Prospects
Alingsås Energi 2060
- Sustainable Energy System

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Prospects Alingsås Energi 2060

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Abstract

Alingsås Energi supplies district heating, the used hot water plant was evaluated in 2011. It was a strong urge within the city to find a sustainable pathway for the future. A literature study was performed and an overview was made of different projects and strategies in Sweden. The study leads to six strategically important parameters for the future district heating industry. In the last part of this thesis an evaluation of a possible regional cooperation option vs. local production option is discussed. The conclusion is that Alingsås Energi and Alingsås should be a part of a CHP (combined heat and power) plant in one of the regional options including a transit pipe. This gives Alingsås and the surrounding region, the possibility to contribute to environmental development, supporting an energy neutral vision and provide environmental friendly energy. The regional cooperation option also increases the chances for Alingsås Energi to gain support and development from others with a diversified product portfolio. The energy combine possibility is the biggest challenge and at the same time a huge possibility for Alingsås. This would enhance the status of the whole region and such a regional investment would influence Alingsås society and surrounding region in a positive way in the future.

Keywords:

- future scenario, 2060, district heating, parameters, regional cooperation, energy vision, energy combine
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1 Introduction

Background of this master thesis is described and the targets are defined. Two possible options for the city of Alingsås and Alingsås Energi will be presented.

1.1 Background

Today, more than half of the houses in Sweden are supplied with district heating (Svensk Fjärrvärme, 2011). The adaption of the business to renewable energy sources has contributed to less emissions and less contributions to climate change in Sweden. According to Regeringskansliet the district heating industry is the main reason for reaching the Kyoto protocol aims of emissions, due to the reason that fossil fuel is not used (Sveriges femte nationalrapport om klimatförändringar, 2009).

Sustainable development is stressed presently as the main issue. The grandiose work with lowering the energy usage, changing to renewable raw materials and most important; changing our life style simultaneously is strongly needed. These tasks have to be performed in all levels of society and around the world. The Western World is obliged to help the developing countries and new strategies are needed to be sought for all of us. The importance of a new strategic attitude and new ways of decisions within the energy business is well stated in the report Our common future, 1997, an report made by World Commission on Environment and Development also known as the “Brundtland report”:

“Energy is not so much a single product as a mix of products and services, a mix upon which the welfare of individuals, the sustainable development of nations, and the life-supporting capabilities of the global ecosystem depend. In the past, this mix has been allowed to flow together haphazardly; the proportions dictated by short-term pressures on and short-term goals of governments, institutions, and companies. Energy is too important for its development to continue in such a random manner. A safe, environmentally sound, and economically viable energy pathway that will sustain human progress into the distant future is clearly imperative. It is also possible. But it will require new dimensions of political will and institutional cooperation to achieve it.”

District heating business is an important part of this future and has a common responsibility together with the politicians in this global challenge.

1.2 Alingsås Energi

Alingsås is a small town with about 30 000 inhabitants, which has worked in the area of energy efficiency for a number of years. Among these activities is the Passive house centre where energy efficient buildings are promoted. The hot water plant, a biomass boiler, is currently evaluated. It is a strong urge within the city to find a sustainable pathway in the future and a method to supply heat to the housing is under development.

Today Alingsås Energi distributes district heating, with Statkraft as a partner. Statkraft owns the hot water plant, a grate fired biomass boiler and Alingsås Energi is buying the hot water transferred to the district heating network. The size of the plant is 23 MW (including a 5 MW flue gas condensor) there is also an additional bio oil burner with a capacity of 12 MW oil in Sävelund.
The first alternative if Sävelund has a breakdown is Gjutaren with 32 MW oil boiler. The start-up time is a couple of hours.
Another 18 MW oil boiler is placed in Noltorp, the start-up time here is 48 hours. This will be used if both of the other plants is not working efficiently.
The energy bought in 2008 was 126.5 GWh, and in 2010 the amount was 160.3 GWh (2010 was a cold year), this gives an increase of 26%. When this increase was indicated in autumn 2009 a decision was made to cancel the agreement with Statkraft since the plant has reached its production limit. The biomass part of the fuel is decreased from 96.5 % to 81.4 % in favor of oil combustion which is not acceptable.
Alingsås Energi has done a prognosis for the heat demand until 2030. This can be seen in Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Energy usage /year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>140 GWh</td>
</tr>
<tr>
<td>2015</td>
<td>152 GWh</td>
</tr>
<tr>
<td>2030</td>
<td>180 GWh</td>
</tr>
</tbody>
</table>

*Table 1 Energy usage prognosis*

The cooperation agreement with Statkraft has a term of notice of three years and the cooperation, in its present form, will be ended in autumn 2014. A new solution is sought. The company has two different possibilities to continue, a regional partnership or a local production facility. The target for Alingsås is to make a strategic decision in this area before July 2011.

**Local project options:**
Three different options are suggested for the local solution.

**A** – An additional boiler and condenser to the existing hot water plant.  
Effect: 20 MW heat

**B** – An additional CHP plant including boiler, turbine and condenser.  
Effect: 22 MW heat; Electricity production: 6 MW

**C** – A total new CHP plant, two boilers, one turbine and two condensers  
Effect: 43 MW heat; Electricity production: 11 MW  
The option C boilers are fired with biomass and demolition wood chips.

**Regional project options:**  
The following D and E option are regional options.

**D** – New regional transit pipe from Angered via Gråbo and Sjövik to Alingsås. An regional partner produces all heat needed and transfer it to Alingsås.

**E** – New transit pipe from Angered via Gråbo and Sjövik together with a new combined heat and power plant (CHP) plant in Alingsås. Effect: 100 MW heat; Electricity production: 40 MW; Length pipe: 43.2 km

The new CHP plant in the E-option could transfer district heating in both directions, this could give the possibility to transferring waste heat from Göteborg in summertime and transferring back heat to Göteborg in autumn, winter and spring.


1.3 Thesis target:

The target of this master thesis is to enlighten the different possibilities within the energy system in Alingsås and how they will fit into a future scenario of the city. The work will be performed in two parts.

Part I – Literature study, an overview

How does the Swedish society look like in the year 2060? What scenarios could be possible? How far have Alingsås come with the sustainable city project?

- To investigate what others have done in this area and discuss about which parts that could be applicable for Alingsås.
- To collect current data of the Alingsås energy system

Part II – Prospects Alingsås Energy 2060

- To find the parameters in the energy systems that are important in the long term (50 years and ahead)
- To define future work within this area for Alingsås Energi and Alingsås until 2060

1.4 Thesis structure

The thesis structure is divided in two parts, I - Literature study and II - Prospects Alingsås Energy 2060.

In the first part different projects and future energy strategies of a number of cities studied are described and evaluated. The conclusions about important parameters are made and the reasons behind are stated. To be able to evaluate the importance and possible effects of the different strategies, two scenarios are made up. The scenarios in this thesis are fiction but plausible future scenarios.

In the second part of the report, the chosen energy options from Part I are discussed from the perspective of these parameters. A discussion of which future energy system is the best choice for Alingsås Energi and Alingsås city is presented.
2 District heating industry is changing

This chapter describes some of the changes that district heating industry presently meets. The district heat volume demand is foreseen to decrease in the future compared to today’s level.

2.1 Volume decreases

The district heating industry is suffering from predicted decreased demands and a lack of future expansion possibilities. The reason is mainly depending on higher energy efficiency in the industry, in the private sector as well as in the building industry. When new houses are built, the main focus, today, are on energy saving. The decrease is also dependent of the expected temperature increase. Other reasons are competitive heating sources that are available, like heat pumps, other local heat sources for combustion of pellets or similar. Regardless of these facts, the district heating is expected to increase the number of customers. The customers increase is in the same speed as the settlements, but the problem is that the total usage of energy is decreasing. Other nontechnical aspects are also valid, as where people have their level of comfort, knowledge and interest of the energy situation. Block of flats, self-contained houses and small houses can be included in the district heating net if water based warming system is installed, but it is the owner of the building that decides what kind of heating system that should be used.

Svensk Fjärrvärme is an organisation for the district heating business with approximately 140 members. Svensk Fjärrvärme represents the business in contacts with government, institutions and authorities for examples in reports and other considerations. This organisation has evaluated the growing potential for district heating and this resulted in four areas of volume increase possibilities (Svensk Fjärrvärme AB, 2008)

- Concentration of the existing net
- Establishment of district heating in an increased number of smaller villages
- Increased usage of district heat within the industry
- Increased connection to self-contained houses

All four areas are indicated to be needed to maintain and increase the volumes of today.

2.2 District heating techniques

The decrease of district heat volumes increases the need for new techniques to minimize the production costs etc. The first generation district heating was produced by steam, the second by hot water. Today we have median temperature district heating, Swedish systems are often dimensioned for maximum 100 - 120ºC. The fourth generation is accordingly supposed to use low temperature water. Today there is an application made to International Energy Agency (IEA) where the target is to develop the new generation of district heating systems. DH4G (district heating fourth generation) is the working name of this new technique and water temperatures around 50 – 60 ºC will be the target (Andersson, 2011). The technique of the heating systems in buildings must accordingly be adapted to this development, hot tap water needs to be produced close to the final user to prevent legionella problems. Development of bio refineries, electricity production, production of biofuel and bio based products is strongly connected to the technical development in district heating since the systems often are integrated. Customers future demands is also an important part of district heating future, the inhabitants of Alingsås have a general good knowledge of diverse

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environmental issues today. Since the city is very forward in this area overall, this will most probably result in an increased demand for environmental friendly energy resources. One key to future customers are interaction of environmental techniques and energy sources. All kinds will need to interact, sun, wind, water, heating pumps and district heating etc. The customer’s interest, knowledge and demands in this area will have strong impact on the future for the district heating business. The coming generation is an “everything in order” generation (Andersson, 2011) and with this comes demands of full service and maintenance of the technique used for heating their houses. According to Fastighetsägarnas Jan Thorsson (Energiutblick, 2011) the customer’s needs and/or expectations are:

- Free consultancies and advice of energy issues
- Help with the current technique / installation
- Access to energy usage statistics
- Proposals of complementary energy solutions as solar, wind or other power or other techniques for lowering the energy costs.

These demands are creating big challenges for the energy service companies to build up knowledge of support creating a diversified product portfolio.

### 2.3 Raw material

The accessibility of raw materials is one of the issues that could have impact on development in district heating. Energimyndigheten raises a warning for possible considerable changes in raw materials accessibility due to big increase of waste combustion, increased usage of natural gas and total stop of oil as raw material. Waste heat from the industry seems to be constant despite the growing industry volumes probably depending on the work on energy efficiency. The usage of waste is foreseen to be in the range of 16-18 TWh/year in year 2030, this is an increase from 2007 figures with 8-10 TWh/year. These volumes raise the question of security of supply-thinking when preparing an investment using waste or bio raw material, not only regarding availability but also raw material cost.

### 2.4 Building techniques

Today the building and service sector is using roughly one third of Sweden’s energy usage, which is 140 TWh/year. Focus on energy savings in this sector increases and the incentives can be considerably larger if the political targets that have been presented also should be reached. The energy used in public buildings could be reduced by roughly 10 – 70%, depending on the taken measures. An average value of 25% heat usage reduction in buildings built in the 60th and 70th would result in a reduction which corresponds to roughly 10% of district heating usage in block of flats and roughly 5% of the total usage of district heating.

### 2.5 Energy combine

Energy combine as a concept is built on the idea of using synergic effects between the energy companies and process industry. The purpose is to achieve good energy systems and high utilization of raw material i.e. high utilization of the resources used. The yearly production from CHP (combined heat and power) plants is estimated to increase from 8 TWh to roughly 20 TWh in 2025. The increase is depending mostly of new energy combines in Malmö and Göteborg, increased biomass use for combined CHP plants and waste usage. Energy combines increases the volumes of waste heat and the expansion of district
heating could be possible in combination with lower return temperatures. This in its turn could be positive regarding the usage of straw, solar power and other techniques for district heating supply.

External conditions as energy combine development, different heat and power techniques and the development of alternative heat production is affecting the district heating industry. Integration between district heating system and advanced technical solutions are therefore strongly needed, hopefully this can also result in increased length of district heating nets.

### 2.6 TPA - Third Party Access

During the last years, the district heating industry has had some complaints regarding its strong position compared to its customers. Due to this, the industry is gaining low confidence figures. Other arguments are that the trade is ongoing on local markets with no competition in the nets, i.e. a kind of monopoly trade. The target of the Third Party Access (TPA) report is to strengthen the customer’s choice of supplier and to make a more effective heating market with lower district heating prices possible. Another target is to make it possible for a third party access to the district heating nets, which will lead to a competitive situation and finally a better environment.

The district heating market can, in some aspects, be compared to the market for electricity and distribution, the difference is that the distribution net are local and the district heating supply is strongly dependent on the local conditions. The district heating industry does not have the physical possibilities to be a national energy source and therefore it’s problematic for a third party to really get access to the district heating nets and possibilities to supply energy.

The proposal is based on the following suggestions:

1. Third party access to all nets without exception, giving a competitive situation for both producers and trade.
2. Demands for a distinction between production, distribution and trade of district heating.
3. Price regulation for distribution of energy, the ownership of nets is a natural monopoly.

A schematic figure over the proposal can be seen in Figure 1.

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**Figure 1: Schematics over the competitive market with TPA (SOU, 2011)**
Svensk Fjärrvärme, with Ulrika Jardfelt as CEO, has commented the report. Clear incentives and responsibilities for net extension are needed to secure the benefits of this proposal. Quality demands on waste heat producers for entrance in district nets are needed to make the transition to TPA regulations manageable for the district heating net owners, suppliers and customer today.

The report from Statens Offentliga Utredningar (SOU 2011:44) shows that Göteborg’s district heating net is always under the pressure of regional expansion. One study have been made within the TPA report (Wårell och Söderholm, 2010) regarding possible expansions in Göteborgs district heating net. The report states that the development of the competitive district heating market in Göteborg will most probably be supplier driven to a high grade.

2.7 Marketing and new markets for DH

The district heating industry is generally struggling with low customers confidence mainly due to the reasons discussed above in chapter 2.6. The fundamental target of district heating production is to use resources that otherwise would be wasted, this also implies a strong environment and resource argument for district heating. The future of district heating industry is therefore tightly bound to the need of environmental assessments of district heating and to develop principles, definitions and values in this direction. New market applications can be hot water used for heating of washing machines, dish washers etc. A development/reference villa is constructed and built in Göteborg where all the devices inside are heated with district heating. The technique for this is still unique and expensive but it will be available in the future. Other applications are, for example, industrial processes, slippery free pavements, football arenas and motor ways. The challenge for the companies will be to implement new techniques, services and adapt to the local conditions and inhabitants.
3 Single city projects

This chapter describes future energy strategies for a number of cities in Sweden. Important factors that could be applicable to the Alingsås system are pointed out. Different projects that include district heating have been studied and are discussed.

3.1 Otterbäcken

Vänerply AB, one of Europe’s biggest manufacturers of plywood is located in Otterbäcken, Västra Götaland. There is a need for expansion of the production volume and with that an increased demand of steam and heat. A discussion was initiated between Gullspångs kommun, Biogas Väst, Vänerply AB, Stora Enso Bioenergi AB, Skaraborgs kommunalförbund, Beijer Electronics Automation AB and Vattenfall AB. This resulted in a pre-study of an energy combine placed in Otterbäcken. An overview of the plant can be seen in Figure 2. Vänerply AB would be a customer of the planned energy combine since they use steam and heat.

One of the targets with an energy combine establishment is to contribute to an integrated, environmental friendly and resource effective production by usage of local renewable resources. Another target in this project is to develop the local agriculture and industry in the region and to create permanent and profitable companies together with work openings.

![Figure 2: Planned energy combine Otterbäcken](image)

Through establishment of an energy combine there will be collaboration between the industry and the public sector, this can in the long run result in surplus values as other projects and a better understanding of the different parties interests, requirements and needs. The already established industry and Otterbäcken as society/village will have better possibilities for development also in other fields. Local raw materials should be used to prevent both national and global fluctuations of raw material price. Today there is a strong general interest for using bio fuel and bio raw materials. This has another drawback; it has increased the competition for the bio raw materials. Potential suppliers of raw material are
Stora Enso, Sveaskog and Södra Skogsägarna. Wooden industries can be a supplier of sawdust and bark. The report indicates that the theoretical volume of raw material is big in theory but in practice it is not that much. Firstly due to some practical obstacles to get the raw material and secondly there is a keener competition of the raw material. Otterbäcken is located in the middle of the cereal area of flat lands of Vara, Nerrike and Väse which otherwise gives good possibilities of raw material of cereals.

The logistics possibilities were also evaluated, the planned extensions of E20 is enlightened together with the advantage of the harbour in the lake Vänern. Otterbäcken have the only deep-water harbour in Vänern. This could give good transport possibilities by boat. Transports by road are supported by E20 and RV26.

The disadvantages could be that there is no district heating net in Otterbäcken which means no user of heat is available except Vänerply. Another drawback is that there are no industry establishments in the neighbourhood in a foreseeable future.

**Important energy system parameters found in Otterbäcken**

Specific parameters that can be pointed out from Otterbäcken project:

- Industrial symbiosis – this is a situation that is positive as long as the advantages can be used for all the companies involved.
- Region development – for the regional development the investment are positive, both in real estates, technique and people.
- Contribution to environmental development – this is done with all the invested bio gas technique.

### 3.2 Borås

Borås Energi och Miljö has an overall vision which has grown through the years: A fossil fuel free town. They started to build up a system for waste handling and combustion of waste. This system has allowed Borås to, step by step, increase the value of waste into electricity and heat. Their business concept is to offer adjusted solutions to each customer within the energy-waste- and environmental area. The target is, with help of science, development and education to be the driving force of infra-structure for waste handling and combustion in the future. The field of activities are district heating, district cooling, biogas, waste handling, drainage and water supply together with energy services.

In February 2011, an cooperation started between Borås Energi och Miljö and Uddevalla Energi regarding an energy service tool named KeepAnEye. This makes it possible to supervise all the media used (district heating, district cooling, water and electricity) hour by hour. Uddevalla Energi and Borås Energi och Miljö will share the development of this tool in the future. There is also a pre study on-going regarding an energy combine in Borås.

**Important energy system parameters found in Borås**

- The city has a vision of a fossil fuel free town and has built a system to be able to develop the city in the direction of this vision.
- Diversified product portfolio is a good base for both customer relation and economy when district heating volumes is getting lower.
• Contribution to environmental development - Borås Energi and Miljö is working together with Borås University supporting the development in this area and gaining new knowledge.
• Planned Energy combine

3.3 Norrköping
"Norrköpings energy system" is a concept, which includes all handling of raw materials, internal and external distribution and utilization of energy within the geographical area of Norrköping. Norrköping have a target for this system, it should be effective, only use renewable sources, be robust and manage the increased stresses from a changing climate. Physical climate stresses could be storms, cloudburst and other weather phenomena. Socio economic stresses could be increased price of the raw materials, instability in the rest of the world and streams of refuges to Sweden and Norrköping. Industriell symbiosis i.e. cooperation between close by companies, as illustrated in Figure 3, are one of the interesting strategies in Norrköping. Here are several parts of society taking advantage of each other’s products and surplus materials.

An example is EON which is producing electricity and steam. Steam is transported to Lantmännens Agroetanol which in its turn send their surplus product (drank) to Svensk Biogas and the farmers in the close by area. Econova gets ash from EON and produces bio fuel and send back waste to EON for combustion. This cooperation is possible to make if the companies are willing to invest their business models to interact with each other.

![Figure 3 Industrial symbiosis, Source: Energikombinat EON](image)

**Important energy system parameters found in Norrköping**
• Industrial symbiosis – cooperation’s between companies exists and is working well.
• Diversified product portfolio – giving opportunities for companies and customers.
• System flexibility – Norrköping tries to be prepared for the future by preparing a robust system
• Energy combine – giving flexibility and other opportunities
3.4 Helsingborg
Helsingborg has an overall vision: “The energy neutral area” This indicates that an equal amount of energy used in the region should be equal to the transformed energy inside the same region. The energy utilization should be effective and the supply sustainable and varied. The raw material used are locally produced which gives a robust system, both for energy supply and transport possibilities. The district heating net is connected to other villages net in a grid which results in robust system and higher energy efficiency. Increased part internal produced electricity gives a less vulnerable area around Helsingborg. Increased electricity production also increases raw material efficiency. Security of supply is one of the fundamental blocks in EU’s energy strategy. Energy combine could be a possibility to exclude the oil usage in the transport sector and the nature gas in the industry sector. The combine gasifies biomass to methane with heat as a surplus product. Bio gas and bio methane gives a sustainable future system in Helsingborg.

Important parameters found in Helsingborg
- Energy neutral region – the energy utilized in the region should come from local sources.
- Local electricity production – gives a robust system in case of time of higher stresses in the future for the region.
- System vulnerability – a thinking of robust systems gives higher system stability for coming harsh times.
- Future energy combine gives flexibility to the system and also increases the possibilities for the energy neutral region.

The parameters from the projects above will be further discussed in chapter six.
4 Regional cooperation projects

This chapter describes different energy strategies for a number of regional cooperation projects in Sweden. Important factors that could be applicable to Alingsås system are discussed.

4.1 Helsingborg – Ängelholm

Öresundskraft provides Helsingborg, Ängelholm, Råå, Ödåkra, Laröd, Vittarp, Vejbystrand och Hjärnap with district heating. The district heating net in Ängelholm is 150 km and connected with the Helsingborg district heating net. An overview of the district heating net can be seen in Figure 4.

The company is labelled with “Bra Miljöval”. This is one of the main arguments which Öresundskraft uses when advertising the district heating as a service to the customers. It is stated that the production of district heating cannot be on the expense of the ecological variability or social, cultural or economical welfare. Öresundskraft is the 9th district heating company in Sweden that is connected to “Bra Miljöval” in Sweden, this is a strategic choice of marketing the environmental friendly energy. There are 150 district heating companies in Sweden. They are producing district heating with combustion of biomass.

4.2 Linköping – Mjölby

Tekniska Verken, Linköping and Mjölby Svartådalen Energi in Mjölby initiated a cooperation to find a common solution for the future energy supply. A biomass based combined heat and power plant of 150 MW will be located between the two cities. Because of the large district heating net grid a plant with higher efficiency is possible. The transit pipe between the cities
was once the longest in Sweden. A pilot study is started to investigate the possibilities for this project.

The location of the plant is settled between Linköping and Mjölby, given the advantage of fewer disturbances for the inhabitant, this provides as well the logistics advantage according to the CEO’s of Tekniska Verken and MSE. The strategy is to build regional cooperation’s for diverse services i.e. not only district heating. Electricity and broadband is also included in the service portfolio since before, an electricity commerce company and broadband, Bixia. The future target is to include all the municipalities around Linköping.

“-This project gives us the opportunity to develop the region further than we could have done by working alone” says Anders Jonsson, CEO of Tekniska Verken.

4.3 Linköping – Norrköping

Linköping and Norrköping have cooperation where the climate issue has been identified as a strategically joint action. This has led to a common climate vision which include several strategically steps.

At a workshop together with the climate commission three key concepts were established (Norrköpings Energiplan 2009-2030, 2009):

- New renewable energy sources
- High energy efficiency
- Use sustainable thinking for all issues in society.

This workshop leads to that Norrköping and Linköping have a municipal cooperation and a common goal: “The climate smart region”. Target is to stop global and local influence on the climate. All municipal activities are done with the following in focus on climate issues and the goal to adapt the society to future climate changes. The transport and energy systems are one issue in this matter, so as purchasing situations when demands on climate and environment issues should be made. The two cities is also trying to increase the climate engagement overall and communicate the issue and also support entrepreneurship within environmental engineering. By having the same goal the two cities can inspire and help each other during the way.

4.4 Important parameters

Following important parameters are found in the discussed projects above and these will be discussed in chapter 6:

- Regional cooperation gives advantages
- Common projects – gives higher utilization of the resources
- System vulnerability – “robust thinking”
- Diversified product portfolio – gives a broader supply to the customers and a more stable region
5 Scenarios of Alingsås, Sweden in year 2060

In this chapter, two future scenarios of the world and Alingsås situation in 2060 are presented. The comparison of the alternatives for Alingsås Energi will be related to and discussed in relation with these two scenarios.

5.1 World scenarios 2060

In a master thesis named G2060 (Metso F., 2011) two future scenarios are invented and described, one is optimistic and the other pessimistic, see Figure 5. With these two scenarios as a base, adapted versions are made to fit Alingsås city in 2060, see Figure 6. From the different perspectives of the pessimistic (A) and optimistic (B) scenario the chosen parameters could be evaluated.

![Scenarios 2060 - World](source: Fredrik Metso, G2060)

**Figure 5: World scenario. Source: Fredrik Metso, G2060**

5.2 Scenario A – a pessimistic future

The climate in 2060 is warmer than ever before, the temperature has increased 10 degrees in the last 50 years. Sea level is rising due to melting glaciers and biodiversity in the world has decreased in general. Also in Sweden the temperature increase has created problems, even if the situation is a lot better here than in southern Europe. Africa and Asia is suffering of severe deforestation, which has led to expanded deserts and large areas are nowadays inhabitable. The small fraction of oil and gas that still remains is a source of great difficulties to the local people, due to armed conflicts. The exploitation of land areas during the search for new energy sources has led to severe reduction of biodiversity, this in its turn leads to desert conditions.
expansion and ecological system breakdown. There is no longer, for example, the needed number of bees, flies and birds to pollinate different plants. This is followed by lower harvests volumes which lead to poverty in the end. Massive movements of people have therefore occurred from these areas.

Figure 6: Alingsås adapted scenario map 2060

During this period Swedish society somehow collapsed, depending on the climate change. The infrastructure as electricity, water and district heating net became eventually unreliable and suffered of break down. People in Alingsås are living in the areas of the city where the buildings are still liveable after the flooding of Säveån. The inhabitants have to produce whatever is needed. People live mostly in groups for sharing the available resources, and also to get the protection given by many. Some people live in collective farms outside Alingsås together with other families. In this way, they get help during the daily life.

There is no such thing as global communication left, this means no or very small interaction with the outside world. The climate refugees who immigrating to Sweden are the exception, they travel with hope for a better life up in the north.

Fuel for vehicles is rare these days and the railroads are not available for traffic anymore. Even if some parts of the rail are still at place, no fuel is available to run the trains. Transports are instead made by foot, bicycling and some small motor driven vehicles. Some animal riding also occurs. The energy needed is coming from sun, wind, water and small local biofuel plants in general. Part of a combined heat and power production plant in Alingsås was destroyed some years ago but was repaired and a small part of the district heating net is still in...
use. Since there is a shortage of raw material for the CHP plant it produces at the moment mostly electricity and heat in wintertime. Due to the harsh times also known dangerous substances for both human and nature are used in the system in these days. Nuclear waste is a source for interest due to the high energy it still contains even if it’s deadly for the environment and the people that process it. The people of Sweden have been forced to change their way of living in a harsh way.

5.3 Scenario B – a positive future

The climate in 2060s is stabilized even if there are still storms and hurricanes more frequently than for 50 years ago. Indeed the global warming has stopped and the GHG (Greenhouse gases) levels have decreased. Biodiversity has increased in the last decades due to massive investments in new technique and nature development projects. The possibility for mankind to live and work in symbiosis with nature has now increased dramatically.

Global investments are made to stop the environmental pollution by using renewable energy. Sweden is one of the countries which have been a forerunner in this area. National decisions have been taken with a global horizon and this has been of vital importance. This has led to a good foundation from an environmental point of view.

Alingsås is a fully developed city today, with a complete renewable system for all the resources that are used, both by industry and by the inhabitants of Alingsås. Energy saving techniques (as Passive house techniques) is used when new small houses and apartment blocks are built or restored. Sun cells, water power, hydrogen gas, battery and hydrogen energy production are commonly used and the systems are integrated.

People are living in well insulated houses which decrease the energy demand. Bio fuels are used and people are living in cities with fewer cars. The changed life style gives people a chance to spend more time on other things than work.

Climate and war refugees have together contributed the increase of population in Sweden. The cities have grown accordingly, even if more people are living at the country side now, side by side with land and forest. The climate change issue that was raised 50 years ago has resulted in that more people have an urge to live close to nature and in a symbiosis with the same.

Fruit, spices and coffee is still imported with bio fuel driven boat or air ships from foreign countries. Market trade is widely used to sell the locally produced food, Västra Götaland region produces mostly of the needed food within the immediate surroundings. The technical level has increased dramatically. On land, water and in the air, biofuel driven vehicles are trafficking people and supplies from one part of the world to another. At the same time oil as raw material is still a minor part of the used raw materials. We have passed on to other renewable supplies even if oil and gas still are available to the market.

The railroad through Alingsås gives an advantage to the region due to logistic possibilities for products and raw material transports in and out from Alingsås. Göteborg harbour is the largest in the country with 65% of the container export in Sweden and Alingsås uses water freight for exports. The investment level has been high and has increased in the last years within the environmental technique and this has led to opportunities for Alingsås industry. The energy combine that was installed 40 years ago is still running and produces electricity and biofuels. Ethanol and biogas is supplied to the Göteborg and Alingsås area. Other products for the inhabitants such as district heating, district cooling and energy service are available for the district heating net customers. It has also after the implementation given other surplus effects for the area such as technological and processing skills. This big investment did attract other
investors to invest in Alingsås and today Alingsås Energi Service is expanding their idea of an energy service package kit for the inhabitants of Alingsås.
6 Important parameters - Alingsås system applications

This chapter summarize and discuss the parameters that are outlined in chapter three and four. The base of the discussion are the scenarios in chapter 5, A and B. The discussion will end up with specific parameters which are predicted to have impact for Alingsås Energi in the next 50 years.

6.1 Region development

If the pessimistic scenario A will be realized in 2060, then Alingsås inhabitants will have problems with energy and food supply. This leads to a focus on local solutions in the future. Gardens for vegetables and farms for meat and raw materials for the energy supply are needed. The techniques for buildings and energy need to be robust and simple. For scenario A the “region development” parameter will be the immediate surroundings around Alingsås, roughly 10-15 km radius and therefore a more local thinking and development will be more beneficial. This small region will have to provide the city and the inhabitants with the needed resources. Occasional transports will occur to other areas or cities but not on a daily basis. Cooperation with others regions are essential, however in the pessimistic scenario this could be problematic to carry through in an optimal way.

For scenario B the strategy for region development will be different. The climate is stabilized, the technical development have reached the level of a secure and sustainable supply of food and raw materials. Cooperation with other regions gives development possibilities and strengthens the region and its inhabitants. Investment cost and experience could be shared and the difficulties in a project could be minimized. The bonds between the regions would be strong and valuable in this scenario, where the globalization is strong and the competitiveness high.

The region development is supposed to mean cooperation between cities and regions for roughly 100 – 150 km apart. The regional cooperation parameter seems to be most beneficial for Alingsås in the positive B scenario.

6.2 Contribution to environmental development

The development of district heating supply is strongly connected to the environment issue by its low emission versus heat supplied. Usage of district heating is therefore a strong contribution to environmental development, when renewable raw material for combustion is used. All parts of the society, especially companies and people in the energy supply business, have a responsibility to increase and update the environmental technical level of society wherever possible and needed.

CDM (Clean Development Mechanism) is a project under the Kyoto protocol, and the target is to prevent that increased economic growth do not result in growth of environmental pollution. Another project target is to let the industrial countries, which have joined the agreement of reducing carbon dioxide emissions, invest in projects in developing countries to reduce GHG emissions in these countries instead of in their own countries.

The parameter Contribution to environmental development is important and a duty for Alingsås Energi and is valid for both future scenarios.

6.3 Diversified product portfolio

The need of a diversified product portfolio is dependent of peoples change in lifestyle, actions and attitudes. The urge from the inhabitants to have a small house with a garden forces the city to grow in the direction from the city centre, counter act the wish of concentration for
district heating net. The technical solutions must be adapted to the global climate issues but also to the local surroundings and demands. The product portfolio will become more and more important in the future for energy companies. People are getting more and more interested in a total renewable energy supply for their homes and the need for interaction of heating sources will increase. This means that total energy services and coordination between electricity, district heating, district cooling, heat pump energies, wind and water power supply etc. are wanted and needed in the future. One specific solution for one specific customer is required. Diversified product portfolios are of importance for any scenario. This is one key to success for district heating companies for any future.

6.4 Security of supply

The accessibility to energy in every form is essential in any scenario, this is obvious. Not only in electrically heated houses but also for other heating systems, where a lack of energy supply could lead to evacuation of people. The heating system in the district heating houses have a little advantage due to self-circulation in the system, which means that you still have heating possibilities, even if lacking electricity.

Liability principal
Central in the Swedish crisis management is the fundamental principle of liability which includes all the actors within energy supply, (Energimyndigheten, 2010). The meaning of this principle is that the responsible for a business during normal circumstances is also responsible during a crisis. The crisis management is dependent of the fact that authorities, organisations and companies are working together. The problem occurs if the energy supply is reduced dramatically, then might the inhabitant’s life be on stake and therefore must the energy system be robust and withstand extreme situations. Investigations have shown that the inhabitants meaning is that the energy companies, authorities and the government, in that order, have responsibility of secure supply of energy.

Energy distributions risks
A fire, flooding or sabotage in the district heating supply followed by a prolonged interruption in district heating supply can lead to difficulties in the local society. The economic cost for frozen piping in buildings can be very high. The climate change will in its turn create a necessity for all the actors within the energy system to improve their ability to withstand climate related risks and crisis.

The Swedish capacity for electricity production increases and also the awareness of the dependency between electricity distribution and heat supply. The possibility of importing electricity during winter is low. This information gives at hand that security of supply is of great importance independent of which scenario we will meet.

6.5 Expansion of district heating net

Expansion of the district heating net is one of the important parameters for the company profitability and is one of the parameters that Svensk Fjärrvärme is foreseen to have impact on the future volumes. This will give the customers, that is not yet connected to district heating, along the net the possibility to do this. In both scenarios this will be of interest, independent of the future scenario is the expansion an on-going and never ending story for all district heating companies. This parameter is therefore evaluated as of not specific interest in the investigation for the future for district heating, even if it has some influences in contribution to environmental development.
6.6 **Energy neutral**

Energy neutral means that a region (big or small) transforms the same volume of energy that is utilized in the same region. This is not excluding import or export of any kind it is simply a calculation of energy figures and a way of calculating an energy equilibrium state. This will help to even out the energy balance with nature. The idea of an energy neutral region is a good starting point for further development of district heating.
For scenario A this parameter will probably be of great importance due to the few resources at hand. The energy neutral thinking has hopefully helped to achieve the good B scenario to reduce and optimize the energy production and use. This parameter is therefore equally important as independent of the type of scenario that lies ahead.

6.7 **Electricity production**

Electricity production and availability is of extreme importance. Liability of the energy supply whatever kind is based on the electricity production and distribution robustness. Without electricity the modern society that we know of today is knocked out. Alingsås city and their inhabitant is dependent of electricity. With the Swedish crisis management fundamental principle of liability in mind (described in chapter 6.4) it is given by hand that electricity production should be the focus in both future scenarios!

6.8 **Energy combine / Industrial symbiosis**

The energy combine parameter is a bit more complicated than the others since this one requires a high technical level, for both the technique itself and the companies or industry net around it. The requirements for logistics like raw material supply, transport and distribution of product possibilities as well as the end use of the products should be highly developed and available. This is hardly found in the rough scenario A. Despite this fact it is strongly emphasised that this parameter should be included in this discussion of important parameters!

Integrated systems and the gained knowledge give stronger interaction and a more stable system. As the Otterbäcken pre study shows, an establishment of an energy combine in the long run result in surplus values like other projects and a better understanding of the different parties’ interests, requirements and needs.

An energy combine increases the raw material efficiency by using the cooperation between different companies. This seems to be one of the fundamental positive strategic steps for a company. When the heat or other products from a combined heat and power plant can be used in the industry then the environmental result can be brilliant. The cost for district heating production can decrease, so is the energy cost for the industry and the CO\textsubscript{2} emissions can be lowered.

A drawback could be, in the case of crisis of any kind, that the energy combine or industrial symbiosis not could be utilized due to technical problem or break-down for one of the parts. This however is strongly connected to which level of robustness the system has and what kind of crisis it is. In case of one or more production lines in the energy combine plant are working during the crisis this can be of great importance for city and its inhabitants.

Alingsås has more to win than to lose in this respect and the conclusion is therefore that energy combine will be one of the strategic important parameters to focus on.
7 Conclusion Part I

In this chapter a summary of the important parameters is made and the targets of Part II will be settled.

7.1 The strategically important parameters

After the literature study and evaluation of the chosen projects and cities, the strategically important parameters for the future are:

- Contribution to environmental development
- Electricity production
- Energy neutral
- Security of supply
- Diversified product portfolio
- Energy combine/Industrial symbiosis

The parameters above are important for both the pessimistic and optimistic future scenario and therefore valid for Alingsås Energi in the next 50 years. The CHP plants in general were chosen due to the parameter electrical production. The parameters security of supply and energy neutral is strongly bonded and had also an impact on the decision.

7.2 The chosen options for Part II

After evaluation of the literature study two targets for part II were settled.

- An evaluation of the regional cooperation should be done, with the six strategically important parameters in mind
- To determine which alternative of C (local CHP plant) and E (regional CHP plant) that is the best from the viewpoint of Alingsås city

In chapter five, two future scenarios were presented, both of them rather extreme. The reality will most likely be a mix of these two. The scenario B, where the world will enter an optimistic future, is chosen in this thesis to have bigger impact that the crisis scenario A. The back casting method and perspective is used as a base for this choice. This implies that a desirable future scenario is established and the present situation, with known trends etc, will be adjusted toward the desired scenario.
8 Evaluation of the regional cooperation option

An evaluation of option E (CHP plant + transit pipe) will be done with the chosen parameters found as a base and the arguments for this cooperation will be stated.

8.1 Survey of the transit piping

A regional cooperation will include two or more companies and cities working together. Some of the targets will be to increase the district heating net, develop the region, companies and to strengthen district heating industry.

A transit pipe for district heating can be planned to be established between Alingsås and Göteborg for connection to the district heating net in Göteborg. Through Gråbo and Sjövik there is an embankment by road 190 to bring up the transit pipe, see Figure 7. The total length of this pipe should be roughly 40 km and go west and north of the lake Mjörn to Alingsås city. This pipe extension will increase the district heating connections by giving the opportunity of connections to inhabitants in Gråbo, Sjövik etc. A planned pipe south and east of Mjörn may give higher possibilities to increase the number of connections due to higher population in Partille, Lerum and Floda. Partille and Lerum have an existing district heating net today though. On the other hand, Göteborg is most probably growing east from Surte and Kungälv towards Gråbo and Sjövik in a not so far future, since the sea is stopping a growth in the west side.

8.2 Discussion

The transit pipe and with it the increased district heating net will give higher plant efficiency. When including an energy combine, this constellation will give an even higher utilization of the raw material. Today, one of the common established views of wood chips is that the first
priority should be to produce products (biofuel) second should be to produce heat. But research is done in this area to optimize the wood chips volume from our forests in a more effective ways without disturbing the forest industry and the forests itself. The CHP plant investment increases the development level in Alingsås, both for new investors of other companies, students or other persons that thinking about moving to Alingsås. Establishment of district heating in an increased number of smaller villages was one strategy to increase the volumes according to Svensk Fjärrvärme (Svensk Fjärrvärme AB, 2008). This will be a possibility if a transit pipe project will be carried through. Partnership is another way to increase both knowledge and integration of the technical systems. It could also create synergy effects between the companies such areas as products, service strategy etc.

![Figure 8 District heating net Göteborg](image)

Increasing the security of supply level for energy is one of the main reasons to include electricity production in Alingsås. This strategy is also decreases the need for electricity production elsewhere and one step forward to the energy neutral region. The electricity production itself is also decreasing the need of offset of heat inside the plant.

The close distance between Göteborg and Alingsås gives a lot of opportunities for industrial symbiosis in a future scenario. If the transit pipe option will be realized a new possible business area west of Mjörn will be a reality. This will be an opportunity for new industrial hotels, new establishments and new hot water suppliers and give more opportunities for industrial symbiosis. The companies will maintain the district heating system and their collaboration, which in its turn will strengthen the system itself.

Since the importance of a diversified product portfolio cannot be of more importance it is supposed that the collaboration with another company in this area is preferable. The influence of TPA is today very uncertain but nevertheless the strength of a region development is high and collaboration with another company will increase the possibility for Alingsås Energi to share the discussions of which services can be most practical and profitable in the future.
Most probably Alingsås Energi will be exposed for competition in their district heating net in the future even if they are not choosing the regional option today.

Göteborg city is expected to have a need for three energy combines in the future, one in the south, north and east of the city; this will preferably be connected to today’s district heating net which can be seen in Figure 8. The eastern plant, with a transit pipe, could be a future possibility of also transporting other products than heat from and to Alingsås.

Power produced from energy combines will increase in the future. Energimyndigheten foresee an increase of 8 TWh until 2025. A rough estimation would raise this figure roughly to, in total figures, 50 TWh in year 2060. From a logistic point of view, Alingsås have advantages compared to Göteborg. This could easily be planned in Alingsås with E20 and the railroad going through the city, even a dead end rail could be connected to the energy combine.

The combined CHP with a transit pipe i.e. the regional option will greatly increase the chances for Alingsås to have an energy combine in the future. A future partner in this area, together with the research and development possibilities, could be profitable for Alingsås Energi and Alingsås city. The main target should be an energy combine.

When choosing the regional option all of the four areas of growing potential for district heating can be fulfilled – all of them advantage for Alingsås Energi:

- Concentration of the existing net.
- Establishment of district heating in a increased number of smaller villages
- Increased usage of district heat within the industry
- Increased connection to self-contained house
9 Evaluation of the C option – Local CHP plant
This chapter will describe the evaluation of the local production option, a new CHP plant with two boilers.

The C option includes only a local CHP plant investment (all the options are described in chapter 1.2). Compared with the regional option the plant efficiency vs. raw material will be lower.

One of the raw materials, the demolition wood waste, is not so commonly used in Sweden today. In this area there will be possible to increase the common knowledge. From this aspect is the demolition wood waste usage an advantage for the environment.

Regarding electricity production, the advantages is almost the same as for the regional option. Electricity is one of the basic needs in our society, without electricity almost everything will stop and the security of supply is one of the reasons to include electricity production in the investment.

![Real price for biomass fuel to district heating plants in Sweden](image)

**Figure 9** Real price for biomass fuel Sweden. Source: Sven Werner

A CHP plant will decrease the need of electrical energy import from other areas and contribute to an energy neutral region. The usage of demolition wood waste will give Alingsås Energi a more flexible system with two types of raw materials for the CHP plant. Accordingly the cost for this secondary fuel will, at present, be roughly half the price of ordinary wood chips, Figure 9. This will strengthen the security of supply strategy and also support the robustness of the system. A partner is needed to realize the scenario of an energy combine in Alingsås. Since great expertise and also investment are needed, Alingsås Energi will have problems to handle this project alone.
10 Conclusion and future work

The best choice for Alingsås city is the regional cooperation, including a prestudy of investment possibilities for an energy combine. The main reason for this statement is that the energy combine could be realized if cooperation between industry and the public sector would be done over the communities. This would develop the whole area around the city and increase the “PR status” of the same. Alingsås has a logistic benefit compared to Göteborg, due to the transport possibilities of E20 and railway through Alingsås and the city also have an overall better traffic situation, this would benefit also the local region. The regional cooperation is beneficial in other areas as well, like common development in energy products. The increased district heating connections done with a transit pipe will open up the area between Surte, Kungälv and Alingsås for industry expansion and new villages. Göteborg will most certainly grow east. This leads to the conclusion that the single city project not to be favourable in this evaluation.

The conclusion is therefore to focus on the regional option E for Alingsås city and Alingsås Energi. An combined heat and power plant with an including prestudy to investigate the possibilities for an energy combine. A natural step toward this direction would be to work out a strategy for this, with one or several nearby municipalities. In the discussion regarding the energy combine a common energy strategy for the region could be included and the figures for the future need of bio fuels western part of Sweden could be settled.

For Alingsås Energi one idea could be to investigate the possibilities of creating an interaction between local energy sources. This ought to be done together with local energy companies to get a broader knowledge and a wider service area to Alingsås customers. Also the technical side of interaction between different energy sources are interesting and should be investigated. To continue in this direction and for marketing the technique a reference villa should be built in Alingsås, a passive house with district heating as energy source for dish washer, dryer, washing machine etc. District heating could, for example, be warming up a greenhouse, garage drive way or the pool. Solar panels and wind energy could be connected to the house for electricity production. By these measures Alingsås would create an advantage for the inhabitants locally by showing the possibilities of how renewable new techniques could be integrated with district heating technique in their daily life to be, more or less, self-supported in energy and food.

Sweden is suffering of high biofuel prices and low availability today. There is a national need for increased variety of energy sources as biofuels, increased volumes and gas stations etc. Alingsås has today a unique opportunity to prepare the city and the region for the future.

“But it will require new dimensions of political will and institutional cooperation to achieve it.” (Our common future, 1997)
References

Reports

Gullspångs kommun, Värnerply AB Stora Enso Bioenergi AB Skaraborgs kommunalförbund Beijer Electronics Automation AB Vattenfall AB, 2009, Förstudie för energikombinat Otterbäcken, Gullspång, Report Number 001:10 2010-02-12

Metso F., 2011, G2060, Göteborg University, Göteborg


Wårell, L. och Söderholm, P. (2010), ”Tredjepartstillträde till fjärrvärmenäten i tre svenska kommuner”, konsultrapport från Luleå tekniska universitet på uppdrag av TPA-utredningen, oktober 2010

Internet
Access: 201105-01

www.energimyndigheten.se

www.goteborgenergi.se/Om_oss/Hallbar_utveckling/Forskning_och_utveckling
Access: 2011-03-31

www.un-documents.net/ocf-02.htm#I

Magazines
Part II – Prospects Alingsås Energi 2060

Publications
EON, 2009, Energikombinat_RGB.pdf, EON 2009.09


Tekniska verken publikation, 2010, Projektmeddelande: Regionalt milöjprojekt inlett, Linköping

Interviews
Björn Malbert Sustainable Urban Development, Göteborg university
Sven Werner Energy technology, Halmstad University
Anders Kyrkander Passive house center, Alingsås

Other
Energiutblick, Göteborg, 2011