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Costumer Perspectives on District Heating Price Models

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ABSTRACT

In Sweden there has been a move towards more cost reflective price models for district heating in order to reduce economic risks that comes with variable heat demand and high shares of fixed assets. The keywords in the new price models are higher shares of fixed cost, seasonal energy prices and charging for capacity. Also components that are meant to serve as incentives to affect behaviour are introduced, for example peak load components and flow components. In this study customer responses to these more complex price models have been investigated through focus group interviews and through interviews with companies that have changed their price models. The results show that several important customer requirements are suffering with the new price models. The most important ones are when energy savings do not provide financial savings, when costs are hard to predict and are perceived to be out of control.

Keywords:

District heating;
Price models;
Customer preferences;
Cost reflective;

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1. Introduction

Within the framework of the district heating business, district heating (DH) must have a price in the heating market that is competitive and that also give the supplier a desired return on investment in the DH system.

In Sweden there are no regulations regarding the pricing of DH [1]. This means that each and every DH supplier determines how their price models should look like to different customer groups as well as the actual cost level. Different ways to control the DH price has been discussed in various contexts, and the Swedish Competition Authority has argued that a price regulation should be imposed on DH [1]. The DH industry on the other hand wish to strengthen the customers' position on the heat market through increased transparency and self-regulation [2, 3].

Recent studies on the design of DH price models [7, 8, 9, 10, 11, 13, 14, 16, 28, 29] bring up many important considerations on price model design in respect to the financial challenges for the DH business like for example competitiveness with alternative heating solutions, the challenges of weather dependency and low capacity factor, the need for improvements in system efficiency, as well as the challenges associated with a declining heat market.

Although competitiveness on the heat market and system efficiency indeed are important matters to consider when deciding the price models for the DH industry, and for society at large since DH can play an important role as a cost effective way to decarbonize the future energy system [4, 5], it is evident that these studies holds on to a techno-economic system perspective on DH price model design with the goal to reduce the financial risks of the DH supplier. The customer is treated as system component, but not as an actor with its own needs, preferences and world view. Questions can be raised regarding the customer benefits of the new price models and whether the DH industry can expect the customers to take on a system perspective when paying for the commodity of heat.

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Most recent studies about price models for DH that we have found in scientific journals are actually Swedish studies. Maybe this is not surprising since this has been a topical issue in Sweden for some years now where many DH companies have started to review their price models. At the same time customer confidence in DH has been questioned in Sweden. The debate has concerned pricing, the owners' high requirements on return of investments, the lack of customer service and responsiveness to the customers' situation [6]. Given these circumstances, we have found it interesting to conduct a study were the customer perspective on those new DH price models is investigated.

1.1. Aim of study

The aim of this study is to investigate how Swedish customers perceive the more complex price models which are now starting to take hold in the Swedish DH sector. Questions like the benefits for the customers, if the price models seems fair, how easy the price models are to understand and to use in calculations of energy efficiency measures, how important it is for the customers to have options to choose between in the price model and how a good price model for DH would look like from a customer perspective are investigated in this study.

In order to study customer preferences we have worked together with three DH companies in Sweden that all had made recent changes in their price models: Södertörn Fjärrvärme AB in Södertälje, Öresundskraft AB in Helsingborg and Sala-Heby Energi AB in Sala. The three companies all had different price model strategies and different reasons for changing their price models. Six focus group interviews with customers to the three companies were carried out as well as several interviews with company staff in order to understand customer responses and preferences to different components in the price models, strategic decisions behind the price model design, and experiences of the process of changing price models.

To give the reader a background of recent studies' advices on the design of DH price models as well as on components used in the models, a background of this is given in the next section (Section 2).

2. Components in the DH price models in Sweden

In a country like Sweden with large temperature differences between the seasons the production costs for DH is usually characterized by cheap summer production and expensive winter production. The fixed assets in terms of large production plants and DH networks implies large capital costs for the DH utilities.

Previous Swedish studies about DH pricing have indicated that the price models do not seem to reflect the underlying cost structure of production and distribution of DH to a satisfying extent [7, 8, 9].Two primary problems have been emphasized associated with this situation. Firstly: not having a cost reflecting price model implies an increased financial risk, as the revenues from heat sales may not reflect the actual costs. Secondly: price models that do not reflect the actual cost structure from production and distribution means that customers can make energy efficiency measures or investments that are contra productive to system efficiency as the customers do not get enough incentives to follow system costs.

In Song et al [8] 237 pricing schemes were collected and classified at 80 Swedish DH companies in four different price model components. The yearly heat production from these 80 companies accounted for the major part (85%) of the total heat production from DH in Sweden. The study was made in 2015 and the components proportion of the total price to the customer was calculated for a typical multifamily house with a yearly heat consumption of 193 MWh, see Figure 1. The grey bars shows the share of the cost for energy demand components (ECD) in the schemes. The orange bars stands for the share that comes from a load demand component (LDC). The yellow bars shows the share that come from a flow demand component (FDC). The lowest share of the costs, the black bars, constitutes the share from the fixed component within the schemes (FxC). As can be seen in Figure 1, the energy demand component constitutes the largest part of the cost in the price model in most schemes.

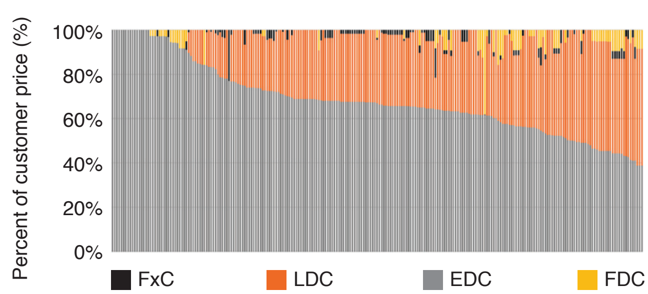

Figure 1: Proportion of price components in cost calculation of template building upon 237 pricing schemes as presented in Song et al [8]

According to the same study, 63% of the investigated pricing schemes used a constant energy price throughout the year. The fixed fee used in many companies only covered administration costs for meter-reading and billing. Some kind of load demand component was used in the majority of the schemes, although the most commonly used type of LDC was based on an engineering approximation (the category number method) which, according to the authors, does not provide sufficient incitement for operation optimization. A flow demand component was used in a third of the investigated pricing schemes [8].

The conclusions that the authors make in the study is that most pricing models used today do not take into account customers' consumption patterns and heat production costs for the heat. This, the authors argue, does not encourage customers to respond to the needs of the system and exposes the district heating suppliers to financial risk.

2.1. Energy demand component

In a deregulated DH market, the pricing method based on marginal cost is commonly used to determine the price of DH [10, 11]. The heat demand for space heating and thus the revenue from sales of heat is highly weather dependent. Only the demand for hot tap water preparation is fairly constant over the year [12]. Due to weather dependency the demand and heat sales can vary very much within the same day, between seasons or between the same season different years.

In larger DH systems different production plants will be used to supply the different levels of energy demand and the plants with the highest operational cost will be started only when there is no capacity left in the ones with lower operational cost. Hence, the marginal cost– defined as the cost to produce the last unit – will be defined by the plant with the highest operational cost running [10].

By reflecting the marginal cost in the price model to the customers, the price for energy will be higher in winter time when the demand is large and lower in the summer when there is only use for hot water preparation and not for space heating. In Stridsman et al [7] the authors proposed that the marginal production cost could be broken down into three seasons instead of monthly price levels in an attempt to make the price model simpler to understand. They also proposed that the summer prices could be pressed to a very low level, if this reflects the actual case of low marginal costs for heat in the summer period. Figure 2 shows an example of how the marginal production costs might look like over a year and how the energy demand component can be set at three levels.

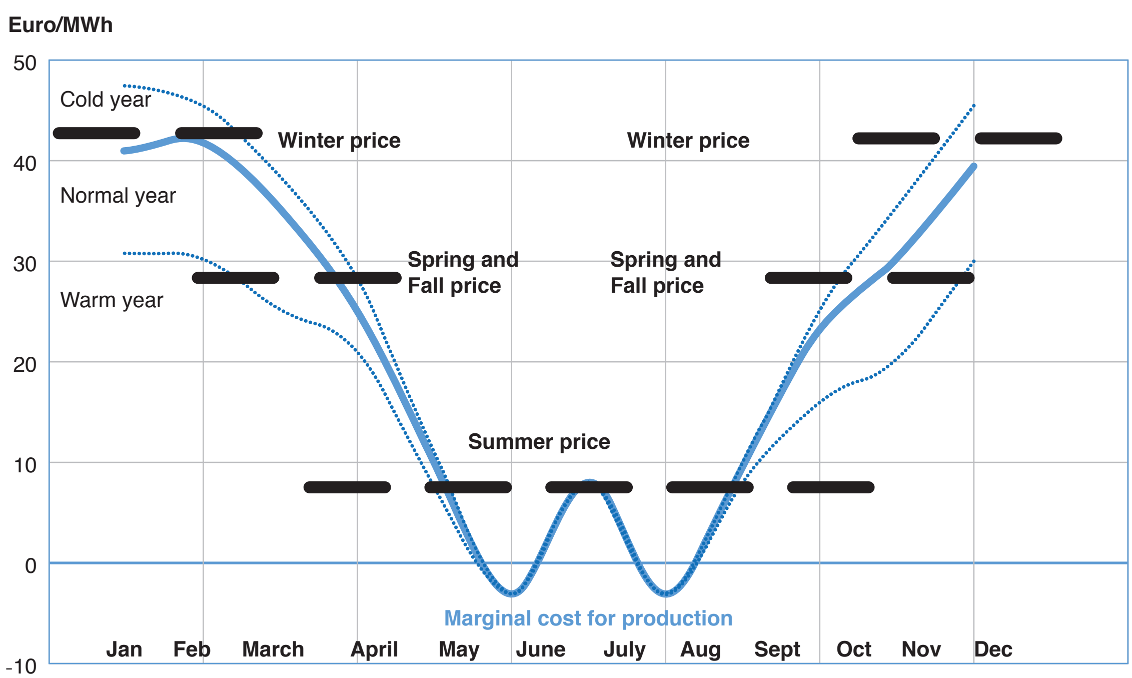

Figure 2: Marginal cost of DH production and seasonal pricing [7] (the text in the figure has been translated from Swedish and the cost per MWh has been converted from SEK to EUR)

Using a price model based on marginal production cost can also be a strategy to prevent customers from investing in partial conversions to other heating systems (such as heat pumps and solar heating systems) used together with DH, since this erase the economic incentives to make such installations. This has been shown for example in Rolfsman & Gustafsson [13].

2.2. Share of fixed and variable components in the price model

A way to reduce financial risks in the price model is to have one fixed component for example based on an annual fee per installed kW or per year and one variable component in the DH price model [14]. A high share of fixed cost in the price model means that the company's revenue will become less dependent on changes in heat demand [15].

In Stridsman et al [7], the authors raised the issue that the Swedish DH companies generally have a too high share of variable energy price in their price models. Such pricing schemes will, according to the authors lead to a too high incentive for customers to improve energy efficiency, and the customers' cost reduction when making energy efficiency measures will be greater than the cost reductions that are made from a system perspective. Stridsman et al argues that the situation with a high share of variable costs could lead to an untenable situation for the DH companies pointing at the risk of undermining the profitability of the DH companies or on the risk of having to raise the price level of DH to the customers if the costumers energy demand decrease. A good starting point for deciding the level of the variable energy price, according to the authors, would be to use variable marginal production cost for production together with the costs for distribution heat losses [7].

Also other studies of pricing of district heating found good cause not to have a too high share of variable price in the price model [8, 16], where the stricter requirements in the national building regulations on specific energy consumption per square meter was seen as risk factor, that ultimately leads to lower heating demands in the building stock. Also future changes to a warmer climate [17] together with energy retrofits in the existing building stock [18, 19] might further exacerbate these risks.

2.3. Load demand component

The capacity utilisation, expressed as the load factor, is usually low for temperature dependent services like space heating and thus for DH. A low load factor means that the investment costs for the system will be shared by fewer product units and the product will be more expensive to produce [12]. If peak loads could be lowered in the DH system, this could lead to financial savings and environmental benefits as the use of expensive peak production - usually fossil-fired boilers - could be avoided [20].

Load demand components in the DH price model can serve different motives. Depending on how the component is designed, it could act as an incitement for costumers to lower their peak load demands [20]. Partial conversion to air heat pump represents a competitive disadvantage for the DH system [21], not only because of the loss of sales volume for DH, but mainly because of the unfavourable load pattern on cold days where the air heat pumps drops in efficiency and high sudden peaks for the DH system evolves. Introducing a load demand component in the price model may lower costumer interest in making partial conversions in alternative heating systems. Another motive to charge the customers for their use of capacity is to get a fairer distribution of the real costs associated with installed capacity in boilers and network among the customer collective. Several Swedish DH companies that recently changed their price models are referring to their new price models as more "fair" using seasonal pricing and load demand components in their price models [22, 23, 24, 25, 26 and 27].

The installations of remote meter readings have opened up for new possibilities to measure customer energy use on hourly bases which means that new ways to charge for load demand can be developed [28].

In the study of price models for DH in Sweden from 2015, five different pricing principles of charging for capacity were identified [8]:

- Estimate based on total consumption: The method is to use consumers' total consumption during a certain period of time, either during the previous year or the previous high peak period, to determine the load demand.
- The category number method, which is the most commonly used method in the Swedish DH companies, assign costumer consumption hours per year (alternatively per winter) to different costumer groups – typically 2200 hours/year for multi-family houses - and then divide the consumption of that period by the assigned consumption hours to calculate customers' load demand.

- Load signature method: This method use the correlation between customers' historical heat consumption and outdoor temperature to predict customer consumption at the extreme weather condition through simple linear regression.
- Measured peak method: Costumer peak load determines the level of the fee. The fee could be based either on the highest peak or a mean value of several high peaks.
- Subscribed/exceeded level method: The customer subscribe to a certain load level at which the customer will pay a relatively low variable price for energy. Once the subscribed load level is exceeded, the customer will pay a higher cost for the energy exceeding the level.

The authors concluded that the first three methods are merely engineering approximations that cannot provide sufficient incitement for operation optimization, while the last two methods can give reasonable incitements for customers to alter their consumption pattern.

Stridsman et al [7] proposed that the charge for capacity should be based on the highest peak measured at the customer, based on the daily energy usage divided by 24 (h). Basing the fee on the highest hourly peak was seen as unnecessary due to the inertia in production and the buffer effect in the distribution network, which means that there is no need to cover peak demand on one hour basis. The authors also suggested that a rolling over 12 month would be a good solution, meaning that the customers are charged for the highest average daily power peak for 12 month if the peak is not exceeded, then the new peak would set the new level for the fee.

2.4. Flow demand component

Using a flow demand component in the price model is a way for the DH companies to work with the cooling of the network. A decrease in return temperature - sometimes with the result that also the supply temperature can be lowered - can enhance the conditions for production units such as the use of flue gas condensation, heat pumps and industrial waste heat. Lower return temperatures also gives other system benefits like lower heat losses, reduced pump work and an increase in the capacity of the network [29].

There are basically two models for flow charges used by the Swedish DH companies. One model consists of a fixed price for each cubic meter of water passing substation, while the other model is designed as a bonus-malus system where DH customers with poor cooling will pay a fee which is in turn used to pay a bonus to customers with good cooling. For both models these fees can be charged either throughout the year or during the heating season only. In the summer months when the demand for heat is low, the supply temperature will vary in the network. The supply temperature in the outer areas far from the production plant can be several degrees lower than in the central areas. When flow rate is charged for throughout the year, customers in peripheral areas will be disadvantaged because the conditions for good cooling deteriorates at low incoming supply temperature. A few district heating companies have therefore introduced some form of correction factor to avoid disadvantaging between customer groups [29].

2.5 Conclusions from the literature review

The review above shows that earlier studies on how district heating price models should be designed focus on a techno-economic system perspective on district heating and on reducing the financial risks of the district heating supplier. The authors express logical arguments for changes in pricing models that can benefit the district heating suppliers. However, how these changes will affect the costumers are not discussed or considered. Questions can be raised regarding customer benefits, the fairness of the components in the price model, if the changes will lead to sustainability, how customers experience the complexness of the new models, and how it will affect customer choice and freedom of action.

3. Method

In order to investigate customer perspectives on the new price models a qualitative approach was chosen in this study. The reason for this was the character of the research issue. Not all DH customers are familiar with their price model - which components are included, how changes in customer energy consumption may affect the price, etc. We therefore saw a need to discuss these things with the customers, and to ask follow-up questions.

The study was carried out in cooperation with three Swedish DH companies that had recent experiences of changing their price models. Customer responses were investigated through six focus group interviews with customers from the three companies, two at each company - one with larger customers represented by large private or municipally owned real estate companies and one with smaller customers with representatives from housing associations, community associations and residential customers. The recruitment of participants were made through advertisement on the company web site and through calling customers from customer lists provided by the DH companies. The number of participants in the focus groups were between seven and eleven persons in each group. Totally more than 50 customers participated.

The focus group interviews took place at the DH companies head offices. The focus group interviews were led by a moderator. The discussion was recorded by a secretary. A few representatives from the companies were invited to sit in and listen to the interviews with clear instructions not to interrupt the discussion. The listeners were told to keep a very low profile. In the start of the focus group interview they got to say their name, but not giving any information about what position they had at the company or anything else. Only at the end of the interviews were the representatives given the possibility to ask questions to the customer group and to comment on what had been said in the interview. The former experience we have had from inviting listeners to focus group interviews has been positive. That someone who has an interest in the question is sitting in and listening intensifies the discussion according to our experiences. The presence of representatives from the energy company could perhaps prevent participants from speaking up their mind about negative attitudes to the company or to the things that the company do. From the responses in our interviews we did not have the impression that this was a large problem in any of the focus group interviews, since the customers expressed both criticism and scepticism to components in the price model, to things that the companies did in the process to change price model and to other concerns connected to the DH company.

Interviews were also made with personnel staff at the DH companies, both with strategic staff such as CEO, director of marketing, business development, etc. and with staff who worked more customer-oriented such as salespersons, customer service, service, etc. 16 persons were interviewed in total, five to six persons at each company. The interviews focused on investigating how the work with the design and the launching of the price model was implemented, and to get the representative's views on the customer response to the new price models. Interviews were conducted with one or sometimes two interviewees at the time and lasted one to two hours. The interviews were carried out by two researchers, one taking notes and the other asking the questions.

4. Analyses of price models and customer reactions

The following section gives a short description of each district heating company, their price models and the customer response that was given in the focus group interviews. After this, a compilation of customer reflections on what qualities a good price model for district heating should have from a customer perspective is given.

4.1. Södertörns Fjärrvärme AB

Södertörns Fjärrvärme AB (SFAB) delivers district heating and cooling to customers in the municipalities of Botkyrka, Huddinge and Salem close to Stockholm area. SFAB is owned by Huddinge (50 %) and Botkyrka (50%). SFAB is the majority owner of Söderenergi (58%), which is the company that produces the lion's share of the heat that SFAB delivers to its customers. The heat production is based on biofuels like wood chips from forest and from recycled wood. Bio-oil is also used and a small share of fossil oil for some part of peak load production. About half of the deliveries go to apartment buildings, ten percent goes to community associations, five percent goes to homeowners and the rest goes to municipal buildings, hospitals, industrial customers etc.

4.1.1. Construction of price models at SFAB

New price models were introduced in 2015 for large customers, while the price model for homeowners remained unchanged. For customers that use district heating for all their space heating and domestic hot water preparation, a choice between two different price models was imposed. Table 2 shows the price list to large customers at SFAB.

The load component in the price model is built on a subscription load level. The subscription load level is measured at -5°C outdoor temperature. Measurements are made every third year (or when the customer demands this). The load component is designed so that customers with larger power demand pay a lower fee in SEK / kW.

The motive to introduce the new price model called "Fixed" with a higher share of fixed cost was not to give customers freedom of choice. The strategy was to make

Table 1: District heating prices SFAB 2015, with the two models "Base" and "Fixed" that customers can choose from

	Base	Fixed
Load component		
Subscription load level		
0–300 kW	880 SEK/kW	5 200 SEK/year + 1 115 SEK/kW
301–875 kW	42 000 SEK/year + 740 kr/kW	60 000 SEK/year + 940 kr/kW
>876 kW	230 000 SEK/year + 525 SEK/kW	270 000 SEK/year + 700 SEK/year
Energy component		
Period		
December–March	500 SEK/MWh	400 SEK/MWh
April, September–November	315 SEK/MWh	255 SEK/MWh
May–August	120 SEK/MWh	120 SEK/MWh

Table 2: District heating prices SFAB 2015 for customers with complementing heating system to district heating

Customers who meets any of the following criteria is referred to the price list "Top":
1) *Customers with other baseload than district heating. With other base-load means that you have a heat pump that covers the basic needs for heating and domestic hot water and that the use of district heating only covers parts of the need concentrated in the cold season.*
2) *If the installation has other sources of energy for heating along with the district heating, where the ratio of the annual heat consumption (kWh) and maximum power demand (kW) of heating is less than 2000.*

Load component	
0–425 kW	685 SEK/kW
426–1 250 kW	46 000 SEK/year + 580 SEK/kW
1251 kW	221 000 SEK/year + 440 SEK/kW
Energy component	
January	545 SEK/MWh
February	560 SEK/MWh
March	485 SEK/MWh
April	375 SEK/MWh
May	140 SEK/MWh
June	120 SEK/MWh
July	120 SEK/MWh
August	120 SEK/MWh
September	185 SEK/MWh
October	320 SEK/MWh
November	430 SEK/MWh
December	515 SEK/MWh

the price model with a higher proportion of fixed rate more favourable to the customers over some years, and by this make the customers more apt to choose this alternative. In this way SFAB hoped to avoid a negative customer reaction on the increased proportion of fixed costs in the pricing. The reason that SFAB wanted to increase the fixed share in the price model was because they saw a future risk of reduced heat sales as their major customers, the municipal housing companies, was facing a great need for renovation of apartment buildings built in the 60s and 70s which would probably lead to some energy efficiency measures in the buildings.

According to the interviews with staff at SFAB, an increase in competition from heat pumps had been noticed and unfavourable load patterns from customers who had partially converted their heating systems were detected. SFAB therefore wanted to design a special price model to these customers. These customers did not have any alternative price model to choose between. The price list for these customers is shown in Table 2.

4.1.2. Customer reactions to SFAB's price models

The participating customers in the two focus group interviews at SFAB generally thought that SFAB's pricing models were relatively easy to understand, except from the load component were the customers did not understand why this component would have to be so inflexible and why it was measured only every third year.

In the focus group with smaller customers, mainly housing and community associations, it became evident that some of the customers did not care to understand the price model at all, while others had great difficulty trying to communicate the price model to other members in the housing association.

The price model "Top" that is the option for those who have a heat pump or other supplemental heating alternatives, was seen as problematic by the representatives from condominium associations who represented many housing associations. They felt that it was difficult to communicate this kind of price model with members of the housing associations. They also expressed that they felt punished by the price model. Example of quotation from the interview:

"If you look on it from our associations' perspective, they are not very familiar with any price model, which is why they have us, we'll help them. But if you live with general perceptions that it is good and fine to save energy, then you get upset when you get punished for investing in a heat pump."

The two alternative price models "Base" and "Fixed" that costumers with only DH could choose from were discussed. Participants were aware of this option, but they did not understand why there were two different price models to choose from. The choice was not seen as so important, especially in light of that the options were quite similar. Examples of quotations:

"This freedom of choice is overrated. We want a model that is reasonable and sensible, that's enough. We do not have the ability to make a choice where the outcome is uncertain and the difference between the models are too small. So there is really no need to put energy to this choice".

"Why don't they have a model that stands out more, if we now have an option? A model with only variable energy price? You get no clear indications from SFAB why they have this fixed tariff. What is the point?"

Customers expressed that if one, nevertheless, should have choices, then the DH company should help and guide the choice. The customers felt that they did not prioritize this issue. Having to choose the pricing model was rather seen as a burden to the customers, than an opportunity for the customers to influence their situation.

4.2. Öresundskraft AB

Öresundskraft AB is owned by the municipality of Helsingborg, that is located on the south east coast of Sweden. Öresundskraft delivers electricity, gas, heat, cold and broadband to citizens in Helsingborg and Ängelholm. It also offers energy efficiency services. The heat production in Helsingborg consists of residual heat from the nearby industry Kemira and heat from a waste CHP plant and some smaller plants fired by pellets and wood chips. Fossil fuel is only used at the start of operation or at disruptions. 80% of the heat is delivered to 3,000 industrial customers and housing associations, and the remaining 20% is delivered to 11 000 small house customers.

4.2.1. Construction of price models at Öresundskraft AB

A new price model were introduced in 2012 for all customers in Helsingborg. In the new model the energy price had a greater seasonal variation, the proportion of variable energy price was enlarged and another type of load component was imposed (peak load with rolling 12 month instead of the category number method).

The reasons for the change in price model was the desire to be more competitive against other heating options. The company also wanted to encourage energy efficiency measures which would give energy and load savings in winter time. A third season price level was introduced and the different price levels between the seasons were increased. Also homeowners got a new price model with seasonal energy price. Clear guidelines were developed by the management for the development of the new price model:

1. The model would encourage energy efficiency and reduction of electricity use
2. The revenue from the new price model should be a zero sum game and would not lead to any increase in the price for heat for the customer community as a whole. A redistribution of costs would however be done between different groups of customers.

3. The distribution between the parameters of energy/load/flow was set at 70/20/10 over the entire customer community.
4. The model should reflect production costs

Price list for Öresundkraft is shown in Table 3.

4.2.2. Costumer reactions to Öresundskraft's price model

The participants in the focus group interview seemed to have some understanding of why Öresundskraft wanted to impose a seasonal differentiation of the energy price. A reflection that came up was that seasonal price means that energy becomes more expensive when you need it the most, and this has negative consequences for the customers. The housing associations stated that they would prefer a more uniform energy price level over the year, because this would better reflect on the way that the associations receives funds from their own members.

Representatives from large real estate companies also saw seasonal energy prices as something negative. The commercial property owners expressed concerns about losing customers if they did not keep a good indoor climate and thought that they might have difficulties saving energy in winter time Table 3 (Page 55) Energy component:

"We're on the commercial side. We measure customer satisfaction index and we measure the indoor climate in our facilities. It is just too expensive to lose a customer. We cannot reduce the indoor temperature, we must have satisfied customers"

As explained earlier, Öresundskraft base their load component on the customer's highest peak (daily average). The highest daily average consumption is used to set the fee level for 12 months, unless this value is exceeded, then a new period of 12 months begins. The logic of this procedure was not appreciated by the participants, neither by the smaller nor the larger customers. It did not seem fair to them that the consumption a cold winter day would set the level of the fee for a whole year. Twelve months was considered to be a too long period. Some participants said that this load component made them feel insecure of the coming costs. What if there were suddenly an error in the customer DH substation? Could this lead to a very high fee for the coming twelve month?

"We would like to have alarms, warnings. It may be something wrong in the system. Not everyone can handle the DH substations".

Regarding the flow demand component not all customers understood how the component worked and

Table 3: District heating The price list of Öresundkraft, 2015

(A) Maximum daily consumption / 24 h	**(B) Fixed price SEK/year**		**(C) Load component SEK/kW**	
	VAT excluded	**VAT included**	**VAT excluded**	**VAT included**
0–30 kW	600	750	529,20	661,50
30–100 kW	2 808	3 510	455,60	569,50
100–250 kW	10 248	12 810	381,20	476,50
250–500 kW	28 748	35 935	307,20	384,00
>500 kW	65 748	82 185	233,20	291,50

Energy component

Season	**Price SEK/kWh VAT excluded**	**VAT included**
Winter Nov–March	50,46	70,58
Spring/Fall April–May, Sept – Oct	32,52	40,65
Summer June–Aug	9,98	12,40

Flow component

Season	**Price SEK/cubic meter VAT excluded**	**VAT included**
Winter Nov–March	3,78	4,73

the company's motive to use this kind of component in the price model. More informed customers saw problems with the flow demand component in the summer time when the supply temperature was low in the grid. With a lower supply temperature the customer automatically gets a higher flow demand without using more energy. There is nothing the customer can do to control this.

Customers that had been contacted about high flow levels were grateful to the company about this alert.

4.3. Sala-Heby Energi AB

Sala-Heby Energi AB (SHEAB) is a relatively small energy company owned by the municipalities of Sala (87.5 %) and Heby (12.5 %). Sala and Heby are situated about 120 km North West from Stockholm. SHEAB is a local supplier of electricity, heat and energy efficiency services. In addition to these services the company also sells wood pellets. In 2010 a subsidiary was formed, HESAB, that sells photovoltaic packages and energy efficiency services. The heat production is based on local wood chips or wood pellets, and bio-oil is used for peak load. SHEAB has about 1400 district heating customers, 900 of these are homeowners. There is only a few industrial customers, but quite many housing associations and housing companies.

4.3.1. Construction of price models at SHEAB

In 2010 SHEAB changed their price model for larger customers, while the price model for homeowners stayed the same. The price model contains only an energy price and a quantity discount to customers with high heat demand. The customers is given a possibility to bind their energy price for one, three, five or ten years (the same principle as interest rates could be bound in home loans). According to the interviews with strategic staff at SHEAB, the motive to change the price model was a desire to provide customers with a clear opportunity to influence their heating costs while providing a strong incentive to adopt cost-savings and energy efficiency measures. This also corresponded well with the new subsidiary HESAB that offers energy efficiency services. When changing the price model SHEAB wanted to keep the overall level of income constant, and did this by distributing the previously fixed part to the price of energy instead. A typical price list to customers for district heating in SHEAB is shown in Table 4.

The table is depicted from the company's website. Note that the company has a column for the fixed price, where this price is set to zero. The company uses its variable price in their marketing and do the same thing when they sell electricity.

4.3.2. Costumer reactions to SHEAB's price model

According to the focus group interviews, the customers seemed to be very satisfied with the fact that SHEAB had no fixed fee in the price model. With such a price model, energy savings and energy-efficiency measures will have much greater impact on customer costs for heating. Some customers indicated that they were aware that a completely variable price for DH entails certain risks and disadvantages, but these customers were still in favour of a fully variable price anyway.

Seasonal Energy price: The reason why the energy prices should be higher in the winter was not obvious to the participants. For most commodities the marginal production costs become lower not higher when larger volumes are produced. This is not the case for DH. Even if the customers did not understand the reason for the season based energy price, they accepted the higher winter price:

"We have learned that it is more expensive to live in a cold climate when it is winter. We need more clothes and other things."

SHEAB use a bonus/malus system to charge the customers for flow demand. In the interviews some customers stated that the fee really worked as an incentive for them to work with their DH substations. Some customers had signed service contracts to get help in improving their cooling.

Table 4: District heating prices for Sala-Heby Energi from 2014-01-01

Yearly energy use (MWh)	Fixed fee (SEK/year)	Variable energy price SEK/MWh. Winter time/ other time*
0–35	0	935/845
35–100	0	904/845
100–200	0	881/821
200–500	0	868/805
>500	0	812/756

** The higher price for energy apply during the period from November to March and the lower in April-October.*

4.4. Customer views on the qualities of a good price model

In all focus group interviews the participants were asked to describe what qualities characterize a good price model for DH from a customer perspective. The responses resulted in a list that was written on the whiteboard. In four of the interviews there participants also made a priority of the qualities that they felt were the most important ones by giving two points to the most important characteristic and one point on the second most important. A compilation of the results from the six focus group interviews is showed in Table 5.

Given that customers are coloured by their own past experiences of DH price models, it was interesting to see that the characteristics of what constitutes a good price model to the customers were repeated in the various focus group interviews. To summarize the result shown in Table 5, the customer emphasized the following qualities in a good price model from a customer perspective:

1. Energy efficiency must be worthwhile. Customers want to feel that it pays to improve energy efficiency and to save energy in their own buildings. Qualities that were listed on the white board that reflects on this were "stimulating energy efficiency", "able to influence by behaviour", and "variable cost".
2. Customers want to pay for "what they consume", and they equate this with having a high share of variable cost in the price model. A high fixed cost means that the customer will have to pay regardless if any energy has been used or not.
3. Predictability for budget work. The large customers emphasized that they wanted a price model that is easy to make a budget from. The customers particularly criticized components in the price model that was based on peak load behaviour.
4. Customers must understand what they are paying for. This was expressed by qualities like that the price model should be "simple," "understandable" and "be able to explain to others." Components that were perceived as difficult to understand and communicate was primarily flow demand components and load demand components.
5. Fairness: The customers did not have the same view as the DH companies of the concept of fairness regarding price models of DH. DH companies referred to fairness in the meaning that no customer group should subsidize costs generated by other costumer groups. For the customers a "fair" price model should not punish

Table 5: Compilation of customer preferences and priorities of the characteristics of a good price model. Results from six focus group interviews

ÖRESUNDSKRAFT	SHEAB	SFAB
Housing associations/Homeowners	**Homeowners**	**Housing associations / Community associations**
• Pay for what you consume • Simple • Understandable	• Variable cost (16 p) • Be influenced by behaviour (6 p) • Understand what you pay for (1p) • Environmental choice (1p) • Simple (0 p)	• Variable cost • Able to explain to others • Measuring the installed capacity in a fair way
Real estate companies	**Housing associations/Industries**	**Real estate companies**
• Stimulate improved energy efficiency (14 p) • Be influenced by behaviour (5 p) • Predictable - so that one can make budget (3 p) • Freedom of choice (2 p)	• Able to be influenced by behaviour (13 p) • Understand what you pay for (7 p) • Simple (7 p) • Fair (0p)	• Understandable (11p) • Predictable – to be able to make calculations (8p) • Provide incentives to run district heating production better (2 p) • The company cost recovery (0 p) • Fair (0 p) • Freedom of choice (0 p)

the customer for making investments in solar heat or an air heat pump, of for having a single high peak load demand some winter's day. Also, full fairness between customer groups did not seem to be a customer driven issue according to the answers given in the focus group interviews. The customers do not have sufficient insight in how district heating prices are set to be able to see if one customer group subsidizes another. As one representative from a large real estate company put it: "*You can design a price model that is quite fair, but I think you have to find that golden middle ground in the choice between fairness and simplicity, were simplicity is the more important one. You must be able to explain the price model to the customer*".

6. Optional price models. Freedom of choice and environmental choices were raised in some cases as can be seen in Table 5, although these qualities did not get any points when the participants were asked to prioritize the qualities. Giving the customer a choice, simultaneously means that you expose the customer to the risk of making a choice which eventually proves to be the least advantageous to the customer. Neither large nor small customers in the interviews seemed to demand the possibility to choose between several different alternatives. If you are to give the customer the option to choose, the options should be sufficiently differentiated and you should give the costumers some guidance in benefits and risks concerning the different alternatives.

The responses from customers in the focus group interviews show that with a complex price model follows an increased need to inform and educate the customers. If incentive-based components are used the customers must be provided with information on how the customer can save money. It is also important to harmonize the price model with the company's profile and the range of services the company provides. If an energy company sells energy efficiency services, a high share of fixed cost in the price model of DH would not benefit this kind of business.

5. Conclusion

The results show that several important customer requirements are actually suffering with the new price models. The most important issues for the customers are when price models are designed in a way so that energy savings do not provide any financial savings to the customer, when the costs for heat or load demand are hard to predict which makes it difficult for the customers to budget the costs and to develop accurate investment estimates for energy efficiency measures.

The results from this study should be seen as one puzzle piece in the input in how price models for DH should be designed. Factors like weather dependency, sunk costs from fixed assets and new competition on the heat market constitute challenges and business risks for the DH industry that must be considered, no doubt. But dissatisfied customers voting with their feet constitutes another financial risk for the DH business.

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References

[1] SOU 2011:44 Fjärrvärme i konkurrens, delbetänkande av TPA-utredningen. URL: http://www.regeringen.se/ contentassets/ 16997649e2184e9a9b0f234869f1b042/fjarrvarme-i-konkurrens-sou-201144

[2] Svensk Fjärrvärme: Varför prisreglering, när ingen vill ha det? http://svenskfjarrvarme.se/Nyheter/Nyhetsarkiv/2014/Langtids utredaren-drar-fel-slutsats/

[3] Prisdialogen mellan kunder och företag. Prisdialogen för fjärrvärme växer, omfattar 1.7 miljoner hushåll 2017. URL: http://www.prisdialogen.se/prisdialogen-for-fjarrvarme-vaxer-omfattar-17-miljoner-hushall-2017/

[4] Connolly, D, Lund, H, Mathiesen, B, Werner, S, Möller, B & Persson, U. Heat Roadmap Europe: Combining DH with the heat saving to decarbonize the EU energy system. Energy Policy 66 (2014) pages 475-489. URL: http://www.sciencedirect.com/ science/article/pii/ S0301421513010574

[5] Connolly, D, Lund, H, & Mathiesen, B. Smart Energy Europe: The technical and economic impact of one potential 100 % renewable energy scenario for the European Union. Renewable and Sustainable Energy Reviews 60 (2016), pages 1634-1653. URL: http://www.sciencedirect.com/ science/article/pii/ S1364032116002331

[6] Kundens förtroende. Från pålitlig fjärrvärmeleverans mot en tillitsfull relation http://www.fjarrvarmensaffarsmodeller.se /pdf/KF.pdf

[7] Stridsman, Daniel, Rydén, Bo & Göransson, Anders, Lilla prismodellsboken – om införande av en ny prismodell för fjärrvärme. Print: PR-Offset, Mölndal. URL: http://www.fjarrvarmensaffarsmodeller.se/pdf/LP.pdf

[8] Song, Jingjing, Wallin, Fredrik, Li, Hailong & Karlsson, Björn, Price models of DH in Sweden, Energy Procedia 88 (2016) pages 100 – 105, CUE2015-Applied Energy Symposium and Summit 2015: Low carbon cities and urban energy systems. URL: http://www.sciencedirect.com/science/article/pii/S1876610216300959

[9] Byseke, David & Högberg, Jonas. Prissättning av fjärrvärme. Är en spegling av ett fjärrvärmebolags kostnader i priset rimlig och önskvärd? Bachelor thesis at the Department of Industrial and Financial Management at Gothenburg University. URL: https://gupea.ub.gu.se/bitstream/2077/29499/1/gupea_2077_29499_1.pdf

[10] Difs, Kristina & Trygg, Louise, Pricing District Heating by marginal cost. Energy Policy 37 (2), (2009), pages 606-616. URL: http://www.sciencedirect.com/ science/article/pii/S0301421508005715

[11] Li, H, Sun, Q, Zhang, Q & Wallin, F. A review of the pricing mechanisms for DH systems, Renewable and Sustainable Energy Reviews (42), (2015), pages 56-65. URL: http://www.sciencedirect.com/science/article/pii/S136403211400820X

[12] Frederiksen, S & Werner, S, DH and Cooling. Studentlitteratur. Printed by Exaktaprinting AB, Sweden, 2013.

[13] Rolfsman, B & Gustafsson, S.I. Energy conservation conflicts in DH systems. International Journal of Energy Research 27, (1), 2003, pages 31-41. URL: http://onlinelibrary.wiley.com/doi/10.1002/er.857/abstract

[14] Björkqvist, O, Idefeldt, J, Larsson, A. Risk assessment of new pricing strategies in the DH market: a case study at Sundsvall Energi AB. Energy Policy. Volume 38 (5) (2010), pages 2171–2178. URL: http://www.sciencedirect.com/science/article/pii/S0301421509009148

[15] Reidhav, C & Werner, S, Profitability of sparse DH. Applied Energy 85 (2008) pages 867-877. URL: http://www.sciencedirect.com/science/article/pii/S0306261908000299

[16] Åberg, M & Henning, D, Optimization of a Swedish district heating system with reduced heat demand due to energy efficiency measures in residential buildings. Energy Policy 39 (2011) pages 7839-7852. URL: http://www.sciencedirect.com/science/article/pii/S0301421511007208

[17] Frank, Th. Climate change impacts on building heating and cooling energy demand in Switzerland. Energy and Building 37 (11) (2005), pages 1175-1185. URL: http://www.sciencedirect.com/science/article/pii/S0378778805001106

[18] Profu. Värmemarknaden i Sverige – en samlad bild. Juni 2014. URL: http://www.varmemarknad.se/pdf/ViS.pdf

[19] Difs, K, Bennstam, M, Trygg, L & Nordenstam, L. Energy conservation measures in buildings heated by DH – A local energy system perspective. Energy 35 (8), (2010), pages 3194-3203. URL: http://www. sciencedirect.com/ science/article/pii/S0360544210001921

[20] Sernhed, Kerstin, Energy Services in Sweden – Customer Relations towards Increased Sustainability. Doctoral Thesis at the Department of Energy Sciences, Lund University, 2008. URL: http://portal.research.lu.se/portal/files/3613449/1150982.pdf

[21] Göransson, A, Johnsson, J, Sköldberg, H, Stridsman, D, Unger, T & Westholm, E. Fjärrvärmen i framtiden – behovet. Fjärrsyn, report 2009:21. URL: http://www.svenskfjarrvarme.se/Global/FJ%C3%84RRSYN/Rapporter%20och%20resultatblad/Rapporter%20omv%C3%A4rld/2009/Fj%C3%A4rrv%C3%A4rmen%20i%20framtiden.pdf

[22] Norrenergi, Priser och avtal fjärrvärme. URL: http://www.norrenergi.se/norrenergi-dig/foretag-fastighetsagare/priser-och-avtal-fjarrvarme/. (Available 2017-04-28)

[23] Karlstad Energi, Karlstad Energi AB prissättningsmodell för fjärrvärme 2015. URL: https://www.karlstadsenergi.se/globalassets/fjarrvarme/prisdialogen/karlstads-energi-ab-prisandringsmodell-fjarrvarme-2015.pdf (Available 2017-04-28)

[24] Västervik Miljö & Energi AB, Ny prismodell fjärrvärme. URL: https://www.vastervik.se/globalassets/vastervik-miljo-och-energi/fjarrvarme/pdf/ny-prismodell-foretag-webb.pdf (Available 2017-04-28)

[25] Lidköping Energi AB, Priser privatkunder 2017. URL: http://lidkopingsvarmeverk.se/ny-prismodell-smahus.aspx (Available 2017-04-28)

[26] Uddevalla Energi AB, Så här fungerar den nya prismodellen för fjärrvärme till villor som införs 2015. URL: http://www.uddevallaenergi.se/privat/fjarrvarme/nyprismodell2015.4.7d9048741460bf57c621783.html (Available 2017-04-28)

[27] Hedemora Energi AB, Ny prismodell för fjärrvärme villa. URL: http://www.hedemoraenergi.se/wp-content/uploads/2016/02/Fordjupad-information-for-villakunder.pdf (Available 2017-04-28)

[28] Jung, T. Effekter av prismodellsförändringar inom fjärrvärme. Master thesis at the Department of Energy Sciences, Lund University. URL: http://lup.lub.lu.se/luur/ download?func=downloadFile&recordOId=8878591&fileOId=8878677

[29] Petersson, S & Dahlberg Larsson, C, Samband mellan flödespremie och returtemperatur. Fjärrsyn report 2013:25. URL: https://energiforskmedia.blob.core.windows.net/media/18653/2013-25-samband-mellan-floedespremie-och-returtemperatur.pdf