# PreVent

# - Study of the energy use at Oy Prevex Ab

Simon Kula

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**BACHELOR'S THESIS**
Author: Simon Kula
Degree Programme: Environmental Engineering, Vaasa
Supervisors: Mats Borg, Novia University of Applied Sciences and Kim Westerlund, Edupower Oy Ab

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**Summary**

This thesis work is an energy audit, an analysis of the energy consumption with action suggestions and profitability calculations, for the company Oy Prevex Ab. The energy audit follows the general principles in executing an energy audit. The scope of the work is limited to the facilities of the company and its heating systems, electrical systems and water consumption. The production and its machinery are excluded from the audit. One of the key factors in the energy audit is the district heat consumption. The company has high peaks in district heat consumption and one main target is to investigate the reasons and the possibility to limit these peaks.

The project started with collecting the overall consumption and then splitting it into different processes by calculating and measuring the processes. The data was analysed and based on the analysis action suggestions were presented. The profitability of the action suggestions was calculated. Most focus was put on district heat consuming processes within the company. The result of the energy audit is that cost and energy can be saved with a reasonably low investment.

In conclusion, very significant saving possibilities have been identified and if the suggested actions are carried out, the company will save a significant amount of costs. These actions are believed to lower the high peaks in district heat consumption. In addition, the energy audit project itself and the result from the project woke the interest in energy-related questions and saving energy, within the company's staff.

Language: English Key words: energy audit, energy consumption, savings potential

**EXAMENSARBETE**

Författare: Simon Kula

Utbildningsprogram och ort: Environmental Engineering, Vasa

Handledare: Mats Borg, Novia University of Applied Sciences och Kim Westerlund, Edupower Oy Ab

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## Abstrakt

Detta lärdomsprov är en energikartläggning, en analys av energiförbrukningen med åtgärdsförslag och lönsamhetsberäkningar, för företaget Oy Prevex Ab. Energikartläggningen följer de allmänna direktiven för genomförandet av en energikartläggning. Omfattningen av arbetet är begränsad till företagets byggnader, dess uppvärmningssystem, elsystem och vattenförbrukning. Produktionen och dess maskiner är uteslutna ur kartläggningen. En av nyckelfaktorerna i energikartläggningen är fjärrvärmeförbrukningen. Företaget har höga pikar i fjärrvärmeförbrukningen och ett av de huvudsakliga målen är att undersöka orsakerna och möjligheterna att utjämna dessa pikar.

Projektet startade med att samla in data över den övergripande förbrukningen och därefter dela upp i olika processer genom att beräkna och mäta dessa processer. Data analyserades och baserat på denna analys presenterades åtgärdsförslag. Lönsamheten för dessa åtgärdsförslag beräknades. Mest tyngd sattes på de fjärrvärmeförbrukande processerna inom företaget. Resultatet av energikartläggningen är att både kostnad och energi kan sparas med rimlig investering.

Sammanfattande har mycket betydande sparpotential blivit identifierad och om åtgärdsförslagen förverkligas, kommer företaget att spara betydande kostnader. Åtgärdsförlagen bedöms också sänka pikarna i fjärrvärmeförbrukningen. Ytterligare har själva energikartläggningsprojektet och dess resultat väckt intresse för energirelaterade frågor och att spara energi, hos företagets anställda.

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Språk: Engelska Nyckelord: energikartläggning, energianvändning, sparpotential

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OPINNÄYTETYÖ

Tekijä: Simon Kula

Koulutusohjelma ja paikkakunta: Environmental Engineering, Vaasa

Ohjaajat: Mats Borg, Novia University of Applied Sciences ja Kim Westerlund, Edupower Oy Ab

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**Tiivistelmä**

Tämä opinnäytetyö on energiakartoitus, analyysi energiakulutuksesta toimenpide-ehdotuksilla ja kannattavuuslaskelmilla, yhtiölle Oy Prevex Ab. Energiakartoitus seuraa yleisiä ohjeita energiakartoituksen toteuttamisesta. Työn laajuus on rajoitettu yhtiön rakennuksiin, niiden lämmitysjärjestelmiin, sähköjärjestelmiin ja veden kulutukseen. Tuotanto ja sen konekanta ovat erotettuja kartoituksesta. Yksi avaintekijöistä kartoituksessa on kaukolämmön kulutus. Yhtiöllä on korkeita kaukolämmön kulutuspiikkejä ja yksi ensisijaisista tavoitteista on tutkia syyt ja mahdollisuudet tasoittaa nämä piikit.

Projekti alkoi keräämällä kokonaisvaltaisen kulutuksen ja seuraavaksi jakamalla prosesseja osiin laskemalla tai mittaamalla niitä. Dataa analysoitiin ja analysoinnin perusteella esitettiin toimenpide-ehdotuksia . Ehdotettujen toimenpiteiden kannattavuus laskettiin. Yhtiön kaukolämpöä kuluttaviin prosesseihin panostettiin eniten. Energiakartoituksen tulos näyttää, että sekä kuluja että energiaa voidaan säästää kohtuullisella sijoituksella.

Yhteenvetona hyvin merkittäviä säästömahdollisuuksia on tunnistettu ja jos ehdotetut toimenpiteet toteutetaan, yhtiö tulee säästämään merkittävä määrä kustannuksia. Toimenpideehdotukset uskotaan myös laskevan kaukolämpökulutuspiikit. Lisäksi itse energiakartoitusprojekti ja sen tulokset ovat herättäneet kiinnostusta energiakysymyksiin ja säästämään energiaa yhtiön työntekijöiden keskuudessa.

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Kieli: Englanti Avainsanat: energiakartoitus, energiankulutus, säästöpotentiaali

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# 1 Introduction

## 1.1 Background and goal

Oy Prevex Ab (Prevex) is a member of the KWH-Group, founded in 1955, and one of the oldest plastic working companies in Finland. The company is a leading supplier of siphons for kitchens and bathrooms in Europe.

Edupower Oy Ab (EduPower) is an innovative company located in the energy cluster of Vaasa with operations in energy and company development. A big part of the operations are export. EduPower works in cooperation with industry and higher education for example with operational development thesis work and expert tasks in energy economics.

Prevex was contacted by EduPower in search of a thesis project. Discussions about an energy audit took place and based on the discussions a project was offered by EduPower to which Prevex responded positively. A kick-off meeting took place where the roles in the project were decided. The goal of the project is to create/carry out an energy audit including an action plan with profitability calculations. A further goal is to lower the specific energy consumption of the company.

This energy audit follows the general principles in executing an energy audit, but is limited to some extent. The whole energy consumption of the company is analysed and split down, by calculating and measuring some specific energy consuming activities decided by the customer and the executers of the energy audit. Since this is a thesis work, the frames of the project needed to be set. Only a few of the processes in the company are taken into consideration, most focus is put on the consumption of the facilities, achieving useful energy savings and cost savings results. The production machinery in the company is not taken into consideration.

## 1.2 Structure of the report

Chapter 2 gives further information of the project. In this chapter the problem in the project is presented.

Chapter 3 presents previous research done in the field and also research done within the company.

Chapter 4 presents the methods of executing an energy audit. It explains the energy audit on a general level.

Chapter 5 presents the executed energy audit, done by the thesis worker, in detail.

Chapter 6 presents the conclusions made by the thesis worker, of the energy audit project.

Chapter 7 presents the references to this project.

## 1.3 The execution group of the project

The execution group of the project consists of the thesis worker, the contact person of the customer and the support team of EduPower. On the customer side a great number of persons including the contact person and others have been of tremendous help with distributing material and otherwise supporting the thesis worker.

## 1.4 The role of the thesis worker in the project

The role of the thesis worker is the main executor of the project. Novia University of Applied Sciences provides the formal advisor from their side as always.

# 2 The problem

The main problem is that at the company the peaks in district heat power exceed the power limit set by the district heat distributor, Nykarleby Kraftverk. During discussions it was found out that the local energy distributor has made a demand on Prevex to lower their peak power in district heat or the basic charge will rise.  Overall the energy consumption at the company is pretty high, and therefore also the bills are high. Because of this the energy audit project was created. The energy auditor’s job is to find out reasons why the peaks are so high, collect the energy consumption data, like electricity, district heat and water consumption data, analyse the consumption, make action suggestions on how to save energy and costs and calculate the profitability of these actions.

The general problem with energy consumption in buildings is that the consumers are unaware of or simply don’t care about their consumption. In households the consumers pay their bills without thinking about the opportunities of saving energy and costs. Concerning industrial buildings and their consumption, the companies prioritise other projects before energy saving projects. The problem is that the consumers do not see the opportunities in saving both energy and money. Even if the savings figures are put in front of them, they still might not prioritise their investments in saving energy. Another problem concerning company consumers is the lack of resources to put on energy savings projects.

# 3 Previous research

## 3.1 Previous research regarding methods

The methodology of carrying out energy audits has been developed on a national and EU level. When the focus on energy saving and energy auditing has strengthened, the need to standardize methods was realized. A number of different auditing models have been developed and implemented in a multitude of audits spanning over a wide variety of business sectors.

For example Motiva has created several models for energy auditing. Motiva has a model for Industrial energy audit. Other models are Building Energy Inspection, Building Energy Audit, Industrial Energy Analysis, Process Industry Energy Analysis, Power Plant Energy Analysis, District Heating Energy Audit, Post-acceptance Audit, Follow-up Energy Audit, and Energy Audit for the Logistic Chain. The market in energy auditing is very strong at the moment and there are many companies who execute them due to this. On Motiva's web-page a list of qualified energy auditors can be found. Motiva also organizes basic and follow-up training for energy auditors. /1/ /2/

Motiva has also listed savings potential for SME companies based on the different energy audits done in Finland.

***"SME energy use below 10 GWh/a***

*Between 1992-2009 altogether 539 facilities in the SME sector were audited, whose joint annual overall energy use is over 1 770 GWh. The saving potentials of heating energy and fuel in these facilities has on average been 24% (c 226 GWh/a), the saving potentials of electrical energy about 8% (c 65 GWh/a) and the saving potentials of water about 12% (c 0.6 million m3).*

***SME energy use between 10-70 GWh/a***

*Between 1992-2009 altogether 201 facilities in the SME sector were audited, whose joint annual overall energy use is over 5 000 GWh. The saving potentials of heating energy and fuel in these facilities has on average been 21% (c 586 GWh/a), the saving potentials of electricity about 6% (c 135 GWh/a) and the saving potentials of water about 7% (c 2.3 million m3).*

***SME energy use between 70-500 GWh/a***

*Between 1992-2009 only 33 of these facilities in the SME sector were audited. The emphasis of the energy audits in this category of the SME sector is for the most part clearly under 70 GWh a year concerning the facilities' energy consumption. The saving potentials of heating energy and fuel in these facilities has on average been 12% (c 450 GWh/a), the saving potentials of electrical energy about 4% (c 51 GWh/a) and the saving potentials of water about 10% (c 1.5 million m3)."* /3/

There is also a savings potential list by sector. The list is presented in Appendix 1.

## 3.2 Previous research regarding energy auditing for this target

Before the current project one other energy audit project has been done at Prevex. The previous audit took place between 29.9.2006 and 30.6.2007 and was executed by WSP Environmental Oy. During this period oil and direct electricity were used as heating sources. The company has not taken action on most of the energy saving suggestions and therefore some of the suggestions have been analyzed and developed in this report.

# 4 Methods – execution of energy auditing

This chapter explains the steps in an energy audit.

Energy auditing is an investigation on where, when, how and why energy is used in a facility, to identify the opportunities to improve efficiency. The main goal of an energy audit is to suggest energy saving actions and present their savings potential, with profitability calculations. “*An energy audit, therefore, is a detailed examination of a facility’s energy uses and costs that generates recommendations to reduce those uses and costs by implementing equipment and operational changes.”* /4/

The execution of an energy audit is done through cooperation between field experts and the customer. The customer appoints a contact person from among its staff to support the energy auditor.

## 4.1 Inspection of the target and its energy systems

The first step in an energy audit is to perform a physical assessment of the facility and investigate the energy systems used. The first step is getting data on building sizes, age of the buildings and number of people living/working in the buildings. Then, perform an inspection of the buildings’ key elements, like construction details and making an inventory on heating and cooling systems, like what heating system is used at the company and how the heat is distributed in the facility. What electricity system is used in the facility, where it is bought from, who is the distributor and how is it distributed within the facility. Who is the distributor of water and who handles the purification of the sewer water. /5/

## 4.2 Collection of data

The next step in an energy audit is to perform an evaluation on preliminary energy use. This is done through examining utility data, electricity consumption, energy consumption of heating system and water consumption. It is advisable that the energy auditor collects and reviews at least the two past years, preferably three years, of utility data to be able to account for seasonal variations and especially the pattern of energy consumption. The most common method of collecting the data is to read the bills of purchased energy to get an overview. The data from bills are often on a monthly basis, to get more specific data there are different alternatives. If the local energy provider has online services it is also possible to get the information from there. For example district heat and electric companies often have online services where you can log in and get statistics of the consumption. Depending on the service it is possible to get data on an hourly, daily, monthly or annual basis.

A further step is to investigate energy consuming activities, like lighting, ventilation, production (in industrial buildings) which are either measured or calculated. To get exact data on for example some operations within the building, like the amount of energy a part of the lighting consumes, measuring is required. The data is then exported using software.

The customer should inform the energy auditor about previous energy audits if there are any. /6/

## 4.3 Analyzing the data

After collecting the data the analysis of the energy and cost begins. From the data gotten, it is possible to make the first conclusions. Using spreadsheets for analysing the data is very common. The spreadsheets account for variation in time of day and season and made in hourly, daily, monthly and annual forms, for easier analysis. The heating energy is often compared with the outside temperature to be able to account for the seasonal changes, to see if there are changes in energy consumption due to changes in outside temperature.

The calculated or measured consumption of the different activities within the building is then analysed. From the calculations on the different activities it is easy to see which of them are consuming the most energy. This analysis can also be done with measuring devises.

From the data it is possible to make the first conclusions. With the help of diagrams it is easy to, for example, identify the top levels of the consumption. To lower the top-levels of the consumption can save costs. By analysing this data it is only possible to make assumptions on which activities use the most energy.

With real-time measuring it is possible to analyse the consumption even further. By measuring the energy of different actions within the company it is easy to find out which activities consume more than others and which activities to focus on. /6/

## 4.4 Action plan

Based on the analysis different actions for saving energy are investigated. Questions like, “what can be done to save energy?”, “how do we do it?” and “what are the best solutions?” get answers. These actions can be from changing working routines, optimizing heating systems to replacing old devices. The goal in an energy audit is to save energy and without actions it is impossible to save energy. The action plan serves as a guideline for the customer in their path to lower energy consumption. The action suggestions are prioritised according to profitability.

Some easy non-costing actions can be to lower the indoor temperature for saving heating costs. Regarding electricity e.g. not leaving any devices, like TVs or computers, on standby is an easy non-costing action. Checking the running hours of the ventilation systems will also save electricity costs.

Some small actions that have some costs are for example replacing old fridges, old washing machines or dish washing machines, in households, with new low energy consuming ones. Checking the condition and cleaning the ventilation systems save electricity costs. Maintenance of the equipment or machines in industrial facilities is important both for functional reasons and energy reasons. A well functioning machine for example consumes less energy than a poorly functioning machine.

More expensive investments like replacing the heating systems are also often presented, especially if the current heating system is oil heating or direct electricity. /7/

## 4.5 Savings potential with profitability calculations

Savings potentials on the different action suggestions are calculated with investment costs and profitability calculations. There are several different profitability calculation methods, present value, future value, equivalent annual cost, accounting rate of return, internal rate of return and the payback method. In this report, only the payback method is used.

**The payback method** has two different methods:

*Simple payback*, which refers to the time in years required to pay back an investment. For example an investment cost of 2000 € which saves 500 €/year has a payback time of 4 years.

$$\text{Time} = \frac{\text{Investmen}}{\text{savings}} \quad \Rightarrow \quad \frac{2000}{500} = 4 \text{ years}$$

*Payback considering interest* is the payback time for the investment cost with adding an interest to the annual savings, present value. An example of the Payback considering interest with 10% interest is presented in Table 1.

**Table 1** Payback method considering interest

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| Savings (€) | -2000 | 500 | 500 | 500 | 500 | 500 | 500 | 500 |
| Present value (€) | -2000 | 454 | 413 | 376 | 342 | 310 | 282 | 257 |
| Accumulated value (€) | -2000 | -1546 | -1133 | -757 | -415 | -105 | 177 | 434 |

The table shows that the investment cost with an interest of 10% would be paid back in the 6th year after investing. /8/

## 4.6 Report

The general rule in projects is that what is not documented does not exist. The end goal is to present the findings resulting from the inspection of the target in a report. The report also serves as a guide for the customer in the decision making on which actions to take in order to save energy and costs. "*Any audit report should provide enough information to allow you to make informed decisions about next steps to meet your energy savings and financial goals"* /6/

# 5 The energy audit

The current energy audit project, named PreVent, was executed during the period 10.9.2013 – 10.4.2014. Some of the data in this report is confidential, like total energy consumption, energy prices and energy costs. The data is presented in appendices. For the same reason the cost savings calculations are presented in appendices.

## 5.1 Description of the target

A description of the company, its buildings and its different systems like heating systems and electricity systems is presented in this chapter.

### 5.1.1 The company

Prevex was founded, as mentioned, in 1955 and has made siphons for kitchens and bathrooms since 1971. The company is a member of the KWH Group and is one of the leading suppliers of siphons in Europe. They invest every year significantly in R&D and constantly reduce the environmental impact of their products by minimizing the steps in their production process. /9/

### 5.1.2 The buildings

Prevex operates in 5 buildings of which one is an office building, presented in Figure 1 with naming for all the different areas within the buildings.

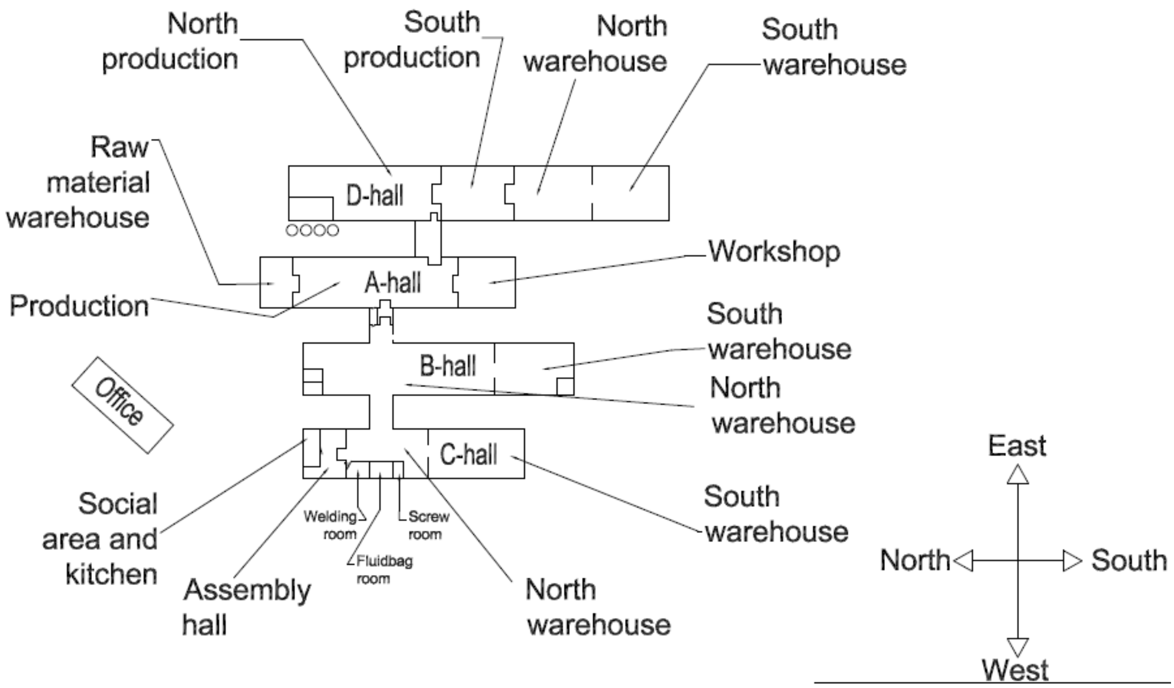



**Figure 1.** Overview of the factory area.

**A-building**

The A-building, which is a production-hall, was built in 1974 and extended the first time in 1989 and the second time in 1994. There are also office, social and dressing rooms in the building. The building has a small warehouse in the north end and a workshop in the south end.

**B-building**

The B-building is a warehouse building and was built in 1979. The building was extended in 2008. There is a small office section in the north end of the building and in the south end a space for charging the forklifts.

**C-building**

The C-building was built in 1989 and extended in 1999. The building has an assembly area divided into one big room, called assembly hall, and 3 small rooms, called the welding room, the Fluid-bag room and the screw room. There is also a warehouse in this building and a social area with a kitchen and dressing rooms.

**D-building**

The D-building is a combined production hall and warehouse building. There are office, conference and dressing rooms in the building. The building was built in 1998 and extended in 2002.

**The area of the buildings**

The area of the different company buildings is presented in Table 2.

**Table 2. Area of the buildings.**

| Building | A | B | C | D | Office |
|---|---|---|---|---|---|
| Area | 3035 $m^2$ | 3083 $m^2$ | 2482 $m^2$ | 4821 $m^2$ | 195 $m^2$ |

The total area of all the buildings is **13616 $m^2$**.

### 5.1.3 Working hours

The working hours in the different buildings are presented below. The workers work in different shifts depending on what job description the worker has. There are workers who work only during day-time, some work in two shifts, some work in three shifts and some work in 5 shifts.

**A-building**

Production: Sunday 22:00 – Friday 22:00
Workshop: Monday – Friday 07:00 – 15:30

**B-building**

| | |
|---|---|
| Warehouse: | Monday – Friday 07:00 – 15:30 |
| Office: | Monday – Friday 08:00 – 16:00 |

**C-building**

| | |
|---|---|
| Assembly-hall: | Monday – Friday 06:00 – 22:00 (07:00 – 15:30) |
| Warehouse: | Monday – Friday 07:00 – 15:30 |

**D-building**

| | |
|---|---|
| Production: | 24/7 |

Office workers have flexible eight hour work days.

## 5.2 System descriptions

The different systems used at Prevex are presented in this chapter, like heating system, electricity system, water and sewer system and ventilation system. There are three main heat sources used at Prevex, district heating, direct electricity and air to air heat pumps.

### 5.2.1 Heating system

In September 2009 Prevex was connected to the district heat system owned by Nykarleby Kraftverk. Before the installation oil heating was used. Besides the district heat, direct electricity and heat pumps are used, and heat from the processes is utilized to heat the production areas. Heat from the compressor in building D is used to heat the warehouse, while the compressors in building A only heat the room they are located in. Heat from the cooling compressors is distributed to the exhaust air to heat buildings A and D.

**District heating**

The district heating plant is dimensioned for a large-scale production and distribution under controlled forms. The plant is a multi-fuel plant and the heat is produced with solid bio-fuel, like peat and wood chips. Heavy oil is used only during colder weather and during maintenance of the plant. The district heat network is 7.3 km long and the plant provides heat to 60 different customers, of which most are apartment buildings and buildings owned by the municipality. /10/

The maximum power of the district heat at Prevex is set to 300 kW. The agreement from Nykarleby Kraftverk’s side ends at the heat exchanger and the strainer. There is also a consumption meter that Nykarleby Kraftverk owns. The installation of the unit, which is owned by Prevex, was done by the company Ouman.

**Direct electricity**

There are electric radiators in every building, mainly located in social and office rooms.

## Heat pumps

There are 10 heat pumps installed in both the assembly area and social area of the C-building. Specifics about the heat pumps are listed in Table 3.

There are six Mitsubishi G-Inverter MSZ-GE35VAH heat pumps installed in the assembly hall that are all controlled with one remote control, which means that the workers are not supposed to control the heat pumps separately. Both the welding room and the Fluid-bag room have one Toshiba RAS-B10GKVP-E installed. The kitchen has two Mitsubishi Kirigamine MSZ-FD35VABH heat pumps installed.

**Table 3.** Information on the heat pumps

| **Model** | **Unit** | **Mitsubishi MSZ-GE35VAH** | **Toshiba RAS-B10GKVP-E** | **Mitsubishi MSZ-FD35VABH** |
|---|---|---|---|---|
| Heating power | kW | 1.6 - 5.3 (4.0) | 5.8 (max) | 1.3 - 6.6 (4.0) |
| Outside temp range | ˚C | (-)25 - (+)24 | (-)25 - (+)24 | (-)25 - (+)24 |
| Cooling power | kW | 1.1 - 4.0 (3.5) | 3.5 (max) | 0.8 - 4.0 (3.5) |
| Outside temp range | ˚C | (-)10 - (+)46 | (+)5 - (+)43 | (-)10 - (+)46 |
| Power input heating | kW | 0.955 | 0.71 | 0.84 |
| Power input cooling | kW | 0.865 | 0.55 | 0.835 |
| Indoor unit dimensions | mm | 295 x 798 x 232 | 250 x 790 x 215 | 752 x 897 x 592 |
| Outdoor unit dimensions | mm | 550 x 800 x 285 | 550 x 780 x 290 | 550 x 800 x 285 |
| Air flow indoor unit heating | $m^3/h$ | 246 - 690 | 632 (max) | 282 - 750 |
| Air flow indoor unit cooling | $m^3/h$ | 246 - 762 | 565 (max) | 282 - 750 |
| Air flow outdoor unit heating | $m^3/h$ | 2088 | | |
| Air flow outdoor unit cooling | $m^3/h$ | 2178 | | |

/11/ /12/ /13/

## Distribution within the buildings

Buildings A and D are heated with district heat and excess heat from the machines.

The district heat is distributed in buildings A and D to the air supply and to circulated heat fans through water circulated heat. During summer times the incoming air of the same buildings is cooled. The cooling is needed because otherwise there may be condensing issues with the tools in the machines.

During production, buildings A and D are partly heated with excess heat from the cooling compressors as well as from the plastic moulding machines, distributed via the ventilation system.

The heat distributed via the ventilation system is transferred via the heat recovery system.

Buildings C and B are heated with direct electricity and air to air heat pumps. During summer times, the heat pumps cool the building.

The office building is heated with electric radiators and exhaust air heat pumps.

### 5.2.2 Electricity system

The electricity is bought from Vattenfall and distributed by Nykarleby Kraftverk.

The factory is connected to the 20 kV network. The transfer fee is divided in day/night electricity and is based on the power. The sales tariff is set according to the price of Nordpool Spot Finland.

**Lighting**

For high bay lighting the company uses fluorescent lights and floodlights. The lights are presented in Table 4.

Fluorescent lights:

**Table 4.** Specifics on the lights used at the company.

| Model | Specralux (warm/cold) | Airam | Treston | Philips |
|---|---|---|---|---|
| Power | 58/58 W | 58 W | 36 W | 49 W |
| luminous flux | 5200/5000 lm | - | 3350 lm | - |
| Length | 1500/1500 mm | 1500 mm | 1200 mm | 1500 mm |

Flood lights:

Two types, 250 W and 400 W

The smaller fluorescent lights are not taken into consideration in this report because they are located in office areas and the lighting investigation is limited to the factory side of the company. The electricity consumption of the lighting has been calculated in chapter 5.4.2.

**Air compressors**

Compressed air is produced by three different air compressors. Two of them are located in building A in a separate room and one is located in the warehouse of building D. The models, their power and pressure are listed below.

Building A:

Kaeser BSD 72 (37 kW, 7-8 bar)

Kaeser AS 44 (30 kW, 7-8 bar)

Building D:

Kaeser ASD 47T (25 kW, 7-8 bar)

The Kaeser BSD 72 air compressor in building A is used the most and the Kaeser ASD 47T air compressor in building D and the Kaeser AS 44 air compressor in building A are used as back-up compressors at times when production requires it. The compressor in building D is also used to heat the warehouse and the heat from the two compressors in building A is not utilized but distributed outside and to the cold room they are located in. The running hours and consumption of the air compressors are calculated.

**Socket boxes for heating the car engines**

On the parking lot there are 33 socket boxes for heating car engines. The boxes are pretty old and they are controlled from the electrical switchboard with timers. During inspection the running hours were checked. The running hours for the boxes are 04:00 – 07:30, 10:00 – 18:00 and 20:00 – 22:30.

### 5.2.3 Water and sewer system

Prevex is connected to the water pipe system owned by Nykarleby Kraftverk. Purification of the waste water is done by the water treatment plant in Jakobstad.

There are three meters measuring the water consumption at the company. One is located in the office building, one in building C and one in building A. The meter in building A is read every quarter of a year and the two other meters are read very seldom, when the owner of the water pipe system has time to do it.

### 5.2.4 Ventilation system

In building A there are two air supply units, one for the production and warehouse area and one for the workshop. The incoming air is heated by utilizing the heat produced by the cooling compressors. For the production area there are two exhaust fans, one for the machines and one for the building. For the workshop there is one exhaust fan. The ventilation system for the production area is running during production when the cooling compressors are running. The ventilation system in the workshop is running according to the working hours.

There is one small air supply/exhaust unit in building B for the office area. The unit runs during office hours.

In building C there are two units, one for the assembly hall, the welding room, the Fluidbag room and the screw room and one for the social area and the kitchen. In this building there is one supply fan and one exhaust fan for each unit. The running hours of these units are presented in Table 5.

In the north part of building D there are two air supply units and one separate exhaust unit. One air supply unit is for the production area and one is for the social and the office rooms. The exhaust unit is for the production area of the building. The air is heated and cooled with district heat. In addition to the exhaust unit there are two exhaust fans for the machines and one exhaust fan for the social and office rooms. In the south part of the building there are two air supply units, one for the production area and warehouse and one for the social and office rooms. There is one exhaust fan for the production area, one for the machines, one for the technical area, one for the transformer and one for the social and office rooms. The ventilation system in building D is running all the time. The models and the running hours of the units are presented in Table 5.

Many of the ventilation units have been renewed recently. The ventilation system in the production and warehouse area of building A was installed in 1986 and has not been renewed since, but the workshop ventilation system in the same building was renewed in 2013. The ventilation system in the office area in building B was installed in 2013. Before, there was no ventilation in the office area. The system in building C was renewed in 2013. The ventilation system in the south production area in building D was installed in 2008. Before 2008 the ventilation system in the north end of the building was used for the whole building. The ventilation systems all have heat recovery.

**Table 5.** Models and running hours of the ventilation units

| Building | Area | Type | Model | Running hours |
|---|---|---|---|---|
| **A** | Workshop | Air supply unit | Systemair DVCompact 20 | Monday – Friday 07:00 – 16:00 |
| **A** | Production | Air supply unit | Koja Heli-4 | Sunday 21:00 – Friday 22:00 |
| **B** | Office | Air supply unit | Deekax DIVK 300-D | Monday – Friday 07:00 – 16:00 |
| **C** | Social rooms & Kitchen | Air supply unit | Systemair Topvex TX-06 | Monday – Friday 05:00 – 22:00 |
| **C** | Assembly hall + 3 rooms | Air supply unit | Systemair DVCompact 20 | Monday – Friday 05:00 – 22:00 half-speed 22:00 – 05:00 |
| **D** | North production | Air supply unit | Mastervent WUDA160MJ/4-8 | Monday 0:00 – Friday 23:59 full speed Saturday 0:00 – Sunday 23:59 half speed |
| **D** | Social rooms & office rooms | Air supply unit | Mastervent UDA90SZ/4-8 | 06:30 – 17:00 full speed 17:00 – 06:30 half speed |
| **D** | North production | Air exhaust unit | Mastervent WUDA100LJ/4-8 | Monday 0:00 – Saturday 0:00 full speed Saturday 0:00 – Monday 0:00 half speed |

## 5.3 Collection of data

The data was collected through reading bills and through collecting data from online services. Both Nykarleby Kraftverk and Vattenfall have online services. To log in to Nykarleby Kraftverk's online service is simple. A consumption location ID and a customer number are needed, both of which can be found on the bills. From the website it is easy to get both electricity and district heat consumption. The site also has tables with the consumption compared to the temperature, and the data can be exported to spreadsheets. /14/ /15/

To log in to Vattenfall's online-service is a bit more difficult. On the website a registration is required. The registration was done together with the chief of staff. This website has more detailed data on the electricity consumption than the data from Nykarleby Kraftverk, the former including daily consumption.

Measurements were also done on three of the heat pumps in the C-building to get electricity consumption data.

### 5.3.1 District heating

The district heat consumption is collected through exporting data from Nykarleby Kraftverk's online service and through reading bills. The cost data is collected through reading bills. The consumption on the online service differs a bit from the consumption on the bills. /14/

The person responsible for district heating in Nykarleby Kraftverk was contacted to collect power reports. The data was exported to spreadsheets and provided to the thesis worker by Nykarleby Kraftverk. /16/

### 5.3.2 Electricity

The electricity consumption was also collected through reading bills and exporting data from online services. In this case data was collected from both Vattenfall's and Nykarleby Kraftverk's online service. In addition Prevex has made power reports which are also used for collecting the data. The data in Nykarleby Kraftverk's online service is not that detailed since they are the distributor of the electricity. More detailed data was found in Vattenfall's online service. /14/ /15/

### 5.3.3 Water

The water consumption is collected through reading bills and by reading the meters in building C and the office building.

### 5.3.4 Temperature

Since both district heat and electricity (heat pumps) consumption is very much in relation to the outside temperature, temperature data was also collected. It is collected from Nykarleby Kraftverk's on-line service. The monthly and annual average temperature is presented in Table 6. /14/

**Table 6.** Monthly average temperature in ˚C for the years 2010 - 2013

| | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|
| **Jan** | -14 | -7 | -7 | -6 |
| **Feb** | -13 | -14 | -9 | -4 |
| **Mar** | -8 | -5 | -1 | -8 |
| **Apr** | 1 | 2 | 1 | 2 |
| **Maj** | 8 | 7 | 8 | 13 |
| **Jun** | 10 | 13 | 12 | 16 |
| **Jul** | 17 | 15 | 13 | 17 |
| **Aug** | 13 | 13 | 12 | 16 |
| **Sep** | 8 | 11 | 10 | 11 |
| **Okt** | 3 | 3 | 3 | 5 |
| **Nov** | -4 | 2 | 2 | 2 |
| **Dec** | -12 | 0 | -10 | 0 |
| **Annual** | **0.8** | **3.3** | **2.8** | **5.3** |

## 5.4 Energy consumption of the target

In an energy audit it is recommended to present consumption data from the past three years. In this report, data from the years 2011, 2012 and 2013 are presented, unless otherwise mentioned. The running hours of the different processes in the company are calculated with 251 work days/year. The number of work days per year is different from year to year, so it was decided to use the number of work days in 2013, which was 251 days. Weekends and holidays are not calculated in the work days per year. In building D where production is running 24/7 the number of workdays is calculated with 24 h * 365 days. It was decided to count for all the days in the year. Since the number of days when there is no production is so few, these days are negligible.

No separate energy consumption calculations have been made for the office building, because the target of this energy audit was set to be on the factory buildings and the energy consuming operations within these buildings. The office building is included in the total energy consumption of the company, including electricity and water consumption.

### 5.4.1 Heating systems

**District heating**

Despite the recommendation of presenting consumption data from the past three years it was decided it is relevant to show data from the beginning of 2010 since installation of the district heat took place in September 2009. The data from 2009 is excluded because there is data only from a few months and it can therefore not be compared to the other years. The annual consumption for the years 2010 – 2013 and the monthly consumption for the year 2013, compared with the temperature, are presented in Diagram 1 and Diagram 2. Due to confidentiality the charts are presented without axis scale for consumption data. The district heat consumption data per year and month for the years 2010 - 2013 is presented in a spreadsheet in Appendix 2.

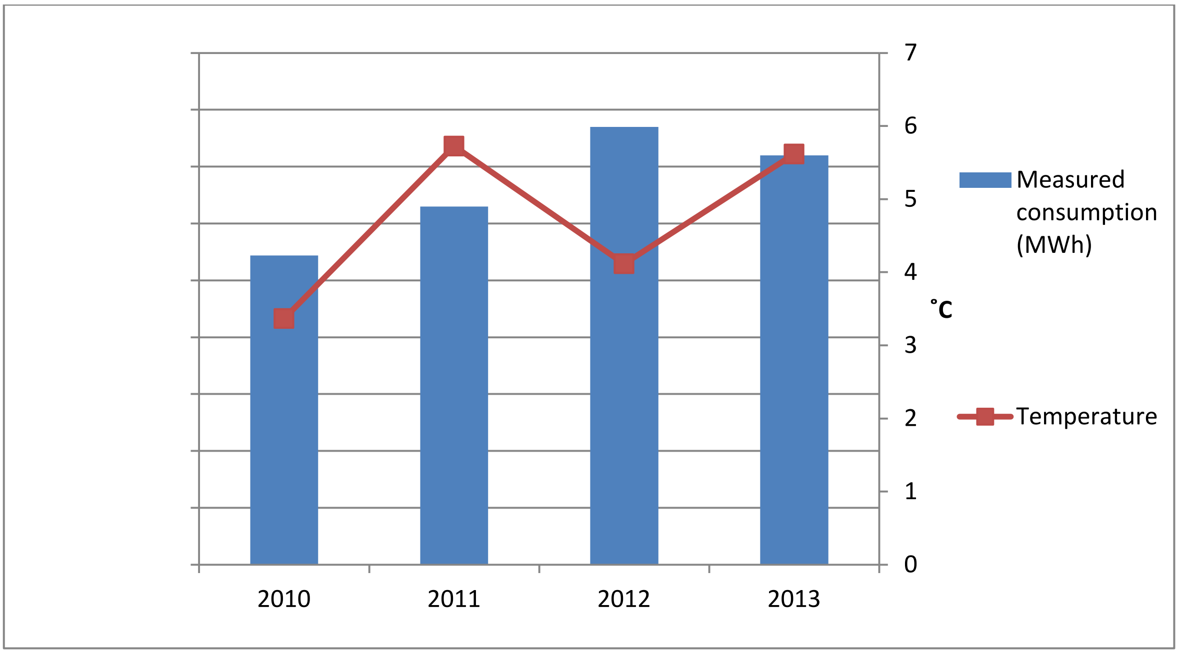



**Diagram 1.** Annual district heat consumption for the years 2010 – 2013 compared with the outside temperature

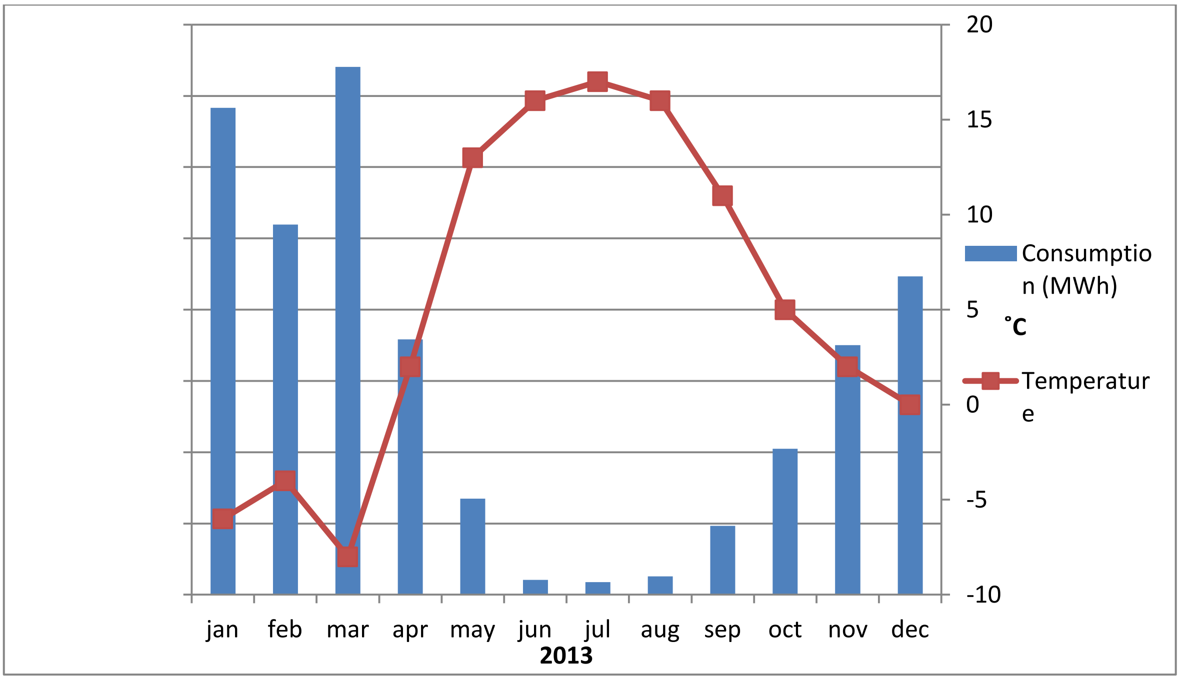



**Diagram 2.** Monthly district heat consumption of the year 2013 compared with the outside temperature

The annual district heat consumption compared to the temperatures in the winter months, October – March is also presented in Diagram 3.

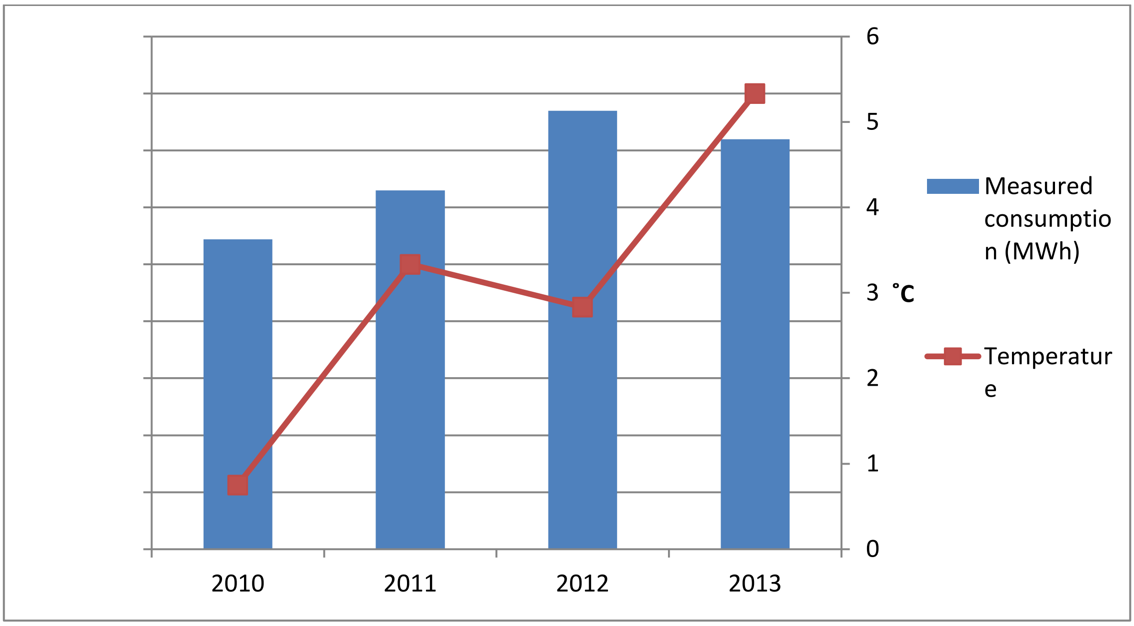



**Diagram 3.** The annual district heat consumption for the years 2010 - 2013 compared with the winter months' outside temperature

The more detailed information collected from Nykarleby Kraftverk shows the changes in power on an hourly basis. Because of the large amount of data, some specific periods have been chosen and presented in Diagram 4, Diagram 5 and Diagram 6. The power shown in the tables are compared to the outside temperature. The data of the power is, however, not shown because of confidentiality. The power data of the specific periods is also presented in a spreadsheet in Appendix 3.

The different periods are chosen because of the difference in how the district heat supply changes from very low temperature to semi-low temperature. Also a chosen period from each year is important in the analysis phase.

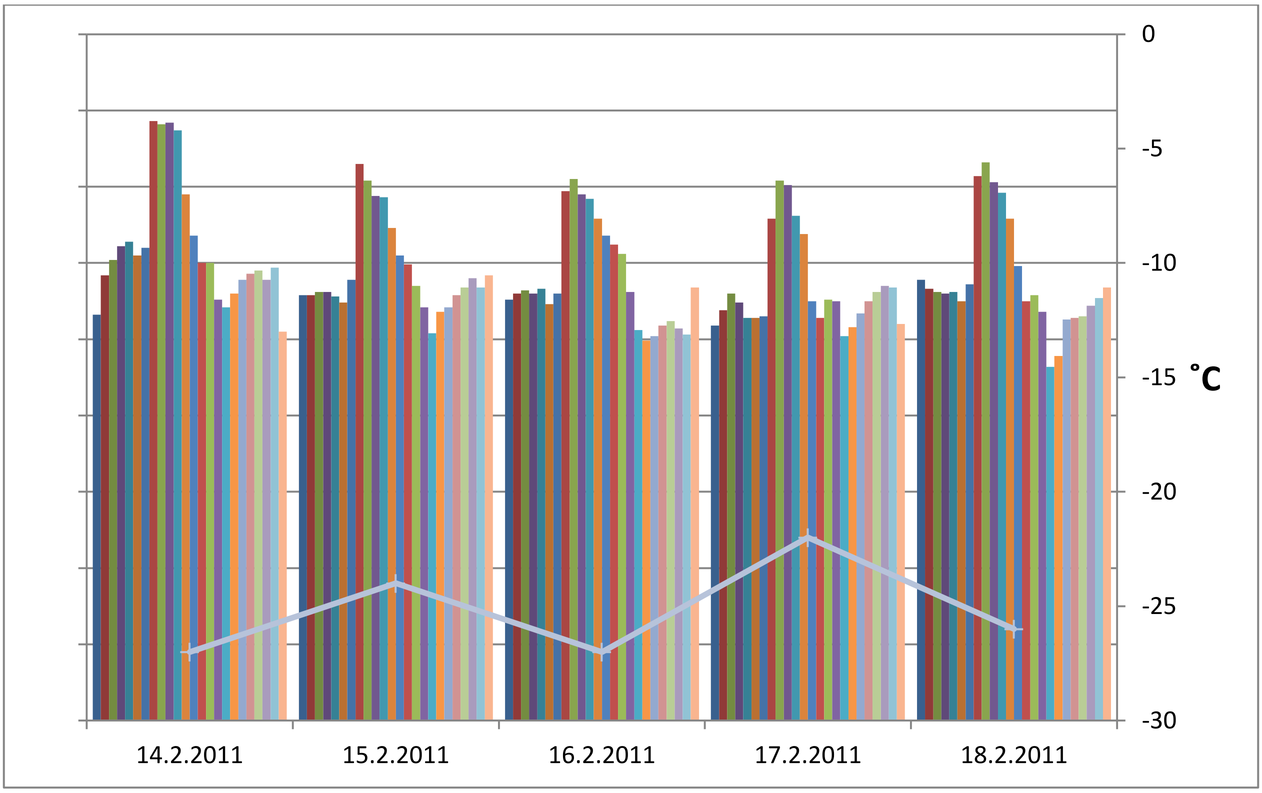



**Diagram 4.** District heat power compared to the outside temperature for the period Monday 14.2.2011 – Friday 18.2.2012

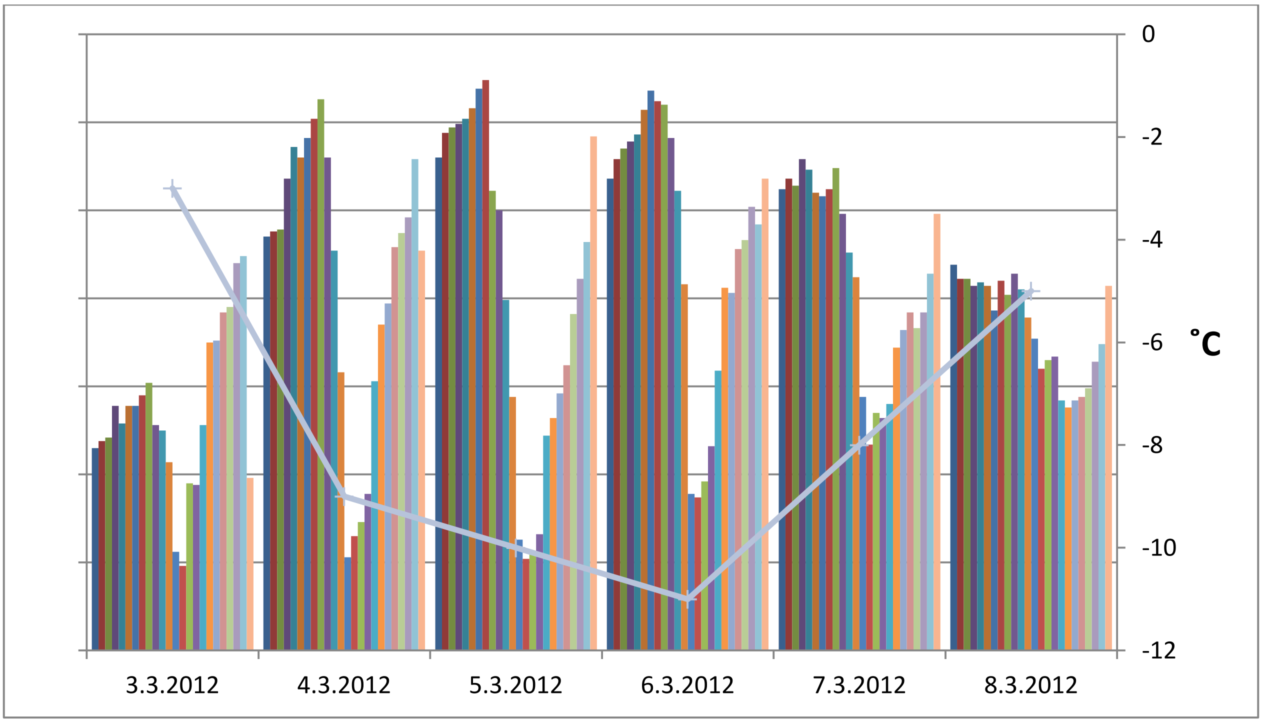



**Diagram 5.** District heat power compared to the outside temperature for the period Saturday 3.3.2012 – Thursday 8.3.2012

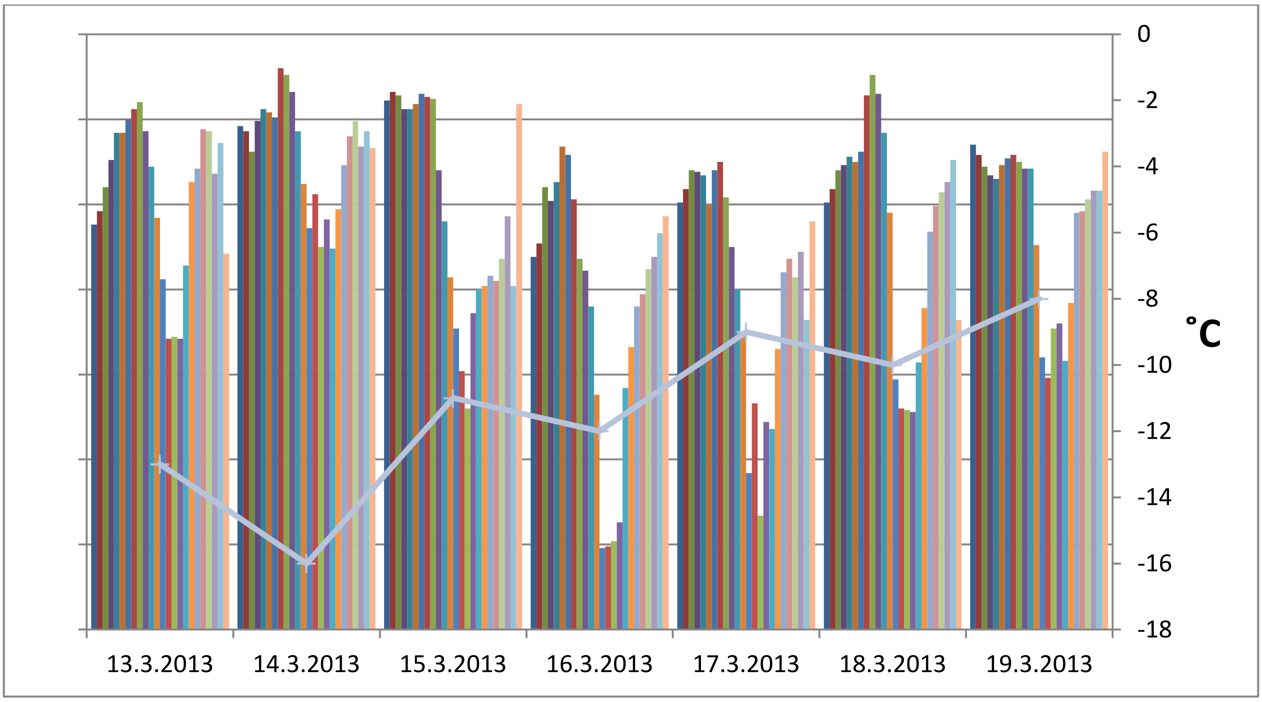



**Diagram 6.** District heat power compared to the outside temperature for the period Wednesday 13.3.2013 – Tuesday 19.3.2013

### The warehouse in building D

The warehouse in building D is heated and is therefore an area that consumes much district heat, because of doors being open and cold air spreading in the building when loading and unloading trucks. The consumption for heating the warehouse after the loading and unloading of trucks is calculated. To make the consumption, cost and profitability calculations more understandable the consumption calculations can be found in the savings calculations chapter.

### "Slussen"

The energy consumption of heating the small area between buildings A and B is also calculated. This calculation can be found in its savings calculation.

### Heat pumps

Three of the heat pumps in the assembly hall were measured, two on the east side of the hall and one on the west side. The locations of the heat pumps in the assembly hall are presented in Figure 2. In the picture the left side is the north side and the heat pumps measured are marked with a red, purple and green dot. The daily data of the measurements are presented in Diagram 7 and the hourly data of the measurements are presented in Diagram 8,

Diagram 9 and Diagram 10. At which dates the different pumps are measured is presented below. Pump 1 is located on the west side of the hall and pumps 2 and 3 are located on the east side of the hall. A one-week-long period was measured for each pump. The consumption data of the 3 heat pumps are presented in Appendix 4.

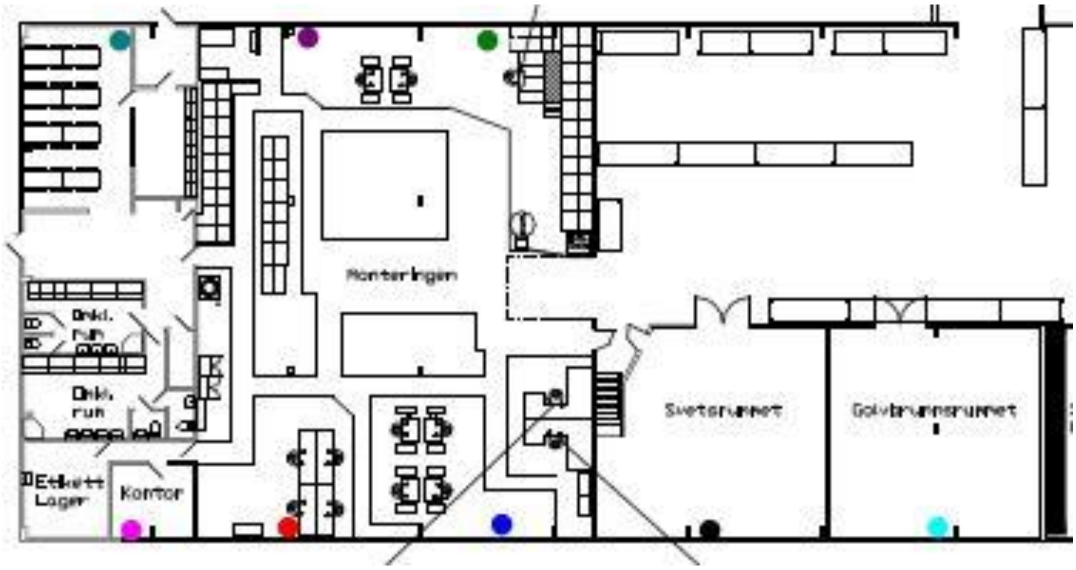



**Figure 2.** The locations of the heat pumps marked with coloured dots

The measuring periods:

Heat pump 1: 7.2.2014. 12:00 – 14.2.2014. 12:00
Heat pump 2: 14.2.2014. 12:00 – 21.2.2014. 12:00
Heat pump 3: 21.2.2014. 12:00 – 28.2.2014. 12:00

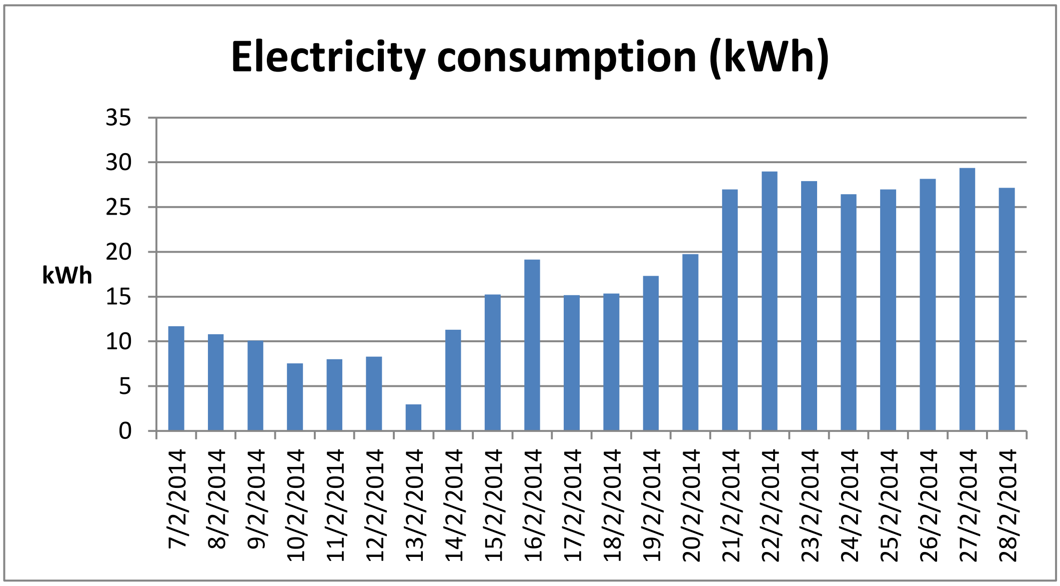



**Diagram 7.** Daily electricity consumption of all the heat pumps for the period 7.2.2014 - 28.2.2014

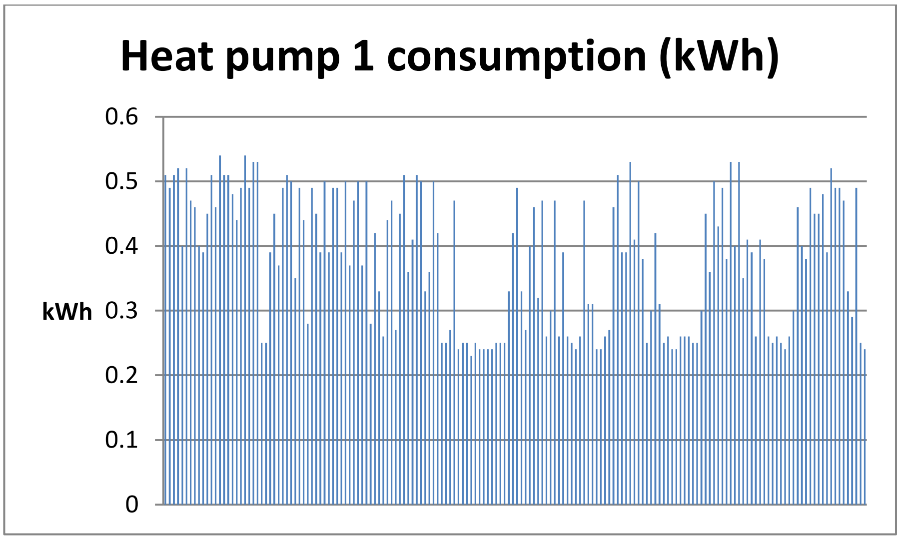



**Diagram 8.** Hourly electricity consumption of heat pump 1 for the period 7.2.2014 – 14.2.2014

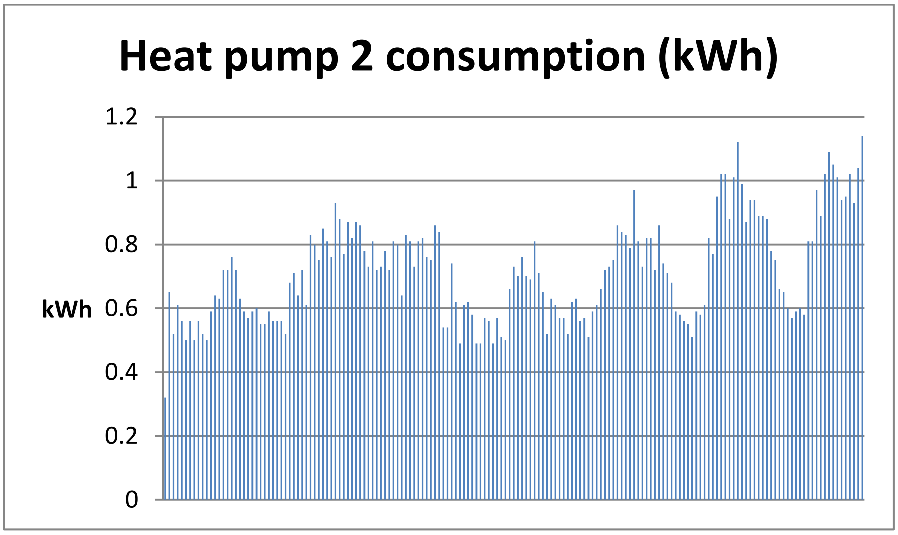



**Diagram 9.** Hourly electricity consumption of heat pump 1 for the period 14.2.2014 – 21.2.2014

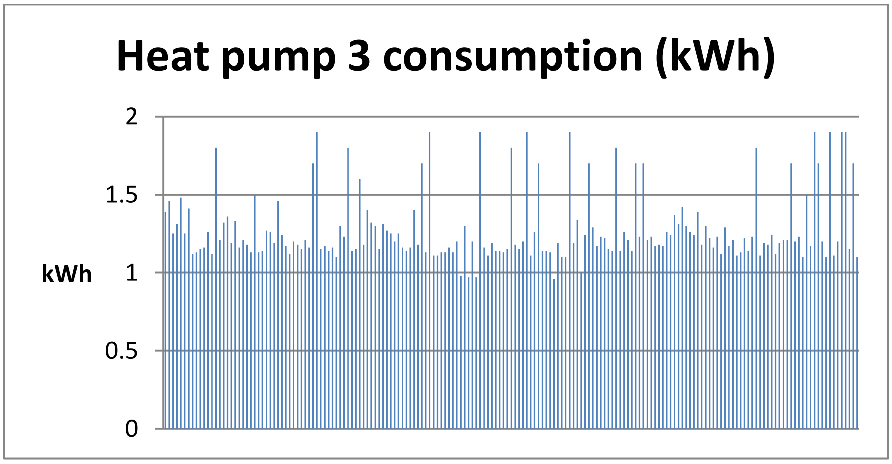



**Diagram 10.** Hourly electricity consumption of heat pump 1 for the period 21.2.2014 – 28.2.2014

The total consumption of the different pumps for their respective time periods is:

Heat pump 1: 64 kWh
Heat pump 2: 121 kWh
Heat pump 3: 229 kWh

### 5.4.2 Electricity systems

The data is divided into monthly and annual reports presented in Diagram 11, Diagram 12 and Diagram 13. The values of the consumption are not shown due to confidentiality. For some reason the consumption of October/2011 was missing in the daily consumption table on Vattenfall's online service. The monthly and annual consumption data of the years 2011 - 2013 is presented in Appendix 5. The daily data is not presented due to large amount of data.

| | Consumption | Consumption growth | Growth % |
|---|---|---|---|
| 2011: | 3942 MWh | | |
| 2012: | 4121 MWh | 179 MWh | 4.5 % |
| 2013: | 3658 MWh | -463 MWh | -11.2 % |

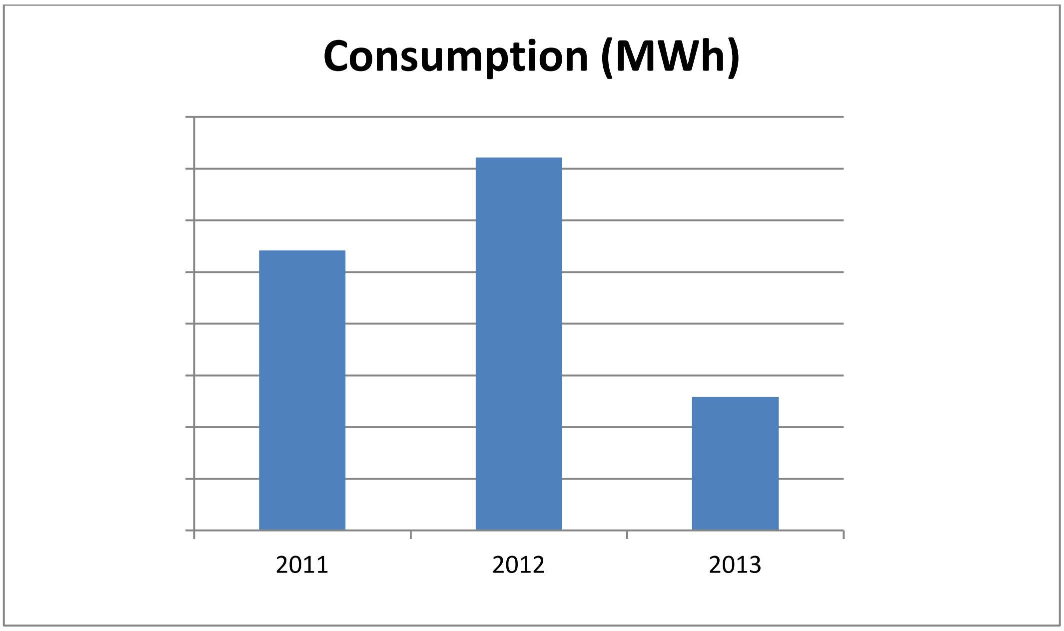



**Diagram 11.** Annual consumption of the past three years

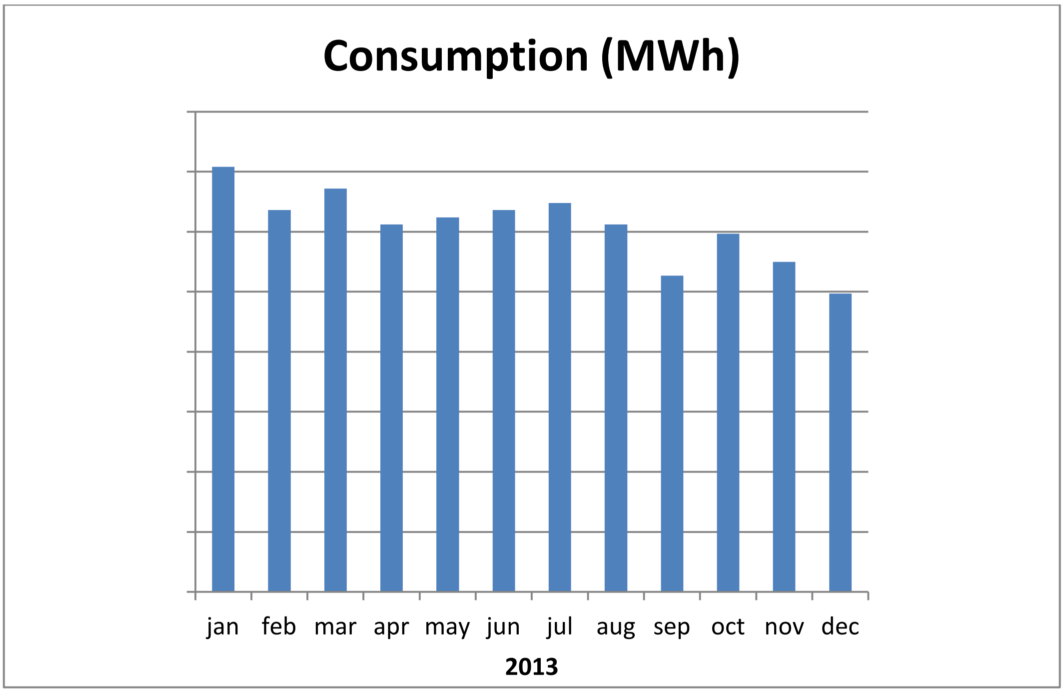



**Diagram 12.** Monthly electricity consumption of the year 2013

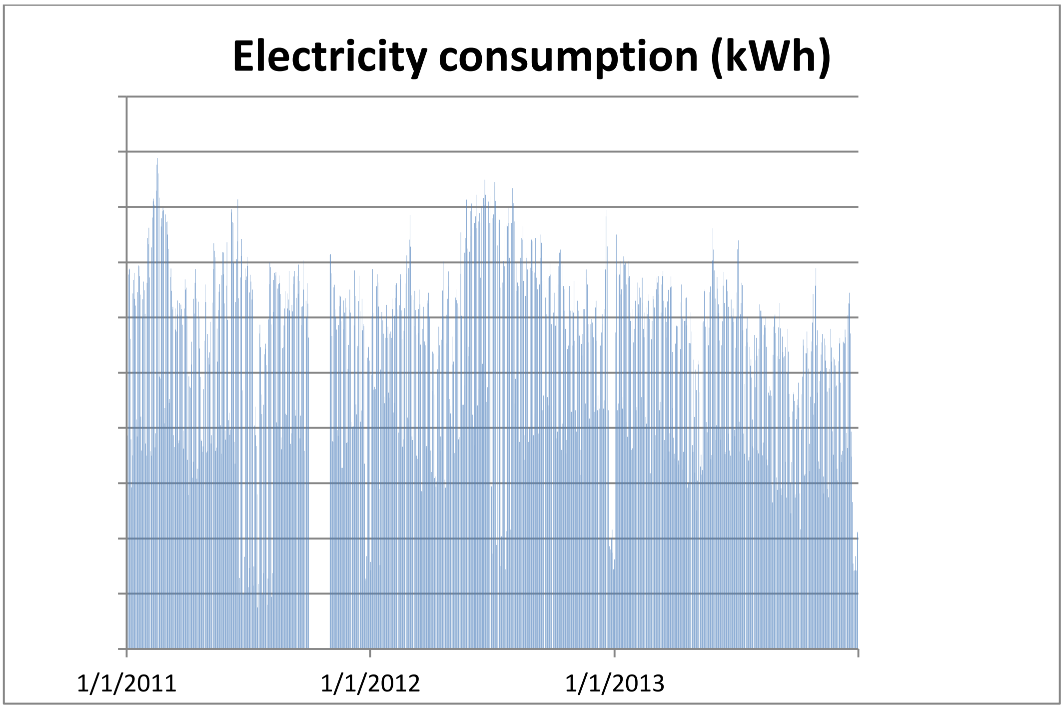



**Diagram 13.** Daily electricity consumption of the years 2011-2013

### Ventilation

The electricity consumption of the motors and fans was calculated for the ventilation system. The running hours of the ventilation systems in the different buildings were checked by the person responsible for the facilities. The consumption calculations, presented in Table 7, are calculated by multiplying the running hours with the power of the fans and motors.

**Table 7.** The electricity consumption and the running hours of the motors and fans of the ventilation systems

| Building | Area | Power (kW) | Times when running | Running hours full speed (h) | Running hours half speed (h) | Consumption (kWh) |
|---|---|---|---|---|---|---|
| **A** | Work-shop | 2.2 | 07:00 - 16:00 | 2259 | | 4970 |
| **A** | Production | 10 | Sun 21:00 - Fri 22:00 | 6025 | | 60250 |
| **B** | Office | 0.27 | 07:00 - 16:00 | 2259 | | 610 |
| **C** | Assembly hall + 3 rooms | 2.2 | 05:00 - 22:00; 22:00 - 05:00 | 4267 | 1757 | 11320 |
| **C** | Social rooms & kitchen | 2.168 | 05:00 - 22:00; 22:00 - 05:00 | 4267 | | 9251 |
| **D** | North production | 18 | Mon 00:00 - Fri 24:00; Sat 00:00 - Sun 24:00 | 6240 | 2496 | 134784 |
| **D** | North social and office | 1.07 | 06:30 - 17:00; 17:00 - 06:30 | 2730 | 6006 | 6134 |
| **D** | South production | 8.62 | 24/7 | 8736 | | 75304 |
| **D** | South social and office | 2.2 | 24/7 | 8736 | | 19219 |
| **Total** | | | | | | **321 843** |

Electricity consumption calculation example:

<u>South production</u>

Power: 8.62 kW
Running hours: $24\text{ h} * 365\text{ days} = 8736\text{ h}$

Consumption: $8.62\text{ kW} * 8736\text{ h} = \mathbf{75304\ kWh}$

The total electricity consumption for all the ventilation systems is **321.8 MWh**

### Lighting

For lighting, in all the buildings, fluorescent lights and some flood lights are used. The number of the 58 W fluorescent lights and the flood lights were counted. Based on the amount, the power and the running hours of the lights, the electricity consumption was calculated.

<u>A-building</u>

Power:

| | |
|---|---|
| Workshop: | $92\ \text{pcs} * 0.058\ \text{kW} = 5.34\ \text{kW}$ |
| Tool warehouse: | $24\ \text{pcs} * 0.058\ \text{kW} = 1.39\ \text{kW}$ |
| Production: | $140\ \text{pcs} * 0.058\ \text{kW} = 8.12\ \text{kW}$ |
| Warehouse: | $36\ \text{pcs} * 0.058\ \text{kW} = 2.09\ \text{kW}$ |
| Total power: | 16.94 kW |

Running hours:

| | |
|---|---|
| Workshop: | $9\ \text{h} * 251\frac{\text{days}}{\text{year}} = 2259\ \text{h/year}$ |
| Tool warehouse: | $24\ \text{h} * 251\frac{\text{days}}{\text{year}} = 6024\ \text{h/year}$ |
| Production: | $24\ \text{h} * 251\frac{\text{days}}{\text{year}} = 6024\ \text{h/year}$ |
| Warehouse: | $24\ \text{h} * 251\frac{\text{days}}{\text{year}} = 6024\ \text{h/year}$ |

Consumption:

| | |
|---|---|
| Warehouse: | $\frac{(5.336\ \text{kW})}{1000} * 2259\frac{\text{h}}{\text{year}} = 12.1\frac{\text{MWh}}{\text{year}}$ |
| Production+warehouse: | $\frac{1.392\ \text{kW}+8.12\ \text{kW}+2.088\ \text{kW}}{1000} * 6024\frac{\text{h}}{\text{year}} = 69.9\frac{\text{MWh}}{\text{year}}$ |
| Whole building: | $12.054\frac{\text{MWh}}{\text{year}} + 69.878\frac{\text{MWh}}{\text{year}} = \mathbf{81{,}9\ MWh/year}$ |

<u>B-building</u>

Power:

| | |
|---|---|
| Charging room: | $16\ pcs * 0.058\ kW = 0.93\ kW$ |
| Warehouse (north end): | $13\ pcs * 0.4\ kW = 6.4\ kW$ |
| Warehouse (south end): | $116\ pcs * 0.058\ kW = 6.73\ kW$ |
| Office: | $14\ pcs * 0.058\ kW = 0.81\ kW$ |
| Total power: | 14.9 kW |

Running hours:

| | |
|---|---|
| Whole building: | $9\ h * 251\frac{days}{year} = 2259\ h/year$ |

Consumption:

| | |
|---|---|
| Whole building: | $14.9\ kW * 2259\frac{h}{year} = \mathbf{33.6}\ \boldsymbol{MWh/year}$ |

<u>C-building</u>

Power:

| | |
|---|---|
| Social area: | $24\, pcs * 58W = 1.39\, kW$ |
| Assembly hall: | $96\, pcs * 58W = 5.57\, kW$ |
| Welding room: | $20\, pcs * 58W = 1.16\, kW$ |
| Fluidbag room: | $20\, pcs * 58W = 1.16\, kW$ |
| Screw room: | $6\, pcs * 58W = 0.35\, kW$ |
| Warehouse: | $114\, pcs * 58W + 6\, pcs * 400\, W = 9.01\, kW$ |
| Total power: | 18.64 kW |

Running hours:

| | |
|---|---|
| Assembly hall/Social: | $16\, h * 251\, working\ days/year = 4016\, h/year$ |
| Other areas: | $8\, h * 251\, working\ days = 2008\, h/year$ |

Consumption:

| | |
|---|---|
| Assembly hall/Social: | $6.96\, kW * 4016 \frac{h}{year} = 27.95\, MWh/year$ |
| Other areas: | $11.68\, kW * 2008 \frac{h}{year} = 23.45\, MWh/year$ |
| Whole building: | $27.95\, \frac{MWh}{year} + 23.45\, \frac{MWh}{year} = \mathbf{51{,}4\, MWh/year}$ |

<u>D-building</u>

Power:

| | |
|---|---|
| Warehouse (north end): | $12\, pcs * 58W = 0.7\, kW$ |
| Production (north end): | $156\, pcs * 58W = 9.05\, kW$ |
| Production (south end): | $64\, pcs * 58W + 21\, pcs * 250\, W = 8.96\, kW$ |
| Warehouse (south end): | $104\, pcs * 58W = 6.03\, kW$ |
| Total power: | 24.74 kW |

Running hours:

| | |
|---|---|
| Whole building: | $24\, h * 7\, days * 52\, weeks = 8736\, h/year$ |

Consumption:

| | |
|---|---|
| Whole building: | $24.738\, kW * 8736\, h/year = \mathbf{216{,}1\, MWh}$ |

<u>Total lighting consumption</u>

The total electricity consumption for lighting in all the buildings is:

$$68.9\, MWh/year + 30.5\, MWh/year + 35.6\, MWh + 216.1\, MWh = \mathbf{383\, MWh/year}$$

**Air compressors**

To be able to calculate the consumption of the air compressors, the efficiency and the running hours of the air compressors had to be established. The running hours are calculated by dividing service interval hours with the amount of hours during the period between services. The result from the calculations is percentage in running hours. According to information gotten from the person responsible for facilities, the efficiency of the air compressor in building D is 50% so the other compressor's efficiency, which is unknown is also estimated to be 50 %. Since the Kaeser AS 44 in building A is only used as back up for the other two and almost never operates, the consumption of this air compressor is negligible. The other two compressors are running during production in respective building.

The running hours and motor efficiency of the Kaeser BSD 72 and the Kaeser ASD 47T air compressors are:

<u>Kaeser ASD 47T</u>

| | |
|---|---|
| Service interval (from – to): | $10.1.2013 - 13.12.2013 = 8088\ h$ |
| Running hours during the period: | $28\ 226\ h - 24\ 100\ h = 4126\ h$ |
| Capacity factor: | $\frac{4126\ h}{8088\ h} = 0.51$ |
| Air compressor running hours: | $365\ work\ days * 24\ h * 0.51 = 4468\ h/year$ |

<u>Kaeser BSD 72</u>

| | |
|---|---|
| Service interval: | $3.6.2013 - 3.10.2013 = 2928\ h$ |
| Running hours during the period: | $67164 - 64284 = 2880\ h$ |
| Capacity factor: | $2880\ /\ 2928 = 0.98$ |
| Air compressor running hours: | $365\ work\ days * 24\ h * 0.98 = 8585\ h/year$ |

The annual electricity consumption of the air compressors is calculated by multiplying the power of the motor with the annual running hours.

The annual electricity consumption of the air compressors is:

<u>Kaeser ASD 47T</u>

Consumption: $25\ kW * 4468 \frac{h}{year} = \mathbf{111,7} \frac{\mathbf{MWh}}{\mathbf{year}}$

<u>Kaeser BSD 72</u>

Consumption: $37\ \mathrm{kW} * 8585 \frac{\mathrm{h}}{\mathrm{year}} = \mathbf{317,6}\ \frac{\mathbf{MWh}}{\mathbf{year}}$

**Car engine heating**

To get an idea of how many of the workers use car engine heating at the company the number of cars connected to the socket boxes was counted for ten days. The average number of the counted cars was then calculated and presented in Table 8. The running hours of the boxes are regulated by a timer on the electrical switch board. The timer is set to the hours 04:00 – 07:30, 10:00 – 18:00 and 20:00 – 22:30 and the running hours are calculated based on these hours and the amount of cold months in a year. This is estimated to be four months per year. In the calculations the rather conservative number of three months per year is used to reflect the current season with a mild winter. However, for the general case it should be realistic to use four months.

It is unknown how many cars use both heating for the car engine and for heating the cabin of the car and therefore the power is estimated. The power of car engine heating system is 400 – 600 W and the power of the cabin heating system is 1200 – 1400 W, so the power in this calculation was estimated to be 1000 W. The consumption is calculated by multiplying the power with running hours and the number of cars and it is also presented in Table 8.

**Table 8.** The electricity consumption of car engine heating

| | **Weekdays** | | | | **Weekends** | | | **Total** |
|---|---|---|---|---|---|---|---|---|
| | 04:00-07:30 | 10:00-15:30 | 15:30 - 18:00 | 20:00-22:30 | 04:00-07:30 | 10:00-18:00 | 20:00-22:30 | |
| Sockets used | 4 | 28 | 4 | 4 | 3 | 3 | 3 | |
| Power (W) | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | |
| Running hours (h/a) | 210 | 330 | 150 | 150 | 105 | 240 | 75 | |
| Consumption (kWh/a) | 840 | 9306 | 600 | 600 | 315 | 720 | 225 | **12606** |

<u>Consumption calculation example:</u>

Hours/day: $10{:}00 - 15{:}30 = 5.5\ h/day$
Running hours/year: $5.5\ h * 20\ days * 3\ months = 330\ h$
Consumption/year: $330\ h * 28.2\ pcs * 1000\ W\ /\ 1000 = 9306\ kWh/year$

The total consumption/year for car engine heating is **12.6 MWh/year**.

## 5.5 Water consumption

Both the consumption of the distributed water and the sewer water is presented in this chapter. In the tables the consumption equals to both distributed water and sewer water, not added together, since the sewer water is estimated to be the same as the water consumed.

**The meter in building A**

The meter in building A is read every quarter of the year, so the consumption data is presented in both annual consumption and consumption per period, or quarter of a year. Due to confidentiality the consumption is presented in Appendix 6. The meter measures the water consumption in buildings A, B and D.

**The meter in building C**

This meter is read very seldom and the consumption is therefore estimated until the meter is read. Therefore the consumption on the bills might not be accurate but the meter was read 15.4.2014. The last time the meter was read was 3.12.2012. Due to confidentiality the periods and the measured/estimated consumption per period are presented in Appendix 6. The meter measures the consumption in building C.

**The meter in the office building**

As for the meter in building C, this meter is also very seldom read. The meter was last read 3.12.2012 by the distributor and therefore the meter was read 31.3.2014 during inspection. The estimation of this meter was totally wrong and the distributor was notified of the real consumption of this meter. The estimated consumption of the last period was 74% higher than the real consumption. Due to confidentiality the periods and the measured/estimated consumption per period are presented in Appendix 6. The meter measures the consumption in the office building.

The total annual water consumption of the office building and building C cannot be calculated due to the periods and when the meters have been read.

## 5.6 Energy cost

All the energy costs and prices are with VAT 0%, if separately not mentioned. Some of the costs are copied from the bills and some are calculated with the electricity price, which is a total price including spot price and distribution price. Due to confidentiality, no energy prices or costs will be presented in the report, instead the data is presented in appendices. The calculated costs for the different operations in the company will also be presented in appendices. The electricity price is presented in Appendix 8 and the district heat price is presented in Appendix 7. In the calculations the latest district heat price set by the distributor is used and an average price for electricity is used. /17/

### 5.6.1 Heating systems

The annual costs and the costs divided into billing periods are presented in Appendix 7. It can be mentioned that both the annual basic charge and the energy price have risen since the installation of the district heat.

### 5.6.2 Electricity

The annual and monthly electricity costs from the past three years are presented in Appendix 8 and show both spot price and cost, future price and cost and distribution costs. The cost is calculated by multiplying the spot price and the future price with the electricity consumption and adding the distribution cost. The distribution cost includes electricity taxes.

**Lighting**

The energy cost for lighting is presented in Appendix 8. The cost is calculated by multiplying the electricity consumption price with the electricity consumption.

**Car engine heating**

The energy cost for heating car engines is presented in Appendix 8.

## 5.7 Water cost

The basic charge and the distribution price are determined by the distributor and the price of the sewer water is determined based on the contamination of the sewer water.

The water consumption costs are presented in Appendix 9.

## 5.8 Analysis and action suggestions

### 5.8.1 Heating

The reason for the increasing annual district heat consumption as seen in Diagram 1 is that the company has invested in more energy efficient machines, which produce less excess heat than before. As seen from Diagram 4, Diagram 5 and Diagram 6 the outside temperature directly affects the district heat consumption. During colder weather the consumption of the district heat rises significantly. Both poorly insulated buildings and the logistic traffic in and out of the buildings by the warehouse workers are the cause of the high consumption.

**Control curve**

During the time spent at the company it was noticed that during milder weather the indoor temperature was lower than usual in the workshop in building A and during colder weather higher indoor temperature. The temperature overall feels a bit too high inside the buildings A and D. The regulating curve was set when the district heat was installed in year 2009 and has not been changed since. The curve is a standard curve for most district heat systems. The temperature of the incoming water according to the outside temperature is presented in Table 9, where L1 is the production area in buildings A and D and L2 is the work shop in building A. The control curves for each area are presented in Diagram 14 and Diagram 15. The curve could be adjusted in two different ways. One way is to shift the curve by raising the incoming water temperature of the district heat system when the outside temperature is higher and by lowering the water temperature when the outside temperature is lower. This is presented in Diagram 15. The second way is to parallel adjust the curve, meaning that the temperature will be lowered. This is presented in Diagram 14. During inspection, it was noticed that the indoor temperature in building D was 23 ˚C. The temperature could be lowered to 20 degrees to save energy.

A rule of thumb is that lowering the indoor temperature 1˚C saves 5% of the energy cost. This means that by lowering the indoor temperature 3 degrees, nearly 15% of the district heat consumption could be saved. The savings potential for lowering the indoor temperature has been calculated. /18/

**Table 9.** Incoming water temperature according to outside temperature

| Outside temperature | L1 Water temperature | L2 Water temperature |
|---|---|---|
| 20 | 20 | 21 |
| 0 | 42 | 41 |
| -20 | 62 | 58 |

The adjusted control curves are just examples of how the curve could be adjusted, based on advice given by the head of district heating at Nykarleby Kraftverk. An expert in the HVAC field should be contacted for the adjustment of the curve to get the best possible outcome. /16/

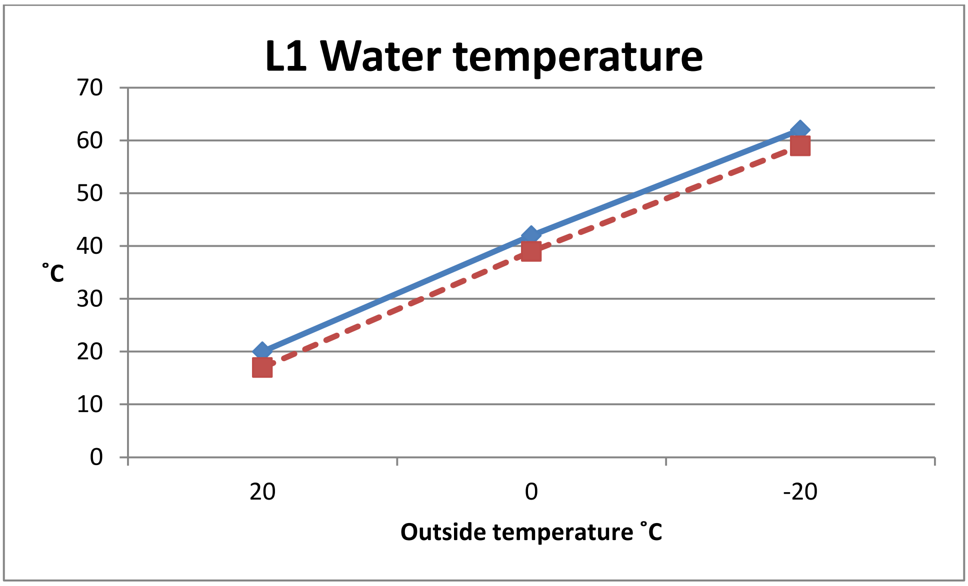



**Diagram 14.** Current control curve (blue line) for L1 compared with parallel adjusted control curve (red line)

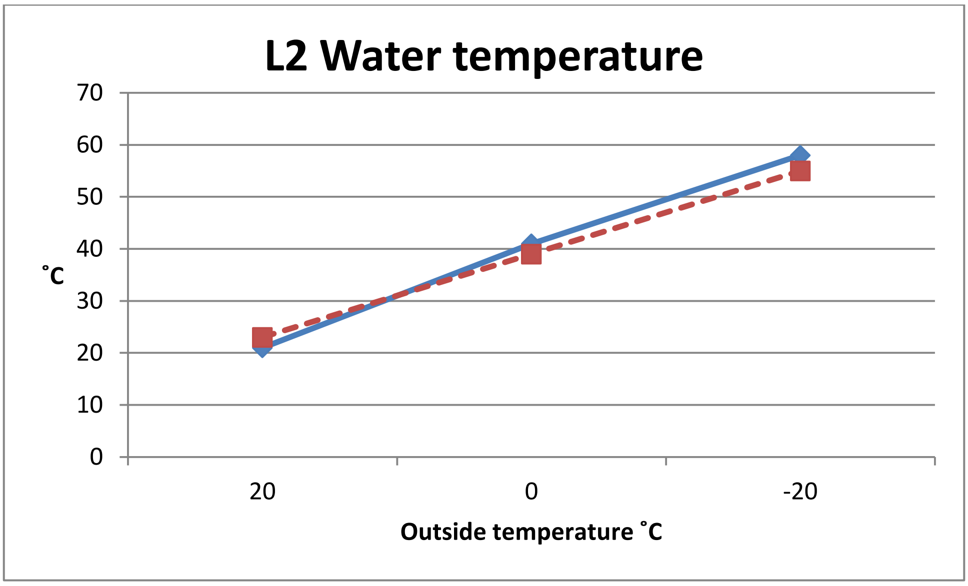



**Diagram 15.** Current control curve (blue line) for L1 compared with a shifted control curve (red line)

During inspection of the district heat equipment it was noticed that the outside sensor, which measures the temperature to regulate the district heat flow, was placed in the sun. The sensor being in the sun will affect the flow negatively. The sensor needs to be moved to a place in the shadow of the sun.

### Loading and unloading of trucks

Through analyzing the power table it is seen that on most days the peaks take place between 08:00 – 13:00 and rise during colder weather, approximately under -10°C, above 300 kW. The cause of this was thought about and it was concluded that loading and unloading of trucks in the heated warehouse, where the door is open during loading and unloading, would be one reason for the high peaks. The loading and unloading usually take place at the door in the south end of the warehouse, beginning in the morning and ending around lunch time and happen in average 3 times a day. To save some energy a door could be installed between the north part of the warehouse and the south end part, see Figure 1. **Overview of the factory area.** This action would prevent the cold air from spreading to the north end of the warehouse. This would also prevent the cold air from spreading to the production area in the building, if the door to the production is opened during the time trucks are loaded or unloaded, and improve the working environment. The savings potential has been calculated for installing the door.

Another problem at the warehouse is when Prevex subsidiary company Nykarleby Monteringstjänst Ab (NMT) loads and unloads their truck. This happens also several times per day and is often done at the door in the north end of the warehouse. A solution for the problem of heat going out the door could also be installing air curtains. This action has a significantly higher investment cost, but the heat loss reduction is very good, up to 80 % depending on the model, so the payback time is fairly short. /19/

## Traffic between buildings A and B

Another reason for the high peaks in district heat consumption is the traffic between building B and building A. During morning time there is a lot of traffic between the buildings, when the warehouse workers bring empty pallets to the production in building A plus collect products from the production for storing in the warehouse. During this period, the door to building A is opened many times, which makes cold air, from the warehouse in building B, spread into building A. There is also traffic during the rest of the day, but not as much as in the morning. There are two doors to go through when driving into building A. The space between the doors is called “slussen” and has an area of 40 $m^2$. This is the space where the workers in the production bring the products from the machines and from where the warehouse workers collect the products. The routine for the warehouse workers is to open one door, drive into ”slussen” close the door and then open the second door. This is a good energy saving routine, but it is not followed all the time. The area is not heated and is most of the time cold, so even if the routine is working, cold air will spread into the building.

Distributing the unutilized heat that the compressors in building A produce to ”slussen” could help this problem. It would create a warm air barrier that would decrease the cold air flow into building A. During summer time when heating is not needed, the heat from the compressor would have to be distributed outside. This can be done by installing a valve in the pipe. Energy wise this is not a good solution, because the compressor produces more heat than is required for heating “slussen”, which will be presented in the profitability calculations. Comfort wise it is a very good solution. It is an action that the workers at the company themselves would prefer. A solution drawing, created by the EduPower team, for how the heat could be utilized for heating ”slussen” is presented in Figure 3.

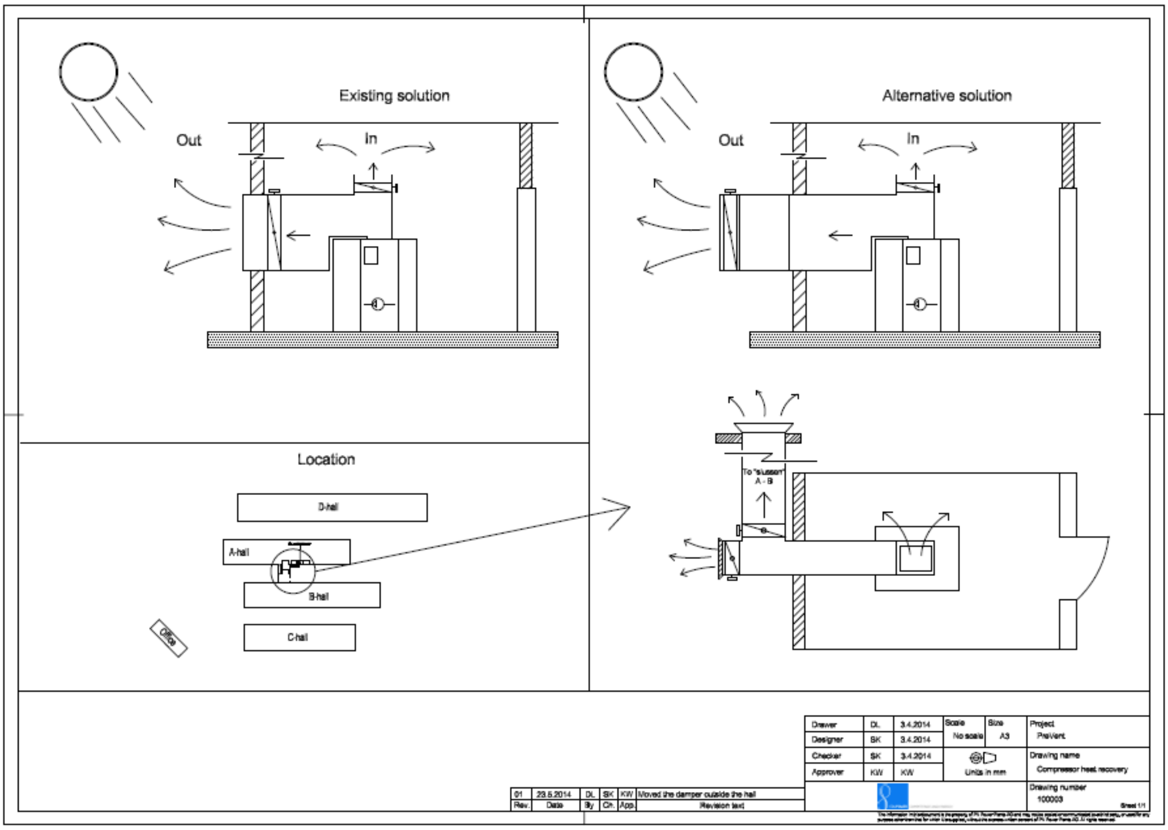



**Figure 3.** Solution drawing for utilizing compressor heat.

**Utilizing the compressor heat for heating building A**

Another solution for the heat produced by the air compressor could be heating the production area of building A, and distributing it to the building the same way as for the heat from the cooling compressor. For this action a valve would also have to be installed to distribute the heat out of the building during summer times. This is a further energy saving action. The excess heat recovered would directly save the equivalent amount of heating energy. This is shown in the savings calculations.

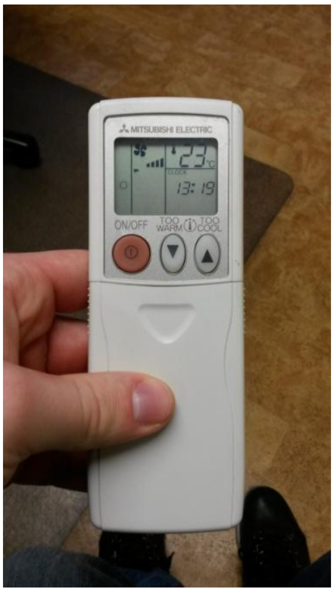
**The heat pumps in building C**

As seen from Diagram 7, the heat pumps on the east side of the hall consume more electricity than the one on the west side. During inspection it was discovered that the temperature of the heat pumps was set to 23˚C, seen on the remote control in Picture 1. The remote control sets the temperature for all the heat pumps. Although the temperature is the same for all the heat pumps, the ones on the east side consume more electricity, of which one consumes more than the other. During inspection it was also noticed that there is a greater air flow from the heat pumps on the east side than from the ones on the west side.

The reason for this was initially thought to be the sun shining on the west side of the building during day time and the east side being in shadow of the sun the whole day.

An alternative reason emerged as being incorrect settings of the heat pumps. After further investigation it was found out that the workers had taken the control and raised the temperature of the two heat pumps on the east side.

The manager of the assembly hall is the only person who should have access to the remote control and it needs to be for example locked away. The temperature in the hall could be lowered at least two degrees, preferably three degrees. The work in the hall is mostly packaging and assembling the siphons, meaning medium-hard body work, for which the temperature recommendations are 17˚C - 21˚C, seen in Table 10. These actions would save energy.




**Picture 1.** The remote control of the heat pumps showing the temperature.

**Table 10.** Temperature recommendations according to work classification.

| Work classification | Heat produced | Temperature recommendations |
|---|---|---|
| easy sitting work | under 150 W | 21 - 25 °C |
| other easy work | 150 - 300 W | 19 - 23 °C |
| medium hard work | 300 - 400 W | 17 - 21 °C |
| hard work | 400 - | 12 - 17 °C |

/20/

### 5.8.2 Electricity systems

The change in electricity consumption on an annual basis, seen in Diagram 11, is because of changes in production. The turnover in 2013 was much lower than in 2012, for example. The seasonal changes and the weather changes also affect the electricity consumption since two of the buildings are heated with direct electricity and electricity air to air heat pumps.

**Ventilation systems**

All the ventilation systems at the company are relatively new, except for the unit in the production area in building A. Therefore the condition of the ventilation should be good. The ventilation systems are also frequently cleaned. The running hours, however, could be adjusted a little to save some energy. The building where the running hours could be adjusted is building C. The other systems' running hours are optimized as good as they can get and there is no room for adjustment.

The current running hours of building C are:

| | Full speed | Half speed |
|---|---|---|
| Assembly hall: | 05.00 – 22:00 | 22:00 – 05:00 |
| Social & kitchen area: | 05:00 – 22:00 | - |

The new running hours could be:

| | Full speed | Half speed |
|---|---|---|
| Assembly hall: | 05:00 – 22:00 | - |
| Social & kitchen area: | 05:00 – 16:00 | 16:00 – 22:00 |

There is no need for the ventilation system to run on half speed during night time, when no one is working in the hall. It is enough if the ventilation system starts one hour before the morning shift starts. During night time, when fewer people are working, it is enough if the ventilation system in the social & kitchen areas runs on half speed after 16:00 when the rest of the workers have left for the evening.

In addition, there is over pressure in building D. This is because of a former company's operations in the building, when over pressure was needed. This is, however, not longer needed and the settings of the ventilation systems should be adjusted.

**Lighting**

The large amount of lighting needed at the company consumes a lot of electricity. The type of lighting used at the company has a short life length, are high powered but cheap. The fluorescent lights could be replaced with LED-fluorescent lights. LED lights have a three times longer life time, they consume much less electricity, but unfortunately they are a lot more expensive, although the price is getting lower with time. When replacing conventional with LED lighting, the colour and the luminous flux, measured in lumen [lm], of the lights need to be taken into consideration. The idea of replacing the lighting was presented to the company at an early stage of the investigation. The idea of a pilot project to replace the lighting at a specific area in building D was suggested by Prevex. The area in question is the area where the company has a semi-automated line for packaging of kitchen siphons.

In some areas the lights are on although it is not necessary because of the areas being most of the time unmanned. The routine of switching off the lights after leaving the area does not work, so installing motion sensors would be a solution for this problem. Some of the areas are the warehouse for the tools and both of the raw material warehouses. In the dressing room in the south production of the building D, there is a motion sensor installed. It works perfectly. In the heated warehouse in building D a motion sensor could be installed also. Especially in night time and during weekends, there is very little traffic in the warehouse. The lights need to be switched on only when the production workers transport the products from the production to the warehouse, but now they are on all the time.

**Car heating**

The running hour for heating car engines is too long. The problem is that the workers end their shifts in very different times and that is why the timers are set the way they are. This problem could be solved by installing new socket boxes with timers on the boxes. The investment cost for these boxes is not that big and it would be a profitable investment. With these boxes the running hours could be cut down to 2 hours/car, or whatever the workers feel suitable for heating the car engine. In very cold weather, the recommendation is 2 hours. This would save electricity for the company.

### 5.8.3 Water system

The company does not use exceptionally much water and the cost is low. The meters in building C and the office building are very seldom read and therefore is the consumption of these buildings estimated. The estimations have been very much from the reality of the consumption and the meters could be read more often. If the company pays too much for water consumption they will be refunded by the distributor company. Paying too much would be prevented if the meters were read frequently, either by the distributor or the company itself. The meter in building A is read every three months.

## 5.9 Profitability calculations

The savings calculations are separated from the investment and profitability calculations because some of the calculations only have savings calculations due to lack of information on investment cost. This is due to difficulties in estimating the investment cost and difficulties in estimating the cost for the work.

### 5.9.1 Savings calculations

**District heat basic charge**

Since the district heat distributor Nykarleby Kraftverk wants to raise the power limit to 380 kW, the basic charge of the district heat will also rise. The actions will prevent the massive leakage of cold air due to logistics, and therefore cut the peaks in district heat consumption. Because of this, some of the savings calculations include the effect on the basic charge.

The basic charge can only be used for one of the action suggestions, but is presented in several to show how much the action would save with the basic charge not rising.

The basic charge is calculated with a formula taken from the Nykarleby Kraftverk's webpage:

$$Basic\ charge = k * (a + b * P)$$

Where k, a and b are constants, depending on the customer's agreed power limit, and P is the agreed power limit. /17/

Due to confidentiality the profitability calculations are presented in Appendix 10.

**Control curve**

Lowering the indoor temperature by 1˚C saves 5% of the energy consumption. Lowering the indoor temperature from 23˚C to 20˚C = 3˚C would save nearly 15% of the district heat consumption. The cost and cost savings calculations are presented in Appendix 11.

**Installing a door in the warehouse in building D**

<u>Consumption:</u>

To be able to calculate the energy consumption in the warehouse, due to the loading and unloading of trucks, the amount of energy required to heat 1 $m^3$ air 1˚C was calculated. Knowing the volume of the warehouse the amount of energy needed to heat the whole warehouse could then be calculated. The temperature changes in the warehouse have been measured.

The energy demand to heat 1 $m^3$ air 1˚C is:

The demand for heating 1 kg air 1˚C is 1.01 kJ, then the energy demand for heating 1 kg air 1˚C is also 0.2778 Wh. The density of air is 1.2041 kg/m$^3$ at 20°C, thus by multiplying the energy for heating 1 kg air 1˚C with the density of air, the energy for heating 1 m$^3$ air 1˚C will be:

$$0.2778\,Wh * 1.2041\frac{kg}{m^3} = 3.3 * 10^{-4}\,kWh$$

The energy demand for heating 1 m$^3$ air 1˚C is **3.3*10$^{-4}$ kWh.**

The consumption calculations are based on heating the warehouse on average 10 degrees with a frequency of 3 times per workday and 120 days per year, which are the cold days of the year, meaning months that have an average temperature under 5 degrees. Heating is of course also needed during milder weather, but not taken into consideration in these calculations. The focus is on the coldest days, since the goal is to lower the peaks in district heat consumption. By analysing the consumption and power tables, Diagram 1, Diagram 2 Diagram 3, Diagram 4, Diagram 5 and Diagram 6 it is seen that peaks appear only during colder outside temperatures. Measurements on the temperature changes in the warehouse were made, from which the average temperature change was calculated. The average change in temperature is 10 degrees.

As mentioned earlier in the report, there is also a compressor that produces heat in the warehouse. The power of the compressor is 25 kW. The efficiency of the compressor + motor (“compressor package”) is 50 % and it runs 50 % of the time. The relative heat loss from the compressor package is *1 – the efficiency of the compressor package*. Thus the heat energy is calculated by multiplying the power of the motor with (1 - the efficiency) and the running hours:

$$25\text{ kW} * (1 - 50\%\ efficiency) * 50\%\ \ running\ hours = 6.25\text{ kW}$$

The compressor produces 6.25 kW heat but the heat produced by the air compressor will not be taken into account. This is because while the temperature was measured, the compressor was producing heat and the heat is therefore negligible. But also because the heat produced by the compressor is only enough for the base load of the warehouse, meaning it produces as much as the amount that leaks out through the walls and therefore it will not assist the heating when the warehouse gets cold. It still produces the same amount of energy, which is only enough for the base load and the district heat will distribute heat to the warehouse for heating the cold warehouse. If the measurements were done without the utilization of the heat produced by the compressor and utilization of heat produced by the compressor would be installed, the heat from the compressor would have to be subtracted, because then the compressor would assist the district heat. This is presented in the utilization of the compressor in the building A chapter.

The total volume of the warehouse is 14 833 m$^3$ so the amount of energy required for heating the warehouse ten degrees for 120 days and three times per day is:

$$14833\text{ m}^3 * 10°\text{C} * 3.3 * 10^{-4}\ \frac{kWh}{m^3°C} * 120\text{ days/year} * 3\frac{\text{times}}{\text{day}} = \mathbf{17\ 921\ kWh/year}$$

If the door to the production is open during loading and unloading of trucks, which it sometimes is, the temperature in the whole building will drop a few degrees. The temperature was measured near the door and at the lowest the temperature was 12 degrees. The average temperature in the north production area if the door to the production is open during loading and unloading is estimated to be 1 degree. Under the same conditions the estimated drop in temperature for the south production area is estimated to be 3 degrees.

The estimated frequency of the door being open during loading and unloading is estimated to be one time per day.

The volume of the north production is 9866 $m^3$ and the volume of the south end is 6960 $m^3$. Based on these volumes the required amount of energy is calculated.

$$9866\, m^3 * 1^{\circ}C * 3.3 * 10^{-4}\ \frac{kWh}{m^3{}^{\circ}C} * 120\frac{days}{year} * 1\frac{times}{day} = \mathbf{838}\ \frac{\mathbf{kWh}}{\mathbf{year}}$$

$$6960\, m^3 * 3^{\circ}C * 3.3 * 10^{-4}\ \frac{kWh}{m^3{}^{\circ}C} * 120\frac{days}{year} * 1\frac{times}{day} = \mathbf{396}\ \frac{\mathbf{kWh}}{\mathbf{year}}$$

The total energy consumption for heating the production area of the building is **1234 kWh/year**.

The total energy consumption for both the production areas and the warehouse is **19 155 kWh/year**.

Energy cost:

The energy cost is presented in Appendix 12.

Energy consumption savings:

By installing the door only the small area in the south end would have to be heated, so the required energy for heating the area is calculated.

The volume of this area is 6867 $m^3$.

$$6867\ \text{m}^3 * 10℃ * 0.33\ \text{Wh} * 120\ \text{days} * 3\frac{\text{times}}{\text{day}} = 8269\ \text{kWh/year}$$

The energy consumption after installing a door in the warehouse is **8269 kWh/year**.

Thus the energy consumption saving when installing a door is:

$$19\,155\frac{kWh}{year} - 8269\frac{kWh}{year} = \mathbf{10\,886}\ \frac{\mathbf{kWh}}{\mathbf{year}}$$

Energy cost savings:

The energy cost savings calculations are presented in Appendix 12.

**Installing an air curtain at the doors in the warehouse in building D**

Consumption:

Loading and unloading of the subsidiary company's truck are done on average 5 times per day during which time the estimated average temperature drop is 5 degrees. Based on this the energy consumption for heating the warehouse 5 degrees 5 times per day is calculated.

$$14883\, m^3 * 5\ ^{\circ}C * \frac{0.33Wh}{m^3{}^{\circ}C} * 120\ days * 5\frac{times}{day} = \mathbf{14934}\frac{\mathbf{kWh}}{\mathbf{year}}$$

The consumption for loading and unloading trucks at the south end of the warehouse is taken from the calculations for installing a door in the warehouse, which is **19 155 kWh/year**.

After unloading the truck the products are delivered into the production. This happens on average 3 times per day. When the warehouse is cold, the cold air will spread to the production and the average drop in temperature is 3 degrees in the south end of the production and 1 degree in the north production. Based on this the consumption for heating the production is calculated.

South end:

$$6960\ m^3 * 3℃ * 0.33Wh * 120\ days * 3\frac{times}{day} = 2514\frac{kWh}{year}$$

North end:

$$9866\ m^3 * 1℃ * 0.33Wh * 120\ days * 3\frac{times}{day} = 1188\ kWh/year$$

The total consumption per year for loading and unloading the trucks at both doors is:

$$14\,934\ \frac{kWh}{year} + 19\,155\ \frac{kWh}{year} + 2514\ \frac{kWh}{year} + 1188\ \frac{kWh}{year} = \mathbf{27\,790}\frac{\boldsymbol{kWh}}{\boldsymbol{year}}$$

<u>Energy cost:</u>

The energy consumption cost is presented in Appendix 13.

<u>Energy consumption savings:</u>

As mentioned before, installing an air curtain at the doors can save up to 80 % of the energy consumption. Based on the 80% consumption reduction, the consumption savings is calculated.

$$27\,790\frac{kWh}{year} * 0.8 = 22232\frac{kWh}{year}$$

The energy consumption saving for installing air curtains is **22 232 kWh/year**.

<u>Energy cost savings:</u>

The energy cost savings calculations are presented in Appendix 13.

**Utilizing heat from air compressor for heating building A**

The Keaser AS 44 (30) is only used as a back-up compressor and is hardly ever used and is therefore neglected in these calculations. The heat produced by the Keaser BSD 72 (37 kW) is calculated based on the running hours per year of the compressor and its efficiency. The running hours and motor efficiency of the Kaeser BSD 72 air compressors is, as already mentioned:

| | |
|---|---|
| Service interval: | 3.6.2013 – 3.10.2013 = 2928 h |
| Running hours during the period: | 67164 – 64284 = 2880 h |
| Running hours share: | 2880 / 2928 = 0.98 |

Air compressor running hours: 365 work days * 24 h * 0.98 = **8585 h/year**
Efficiency of the motor: 50 %

Since it is unknown how much energy is used to heat building A, the savings calculations are calculated for the total district heat consumption. The power of the compressor motor is 37 kW, its efficiency is 50% and the running hours/year of the compressor is 5925 h. The heat from the compressor would only be utilized during the colder months of the year, from beginning of October until the end of April, depending on the weather. The running hour percentage for one year is calculated so that the running hours for the colder months can be calculated.

There are 212 days in the period October – April.

During these 212 days, the compressor operates 98 % of the hours:

$$212\ work\ days * 24\ h * 0.98 = 4\ 986\,\frac{h}{year}$$

The heat from the compressor would be utilized **4 986 h/year**. The rest of the time of the year, the heat would be distributed outside.

<u>Energy savings:</u>

By multiplying the power with the efficiency and the running hours, the heat energy produced is calculated.

$$37\ kW * 0.5 * 4\ 986\,\frac{h}{year} = 92\ 241\ kWh/year$$

The air compressor produces 92.2 MWh/year of heat. As mentioned in the text about the savings potential in the warehouse in building D, this heat can be directly subtracted from the total district heat since the heat has never been utilized before. Therefore the heat produced by the air compressor directly saves the amount of energy it produces, which is **92.2 MWh/year**.

<u>Energy cost savings:</u>

The energy cost savings calculations are presented in Appendix 14.

**Utilizing the air compressor heat for heating "slussen" between buildings A and B**

<u>Energy consumption saving</u>

The savings calculation for heating "slussen" with heat from the compressor in building A is done by using the same principle as in heating the warehouse in building D, that the requirement for heating $1m^3$ air 1˚C is 0.33 Wh.

The primary interest here is related to the peaks in district heat consumption, and the economic impact associated with these. Therefore the continuous heat losses are omitted.

“Slussen” has a volume of 175 $m^3$. The estimated temperature to be heated is 10˚C with the estimated frequency of 5 times per day. Based on these estimations the demand for heating “slussen” is:

$$175\, m^3 * 0.33\, Wh * 10^{\circ}C * 5 \frac{times}{day} * 150\, days = 439 \frac{kWh}{year}$$

If the compressor produces 92 241 kWh/year and the heating demand for “slussen” is 439 kWh/year, the compressor heat is much more than enough to cover the demand for heating “slussen”. Since the demand for “slussen” is small compared to the heat from the compressor, there is still heat available for further utilization:

$$92\,241 \frac{kWh}{year} - 439 \frac{kWh}{year} = 91\,802 \frac{kWh}{year}$$

This means that with this action 439 kWh/year of the energy consumption is saved and 91 802 kWh/year of the heat produced by the air compressor would be considered spill-over. To utilize all the energy produced by the air compressor, the door to the production in building A would have to stay open when the “slussen” area is warm enough, to be able to utilize the heat that otherwise would be unutilized, for heating the production in building A. This means new work routines for both the production workers and the warehouse workers.

Alternatively the rest of the compressor heat could be used directly to heat building A.

Energy cost saving

The energy cost savings calculations are presented in Appendix 15.

**Lowering the temperature of the heat pumps**

Lowering the indoor temperature in the assembly hall in building C would save energy. The current temperature is 23˚C and it could be lowered to 20˚C. The general rule is that lowering the temperature one degree saves 5 % of the energy consumption, so lowering the temperature three degrees would save nearly 15% of the energy consumption.

The average consumption/day per heat pump during the time period when the consumption was measured is:

Heat pump 1: 8.48 kWh/day
Heat pump 2: 16.18 kWh/day
Heat pump 3: 27.74 kWh/day

The total consumption of the different pumps for their respective time periods is:

Heat pump 1: 64.07 kWh
Heat pump 2: 121.3 kWh
Heat pump 3: 229.29 kWh

The cost for each pump for their respective time period is presented in Appendix 16.

The average temperature of February/2014 was 0.6˚C, which are a few degrees under the average annual temperature in Nykarleby. To get an understanding of the annual consumption of the heat pumps these daily average consumptions are directly multiplied with the number of days in a year, with a 10 % reduction of the consumption because of the difference in average temperature in February/2014 and the annual average temperature. All the days are counted for because during summertime, the heat pumps cool the hall.

Pump 1: $8.48 \frac{kWh}{day} * 365\ days * (1 - 0.10) = 2786 \frac{kWh}{year}$

Pump 2: $16.18 \frac{kWh}{day} * 365\ days * (1 - 0.10) = 5315 \frac{kWh}{year}$

Pump 3: $27.74 \frac{kWh}{day} * 365 * (1.0 - 0.10) = 9113 \frac{kWh}{year}$

The cost per day and year of the different heat pumps is calculated and presented in Appendix 16.

<u>Energy consumption savings for the three heat pumps</u>

If the temperature had been 20˚C instead of 23˚C during the measuring period, the company would have saved in electricity consumption. If lowering the temperature 3 degrees reduces the energy consumption with 15%[1], the energy consumption saving would have been:

Heat pump 1: $64.07\ kWh * 0.15\ = 9.61\ kWh$
Heat pump 2: $121.3\ kWh * 0.15\ = 18.2\ kWh$
Heat pump 3: $229.29\ kWh * 0.15\ = 34.4\ kWh$

On an annual level, the rough energy saving estimate on same basis as previously declared would be:

Pump 1: $2785.68 \frac{kWh}{year} * 0.15\ = 417.9 \frac{kWh}{year}$

Pump 2: $5315.13 \frac{kWh}{year} * 0.15\ = 797.3 \frac{kWh}{year}$

Pump 3: $9112.59 \frac{kWh}{year} * 0.15\ = 1367 \frac{kWh}{year}$

[1] Generally 5% energy saving from 1 °C lower temperature is used as annual average. Here it is used for a short period of the year to get a rough estimate.This period in question has a temperature close to the annual average.

Energy cost savings for the three heat pumps

The energy cost savings calculations are presented in Appendix 16.

There are still seven heat pumps in the assembly hall and social areas in the building of which the consumption has not been measured or calculated, due to lack of time and complications with getting the device connected to the internet. It is not possible to calculate the consumption of the rest of the heat pumps without some kind of measuring and therefore are the savings calculated only for the ones measured. The actual savings for lowering the temperature are not the calculated cost savings, they are even bigger.

**Replacing existing fluorescent lights with LED-lights in all buildings**

The power of the LED-light chosen is 25 W. The luminous flux is 2000 lm compared to 4319 lm for the current type of lighting. There is floodlight in areas requiring more light. The question whether the LED-light is acceptable without further changes or not is beyond the scope of this report.

To be able to calculate the energy consumption and cost savings, the consumption of the LED-lights had to be calculated in the same way as for the current consumption. The consumption of the current lighting, the LED-lighting and the consumption saving for the different areas is presented in Table 11. The savings calculations are based on only replacing the fluorescent lighting, the flood lighting will not be replaced.

**Table 11.** The consumption savings for replacing the current lighting with LED-lighting.

| | | | Current lighting | | LED - lighting | | |
|---|---|---|---|---|---|---|---|
| **Building** | **Area** | **Running hours (h)** | **Power (W)** | **Consumption /year (MWh)** | **Power (W)** | **Consumption /year (MWh)** | **Consumption saving (MWh)** |
| A | Work-shop | 2259 | 58 | 12.1 | 25 | 5.2 | 6.9 |
| A | Tool warehouse | 6024 | 58 | 8.4 | 25 | 3.6 | 4.8 |
| A | Production | 6024 | 58 | 48.9 | 25 | 21.1 | 27.8 |
| A | Raw material warehouse | 6024 | 58 | 12.6 | 25 | 5.4 | 7.2 |
| A | **Total** | | | **81.9** | | **35.3** | **46.6** |
| B | Charging room | 2259 | 58 | 2.1 | 25 | 0.9 | 1.2 |
| B | Warehouse (north) | 2259 | 58 | 15.2 | 25 | 6.6 | 8.6 |
| B | Office | 2259 | 58 | 1.8 | 25 | 0.8 | 1.0 |
| B | **Total** | | | **19.1** | | **8.2** | **10.9** |
| C | Social rooms | 4016 | 58 | 5.6 | 25 | 2.4 | 3.2 |
| C | Assembly-hall | 4016 | 58 | 22.4 | 25 | 9.6 | 12.7 |
| C | Warehouse | 2008 | 58 | 7.9 | 25 | 3.4 | 4.5 |
| C | Attic | 2008 | 58 | 4.0 | 25 | 1.7 | 2.3 |
| C | Welding room | 2008 | 58 | 2.4 | 25 | 1.1 | 1.4 |
| C | Fluidbag-room | 2008 | 58 | 2.3 | 25 | 1.0 | 1.3 |
| C | Screw room | 2008 | 58 | 0.7 | 25 | 0.3 | 0.4 |
| C | "Under the roof" | 2008 | 58 | 1.4 | 25 | 0.6 | 0.8 |
| C | **Total** | | | **46.7** | | **20.1** | **26.6** |
| D | Raw material warehouse | 8736 | 58 | 6.1 | 25 | 2.6 | 3.5 |
| D | Production (north) | 8736 | 58 | 79.0 | 25 | 34.1 | 45.0 |
| D | Production (south) | 8736 | 58 | 32.4 | 25 | 14.0 | 18.5 |
| D | Warehouse | 8736 | 58 | 52.7 | 25 | 22.7 | 30.0 |
| D | **Total** | | | **170.2** | | **73.4** | **96.9** |
| **Buildings** | **Total** | | | **318** | | **137.1** | **180.9** |

Energy cost savings

The energy cost savings calculations are presented in Appendix 17.

**The pilot project – replacing lights at a specific area**

The pilot project is to replace the lighting at the south production in building D and the amount of lighting being replaced is 40 pcs, making the total power of the LED-lights 1 kW compared to the current power of 2.32 kW. The running hours in building D is 8736 h.

Consumption savings

The current electricity consumption of the lighting at the area is:

$$2.32\ kW * 8736\ h = 20.268\ MWh/year$$

Replacing lighting with LED-lights, the consumption is:

$$1\ kW * 8736\ h = 8.736\ MWh/year$$

The electricity consumption saving is:

$$20.268\frac{MWH}{year} - 8.736\frac{MWh}{year} = 11.532\frac{MWh}{year}$$

The annual energy consumption saving per year for replacing the fluorescent lights with LED-lights at the specific area is **11.532 MWh/year**.

Energy cost savings

The energy cost savings calculations are presented in Appendix 18.

**Installing motion sensor**

Energy savings calculation

To be able to calculate the savings potential in installing motion sensors for the lighting in some specific areas, the electricity consumption of these areas was calculated. To be able to calculate the consumption the number of lights needed to be counted. The light hours of the lights were calculated and then the consumption. The consumption of the different areas is presented in Table 12.

$$Consumption\ (MWh) = Light\ power\ (MW) * Light\ hours\ (\frac{h}{year})$$

**Table 12. Energy consumption and cost of the different areas.**

| Building | Area | Light hours (h/year) | Amount of lights | Power (W) | Total power (W) | Consumption (MWh) |
|---|---|---|---|---|---|---|
| D | South warehouse | 8736 | 48 | 58 | 2784 | 24.32 |
| D | North warehouse | 8736 | 56 | 58 | 3248 | 28.38 |
| D | Tool warehouse | 2134 | 10 | 58 | 580 | 1.24 |
| D | Raw material warehouse | 2134 | 12 | 58 | 696 | 1.49 |
| A | Raw material warehouse | 6024 | 36 | 58 | 2088 | 12.58 |
| | Tool warehouse | 2134 | 24 | 58 | 1392 | 2.97 |
| C | Attic | 2134 | 20 | 58 | 1160 | 2.48 |
| | Screwroom | 2134 | 6 | 58 | 348 | 0.74 |
| **Totalt** | | | | | | **74.18** |

By installing motion sensors for the lighting, the light hours will decrease. The new light hours are calculated with an estimated percentage reduction of the current light hours. The percentage is estimated through observation of the traffic in these areas. Based on the new light hours the new energy consumption is calculated and presented in Table 13. The savings potential is also presented in the same

Table 13. The calculations are based on the lights for these areas being switched on during the work hours of each specific area.

$$New\ light\ hours\ \left(\frac{h}{year}\right) = New\ light\ hour\ persentage\ (\%) * Current\ light\ hours\ (\frac{h}{year})$$

$$New\ energy\ consumption\ (kWh) = New\ light\ hours\ \left(\frac{h}{year}\right) * Light\ power\ (kW)$$

**Table 13.** The energy consumption savings for replacing lights at the specific areas.

| Building | Area | New light hours (%) | New light hours (h/year) | New consumption (MWh) | Current consumption (MWh) | Consumption savings (MWh) |
|---|---|---|---|---|---|---|
| D | South warehouse | 75 % | 6552 | 18.24 | 24.32 | 6.08 |
| D | North warehouse | 75 % | 6552 | 21.28 | 28.38 | 7.09 |
| D | Tool warehouse | 50 % | 1067 | 0.62 | 1.24 | 0.62 |
| D | Raw material warehouse | 25 % | 533 | 0.37 | 1.49 | 1.11 |
| A | Raw material warehouse | 75 % | 4518 | 9.43 | 12.58 | 3.15 |
| | Tool warehouse | 50 % | 1067 | 1.49 | 2.97 | 1.49 |
| C | Attic | 20 % | 427 | 0.5 | 2.48 | 1.98 |
| | Screw room | 30 % | 640 | 0.22 | 0.74 | 0.52 |
| **Total** | | | | 52.15 | 74.18 | **22.04** |

<u>Energy cost savings</u>

The energy cost savings calculations are presented in Appendix 19.

**Replacing existing socket boxes for car engine heating with socket boxes with timers**

<u>Savings calculation</u>

With the current running hours the car engine heating consumption is 12.606 MWh. The consumption and cost if boxes with timers are installed are presented in Table 14.

**Table 14.** The consumption and cost if socket boxes for car engine heating are installed

| **With timers** | |
|---|---|
| Timer | 2 h |
| Sockets used | 45.20 |
| Power (W) | 1000 |
| Running hours (h) | 120 |
| Consumption (kWh) | 5424 |

As mentioned before, the recommendation for heating a car engine in cold weather is 2 hours, so the running hour calculations are based on 2 hours/day for 20 days/month and 3 months/year. The amount of sockets used is based on the calculations done by the auditor. The power of the car engine heating is an estimation based on how many cars use interior heater in their car.

The running hours: $2\ \text{h} * 20\ \text{days} * 4\ \text{months} = 120\ \text{h/year}$

The consumption calculation: $45.2\ \text{sockets} * 120\,\frac{\text{h}}{\text{year}} * 1000\ \text{W} = 5424\ \text{kWh/year}$

The cost calculation is presented in Appendix 20.

**Savings:**

Consumption: $18500\,\frac{\text{kWh}}{\text{year}} - 5424\,\frac{\text{kWh}}{\text{year}} = 13076\ \text{kWh/year}$

The cost saving calculation is presented in Appendix 20.

The annual energy saving for installing socket boxes with timers is: **13076 kWh/year**

### 5.9.2 Investment costs and profitability calculations

**Control curve**

There are no investment costs for adjusting the control curve for district heating except for hiring a field expert to do the job. The average expert hiring fee is around 60 €/hour and the job is estimated to take 4-8 hours. The calculations are based on the estimate that the job would take 8 hours. If the company has the expertise within the company, there is no investment cost.

Cost for hiring an expert: $8\ hours * 60\,\frac{€}{hour} = 480\ €$

The total investment cost is: **480 €**

If the company has the expertise to adjust the curve themselves, the payback time is 0 years and the action would save energy costs immediately.

The payback calculation is presented in Appendix 21

**Installing a door in the warehouse in building D**

The investment cost for installing a fast door between the south and the north part of the warehouse is 7900 € according to information gotten from the person responsible for the company facilities at the company. The annual service cost for the fast door is 300 €/year, also gotten from the person responsible of the facilities.

The payback calculation is presented in Appendix 22.

### Installing air curtains in the warehouse in building D

A price list was found on Airtecnincs webpage. The model MAX is suitable for industrial doors and the price of these models varies from 2000 € to 10 000 €. Because it is so uncertain how powerful an air curtain is needed at the warehouse, the most powerful and expensive model is chosen, which costs 13 001 USD. According to today's currency 13 001 USD is 9396.98 €. On the basis of this investment cost a simple payback was calculated. The installation cost is not included in the calculation because of difficulties in estimating the cost. /19/ /21/

The payback calculation is presented in Appendix 23

### Utilizing the compressor heat for heating building A

Due to difficulties in estimating the cost for utilizing the heat from the compressor for heating building A, the payback time is not calculated.

### Utilizing the compressor heat for heating "slussen" between buildings A and B

Due to difficulties in estimating the cost for utilizing the heat from the compressor for heating "slussen", the payback time is not calculated.

### Lowering the temperature of the heat pumps

For lowering the temperature of the heat pumps there is no investment cost and therefore the payback time is zero years.

### Replacing existing fluorescent lights with LED-lights in all buildings

<u>Investment cost:</u>

The price for the LED-fluorescent lights is taken from Lamppuexpress's webpage. The lights are the kinds that can be installed in the existing armature, so there is no extra cost for installing new ones, and the price for ordering over 40 lights is 36.25 €. The amount of fluorescent lights being replaced is 1055 pcs. The lifetime of a LED-fluorescent light is 50 000 h compared to the 15 000 h of the regular fluorescent light, meaning that the regular fluorescent light would have to be renewed 3 times during the lifetime of a LED-light. /22/

$$1055\ pcs * 36.25\ € = 38\ 243.75\ €$$

The total investment for replacing the existing lighting with LED-lighting is **38 243.75 €**.

The average running hours of the lighting in the company is 4521 h and the lifetime of the LED-lights is 50 000 h making the lifetime in years:

$$\frac{50\ 000\ h}{4521\ h} = 11\ years$$

The lifetime of the current lighting is 15 000 h making the lifetime in years:

$$\frac{15\ 000\ h}{4521\ h} = 3.3\ years$$

Payback

Based on the lifetime the payback is calculated and presented in Appendix 24.

**The pilot project – replacing lights at a specific area**

Investment cost

The same LED-light price as for the calculation for all the buildings is also used in this calculation. 40 lights will be replaced and the price of one LED-light is 36.25 € so the investment cost is:

$$40\ pcs * 36.25\ € = 1450\ €$$

Payback

The payback calculation is presented in Appendix 25.

**Installing motion sensor**

Investment costs

Different motion sensors were chosen for the different areas based on the maximum power capacity the sensors have and the total power of the different areas. The sensors are chosen from Finnparttia's price list on their webpage, where the price and the specifics of the sensors are listed. The sensors chosen are presented in Table 15. /23/

**Table 15.** Specifications of the sensors

| Model | Power capacity (W) | Reaction area | Reaction distance (m) | Light time | Price (€/pcs) |
|---|---|---|---|---|---|
| VAHTIJUSSI 2 | 1000 | 240° | 12 | 5 s - 12 min | 49 € |
| VAHTIJUSSI 4 | 3600 | 220° | 16 | 10 s - 30 min | 109 € |

Payback

The payback calculation is presented in Appendix 26.

**Replacing existing socket boxes for car engine heating with socket boxes with timers**

Investment calculation

The investment cost is presented in Table 16 with socket box price, cost for the installation and the work hours for the installation. The price of the boxes is collected from Finnparttia's product catalogue on their webpage. The work hours were estimated by an employee at Jeppo Kraft and are based on three boxes being installed per hour. An extra hour is added to the work hours in case of delay. The work hour price is the price Jeppo Kraft charges by the hour for installation work. /23/

**Table 16.** Investment cost for installing socket boxes with timers

| | | |
|---|---|---|
| Amount of boxes | 33 | boxes |
| Price for boxes | 149 | € |
| Cost/ hour for installation | 32 | €/h |
| Work hours | 12 | h |
| **Total cost** | **5 301** | € |

Work hours:

$$\frac{33\text{ boxes}}{3\text{ boxes/hour}} = 11\text{ h}$$

11 h + 1 extra hour = 12 h

Investment cost:

$$\left(33\text{ boxes} * 149\frac{€}{\text{box}}\right) + \left(12\text{ h} * 32\frac{€}{\text{h}}\right) = 5301\text{ €}$$

The total investment cost is: **5301 €**

Payback

The payback calculation is presented in Appendix 27

# 6 Conclusion

During the project it was noticed that the company had not given much thought to their energy use. There are power reports and follow-ups on their electricity and district heat consumption, but there are not enough resources within the company to take actions towards saving energy. An energy audit was done in 2006, but not many of the action suggestions in that report have been utilized.

The overall electricity consumption is very much depending on the production within the company, during slower production years the electricity consumption is much lower. The company is constantly investing in new energy efficient machines and the electricity consumption will decrease due to this. The peaks in district heat consumption are the biggest problem. According to the analysis the forklift traffic in and out of the buildings is believed to be the reason for the peaks and the action suggestions presented in this report will reduce the peaks. Because of this, preventing the basic charge to rise is considered a saving for the company.

## 6.1 Conclusions about action suggestions

The conclusions about the action suggestions are presented in the order of profitability.

**Adjusting the control curve**

As mentioned about the discussions on indoor temperature being too low during milder outside weather and too high during colder outside weather, the conclusion is that the problem will be solved by optimising the control curve. This action has no costs unless an expert is hired, but the company has the competence to do the adjustment themselves. The indoor temperature overall in all the buildings is too high. Lowering the temperature might not lower the district heat peaks, but will save energy and make the work place more pleasant. It is not healthy to work in too high temperatures. This action will save nearly 15 % of the energy consumption and has no investment cost. Both actions are pure savings for the company with no payback time.

**Lowering the temperature on the heat pumps**

The temperature on the heat pumps in the assembly hall was set to 23°C during inspection, which is too high for the work taking place in that area. It was also noticed during the inspection that the heat pumps on the east side consume a lot more electricity. The reason for this was that the workers had set the heat pumps themselves and the heat pumps were working against each other. The remote control should be hidden away so that only the manager of the assembly hall can control the settings.

Lowering the temperature and a better control of the settings of the heat pumps are pure savings without investment costs. Lowering the temperature 3°C will save nearly 15 % of the energy consumption.

**Adjusting running hours for the ventilation system**

The running hours are important for the comfort of the workers and need to be thought about carefully. There is not much room for change in the running hours in the systems except for the systems in building C. This action saves a little money and has no investment cost.

Otherwise the ventilation systems are in good condition. They are all relatively new except for the one in the production area of building A, which could be considered to be replaced. The systems are also cleaned frequently.

**Utilizing the heat from air compressor in building A**

Distributing the heat produced by the air compressor outside is not optimal when thinking about saving energy. It has been thought, within the company, about taking actions against this problem, but again the resources are not enough. Now it is known how much energy can be saved by utilizing the heat and the decision making towards taking action against this problem will be easier. This is the most important action in the sense of lots of heat not being utilized. The investment cost for both actions is unknown because of difficulties in estimating the cost of the work and the work hours, but the guess is that it is fairly high. Still the action is very important since there is 65 000 kWh of heat that is not being utilized.

Distributing the heat produced by the air compressor to the heat distribution system is the best solution when looking at saving energy. The heat the compressor produces would then be direct district heat consumption saving. The investment cost for the action might be pretty high.

Considering energy savings, utilizing the heat for heating “slussen” is not optimal. The energy demand for heating the small area is much smaller than the amount of heat the air compressor produces. Routines with keeping the doors open or closed would have to be changed with this action to be able to utilize all the heat the air compressor produces. Heating “slussen” with the heat is more a comfort thing for the workers, since they leave the products the machines produce in the area. A reason for the high peaks in district heat consumption is the traffic in and out of building A. Distributing the heat to “slussen” would also create a sort of air barrier for the cold air spreading into the building, but not very efficiently. However, this action might even out the peaks a little. The investment cost for the action is believed to be high.

**Installing motion sensors for lighting**

There are many areas in the company that are unmanned but lighting is running. By installing motion sensors the running hours of the lighting will increase and therefore also the energy consumption. The investment cost for the sensors is low, but the cost for installing the motion sensors is unknown because of the difficulty in estimating the cost for cables and work hours. Without the cost for installing the sensors the payback time is really low. This is an action that saves much money with very little investment and effort.

### Replacing existing socket boxes for car engine heating with socket boxes with timers

With the existing running hours the car engines are being heated too long. By installing socket boxes with timers the workers would be able to set the running hours themselves. The need for heating the car engine is not more than two hours. The condition of the existing socket boxes is not that good either and it would be recommended to replace them anyway. The investment cost and the cost for installing the new boxes are not that high and the savings potential is fairly good. It is a good action that can be carried out with very little effort.

### Replacing existing fluorescent lighting with LED-lighting

The lighting consumes a lot of electricity and by replacing the existing fluorescent lights with LED-lights the electricity consumption decreases considerably. The LED-lights are expensive making the investment cost high. There is no cost for installing because the LED-lights today can be installed in existing armatures. In addition, there is no cost for replacing the lights because they need to be renewed sooner or later anyway, and the replacing can be done when the existing lights break. The payback time for replacing the lights is good. The action has a high investment but very good savings potential.

A problem with installing LED-lighting is the colour of the lighting. It might disturb quality control camera systems and it takes some time for the workers to get used to. This is why a pilot project was suggested for testing how the workers react to the colour. Another problem is that the LED-lighting does not produce as much heat as regular fluorescent lights. On the other, hand during summertime less cooling is needed with LED-lighting, making the heat loss evened out with savings in cooling the building.

### Loading and unloading of trucks

Lots of cold air spread in the warm warehouse in building D when the loading and unloading of trucks take place. This is a big reason for the high peaks in district heat consumption. Two actions are presented for preventing the cold air from spreading to the building. Because of the over pressure in building D once the cold air spreads to the production side, the cold air will also spread to building A, which is connected to building D. It would be very important to prevent the cold from spreading in the building both for evening out the peaks and for the comfort of the workers.

Installing an air curtain at the door where the loading and unloading take place is the most efficient way to keep cold air and dust from spreading in the building. As mentioned before the heat loss reduction of air curtains can be up to 80%. With this action some routines in the loading and unloading of the subsidiary company’s truck will have to change. All loading and unloading will have to take place at the same door, which might cause some problems. The investment cost for installing the air curtain is pretty high, but the savings potential being so good, the payback time is not that long. Especially when taking into consideration the savings in basic charge. This is the best action for evening out the high peaks in district heat consumption.

Installing a door between the north and the south side of the warehouse will prevent the cold air from spreading to the whole warehouse. The north end, where the loading and unloading of trucks takes place, still needs to be heated. The investment cost for installing a door is relatively high. The action is not the most efficient one to lower the district heat consumption. It will even out the peaks and therefore the basic charge savings are included in the calculations. Without taking the basic charge saving into consideration the payback time is very long, but by including the basic charge saving the payback time is much shorter, but still pretty long.

## 6.2 Further research

Instead of utilizing the heat from the compressor in building A for heating “slussen” or the production area, the possibility of utilizing the heat as an air curtain to prevent cold air from spreading into the building could be researched. This is a more complicated action but would save much energy.

Research could also be done on how to utilize the heat from the air compressor in building D. It could also be used as an air curtain for the door in the south end of the warehouse located next to the compressor. This would mean that the loading and unloading of the subsidiary company’s truck could be done at this door as it is being done for now.

Research on how much heat is leaking out through the walls and roofs of the buildings could be done. Most of the buildings are pretty old and no or very little renovating has been done to the buildings.

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The savings potential list by sector, created by Motiva. /24/

| RAPORTOIDUT KOHTEET 1992-2012 (6 276 KOHDETTA) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SEKTORI | KOH-TEET | SÄÄSTÖ-POTENTIAALI YHTEENSÄ | TMA | INVES-TOINTI | SÄÄSTÖPOTENTIAALI | | | | | | | |
| | | | | | | LÄMPÖ | | | SÄHKÖ | | | VESI | |
| | | | | | | energia | kustannukset | | energia | kustannukset | | kulutus | kustan-nukset |
| | | | | | | | energia | teho | | energia | teho | | |
| | | lkm | milj. €/a | a | milj.€ | GWh/a | milj. €/a | milj. €/a | GWh/a | milj. €/a | milj. €/a | km³/a | milj. €/a |
| | | | | | | | | | | | | | |
| PJ | Kunta-ala | 3684 | 23.4 | 4.1 | 97.0 | 474.4 | 12.6 | 1.4 | 98.0 | 5.6 | 2.0 | 845.0 | 1.7 |
| PY | Yksityinen palvelu | 1625 | 24.4 | 1.8 | 44.8 | 411.1 | 11.4 | 0.9 | 161.4 | 9.4 | 1.6 | 570.5 | 1.1 |
| TE | Teollisuus alle 500 GWh | 937 | 74.6 | 2.9 | 218.9 | 1 700.6 | 46.8 | 3.4 | 321.1 | 17.3 | 3.0 | 5 133.3 | 4.2 |
| TE | Teollisuus yli 500 GWh | 9 | 27.0 | 3.7 | 99.3 | 1 256.3 | 16.9 | 0.2 | 249.8 | 7.9 | 1.7 | 6 873.5 | 0.2 |
| EA | Energia-ala | 21 | 0.2 | 1.4 | 0.2 | 6.2 | 0.1 | 0.0 | 1.5 | 0.1 | 0.0 | 21.9 | 0.0 |
| | | | | | | | | | | | | | |
| | **YHTEENSÄ** | **6 276** | **149.4** | **3.1** | **460.2** | **3 849** | **87.7** | **5.9** | **832** | **40.3** | **8.3** | **13 444** | **7.2** |

The monthly and annual district heat consumption data for the years 2010 - 2013

The district heat power data of the specific periods

The measured consumption data of heat pump 1.

| Date | Hour | kWh | Date | Hour | kWh | Date | Hour | kWh | Date | Hour | kWh |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.2.2014 | 12:00:00 | 0.51 | 9.2.2014 | 06:00:00 | 0.39 | 11.2.2014 | 00:00:00 | 0.49 | 12.2.2014 | 18:00:00 | 0.25 |
| 7.2.2014 | 13:00:00 | 0.49 | 9.2.2014 | 07:00:00 | 0.50 | 11.2.2014 | 01:00:00 | 0.33 | 12.2.2014 | 19:00:00 | 0.25 |
| 7.2.2014 | 14:00:00 | 0.51 | 9.2.2014 | 08:00:00 | 0.37 | 11.2.2014 | 02:00:00 | 0.27 | 12.2.2014 | 20:00:00 | 0.30 |
| 7.2.2014 | 15:00:00 | 0.52 | 9.2.2014 | 09:00:00 | 0.47 | 11.2.2014 | 03:00:00 | 0.40 | 12.2.2014 | 21:00:00 | 0.45 |
| 7.2.2014 | 16:00:00 | 0.40 | 9.2.2014 | 10:00:00 | 0.50 | 11.2.2014 | 04:00:00 | 0.46 | 12.2.2014 | 22:00:00 | 0.36 |
| 7.2.2014 | 17:00:00 | 0.52 | 9.2.2014 | 11:00:00 | 0.37 | 11.2.2014 | 05:00:00 | 0.32 | 12.2.2014 | 23:00:00 | 0.50 |
| 7.2.2014 | 18:00:00 | 0.47 | 9.2.2014 | 12:00:00 | 0.50 | 11.2.2014 | 06:00:00 | 0.47 | 13.2.2014 | 00:00:00 | 0.43 |
| 7.2.2014 | 19:00:00 | 0.46 | 9.2.2014 | 13:00:00 | 0.28 | 11.2.2014 | 07:00:00 | 0.26 | 13.2.2014 | 01:00:00 | 0.49 |
| 7.2.2014 | 20:00:00 | 0.40 | 9.2.2014 | 14:00:00 | 0.42 | 11.2.2014 | 08:00:00 | 0.30 | 13.2.2014 | 02:00:00 | 0.38 |
| 7.2.2014 | 21:00:00 | 0.39 | 9.2.2014 | 15:00:00 | 0.33 | 11.2.2014 | 09:00:00 | 0.47 | 13.2.2014 | 03:00:00 | 0.53 |
| 7.2.2014 | 22:00:00 | 0.45 | 9.2.2014 | 16:00:00 | 0.26 | 11.2.2014 | 10:00:00 | 0.26 | 13.2.2014 | 04:00:00 | 0.40 |
| 7.2.2014 | 23:00:00 | 0.51 | 9.2.2014 | 17:00:00 | 0.44 | 11.2.2014 | 11:00:00 | 0.39 | 13.2.2014 | 05:00:00 | 0.53 |
| 8.2.2014 | 00:00:00 | 0.46 | 9.2.2014 | 18:00:00 | 0.47 | 11.2.2014 | 12:00:00 | 0.26 | 13.2.2014 | 06:00:00 | 0.35 |
| 8.2.2014 | 01:00:00 | 0.54 | 9.2.2014 | 19:00:00 | 0.27 | 11.2.2014 | 13:00:00 | 0.25 | 13.2.2014 | 07:00:00 | 0.41 |
| 8.2.2014 | 02:00:00 | 0.51 | 9.2.2014 | 20:00:00 | 0.45 | 11.2.2014 | 14:00:00 | 0.24 | 13.2.2014 | 08:00:00 | 0.39 |
| 8.2.2014 | 03:00:00 | 0.51 | 9.2.2014 | 21:00:00 | 0.51 | 11.2.2014 | 15:00:00 | 0.26 | 13.2.2014 | 09:00:00 | 0.26 |
| 8.2.2014 | 04:00:00 | 0.48 | 9.2.2014 | 22:00:00 | 0.36 | 11.2.2014 | 16:00:00 | 0.47 | 13.2.2014 | 10:00:00 | 0.41 |
| 8.2.2014 | 05:00:00 | 0.44 | 9.2.2014 | 23:00:00 | 0.41 | 11.2.2014 | 17:00:00 | 0.31 | 13.2.2014 | 11:00:00 | 0.38 |
| 8.2.2014 | 06:00:00 | 0.49 | 10.2.2014 | 00:00:00 | 0.51 | 11.2.2014 | 18:00:00 | 0.31 | 13.2.2014 | 12:00:00 | 0.26 |
| 8.2.2014 | 07:00:00 | 0.54 | 10.2.2014 | 01:00:00 | 0.50 | 11.2.2014 | 19:00:00 | 0.24 | 13.2.2014 | 13:00:00 | 0.25 |
| 8.2.2014 | 08:00:00 | 0.49 | 10.2.2014 | 02:00:00 | 0.33 | 11.2.2014 | 20:00:00 | 0.24 | 13.2.2014 | 14:00:00 | 0.26 |
| 8.2.2014 | 09:00:00 | 0.53 | 10.2.2014 | 03:00:00 | 0.36 | 11.2.2014 | 21:00:00 | 0.26 | 13.2.2014 | 15:00:00 | 0.25 |
| 8.2.2014 | 10:00:00 | 0.53 | 10.2.2014 | 04:00:00 | 0.50 | 11.2.2014 | 22:00:00 | 0.27 | 13.2.2014 | 16:00:00 | 0.24 |
| 8.2.2014 | 11:00:00 | 0.25 | 10.2.2014 | 05:00:00 | 0.42 | 11.2.2014 | 23:00:00 | 0.46 | 13.2.2014 | 17:00:00 | 0.26 |
| 8.2.2014 | 12:00:00 | 0.25 | 10.2.2014 | 06:00:00 | 0.25 | 12.2.2014 | 00:00:00 | 0.51 | 13.2.2014 | 18:00:00 | 0.30 |
| 8.2.2014 | 13:00:00 | 0.39 | 10.2.2014 | 07:00:00 | 0.25 | 12.2.2014 | 01:00:00 | 0.39 | 13.2.2014 | 19:00:00 | 0.46 |
| 8.2.2014 | 14:00:00 | 0.45 | 10.2.2014 | 08:00:00 | 0.27 | 12.2.2014 | 02:00:00 | 0.39 | 13.2.2014 | 20:00:00 | 0.40 |
| 8.2.2014 | 15:00:00 | 0.37 | 10.2.2014 | 09:00:00 | 0.47 | 12.2.2014 | 03:00:00 | 0.53 | 13.2.2014 | 21:00:00 | 0.38 |
| 8.2.2014 | 16:00:00 | 0.49 | 10.2.2014 | 10:00:00 | 0.24 | 12.2.2014 | 04:00:00 | 0.41 | 13.2.2014 | 22:00:00 | 0.49 |
| 8.2.2014 | 17:00:00 | 0.51 | 10.2.2014 | 11:00:00 | 0.25 | 12.2.2014 | 05:00:00 | 0.50 | 13.2.2014 | 23:00:00 | 0.45 |
| 8.2.2014 | 18:00:00 | 0.50 | 10.2.2014 | 12:00:00 | 0.25 | 12.2.2014 | 06:00:00 | 0.38 | 14.2.2014 | 00:00:00 | 0.45 |
| 8.2.2014 | 19:00:00 | 0.35 | 10.2.2014 | 13:00:00 | 0.23 | 12.2.2014 | 07:00:00 | 0.25 | 14.2.2014 | 01:00:00 | 0.48 |
| 8.2.2014 | 20:00:00 | 0.49 | 10.2.2014 | 14:00:00 | 0.25 | 12.2.2014 | 08:00:00 | 0.30 | 14.2.2014 | 02:00:00 | 0.39 |
| 8.2.2014 | 21:00:00 | 0.44 | 10.2.2014 | 15:00:00 | 0.24 | 12.2.2014 | 09:00:00 | 0.42 | 14.2.2014 | 03:00:00 | 0.52 |
| 8.2.2014 | 22:00:00 | 0.28 | 10.2.2014 | 16:00:00 | 0.24 | 12.2.2014 | 10:00:00 | 0.31 | 14.2.2014 | 04:00:00 | 0.49 |
| 8.2.2014 | 23:00:00 | 0.49 | 10.2.2014 | 17:00:00 | 0.24 | 12.2.2014 | 11:00:00 | 0.25 | 14.2.2014 | 05:00:00 | 0.49 |
| 9.2.2014 | 00:00:00 | 0.45 | 10.2.2014 | 18:00:00 | 0.24 | 12.2.2014 | 12:00:00 | 0.26 | 14.2.2014 | 06:00:00 | 0.47 |
| 9.2.2014 | 01:00:00 | 0.39 | 10.2.2014 | 19:00:00 | 0.25 | 12.2.2014 | 13:00:00 | 0.24 | 14.2.2014 | 07:00:00 | 0.33 |
| 9.2.2014 | 02:00:00 | 0.50 | 10.2.2014 | 20:00:00 | 0.25 | 12.2.2014 | 14:00:00 | 0.24 | 14.2.2014 | 08:00:00 | 0.29 |
| 9.2.2014 | 03:00:00 | 0.39 | 10.2.2014 | 21:00:00 | 0.25 | 12.2.2014 | 15:00:00 | 0.26 | 14.2.2014 | 09:00:00 | 0.49 |
| 9.2.2014 | 04:00:00 | 0.49 | 10.2.2014 | 22:00:00 | 0.33 | 12.2.2014 | 16:00:00 | 0.26 | 14.2.2014 | 10:00:00 | 0.25 |
| 9.2.2014 | 05:00:00 | 0.49 | 10.2.2014 | 23:00:00 | 0.42 | 12.2.2014 | 17:00:00 | 0.26 | 14.2.2014 | 11:00:00 | 0.24 |

The measured consumption data of heat pump 2.

| Date | Hour | kWh | Date | Hour | kWh | Date | Hour | kWh | Date | Hour | kWh |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14.2.2014 | 12:00:00 | 0.32 | 16.2.2014 | 06:00:00 | 0.88 | 18.2.2014 | 00:00:00 | 0.73 | 19.2.2014 | 18:00:00 | 0.55 |
| 14.2.2014 | 13:00:00 | 0.65 | 16.2.2014 | 07:00:00 | 0.77 | 18.2.2014 | 01:00:00 | 0.70 | 19.2.2014 | 19:00:00 | 0.51 |
| 14.2.2014 | 14:00:00 | 0.52 | 16.2.2014 | 08:00:00 | 0.87 | 18.2.2014 | 02:00:00 | 0.76 | 19.2.2014 | 20:00:00 | 0.59 |
| 14.2.2014 | 15:00:00 | 0.61 | 16.2.2014 | 09:00:00 | 0.82 | 18.2.2014 | 03:00:00 | 0.70 | 19.2.2014 | 21:00:00 | 0.58 |
| 14.2.2014 | 16:00:00 | 0.56 | 16.2.2014 | 10:00:00 | 0.87 | 18.2.2014 | 04:00:00 | 0.69 | 19.2.2014 | 22:00:00 | 0.61 |
| 14.2.2014 | 17:00:00 | 0.50 | 16.2.2014 | 11:00:00 | 0.86 | 18.2.2014 | 05:00:00 | 0.81 | 19.2.2014 | 23:00:00 | 0.82 |
| 14.2.2014 | 18:00:00 | 0.56 | 16.2.2014 | 12:00:00 | 0.78 | 18.2.2014 | 06:00:00 | 0.71 | 20.2.2014 | 00:00:00 | 0.77 |
| 14.2.2014 | 19:00:00 | 0.50 | 16.2.2014 | 13:00:00 | 0.73 | 18.2.2014 | 07:00:00 | 0.65 | 20.2.2014 | 01:00:00 | 0.95 |
| 14.2.2014 | 20:00:00 | 0.56 | 16.2.2014 | 14:00:00 | 0.81 | 18.2.2014 | 08:00:00 | 0.52 | 20.2.2014 | 02:00:00 | 1.02 |
| 14.2.2014 | 21:00:00 | 0.52 | 16.2.2014 | 15:00:00 | 0.72 | 18.2.2014 | 09:00:00 | 0.63 | 20.2.2014 | 03:00:00 | 1.02 |
| 14.2.2014 | 22:00:00 | 0.50 | 16.2.2014 | 16:00:00 | 0.73 | 18.2.2014 | 10:00:00 | 0.61 | 20.2.2014 | 04:00:00 | 0.88 |
| 14.2.2014 | 23:00:00 | 0.59 | 16.2.2014 | 17:00:00 | 0.78 | 18.2.2014 | 11:00:00 | 0.57 | 20.2.2014 | 05:00:00 | 1.01 |
| 15.2.2014 | 00:00:00 | 0.64 | 16.2.2014 | 18:00:00 | 0.72 | 18.2.2014 | 12:00:00 | 0.57 | 20.2.2014 | 06:00:00 | 1.12 |
| 15.2.2014 | 01:00:00 | 0.63 | 16.2.2014 | 19:00:00 | 0.81 | 18.2.2014 | 13:00:00 | 0.52 | 20.2.2014 | 07:00:00 | 0.99 |
| 15.2.2014 | 02:00:00 | 0.72 | 16.2.2014 | 20:00:00 | 0.80 | 18.2.2014 | 14:00:00 | 0.62 | 20.2.2014 | 08:00:00 | 0.87 |
| 15.2.2014 | 03:00:00 | 0.72 | 16.2.2014 | 21:00:00 | 0.64 | 18.2.2014 | 15:00:00 | 0.63 | 20.2.2014 | 09:00:00 | 0.94 |
| 15.2.2014 | 04:00:00 | 0.76 | 16.2.2014 | 22:00:00 | 0.83 | 18.2.2014 | 16:00:00 | 0.56 | 20.2.2014 | 10:00:00 | 0.94 |
| 15.2.2014 | 05:00:00 | 0.72 | 16.2.2014 | 23:00:00 | 0.81 | 18.2.2014 | 17:00:00 | 0.57 | 20.2.2014 | 11:00:00 | 0.89 |
| 15.2.2014 | 06:00:00 | 0.63 | 17.2.2014 | 00:00:00 | 0.73 | 18.2.2014 | 18:00:00 | 0.51 | 20.2.2014 | 12:00:00 | 0.89 |
| 15.2.2014 | 07:00:00 | 0.59 | 17.2.2014 | 01:00:00 | 0.81 | 18.2.2014 | 19:00:00 | 0.59 | 20.2.2014 | 13:00:00 | 0.88 |
| 15.2.2014 | 08:00:00 | 0.57 | 17.2.2014 | 02:00:00 | 0.82 | 18.2.2014 | 20:00:00 | 0.61 | 20.2.2014 | 14:00:00 | 0.78 |
| 15.2.2014 | 09:00:00 | 0.59 | 17.2.2014 | 03:00:00 | 0.76 | 18.2.2014 | 21:00:00 | 0.66 | 20.2.2014 | 15:00:00 | 0.75 |
| 15.2.2014 | 10:00:00 | 0.60 | 17.2.2014 | 04:00:00 | 0.75 | 18.2.2014 | 22:00:00 | 0.72 | 20.2.2014 | 16:00:00 | 0.66 |
| 15.2.2014 | 11:00:00 | 0.55 | 17.2.2014 | 05:00:00 | 0.86 | 18.2.2014 | 23:00:00 | 0.73 | 20.2.2014 | 17:00:00 | 0.65 |
| 15.2.2014 | 12:00:00 | 0.55 | 17.2.2014 | 06:00:00 | 0.84 | 19.2.2014 | 00:00:00 | 0.75 | 20.2.2014 | 18:00:00 | 0.60 |
| 15.2.2014 | 13:00:00 | 0.59 | 17.2.2014 | 07:00:00 | 0.54 | 19.2.2014 | 01:00:00 | 0.86 | 20.2.2014 | 19:00:00 | 0.57 |
| 15.2.2014 | 14:00:00 | 0.56 | 17.2.2014 | 08:00:00 | 0.54 | 19.2.2014 | 02:00:00 | 0.84 | 20.2.2014 | 20:00:00 | 0.59 |
| 15.2.2014 | 15:00:00 | 0.56 | 17.2.2014 | 09:00:00 | 0.74 | 19.2.2014 | 03:00:00 | 0.83 | 20.2.2014 | 21:00:00 | 0.60 |
| 15.2.2014 | 16:00:00 | 0.56 | 17.2.2014 | 10:00:00 | 0.62 | 19.2.2014 | 04:00:00 | 0.79 | 20.2.2014 | 22:00:00 | 0.58 |
| 15.2.2014 | 17:00:00 | 0.52 | 17.2.2014 | 11:00:00 | 0.49 | 19.2.2014 | 05:00:00 | 0.97 | 20.2.2014 | 23:00:00 | 0.81 |
| 15.2.2014 | 18:00:00 | 0.68 | 17.2.2014 | 12:00:00 | 0.61 | 19.2.2014 | 06:00:00 | 0.81 | 21.2.2014 | 00:00:00 | 0.81 |
| 15.2.2014 | 19:00:00 | 0.71 | 17.2.2014 | 13:00:00 | 0.62 | 19.2.2014 | 07:00:00 | 0.73 | 21.2.2014 | 01:00:00 | 0.97 |
| 15.2.2014 | 20:00:00 | 0.64 | 17.2.2014 | 14:00:00 | 0.58 | 19.2.2014 | 08:00:00 | 0.82 | 21.2.2014 | 02:00:00 | 0.89 |
| 15.2.2014 | 21:00:00 | 0.72 | 17.2.2014 | 15:00:00 | 0.49 | 19.2.2014 | 09:00:00 | 0.82 | 21.2.2014 | 03:00:00 | 1.02 |
| 15.2.2014 | 22:00:00 | 0.61 | 17.2.2014 | 16:00:00 | 0.49 | 19.2.2014 | 10:00:00 | 0.72 | 21.2.2014 | 04:00:00 | 1.09 |
| 15.2.2014 | 23:00:00 | 0.83 | 17.2.2014 | 17:00:00 | 0.57 | 19.2.2014 | 11:00:00 | 0.86 | 21.2.2014 | 05:00:00 | 1.05 |
| 16.2.2014 | 00:00:00 | 0.80 | 17.2.2014 | 18:00:00 | 0.56 | 19.2.2014 | 12:00:00 | 0.74 | 21.2.2014 | 06:00:00 | 1.01 |
| 16.2.2014 | 01:00:00 | 0.75 | 17.2.2014 | 19:00:00 | 0.49 | 19.2.2014 | 13:00:00 | 0.71 | 21.2.2014 | 07:00:00 | 0.94 |
| 16.2.2014 | 02:00:00 | 0.85 | 17.2.2014 | 20:00:00 | 0.57 | 19.2.2014 | 14:00:00 | 0.68 | 21.2.2014 | 08:00:00 | 0.95 |
| 16.2.2014 | 03:00:00 | 0.81 | 17.2.2014 | 21:00:00 | 0.51 | 19.2.2014 | 15:00:00 | 0.59 | 21.2.2014 | 09:00:00 | 1.02 |
| 16.2.2014 | 04:00:00 | 0.76 | 17.2.2014 | 22:00:00 | 0.50 | 19.2.2014 | 16:00:00 | 0.58 | 21.2.2014 | 10:00:00 | 0.93 |
| 16.2.2014 | 05:00:00 | 0.93 | 17.2.2014 | 23:00:00 | 0.66 | 19.2.2014 | 17:00:00 | 0.56 | 21.2.2014 | 11:00:00 | 1.04 |

The measured consumption data of heat pump 2.

| Date | Hour | kWh | Date | Hour | kWh | Date | Hour | kWh | Date | Hour | kWh |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21.2.2014 | 13:00:00 | 1.39 | 23.2.2014 | 07:00:00 | 1.14 | 25.2.2014 | 01:00:00 | 1.19 | 26.2.2014 | 19:00:00 | 1.17 |
| 21.2.2014 | 14:00:00 | 1.46 | 23.2.2014 | 08:00:00 | 1.16 | 25.2.2014 | 02:00:00 | 1.14 | 26.2.2014 | 20:00:00 | 1.18 |
| 21.2.2014 | 15:00:00 | 1.25 | 23.2.2014 | 09:00:00 | 1.10 | 25.2.2014 | 03:00:00 | 1.14 | 26.2.2014 | 21:00:00 | 1.17 |
| 21.2.2014 | 16:00:00 | 1.31 | 23.2.2014 | 10:00:00 | 1.30 | 25.2.2014 | 04:00:00 | 1.13 | 26.2.2014 | 22:00:00 | 1.26 |
| 21.2.2014 | 17:00:00 | 1.48 | 23.2.2014 | 11:00:00 | 1.23 | 25.2.2014 | 05:00:00 | 1.15 | 26.2.2014 | 23:00:00 | 1.24 |
| 21.2.2014 | 18:00:00 | 1.25 | 23.2.2014 | 12:00:00 | 1.80 | 25.2.2014 | 06:00:00 | 1.80 | 27.2.2014 | 00:00:00 | 1.37 |
| 21.2.2014 | 19:00:00 | 1.41 | 23.2.2014 | 13:00:00 | 1.14 | 25.2.2014 | 07:00:00 | 1.18 | 27.2.2014 | 01:00:00 | 1.31 |
| 21.2.2014 | 20:00:00 | 1.12 | 23.2.2014 | 14:00:00 | 1.15 | 25.2.2014 | 08:00:00 | 1.15 | 27.2.2014 | 02:00:00 | 1.42 |
| 21.2.2014 | 21:00:00 | 1.13 | 23.2.2014 | 15:00:00 | 1.60 | 25.2.2014 | 09:00:00 | 1.20 | 27.2.2014 | 03:00:00 | 1.30 |
| 21.2.2014 | 22:00:00 | 1.15 | 23.2.2014 | 16:00:00 | 1.18 | 25.2.2014 | 10:00:00 | 1.90 | 27.2.2014 | 04:00:00 | 1.26 |
| 21.2.2014 | 23:00:00 | 1.16 | 23.2.2014 | 17:00:00 | 1.40 | 25.2.2014 | 11:00:00 | 1.11 | 27.2.2014 | 05:00:00 | 1.24 |
| 22.2.2014 | 00:00:00 | 1.26 | 23.2.2014 | 18:00:00 | 1.32 | 25.2.2014 | 12:00:00 | 1.26 | 27.2.2014 | 06:00:00 | 1.39 |
| 22.2.2014 | 01:00:00 | 1.12 | 23.2.2014 | 19:00:00 | 1.30 | 25.2.2014 | 13:00:00 | 1.70 | 27.2.2014 | 07:00:00 | 1.18 |
| 22.2.2014 | 02:00:00 | 1.80 | 23.2.2014 | 20:00:00 | 1.15 | 25.2.2014 | 14:00:00 | 1.14 | 27.2.2014 | 08:00:00 | 1.30 |
| 22.2.2014 | 03:00:00 | 1.21 | 23.2.2014 | 21:00:00 | 1.31 | 25.2.2014 | 15:00:00 | 1.14 | 27.2.2014 | 09:00:00 | 1.22 |
| 22.2.2014 | 04:00:00 | 1.32 | 23.2.2014 | 22:00:00 | 1.27 | 25.2.2014 | 16:00:00 | 1.13 | 27.2.2014 | 10:00:00 | 1.16 |
| 22.2.2014 | 05:00:00 | 1.36 | 23.2.2014 | 23:00:00 | 1.25 | 25.2.2014 | 17:00:00 | 0.96 | 27.2.2014 | 11:00:00 | 1.23 |
| 22.2.2014 | 06:00:00 | 1.19 | 24.2.2014 | 00:00:00 | 1.20 | 25.2.2014 | 18:00:00 | 1.19 | 27.2.2014 | 12:00:00 | 1.12 |
| 22.2.2014 | 07:00:00 | 1.33 | 24.2.2014 | 01:00:00 | 1.25 | 25.2.2014 | 19:00:00 | 1.10 | 27.2.2014 | 13:00:00 | 1.29 |
| 22.2.2014 | 08:00:00 | 1.16 | 24.2.2014 | 02:00:00 | 1.16 | 25.2.2014 | 20:00:00 | 1.10 | 27.2.2014 | 14:00:00 | 1.17 |
| 22.2.2014 | 09:00:00 | 1.21 | 24.2.2014 | 03:00:00 | 1.14 | 25.2.2014 | 21:00:00 | 1.90 | 27.2.2014 | 15:00:00 | 1.21 |
| 22.2.2014 | 10:00:00 | 1.18 | 24.2.2014 | 04:00:00 | 1.16 | 25.2.2014 | 22:00:00 | 1.19 | 27.2.2014 | 16:00:00 | 1.11 |
| 22.2.2014 | 11:00:00 | 1.13 | 24.2.2014 | 05:00:00 | 1.40 | 25.2.2014 | 23:00:00 | 1.34 | 27.2.2014 | 17:00:00 | 1.13 |
| 22.2.2014 | 12:00:00 | 1.50 | 24.2.2014 | 06:00:00 | 1.18 | 26.2.2014 | 00:00:00 | 1.00 | 27.2.2014 | 18:00:00 | 1.22 |
| 22.2.2014 | 13:00:00 | 1.13 | 24.2.2014 | 07:00:00 | 1.70 | 26.2.2014 | 01:00:00 | 1.24 | 27.2.2014 | 19:00:00 | 1.14 |
| 22.2.2014 | 14:00:00 | 1.14 | 24.2.2014 | 08:00:00 | 1.13 | 26.2.2014 | 02:00:00 | 1.70 | 27.2.2014 | 20:00:00 | 1.23 |
| 22.2.2014 | 15:00:00 | 1.27 | 24.2.2014 | 09:00:00 | 1.90 | 26.2.2014 | 03:00:00 | 1.29 | 27.2.2014 | 21:00:00 | 1.80 |
| 22.2.2014 | 16:00:00 | 1.26 | 24.2.2014 | 10:00:00 | 1.11 | 26.2.2014 | 04:00:00 | 1.17 | 27.2.2014 | 22:00:00 | 1.11 |
| 22.2.2014 | 17:00:00 | 1.19 | 24.2.2014 | 11:00:00 | 1.11 | 26.2.2014 | 05:00:00 | 1.23 | 27.2.2014 | 23:00:00 | 1.19 |
| 22.2.2014 | 18:00:00 | 1.46 | 24.2.2014 | 12:00:00 | 1.13 | 26.2.2014 | 06:00:00 | 1.22 | 28.2.2014 | 00:00:00 | 1.18 |
| 22.2.2014 | 19:00:00 | 1.24 | 24.2.2014 | 13:00:00 | 1.13 | 26.2.2014 | 07:00:00 | 1.15 | 28.2.2014 | 01:00:00 | 1.24 |
| 22.2.2014 | 20:00:00 | 1.17 | 24.2.2014 | 14:00:00 | 1.16 | 26.2.2014 | 08:00:00 | 1.14 | 28.2.2014 | 02:00:00 | 1.12 |
| 22.2.2014 | 21:00:00 | 1.12 | 24.2.2014 | 15:00:00 | 1.13 | 26.2.2014 | 09:00:00 | 1.80 | 28.2.2014 | 03:00:00 | 1.19 |
| 22.2.2014 | 22:00:00 | 1.20 | 24.2.2014 | 16:00:00 | 1.20 | 26.2.2014 | 10:00:00 | 1.14 | 28.2.2014 | 04:00:00 | 1.21 |
| 22.2.2014 | 23:00:00 | 1.18 | 24.2.2014 | 17:00:00 | 0.98 | 26.2.2014 | 11:00:00 | 1.26 | 28.2.2014 | 05:00:00 | 1.21 |
| 23.2.2014 | 00:00:00 | 1.15 | 24.2.2014 | 18:00:00 | 1.30 | 26.2.2014 | 12:00:00 | 1.21 | 28.2.2014 | 06:00:00 | 1.70 |
| 23.2.2014 | 01:00:00 | 1.21 | 24.2.2014 | 19:00:00 | 0.97 | 26.2.2014 | 13:00:00 | 1.14 | 28.2.2014 | 07:00:00 | 1.20 |
| 23.2.2014 | 02:00:00 | 1.16 | 24.2.2014 | 20:00:00 | 1.20 | 26.2.2014 | 14:00:00 | 1.70 | 28.2.2014 | 08:00:00 | 1.23 |
| 23.2.2014 | 03:00:00 | 1.70 | 24.2.2014 | 21:00:00 | 0.97 | 26.2.2014 | 15:00:00 | 1.23 | 28.2.2014 | 09:00:00 | 1.10 |
| 23.2.2014 | 04:00:00 | 1.90 | 24.2.2014 | 22:00:00 | 1.90 | 26.2.2014 | 16:00:00 | 1.70 | 28.2.2014 | 10:00:00 | 1.50 |
| 23.2.2014 | 05:00:00 | 1.15 | 24.2.2014 | 23:00:00 | 1.16 | 26.2.2014 | 17:00:00 | 1.21 | 28.2.2014 | 11:00:00 | 1.17 |
| 23.2.2014 | 06:00:00 | 1.17 | 25.2.2014 | 00:00:00 | 1.11 | 26.2.2014 | 18:00:00 | 1.23 | 28.2.2014 | 12:00:00 | 1.90 |

CONFIDENTIAL Appendix 5
The monthly and annual electricity consumption data of the years 2011 – 2013

The monthly and annual electricity consumption data of the years 2011 – 2013

The monthly and annual electricity consumption data of the years 2011 – 2013

The water consumption for the years 2011 – 2013

CONFIDENTIAL Appendix 7

The annual district heat costs for the years 2010 – 2013 and costs divided in to billing periods

The annual district heat costs for the years 2010 – 2013 and costs divided in to billing periods

The annual and monthly electricity costs and electricity cost for the different operations

The annual and monthly electricity costs and electricity cost for the different operations

The annual and monthly electricity costs and electricity cost for the different operations

CONFIDENTIAL Appendix 18

The pilot project – replacing lights at a specific area

Payback for installing a door in the warehouse in building D

Payback for installing air curtain in the warehouse in building D

Payback for replacing existing fluorescent lights in all buildings

Payback for replacing existing socket boxes with socket boxes with timers