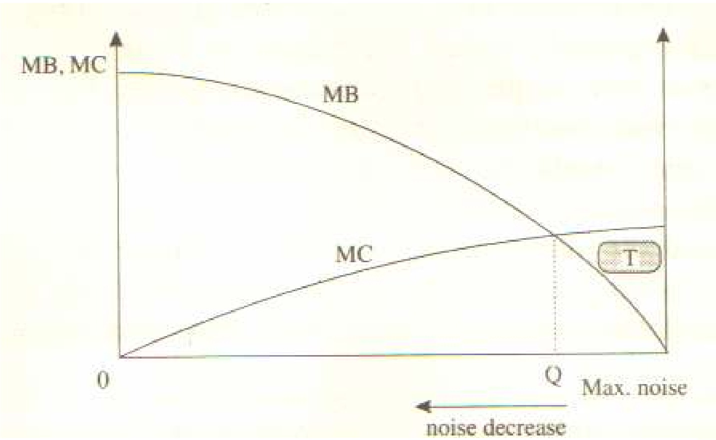

Figure A6 The initial allocation of rights are in favour of the noisemakers and are entitling them to make noise unrestricted. This makes the potential victims demand a relative small compensation for accepting noise. The transaction costs are again visualised as the T-box which indicates that there are more benefits than transaction costs, this time must the victims however reduce their benefits and bear the burden of the transaction costs.

Transaction costs can make markets fail because of the problematic nature of making agreements and providing information (Papandreou 1994). In an example provided by Mishan concerning spill over noise from aircrafts, identifying concerned people, making all bargain together, bargaining with noise makers and making all accept a joint offer where identified as transaction costs. (ibid) With transaction costs as high, which is a common situation in the real world, it is likely that a competitive market would fail to provide an efficient outcome without any help by some kind of authority to make the arrangements. (ibid)

A1.2 THE INSTITUTIONAL SCHOOL OF ECONOMIC ANALYSIS

The institutional school of economics has another approach than the neoclassical; it insists that present environmental problems cannot be eliminated simply by integration of external costs and other market distortions to correct for market failures. Problems are viewed not only as market failures but institutional failures. The view point of the institutional school of economic is outlined below and in appendix two and will together with the neoclassical theory above be the basis for the analysis of the case study.

A1.2.1 THEORETICAL FOUNDATION OF INSTITUTIONAL ECONOMICS

For the purpose of this thesis, institutional economics can be defined as a pragmatic theory of socioeconomic human behaviour, derived empirically through the application of inductive logic to qualitative and quantitative historical developments, and applied as an instrument to “solve” economic problems. Institutional economics is based on pragmatic philosophy, on empirical epistemology, on inductive logic, and on historical methodology. (Hill and Doyle Smith 1989) According to North (1990) are institutions the rules of the game in a society or more formally are the humanly devised constraints that shape human interaction. Institutions affect the development of economies overtime and are a reason for the unlike performance of different regions in economic, social and other matters. The Major role of institutions is, according to North (1990) to reduce the uncertainly by establishing a stable, but not necessarily efficient, structure of the economy and human interaction. The efficiency of institutions are discussed by Papandreou (1994), inefficient institutional arrangements are argued to be a reason for high transaction costs and possibly market failures which are caused by the underlying institutional failures.

The institutional view of the social system is organic and holistic according to Swaney. (Kim 2005) Wants (consumer preferences in neoclassical economics) are to a large extent determined within the economic boundaries of a market and also with significance within the culture in which the economy is present. The structure of wants also depends on the existing distribution of income and wealth. Furthermore is society it self viewed as organic, with values and wants separate from, and in addition to, the mere aggregation of individual wants. (Kim 2005) This organic view is how ever questioned by the neo-institutionalists which are closer to the neoclassical school. They are viewing institutions as rules which are formal and informal which are affecting the performance of the economy. (Papandreou 1994)

The institutional environmental economics recognizes economic systems as open systems. That is, social and natural systems are mutually interdependent, coevolving and are receiving a wide array of other feedback effects. This is a major difference from other and more individualistic economic theory, as neoclassical, which treat allocation, production, exchange, and distribution as if they occurred in an essentially closed sphere with only minor effects on man's natural and social environment. (Kim 2005 and Vatn 2005) In institutional economic theor the individual act on the basis of cognitive and normative structures that are socially constructed. Institutions are not only constraints. They are what shape the individual and define which rationality is relevant or appropriate in each type of setting. (Vatn 2005)

A1.2.2 INFORMAL INSTITUTIONS

All societies from the most primitive to the most advanced have unwritten sets of rules which give structure to the interaction between people. (North 1990) In the western world we think of the economy as a web of written rules and regulations. This is only making up a small (although very important) part of the sum of constraints that shape choices and decides what is possible or not (ibid). The informal institutions come from the socially transmitted heritage, the culture which has evolved in the society over hundreds of years. The culture provides a language based conceptual framework for encoding and interpreting the information which is transmitted to the receptors. (ibid)

Informal institutions are proven to reduce the transaction cost in a society (Davis 2006) Informal institutions consist of a set of conventions regarding behaviour among members of a society and are crucial for establishing a stable social order. In the economic sphere, these institutions reduce contract enforcement costs and facilitate the coordination of productive activity. (ibid) If a society is characterised by a lack of trust and the simplest commercial arrangement must involve a rigid formal contract the likelihood of lower economic activity is high. Lacking the threat of official force, informal institutions arise from spontaneous cooperation among members of a group which leads to greater options of economic cooperation and labour specialisation. (Ibid)

Even the most basic human behaviour is subjected to informal constraints, North (1990) has divided the constraints in to three major categories, below.

- Extensions, Elaborations and modification of formal rules. The example of this, given by North, is that the power of a congressional committee can not be explained by the formal rules assigned to it. The power is actually coming from the informal and repeated interaction by the committee members.
- Socially sanctioned norms of behaviour. This is exemplified by the irrational behaviour of men in the upper classes of society during the 1900s which was challenged to duel for life or death only to keep their honour and respect from other members of society. Social pressure and no formal rules decided their actions.
- Internally enforced standards of conduct implies constraints which makes the individual due to informal constraints will to give up wealth or income for some other value in his/her utility function. This has been exampled by legislators voting behaviour, where the legislator faithfully mirror the interests of his/her constitutes.

Table A1 Three different categories of informal institutions (North 1990)

There are explanations for why these rules are followed, the first two categories above can be put in the context of a neoclassical wealth maximising model in which the participants can be claimed to gain utility by maximizing wealth through participating. The last internally enforced standard of conduct is harder to explain when it involves the trade-off between wealth and other values. These can be exemplified as strong religious beliefs or political conviction. (North 1990)

A1.2.3 FORMAL INSTITUTIONS

The difference between formal and informal institutions is one of degree, the formalisation has happened over time and evolved as the culture and society have become more specialised and advanced. (North 1990) Formal institutions include political (including judicial) institutions, economic rules and contracts. There are in most instances a clear structure of hierarchy in the formal institutional landscape beginning with constitutions followed by statutory and common law down to specific by laws finalised by individual contracts. The main purpose of all the formal institutions is to formalise constraints of societal behaviour. (ibid)

The importance of strong formal institutions for the development of nations and to avoid market failures is well known from numerous sources. Authors as Garretsen (2003) have discussed the importance of a rigid legal institutional structure for a strong economic performance of the financial sector in an economy. The acceptance of the rules of the legal system seems to be important for how efficient and how much trust the market players put in the structure. This is a central finding because all foundations of laws have been formalised by the informal constraints of the culture in which they have developed (ibid). More over is Papandreou (1994) emphasising the significance of well defined property rights for the avoidance of market failures. A loosely and undefined institutional structure can give rise to undefined property rights which in turn can lead to markets to fail and externalities to arise. (ibid)

The formation of formal institutions does not automatically lead to efficient allocation of resources (North 1990 and Papandreou 1994) Institutional structures can be costly and inefficient which lead Arrow to formulate a theory of relative market failure where he blamed high institutional transaction cost to be a cause of inefficient markets. (Papandreou 1994) These institutional failures can arise where high rates of uncertainty and low rates of cooperation is observed from the governing institutions, the failure of international fisheries is a prime example of this development. (Papandreou1994)

North (1990) is pointing out the value of an efficient and well defined system of enforcement. The third-party enforcement function of the state is according to him an important reason why states where formed through out history. Without a way of enforcing formal regulations they become of less value and can sometimes be ignored.

A1.2.4 INSTITUTIONAL CHANGE

To explain the underlying foundation of institutional change North (1990) returns to Coase arguments of the reason for the existence of the firm. The firm is argued to subsist because it significantly decrease transaction costs and make organisations able to more efficiently exploit the workforce and have better control of information. The firm which according to Coase always seeks to maximise benefits, which are defined by the leaders in the firm and not automatically is to maximise wealth, is constrained by the formal and informal institutions in society. One way of maximising benefits is to change the arrangements and not be constrained by them. (ibid) Demsetz (in Papandreou 1994) argues that institutional changes come about because of the discrepancy in the net benefits arising form human interaction under one institutional regime. Institutional inefficiency provides the incentive for institutional innovation which is exemplified by the change from a hunter gatherer society to one based on agriculture where the later proved to be more efficient as conditions changed.

A1.2.4.1 INSTITUTIONAL CHANGE AS A DRIVER FOR TECHNICAL DEVELOPMENT

Institutions are not only important because they provide the framework in which the market functions; they can also be a source of technological innovation on their own. If policy makers decide on setting up a new institution or redesign an old and established body, formal institutions that is, a successful design needs to have certain features. It can not simply be the product of the designers objectives or be set up in a discussion with certain interest groups. The design must be allowed to respond to the environment in which it will exist, and must be allowed to initiate policy and take action if factors such as labour cost, land prices, energy prices and valuation of environmental assets change. If institutions are allowed to act in relatively free way within there defined boundary's without having limits imposed on them they can push a technological development. (Ruttan 2001)

The last part of the literature review will continue on this theme and look in to the deffernt theories of incentives for technical innovation and the uptake of CHP technology. Institutional innovation will be shown to be an important part of this process.

A1.3 DIFFERENT THEORIES OF TECHNOLOGICAL DEVELOPMENT AND CHP DIFFUSION

This section of the thesis is reviewing different theories of technological change. The section is covering material from the Induced model where the demand pull or supply push will be studied to the Path Dependency model where falling marginal cost due to economies of scale lock society to one single technology. (Ruttan 2001) The reader should have the previous section of neoclassical and institutional economics in mined when reading the following, the importance of institutional innovations is shown repeatedly in the below section 2.5.

A1.3.1 INDUCED INNOVATION

The concept of induced innovation developed by (Ruttan 2001) in the mid 70s is consistent of demand pull or supply push in the context of relative prices. When a relative price of an input in a production process increases there will be a natural incentive for substitution of the input ether by replacing it with a close substitute or by eliminating the input by change in the production process se figure 2.7. This is a standard assumption of neoclassical micro-economic theory as above, all economic agents are supposed to be profit maximisers. The most sigificant aspect of this theory is to determine if the induction to innovate is coming from a demand for new processes or reduced consumption of inputs or if the innovation of technology can be induced by the findings of the science community. (ibid)

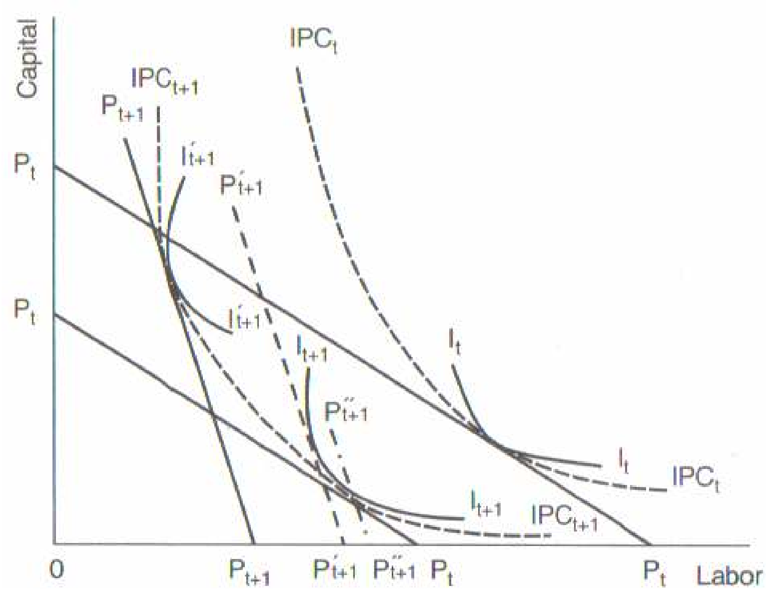

Figure A7. The induced innovations model. When relative prices are Pt Pt the technology is It. The technological development is represented by IPCt. When the technological development line IPCt shifts to IPCt+1 because of technological development the technology will follow to It+1. If there is a change in price of the inputs the new technology will end up on the Pt+1 Pt+1 line instead on the shifted Pt Pt line. There is as seen a combination of supply and demand side innovation in the induced innovations model. (Ruttan 2001)

A1.3.1.1 INDUCED INNOVATION AND CHP TECHNOLOGY

The technical development of the Combined Cycle Turbine Systems (CCGT) which made it possible to make electricity with a thermal efficiency of 55-58% combined with more stringent legislation for SO2 and NOX emissions in the US and in the EU created a very CHP friendly environment in the early 1990s. (Ruttan 2001) The legislation created a institutional driver for more environmental friendly electricity generation and the advances in turbine technology made CHP a low cost alternative for fulfilling the new requirements. The development is a good example of a supply push (new and very efficient generation technology) and demand pull (stricter and more demanding emission legislation). (ibid)

The conclusion which can be made from the above is that technological innovation is a combination of pressure from firms and economic agents to minimise cost and maximise revenue combined with the ability of scientists to facilitate technological change by supplying solutions so firms and economic agents can be utility maximisers. (Ruttan 2001)

A1.3.2 PATH DEPENDENCY

The theory known as path dependency, mentioned above is in essence a theory of increasing marginal returns on investments or production as economies of scale comes in to force. The problem the theory has identified is the likelihood of a non optimal technology being selected by a manufacturer/policymaker as the technology to be used and then later being found to be inferior to other technologies. What usually happens by that stage is that economies of scale and investment in the non-optimal technology are irreversible and the superior product/technology has to be refused because of the low cost and accessibility of the inferior. (Ruttan 2001). Unruh (2000) empresses the roll of a technological system and the importance of technological systems lock-in especially in the energy sector. Historical events and time considerations seems to be equally if not more important for the developments of technological systems than optimality. The positive feedback a technology feeds in to the system when falling margin cost is experienced is usually identified to be more important for a board of directors than the choice of optimal deign. Publicly traded companies which want to maximise share holder value in the short run are likely to aim for fast increasing returns on investment than change to another technology for slightly higher profits in the future. Firms are also unlikely to change technology to benefit a greater common good like the environment. (Madura 2003).

A1.3.2.1 INSTITUTIONAL LOCK-IN AND CHP

Unruh (2000) has also shown institutional behaviour to be influencing technological lock-ins. Formal institutions as described by North, Garretsen and Papandreou all shape the environment in which technological development occur. If the government and its institutions have a hostile attitude towards a technology, as the Swedish government had towards CHP during the Nuclear excess electricity production years through the 80’s and mid 90’s or have very conservative values where technological development is viewed as something bad by definition this will influence the rate of invention and innovation. The clusters of innovation as discussed by Freeman (2001) will not happen. Informal institutions does also play an important part in the development of new technology, if the general behaviour in a society is negative towards technological change and development the technological systems in this country/region will most probably experience a low rate of change due to this informal institutional lock-in. (Unruh 2000)

CHP technology has recently experienced a push from the EU institutional framework with the introduction of the CHP directive. (EU 2006) The technology is favoured by many official guidelines and best practise guides issued by official authorities within the EU system which would imply that formal institutional arrangements would be positive for CHP. (euroheat 2006) If sufficient sums are invested in the technology it is likely for DH and CHP to start experience increasing marginal returns, then it could start to experience a positive lock in which would benefit the technology.

A1.3.3 INNOVATION SYSTEMS AND THE UPTAKE OF CHP

Foxon (2004) is defining an innovation system as ‘‘the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge’’. Thus, rather than being categorised as a one-way, linear flow as the induced innovation system discussed by Ruttan (2001) which implies a flow from R&D to new products, innovation is seen as a development of matching technical potential to market opportunities, involving clustering of technologies and interactions between research and diffusion. (Foxon 2004) This reasoning of a systems view of innovation where interaction can be seen as an ongoing process with feedback from multiple sources is also developed by other authors and is used in practise by organisations as the OECD. In the systems view many components are working together as ambitions of firms and organisations to maximise profits, institutional arrangements for controlling and inducing the technological development and constraints from informal interactions within society and organisations. (ibid and Ruttan 2001)

Foxon (2004) has by developing a technological maturity model (the s-curve) managed to illustrate how the typical innovation system can be modelled and has by doing so showed the importance of having a consistent system with components and institutions working together. In figure 2.8 below CHP technology has been divided in to two different innovation paths which are in different stages of technical development. Foxon (2004) has showed CHP to be fully commercial on a medium and large scale level (DH, industrial and large scale CHP) authors as Westin and Lagergren (2001) concur to this conclusion. Small scale and especially micro CHP is in a demonstration and supported commercial stage in the innovation systems model. The model below gives a good illustration of where CHP development is today and provides a good research question for this thesis primary research, if CHP is fully commercial WHY is it not extensively used?

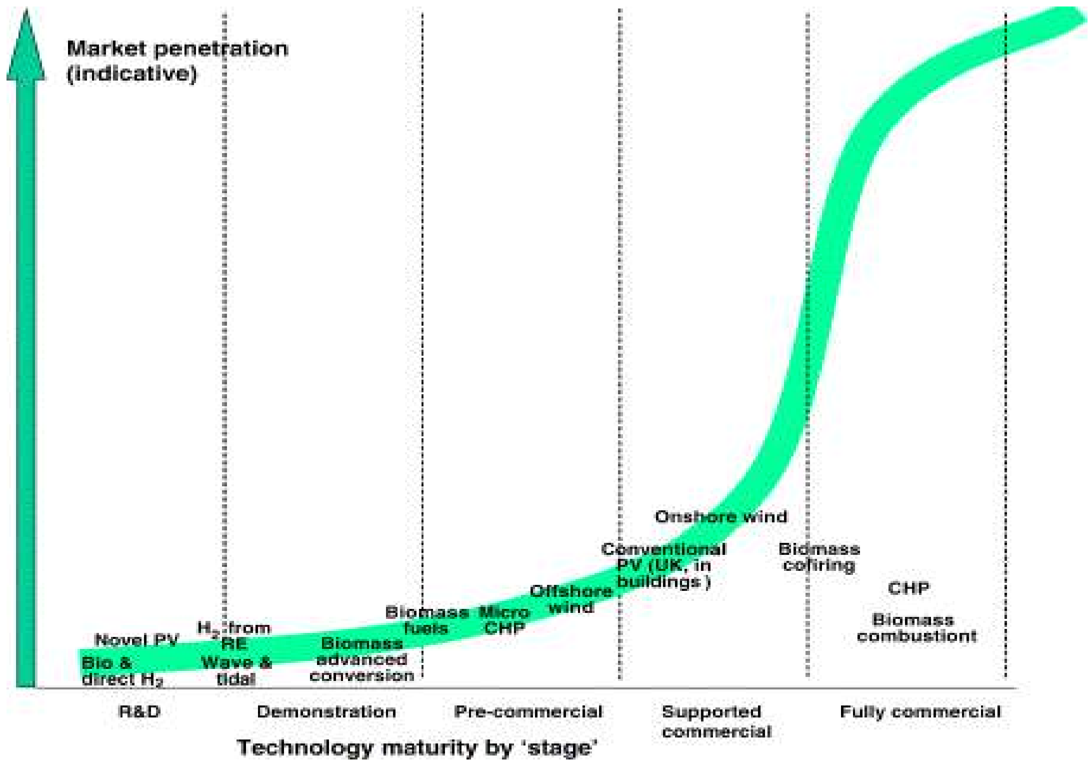

Figure A8. S-curve of technological development in the field of energy efficient and renewable technology. CHP is as seen fully commercial with micro CHP in the Pre-commercial stage. (Foxon 2004)

A2 INTERVIEW TRANSCRIPT

A2.1 FULL TRANSCRIPT OF INTERVIEW WITH RESPONDENT (L) RESEARCH ASSISTANT COMBINED HEAT AND POWER ASSOCIATION LONDON

(I = Interviewer / R = Respondent)

I: To start this interview I would like to ask you what your work responsibilities are and what your role is in the organisation, to get that established for the record.

R: Mmm I am a Research assistant and I actually work for two organisations, the CHPA and the UK Business council of sustainable energy which obviously more represents the wider ehh larger pictures of energy technologies than only CHP. The majority of my work is done with the CHPA. I work directly under the Head of policy, Mr Triad Hamed, so my work is very varied it ranges from having to respond to consultations, to having to arrange briefings for our members to having to send out different information circulations of all various kinds of things to our members to trying to ask parliamentary questions to lobbying various MPs on CHP. The CHPA have about 100 members, allot of our work, I mean directly what we do is to represent their interests as much as helpful and as you know because CHP in the UK is not as favourable as it should be so we tend to take on a more lobbying focus than most trade organisation probably do. Which is why we have to do government “bulling” as you can call it to try to make our voice heard. Which amm David Green who is now the head of the British business council who used to be the director of both the business council and the CHPA but David green is a truly amazing Lobbyist and has allot of experience of how to lobby government which is why as I said we try to make it to the higher levels of government.

I: Right, Right

R: Our voice is defiantly heard, whiter it is having an effect or not is taking longer to find out (mumbling)

I: So the main goal of the organisation is to promote CHP, well in government?

R: Well we basically have four forums within the Association to represent the four sectors that we work with, one is the micro CHP one, one it the small scale packaged CHP. We have a large scale one representing the industrial sites and than we have the district energy initiative which is representing our community energy companies and basically we hold quarterly amm four meetings one with each of the forums. This is done to basically A update every one of what is going on and for them to have an opportunity to network with each other which is hughly helpful. And we also have monthly member briefings on all kinds of topics, the previous one we had was on the soon so be published government response to the biomass taskforce. Which had allot about a possible heat obligation in there and a biomass incentive scheme. It is free for our members to join our monthly briefings and have a sandwich and again network with each other.

I: Ok thanks for that, so now after getting to know the organisation, now down to the questions. Can you tell me briefly about the history of what happened though out the last 10 years of CHP development in the UK and what have been the major issues?

R: Amm, well prior to 2001 CHP had a very healthy growth and was a good industry. Amm I am just going to warn you I have only been in this industry for two years. I am very recent to these things; I can't tell you that much about the previous. I know the main problems with CHP which I think is probably what you want to know. Amm yeh CHP had a very, very healthy growth the 2000 target was actually just met last year by a very, very huge site in Immingham by a company called Connaco Philips they installed a 740 MW site

I: Yes I have heard about it.

R: The largest in Europe. Because of that we have now crossed our 2000 target which is 5000 MW we then obviously have our 2010 target of 10000 MW which by all projections we are not going to meet (mumbling). The latest projections says that we will only get 8100 MW

I: Is that still a valid projection?

R: That is the latest projection, the target still stands as such, every time there is a ministry projection and every time you hear announcements by government that is the target, however there is no movement towards that target and apart from that 740MW scheme there are no industrial site schemes being planed or developed. This is a massive problem for the CHP industry and as you said in your email asking for the market potential is huge. It is an big unfortunate that it is not due to the technology side of things but it is mainly policy and market condition obviously. I think historically what happened in 2001 was the introduction of NETA, the new electricity trading arrangements which caused a lot of problems for small electricity generators basically favouring large scale generation imposing huge lowering of electricity prices. Amm this caused a gap in price between different generators to increase… a huge load of things happened but nothing was done to rectify that for CHP. The problems with NETA also affected renewals but for them the government introduced the renewables obligation which served as uplift for them and they did not introduce any similar measure for CHP. That is probably why CHP still has allot of difficulties.

I: To clarify, what I understand is NEAT favouring production that can deliver a fixed amount on a fixed time and CHP is not like that, that is the major problem with the system.

R: That is definitely the problem. Obviously you want to look at the problem in more detail. We got a huge issue of much more centralised generation while CHP is much more decentralised.

I: So do you have allot of problems with the gird connections as well than?

R: It depends on the size than, the small scale and the micro have larger problems than the larger scale ones obviously CHP anyway is served on site generally. The larger ones does not generally need national grid connection the smaller ones are a bigger problem depending where they are and micro especially which are hopefully going to come on line the way government wants it the idea is obviously for micro to supply all the energy needs of the household. Micro can export the excess electricity on the grid but the grid is not designed to take the electricity on.

I: All right, moving on, when you are looking at the most important drivers for CHP in the UK today what would you say it to be? Is policy the most important driver?

R: I mean obviously I would probably divide it up in to two, the physical side of things and the policy side of things. In terms of policy I think obviously we got the CHP strategy from 2004 which did not do a huge amount for CHP. We got the energy efficiency commitment EQ which is set to deliver energy improvements in the domestic sector running between 2005-2008. CHP is included in that but the way it works is that it has a tendency to pick what we call the low hanging fruit first which are all the easy options which are things as insulation, low energy light bulbs and CHP kind of gets thrown down the list somehow. This is a big problem, you easily reach the amount if insulation you put in to housing before you can't put more insulation in to a house. It is important that this regulation recognise the CHP problem. I mean last year under EQ the budget announced they would provide uplift for micro CHP at the same time as they announced that micro CHP now benefited from 5% VAT instead of 17.5%. Micro is the one that has had a push but again this is only for CHP in the domestic sector. CHP in the domestic sector is not huge comparatively and you know the major market for CHP in the UK is in heat intensive industry.

I: That is interesting and I want to move this conversation in to this field because this seem to be a major difference between the UK and the Nordic countries the market for heat and the intended policy drives to promote this market. As from what you have said is there a tendency in the UK for allot of talk but not much is happening?

R: We have a huge problem with that in the UK, there is a tendency for allot of fancy talk in this country and I think our policies tend to reflect that. Policies are very, very… things like the energy white paper which came out in 2003 and yet we have an energy review about to be announced within the next one or two weeks but we have not actually implemented our white paper from 2003 recommendations which seem like why have an energy review while you have not fixed the first one. It's a very unfortunate side of things but I think it is a general problem of the government. An other problem we have in contacts with the government is the fact that we are stuck between two departments. CHP is stuck between Defra which handles energy efficiency and the agricultural side of things and the DTI which handles renewal energy and all kind of renewal obligations side of things. CHP falls between those two and that is unfortunately not recognised enough. So you do find that you end up having a meeting with officials or ministers and they are not even talking about the same issues.

I: Not to interrupt, but this is interesting this sounds like an institutional failure.

R: It is, absolutely and I don't think we lobby hard enough, it is no hard to lobby when one department is saying one thing and the other says another. This is a hard issue to push at people.

I: Of course, I understand.

I was just going to say one other really big driver for CHP, which is hopefully coming out in the next day or two is the new national allocation plan under the EU emission trading scheme. Which will not particularly be a community heating thing but more a large scale… it could provide huge incentives for large scale CHP side of things. It was due in March the government announced that they were affecting the output factor for CHP which they had not done in the past and hopefully that will provide advantages for new large shale CHP. It will probably not be enough but a step in the right direction. The publication is coming out in the next day or so, we have to se what it brings. An other huge driver that we lost was our community energy program.

I: I have tried to understand that but I have not got my head around it yet

R: Right, it was cur basically now in March 2006, a hellish month, as a part of the revised energy program that came out. The community heating program was set up in 2001 as a scheme to incentivise or to provide financial support for district heating schemes and the idea was obviously the get actual project off the ground. It raised a huge amount of money, 50 million with a funding contribution of 40% of the total. There are huge problems with the allocation now when it is cut but last time I checked they had allocated 44 million of that fund to various schemes. It you think about it and if that was 40% of the projects the leverage of spending is s few hundred millions. With all that money it created huge incentives for investment in CHP massive, you know, benefits for tenants lowering the fuel bills and helping lowering carbon dioxide however the major problem with the program was yes you can allocate the money and yes you can start the scheme but is it very difficult of getting all the planning, construction and invoicing done within the three years of the program. In 2004 the government announced that it was going to extent the program and put in an extra 10 million, it took allot of lobbying from our side. It took most of 2004 to write to local authorities to make them write to their local MPs which had a district heating scheme in their constringency. Ten extra million was not good but at least it was something. And yes in 2004 it came out with the extra 10 million and we didn't hear any thing more of how that 10 million was going to be divided up. And then in march they announced that it was going to be cut the whole thing.

I: So there are no incentives from the government to push for community heating at all…
When you look at the planning side of things and building regulations how do they work with community heating and CHP, amm do they incentivise

R: Not directly, unfortunately are the planning regulations more up to how the local authorities have to work with planning regulations, the local authorities are not under a strict regulation as you come to fine in most other countries, at the moment we do have a new climate change planning policy paper coming out which hopefully will include something on community heating but… I think the problem is this that what is up at the media at the moment is about micro generation and decentralised energy and community heating is just not factoring in there at all.

I: In terms of building regulations how do they promote CHP? You talked about this earlier but do they in any form force people to install any form of CHP?

R: We just had a revised building regulation which came out in April and basically the building regulation that affect CHP are part L conservation of energy and power. CHP is a very, very small part of that and the only part where it is mentioned is when it referees to the EU energy performance of buildings directive amm.. and only a very, very tiny part of that is about CHP. There is a cod published of how to make a sustainable home, CHP is also only a small part of that, the Idea is that the cod is supposed to signal what will happen to the regulations in the future it that's so not much obviously. There are recommendations of use of CHP but nothing is mandatory. This is a huge problem here, the government usually have a tendency not wanting to interferer with markets and want the markets to work out issues on its own which is all well and good but as you know, I come from Denmark, not that I know what is happening in Denmark, but the experience from there is that if the government really want to have something done they have to make forcing regulations.

I: Chancing to the price of energy, I have a feeling that the energy prices have been very low in this country, how much of the social cost of carbon do you think is included in the price of energy.

R: Probably not.. Well if you see if the EU gets what they wants… if you look at how the price of carbon and the price of energy they hardly follow each other at all in fact carbon has had no effect at all of what's going on. I agree I don't think this country have a reflective price of energy, when the gas prices went through the "roof" last winter I sat back and reflected that this country have been paying significantly less for energy than the rest of Europe, especially gas.

I: Moving on to more about community heating ah, hen you try to promote community heating to your members are they having problems connecting people to community heating grids. Are there perceptions here of not being willing to participate.

R: Amm, I think it not so much nit wanting to than not knowing of the possibility of forming a network. There is a serious lack of knowledge and it does take allot of lobbying form the concerned parties. It is not in our mentality here in the UK.
I: So it is more like a lack of information than a lock of willingness?

R: Yes, the skills are missing there are not enough people out there with the skills needed. All the skill that I know of which are community heating people love it and people are appreciating the benefits. It is not that they are not doing good it is not enough people that know about it. There are allot of people out there that needs to be supported but the problem is that this country is full of inefficient old houses that are difficult to connect to grids. You will probably find more such houses in Scandinavia. We have displaced housing and rugged old tower blocks and other inefficient buildings which is very expensive to make for community heating. So you have that side of thing as well.

I: So to summarise what are the well major barriers to community and district heating in the UK then, what are the main problems really?

R: Yeh, lack of information is probably a major one, probably the planning side as well I don't have that much information on planning but I know that much that it is important. Now the lack of government support is a major barrier, now in any industry if you want to get something going you have to start by giving something. We are going to be lobbying for a new program (mumbling).

I: Did they give any specific reason for cutting the old program?

R: well we actually asked the government for an explanation of this sudden decision and the answered they wouldn't. The only thing they said was that based on research the cost of carbon reduction was too high. Although we would like to know on what that was based I think there is someone competing for the funds out there.

I: It is interesting that you are talking about the lack of information, that is one of the main reasons for a market failure and I think that might be what we are talking about here…
I would like to make an other comparison the Swedish local authorities have a systems perspective when they have connected different issues as energy and waste and built waste incinerators to supply community heating. Do you think the same exists in UK local authorities?

R: It sounds like what you are talking about is joint up issues, that is what I think we have a lack of as well. There has only recently been a huge push for local authorities to take on more sustainable energy targets and have a more green image. Previously it has very much been I do what I have to do and nothing more and I think that is has been very difficult to join up the idea of here we have a waste problem now we have to use it for energy unless it written somewhere in planning regulation or waste regulation it is just not something that someone starts to think about. It is a common attitude in this country waste incineration is not looked on happily. If you ask me it is means to an end and should be in there somewhere. It is definitely better than landfill anyway, it is an very old-fashioned way of looking at the issue and the lack of planning of the issue is according to me striking.

R: I am recommending a dvd that Greenpeace did on decentralised energy and the future energy systems. We can meet our energy demand in the future by decentralising and through energy reduction. I think if there where a serious push for the whole decentralised energy, energy efficiency, renewal energy I think all those things together can provide what the government is trying to get by pushing the nuclear.

I: Do you think there are institutional problems in promoting all these ammm small scale production…

R: There are institutional problems as much as other things our distribution system is geared towards large central power stations it does not have the flexibility or the infrastructure amm to accommodate small scale decentralised power production it is just not out there at the moment the whole grid does need to be seriously redesigned I suppose.

I: Do you view this grid situation as a technological lock in which you cant get out over night?

R: It would not cost that much money to make the changes needed, the thing is if you want to build new central power stations and nuclear will inevitably need new central buildings we will need new infrastructure because the distribution system we have at the moment is already over stretched. If you want to build more nuclear, which is probably coming or if you want to build more gas central generation which is also probably coming new distribution systems will have to be built anyway and if they are going to be built why not build something that is far more efficient. The government is very positive on decentralised energy at the moment but that don't mean that anything really is going to happen. But as a government they will probably try to get a mix because as a government they need to be making tradeoffs. And as I said before media has a huge impact on the micro generation which has been in the news allot at the moment.

I: when your members are making investments in CHP do you know what kind of discount rate they are using or on other words in how many years does an investment have to be paid off?

R: ohh you mean payback periods. That depends what kind of technology we're talking about micro is about 3-5 years larger schale CHP is obviously longer it very much is varies unfortunately the members keep it to them self it is confidential…

I: If you make a guess a rough estimate? It is interesting because of the difference I have found on the Swedish market where council owned utilities generally are using lower rates the private.

R: Well mmm the shorter payback periods here the better well with local council owned energy companies it is more like energy services which with some companies we definitely have here as well but generally it is very, very hard to get people to invest in things that have more than 5-10 years pay back periods they just wont invest in that long we have long term security problems which was some thing I should have mentioned before which I forgot. Oh and an other ting which I should have said before is the climate change levy as probably one of the most important financial drivers from which CHP is exempt from which is s huge, huge investment security thing for CHP however…

I: Is the contribution from the exemption of the levy enough to make companies to invent in CHP.

Definitely, the problem is right now that the current exemption runs out 2012 and the government has to initiate a new application for an exemption of CHP before that and they don't have a fixed time for when they have to make the application. They could wait until 2010-2011 if they want which really, really hurt security problems because no one can be really sure of it is going to continue or not. The budget this year only announced the CCL is going to be increased by inflation which is not a huge amount byt you never know it might be increased further until 2012. it creates a great uncertainty which is I think making many companies withhold investment. You are not going to invest in something if you not know that the benefit is going to be there.

So if you where to design a really efficient policy for promoting CHP and many even district heating in the UK what would it be? What would be the most important things to look into?
R: I think an obligation would be really important.

I: Like the renewals obligation?

R: Yes but focusing on heat, a heat obligation would benefit chp greatly. All our policies are currently coming from electricity as the renewable obligation that is only electricity no heat we have an energy review which is talking about the electricity demand. And CHP as you know is not primarily a electricity technology when it is amid for meeting heat demand and has huge potential for meeting the heat demand and we need a policy which can recognise the whole heat issue. You know that we have a huge issue in this country about fuel poverty which implies a failure in being able to heat your own home by the definition that you are spending more than 10% of your income on heat. Amm the government is coming out with tons of policy in how to tackle this issue and have it gone by 2010. But with energy prices going up every five minutes more and more people will be going in to fuel poverty.

I: It is interesting that you are emphasising the need for a market of heat which also is one of my conclusions so far…

R: I know in Denmark they have the heat act which came in, in 1999 where they decide that any power generation above 1 MW needs to be CHP. You would never find that here, you would never find a government willing to make that kind of obligation which I think is one of the most important things you can do.

I: Did not defra identify a CHP obligation as a way to improve the UKs climate change improvement but in the same report ruled the obligation out along with three other suggestions of how to make CHP more viable?

R: The climate change program review from this year just completely cut every single possible policy that had stimulating effect on CHP including an obligation and a suggestion of guaranteeing a spark spread for CHP which was deemed to expensive. This was very unfortunate we spend a whole year lobbying on those issues and they would have worked but again the government deemed it too expansive.

I: As we have seen is the policy side of CHP very uncertain the fluxuasions in fuels prices are as well, which of the two do you think is the most decisive for CHP investment?

R: The physical uncertainties are more important because industry know that policy always is uncertain, but if the physical foundation is uncertain there are really big problems in investing. Policy can actually help clearing some of theses uncertainties which clerly are causing so big problems. Hopefully you never know the biomass taskforce suggested heat obligation might be taken up by government there is a possibility it has been talked about.

I: How would this heat obligation work would you be forced to have a certain amount of CHP in you energy mix?

R: Not necessary CHP, it would probably work the same way as the renewables obligation is working which would be to demand a certain amount of energy being delivered as heat instead of electricity. Ammm with certain amounts of heat obligation certificates I assume. And obviously the cheapest way of doing that is CHP which is why a heat obligation would automatically favour CHP.

I: Discussing the different types of fuel used in CHP, the UK is very, highly dependent on Natural Gas a fuel for CHP do you do anything to try to extend the fuel mix? It is a risk minimisation strategy if you can choose between different fuels as examples have showed in the Nordic markets.
R: Yehh I fully agree, the UK situation is probably more of a historical heritage UK completely taking the gas onboard with the switch from oil to gas which was just very natural and without much reflection. It was just the cheapest option to install gas equipment. It is first now that people have been forced to think about it while Scandinavia have had to worry more about where to get the energy from. I think companies now is staring to realise the benefits of having a fuel mix… you do find some biomass CHP, there is growth in that sector. There are incentives for renewal CHP which it did not used to be. The renewals obligation has actually started to cover energy from waste as it did not used to. CHP is still included in the total amount of generation capacity a utility needs to by permits for, this is acting as a barrier. We lobby for CHP to be outside that system.

I: That is actually covering all the areas I wanted cover in the session. I want to thank you for taking your time to answer my questions.

R: Thank you for coming here and good look to you thesis.

A3 INTERVIEW ANALYSIS TABLE

Interviews with Swedish Participants	Historic Drivers (HDr)	Historic Barriers (HBa)	Technical Drivers (TDr)	Technical Barriers (TBa)	Policy Drivers (PDr)	Policy Barriers (PBa)	Institutional Drivers (IDr)	Institutional Barriers (IBa)	Information Drivers (InD)	Information Barriers (InB)	Financial Drivers (FDr)	Financial Barriers (FBa)
Respondent E Department of Sustainable development	Oil	Sys	Eff Pos (2)		Eur Nat (3) Com (3) Sta (3)		Loc Pla Sys (2) Gov Tra	Pri (2)	Acc Gov		Ele Gra	Tax Dis
Respondent F Ministry of Finance	Oil (2) Inv Com Uti		Pro Hea Pos	Acc	Nat (3) Com (2) Sta Eur	Nat Sta	Gov (2) Pub (2) Eui	Gov			Gra (3) Ret Fue	Ele (2) Fue (2)
Respondent A Tekniskverken	Com (2) Uti Ava Oil Pla		Pro (2) Pos (2) Lab Acc		Eur Nat	Com Sta (3)	Sys Pla Loc (2) Gov		Acc		Dis Fue Pro Ele	Ele Ful
Respondent G Ministry of Industry, Employment and Communication			Hea		Loc Gov Nat (3) Eur	Nat (2) Sta (2) Com Eur	Loc (2) Sys (2) Cus Gov Tra	Pri Gov Sys* Pla*			Dis (3) Gra (2) Tax Ele	Dis Ele (2)
Respondent D Swedenergy	Oil Com (2) Ava		Eff Lab	Sin	Loc Nat (3) Eur	Sta (2) Com Nat	Loc (2) Pla Sys (2) Pub Cus	Cus* Pub*	Acc		Pro Ret	Ele
RespondentH Swedish District Heating Association	Uti Inv Pla		Eff Pos Hea	Sin	Nat (3) Loc (2) Eur Com	Nat (2) Eur Sta (2)	Sys (3) Loc (3) Pla Gov (2) Cus	Gov Pla Cus* Pub*	Acc		Ret Pro Tax Dis	Ele Ret Dis

*Comments on UK conditions

Respondent C Respondent B Consultants			Pro Eff Acc		Eur (2) Nat (2) Sta	Com Sta (2) Nat (2)	Sys (3) Tra Loc Cus Pub	Cus* Loc* Pub*	Acc		Dis Ele Pro	Dis Ret Ele
*Comments on UK conditions												

Interviews with UK Participants	Historic Drivers (HDr)	Historic Barriers (HBa)	Technical Drivers (TDr)	Technical Barriers (TBa)	Policy Drivers (PDr)	Policy Barriers (PBa)	Institutional Drivers (IDr)	Institutional Barriers (IBa)	Informatio n Drivers (InD)	Information Barriers (InB)	Financia l Drivers (FDr)	Financial Barriers (FBa)
Respondent N Director UK CHP Company	Ava (3)	Sys (2)	Hea Eff (2)	Sin Lab (2)	Nat (2) Eur (2)	Nat (3) Com (3) Sta Eur	Pri (2) Pub Loc (2) Gov	Pla (2) Loc (2) Pub Gov (3)		Inf (5) Acc	Tax Ele (2) Fue (2)	Ret (3) Fue Dis (3) Ele
Respondent I CHP City of London		Ris (2) Man	Acc (2) Eff Pos	Unr Des Sin (2)	Loc	Nat (3) Eur	Pla (2)	Cus (3) Pla Loc (3)	Acc	Inf		Los (2) Fue Lel
Respondent M Defra Sustainable Energy Policy Division		Ris			Eur Nat (2) Com	Sta Com Nat	Pla (2) Loc Gov	Pla Loc	Acc Gov	Inf Gov	Gra Tax	
Respondent L Combined Heat and Power Association	Ava	Man Sys	Pro	Des Lab Acc	Nat (2) Eur (2)	Nat (3) Com (3) Sta (2) Loc (2)	Tra (2)	Gov (3) Pub (2) Loc Sys (2) Pla		Inf (3)	Tax Gra Ele	Los Ret (2) Dis Fue
Respondent K Respondent J Consultants		Sys (2) Man	Eff	Des Neg Sin (2)	Eur Loc Nat	Loc Com Sta Nat (3)		Loc (3) Sys (3) Pla (3) Gov (2) Pub (2)	Inf	Acc	Fue	Fue Los

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