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Analyzing variables for district heating collaborations between energy utilities and industries

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Abstract

One vital means of raising energy efficiency is to introduce district heating in industry. The aim of this paper is to study factors which promote and inhibit district heating collaborations between industries and utilities. The human factors involved showed to affect district heating collaborations more than anything else does. Particularly *risk, imperfect and asymmetric information, credibility and trust, inertia* and *values* are adequate variables when explaining the establishment or failure of industry-energy utility collaborations, while *heterogeneity, access to capital* and *hidden costs* appear to be of lower importance. A key conclusion from this study is that in an industry-energy utility collaboration, it is essential to nurture the business relationship. In summary, successful collaboration depends more on the individuals and organizations involved in the relationship between the two parties than on the technology used in the collaboration.

Keywords: District heating; industry; energy utility; collaboration

1. Introduction

Emissions of greenhouse gases (GHG) are stated to pose a serious threat to the environment. Industrial energy efficiency is an important factor for reducing the threat of increased global warming [1]. The methods for raising industrial energy efficiency are many and diverse. Energy-efficient technology adoption represents one important path; the use of various process integration methods such as pinch and MILP (Mixed Integer Linear Programming) is another [2]. Moreover, energy-efficient behaviour and industrial energy management are stated to have great potential in reducing industrial energy use [3]. Yet another means is district heating in industry [4-8]. The major benefit for the industry is reduction of costs for maintenance, operation and investments of the boilers. Apart from increased revenue from the industrial customer, the major benefit for energy utilities is the possibility to change the duration curve for the base boilers, which in turn enables more electricity to be produced in the case of a Combined Heat and Power (CHP) plant. A major benefit for collaboration as a whole is increased overall system efficiency leading to reduced costs and reduced emissions of GHG.

While the potential use of district heating is huge, many countries lack a developed infrastructure for district heating. The number of district heating utilities varies between different countries and consequently also the amount of delivered district heating. In Greece, Norway and Latvia the total district heating delivery is relatively low compared to other European countries as for example Poland, Germany and Sweden. In Sweden the use of district heating in industry equals 4% of the total energy use [9]. At the same time, Swedish industry is known to use 2-3 times more electricity than plants located elsewhere in Europe [10, 11]. Since the electricity price in Sweden most probably will be affected by higher European prices due to increased cross-border

trading, it will be of increasing importance for Swedish industries to focus on reducing their use of electricity, and converting from electricity to district heating or other energy carriers where possible, in order to remain competitive. A higher electricity price will also encourage the energy suppliers to concentrate their production on more electricity generation, which contributes to reduction of GHG emissions. In combination with an increased demand for district heating, this will be a result of industries converting from electricity or fuel to district heating, which makes investment in CHP plants an interesting option. The district heating grids in Sweden are one of the world's most extensive district heating networks [12]. It will therefore in all probability prove to be attractive for Swedish energy suppliers to consider further investment in these power plants, which consequently would increase electricity production in Sweden.

When considering coal-condensing power as the marginal source of electricity in a common European electricity market, each change in consumption or supply of electricity in Sweden will change the production in a coal-condensing power plant. The efficiency of generating this marginal electricity is assumed to be 33%. Each megawatt-hour of electricity generated in such a coal-fired condensing plant thus releases approximately one ton of carbon dioxide.

This approach implies that in a common European market, each change in consumption or supply of electricity in Sweden will change the production in a coal-condensing power plant. A reduction in electricity use by Swedish industry will thus mean lower emissions of carbon dioxide. It also implies freed capacity for Swedish suppliers and as a result, better possibilities for a Swedish supplier to sell electricity to customers on the European continent. When considering only the impacts from global carbon dioxide electricity generated in Sweden has low

external costs. This means that when industries convert to district heating it will allow further production of electricity in Swedish CHP systems. Electricity generated in Sweden but sold in another European country could then replace electricity produced with higher external costs and as a result lower the global emissions of GHG [9].

In countries where the infrastructure exists, there are still various factors which inhibit the adoption of district heating in industry. In order to increase energy efficiency in the economy it is thus of importance to spot these factors as well as to study factors which promote the adoption of district heating in industry. The annual Swedish industrial energy use is about 157 TWh, of which about 75% relates to the energy-intensive industry and about 25% to manufacturing industry, the latter including about 7% for engineering industry [5].

Energy policies are adopted on various levels of society, e.g. EU ETS, which – together with the deregulation of the European electricity market and increasing fuel prices – will probably lead to increased prices for energy and district heating. The higher use of electricity in Swedish industry, compared with European competitors, may cause a competitive disadvantage for Swedish industry. In order to reduce the threat of rising energy prices, the industry has, in principle, two options: to give attention to the contract with the supplier regarding the price of electricity, and to focus on more efficient end-use of energy. However, for industries located in a region where district heating is available, the conversion from fossil fuels and electricity to district heating may be another means to address the issue, and possibly a win-win solution for both industries and energy utilities. Moreover, collaboration between industries and energy utilities, apart from strictly monetary benefits, also leads to reduced environmental impact.

A wide variety of forms of collaboration exist concerning heat. Which collaboration is suitable depends partly on which type of collaboration the industry is ready to arrange, and which type of manufacturing processes the company has. If the industry has vast amounts of excess heat, one type of collaboration could concern the supply of excess heat; another could be the establishment of a cooperatively owned CHP. Yet another type of arrangement could be shared ownership regarding the boilers, or perhaps the simplest type of collaboration – strict delivery of district heating to the industry. The type of collaboration is also dependent on energy utilities' current fuel mix and their ability to establish such collaboration in practice, e.g. access to capital and current capacity of district heating delivery. Plausible collaborations thus vary widely between different regions, district heating-grids, and which type of industry the collaboration involves. In order to promote and support district heating collaborations between industries and utilities, it is of great importance to identify factors which promote and inhibit the collaborations.

This paper examines factors that promote and inhibit district heating collaborations between industries and utilities. While studies are available on e.g. the potential for excess heat deliveries from industry [13], the utilities' potential for optimal plant operation investments [14], the potential for district heating collaboration [6] and the potential for energy efficiency in industry [15, 16], this paper is unique as it studies actual collaborations between energy utilities and industries, both successful and non-successful. Furthermore, the paper goes beyond the traditional approach studying potentials of energy efficiency and district heating in industry. Instead, the paper focuses on the realm of real district heating collaborations between energy utilities and industry.

2. Collaboration between industries and energy utilities

In the following section, previous studies of heat collaborations are presented together with systems theories applied to collaborations between industries and utilities.

2.1. Previous studies of heat collaborations

Heat collaborations have previously been studied by, among others, Gebremedhin [14], Grönkvist and Sandberg [17], Jönsson et al. [18], Svensson et al. [13], Trygg et al. [19] and Jönsson and Algehed [20] in a Swedish context. Gebremedhin [21] has shown that through expanding the system boundaries from a perspective including only the industry to include the surrounding energy system, both existing plants and new plants can be operated in a more cost-efficient way. This approach has been adopted by Svensson et al. [13] and Jönsson et al. [18] in a study of utilization of excess heat from kraft pulp mills. The importance of pricing of excess heat from kraft pulp mills has been addressed by Jönsson and Algehed [20], who showed that in a heat collaboration the energy utility will take the largest economic risk but also have the opportunity to make the largest profit. The price at which an industry is willing to sell excess heat is much more robust than the price at which energy utilities are willing to buy heat. This is because the energy utilities' willingness to buy heat varies more with prices of electricity and fuel than does the industries' willingness to sell.

2.2. Systems theories applied to collaborations between industries and utilities

According to Churchman [22] a system can be analyzed by defining its objective, describing its components, determining its surroundings and resources, and identifying its leadership. In a study of collaborations between industries and energy utilities, it is possible to define system boundaries on multiple levels depending on the aim of the study and from which perspective the

study is conducted. On a lower system level, a single production process or a building can be studied. Most optimizations are carried out on this level, and for individual components this will result in an optimal solution, but it can be hard to determine the effects on the surrounding system when using a narrow system boundary.

At a higher system level, a whole industry or energy utility can be studied as a coherent system. When the system boundary is drawn around a given industry, it is possible to investigate the profitability and attractiveness of district heating collaboration from the viewpoints of separate companies, the industry and the energy utility. A systems perspective on the industry offers new possibilities compared to studying only a single component of a system. What is optimal on a lower system level may not be so for the company as a whole.

If the system boundary is expanded even further, and an industry and an energy utility are studied as a coherent system, relations between the two parties become relevant. In addition to these relations it is necessary to consider, for example, the relation between the energy utility and its customers and relations to other energy utilities within the same system. For a system consisting of e.g. a whole municipality, it is not certain that the optimal solution is the same as when the system comprises a single industry or energy utility. Widening the system boundary to include actors and their relationships increases the system complexity even further. Boulding [23] categorized systems into various levels depending on their degree of complexity, the highest being that of individuals and groups of individuals. He concluded that when studying the latter level it is very difficult to develop, from an objectivistic viewpoint, a general theory that includes

all the parameters. Such research calls for diverse perspectives in order to enhance understanding of the issues.

The system's surroundings can be defined as the factors that do not belong to it but in some way interact with it [22]. Examples of such factors are national legislation, economic and political policy instruments, European Union directives and market aspects. The system's surroundings are infinitely large if all factors that may influence the system are considered. In a longer perspective it is also possible that the system also influences the surroundings, but when defining a system boundary it is necessary to assume that the surroundings are stable and cannot be influenced.

3. Method, scope and delimitations

Inspired by Boulding [23], nine different theoretical perspectives were applied, derived from various scientific disciplines: e.g. Sorrell et al. [24], Jaffe and Stavins [25], Stern and Aronsson [26]. These perspectives allow a greater understanding of district heating collaboration than if only one perspective had been used. The nine perspectives have been divided into two categories dependent on system complexity; see Table 1. On the first system level – the technology level – the results are quite restricted to technology and its associated costs. On the second level – the technology/human level – the results are heavily influenced by human factors.

The study was carried out as a case study, inspired by Yin [27], with in-depth, semi-structured interviews and a questionnaire centering on factors promoting district heating collaboration. These factors include a selection from an almost infinite chain of factors. By including a literature review of influential factors, and by having a steering group examine the questionnaire,

Table 1

Theoretical perspectives applied in this paper [24-26]

System levels	Theoretical perspectives	Description
The technology level	Heterogeneity	A district heating implementation is dependent on the specific company's conditions etc.
	Hidden Costs	Hidden costs associated with district heating implementation such as overhead, cost of collecting and analyzing information, production disruptions, etc. may limit the investment.
	Access to Capital	Access to capital is naturally a factor of importance when a district heating implementation is undertaken.
The technology/ human level	Risk	Risk affects district heating implementation and may either promote or inhibit an investment.
	Imperfect information	Imperfect information may result in the overlooking of a district heating implementation.
	Asymmetric information	If energy costs are not allocated to the party responsible for the use of the investment, or if one party cannot observe the other, the investment might be terminated.
	Credibility and trust	The information source should be credible and trustworthy in order to successfully deliver information regarding the investment.
	Inertia	Individuals who oppose change within an organization may have the effect that a district heating implementation is not carried out.
	Values	Efficiency improvements such as a district heating implementation are most likely to be undertaken if there are individuals with e.g. environmental values, preferably represented by a key individual within top management.

a limited number of factors that can be considered relevant were included. When presenting the results in this paper, the questions were translated from Swedish to English. As suggested by Yin [27], the questionnaire was reviewed by the steering group, set up and organized by the financier of the project, the Swedish District Heating Association. Since the studied cases may yield information which is sensitive for the energy utility and the industry, all respondents and cases were given full anonymity. Moreover, the study was limited to collaborations between energy utilities and industries, not dealing with collaboration between energy utilities.

Three primary types of collaborations were studied: (1) one regarding direct district heating supply to the industry from the energy utility, where the industry previously had run its own boilers; (2) one boiler cooperation where the boilers at the industry are part of the district heating network and operated, but not owned, by the energy utility; and (3) one cooperation regarding a new CHP plant where the establishment of district heating for the industry would enable a new CHP to be built. A fourth main type was originally planned for study, but had to be omitted due to the sensitivity of the issue for the case to be studied. This case concerned an industry and energy utility currently in the process of signing a business agreement on excess heat deliveries, and the respondents at the industry demanded that the energy utility join the in-depth interviews, something which would create a risk of SDB (Social Desirability Bias). The research group therefore decided, based on scientific uncertainties regarding the results from these planned interviews, to leave out excess heat collaboration in the study. One may argue that it would have been wiser to just change the choice of case. However, such a shift is not easily carried out in the middle of a research project and would have involved yet another round of thorough evaluation

of potential cases by the researchers and the steering group. Except for this case, all respondents agreed to be interviewed.

A total of 12 in-depth interviews were conducted, six with energy utilities and six with industries. The respondents consisted of executives at the utilities, primarily CEOs – but in order to triangulate the results, at least one more executive within the organization was also interviewed. Respondents at the studied industries were the persons in charge of the energy issue. The different cases were selected in order to study various types of collaborations. The respondents at the energy utility and the industry were asked to rank different factors promoting collaboration in the questionnaire as follows: one point if the respondent considered the factor to be often important, half a point for sometimes important, and no point for rarely important. As stated in e.g. Thollander and Ottosson [28,29] and other related articles, one should be aware that in the analysis following from these quantifications, large simplifications are made, as the quantified results contain several more perspectives on the issue than merely a single ranking score [30]. Furthermore, the respondent's answers may include a degree of bias including personal opinions etc. As stated previously, this impact has been minimized by triangulation. It should also be noted that the categorizations of promotion factors are not entirely correct representations. As Weber [31] concluded, “it is empirically impossible to find the ‘true’ reason behind energy conserving action which has not been taken” [32]. Like all theoretical frameworks of complex real-world phenomena involving people, organizations and technology, the theory or theories should rather be seen as an analytical tool important to keep in mind when analyzing the results outlined in the paper; e.g. many of the empirical factors expressed by the respondents fit into more than one theoretical perspective.

4. Results

In the following section, results from the technology level and the technology/human level are presented together with results from the questionnaire.

4.1. *The technology level*

The perspectives addressed on the technology level, i.e. *Heterogeneity*, *Hidden costs*, *Access to capital* [25], are analyzed first.

4.1.1. *Heterogeneity*

Heterogeneity, meaning that district heating may not be a suitable technology in the specific context [25], was not shown to be a major explanatory variable for district heating collaborations in the studied cases. That is, it has not been the technology-specific factors, such as boilers, heat exchangers, and pipes, which have played a central role in the success or failure of district heating collaboration. In fact, none of the respondents from the industry or from the energy utilities mentioned this as a central factor. It should be noted, however, that in one successful collaboration, the industry's primary circuit, before the collaboration was initiated, had too high temperatures as compared with the energy utility's temperature levels ($<120^{\circ}\text{C}$). The industry then initiated a project aimed at lowering the temperature levels, and succeeded in doing so, enabling the collaboration to be established.

A factor related to *heterogeneity* is the technology diffusion which has taken place in the past, and not least the diffusion of information technologies, enabling operation of the system off-site. This has made heat collaborations easier to achieve than before, as an energy utility today can operate e.g. a boiler house located at an industry without necessarily having to be on-site.

Several years after a planned district heating collaboration was terminated, the related industry proposed delivery of heat to the nearby district heating grid from its new boilers during non-production hours. The reason for not shutting down the boilers during non-production hours is that the boilers are biofuel-fired and thus are impossible to shut down intermittently, unlike e.g. gas- and oil-fired boilers. However, the energy utility's base load boilers are also biofuel-fired and thus cannot be regulated momentarily either, so the proposed heat delivery from the industry was not achievable. This *heterogeneity* factor would not have arisen if the planned collaboration had not been terminated in the first place, but it nevertheless illustrates how collaboration may be problematic under some conditions.

4.1.2. *Hidden costs*

Hidden costs such as overhead, cost of collecting and analyzing information, production disruptions, etc. may limit collaboration [25]. In the studied cases, external resources in the form of technology consultants and lawyers were used, but the costs for these have not been stated to have had any influence on the collaboration. The utility respondents instead stated that they had considered increased overhead costs as a means to strengthen the business relationship with the industry. The CEO of an energy utility which has successfully established several industry collaborations said: "I collected exactly the right people for this." In the studied cases, the interviews did not reveal *hidden costs* to be a major factor affecting the decision and negotiations negatively. Rather, it was stated that it could be of importance to accept increased overhead costs in order to successfully establish collaboration.

4.1.3. *Access to capital*

Access to capital is often stated to be a major factor affecting energy efficiency investments [25]. A planned collaboration, where an agreement of intention was signed, failed because the energy

utility's investment calculations included an assumed investment subsidy which was not obtained later. When the investment subsidy was denied, the industry pulled out of the planned collaboration. Even though this is related to limited *access to capital*, the interviews revealed that limited *access to capital* was not stated as a major factor by any of the respondents. Rather, profitability – in particular of the utilities – has been high. One energy utility CEO stated: “We have been lucky and done good business, so we have shown high profits.” Another factor related to profitability which has influenced the collaboration positively is the increase of energy prices, which in turn has influenced investment calculations positively. One respondent stated: “The increasing oil prices have indeed helped.” The willingness to invest, or the utilities' and the industry's *risk aversion*, *information* and *credibility and trust* etc., are factors which do not solely concern the technology and its associated costs, but also involve the actors within the system boundaries. These are presented in the following sections.

4.2. *The technology/human level*

The perspectives addressed on the technology/human level, i.e. *Risk*, *Imperfect information*, *Asymmetric information*, *Credibility and Trust*, *Inertia*, and *Values* [24-26], are analyzed in the following section.

4.2.1. *Risk*

How a company relates to *risk* is a question of great importance as regards investments in district heating collaborations. The risks may be categorized into three groups [24]:

- *External risks* as of increased energy prices
- *Business-related risks* as of business cycles and lending capital
- *Technical risks* as of the reliance and performance of the adopted technologies

In the studied cases, *risk aversion* was shown to be of great importance in explaining the uptake or downfall of a district heating collaboration. An energy utility respondent stated: “We would have gone bankrupt if we had signed the agreement.” In the related case, the agreement had turned out to be so adverse that the energy utility either would have gone bankrupt or, more plausibly, would have switched owner. One industry respondent stated that the size of the energy utility involved – whether it is owned by the municipality or part of a larger private company group – is of central importance for the possibility to reach a business agreement. The respondent meant that large size increased the energy utility’s willingness to take business-related risks: “At the municipality, there is sometimes resistance to deliver to this type of industry...the energy utility is too small. We have never hesitated, but at the energy utility there has been some opposition.” Another factor related to *risk* is whether the energy utility’s or the industry’s boilers are fairly new, or whether an exchange-investment is needed as the latter increases the willingness to take the risk of entering into a potential collaboration. Yet another factor which proved to affect the will to enter a potential collaboration is whether the energy issue is acknowledged as of strategic importance for the industry: “I believe we would have signed anyhow, but this was driving it (the acknowledgement of energy as being of strategic importance)”.

An issue closely related to energy strategy is business strategy, since it affects the company’s *risk aversion*. In one successful collaboration, the energy utility had for several years been quite ambitious regarding market expansion towards larger energy-using organizations with independent heating supplies, i.e. their own boilers. When an organization’s boilers have been in need of larger maintenance, the energy utility has offered to take over the boilers. In another

municipality where collaboration failed, the industry respondent stated that the lack of strategy at the energy utility was a factor inhibiting collaboration: “What type of strategies do they (the energy utility) have?...everything they do is short-term.” In another case, the industry respondent stated that the fact that the energy utility had been very profitable affected its *risk aversion* negatively: “Why should you take risks when you earn so much money?” A further problem, closely related to *risk aversion*, is that publicly owned (municipality) utilities have the citizens’ interests to cope with, and this decreases the willingness to take risks. An energy utility respondent stated: “We work for the citizens’ interest and this is a problem.” It feels problematic if one has to confront citizens regarding the consequences of a (bad) decision.

Yet another factor which affects collaborations was shown to be the *risk* of plausible shifts in ownership or even closure of the business. One energy utility respondent said: “The biggest risk is that the industry will shut down.” The *risk* of an owner shift of the energy utility was also mentioned by the industry as important: “It is an essential factor that the municipality does not go and outsource the energy utility, even though this cannot be included in the agreement.”

In summary, *risk* was shown to be a key factor to take into account regarding a district heating collaboration.

4.2.2. *Imperfect information*

Imperfect information may result in the overlooking of collaborations, due to e.g. lack of information regarding their benefits [25]. Respondents from an energy utility which had experienced failed collaboration stated: “The big thing in this was that they (the industry) did not have knowledge of this...they were out here calculating on their own, they had no external

consultant involved... They based it (the calculation) on natural gas and that is a lack of information which is the energy utility's responsibility to sort out...we negotiated with people who did not know anything about biofuel boilers.” In an industry, lack of competence and knowledge within the company group was also seen as a problem: “...more to do with competence and knowledge...within the company group no one really knows this. No one who has the overall picture and who has the ability to see the overall picture.” According to an energy utility CEO with several successful industry collaborations, competent workers is a very important factor. Yet another factor which was shown to have a catalytic effect in several collaborations was that a university had been involved and built optimization models of the municipality's energy system, including the industry. Based on this, actual monetary benefits with collaboration could be demonstrated by an independent body, i.e. *information imperfections* were effectively minimized. A successful means to cope with *imperfect information* is thus to have an independent body build optimization models where industrial actors are included.

4.2.3. *Asymmetric information*

Asymmetric information is one of the most cited explanations for the non-adoption of energy-efficient solutions. It may be categorized into principal-agent relationships, split incentives, and adverse selection [25]. In one successful case, an energy utility respondent stated: “One problem is when the production manager at an industry wants to keep his guys within the organization – he wants to have the responsibility for the boilers.” In such cases, the timing was shown to be of great importance according to the utility: “*Then it is the timing which is crucial...shifts of staff, retirement and an interest in doing something about the energy situation*”.

One type of *asymmetric information* was shown within a publicly owned energy utility where politicians, being members of the board of directors, pushed the energy utility hard regarding a strict investment calculation in order to establish a new industry in town. The main aim was thus to get the industry to town, not the actual collaboration. In this case, the investment calculations were much slimmed in order to match surrounding municipalities. For example, a 30% subsidy was included in the calculations, despite the fact that it was not yet accepted at the time. Later on, the applied subsidy was denied and the industry was not willing to accept the increased costs which then occurred, and the planned collaboration was terminated on the industry's initiative.

In two cases, reorganizations in industries, where the energy issue responsibility was transferred to an own division or subsidiary company, opened up for collaboration. Two energy utility respondents stated: "The industry split in the middle of the 90s...one part turned out to be responsible for delivery (of energy)...plus the fact that they have set up a facility division..." "The energy issues were not placed last in some operating organization but rather in the facility division, and that is their core competence." A type of *asymmetric information* has thus been observed where control over one's own staff and own heat production has been wished to be kept within one's own organization.

Another type of *asymmetric information* that was found during the interviews was the public sector's governing of the energy issue. As regards environmental permits, this was not shown to be easy: "We had a lot of complications with the environmental permit." In a case where collaboration failed and the industry chose to invest on its own, the environmental permission

process was stated to be unfair according to the energy utility: “We had real difficulty with the County Administrative Board to get a permit, and then the industry gets one in a week.”

Two factors which were found during the interviews to reduce *asymmetric information* were to engage the industry’s staff before collaboration: “The key to success is to include the staff”, an industry respondent said. Also having relatively large premises within the company group helped out: “One thing which enabled us to pursue this within the company group was that we are a large site within the group.”

4.2.4. *Credibility and trust*

Credibility and trust depend on, for example, past experience of information providers and what other actors state regarding the information provider [26]. Informal personal contacts and recommendations have proved more effective at spreading information than books and general written recommendations. If the former are lacking, the information may be neglected. Two energy utility respondents stated: “We are credible when we go out and deliver what we say...when you negotiate with industry, you must know what you are talking about. Otherwise, they see through that immediately...then you must know the language, the business and the technology... Fundamentally, convince them that we are not a municipality – public...but operating with the same conditions as industry.” An interesting notion is that one industry respondent in another municipality said the same thing about the energy utility CEO: “The organization at the district heating plant is extremely professional. He (the energy utility CEO) was exemplary. He was extremely competent. And he had integrity. He stood up for what he said.”

The municipality touch can, as stated previously, sometimes be an inhibiting factor with long decision-making periods etc. An energy utility CEO said: “One has to throw away everything which has to do with municipality thinking.” In other words, the municipality-owned energy utility has more difficulties when it comes to *credibility and trust* than the privately-owned utilities.

4.2.5. *Inertia*

Behavioural research highlights *inertia* as a factor inhibiting energy efficiency [26]. *Inertia* can be summarized thus: change is opposed by an individual or individuals, and this is often justified by rejecting information that challenges the existing order. This may in turn lead to the rejection of opportunities. One energy utility respondent stated: “In the municipality there is sometimes a reluctance to deliver to the industry.” The picture that emerged during the interviews is that collaborations between industry and utilities usually take a long time to achieve: “In 1999 we began negotiations with X (the industry) and it took three years and there were many laps run with the industry... It takes time to establish this kind of collaboration...it’s a long process. We have had contact with X (the industry) for 20 years.” During interview after interview, with both industries and energy utilities, the need to look at the opportunities rather than the threats repeated itself over and over again: “We need to see the possibilities... One should not be satisfied and I believe this is easy among utilities...it has been easy to make money... Then you have to find people on both sides who see the possibilities, who do not defend their position...”

4.2.6. *Values*

The opposite of *inertia* is commitment by individuals and organizations. Environmental *values* among individuals as well as organizations may thus influence collaborations in a positive direction [24]. *Values* regarding the environment and energy are thus an explanatory variable for

the willingness to enter collaborations. The CEO of an energy utility, who previously worked in the private sector, replied as follows to the question of why the energy utility had been so expansive: “It’s because of a motivated CEO. I don’t want to promote myself, but this does matter. X (a CEO in another expansive energy utility) is indeed a role model for me...right now we are exploring the possibility of wind power.” A motivated person is thus of major importance. The same energy utility has, as part of the efforts to enhance partnerships with industry and strengthen the company’s business opportunities, gone beyond the political appointees in the energy utility’s board of directors, and has chosen to bring in two industry representatives: “It is a bit special, our board. Because we have two industrial representatives...they bring a lot of experience to the otherwise politically appointed board.” In one case, an energy utility CEO expressed the following regarding an industry that had previously been difficult to establish cooperation with, but which now has a well-functioning cooperation with the energy utility: “Then they changed the board of directors (at the industry)...a group of younger leaders who understand the environmental focus.”

In collaboration between industry and energy utilities, environmental *values* have proved to be extremely important: “The primary reason why we do like this is the environment... We work not only with profitability, but also with the environment... Energy prices, yes, but the environmental benefits are large – financially it is a zero-sum game. The environment is important.” Statements like this came from both energy utilities and industries. A significant factor which was mentioned from both the energy utility and industry, in a failed collaboration, was that the negotiating parties from the industry came from the corporate headquarters located outside Sweden. During the negotiations, significant differences in what was perceived to be “common”

or “normal” practice at the negotiating table were revealed. Business professionalism was perceived by the corporate headquarters’ representatives to be not so great among the municipality owned energy utility representatives. Both sides’ respondents pointed out the difference in culture as a reason why the negotiations did not work out smoothly: “Then there was the X (a nationality)...X (their nationality) are motivated persons”. In order to overcome *inertia* among individuals and within organizations, it appears that leadership can play a very important role, and in particular the *values* of individuals and organizations.

4.3. *The questionnaire*

Results of the questionnaire are presented in Fig. 1. in the Appendix. Among the high-ranked market-related factors were the desire for reduced costs and the good business relationships with the energy utility. Interesting to note is the large discrepancy between the energy utilities and the industries. While industries value reduced costs significantly higher than the energy utilities, the latter value good business relationships and more effective marketing higher. Responses among the lower-ranked factors also show that the industry is somewhat interested in so-called energy service solutions, in the form of operation and maintenance and third-party financing.

Among the current or previous policy instruments that affect collaboration, it turned out that just one, investment in LIP¹ (Local Investment Program) or KLIMP² (Climate Investment Program), was ranked relatively high. It is interesting that industries generally value the current instruments higher than energy utilities do, as a factor driving the collaboration.

¹ During the years 1998-2002 the Swedish Parliament allocated SEK 6.2 billion in grants with a view to increasing ecological sustainability. A secondary objective was to contribute to employment growth. The program was later named KLIMP.

² The Swedish Parliament allocated during the years 2003-2008 about two billion SEK to support climate investments with the aim of reducing the greenhouse effect.

Fig. 1. Ranked results from the questionnaire of factors affecting collaboration (Always important=1; Often important=0.67; Sometimes important=0.33; Seldom/never important =0.).

Among the various types of policy instruments that do not exist today but which have the potential to be introduced in Swedish industry and energy utilities, an investment subsidy for district heating cooperation was highly ranked. Concessional loans were also ranked relatively high, not least by industry.

Of the six highest-ranked factors, four were in the category of behavioural and organization-related factors. These four were people with real ambition, long-term energy strategy, demand from company owners, and environmental company profile. Highly ranked among the industry representatives were also environmental concerns, such as the threat of increased global warming. Interesting to note is that even here the discrepancy is large between energy utilities' and industries' responses, in particular regarding the existence of people with real ambition. Energy utilities value people with real ambition considerably higher than the industry in order to establish collaboration. In summary, the triangulation using a questionnaire confirmed the findings from the in-depth interviews.

5. Concluding discussion

Results from this paper are derived from a Swedish case study. However, the results may be applicable to other countries' utilities and industries as well, not the least European actors, due to the fact that the EU's energy markets are deregulated. The European countries' utilities and industries have to fulfill the conditions stated by, e.g. the EU directive promotion of the use of energy from renewable sources [32].

5.1. *The technology level*

This paper shows that it is not the technology such as boilers, heat exchangers, pipes, etc., which plays a crucial role in a collaboration. *Heterogeneity* thus proves not to have a significant impact on collaborations. Furthermore, the paper shows that *hidden costs* are not a major factor influencing the decision and negotiations regarding district heating collaborations. Instead, it turned out to be of importance to consider accepting increased overhead costs in order to succeed in the establishment of collaboration. Moreover, the paper shows that *access to capital* was not highlighted by respondents as a significant factor affecting collaboration. In conclusion, the technology and its associated costs, i.e. the technology level, was not shown to be a major factor affecting district heating collaboration.

5.2. *The technology/human level*

In the studied cases, different degrees of *risk aversion* proved crucial in the establishment of collaboration. One thing, among others, which affects the collaboration is whether the energy utility's or industry's boilers are relatively new or require replacement investment, since the latter increases the energy utility's or industry's willingness to take a *risk*. Another factor that positively influences the willingness to take *risks* and engage in collaboration is an industry's decision, before collaboration is initiated, to lift up the energy issue onto a strategic level. An additional factor linked to *risk* and to the energy strategy is business strategy, as the latter is strongly linked to the company's *risk aversion*. In a successful collaboration, the energy utility had for many years taken an ambitious role in linking the major players with their own heating supply to the energy utility. When the boilers among these players were in need of renovation etc., the energy company offered to take over the boilers. In a case where collaboration failed, one industry representative said that the lack of strategy at the energy utility was an obstacle to

collaboration. Further factors affecting collaboration are potential ownership changes and termination of business. One respondent also mentioned collaboration on heat as a way for the municipality to reduce the *risk* of an industry closure. The *risk* that the energy utility will be sold has also been mentioned as an important factor to take into account.

Imperfect information also proved to be crucial, not least in the actual negotiation phase. The importance of the actors having accurate information was shown to be great. A parameter that proved to be a catalyst in several collaborations was the involvement of a university to build optimization models of the local energy system. On this basis, the actual monetary benefits of cooperation could be detected by an independent party. A successful way to overcome problems of *imperfect information* may thus be to involve an independent operator such as a university or even a consultant, building an optimization model that also includes industrial actors' heating loads.

A type of *asymmetric information* which proved to affect collaboration was that the main motive was not cooperation on heat, but the municipality's desire for the industry to be established in its region. When the investment subsidy which was included in the calculation was rejected, the industry pulled out of the co-operation. One factor shown to reduce *asymmetric information*, and open up possibilities for collaboration, arose when the energy issue was delegated to a separate industry division or even a separate facility management company supporting the industry, in which the issue of energy is core competence. Furthermore, it was stated to be important to involve staff in order to enable the industry to enter collaboration – and if the industry was

among the larger ones within its company group, the collaboration turned out to be easier to establish.

As regards *credibility and trust*, being able to demonstrate good skills in both business and technology proved extremely important. Furthermore, to wash off the energy utility's municipal stamp as far as possible, if any exists, was shown to be of importance. For both the energy utility and the industry, it may therefore be sound to involve a third party in the agreement phase.

Inertia among individuals and within organizations was also shown to affect collaborations. The industry sometimes experienced resistance from the energy utility. Furthermore, collaboration between industries and energy utilities usually takes a very long time to achieve. In order to overcome *inertia* among individuals and organizations, it proved important to see the potential for collaboration rather than the problems connected with it. A CEO who is a role model and is motivated, as well as the willingness of the politically appointed board at the energy utility to consider including representatives from industry, has been of positive significance too.

In cooperation between industries and energy utilities, *values* have also proved to be of great importance. Cultural factors are inhibitory and a factor that should be taken into account when negotiating with a counterpart from another culture.

The human factors involved, i.e. on the technology/human level, thus emerge as affecting district heating collaborations more than anything else does. Particularly *risk, imperfect and asymmetric information, credibility and trust, inertia* and *values* are adequate variables when explaining the

establishment or failure of industry-energy utility collaborations, while *heterogeneity*, *access to capital* and *hidden costs* appear to be of lower importance.

In order to increase the validity of the study, the use of a questionnaire for triangulating the results from the in-depth interviews was valuable, and may be suggested to be applied in future research in the area.

A key conclusion from this study is that in an industry-energy utility collaboration, it is essential to nurture the business relationship. What is commonly called personal chemistry has been shown to play a very important role. Establishing collaboration between industry and district heating has more to do with the individuals and organizations involved in the relationship than with the technology used in the collaboration.

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Further work

It is suggested that further studies of successful district heating collaboration be conducted and, not least, studies of collaboration on excess heat, which unfortunately had to be omitted from this study.

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