Intermediate report

Nordic Energy Perspectives

The Future of Nordic District Heating

A First Look at District Heat Pricing and Regulation

March, 2009

Nordic Energy Perspectives

Preface

Nordic Energy Perspectives (NEP) is an interdisciplinary Nordic energy research project with the overall goal of demonstrating means for stronger and sustainable growth and development in the Nordic countries.

NEP analyses the national and international political goals, directives, and policy instruments within the energy area, as well as their influence on the Nordic energy markets and energy systems and the infrastructures and institutional structures. NEP aims at clarifying to decision-makers the consequences of political and strategic decisions for politicians, energy actors and the public. The project is to promote a constructive dialogue among researchers, politicians, authorities and actors on the energy markets.

For further information about the project, please visit: *www.nordicenergyperspectives.org*.

This series of reports are the second reporting from the second phase of the project. The following intermediate and final reports are now presented:

Synthesis report, March 2009:

- Second NEP2 synthesis report *(Responsible: Peter Fritz, Håkan Sköldberg, Bo Rydén)*

Final reports, March 2009:

- Widened view of energy efficiency and the resource management *(Responsible: Bo Rydén)*
- Technology options for a low CO_2 energy system *(Responsible: Tiina Koljonen)*
- Wood markets and the situation of the forest industry in the Nordic countries *(Responsible: Per Erik Springfeldt)*

Intermediate reports, March 2009:

- Reference and policy scenarios *(Responsible: The NEP model group)*
- Global scenarios *(Responsible: Janne Niemi)*
- Biomass market and potentials *(Responsible: Tiina Koljonen)*
- Nordic perspectives on the EU goals relating to CO_2, renewable energy and energy efficiency *(Responsible: Thomas Unger, Bo Rydén)*
- Prominent strategies for environmental sustainability in the stationary energy sector *(Responsible: Anders Sandoff)*
- The future of the Nordic district heating *(Responsible: Monica Havskjold, Håkan Sköldberg)*
- Trade within the RES directive and related power interconnection issues *(Responsible: Berit Tennbakk)*
- Natural gas in the Nordic countries *(Responsible: Peter Fritz)*

Our intention in NEP is to present all reports in English. Due to lack of time, some of the texts in some of the reports are at this stage still in Scandinavian languages. We apologize for this. These texts will as soon as possible be translated into English. The translated texts/reports will be available on the project's web site, *www.nordicenergyperspectives.org*, soon after the Oslo conference.

Oslo, March 2009

The NEP Research Group

Table of contents

1 District heating in the Nordic Countries

1.1 Brief status

District heating is an important carrier in all Nordic countries except for Norway. As shown in Figure 1-1, Sweden has more than 50 TWh district heating, Denmark and Finland approximately 35 TWh while in Norway only 3 TWh district heating is supplied. While the increase in volume seems to level off in Sweden, Finland and Denmark, the annual growth is large and increasing in Norway. This is discussed more closely in chapter 5.

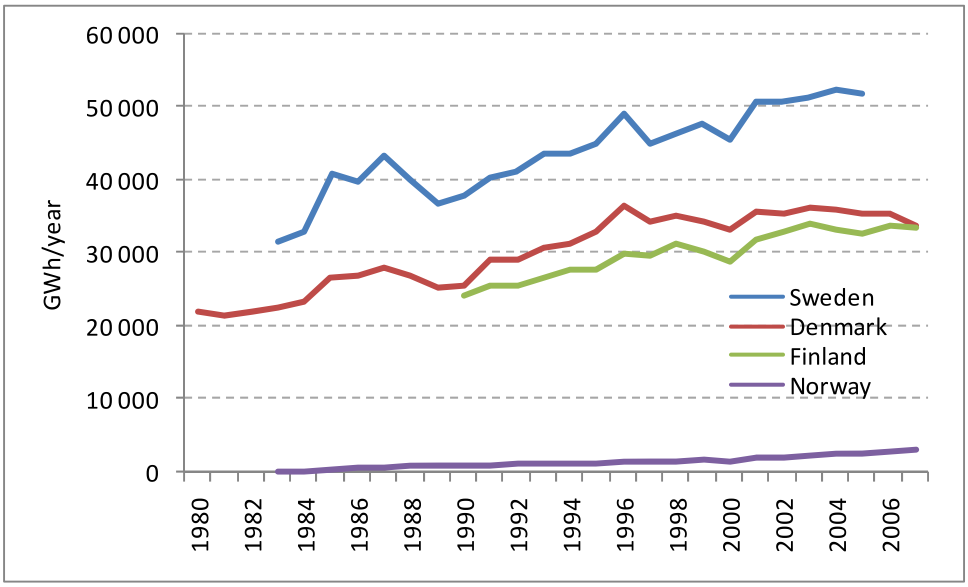

Figure 1-1 District heat production in the Nordic countries

The choice of energy resources depends on local availability and energy infrastructure, thus the differences shown in Figure 1-2 are as expected. In all countries, biomass, peat[1] and/or municipal waste is a major renewable energy resource.

[1] Peat is not seen as renewable in all countries

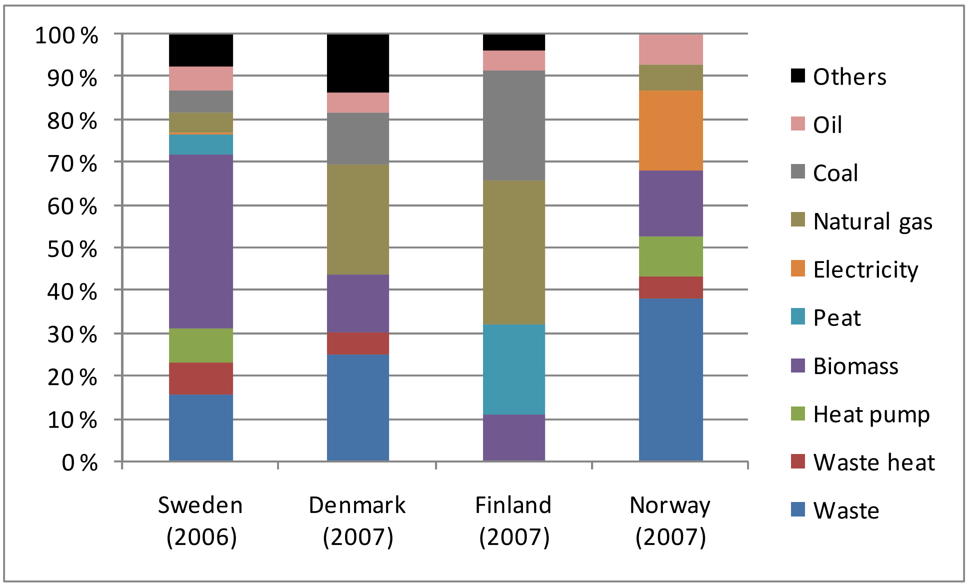

Figure 1-2 Energy carriers in district heat production[2].

1.2 Policy update of district heating in the Nordic counties

1.2.1 Sweden

District heating is the dominating energy carrier on the Swedish heating market. 54 TWh district heating was delivered in 2007. The deliveries have increased rapidly during a long period of years, but during the last five years the growth has slowed down considerably. District heating has been one of the most successful areas in the transformation of the Swedish energy system towards a more sustainable development. Fossil fuels have been phased out, biofuels have been introduced (and is now the dominating fuel) and combined heat and power production is growing rapidly.

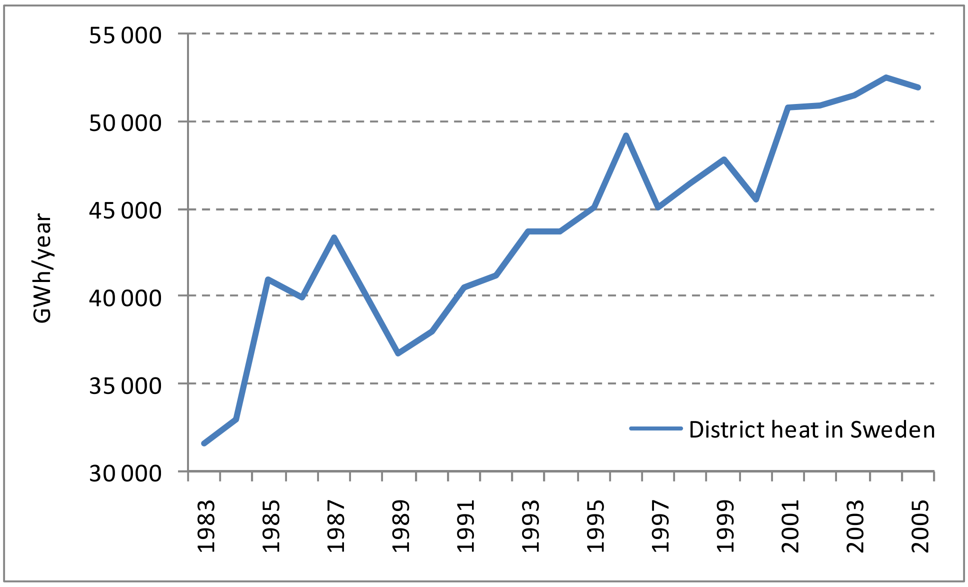

Figure 1-3 Development of district heat in Sweden

[2] The Finnish numbers are for fuel consumption in production of DH and combined production of DH and electricity

On 1 July 2008 the new district heating law came into force. It aims at strengthening the district heating customer's situation, e.g. through increasing the transparency into the district heating business. The law specify an obligation for the district heating company to negotiate with a district heating customer regarding certain contract conditions, e.g. price. If they cannot reacgh an agreement, they could ask for external mediation. The district heating company should present its prices easily available for customers and the general public. If the district heating company gets a request from someone who wants to sell heat to the district heating company or to use the district heating network to distribute heat, the district heating company must negotiate about the possibility to get access to the district heating system. The law does not include any price regulation. (In the mid 1990-ies the self cost principle disappeared and pricing of district heating became free.)

There have been discussions about general third party access to the district heating system. The idea was however rejected by a governmental investigation in 2005.

The price of district heating has, as an average, increased slower than for most competing energy carriers.

Figure 1-4 Commercial energy prices in Sweden ("Fjärrvärme" = District heating)

1.2.2 Denmark

The energy policy in Denmark has a strong focus on energy efficiency and increased utilization of renewable energy resources. District heating has been one of the central measures for the dramatic reduction of CO_2 emission due to heating of building and tap water from 25 kg/m^2 in 1980 till 10 kg/m^2 in 2008.

Through energy planning, the municipalities have designated some areas to district heating and others to natural gas distribution. Electric heating of houses located in these areas is forbidden by law ("elvarmeforbudet"). The municipalities may choose to make accession to collective energy distribution systems (natural gas or district heating) mandatory. A major challenge now arising for the municipalities is to draw the line between district heating areas and areas for local heat production like heat pumps.

District heating is considered a natural monopoly in Denmark, and is obliged to be a "non profit" business. The companies are not allowed to have either net profit or loss ("hvile-i-sig-selv princippet). During a period of several years the heat price should be equal to the heat cost. Several measures are considered to further increase the efficiency in district heating operations, thus reducing the cost of heat to the customers.

The new national goal of a dramatic reduction of CO_2 emission and in the long term full penetration of renewable energy has brought district heating in focus once more. Natural gas areas may now be converted to district heating, thus further increasing its market share. A newly publicized report "Varmeplan Danmark" suggest possibilities for the district heating to increase its market share from 47 % today to 60-70 % in the long term (2020-2050). High focus on energy efficiency, extensive utilization of renewable sources in the district heating systems and local heat pumps, pellet stoves and solar energy enables no CO_2 emissions from the heating sector.

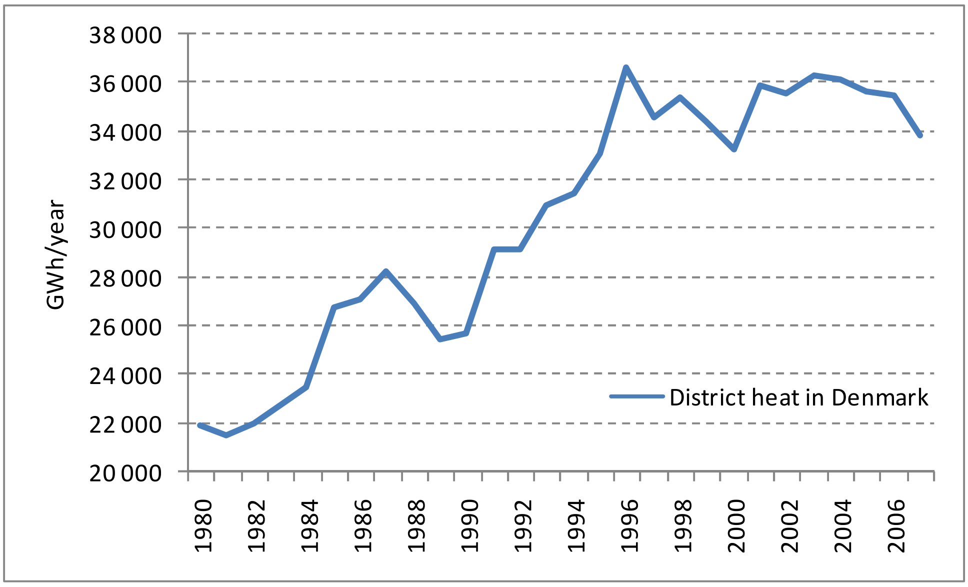

Figure 1-5 Development of district heat in Denmark

1.2.3 Finland

In Finland, 29,4 TWh district heating energy was sold in 2008, with a gross production of 31,9 TWh. The development of district heat production is shown in Figure 1-6. The average price (incl. taxes) was 5,05 c/kWh, resulting in heat sales (incl. taxes) of 1,48 bn. €. Market share of district heat in Finland is 49 %. CHP delivered 74 % of the heat used in Finland.

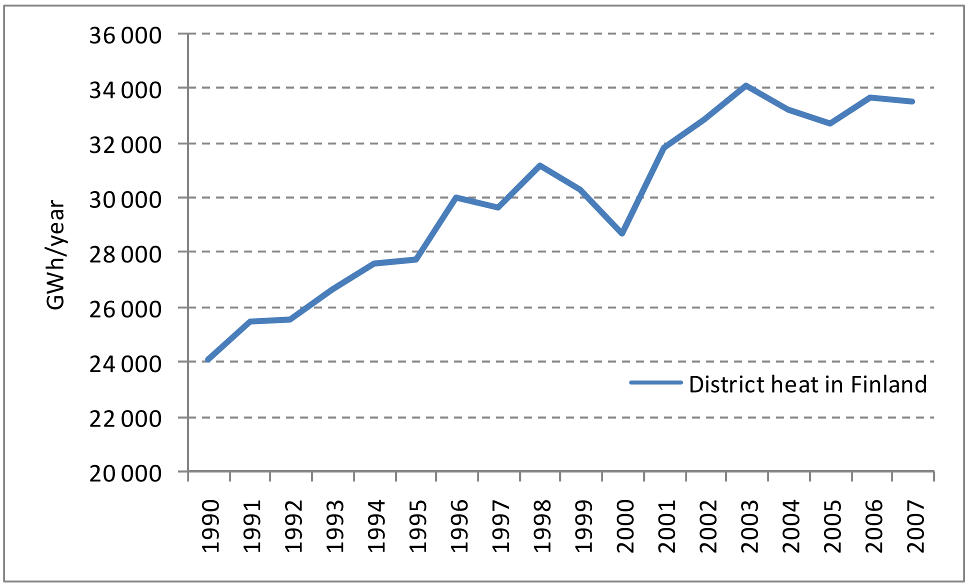

Figure 1-6 Development of district heat in Finland

District heating has a very stable pricing policy in Finland. Most fuel prices have risen steeper than the price of district heating since 1999. One reason why the DH sector has managed this well is the diversified use of fuels, another is the increase in the use of peat and waste wood and a third is the wide spread use of coal. The price of coal has only in recently, since summer of 2007 experienced a steep price hike.

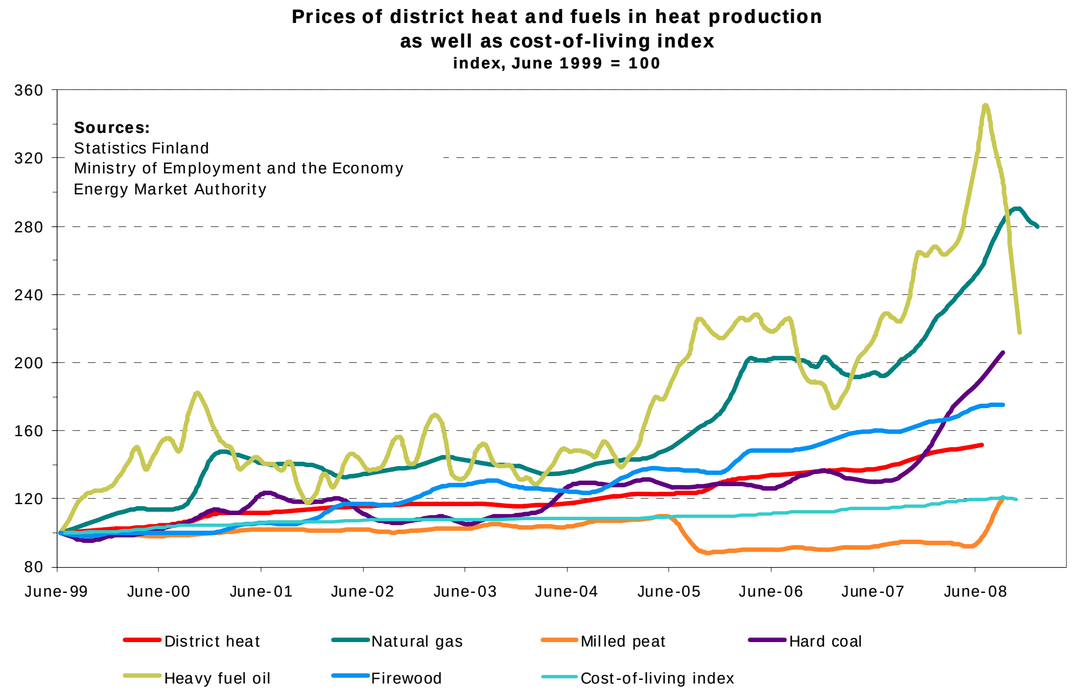

Figure 1-7 Index series (1999=100) of prices in Finland of DH and several fuels for heat production, and the cost-of-living. (FEI 2009)

1.2.4 Norway

District heating is growing extensively in Norway, but from a small base, with a net production of 3 TWh in 2007.

Enova SF was established in 2001 with a main mission to contribute to environmentally sound and rational use and production of energy, relying on financial instruments and incentives to stimulate market actors and mechanisms to achieve national energy policy goals.

Enova is obliged through a contract with the government to reach a sum of 18 TWh through energy efficiency or new renewable energy before the end of 2011, and 40 TWh before the end of 2020. No specific goal is set for district heating, but according to Enova renewable heating is one of the least expensive ways to increase the renewable share of stationary energy use. Recently[3] the government granted Enova an addition of approximately 150 M€. One of the focus areas for this extra funding was district heating. A lot of actors are now competing to establish new district heating systems in Norway.

A concession for district heating is mandatory for plant with more than 10 MW maximum heat loads, but also smaller systems may apply for a concession. Municipalities may decide mandatory connections of new buildings to the district heating system, given they have a concession. According to the Energy Law, the price for district heating may not be above the cost of electric heating.

[3] January 2009

The Ministry of Petroleum and Energy is now considering the future regulation of the district heating business in Norway.

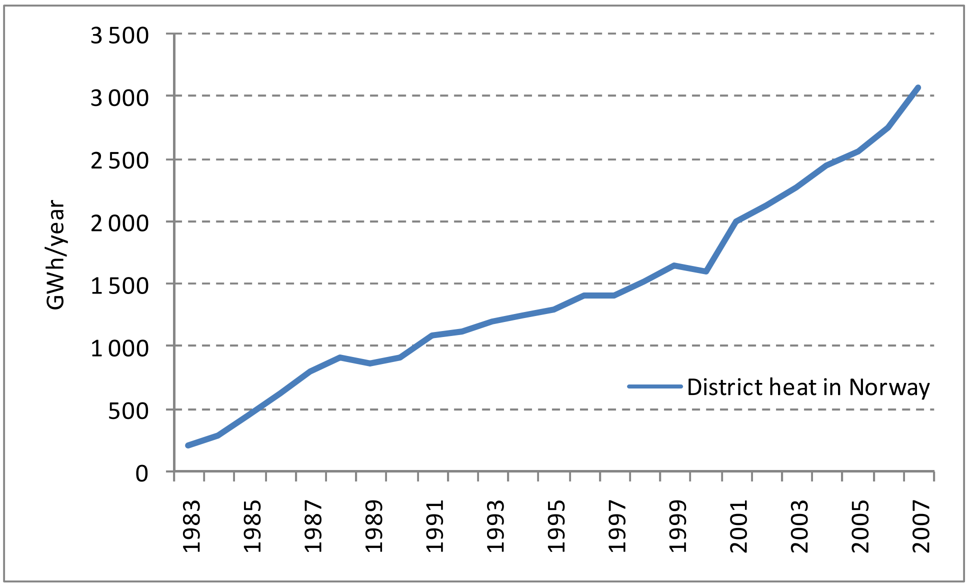

Figure 1-8 Development of district heat in Norway

1.3 Business life cycle and future development of district heating

Business development tends to follow an S-shaped curve (see Figure 1-9). In a district heating context, the volume of energy sold is related to the penetration rate. When (if) you reach a level where all customers have district heating, the volume is bound to be at the same level or decline due to both energy efficiency and substitution to local solutions (e.g. heat pumps). On the other hand, as long as the building stock increases new potential customers enter the market.

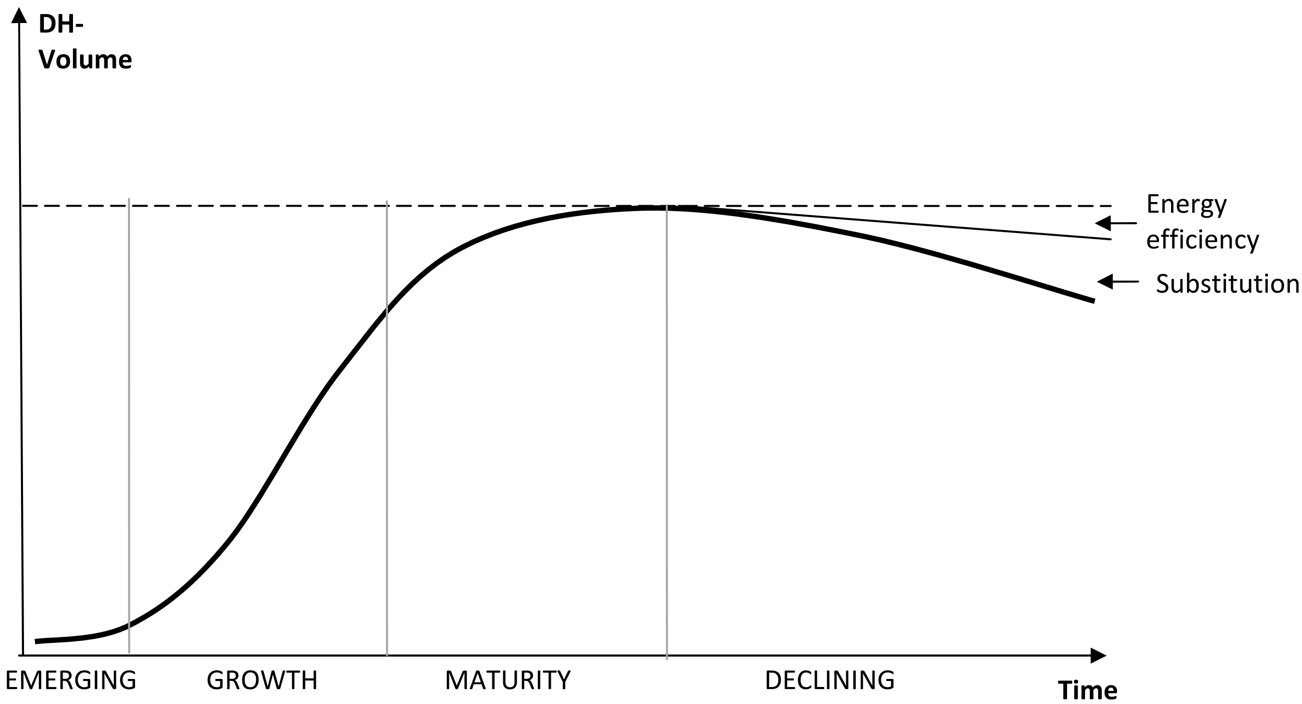

Figure 1-9 S-curve, business development

In this intermediate report the future of the DH market in the different Nordic countries market is just briefly described. The topic will be more extensively treated in the final report.

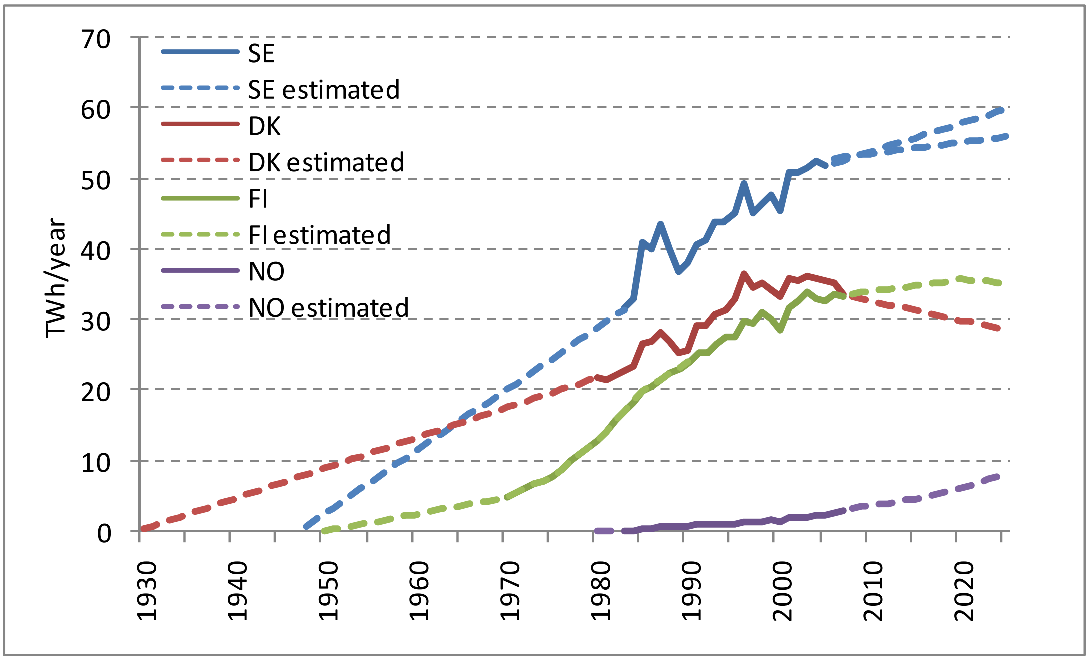

Figure 1-10 Development of District Heating in the Nordic Countries

Sweden seems to be in a late growth period or perhaps crossing over into the maturity period. In Finland the district heating business seems to be in the maturity face, while the Danish district heating business seems to have started the declining face. In Norway district heating is still in the emerging/growth phase. The challenges facing the actors are thus also different.

So what is expected of future development of district heating in the Nordic countries?

1.3.1 Sweden

Energimyndigheten[4] expects the growth in district heat use to be between 4 and 8 TWh in the period 2004-2025. Depending on where in this gap the expectations lie, the district heat business in Sweden will more or less step into the maturity face.

However, many district heating systems experience a situation where the introduction of new district heating customers is offset by more efficient use of energy by existing customers, leading to stagnating heat deliveries.

1.3.2 Denmark

According to Energistyrelsen[5], the total energy demand in Denmark is expected to decrease, and in addition, the fraction supplied by district heating is also reduced, thus the total demand for district heating in Denmark is declining in the period 2008-2025. Due to energy efficiency measures expected to be applied the heat demand in the households is changing. The electrification of the service sector due to the technological development will also affect the heating demand.

[4] Prognoser för utsläpp och upptag av växthusgaser - Delrapport 1 i Energimyndighetens och Naturvårdsverkets underlag till Kontrollstation 2008

[5] Fremskrivning af Danmarks energiforbrug og udledning af drivhusgasser frem til 2025, ISBNwww: 978-87-7844-740-1

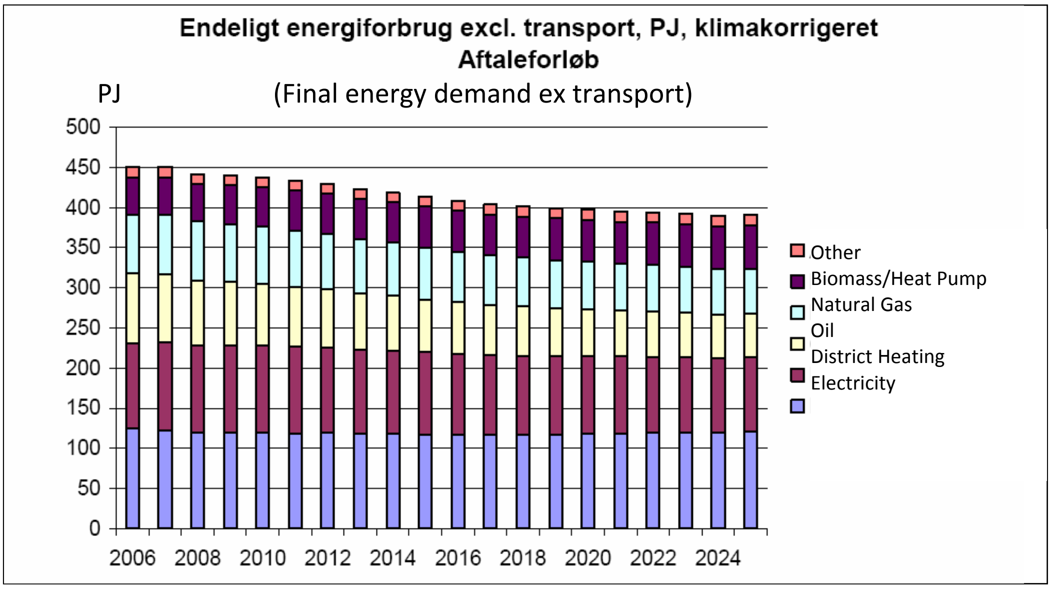

Figure 1-11 Business-as-usual scenario, Denmark (Source: Energistyrelsen 2008)

1.3.3 Finland

As seen before, it seems that Finnish DH production has achieved maturity. However, if we look at the temperature corrected DH consumption as shown in Figure 1-12 we see an altogether different picture. DH consumption is increasing; it is the weather conditions which give a distorted view of maturity. Climate change on the other hand is expected to decrease the increase of DH in the future.

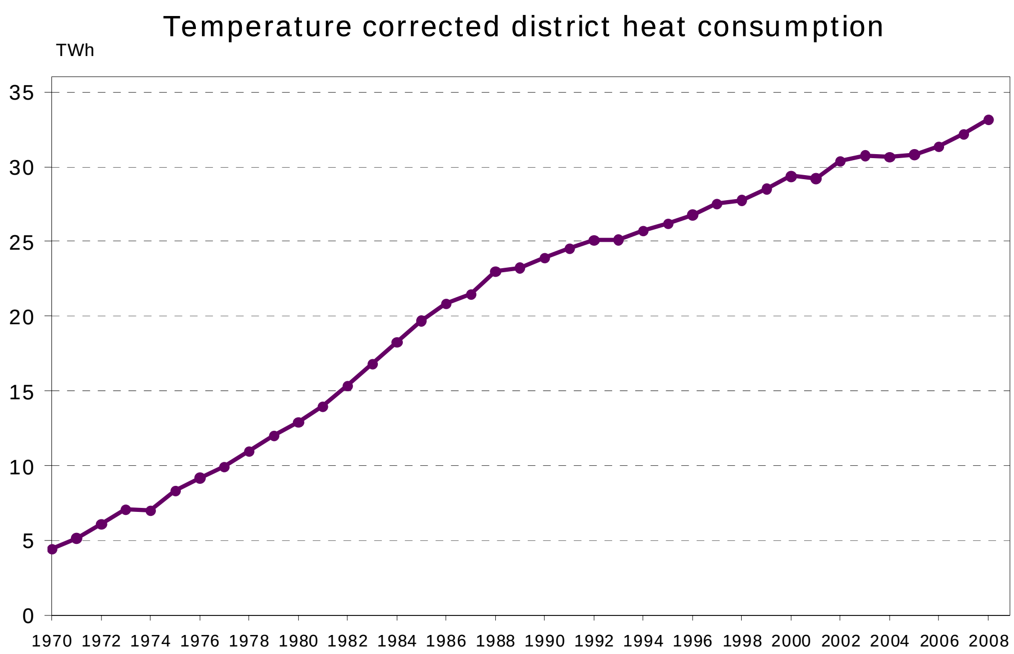

Figure 1-12 Development of temperature corrected district heat consumption in Finland 1970 - 2008 (Source: FEI 2009)

The Ministry for Employment and the Economy has developed a prognosis[6] where district heating demand develops from 30,6 TWh in 2006, to 33,0 TWh in 2020 and 33,1 TWh in 2030. The growth is thus slowing down markedly from 2020, thus reaching maturity.

1.3.4 Norway

An analyses of the expected district heating volume in Norway in 2020[7] concluded that there is potential for a growth of approximately 7,5 TWh district heating in addition to the 3 TWh already established. The technical potential is significantly higher (18 TWh), so new measures and incentives may further increase this volume.

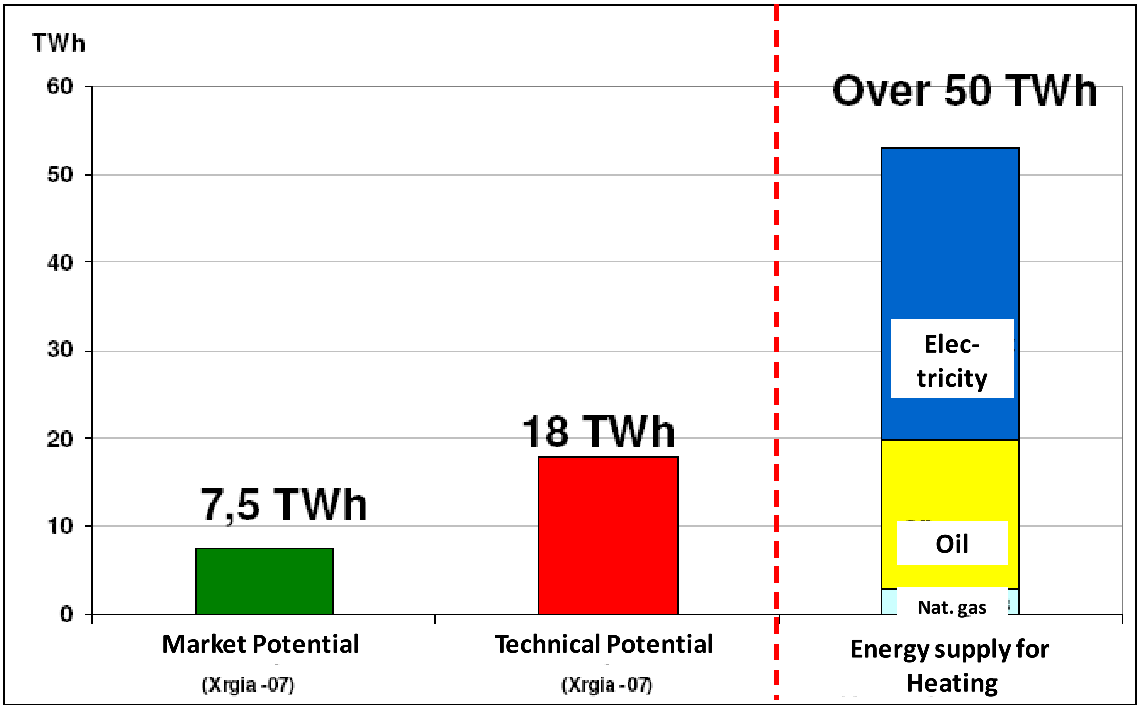

Figure 1-13 Market potential for district heating in 2020 (Xrgia 2007)

1.4 Energy efficiency – a threat?

EU has set high targets, 20 %, for energy efficiency improvements by 2020. This affects the heating of buildings and domestic hot water as well as all other sectors. As the building codes get stricter, with consumption level targets reaching that of low energy houses or even passive energy houses, the overall heat demand in new houses and areas will be much smaller than before.

Another aspect having a go at the district heating potential is the increased use of electric floor heating and for supplementary heating of incoming air. The majority of new detached houses in Finland have floor heating at least in the bathrooms. Even district heated houses get electric floor heating installed.

If a standard small residential house in for example Finland today has a final heat consumption of 21,6 MWh/a, a standard low energy has only 12,9 MWh/a (Motiva 2008). Will there be enough heat demand left after the increase in internal heat sources (floor heating, ventilation air heating, increased amounts of appliances etc) to let investments in DH be profitable? The less energy, the more those heating forms with large investments but low running costs suffer in comparison.

---

[6] The long-term climate and energy strategy. Government Report to Parliament, November 2008
[7] Enova: Potensialstudien 2020, Xrgia

Especially new areas to be built with one family houses and semi-detached houses will find it very difficult to make the investments in DH infrastructure profitable both for the consumers and the DH company.

1.5 Model results

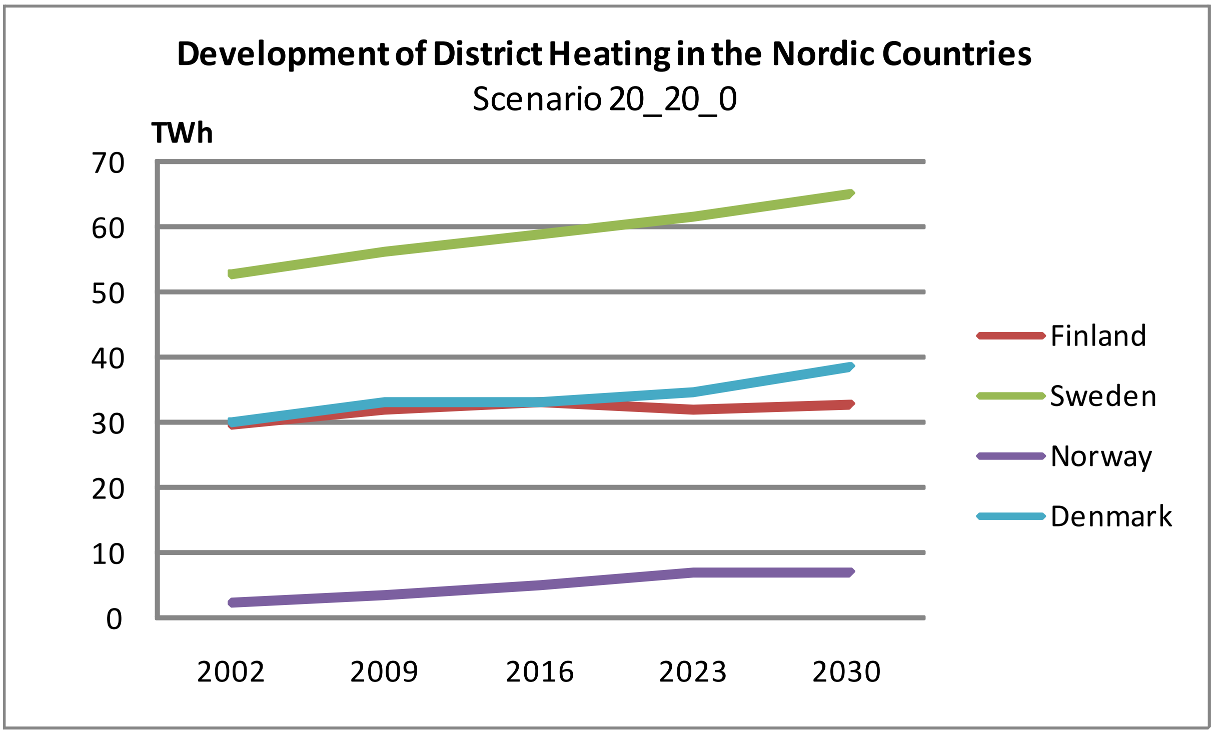

Figure 1-14 Development of DH in the Nordic countries, MARKAL

The model group of NEP is doing a lot of scenarios and runs with different models. Unfortunately only MARKAL models district heating in all the Nordic countries. One result is given in Figure 1-14. Examples of topics to discuss based on the result is (1) what causes the reduction in Finland and (2) why such increase in Denmark?

These results will be further investigated in the final district heating report.

2 District heating prices in Sweden – fixed or variable?

2.1 Introduction

When this analysis began, we had the perception that the district heating rates in Sweden contain a large part that is related to the district heating customers' energy usage. At the same time our impression was that the variable costs for district heat production consist to a great extent of different types of waste heat, and that the costs should thus be very low.

An argument that is often employed for allowing the variable part of the price to be large is that it should be profitable to save energy, since this is said to be good for the environment. For example, this argument was given quite recently in "Environmental goals for the county of Västra Götaland", April 2007 (Länsstyrelsen 2007). As a measure to decrease the emission of greenhouse gases, it is recommended among other things to: *"Review rates and fixed fees in order to give incentives for lower energy use. Decrease the fixed fees and increase the variable ones."* We considered whether it is true that saving is always right, and whether in that case it is a reasonable motive for choosing a rate which perhaps is not cost-correct.

At the same time we can observe that there are often customer desires for a large part of the district heating price to be variable and guided by how much energy is used. The reason is that the customers want to be able to influence their costs through their behaviour. In the report, we will return to the question of how great this possibility of influence is in reality.

For some time, through contacts with district heating companies, we have received information that various types of heat pumps, primarily exhaust-air heat pumps and in some cases air-air heat pumps, and solar heating have been installed in houses which are heated in other respects with district heating. This has the result that a part of the district heating company's energy delivery ceases, but that the power need for district heating (which occurs in the coldest weather when the heat pumps in certain cases no longer give any heat) remains more or less unchanged. That this has become profitable can be explained to some extent by the energy part of the district heating price being high.

An adjacent issue is the district heating companies' argumentation in relation to their customers. The companies often maintain that a large part of the district heating consists of diverse types of waste heat (industrial waste heat, heat from combined heat and power production, etc.). It then becomes peculiar to take large payment for the energy delivery itself. Should waste heat not give low energy costs?

Since a large part of the district heating in Sweden consists of waste heat of diverse types, one may ask whether it is really always justified to prevent large parts of the heat usage. This question is connected with the ongoing discussion of energy and environment performance for various energy carriers, e.g. for heating of buildings. The primary energy consumption is a concept frequently discussed in this context. Should the energy-saving ambitions not stand in proportion to how valuable the supplied energy is, and to what environmental consequences are directly or indirectly associated with the energy usage?

In our study we have assumed that the total level of the district heating price is correct, with regard to the companies' real costs and yield requirements etc. We are interested only in the distribution between fixed and variable parts of the rate.

The presentation is divided into several parts. In section 2.2 we discuss how Swedish district heating prices are typically built up by fixed and variable parts. The discussion is based on a study of 15 Swedish district heating companies that together represents nearly half of the total Swedish district heating deliveries.

In section 2.3 we calculate how much of the 15 studied district heating companies' costs that are connected with average variable energy-production costs. The calculations are based on production statistics and assumed fuel prices. In section 4 we compare these average variable costs with the variable income from the district heating price.

The analysis presented in sections 2.3 and 2.4 deals with the average variable costs. In section 2.5 we instead study the marginal district heating production costs, "the marginal variable cost". This analysis is based on production statistics for all Swedish district heating systems (from the Swedish District Heating Association), which have been processed further by Profu in order to identify the marginal production. This marginal variable cost is also compared to the typical variable income from the district heating price.

The marginal variable costs have been identified month by month. In section 2.6 we discuss the seasonal differences and how they could influence the pricing of district heating.

In section 2.7 we discuss the results and consequences if the district heating rates would not be cost-correct. In section 2.8 finally, we mention some areas for continued studies in the future.

2.2 The energy fee

How much of the district heating price comprises the energy fee? We have turned to diverse sources for information about this. Here we have chosen to concentrate on one of these sources, which contains detailed information about the price composition. By assignment of the Swedish District Heating Association, the EKAN Group has studied statistics on district heating prices. The work is described in the report "Statistics project, a study of district heating prices" dated 2006-01-30 (EKAN 2006). This report presents district heating prices and their composition in Sweden's ten large municipalities and in five additional municipalities. In these 15, the district heating makes up 49% of the total district heating delivery in the Swedish District Heating Association's statistics; see Figure 2-1.

For the given municipalities, the level and composition of district heating prices have been studied for a house type that is used in the so-called Nils Holgersson study, which is made annually by the Fee Group. The house type is a multi residential building with an annual heat consumption of 193 MWh per year.

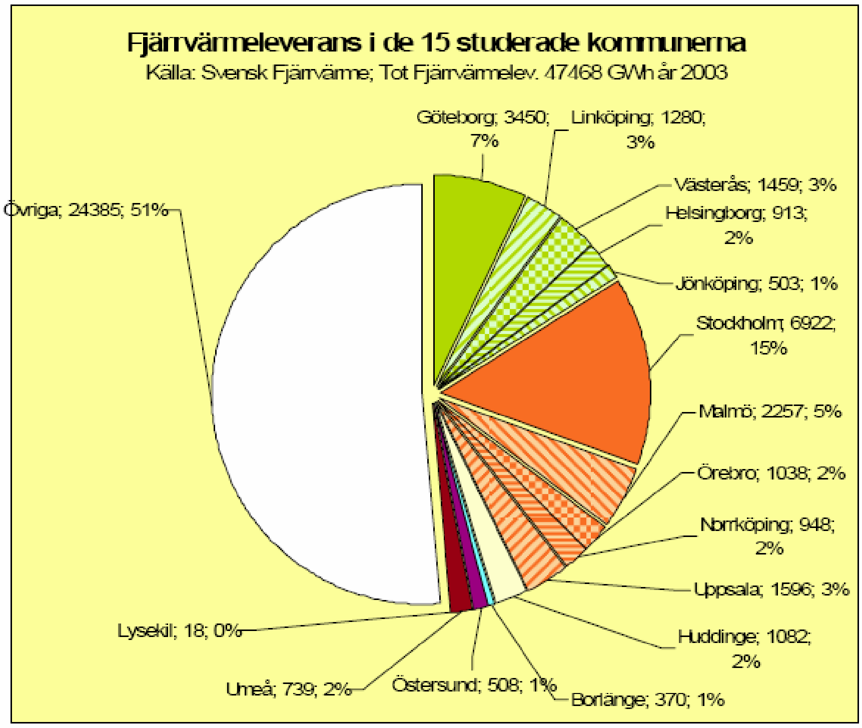

Figure 2-1 DH deliveries in the 15 studied municipalities (EKAN 2006)

The district heating prices and the division into different price parts, for the house type in the 15 municipalities are shown in Figure 2-2.

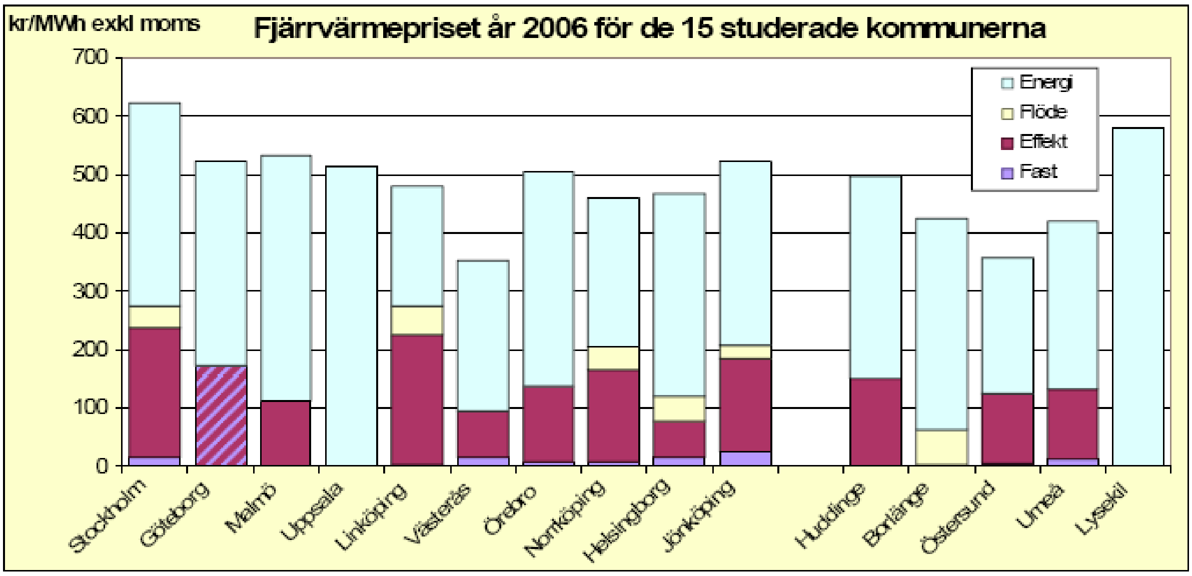

Figure 2-2 District heating prices in 2006 for the studied municipalities [kr/MWh] (EKAN 2006) ***(Energi=Energy; Flöde=Flow; Effekt=Capacity; Fast=Fixed)***

Thus, the district heating prices in 2006 lay between 621 SEK/MWh (Stockholm) and 351 SEK/MWh (Västerås). The part of the prices that is based on energy use – the energy fee – varied between 580 SEK/MWh (Lysekil) and 204 SEK/MWh (Linköping). The energy fee's share in per cent of the district heating price is shown in Figure 2-3.

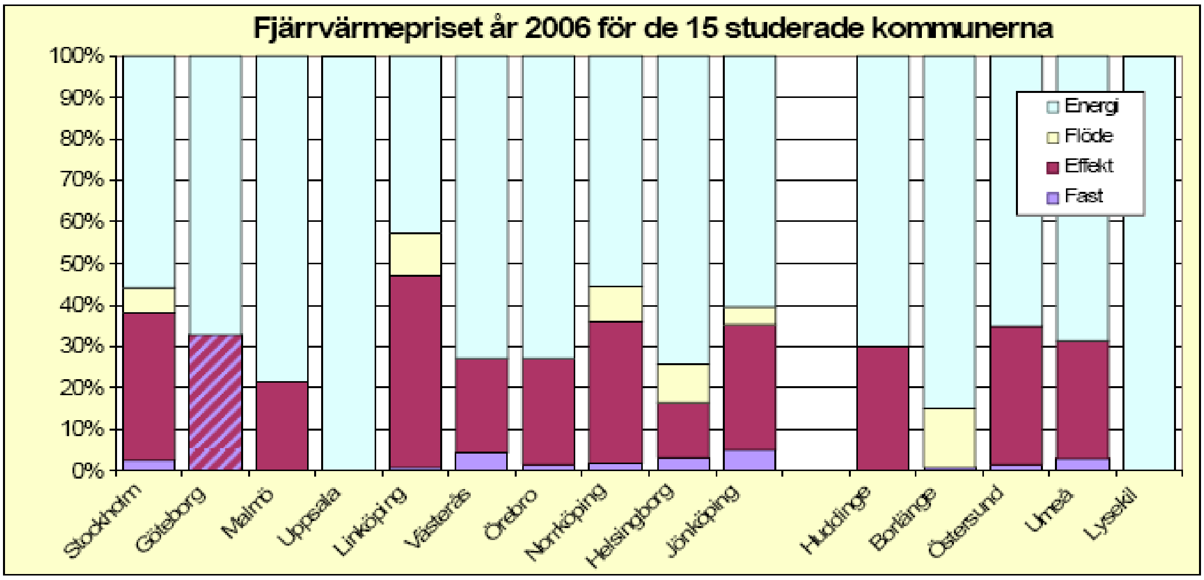

Figure 2-3 District heating price in 2006 for the studied municipalities – distribution into different price components [%] (EKAN 2006) ***(Energi=Energy; Flöde=Flow; Effekt=Capacity; Fast=Fixed)***

The energy fee's part of the total district heating price varies between 100% (Uppsala and Lysekil) and 43% (Linköping). As a calculation example, if one assumes that the 15 studied municipalities are representative for all district heating in Sweden and that the price data are weighted against the district heating deliveries in the 15 municipalities, the average total district heating price and energy fee can be calculated for the house type. The district heating price then becomes 523 SEK/MWh, in which the energy fee is 345 SEK/MWh, both excluding VAT. Thus, the energy fee's share of the district heating price is 66%.

The capacity share of the district heating price, "Effekt" in the figure above, is generally not a genuine capacity price. In most cases it is a price which is directly coupled to the yearly energy consumption through a simple conversion factor (often referred to as "category factor"). Therefore the capacity price could also be seen as a variable income. If the capacity price is added to the energy fee the total variable income would be 490 SEK/MWh.

Does this large share for the energy part of the total district heating price correspond to equally large costs connected with variable energy-production costs? We shall try to find that out in the next section.

2.3 Variable energy-production costs

To get an idea of the 15 district heating companies' variable heat-production costs, we have made an attempt with generally accessible statistics to calculate the heat production costs based on assumed fuel prices and tax costs.

To estimate the variable heat production costs in the chosen municipalities, we have used the Swedish District Heating Association's preliminary statistics for the year 2005 (Svensk Fjärrvärme 2007). These give statistics on which fuels were utilised for heat and electricity production. They were the latest available statistics at the time when the analysis was made. This means that the rates (for 2006) and the heat-production statistics (for 2005) do not actually refer to the same year. However, we judge that the resultant error is small and does not to any great extent influence our analysis and the conclusions we draw.

Our calculation has made the simplification that the variable heat-production costs consist solely of fuel costs for heat and electricity production, including relevant taxes for energy, carbon dioxide and sulphur. The combined power and heating plants' electricity production has been counted in the calculation as an income which thereby reduces the variable heat-production costs. For renewable electricity production in combined power and heating operation, the electricity certificate income also contributes to reducing the variable heat-production costs. [8]

The fuel prices come from diverse sources. Prices for oil, natural gas and coal have been taken from the Swedish Energy Agency's *Energy in Sweden – facts and figures* (Energimyndigheten 2006) which refers to fuel prices for the year 2005. The prices for wood chips and peat come from the Swedish Energy Agency's *Price Sheet* (Energimyndigheten 2007) and refer to 2006. We have set the electricity price to 300 SEK/MWh. (In reality the price was very high during 2006, at 445 SEK/MWh, which we have judged to be non-representative if compared with the prices both before and until now during 2007.) The prices for other energy carriers have been taken from the report *District heating in Sweden 2003* (FVB 2005), where the prices refer to 2003. The taxes refer to the situation on 2006-01-01 and have been taken from the Swedish Tax Agency (Skatteverket 2007). The emission rights price consists of the year-average spot price for 2006 on the European Energy Exchange (EEX 2007). A certificate price of 200 SEK/MWh has been assumed. To the energy prices relevant taxes are added in the calculations, depending on for what purposes the energy is used.

In reality, parts of the operation and maintenance costs are also variable, but this is neglected in the present introductory study. Examples of large fixed costs are the capital costs for production facilities and distribution systems as well as personnel costs.

In a truly long perspective, such as 50 years, almost all costs can be considered variable. During such a long period, probably the entire production and distribution system must be replaced, and the costs for this can then be seen as variable. But in the present study we focus on shorter perspectives

[8] In i.e. Finland, mixing of incomes from electricity sales with district heating costs is not seen as appropriate.

such as 10 years, where costs connected with existing production facilities and distribution systems can be regarded as fixed.

Figure 2-4shows the result from the calculation of the variable fuel and tax costs (“variable gross cost”) for heat and electricity production, and of the variable fuel and tax costs minus the income for electricity produced in combined power and heating operation (“variable net cost”). In both cases the costs per delivered heat unit are reported. In the subsequent analysis, it is the variable net cost that we utilise.

From the figure it can be seen that the variable gross cost lies between 127 and 342 SEK/MWh. The variable net cost (where the fuel and tax costs have been reduced with the income from the combined power and heat production’s electricity deliveries) becomes either the same as the gross cost (if the system lacks electricity production) or lower as a result of the electricity income. Larger electricity production entails a greater gap between the gross and net costs. The variable net cost varies between 33 and 342 SEK/MWh. This spread is very big, primarily due to different fuel costs and different sizes of income from electricity deliveries. The weighted average value for the variable net cost is 157 SEK/MWh. Note that the costs we report are based on elaboration of generally available statistics. Thus, we do not have access to real costs in the given companies.

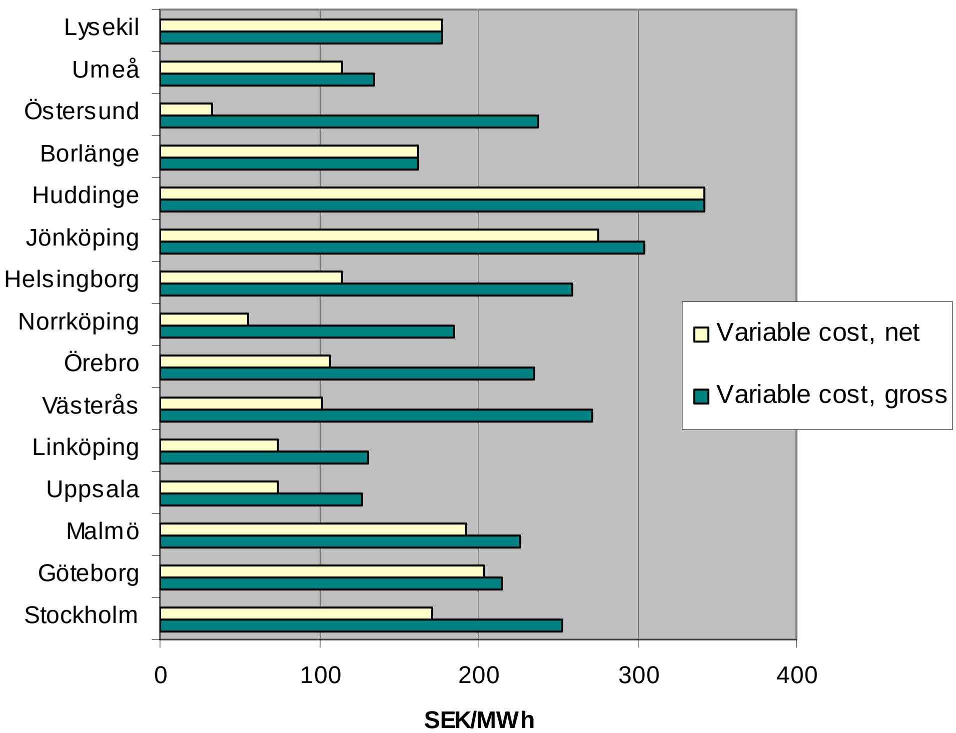

Figure 2-4 Estimated variable costs of district heat production in 15 studied municipalities (note that the costs build on estimates made within the project).

One can assume that the municipalities that show the lowest variable district heating production costs have made relatively great investments in order to enable exploitation of cheap energy carriers, and to enable large electricity production in combined power and heating plants. This probably leads to comparatively high fixed costs. However, we do not analyze it further since the variable costs and the energy part of the rate are what we focus upon in this work.

Our conviction is that the district heat production will be based to an ever greater extent on combined power and heating, waste incineration, industrial waste heat etc. Thereby the district heating consists increasingly of what more or less can be regarded as waste heat, with ever lower variable costs. We thus suspect that the real variable net cost for district heat production will decrease in the future.

In this section we describe the result of an estimation of the average variable heat-production costs, i.e. the total variable costs divided by the heat delivery. Another measure which is used sometimes is the short-term marginal cost, i.e. the variable production cost for the last produced heat unit. This varies over the year and is higher than the average price. Marginal costs are often used as a basis for price-setting, as they give information on what it costs to produce the utility that customers are about to use or not use. Marginal costs as a basis for variable costs for district heating is presented in section 2.5 below.

2.4 Variable income and variable average costs

In the above section we have partly studied the energy fee's size and share of the total district heating price, and partly calculated the variable costs for district heat production. In this section we will compare these two perspectives and analyze to what extent the district heating rate's energy fee corresponds to real variable costs.

Figure 2-5 shows for each of the 15 municipalities the total district heating price (blue), the part of that price which is directly coupled to the energy usage, namely the energy fee (red), and the variable net costs for district heat production (yellow).

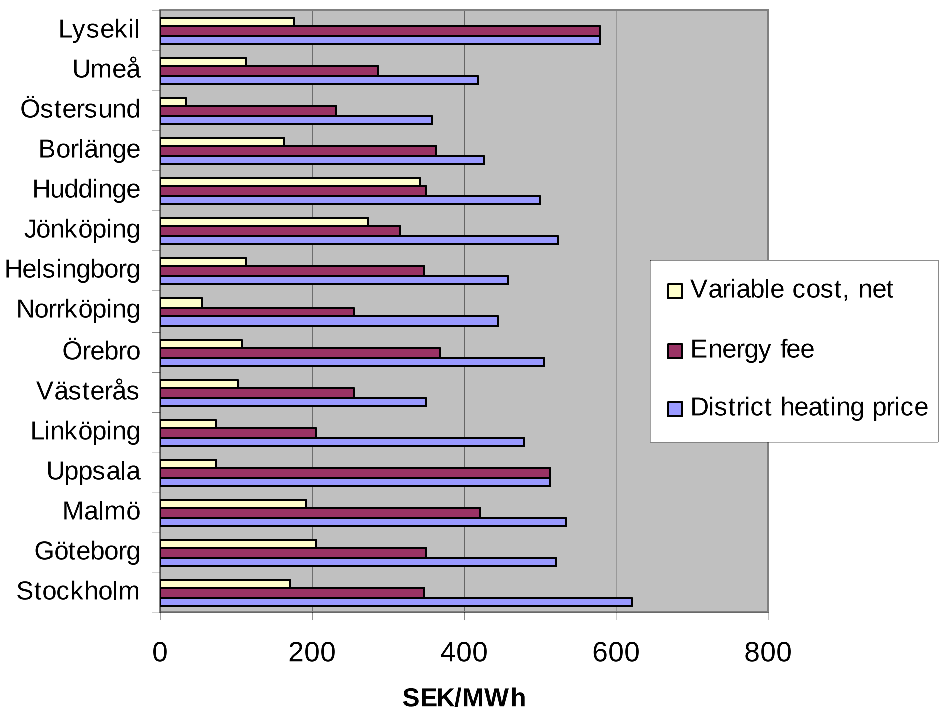

Figure 2-5 Comparison of district heating price, energy fee, and variable net cost for 15 studied municipalities (note that the costs build on estimates made within the project

From the figure it can be seen that the variable costs comprise a small part of the district heating prices. On average, the variable net costs make up 28% of the district heating price. Also in relation to the price's energy fee, the variable net cost is small; see Figure 2-6. On average, the variable net costs for district heat production make up less than half, 43%, of the district heating price's energy fee. However, the spread is very great, and the share varies between 14% and 98%. In all cases, though, the variable costs are less than the energy fee.

In connection with the design of rates, it is generally recommended that the rate should be cost-correct, i.e. that the rate's composition should correspond to that of the cost side. This could be taken to mean that the fee's variable part should comprise about the same share of the total price as the variable costs' share of the total costs. Our introductory study shows that such is not the case. If cost-correctness according to this definition were striven for, the energy fee would on average be half the level they are today, and fixed rate parts or parts related to power consumption would be correspondingly higher. This conclusion is underlined even more if you take into account that the capacity related part of the price, which one could assume should reflect the capacity dimension in reality is directly coupled to the yearly energy use in most companies' district heating price.

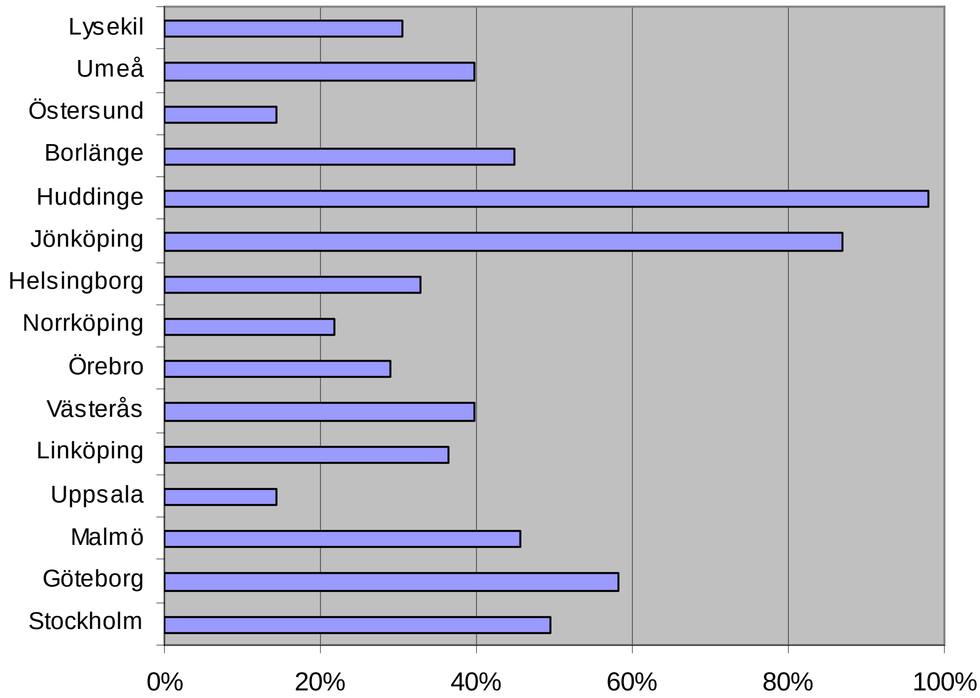

Figure 2-6 The variable net costs as a share of the district heating price's energy fee for 15 studied municipalities (note that the costs build on estimates made within the project)

There are however different ways of presenting the variable cost. In the analysis presented above, the average variable costs have been calculated and compared to the energy fee. If instead the marginal costs are used as variable costs the conclusion might be different. This is presented in chapter 2.5.

2.5 Variable costs for district heating based on marginal costs

In the above reasoning we have started from the variable average cost of district heat production. If one instead presupposes that it is the short-term marginal cost which should reflect the costs and provide the basis for price-setting, the situation is different. Marginal costs are often used as a basis for price-setting, as they give information on what it costs to produce the utility that customers are about to use or not use.

There is a significant difference between the average district heating production and the energy weighted marginal production. (By energy weighted we refer to a marginal production resulting of an added demand with the same seasonal profile as the total district heating production.) The difference between average and marginal district heating production is illustrated by Figure 2-7.

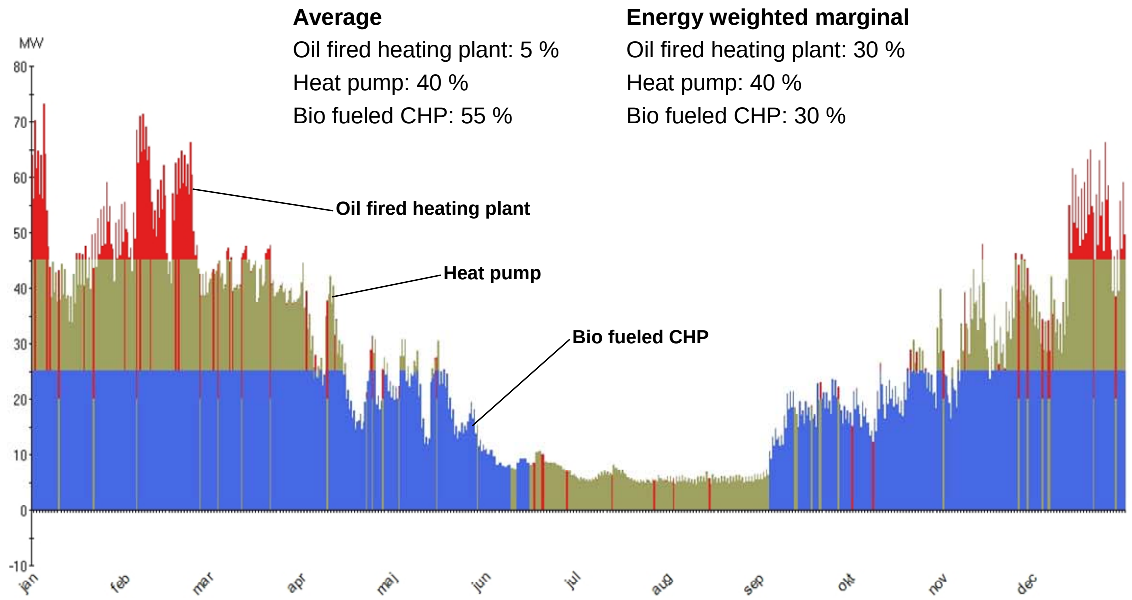

Figure 2-7 A typical Swedish district heating system – heat production mix

In a related study we have, as mentioned above, also analysed the marginal costs for district heating production. This work is based on preliminary yearly statistics for the years 2006 and 2007 from the district heating trade organisation Swedish District Heating Association. This statistics presents the use of fuels for district heating and for electricity production in combined heat and power production (CHP) for all district heating systems in Sweden. From this and additional information, e.g. typical variable costs for all heat production alternatives (primarily based on price statistics from the Swedish Energy Agency), we have developed a database model which makes it possible to, among other things, identify the marginal district heating production source system by system, and month by month.

The results for these approximately 200 district heating systems could then be added together, thereby presenting the energy weighted mix of Swedish marginal district heating production. Since the Swedish marginal district heating production is made up from monthly marginal production system by system, it consist of a mix of a large number of production alternatives.

The district heating marginal production mix has been calculated for the years 2006 and 2007, Figure 2-8.

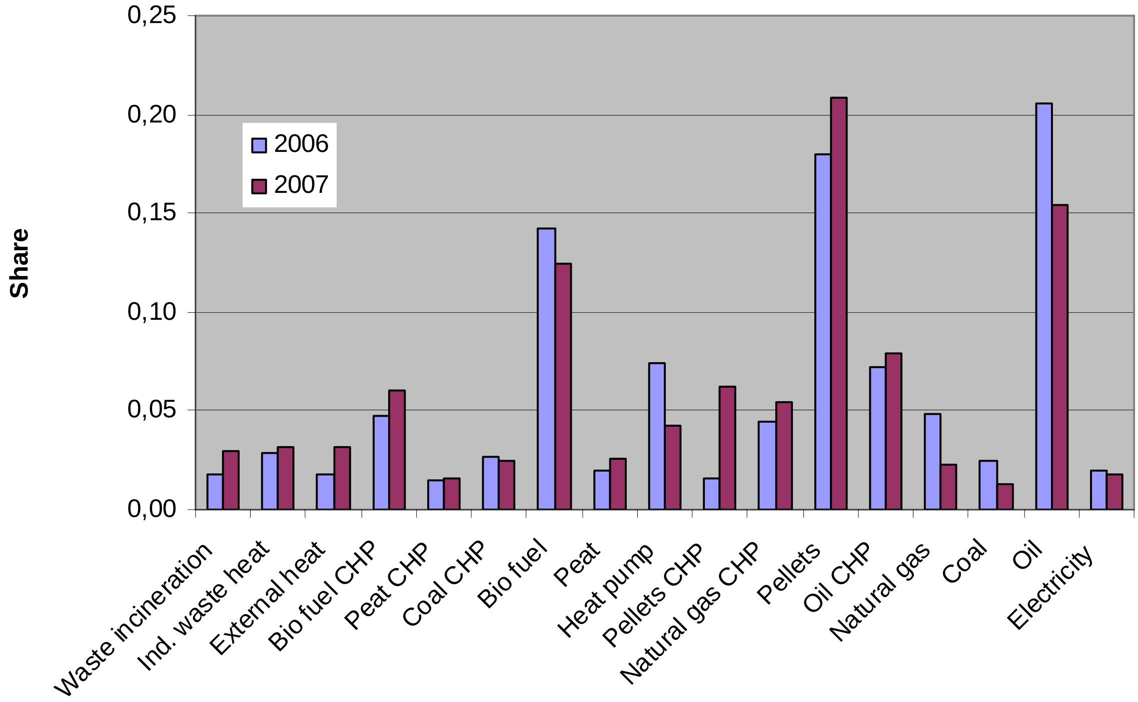

Figure 2-8 District heating in Sweden – the marginal production mix for the years 2006 and 2007

The figure above clearly shows, as mentioned above, that the marginal district heating production is made up from a very large number of production alternatives. This is partly a result of the fact that different production alternatives make up the marginal production during different seasons, and partly that the different district heating systems are very differently built up when it comes to their production mix. The figure also shows that there are differences in the composition of the marginal production between different years. The reason for this is mainly that the prices of different energy carriers vary between the years, thereby changing the merit order between the production alternatives. New production units are also introduced, which influences the resulting production mix.

There are three production alternatives which play a dominating role in the total marginal production mix of district heating during the two analysed years. They are heating plants fired by fuel oil and biomass, both refined biomass ("pellets" in the figure above) and unrefined biomass ("bio fuel" in the figure above). Together they account for approximately 50 % of the marginal district heating production.

The calculation method also facilitates the identification of a weighted average marginal district heating production cost, based on the results for all district heating systems. Assuming a general level of total distribution loss of 9 % this production cost has then been converted to a marginal heat cost for the final consumer. This cost is comparable to the net variable cost presented in section 3 above. There are however two significant differences. The first difference is that the marginal heat cost consists of, as the name indicates, a marginal cost, whereas the cost presented in section 3 is an average cost. The second difference is that the marginal cost is based on all Swedish district heating systems, whereas the cost presented in section 3 is based on data for 15 district heating system.

The typical energy weighted marginal cost for Swedish district heating is 400 SEK/MWh for the year 2006 and 340 SEK/MWh for 2007. An average value for those two years would then be 370 SEK/MWh. If we assume that the average energy fee identified in section 2, 345 SEK/MWh, is representative for all Swedish district heating systems this energy fee would correspond rather well to the marginal cost. This could be seen as an indication that the district heating price is cost correct and therefore well designed in this respect.

However, if you label the capacity price as a part of the variable income (as discussed in chapter 2) the energy part of the price would be significantly higher than the marginal cost – income 490 SEK/MWh compared to cost 370 SEK/MWh.

It is important to bear in mind that the numbers are calculated using different selections of district heating systems and years. The marginal costs correspond to all Swedish systems and the years 2006 and 2007. The energy fee however, corresponds to 15 district heating systems, predominantly large systems, and the year 2006. The energy fee was probably slightly higher in 2007 (the average district heating price increased by 1 % from 2006 to 2007). Since the identified energy fee to a great extent is based on large district heating systems a typical energy fee for all Swedish systems may be higher (if we assume that district heating prices are higher in small systems and that the energy fee share of the district heating price is constant). Both these factors would result in a higher energy fee.

Based on this discussion and considering the precision of the analysis it is probably fair to repeat the conclusion presented above; *the energy fee corresponds rather well to the marginal cost and that this could be seen as an indication that the typical district heating price is reasonable cost-correct and therefore well designed in this respect. However, since the capacity part of the price is often directly coupled to the yearly energy consumption, and therefore could be seen as a variable income, the variable income is generally high in relation to the variable marginal costs. It would therefore be positive if the capacity price would be more directly coupled to the actual capacity demand.*

With the marginal cost as a point of departure for the price-setting, the district heating price's composition may not go wrong at all and the customer might get correct information about the cost structure. In this case the sub-optimizations discussed above do not arise. However, it is important to be aware of the fact that the differences between the district heating systems are large, both regarding the marginal production cost and the energy fee. Therefore, although the conclusion at the national level is that the energy fee corresponds well to the marginal cost, there may be many district heating systems where this is not true. It could go both ways – either that the energy fee is to large compared to the marginal cost, or the other way around.

In the analysis presented above we have used the yearly average of the marginal cost for district heating production. There are however, significant differences in marginal cost for district heat production over the year. This is discussed in chapter 6 below.

2.6 Marginal costs during different seasons

Since district heating production is typically made up from a mix of base load, medium load and peak load production there are significant differences in marginal cost for district heating production over the year. The base load is characterised by large investment costs and low variable costs (e.g. waste incineration), whereas peak load production is characterised by low investment costs and high variable costs (e.g. oil fired heating plants).

By means of the method which is used for calculating the marginal cost for district heating production (chapter 2.5) it is also possible to identify the marginal production month by month. This also makes it possible to identify the marginal cost month by month for the total Swedish district heating production. The results are shown in Figure 2-9.

In the calculations we have assumed zero cost for heat from waste incineration and industrial waste heat. If costs related to actual contracts would be applied the summer marginal cost would be higher.

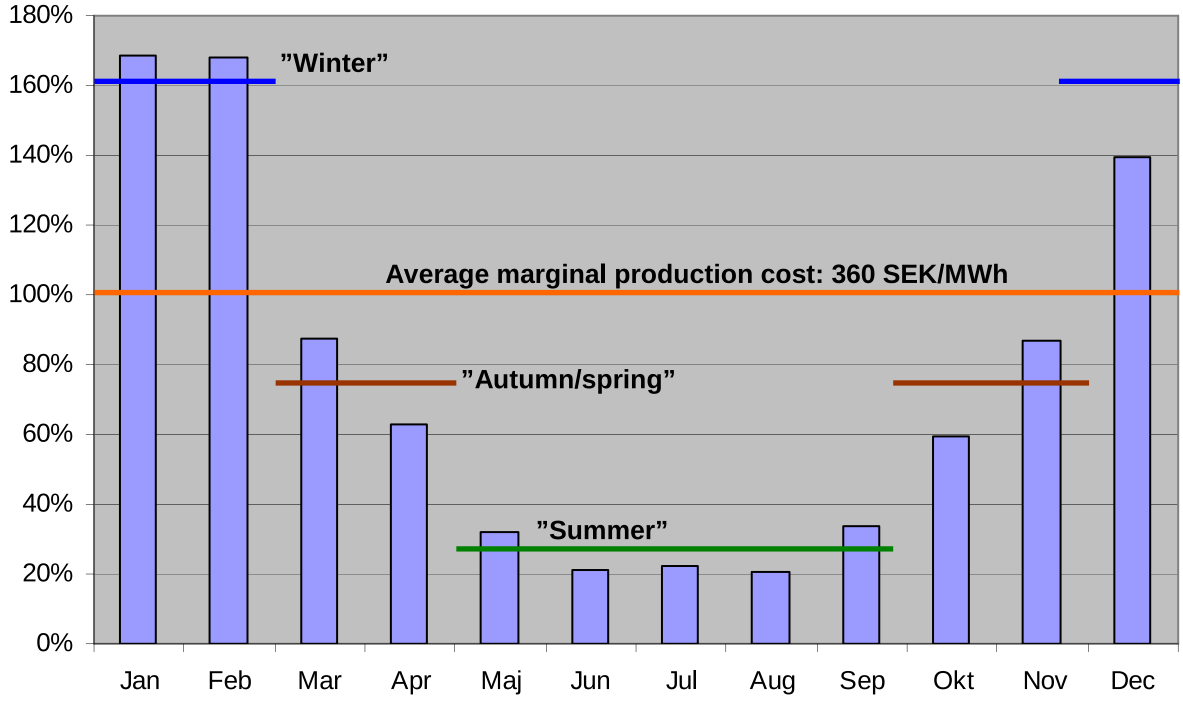

Figure 2-9 Cost of the Swedish marginal district heating production month by month for the year 2006

The figure confirms the great seasonal differences in district heating marginal production cost. If we assume that the marginal cost is the best illustration of the variable costs and in order to have a cost-correct district heating price, this great difference should be expressed through the district heating price. If not, there is for example a risk that too little heat is conserved during wintertime and too much heat is conserved during the summer.

Season-adjusted energy fees are applied in 60 % of the 15 studied municipalities (chapter 2). If we assume that these 15 companies are representative for all Swedish district heating companies and that the situation is the same today as in 2006 almost half the companies use a district heating price without any seasonal differentiation.

In the figure above three seasons are indicated. Of the companies that use seasonal district heating prices no company apply more than two seasons. The price differences between different seasons are, with few exceptions, small.

In order to create more cost-correct district heating prices more companies ought to introduce seasonal prices, maybe with more than two seasons and with seasonal price levels related to actual marginal costs. To what extent this would in practice influence the heat customers' behaviour is no easy to foresee. At this stage we do not even try to speculate about this.

2.7 Discussion and conclusions

Swedish district heating prices typically include a large variable share, the energy fee. A study of the district heating price for 15 Swedish district heating companies shows an average energy fee of 345 SEK/MWh, or 66 % of the total price. The average variable production costs are considerably lower than that, less than half the level of the energy fee.

However, for the purpose of designing cost-correct tariffs the short term marginal cost is a more relevant valuation of variable costs than the average variable cost. Marginal costs are often used as a basis for price-setting, as they give information on what it costs to produce the utility that customers are about to use or not use. The marginal costs are considerably higher than the average costs, since they reflect the cost for the most expensive production alternative that is made use of to satisfy the demand.

There are large variations in marginal costs for the district heating production in different district heating systems, due to the differences in production mix. However, as a national average this study shows that the marginal costs are of the same magnitude as the energy fee in the district heating price. This means that the price is generally cost-correct in this respect.

However, since the capacity part of the price is often directly coupled to the energy consumption, and therefore could be seen as a variable income, the variable income is generally high in relation to the variable marginal costs. It would therefore be positive if the capacity price would be more directly coupled to the actual capacity demand.

In our analysis we have not included any variable costs related to the distribution of district heating. The assumption has been that the distributions costs do not change when the energy demand changes marginally. This is a simplification, but we do not think that it affects the results in any significant way.

The large variations in both variable price (energy fee) and variable cost (marginal cost of production) between different district heating systems indicate that, although the price appears to be cost-correct on a total national level, there are many systems with prices that are not cost-correct. This goes both ways, i.e. both systems with too large variable share of the total price and systems with too small variable price.

As mentioned above the district heating price is designed with more goals than to be cost-correct. The price should e.g. be simple to understand. The customers also often desires for a large part of the district heating price to be variable and guided by how much energy is used. The reason is that the customers want to be able to influence their costs through their behaviour. Therefore we understand that there may be quite rational reasons for choosing a district heating price that may lack in cost-correctness. However, we still discuss this issue, since we feel that it is important to reflect on this and make a conscious choice on how to design the price structure.

Although the marginal costs as a national average corresponds well to the level of the energy fee of the district heating price, the study indicates that marginal costs typically varies a lot between different seasons. The marginal cost for district heating production could often be five times higher during winter than during the summer. The study at the same time indicates that many district heating companies do not differentiate the variable price between seasons at all, and the companies that do so, often only apply relatively small price differences between seasons. If the ambition is to have a cost-correct price in this respect, larger price differences between seasons would generally be encouraged.

What could then be the consequences if a district heating price which does not correctly reflect the true variable costs? Here we discuss a case where the district heating price's energy-related part constitutes a clearly larger share of the price than the variable costs' (marginal cost) share justifies. As mentioned above there could just as well be the opposite situation, that the variable price element is too small. For that situation the discussion below could generally be seen "the other way around".

A situation where the variable parts in the price are presented as a larger share of the district heating cost than they actually constitute leads to, or risks leading to, a number of phenomena. Below we list some of these:

- Greater energy saving than what would be economically optimal
- Heat pumps could be introduced in district-heated buildings to decrease the use of district heat energy

- The district heating’s energy deliveries decrease, which among other things reduces the heat basis for resource-conserving combined power and heating
- The district heating producers risk decreasing their own market
- The specific energy fee must be raised to cover the costs
- If the district heating is presented as if consisting largely of various kinds of waste energy, it can be difficult to explain high energy fees

The district heating in Sweden is to an increasing degree based upon renewable energy and waste heat of diverse kinds. If the district heating price conveys the information that the energy being delivered is very valuable, the users will strive to decrease the use of district heating energy. This may lead to introduction of savings measures that reduce the heating demand more than what would be economically optimal. Some think that this is always a desirable effect for reasons of the environment and climate, and that a high energy fee should therefore be striven for. But the problem is that most energy users have a limited budget and a limited interest in energy-saving and energy efficiency. Would it perhaps be better that the interest and the economic resources for saving/ efficiency are focused on other areas where the utility in terms of environment and climate may be greater, such as transport and/or household electricity?

“Exaggerated” heat-saving and partial conversion to heat pumps decreases the heat market for the district heating companies. If a district heating company takes out a large part of the heating price as an energy fee, it thus risks eventually getting a district heating market that declines – not because the total district heating price lacks competitiveness, but as a result of the fee having an illogical composition.

A largely variable district heating price gives the customers great possibilities of influencing their costs by saving or partially converting away the use of district heating. If the district heating company’s costs in reality are not variable to the same extent, the result is that one must gradually raise the specific district heating price to cover the costs and be able to retain one’s profit. This can rebound upon the customers and one can expect disappointment among those customers who have carried out savings measures to decrease their energy costs, and where the cost reduction does not prove as big as expected since the specific heating price rises.

In a wider perspective, a district heating price with a disproportionately large energy-fee basis can also lead to negative effects on the total resource usage, as well as on the environment and climate. If a high energy fee leads to decreased district heating deliveries, the heat basis is reduced for resource-conserving combined power and heat production. If the decreased district heating deliveries are a result of partial conversion to heat pumps, the North European electricity balance is weakened doubly – the electricity production in combined power and heat plants decreases, and the electricity use increases due to more heat pumps. The consequent additional need for electricity production will be covered partly by condensing power plants, which in environmental terms are clearly worse than combined power and heating plants.

Naturally, we are not arguing here for wastage of energy. We only wish to draw attention to the fact that the urgency of decreasing heat usage depends on how the heat is produced. Different investigations (e.g. Byggforskningsrådet 1996) have shown that the optimal energy-saving level is clearly lower for buildings that are heated with district heating, in comparison to buildings with oil firing or electrical heating.

As already mentioned in the introductory section, certain district heating companies maintain that the dominant part of their district heat production consists of various kinds of waste heat. As a customer, one can then think it strange that this waste heat should have a high variable price. The concept of waste heat rather suggests low variable costs. In this perspective it seems more reasonable to have a low share of variable price and a relatively high share of fixed price. The argument can then be that the waste heat is cheap, but that costly investments have been made to enable the resource-conserving utilisation of this waste heat (which is probably true).

2.8 Further work

After this introductory study we expect to continue the analysis of the district heating price's composition and the consequences that different alternatives may have. Until now, the work has been directed mainly toward Swedish conditions. In the further work, other Nordic countries will also be studied. It is then naturally important to take account of the differing conditions and requirements in those countries.

During the further work we may seek to collaborate with the district heating companies' trade organizations in the Nordic countries. It may then also be relevant to contact individual district heating companies. Obtaining the district heating industry's view of the current issues is very valuable. How are for example the typical district heating tariffs designed and why? In addition, we are hopeful that the trade organizations will be able to contribute information and basic documentation. Initial contacts have been made with the Swedish District Heating Association.

It would also be of interest to compare the price-setting of district heating with that of other energy carriers. Primarily other grid distributed kinds of energy are relevant, such as electricity and natural gas. In connection with this, it is suitable to develop the discussion of average cost and marginal cost further, and how these should be utilised as a basis for rate design.

3 Price of district heating in Finland

The information is based on Finnish district heating statistics from 2007 (*Kaukolämpötilasto 2007*). In 2007 district heating sold to customers was 30 100 GWh. The arithmetic average price of district heating was 50,7 €/MWh and the average price weighted by annual sales of the district heating companies was 45,6 €/MWh. The average energy fee of all district heating companies was 46,8 €/MWh and the weighted average was 39,9 €/MWh. The energy fee varied 27 – 102 €/MWh.

The tariff structures vary between the companies and between different user groups. Generally there are two parts in the Finnish tariffs; a fixed fee that depends on the contracted capacity of the costumer and a variable fee that depends on the actual energy use. The larger share the variable fee forms of the total costs, the larger the customer's incentives are to reduce the energy use.

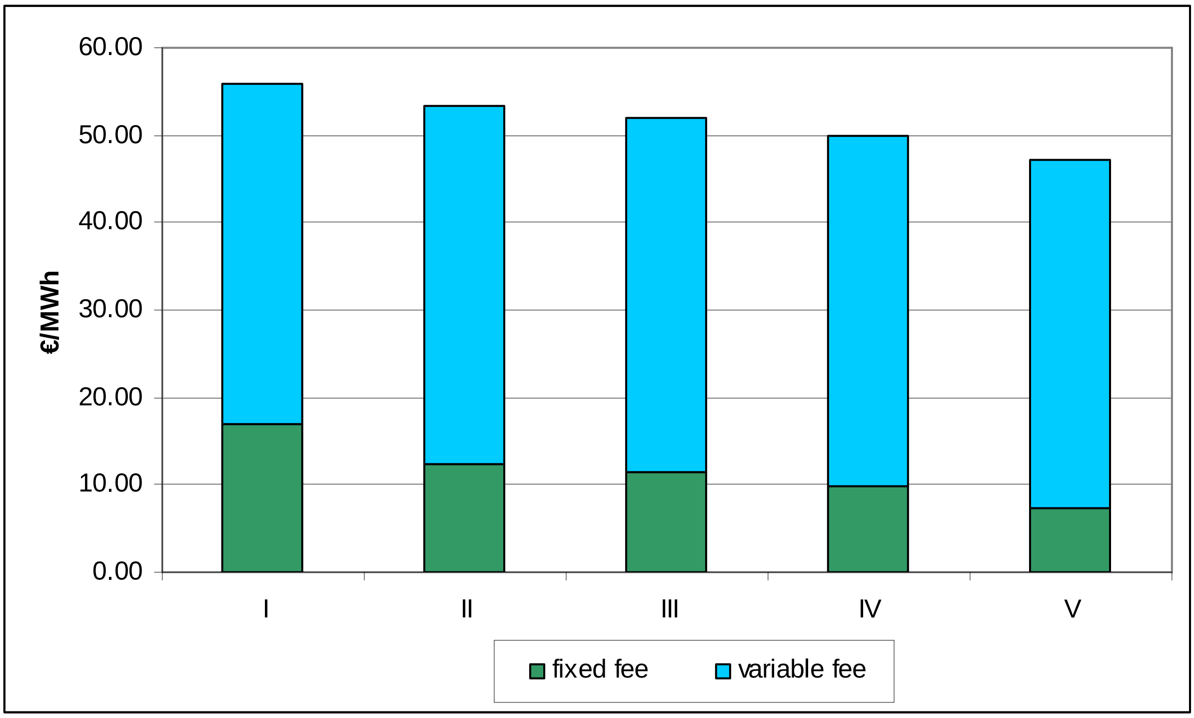

Figure 3-1 Composition of tariffes in Finland. Weighted average fees according to customer size (I –V)

In Figure 3-1 customers are divided into five classes I – V based on their average heat demand. The classes are presented in Table 1.

Table 3-1. Customer classes used in Figure 3-1

	Heat demand, MWh/a	Volume, m^3
I	20	500
II	100	2000
III	225	5000
IV	450	10000
V	1125	250000

Figure 3-2 shows the composition of the district heat price for small-scale block house is in selected district heating companies.

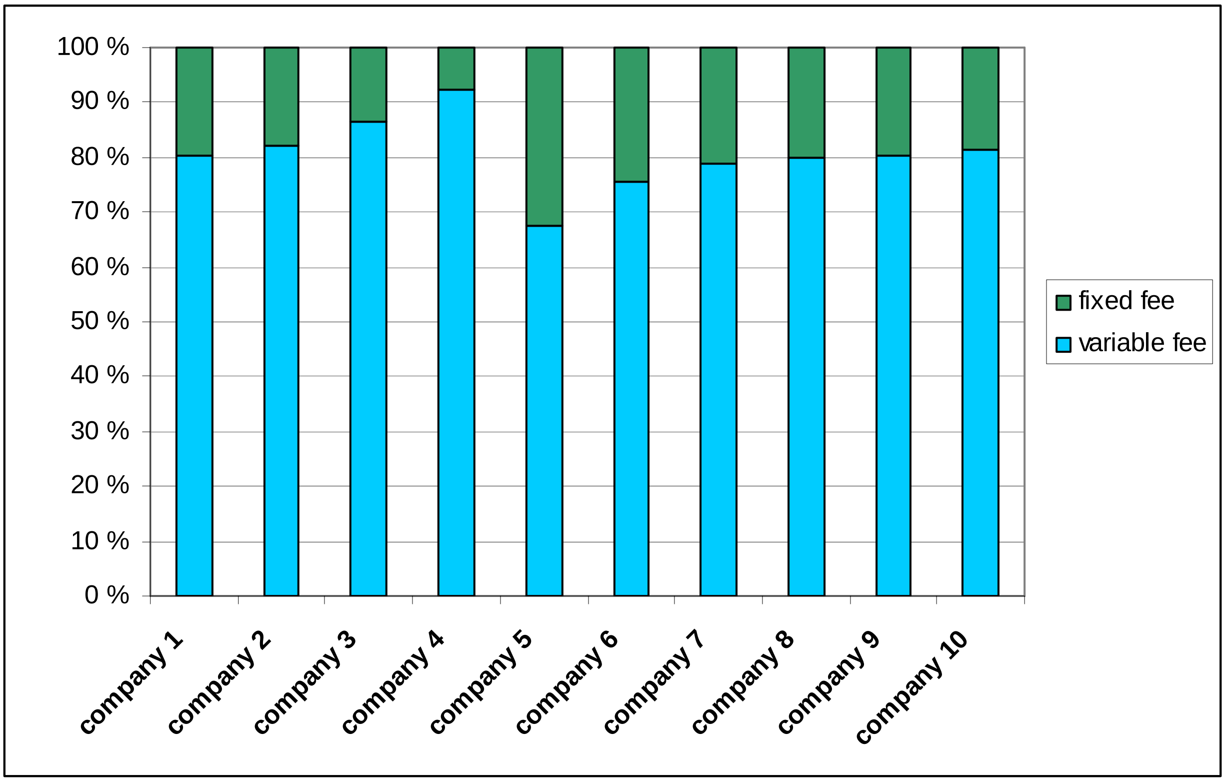

Figure 3-2 Composition of district heat tariffs for small scale block house in selected companies. Average heat demand of a small scale block house is 225 MWh/a.

Companies 1 through 4 produce only heat while companies 5 through 10 have CHP-plants. The range of the variable fee's share of total customer costs was 67 – 92,5 %. The weighted average for variable fee shares is about 76 % for companies with CHP-plants and about 81 % for heat-only companies.

In Figure 3-3 there is a similar comparison of the tariff compositions, but now for households with a heat demand 20 MWh/a. The companies are the same as before.

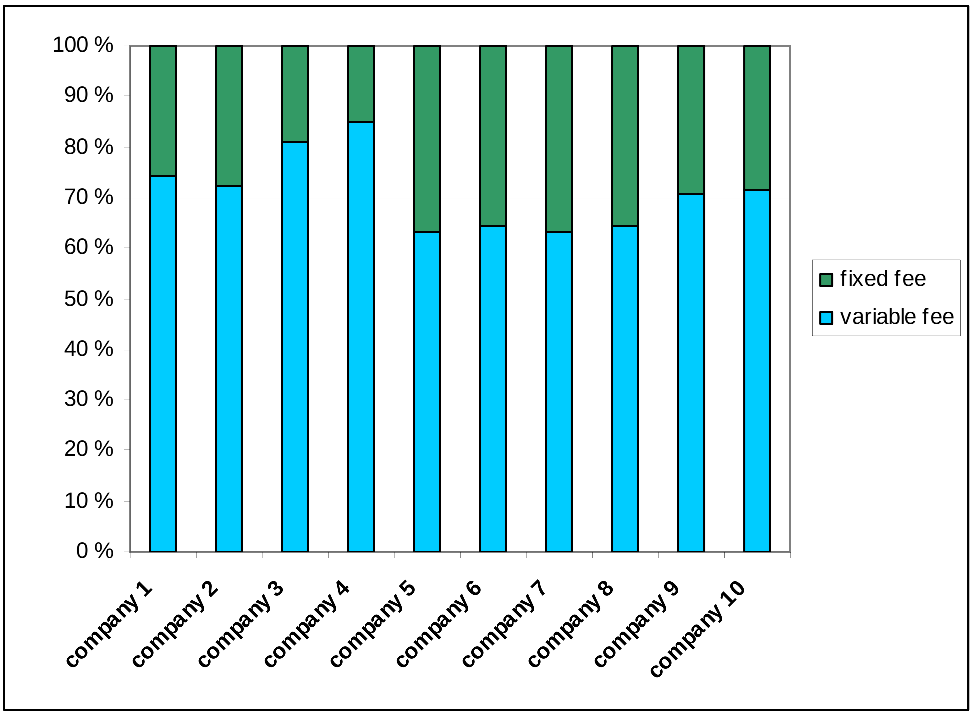

Figure 3-3. Composition of DH tariffs for households in selected companies. Average heat demand of a household is 20 MWh/a.

If we compared the results with those for block houses we can notice that the share of the fixed fee is greater for small consumers (households) than for larger consumers (block houses). The range of the variable fee's share of total customer costs was from 52 % to 90 %. Companies with CHP-plants has the weighted average of the variable fee share's is around 71 % and around 76 % for heat-only companies.

4 Price of district heat in eight Norwegian companies

District heating is far from as common in Norway as it is in the other Nordic countries. Figure 4-1 shows the development in investment in district heat facilities in Norway, demonstrating that the balance between investments in production facilities and distribution facilities are more or less equal, with some yearly variations.

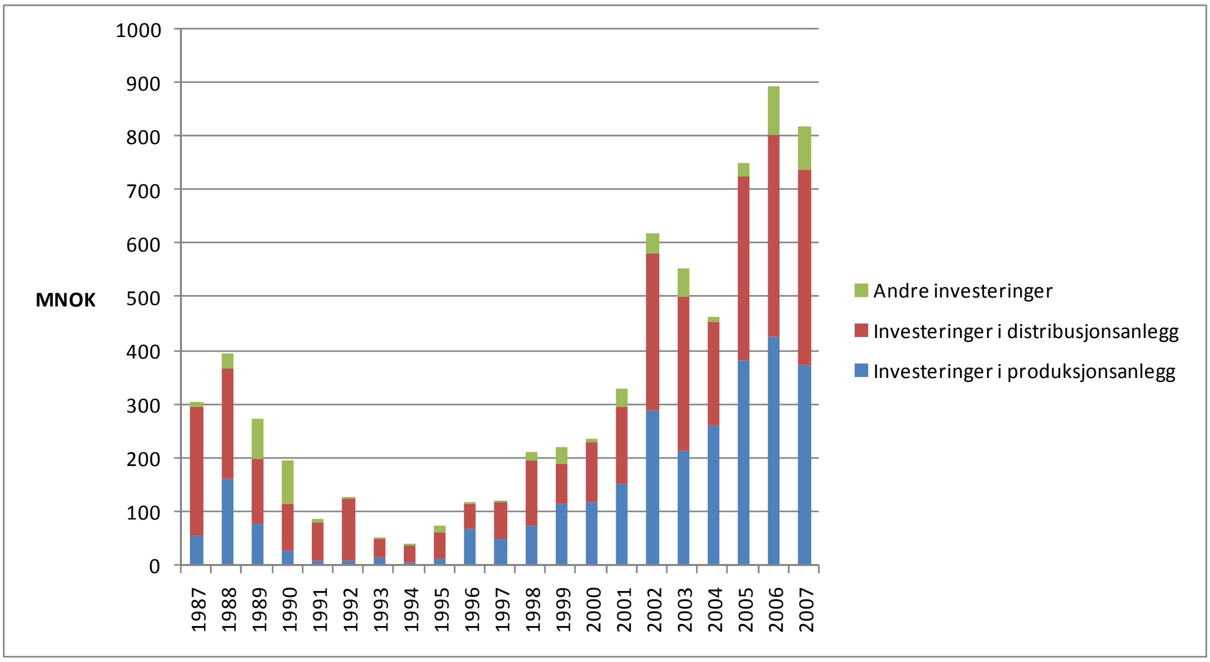

Figure 4-1 Historic investment in district heat in Norway

Waste is the most common energy carrier used for district heat; biomass and electricity are also frequently used.

As shown in **Fel! Hittar inte referenskälla.**, the average price of district heat in Norway tends to follow the electricity price closely. As mentioned earlier, the district heating price has to be lower than the electricity price, but apart from that the district heating providers are free to set the price.

4.1 Survey results

A survey has been executed to look closer at the connection between cost of district heating production and distribution and the price of district heating. The survey looks at eight district heating companies. The companies' installed capacity of different types of boilers is depicted in Figure 4-2. The total installed capacity for the eight companies varies from 10 MW to 781 MW.

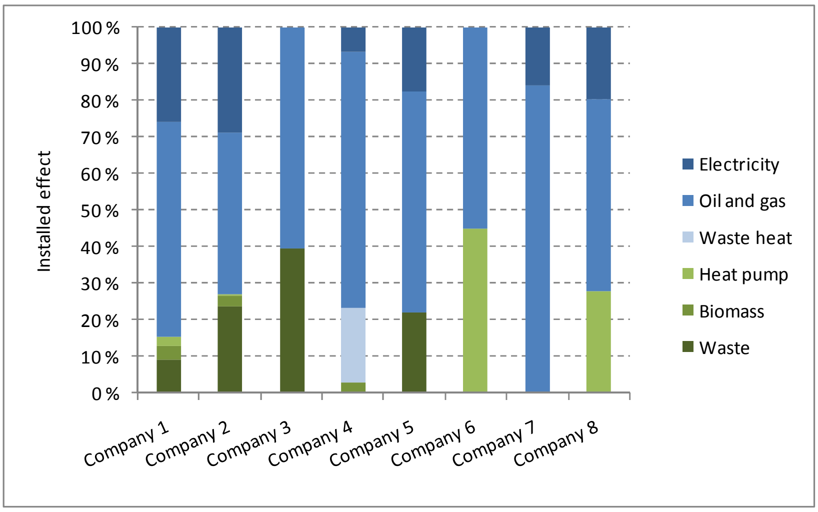

Figure 4-2 Installed capacity

To calculate the actual size of the base load, the time of use is assumed to be 1750 hours and the base load is assumed to run on full effect constantly. These are coarse simplifications, but give a good enough estimate for this use. The results of this calculation are shown in Figure 4-3. Company 7 is most likely in an initializing phase, which is why it seems to have no peak load yet. For the others, the base load varies between 20 and 40 %.

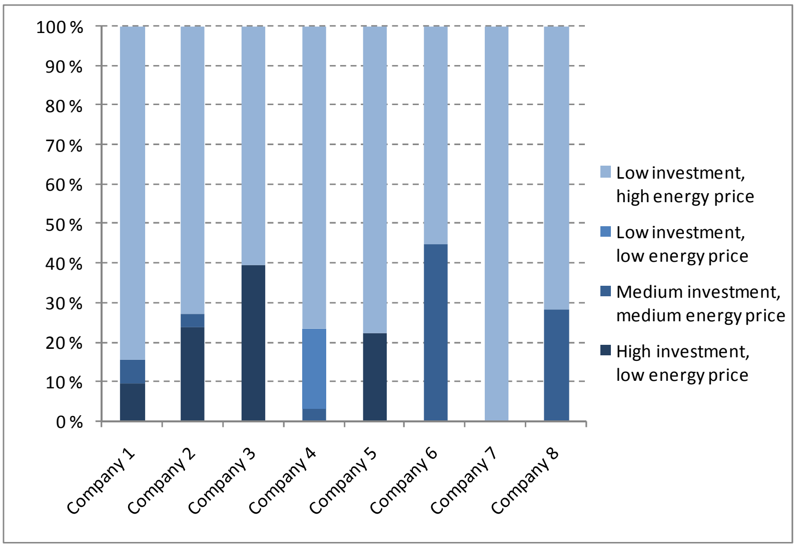

Figure 4-3 Use of boilers for district heating in % of total energy production

The tariff structures vary between the companies and between different user groups. There are three parts of the tariffs; the annual fee, the fixed fee which depends on the maximum capacity that the costumer requires and the variable fee which depends on the actual energy use. The larger the variable parts of the tariff, the larger are the customers’ incentives to reduce the energy use. But that does not reflect the actual costs for the district heating companies. Figure 4-4 shows how the district heating price for households is composed.

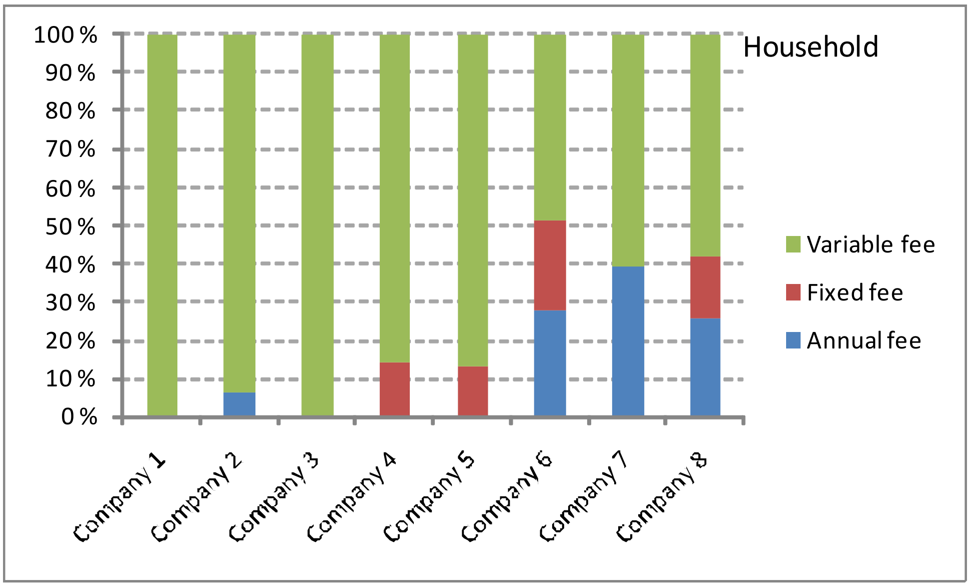

Figure 4-4 Construction of tariff – household that requires 8,5 kW capacity and 15 MWh heat pr year (based on *Enova (2004): "Enøk Normtall"*)

Figure 4-5 shows the composition of district heating for an office building.

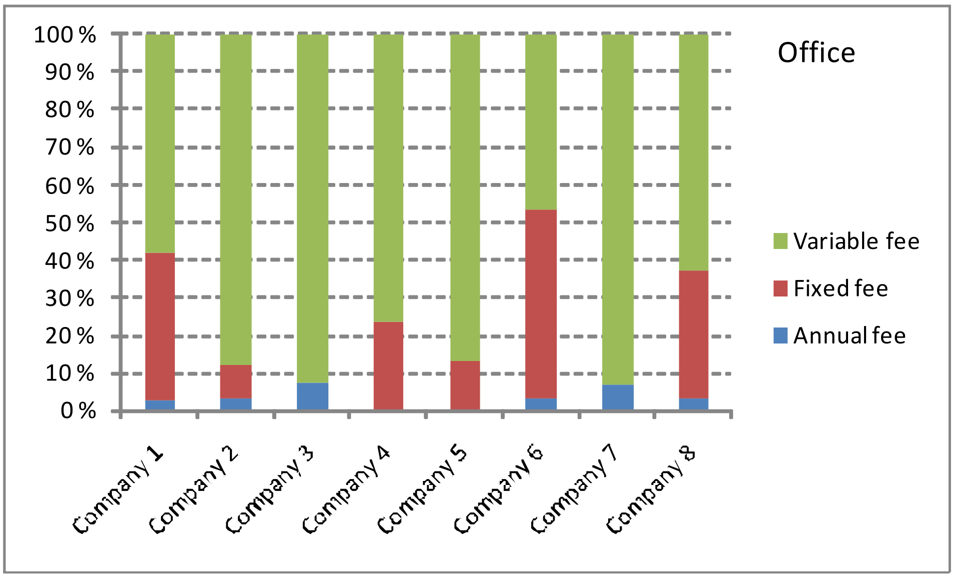

Figure 4-5 Construction of tariffs - office building that requires 138 kW capacity and 128 MWh heat pr year (based on *Enova (2004):"Enøk Normtall"*)

Why do the compositions of the price vary so much? One hypothesis could be that companies that are in an initial phase have recently made big investments and will therefore have a larger fixed part of their price. But analyses show no connection between age of the company and composition of the tariffs.

Another hypothesis could be that district heating companies that have invested in a large proportion of base load boilers will have a larger part of their price as a fixed fee, because base load boilers have high investment costs and lower energy cost. But this also turns out to be untrue for the eight companies in this survey.

4.2 Case study

One of the companies in the Norwegian survey has graciously given us detailed data of their energy use in district heating production, as shown in Figure 4-6. This company uses a total of eight different energy carriers in their production, located in several plants. Waste is by far the most used energy carrier. It is used every month throughout the year. Landfill gas is the least used energy carrier. The electricity use is highest in the months of January and February, indicating that the electricity price was fairly low in this period.

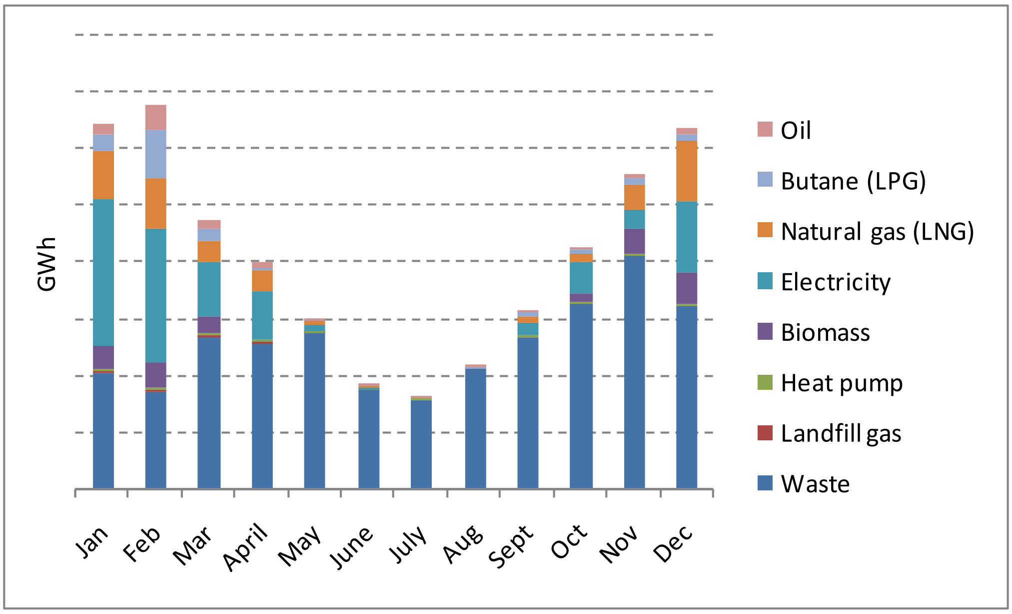

Figure 4-6 Use of energy carriers

As seen in Figure 4-7, the low cost energy carriers dominate the use in the summer time. The more expensive energy carriers constitute a larger part of the energy use in the winter. Although this is expected, the use of base load energy carriers seems unusually low in the beginning of the year. There might be several reasons for this; one possible cause might be that one of the base load incinerators is taken out of use because of maintenance.

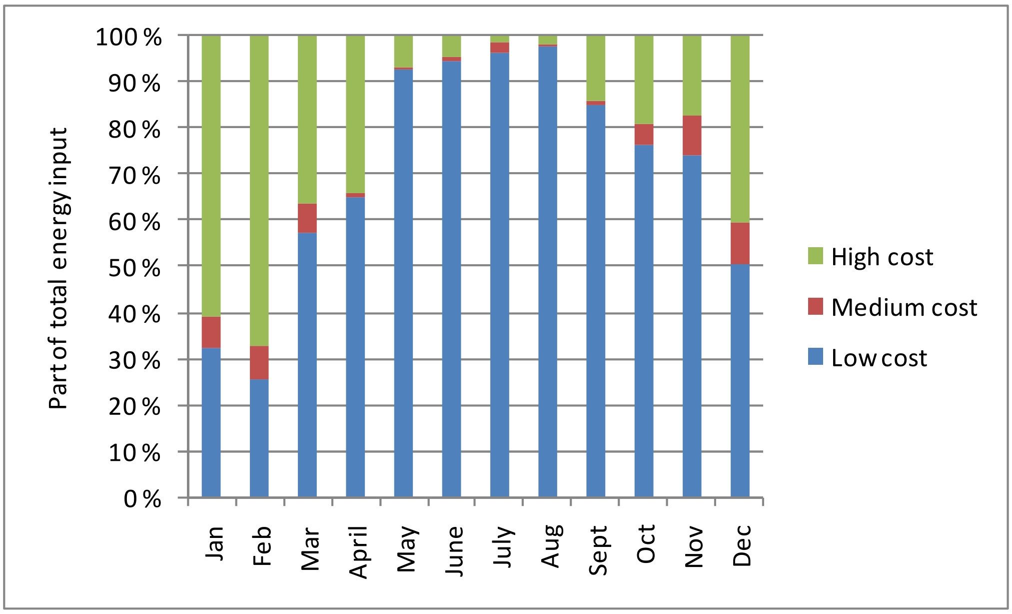

Figure 4-7 Use of different cost energy carriers

Of all the energy carriers used by this company, oil was the most expensive every month. It can therefore be assumed that even though oil is used every month, as little oil as possible is used. But when there are no other energy carriers to use, oil is added to the mix. Since oil is used throughout the year, it is likely that if an extra costumer were to be connected to the district heating system, more oil would be used to produce the extra heat that would be needed. The kWh cost for the extra costumer is shown in Figure 4-8.

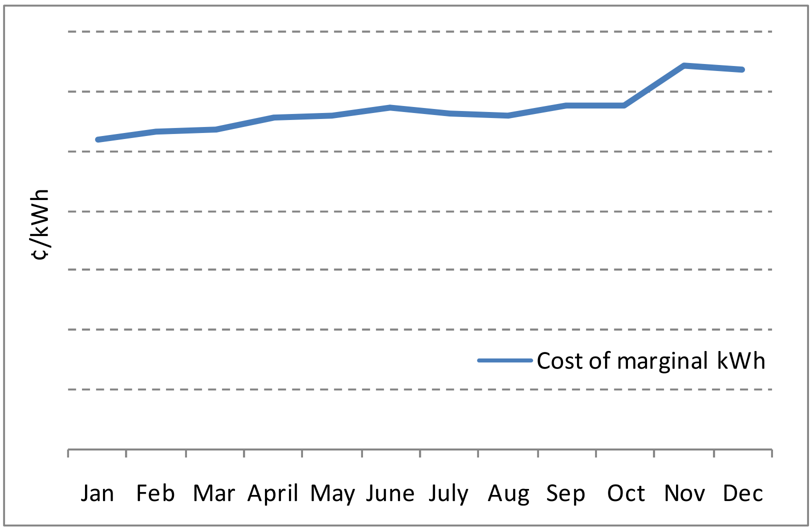

Figure 4-8 Cost per kWh for marginal production

5 Competitiveness of district heating in the future – a discussion based on Swedish conditions

Although district heating is valued as an environmentally friendly way of supplying heating, other solutions are competing for the same market. In all the Nordic countries, the main entrants seem to be heat pumps and local biomass fired production (i.e. pellet stoves). Solar heating is also attracting increased interest. Energy efficiency is high on the political agenda, and reduced demand for heat may influence the district heating business severely in the long term. All these aspects are discussed in the following chapters.

5.1 Rivaling heat solutions, and consequences for pricing

District heating is one of the alternatives that are available on the market for heating of buildings and for tap water. Other important alternatives on the Nordic heating markets are oil fired boiler, electric heating (both direct radiators and with water distributed heating), natural gas fired boiler and heat pumps (ground source, outdoor air or exhaust air).

For several decades district heating has been a competitive heating alternative in at least three of the four Nordic countries covered by the NEP project. Norway is in this respect the exception. Mainly due to an abundance of hydro power and low electricity prices the Norwegian heating market is dominated by electrical heating. In the rest of the countries however, district heating has been the dominating heating alternative in densely populated areas, especially for multifamily houses and for public and commercial buildings.

District heating has mainly taken market shares from heating based on individual oil boilers. The competitiveness of district heating can be explained by a number of factors, e.g. cogeneration providing high total efficiency, the possibility to utilize cheap but complex fuels providing low variable costs, and a flexible production that facilitates rapid adaptation to changing fuel costs.

In many respects district heating is still a competitive heating alternative, but competition from other alternatives is getting increasingly tough. At least in Sweden heat pumps and to some extent pellets boilers are the most competitive alternatives.

District heating is treated differently in the Nordic countries from a regulating point of view. In Norway and in Denmark a connection to district heating is mandatory in certain specified areas, whereas the choice is free in Finland and Sweden. The legislation also differs in other areas.

In this chapter we concentrate on the conditions applicable in Sweden. This means that the competition between different energy carriers and energy conversion alternatives is mainly decided by the economic considerations and not regulation of the heating market.

In this introductory study we focus on district heating, and analyze the competition from other heating alternatives. We have identified four principal cases for a specific building, seen from the district heating perspective:

1. Existing district heating, conversion of the total heating demand to another energy carrier and another energy conversion alternative
2. Existing district heating, conversion of a fraction of the heating demand to another energy carrier and another energy conversion alternative
3. Presently heated by another energy carrier and another energy conversion alternative, conversion to district heating
4. New building, all alternatives starting from scratch, district heating is one of the options.

In chapter 1.4 we discuss the effects of increased energy efficiency on the demand for district heating. Therefore this issue is not considered in this chapter.

The most important factor deciding the competition between the heating alternatives is the total cost for heating, present and future. Other factors influencing the competitiveness could be how easy or difficult operation of the heating alternative is, how space consuming the equipment is, and how the alternative is generally viewed by the user, e.g. environmental aspects, the risk of being in the hands of one supplier (district heating).

One factor that also influences the competition between district heating and other heating alternatives is how the district heating price is designed, e.g. the mix between variable and fixed parts, and possible price differences between seasons. The price structure is especially important for the competitiveness of district heating in buildings that are already connected to district heating.

In the sections below we briefly discuss the competition between district heating and other heating alternatives for different principal cases, as described above.

5.2 Existing district heating, conversion of the total heating demand

In buildings already connected to district heating, the economic competition between the existing heating and other heating alternatives is decided by the comparison of the total district h eating price and the total cost including investments for the other alternatives. In this case, the district heating price structure is of limited importance, i.e. the balance between variable and fixed price elements and differentiated variable price during different seasons is of limited or no importance.

It is not at all common to convert from district heating to another heating alternative. If you get district heating you keep it. However, in Sweden we have recently seen examples of district heating customers who are disappointed with the district heating price, and who have taken the drastic step to convert to another heating alternative, e.g. ground heat pump.

Heat pumps and pellets boiler are examples of heating alternatives which in many cases are economically competitive compared to district heating. The competitiveness of district heating depends on which district heating system we look at and how high the local costs are for the alternatives, e.g. for drilling holes for a ground heat pump. In Sweden, the district heating price varies considerably between different systems. As presented in a report from Swedish Energy Markets Inspectorate, the most expensive district heating supplier has a price that is twice as high as the supplier with the lowest price[9].

In the same report a figure showing the total cost for supplying a multifamily house with heating is presented. The cost for the heat pump alternative is illustrated by a low and a high cost, while the cost for the district heating alternative depends on the price in different systems.

[9] Energimarknadsinspektionen, Uppvärmning i Sverige 2008, Eskilstuna, June 2008

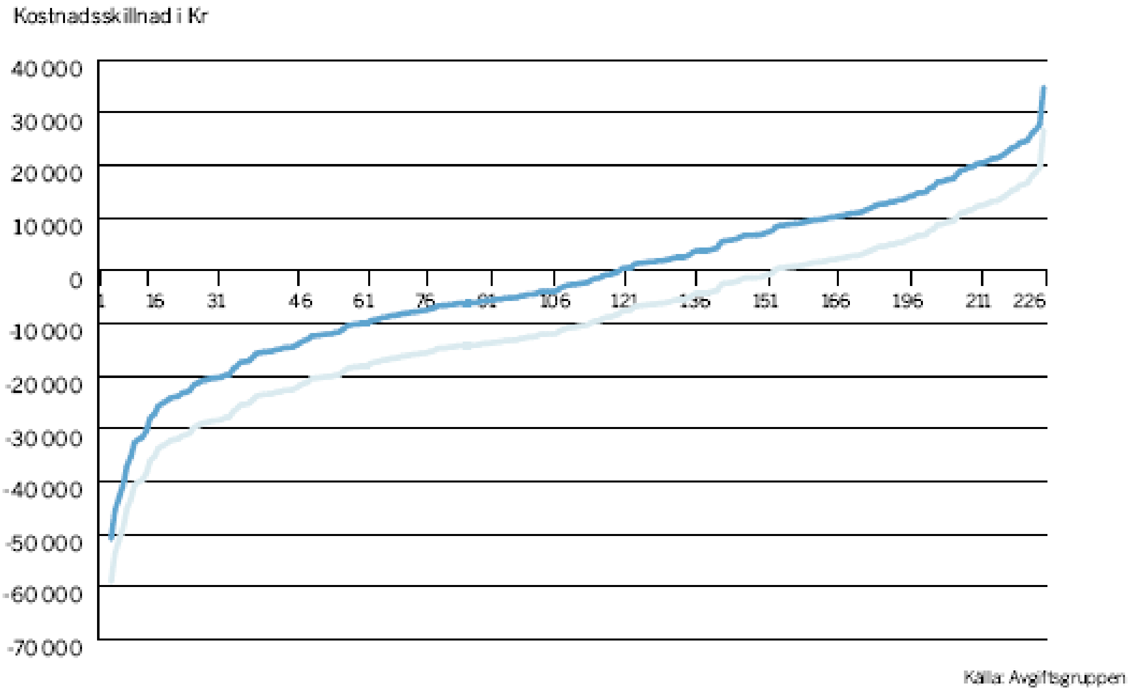

Figure 5-1 Cost difference between district heating and ground heat pump for a multi family house (193 MWh/yr) [SEK/yr].

(On the x-axis different district heating systems are presented. The two curves indicate high and low cost for the heat pump alternative.)

A negative number in the figure indicates that district heating is less expensive compared to a heat pump (left part of the figure), while a positive number indicates that district heating is more expensive than the heat pump alternative (right part of the figure). The figure shows that heat pumps could compete successfully with district heating in a number of Swedish municipalities. Similar results can be found for pellets boiler and the general impression is the same if the situation for single family houses is analyzed. The results presented in Figure 5-1 are based on an assumed heat pump COP of 3 (yearly average). New heat pumps show better and better performance and if higher COP is assumed district heating will have even less favorable competitiveness.

The analysis shows that district heating has strong competition from heat pumps and pellets boilers. The possibility to abandon district heating and chose a different heating alternative will probably be evaluated by an increasing number of customers. For some district heating companies it will be necessary to do their very utmost to regain competitiveness.

5.3 Existing district heating, conversion of a fraction of the heating demand

District heating deliveries to existing customers are not only threatened by full conversion to other heating alternatives. There is also a threat that parts of the heating could be supplied by other heating alternatives, although the customer continues to use district heating as main (or complementing) heating source. There are a number of alternatives for partial conversion from district heating that can be considered, e.g. solar heating, heat pumps (exhaust air, air/air or air/water) and pellets stove. Energy savings in buildings is another measure that reduces the demand for district heating. This is discussed in Chapter 1.4.

The economics of partial conversion is not only decided by the total price for district heating. Since the additional heating alternatives have various “heating profiles” over the year, the balance between variable and fixed price elements and differentiated variable price during different seasons are important.

The importance of the price structure could be illustrated by a principle example. The example consists of a multi family house with a yearly heating demand of 193 MWh and a typical load duration curve. (This building size is often referred to in Swedish price statistics.) Here we assume that base load up to 10 % of the capacity is converted to another heating alternative, Figure 5-2.

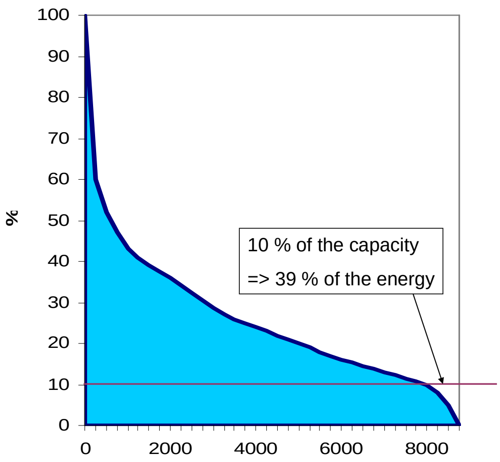

Figure 5-2 Load duration curve for heating. ***10 % of the capacity is indicated***

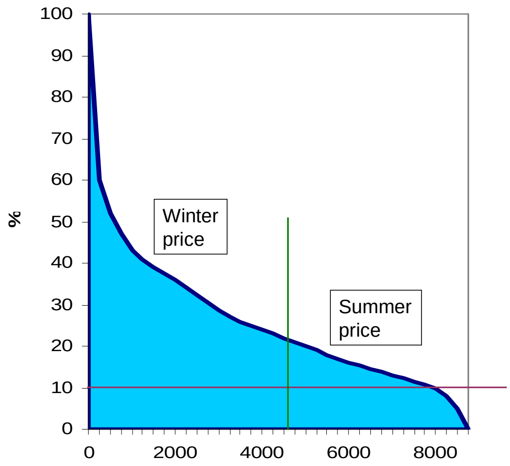

Figure 5-3 Load duration curve for heating. ***Two price seasons are indicated***

10 % of the capacity corresponds here to 39 % of the heating energy, which means 75 MWh/yr. Depending on how the district heating price is designed the reduction of cost related to the district heating delivery varies. Here we analyze four different district heating price alternatives that on a yearly basis give the same total cost for the full district heating delivery of 193 MWh/yr.

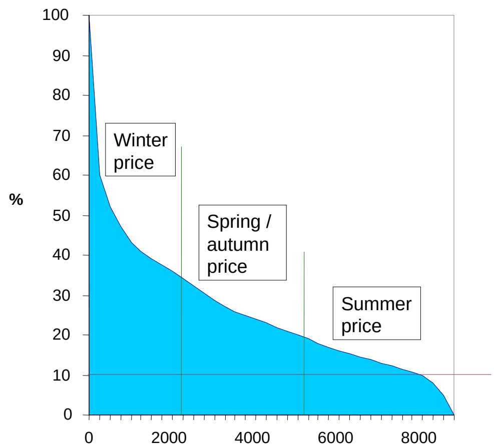

Figure 5-4 Load duration curve for heating. ***Three price seasons are indicated***

The price alternatives are:

- 100 % variable price (100 % related to the energy delivery), no price differentiation for different seasons. The price is 530 SEK/MWh, excl. VAT

- 70 % variable price and 30 % fixed price[10], no price differentiation for different seasons. The variable price is 370 SEK/MWh.
- 70 % variable price and 30 % fixed price, price differentiation for two different seasons, figure 3. The variable prices are: winter = 410 SEK/MWh and summer = 240 SEK/MWh.
- 70 % variable price and 30 % fixed price, price differentiation for three different seasons, figure 4. The variable prices are: winter = 580 SEK/MWh, Spring/autumn = 290 SEK/MWh and summer = 100 SEK/MWh.

The seasonal prices presented in the third alternative above are chosen to illustrate typical Swedish differences between winter and summer prices (for those companies that use seasons differentiated prices), as briefly discussed in chapter 2 above, "District heating prices in Sweden – fixed or variable?" [11]. The seasons' price levels are also chosen to give energy weighted average price of 370 SEK/MWh. The winter season is here 6,5 months and the rest of the year is summer season.

The seasonal prices presented in the fourth alternative above are chosen to illustrate typical Swedish differences in marginal district heating production costs for different seasons, as presented in chapter 2.1 above, "District heating prices – fixed or variable?". The seasons' price levels are also chosen to give energy weighted average price of 370 SEK/MWh. The winter season is three months, the spring/autumn four months and the summer season is, consequently, five months.

As mentioned above the four price alternatives results in exactly the same yearly total cost for the heating of the chosen building through district heating (193 MWh/yr). However, the price alternatives lead to different economic consequences if, as discussed above, the base load up to 10 % of the heat capacity is converted to another heating alternative, Figure 5-2. (In this example we do not pay any attention to the cost of this alternative heating, as the cost is here assumed to be the same regardless of which district heating price model is applied.)

How much does the income from the district heating delivery to the chosen building decrease when 37 % of the base load energy is supplied by another heating alternative? Calculations based on the prices described above give the following results:

- **100 % variable price**: 530 x 75 = 40 000 SEK/yr
- **70 % variable price**: 370 x 75 = 28 000 SEK/yr
- **70 % variable price, two seasons differentiated**: 410 x 39 + 240 x 36 = 25 000 SEK/yr
- **70 % variable price, three seasons differentiated**: 580 x 19 + 290 x 26 + 100 x 30 = 22 000 SEK/yr

The calculations show the consequences of the different price structures. If a 100 % variable price is applied, the consumer can save 40 000 SEK/yr in district heating costs by switching the base load from district heating to another heating alternative. If instead a three seasons differentiated price with 70 % variable share is applied the consumer only saves 22 000 SEK/yr. This is a clear indication that the price structure really matters.

If we assume that the fourth price alternative (70 % variable price, three seasons differentiated) is cost-correct (see discussion in chapter 2.1), the income for the district heating company decreases by 22 000 SEK yearly and production costs decrease by the same amount. If a 100 % variable price is applied the production costs still decrease by 22 000 SEK yearly, but the district heating company's income drops by 40 000 SEK. If a large number of customers do the same thing the scale of the

---

[10] We assume that this fixed price is not changed if 10 % of the capacity is supplied from another heating source. In our example this could correspond to a genuinely fixed price, or a capacity related price where the customer choose to stay with the 100 % capacity from district heating (need for back-up for the complementing heat supply).

[11] Folkesson T., EKAN Gruppen, 2006, Statistikprojektet En studie i fjärrvärmepriser, 2006-01-30

economic consequences can be much greater. The results thus clearly indicate that certain price structures may be harmful for the district heating company's economic result.

In the example we have assumed a partial alternative heating with a constant production profile over the year. If we assume solar heating the centre of gravity of the heat production is moved more towards the summer season. If a 100 % variable district heating price would be applied in such a case the problem discussed above would be even more severe.

The profitability of heat savings is also affected significantly by the district heating price structure. Reduced heating demand as a result of measures to improve energy efficiency in buildings is discussed in chapter 1.4.

5.4 Presently heated by another heating alternative, conversion to district heating

District heating is in most cases still a clearly competitive alternative for heating conversion from e.g. oil fired boiler or electric boiler. The competitiveness is indicated by Figure 5-5[12]. The figure shows the typical situation for a multifamily house, but the situation is similar for single family houses.

The competitiveness indicates that district heating may continue to take market share. However, the most attractive areas (= the most energy dense areas) are typically already connected to district heating. Less and less energy dense areas will then be considered for district heating and the potential additional market becomes smaller.

When considering conversion to district heating from another heating alternative, the economic competition between the existing and new heating alternatives is decided by the comparison of the total district heating price plus investment costs and the variable or total cost for the other alternatives (depending on if the existing heating equipment needs reinvestments or not). In this case the district heating price structure is of limited importance, i.e. the balance between variable and fixed price elements and differentiated variable price during different seasons is of limited or no importance.

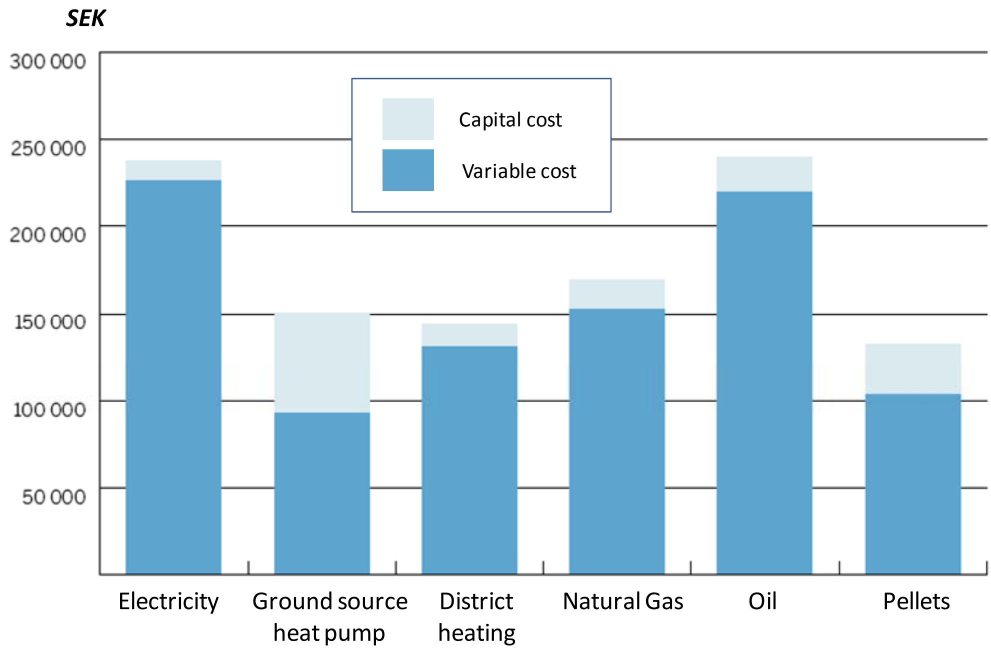

Figure 5-5 Average heating costs for multifamily houses, divided on capital and variable costs

[12] Energimarknadsinspektionen, Uppvärmning i Sverige 2008, Eskilstuna, June 2008

5.5 New building, all alternatives starting from scratch, district heating is one of the options.

For new buildings all heating alternatives are evaluated based on their total costs. In this case the district heating price structure may be of limited importance. However, when evaluating different levels of insulation, heat recovery alternatives, solar heating, etc. the district heating price structure, i.e. the balance between variable and fixed price elements and differentiated variable price during different seasons, influences the evaluation. With price structure is here meant i.e. the balance between variable and fixed price elements and differentiated variable price during different seasons.

6 Regulation

In this intermediate report, regulation is just briefly described. The topic will be more extensively treated in the final report.

6.1 Introduction

The choice of instruments for regulation depends on a lot of factors – including the type of business, the competitive situation and which part of the life cycle the business is in. Thus, the discussions in chapter 1.3 concerning the differences in the Nordic countries are relevant here.

As illustrated in Figure 6-1, the measures to apply differ according to the life cycle. To assist new technology/solutions in the emerging phase, R&D and technology subsidies are applied. In the growth phase, special niche market policies may be developed, while technology that has reached maturity may be regulated more traditionally according to competition policy, monopoly regulation, third party access etc.

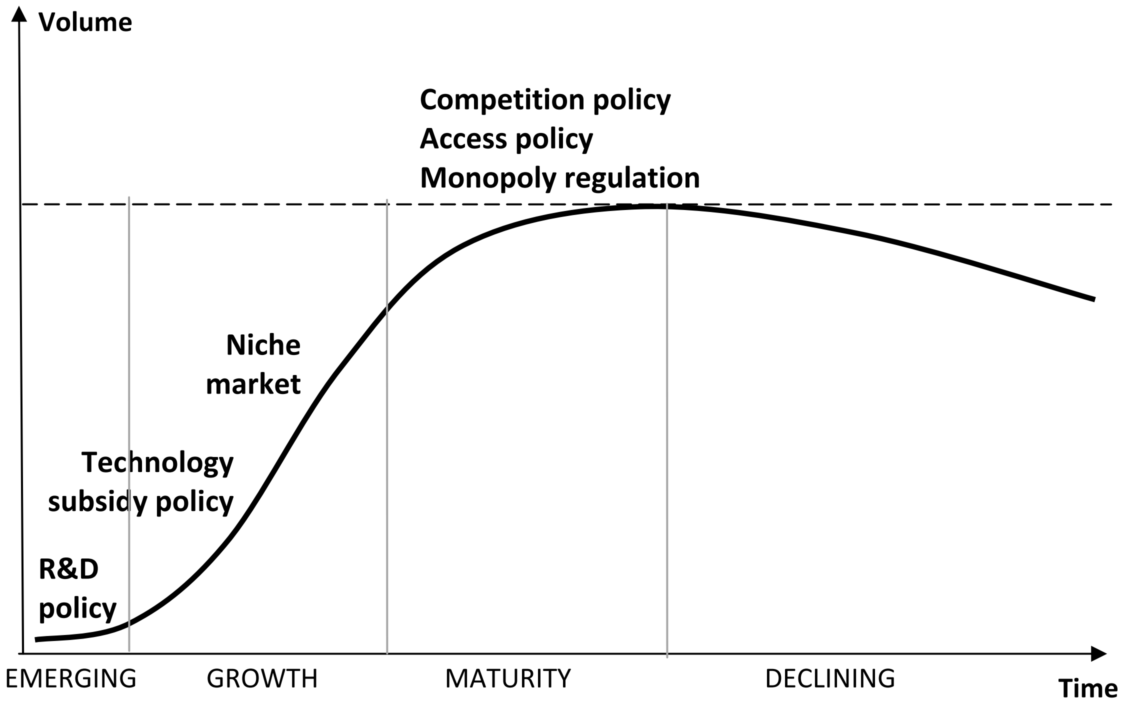

Figure 6-1 Possible public measures in the life cycle

6.2 Status

Even if district heating in itself is a fairly homogeneous product, the historical development, fuel choice, ownership, regulation and competition varies substantially between the Nordic countries. This results in deviating district heating prices, as indicated in Figure 6-2.

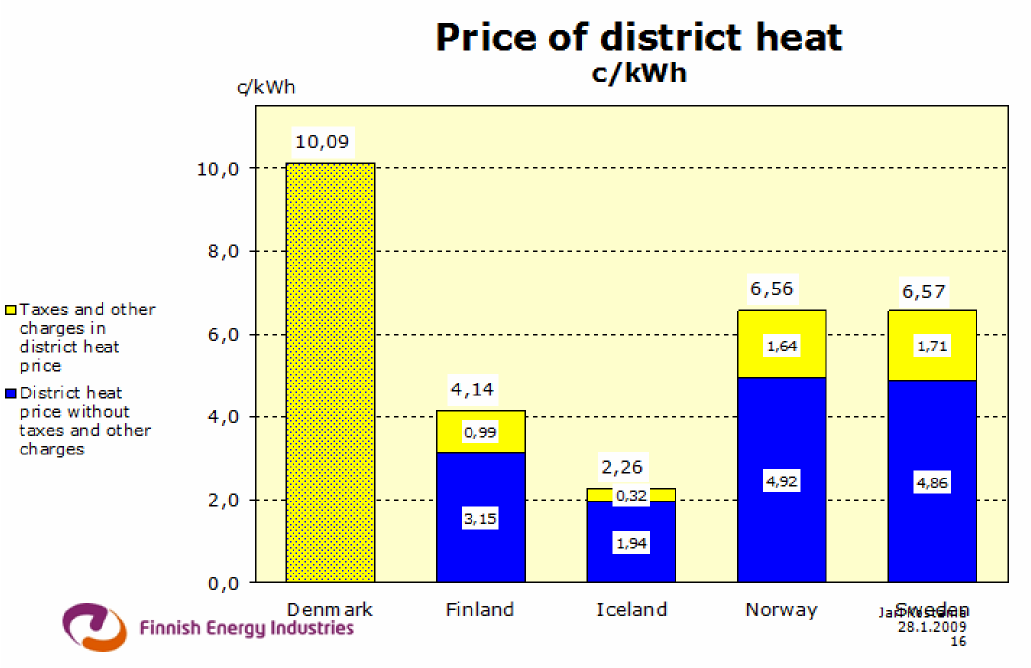

Figure 6-2 Prices of DH in the Nordic countries (source: FEI 2009)

Even more remarkable is the difference in electricity price, mainly due to differences in taxation, as illustrated in Figure 6-3. Due to the obvious divergence in the price for district heating in Denmark in Figure 6-2 and Figure 6-3, this topic will be further investigated in the final report.

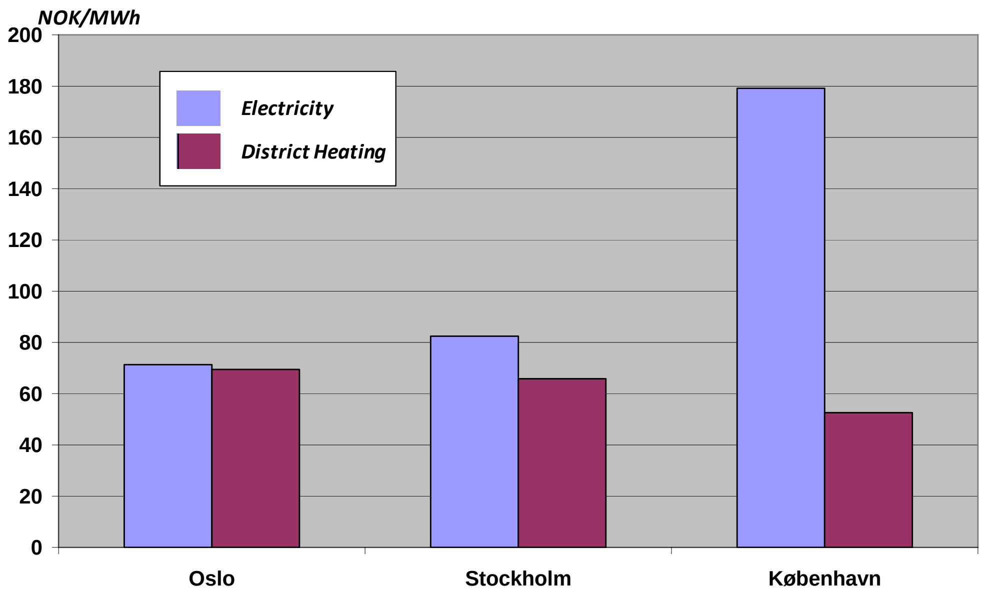

Figure 6-3 District heating prices compared to electricity prices, per 1.9.08 (Fortum Fjernvarme AS)

6.2.1 Sweden

In 2002, Swedish authorities initiated the biggest study of the district heating market in Swedish history. The study was based on customers' dissatisfaction, and it was to look at customer protection and price regulation among other topics. The study concluded with a need for more customer protection, more openness among the actors and clearer rules in the district heating market.

Several of the results from the study are incorporated into the new Swedish district heating legislation of July 2008. The law is designed to improve the customers' rights and confidence of the producers, making district heating the most customer friendly heating option in Sweden. The district heat companies are instructed in the law to negotiate the price and other terms of delivery with the costumers when requested by the costumers. If the parties are unable to find an agreement, they can have the authorities arbitrate for them. The owners of piping are instructed in the new law to always negotiate with other suppliers that want to deliver heat into the pipes, although they do not have to let anybody else use their pipes. This causes more administration and more costs for the suppliers, and may therefore lower the competitiveness of district heating somewhat compared to other solutions for space heating.

There are some complications with the new law; for one thing it overlaps with some other laws making it unclear what regulations are to be followed. There problems are expected to be solved in the upcoming secondary laws. In some areas in Sweden, the price of district heating has increased by almost 50 % over the last five years. But the new law does not include price control. However, as a national average district heating prices have increased by "only" 22 % during the last five years (see also Figure 1-4 above).

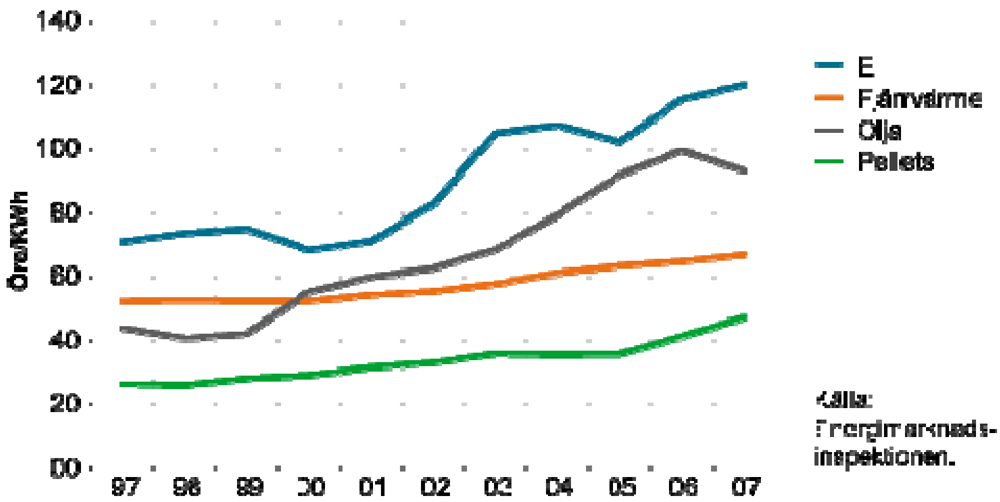

Figure 6-4 Price for heating in Sweden

6.2.2 Denmark

The district heating market in Denmark is regulated by the law on heat distribution. It says that district heat providers can charge the customers enough to cover their expenses for producing and distributing the heat. The Minister for transportation and energy can establish a general revenue ceiling for a number of years. The Danish Energy Regulatory Authority establishes specific revenue ceilings for each district heat company each year. The Minister can also lay down rules for splitting the cost between electricity and heat production in CHP plants.

The district heat providers are allowed to charge different prices from different customers. And whenever it is technically possible, each customer shall have their own gauge and pay according to their own use, even if they are a part of a bigger building.

Danish municipalities are free to instruct building owners in the whole or part of the municipality to connect to the district heat distributing system. This means that the district heat provider can charge connection fee or a yearly fee, but the building owners cannot be instructed to buy district heat. Both new and existing buildings can be instructed to connect, but existing buildings get a nine year delay. Buildings that are to undergo a renovation during those nine years can be instructed to connect earlier. Owners can also be instructed to keep their buildings connected to the district heat system.

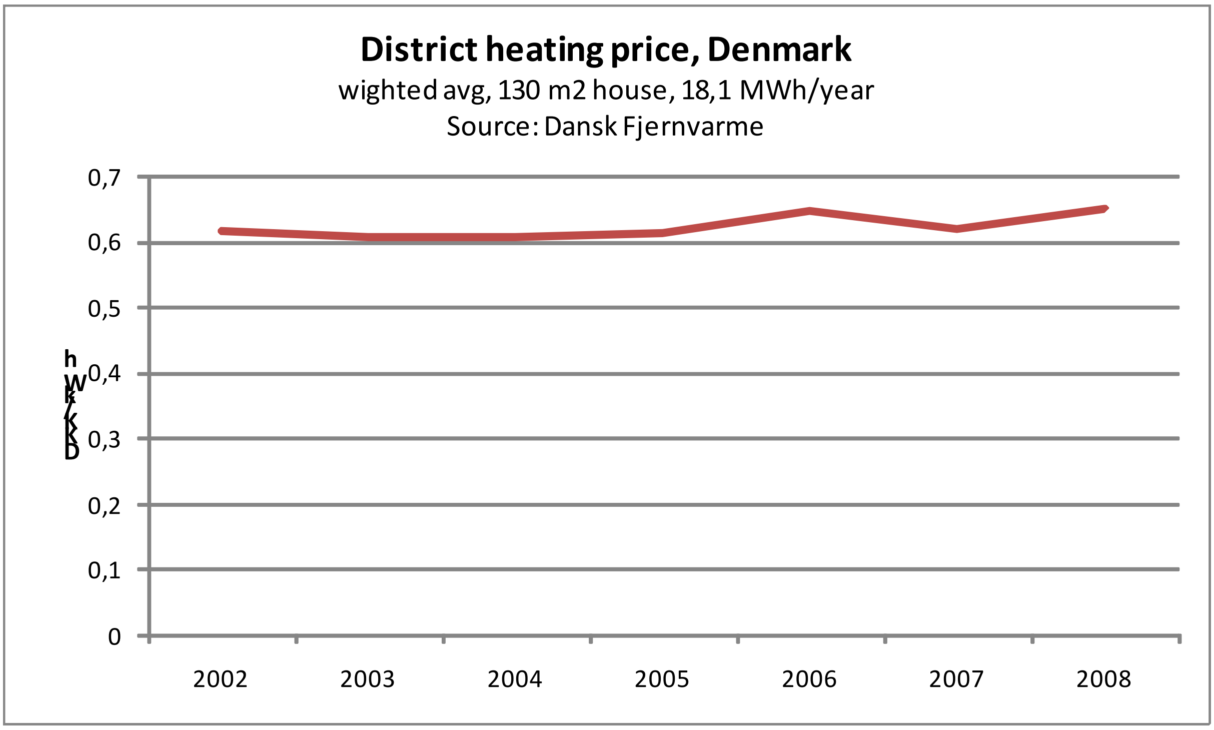

Figure 6-5 District heating prices, Denmark

6.2.3 Finland

The Finnish energy marked is regulated by the Energy Market Authority. Finland is one of the least regulated energy markets in the world, with much flexibility for the energy companies to set their own tariff structures.

The district heat companies in Finland are operated on business economic principles. The price has to reflect the costs of district heat production, in addition to provide for a sufficient long-term development of district heat and allow for a profit. There are about 200 district heat companies in Finland and they all have their own tariff strategies, so the price can differ considerably between the different companies. Most of Finnish district heating companies are part of larger entities (traditional electricity utilities), typically owned by municipalities

There are no tariff regulations, but the price has to be equal for same kind of costumers (residential, industrial, public). The tariffs consist of three elements: connection charge, which is a non-recurrent fee, fixed charge, which depends on the size of the costumer, and the energy charge which is per kWh used. District heating companies are supervised by general legislation like competition and consumer protection legislation, and related authorities.

The Finnish Competition Authority interprets the legislation to state that district heating companies are considered to be in so-called dominant market position towards their customers. Competition legislation prohibits the misuse of the dominant market position. Some requirements for a DH company that is in a dominant market position are: Price level of DH may not be excessive, price setting has to be sufficiently cost related and transparent, it is not allowed to catch customers with a too favorable (dumping) product, same kind of customers must be treated in a same way, if different products (heat, steam, electricity etc.) are delivered to the same customer the product prices may not be artificially bound to each other and extra services, which are under competition, must be priced according their costs.

In 2006, a study on official supervision of district heating was carried out. Targets of the study were: Evaluation of the competitive position of a heating customer connected to a DH network (main target), evaluation of existing supervision of DH and possible amendments to supervision, evaluation of the possibilities of cross-subsidization between DH and electricity and measures to avoid cross-subsidization and evaluation to increase competition by opening the DH networks for competition (capital area). The conclusion from the Ministry of Trade and Industry was that there is no need for action. There is no need for DH specific legislation, no need for changing the current official supervision and roles of different authorities, no cost-effective basis for opening the DH networks and no problems with the price level of DH. The stability of DH prices has been very good, and security of supply is 99,98 %. However, the transparency of DH activities should be increased. In energy companies DH activity should be numerically differentiated from other business, that is separate balance sheets and profit and loss accounts should be published. Another recommendation was to have public comparisons of DH prices.

6.2.4 Norway

Mandatory district heating concession

District heat providers in Norway need a license from the energy regulator if the plant is larger than 10 MW and they are delivering to external customers. Smaller plants can also get the license voluntarily. The municipality can pass a by-law that says that all new and rehabilitated buildings inside the area of the license have to connect to the district heating facility and be adjusted to district heat usage, although they are not obliged to use the district heat.

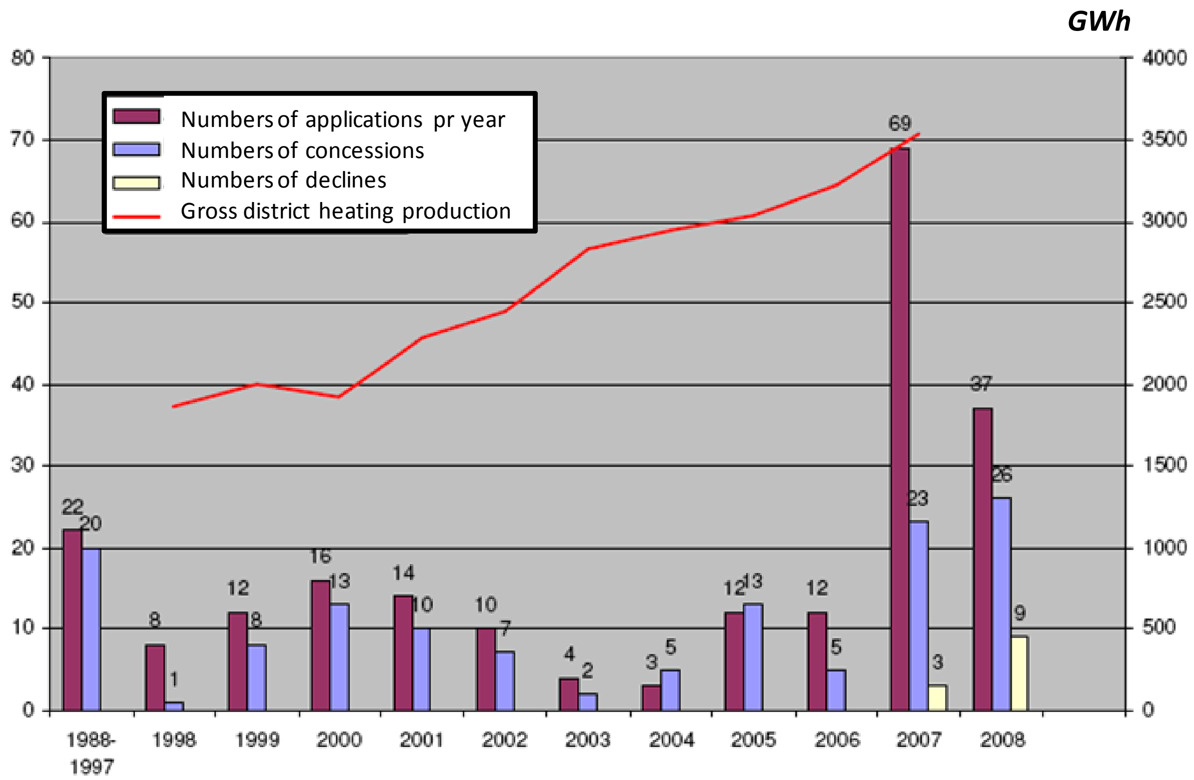

Figure 6-6 Number of licenses, Norway (Source: NVE)

As the district heating business in Norway is still in steep growth, and the financial incentives are sufficiently good, the competition for the most attractive locations is fierce. No specific rules to who should have priority to local concessions existed, and until 2006 the "first come – first served" was applied. In 2007-2008, the interest for new district heating plants increased dramatically (see Figure 6-6) due to new support schemes for DH (Enova), and the concession authority (NVE) had to develop criteria for prioritizing between competing supplicants. The major criterion is efficient resource allocation, including minimized environmental impact, low cost (economy of scale) and high security of supply. A major problem for both the authorities and the energy companies are the delays in the concession process, and the uncertainty of the outcome, which results in delays in implementation of district heating in Norway.

Price regulation

The Energy act states that the price of district heat cannot be higher than the electricity price, thus the electricity price is the price cap. Due to the fact that a substantial part of the customers have their own local oil boilers (existing buildings), the district heating price also has to be lower than the cost of local oil fired heat. This is illustrated in Figure 6-7.

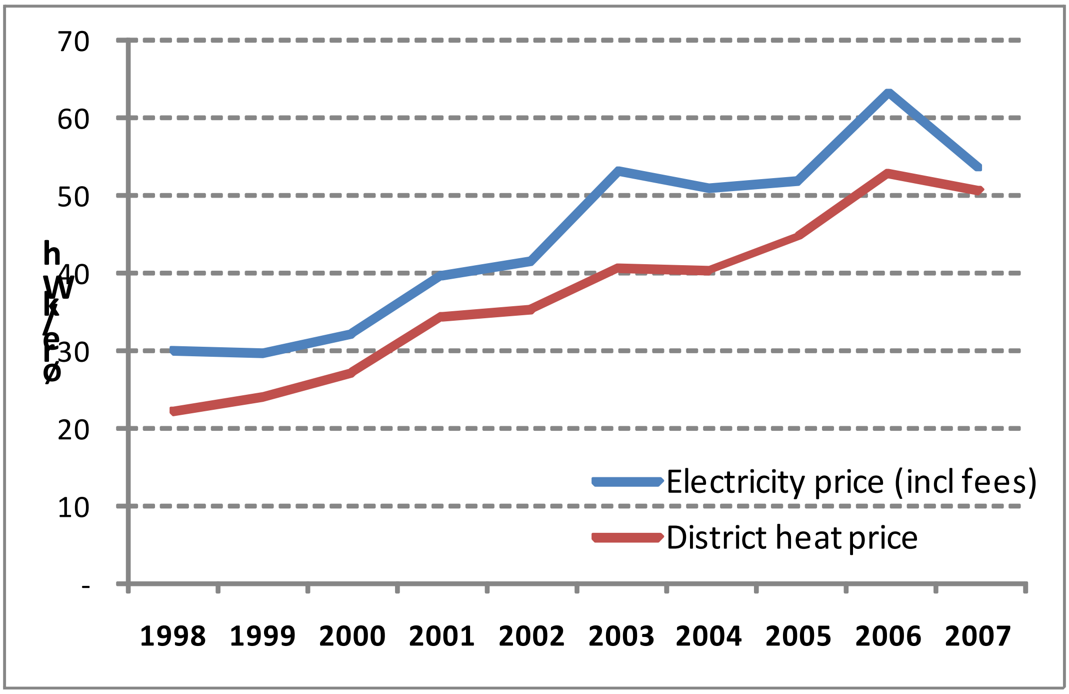

Figure 6-7 Norway: Development in price of electricity and district heat

7 References

Andersson S. och Werner S., FVB, 2005, Fjärrvärme i Sverige 2003, En analys av råvarukostnader, ägande, jämställdhet, priser och lönsamhet i svenska fjärrvärmeföretag, 2005-05-09

Byggforskningsrådet, 1996, The Energy Book – a resume of present knowledge and research

EEX, 2007, www.eex.com/en/download

Energimyndigheten, 2006, Energy in Sweden – facts and figures 2006, ET 2006:44

Energimyndigheten, 2007, Prisblad för biobränslen, torv m.m. Nr 2 / 2007

FEI 2009. Do We Need Regulation For District Heating? Powerpoint presentation held by Jari Kostama of Finnish Energy Industries (FEI) 29.1.2009. Unpublished.

Folkesson T., EKAN Gruppen, 2006, Statistikprojektet En studie i fjärrvärmepriser,

2006-01-30

Länsstyrelsen i Västra Götalands län, 2007, Miljömål för Västra Götalands län, nya och ändrade miljömål, förslag på åtgärder, Remiss april 2007, Rapport 2007:21

Motiva, 2008. Motiva calculation tool for comparison of heating systems in standardized detached houses. Available: http://lammitysjarjestelmat.hosting.ambientia.fi/tyyppitalovertailu.php

Skatteverket, 2007, www.skatteverket.se/skatter/punktskatter

Svensk Fjärrvärme, 2007, Swedish District Heating Association's preliminary statistics for 2005, Excel file dated 2007-05-02

Svensk Fjärrvärme, 2007, Swedish District Heating Association's statistics for 2006 and (preliminary) 2007, Excel file delivered to Profu in December 2008