# Högsbo 20:22 office building

## Energy efficiency improvements according to the Total Concept method

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# 1 Summary

The total specific annual energy use for the Högsbo 20:22 office buildings was about 120 kWh/m² year (including tenants´ electricity use) in 2013. The property has today very low energy consumption compared to similar existing office buildings in Sweden. This low energy use can be explained by the relatively high vacancy level in the buildings and low occupancy rate in the used premises. About 60 % out of the total heated area ($A_{temp}$) was rented out in year 2013 and about 70 % has been rented out in year 2014. According to the property owner a number of tenant adjustments are planned for the year 2015, which will lead to increased energy use in the building. Therefore a new baseline for the property's energy consumption was calculated by using the calibrated energy simulation model, which shows that the total energy use will increase to about 130 kWh/m².

Twelve energy saving measures have been identified and analyzed in this report. A number of measures will be carried out as part of the upcoming renovation for the tenant adjustments and according to the discussions with the property owner the measures for the building Sections C and D will be prioritized first. Therefore two alternative packages of measures have been presented in this report. *Action package 1* contains those measures that most probably will be implemented in Sections C and D.  Internal rate of return of such an action package will be somewhat lower than the property owner's profitability demand 8%. *Action package 2*, is an action package which meets the profitability requirements according to the Total Concept method. The total energy and cost saving potential and profitability of the two action packages are presented in Tables 1 and 2 and figures 1 and 2.

**Table 1.** Summary of the *Action package 1* for the Högsbo 20_22 office buildings.

| | |
|---|---|
| Total annual cost savings: | 217  kSEK/yr |
| Energy investment cost: | 2 938 kSEK (28 % of the total cost) |
| Internal rate of return for the package | 5.5 % |
| Calculated energy savings -  District heating | 173 MWh/yr |
| Calculated energy savings -  Electricity | 91 MWh/yr |

With *Action package 1* the total energy saving potential is 14 % and  total specific energy use of the property will be about 111 kWh/m$^2$ (including tenants' electricity).

**Table 2.** Summary of the *Action package 2* for the Högsbo 20_22 office buildings.

| | |
|---|---|
| Total annual cost savings: | 200 kSEK/yr |
| Energy investment cost: | 2 025 kSEK (28 % of the total cost) |
| Internal rate of return for the package | 9.2 % |
| Calculated energy savings -  District heating | 167 MWh/yr |
| Calculated energy savings -  Electricity | 83 MWh/yr |

With *Action package 2* the total energy saving potential is 13 % and  total specific energy use of the property will be about 112 kWh/m$^2$  (including tenants' electricity).

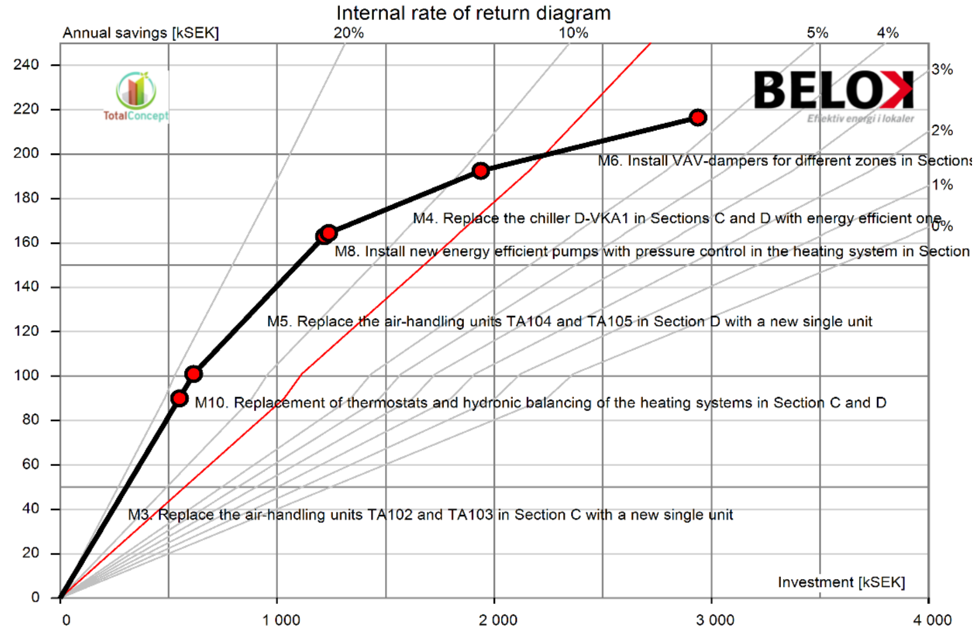


**Figure 1.** Profitability of the"*Action package 1*" presented in an internal rate of return diagram. The property owner´s profitability requirement is 8 % and the estimated relative energy price increase is 2 %. Internal rate of return for the action package is 5.5 %.

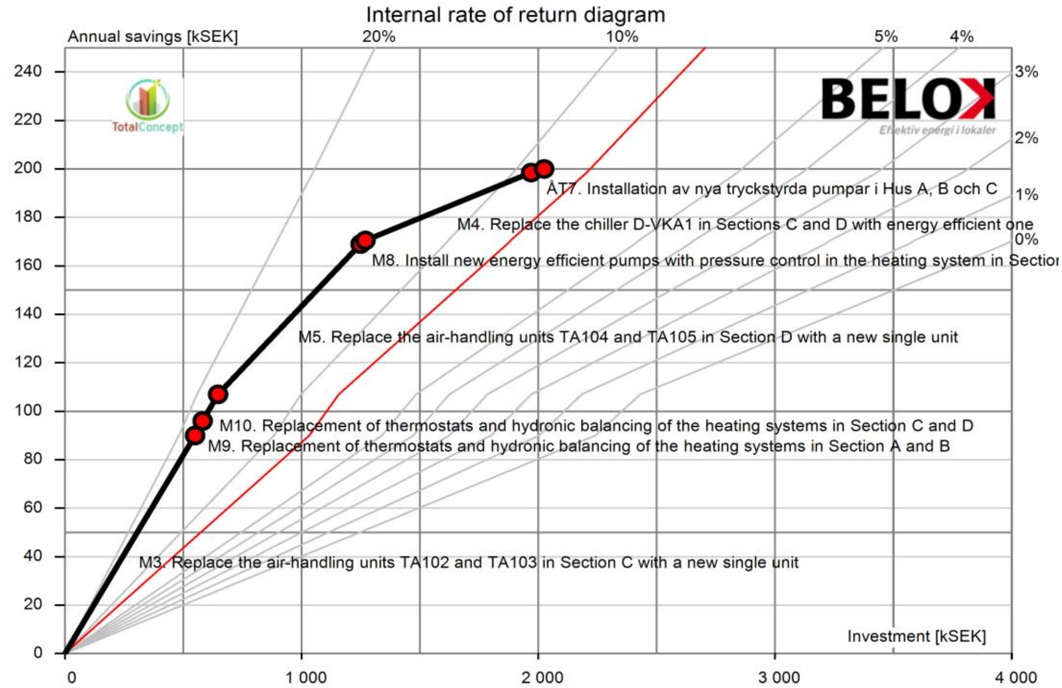


**Figure 2.** Profitability of the "*Action package 2*" presented in an internal rate of return diagram. The property owner´s profitability requirement is 8 % and the estimated relative energy price increase is 2 %. Internal rate of return for the action package is approx 9 %.

# 2 Background

This report has been developed by CIT Energy Management AB as part of the project *“The Total Concept method for major reduction of energy use in non-residential buildings”,* supported by Intelligent Energy Europe Programme and BELOK (Beställargruppen for Lokaler). The project aims to develop, test and promote the Total Concept method in five EU countries in north of Europe: Norway, Finland, Estonia, Denmark and Sweden. The initial development of the Total Concept method has been carried out within the BELOK group.

The Total Concept is a method for improving energy performance in existing non-residential buildings and applies a refined systematic approach to work with energy issues in the building with the aim to achieve maximum savings in a cost efficient way. Total Concept method is based on an action plan comprising a package of measures which meets the profitability conditions stipulated by the property owner. The prerequisite for attaining profitability is that the whole action package is implemented in its entirety.

According to the project plan the Total Concept method will be carried out in selected non-residential buildings in Sweden to test and develop further the tools and materials needed for the Total Concept method implementation. As one of the pilot projects, Högsbo 20:22 office building was selected by the property owner Harry Sjögren AB, member of a BELOK group.

This report provides outcomes of the first step of the Total Concept method. In Step 1 of the Total Concept method a detailed energy audit is carried out in order to find as many energy saving measures as possible. The energy savings of the measures are calculated, investment cost evaluated and a package of measures formed that as a whole fulfills the property owners / investors profitability demands.

The work with the current demonstration project started in June 2014. The following persons have been involved with this project:

| **Participant** | **Contact** |
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The cost calculations and technical specifications for a number of measures have been made in cooperation with Anderssson & Hultmark AB, who will be involved in the design phase of the project.

# 2 Project scope and methodology

The aim of this project has been to carry out Step 1 of the Total Concept method[1] and form a package of measures for energy efficiency improvements in the Högsbo 20:22 office building. The main objective of the renovation in Högsbo 20:22 is to incorporate energy performance improvements to the general upgrade of the building for upcoming tenant adjustments. This has been taken into account when carrying out the analysis for energy performance improvements.

The work is based on the following key activities included to the Step 1 of the Total Concept method:

- Gathering of basic information about the building and compiling technical data.
- Energy audit and identification of energy saving measures.
- Investment cost estimations.
- Energy calculations.
- Profitability calculations and the creation of an action package.

Following background information received from the property owner Harry Sjögren AB and the Högsbo 20:22 office building users and from the auditing on site has been used in this project:

- Building drawings (architectural drawings, structural drawings, HVAC drawings)
- Building permit documents
- Operating and maintenance instructions
- Energy statistics for district heating and electricity for building operation. Monthly values for years 2011-2013 and hourly values for selected dates in 2013.
- Monthly energy statistics for electricity for the different tenants year 2013.
- Annual statistics for water use, years 2011-2013
- Access to the BMS system to get the operating parameters of the HVAC systems
- Latest Mandatory Ventilation Inspection report
- Report from building energy certification

An in-depth energy audit has been carried out on site by CIT Energy Management (CIT EM) in the period of 14 August- 25 September. An energy balance of the building has been simulated with the help of a simulation tool BV[2]. The investment cost calculations are based on the cost books (Sektionsfakta) and calculations done by cost engineers in Andersson & Hultmark

[1] Details of the Total Concept method can be found from: ”The Total Concept method. Guidebook for implementation and quality assurance”. 2014, www.totalconcept.info

# 4 Current situation with the building and its technical systems

Following sections describe the current situation with the building, its function and its technical installations based on observations from the energy audit.

## 4.1 Building and its layout

The Högsbo 20:22 property consists of two office buildings divided into four building sections: A, B, C and D. Sections A and B are part of Building1 and Sections C and D are part of Building 2. The sections A, B and C were built in 1982 and section D was built in 1986. Renovations have been carried out in 1993 and 1998 as well as during continuous tenant adjustments.  All of the building sections are included to the current energy performance improvement analysis.

The total area of the Högsbo 20:22 property is 14543 m$^2$ (heated area as defined in BBR, Swedish Building Code, excluding the area for garage). The total heated area of the property is divided as follows: Sections A&B 4038 m$^2$; Section C is 4055 m$^2$ and Section D is 6450 m$^2$. The layout of the property is shown in Figure 2.

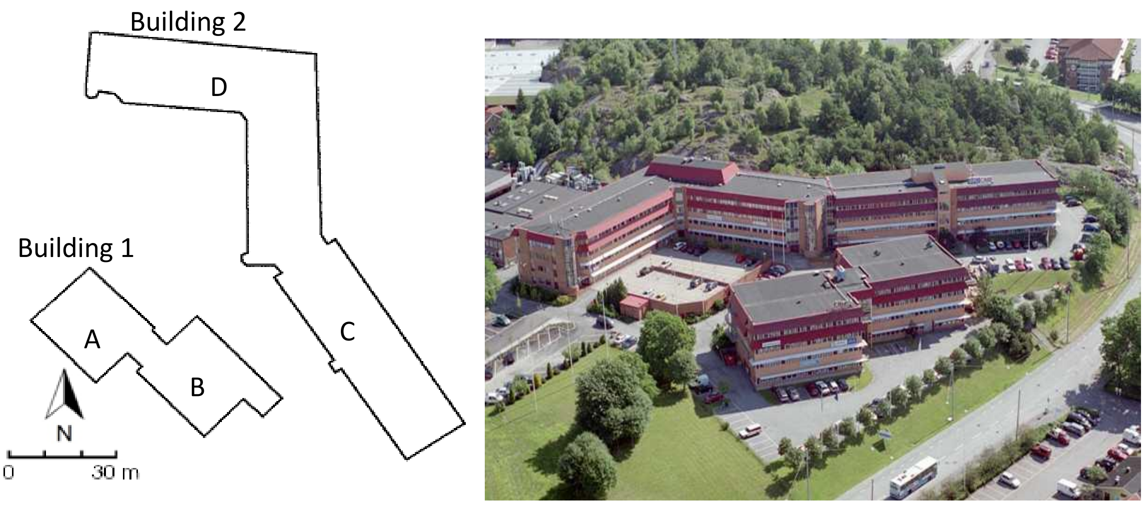



**Figure 2.** The layout and photo of the Högsbo 20:22 property.

## 4.2 The use of the building

All of the building sections in Högsbo 20:22 property have four floors and incorporate mainly office areas (cell offices and office landscapes). There is a lunch restaurant (ca 325 m$^2$) in Section B and Section D has an underground garage.

About 60 % out of the total area ($A_{temp}$) of Högsbo 20:22 property was rented out in year 2013 and about 70 % has been rented out in year 2014. The buildings have 17 tenants in total. Majority of these companies are renting their premises for office work, mainly sales offices, but some of them also have their technical support in the building, using premises also for product repair, testing and storage. In Section D there is a gym (ca 100 $m^2$), which is available for all of the office workers in the building.

The total area for office premises (office area + bi-areas) in the property is about 14200 $m^2$ ($A_{temp}$). The vacancy level of the total office area was approx 40 % in year 2013 and approx 30 % in year 2014. The vacancy level will most probably be somewhat lower in year 2015, as discussions with new tenants are ongoing. According to the property owner the aim is to decrease the vacancy level to 15%, which should be used as baseline for calculations.

Average occupancy in office areas is estimated to be about 65 %, calculated as average number of office workers who are present in the building during occupancy times divided by total number of office workers. In average there are approx 170 persons present in the building during normal occupancy hours for office premises from 8:00 to 18:00 from Monday to Friday. The maximum number of people working in the premises is approx 260. This data is based on the interviews carried out with the tenants and reflects the situation during the current year 2014. Table 3 gives an overview of the occupancy density in the Högsbo 20:22 buildings. Compared to the reference use of office premises in Sweden the Högsbo 20:22 has rather low occupancy density per used area. Normal occupancy density for office buildings in Sweden is considered to be 20 $m^2 A_{temp}$ /person [2].

**Table 3.** Overview of the occupancy in the office areas in Högsbo 20:22 property

| Building section | Total area [1)] [$m^2$] | Total office area [1)] [$m^2$] | Used office area 2013 [%] | Used office area 2014 [%] | mean occupancy density in offices 2014 [$m^2$/person] | max occupancy density in offices 2014 [$m^2$/person] |
|---|---|---|---|---|---|---|
| Section A & B | 4038 | 3713 | 90 | 90 | 45 | 35 |
| Section C | 4055 | 4055 | 40 | 50 | 85 | 25 |
| Section D | 6450 | 6450 | 55 | 70 | 50 | 35 |

*Note 1: Heated area ($A_{temp}$), as defined in BBR, Swedish Building Code, excluding the area for garage*

The lunch restaurant in Section B is open from 11:00-13:30 from Monday to Friday. The restaurant has ca 190 places in total. During the lunch time the expected number of guests is about 100 in total. The restaurant staff works from 7:00 to 15:00 from Monday to Friday and consists of 5 persons.

## 4.3 Indoor climate

Indoor climate requirements set for the office premises in the Högsbo 20:22 property are the same as commonly set for the office environment in Sweden: minimum room

[2] Sveby 2013, Brukarindata kontor

temperature winter time +21°C and summer time +23°C; minimum airflow rates 7 l/s per person + 0,35 l/s·m$^2$. The requirements for lighting and maximum noise levels are in accordance with national requirements set for the work premises.

According to the maintenance personnel and property manager, the indoor climate requirements are generally met in the buildings. Interviews carried out with the tenants revealed that the thermal climate is experienced to be somewhat cold in some office premises during the winter time. The summer temperatures are experienced to be satisfactory. Few tenants mentioned that even summer temperatures indoors have been sometimes too cold.

Indoor temperature measurements carried out in the property during the auditing in August-September showed the indoor temperatures to vary in between +21°C and +24°C. Outdoor temperatures at the same time period were about +20°C. In the majority of the occupied office areas the room temperatures were in between +22°C and +23°C. Majority of tenants have air based comfort cooling system with chilled beams and the room temperature adjustments are done locally by the tenants.

In the lunch restaurant in Section B the measured temperatures in the kitchen area were up to +30°C. The temperatures in the dining areas were about +26°C during the auditing period in September. The premises have no comfort cooling in the restaurant and the dining area has rather big window areas, which has a great impact on thermal comfort during the winter time. According to the maintenance personnel the indoor climate in the dining areas has been experienced to be somewhat cold during colder period of the year. The room is heated with electrical heaters and a local heat pump, which are controlled by the restaurant staff and included to the tenant's electricity.

Problems with noise coming from the ventilation system have occurred previously in Section A&B as well as in Section D. Measures have been undertaken to eliminate the noise.

## 4.4 Building envelope

The technical details about the building envelope and input data used in energy calculations is given in Appendix 1.

The building envelope of the two buildings is considered to be in a good condition based on the visual inspection. The buildings are similar in their construction: the building frame is set on the concrete pillars and the floor frames are made of concrete structure. The ground floor façades consist of concrete, approx 100-120 mm insulation and have bricks on the outside (U-value approx 0.26 W/m$^2$·K). The façades of the upper floors are made of light construction including 50 mm insulation and have metal sheet on the outside (U-value approx 0.24 W/m$^2$·K).

The ground slab is made of concrete and is insulated. Underlying ground material for the buildings is granite stone. Estimated U-value for ground slab is 0.35 $W/m^2 \cdot K$.

Both buildings have flat roofs consisting of (except the ventilation chamber) concrete structure insulation (250 mm mineral wool), timber rafters and double layer roof cover on a wooden surface. Estimated U-value for the roof construction is 0.2 $W/m^2 \cdot K$.

The windows are triple pane wooden windows. All windows are original from the 80s, except for part of the lunch restaurant section, which was built in the early 2000s. Estimated U-value for the windows is 2.0 $W/m^2 \cdot K$, which is considered to be rather high according to today's standards. Visual inspection on site showed the wooden frames of the windows to be in satisfactory condition. Only some windows need maintenance from outside. According to the operational personnel there have been problems with some windows previously, especially with leakage through the window frames. Therefore window replacement has been discussed internally by the property owner. Unfortunately it was not possible to carry out any air leakage test during the inspection on site to evaluate this problem. Also it was difficult to take thermal images with the infrared camera due to warm outdoor temperatures during auditing.

The buildings have external solar shading, which gives a great impact on decreasing the cooling loads in the buildings due to solar radiation. Most of the entrance doors are aluminum framed glass doors. The underground garage and some side entrances (e.g. storage rooms) have steel doors.

## 4.5 Technical systems

Overview of technical data of the ventilation systems and data used in the energy calculations is given in Appendix 1.

### 4.5.1 Ventilation and air conditioning

There are eight supply and exhaust air handling units installed in the two buildings: three units supporting the premises in Section A and B (LA1, TA1, TA2), two ventilation units supporting premises in Section C (TA102, TA103) and two units are connected to Section D (TA104, TA105, TA106). The operating times for the ventilation systems are well adapted to the use of the premises.

Majority of the existing air handling units (except LA1) are original, from the 80-ies and show signs of wear, which can be expected due to the age of the units. The units are put together on site, which means that replacing these units with new ones will require major renovation in the ventilation chambers. All ventilation units have heat recovery. Four units are equipped with regenerative heat exchangers. All other units use return air for heat recovery. Based on the temperature measurements on site the temperature efficiency of the units with return air was in between 60 % - 75 %, depending on the unit. The temperature efficiency of the units with regenerative heat recovery was in between 63 % - 75 %, depending on the unit. The ventilation unit supporting the lunch restaurant in Section B (LA1) has a regenerative heat recovery and an electrical heating battery. The supply air is controlled after room temperature.  According to the BMS system, the supply air temperature can be even as low as +10 °C. Such low temperatures can lead to problems with thermal comfort in the cooler seasons but according technical personnel the tenant wants to adjust the set points themselves in order to save energy.

According to the BMS system the air dampers in the ventilation units that use return air are automatically controlled after the supply air temperature and the maximum return air in the total supply air should be up to 70% of the total airflow rate. However, substantial problems with the function of supply, exhaust and return air dampers have previously occurred. Unfortunately it was not possible to measure the recirculation airflow rates in these units. Systems with return air are not common anymore in office premises in Sweden due to the risk of contamination and possible problems with indoor air quality. However, according to the property manager, no problems with indoor air quality have been reported so far.

All of the ventilation systems connected to office areas are equipped with after heating and/or after cooling coils on the main ducts. The supply air temperatures are controlled after outdoor temperature (except in TA2) and are varying in between +19.5 °C to +20.5°C at outdoor temperatures of +20 °C to -20°C. These supply air temperatures can be considered to be quite high for office premises. According to the maintenance personnel, temperatures are set high to avoid complaints from some tenants. In order to increase the cooling capacity of the supply air and to obtain good mixing of inlet air with the room air, it is recommended to keep supply air temperatures on a lower level. As an example, temperatures of +18 °C to +19°C can be recommended.

Since most of the office premises have water based comfort cooling system with chilled beams then there is no need for air conditioning with after-heating/cooling coils as it was intended originally. All of the after-heating/cooling coils should be removed from the systems because they contribute only to the additional pressure drop. Measurements of fan power show that the ventilation systems have quite high SFP values, for some systems even up to 4.0 kW/(m$^3$/s).

The offices premises are ventilated with constant air volume flow (CAV). Meeting rooms have manually controlled variable air flow (controlled in 2- steps, min/max airflow).  It is strongly recommended that the function of these dampers is checked and where needed replaced with modern VAV-dampers.

Estimated total airflow rate per m$^2$ office area is about 1,6 l/s·m$^2$ for Sections A&B, about 0,8 l/s·m$^2$ for Section C and about 1,8 l/s·m$^2$ for section D. According to the design engineer the airflows in Building C needs to be increased to adapt to the new tenants. A new ventilation unit with increased air flow rate has been planned for the Section C.

#### 4.4.2 Heating

The buildings are connected to the local district heating network since 2003. There are two mixing stations in the property: one placed in Section A, supporting the sections A, B and C and one placed in Section D, supporting only Section D. Each mixing station has two district heating heat exchangers connected in parallel: one for heating systems and one for domestic hot water. Based on the inspection on site, the heat exchangers seem to be in good condition. However, the function of the 2-way control valve on the primary side of the heating system (Rad:A-SV1) in the mixing station in Section A need to be checked. Based on the observation in the BMS system the supply water temperature was about 40°C during summer period, while the valve was showing to be closed (0 %). That high supply temperature was not observed in the mixing station in Section D.

According to the technical personnel the primary side of the heating system was balanced in 2012. However, no hydronic balancing has been made in the radiator circuits. The buildings are heated via 1-pipe radiator system. There are 7 radiator circuits in total. Every building section have two radiator circuits: one for the north side and one for the south side of the building. Based on BMS system the supply water temperatures are set the same for both south and north radiator circuits. It is strongly recommended to investigate and test the possibility to reduce the supply water temperatures to the radiator circuits serving the south side of the building sections, especially in Sections A and B. This should be done after hydronic balancing of the radiator system has been carried out.

A number of radiators seem to be functioning poorly, especially in Section D and the existing radiators are step-by-step replaced with new ones when premises are renovated for the new tenants.  Most of the radiator thermostats are original, from the 80ies.

The heating system in all of the buildings was originally designed as a constant flow system. The property had originally electrical heating boilers for heat production. After the property was connected to the city's district heating system the control valves in the mixing stations of the radiator circuits were adjusted to conform to the new system. To keep the return temperatures to the district heating network as low as possible the 3-way control valves in all radiator mixing stations were changed to function as a 2-way valves by closing the bypass lane in the valve. No adaptation to variable flow has been made on the primary side, which leads to unnecessarily high pressure drop in the system. Also the pumps on the secondary side of each radiator circuit are running in constant speed, which can lead to unnecessarily high pressure drop in the radiator system with functioning thermostats and higher operating costs. Most of the pumps are original from the 80ies.

The garage in Section D has air heaters with recirculation air. The units are manually controlled (on/off) to keep the preset temperature. According to the technical manager, they are switched on only during the extreme cold weather.

### 4.4.3 Cooling

About 75 % of the office premises have hydronic comfort cooling system with chilled beams and it is planned that chilled beams will be installed to all of the office premises in the future. The premises with chilled beams have local temperature control and based on the observation on site, the set points are kept at rather low level by the tenants, in some premises close to +22°C. Such low temperatures have a great impact on the energy use of the cooling system.

Chilled water is produced with two chillers, installed in 1995 (BlueBox).The chiller A-VKA1 supports building sections A and B and chiller D-VKA1 supports buildings C and D. Estimated COP value is 2.5. The chiller D-VKA1 has two screw compressors, unfortunately one of them broke down last summer. Therefore replacing the chiller with the new one has been planned.  A new chiller is also needed to cover the increased loads due to new tenants' adjustments in Section C.

Pumps in the cooling system D-VKA1 are operating all year around. According to the operational personnel this is due some server rooms that are connected to the central cooling system. However, observations during the auditing on site showed that many tenants have their own local DX cooling units in their server rooms. It is recommended to install local cooling units to all server rooms, so that the central cooling system can be switched off during the winter time, when no cooling demand prevails in the office areas.

The chiller A-VKA1 is controlled by the outside temperature and is turned off when the outdoor temperature falls below + 10 °C and the unit is started at + 14 °C outside temperature. However, the distribution pump on the secondary side of the cooling system (chilled beams) is in operation all year around. Possibility to control the pumps on the secondary side in sequence with the chiller operation should be investigated.

### 4.4.4 Lighting

It is the tenants who are responsible for the change of lighting fixtures. The lighting system has been continuously upgraded during the last 10 years, especially when tenants' adjustments are made.  In office premises modern FTL lighting fixtures with T5 tubes are installed. Only in certain premises, especially in the empty offices, there are FTL lighting fixtures with T8 tubes. The lighting system is controlled manually in most premises, only few office rooms and some toilets have occupancy control.

In the common areas low energy light bulbs are installed in the lighting fixtures. The lighting system in the stairwells is operated at the reduced level around the clock. Full lighting effect can be activated manually via switch and it has a time channel of 7- minutes. Garage has FTL lighting fixtures with T5 tubes. The lights are controlled by acoustic occupancy sensors. Outdoor lighting is controlled with an astronomical clock in Sections A and B and with daylight sensors in Building C and D.

#### 4.4.5 Machines

Since the buildings are used for office work mainly then there is standard office equipment used in the premises: computers, printers, copy machines, server systems, etc. Each tenant has a kitchenette with standard kitchen equipment: coffee machines, microwave stoves, fridge, dish washer, etc. Lunch restaurant in Section B has typical restaurant kitchen equipment: frying plates, a big restaurant oven, a pizza oven, blenders, fridges and freezers and restaurant dishwasher, etc. They are also one of the biggest electricity consumers in the building. There are 6 elevators in the building, one elevator per stairwell.

#### 4.4.6 Water supply and domestic hot water

Domestic hot water is produced by district heating via separate heat exchanger. The biggest water consumer in the property is the lunch restaurant. Otherwise water is used only in toilets and in kitchenettes.

#### 4.4.7 Control and monitoring system(s) for technical installations

All of the technical systems are connected to the central building management system (BMS system), manufactured by KTC, installed in 2007. According to operational staff, number of valves and damper motors were replaced when the new BMS system was installed.

# 5 Energy and resource use

## 5.1 Energy statistics

The Högsbo 20:22 property uses district heating and electricity for energy supply. The district heating energy use is measured at the two mixing stations: one placed in Section A, measuring the use for Sections A, B and C and one placed in Section D, measuring the use for only that section. There is a separate metering for electricity used for building operation and electricity for tenants. Every tenant has their own electricity meter and they make their own contract with the utility company. Electricity for tenants includes lighting, equipment and machines used in their premises and their outdoor signs.

Electricity for building operation includes electricity for technical systems, e.g. fans, pumps, chillers, lighting in common areas (stairways, outdoor), machines in common areas (elevators), etc. There are three energy meters measuring electricity for building operation: one meter for Sections A and B, one meter for Section C and one meter for Section D. The two cooling machines are connected to energy meters in Sections A&B and Section D.

Table 4 and Figure 4 give an overview of the total annual energy use of the Högsbo 20:22 property in 2011- 2013. The data is based on energy statistics obtained from the property owner and correspond to measured values. The values for district heating are corrected to normal year. The energy statistics for tenants electricity was obtained only for the year 2013. For calculating the total specific annual energy use the heated area ($A_{temp}$) of the property has been used.

**Table 4**. Annual energy use of the Högsbo 20:22 property. The data is based on energy statistics and correspond to measured values.

| Energy type | Unit | 2011 | 2012 | 2013 |
|---|---|---|---|---|
| Total district heating use (corrected) | MWh | 750 | 804 | 816 |
| *Sections A, B, C* | MWh | *419* | *404* | *441* |
| *Sections D* | MWh | *331* | *400* | *376* |
| Total electricity for building operation | MWh | 495 | 455 | 470 |
| *Sections A, B* | MWh | *116* | *104* | *107* |
| *Sections C* | MWh | *83* | *83* | *80* |
| **Total annual energy use (excl tenants)** | **MWh** | **1246** | **1259** | **1286** |
| **Total annual specific energy use (excl. tenants)** | **kWh/m² yr** | **86** | **87** | **88** |
| Total electricity use for tenants | MWh | - | - | 458 |
| **Total annual energy use (incl. tenants)** | **MWh** | **-** | **-** | **1744** |
| **Total annual specific energy use (incl. tenants)** | **kWh/m² yr** | **-** | **-** | **120** |

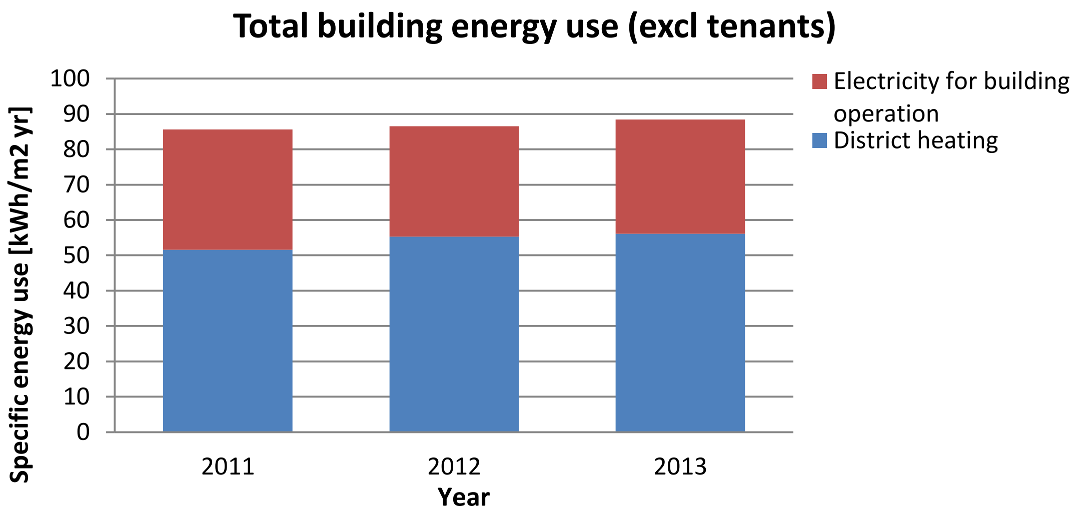



**Figure 4.** Specific annual energy use (excluding tenants) of the Högsbo 20:22 property, based on the energy statistics for the years 2011-2013. The heat energy use has been corrected to normal year.

The Högsbo 20:22 buildings have rather low energy use compared to similar existing office buildings in Sweden. The total specific annual energy use for the Högsbo 20:22 property in 2013 was **120 kWh/m² yr** (including tenants electricity use). The specific energy use for heating was **56 kWh/m² yr,** electricity for building operation was **32 kWh/m² yr** and electricity for tenants was **31 kWh/m² yr.** According to the Swedish Building Code (BBR20) the specific energy use for a new non-residential building in Gothenburg should be not higher than 80 kWh/m$^2$ plus additions for ventilation, if any. According to the energy certification of the property the energy use of similar buildings as for Sections A and B is about 111-116 kWh/m$^2$ per år, for Section C about 118-177 kWh/m$^2$ per år for house D about 143-215 kWh/m$^2$ per år.

Figure 5 below gives an overview of the measured electricity use for the tenants for the year 2013. When calculating the specific energy use for each tenant the rented area ($m^2$) by each tenant, obtained from the property owner, has been used.

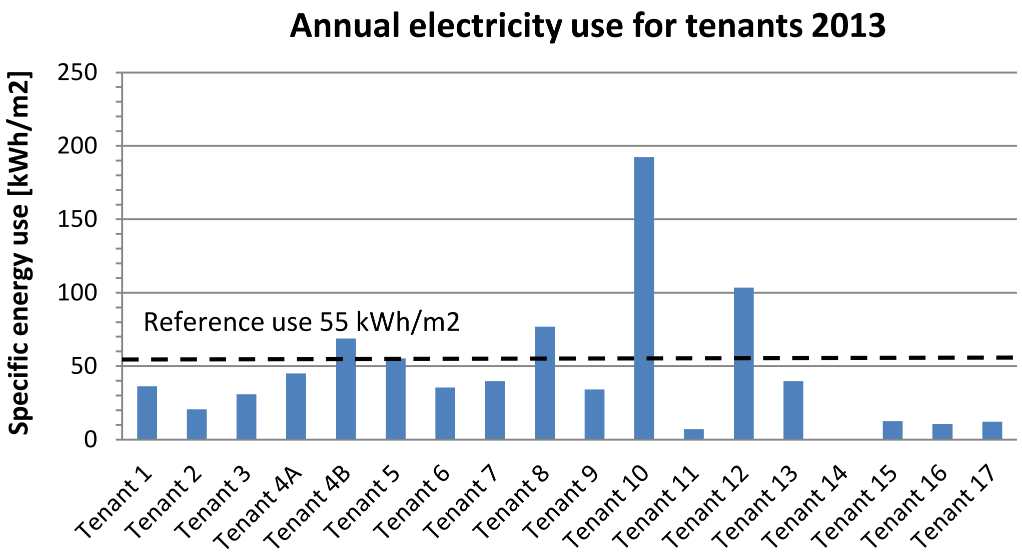
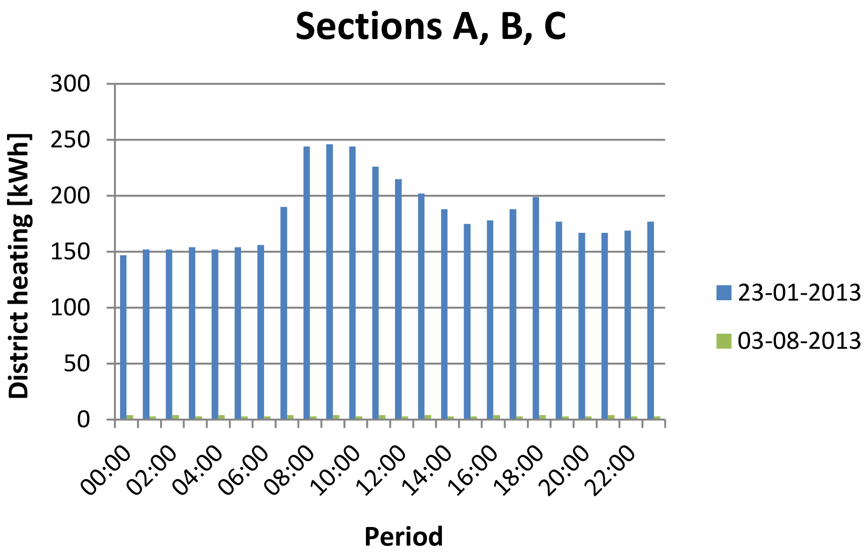



**Figure 5.** Measured electricity use for tenants in 2013 in the Högsbo 20:22 property. Tenant 10 is a lunch restaurant and Tenant 14 moved in year 2014.

The property has 17 tenants, whereas 16 of them are renting office premises. One of the tenants (Tenant 14) moved in year 2014, therefore there is no statistics to display. As can be seen from the figure the electricity use for office tenants varies in between 7- 103 kWh/$m^2$. The biggest energy user in the buildings is expectedly the lunch restaurant (Tenant 10 in the figure 5), using about 190 kWh/$m^2$yr. The highest energy user in the office premises, about 100 kWh/$m^2$ yr, is by the tenant who provides IT support and computer repair services. When excluding this specific tenant, the mean electricity use for office tenants would be about 35 kWh/$m^2$yr, which is much lower than the reference electricity use for tenants in Swedish office premises 55 kWh/$m^2$, based on SVEBY data[3]. This low energy use can be explained with rather low occupancy density in the used premises (see table 1).

Based on the energy statistics the maximum heat power demand was about 250 kW for Sections A, B and C and about 280 kW for Section D (see figure 5). This estimation is based on the measured hourly values of district heating energy use on the coldest workday of the year 2013 (lowest outdoor temperature -12°C). The base load during summer time was about 4 kW for Sections A, B and C and about 2 kW for Section D, which presumably corresponds to system losses in the domestic hot water system.

[3] Sveby 2013, Brukarindata kontor



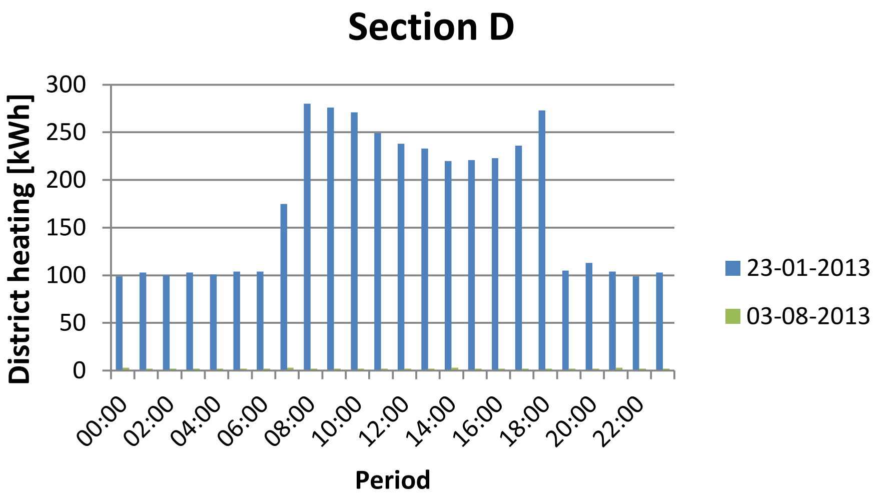




**Figure 5.** Measured hourly values of the district heating use on the coldest day of the year 2013. The start of the ventilation units is at about 7:00 am. The diagram also shows the base load for the district heating during the summertime.

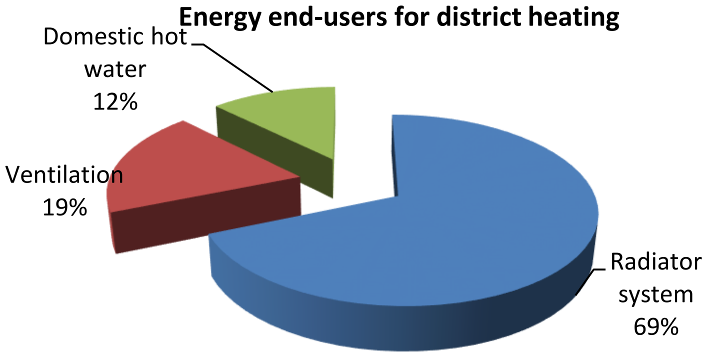
Cold water use is measured by two meters: one measuring the use in Sections A, B and C and the other one the use in Section D. Cold water use statistics is shown in Table 5. The main water user in the property is the lunch restaurant. Otherwise the water is used mainly in toilets and kitchenettes.

**Table 5.** Cold water use of the Högsbo 20:22 property, year 2011- 2013. The values correspond to measured values.

| Resource | Unit | 2011 | 2012 | 2013 |
|---|---|---|---|---|
| Total cold water use | $m^3$/år | 2196 | 1561 | 1682 |
| *Sections A, B, C* | $m^3$/år | *1 415* | *1 561* | *1 682* |
| *Section D* | $m^3$/år | *781* | *769* | *877* |

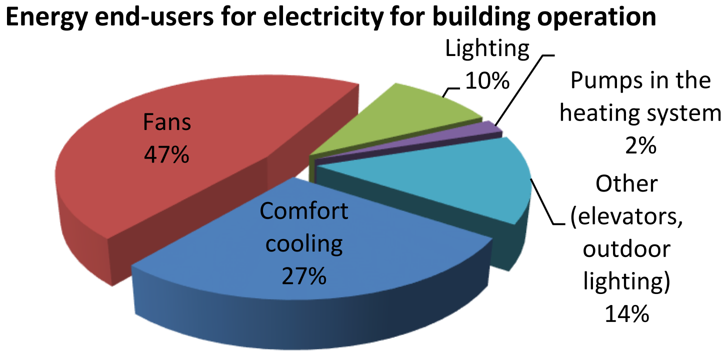
## 5.3 Energy end-users

The energy balance of the buildings has been simulated with the simulation tool BV[2]. The building models have been calibrated with the year 2013 data. Input data used in the energy calculations can be found from Appendix 1. Figures 7-9 shows the different energy end-users for heat energy and electricity (based on the year 2013 data).




| Heat energy end-users | [MWh/yr] | [kWh/m²yr] | [% of tot] |
|---|---|---|---|
| Radiator system | 550 | 38 | 69% |
| Ventilation | 150 | 10 | 19% |
| Domestic hot water | 100 | 7 | 13% |

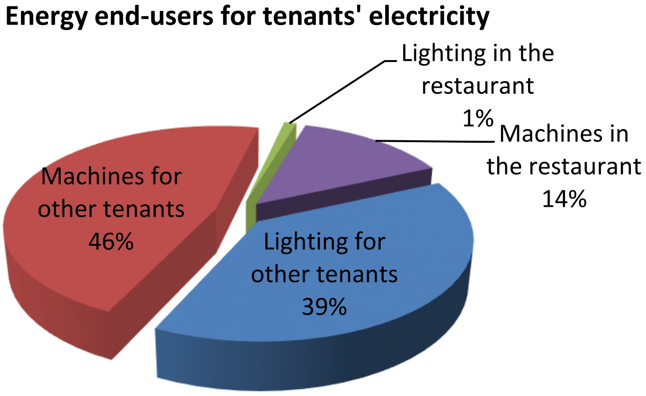
**Figure 7**. The different energy end-users for heat energy in the Högsbo 20:22 property. The calculated total heat energy use of the building is approx 55 kWh/m$^2$·a. Domestic hot water use is based on the energy statistics data. DHW circulation losses are approx. 30 % from the total energy use for domestic hot water.




| Electrical energy end-users | [MWh/yr] | [kWh/m²yr] | [% of tot] |
|---|---|---|---|
| Comfort cooling | 125 | 9 | 27% |
| Ventilation | 215 | 15 | 47% |
| Lighting | 45 | 3 | 10% |
| Pumps in the heating systems | 10 | 1 | 2% |
| Other | 65 | 4 | 14% |

**Figure 8**. The different energy end-users for electricity for building operation in the Högsbo 20:22 property. The calculated total electrical energy demand for building operation is approx 32 kWh/m$^2$·yr.

Energy use for comfort cooling corresponds to the energy demand for chillers and pumps in the cooling systems. The fans and pumps have also the greatest potential for energy savings in the buildings.




| Electrical energy end-users | [MWh/yr] | [kWh/m²yr] | [% of tot] |
|---|---|---|---|
| Lighting in the restaurant | 5 | 0 | 1% |
| Machines in the restaurant | 60 | 4 | 14% |
| Lighting for other tenants | 170 | 12 | 39% |
| Machines for other tenants | 205 | 14 | 46% |

**Figure 9**. The different energy end-users for tenants' electricity in Högsbo 20:22. The calculated total electrical energy demand for tenants is approx 30 kWh/m$^2$·yr.

The results of the energy calculations are within the accepted ± 10% from the measured values of the heat and electricity use for the year 2013. The calculations are based on the data received during the auditing and control set points observed in the BMS system. However, there can be uncertainties about how these set points and time channels varied in recent years.

Energy calculations show that the radiator system is the biggest heat energy end-user, with about 70% of the total heat energy use. Electricity for building operation is used mainly for ventilation systems (about 47%) and comfort cooling (about 27%). Tenants' electricity use corresponds to about 50% of total electricity use. Since lighting systems in buildings have gradually upgraded to more energy efficient lighting in recent years then the saving potential in this part of the energy use can be somewhat modest.

## 5.3 Baseline for energy performance improvements

According to the property owner a number of tenant adjustments are planned for the next year. For example, the capacity of the ventilation system and the cooling system will be increased in Section C to be adapted to the new tenants. It is also planned that a number of vacant premises in Sections D will be rented out. This however means that the energy use of the building will most probably increase.

To calculate the energy savings potential of the identified measures, a new baseline for the property's energy use needs to be established by using the calibrated energy simulation model. According to the agreement with the property owner, the new reference level for calculating the energy saving measures will be based on the assumption that the vacancy level in the buildings will be about 15%. The specification about the input data used in the new baseline calculations is given in Appendix 1.

Figure 10 below shows the calculated energy use for the new baseline for the Högsbo 20:22 office buildings. The buildings' total energy use will be approximately 130 kWh/(m$^2$yr), compared to about 120 kWh/(m$^2$yr) for the year 2013. Increased use of the premises will increase the energy demand for comfort cooling and ventilation. Figures 11-13 show the different energy end-users based on the new baseline calculation.

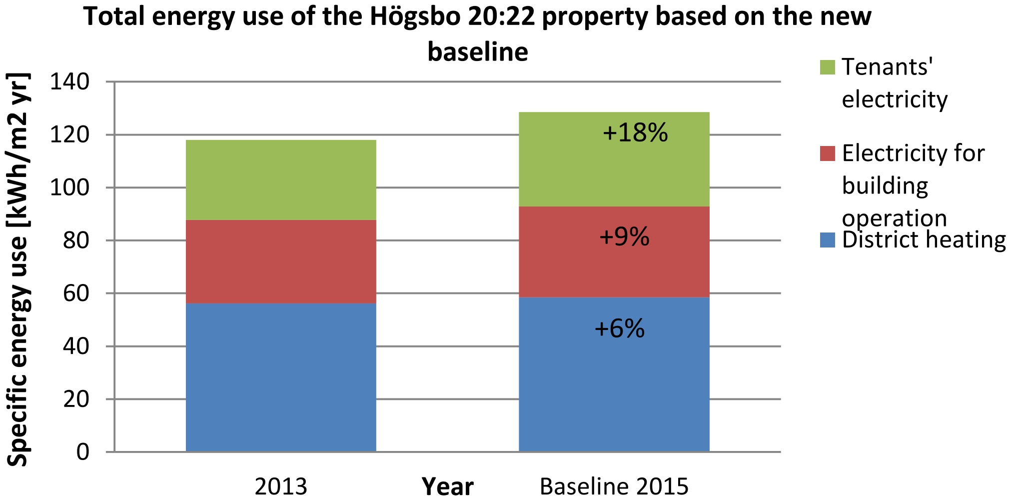
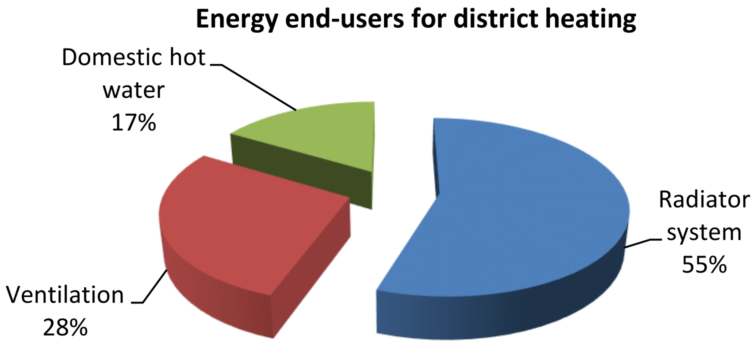
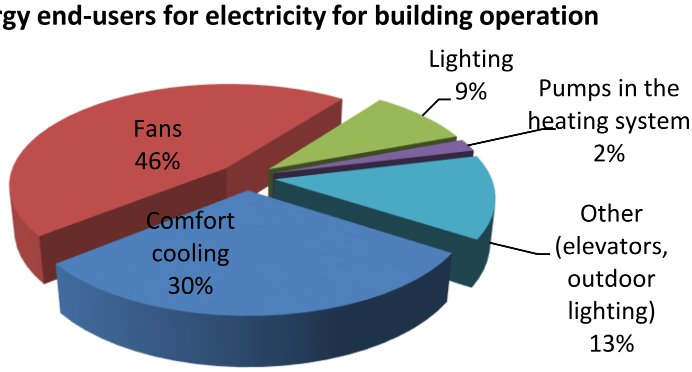



**Figure 10.** Calculated energy use for the new baseline for the Högsbo 20:22 office buildings. The buildings' total energy use will be approximately 130 kWh/(m$^2$yr), compared to about 120 kWh/(m$^2$yr) for the year 2013.



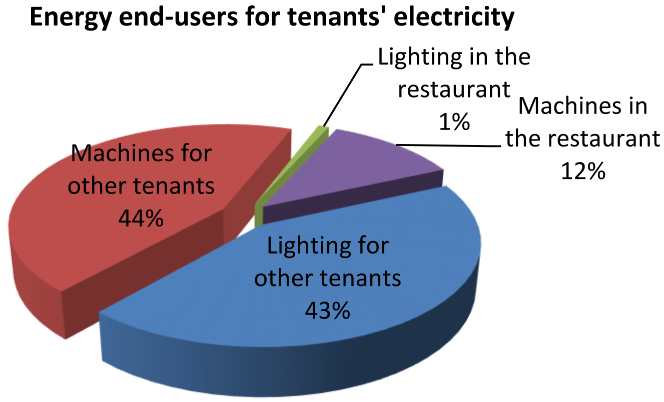

| Heat energy end-users | [MWh/yr] | [kWh/m$^2$yr] | [% of tot] |
|---|---|---|---|
| Radiator system | 470 | 32 | 55% |
| Ventilation | 240 | 17 | 28% |
| Domestic hot water | 140 | 10 | 16% |

**Figure 11**. The different energy end-users for heat energy according to the new baseline of the Högsbo 20:22 property. The calculated total heat energy use of the building will be approx 58 kWh/m$^2$·a.




| Electrical energy end-users | [MWh/yr] | [kWh/m²yr] | [% of tot] |
|---|---|---|---|
| Comfort cooling | 150 | 10 | 30% |
| Ventilation | 230 | 16 | 46% |
| Lighting | 45 | 3 | 9% |
| Pumps in the heating systems | 10 | 1 | 2% |
| Other | 65 | 4 | 13% |

**Figure 12**. The different energy end-users for electricity for building operation according to the new baseline of the Högsbo 20:22 property. The calculated total electrical energy demand for electricity for building operation will be approx 34 kWh/m$^2$·yr.




| Electrical energy end-users | [MWh/yr] | [kWh/m²yr] | [% of tot] |
|---|---|---|---|
| Lighting in the restaurant | 225 | 15 | 43% |
| Machines in the restaurant | 230 | 16 | 44% |
| Lighting for other tenants | 5 | 0 | 1% |
| Machines for other tenants | 60 | 4 | 12% |

**Figure 13**. The different energy end-users for tenants’ electricity according to the new baseline of the Högsbo 20:22 property. The calculated total electrical energy demand for electricity for tenants will be approx. 36 kWh/m$^2$·yr.

# 6. Identified energy saving measures

The technical and economical details of the identified energy saving measures are described in the following sections. The measures are summarized in Appendix 2.

## 6.1 Measure 1. Replace the air-handling units TA1 and TA2 in Section A&B with a new single unit

| | |
|---|---|
| Type of measure | Technical installations |
| Calculated energy savings - District heating | 13 MWh/yr |
| Calculated energy savings - Electricity | 25 MWh/yr |
| Calculated power savings - District heating | 10 kW |
| Calculated power savings - Electricity | 4 kW |
| Calculated other savings (SEK/yr): | - |
| Total annual cost savings: | 33 kSEK/yr |
| Energy investment cost: | 1 725 kSEK (50% of the total cost) |
| Economic calculation period: | 20 years |

Description of the measure

According to this measure, the TA1 and TA2 air-handling units will be replaced with one single air-handling unit with a regenerative heat exchanger, with heating and cooling coils and frequency-controlled direct drive fans. Example type of unit: FläktWoods EQ-068. The design airflow rate of the new unit 6.8/6.8 $m^3/s$, design SFP-value approx. 1.9 $kW/(m^3/s)$. The fans will be controlled by a constant pressure in the duct system. Based on the assessment on site the fan rooms needs to be rebuilt to fit the new unit. After-heating/cooling coils will be removed from the main ducts. New mixing stations and pipes will be installed for the heating coil in the unit.

Energy- and cost savings

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- New unit has airflow rate 6,8/6,8 $m^3/s$, temperature efficiency of approximately 78%, estimated SFP value of the new system approx. 1.93 $kW/(m^3/s)$ and supply air temperature control set points + 18 °C/ +19°C at 20°C -20°C outdoor temperature.
- The operating time of the unit will remain the same 6:30-18:30 M-F.

Investment cost

The total investment cost for this measure has been estimated to be about 3 450 kSEK. The cost estimate includes the dismantling and building costs, installation of a new unit and new mixing stations with new pipes for the coils, balancing of the airflow rates, electrical wiring, control and connections to the BMS system, and design costs. **This measure can be considered also as a maintenance measure. Therefore 50% of the total costs have been included to the costs for energy efficiency improvement.** Economic lifetime of the investment is estimated to be 20 years.

## 6.2 Measure 2. Replace the chiller A-VKA1 in Sections A and B and optimizing pump operation

| | |
|---|---|
| Type of measure | Technical installations |
| Calculated energy savings - District heating | - |
| Calculated energy savings - Electricity | 7 MWh/yr |
| Calculated power savings - District heating | - |
| Calculated power savings - Electricity | 8 kW |
| Calculated other savings (SEK/yr): | - |
| Total annual cost savings: | 7 kSEK/yr |
| Energy investment cost: | 500 kSEK (50% of the total cost) |
| Economic calculation period: | 20 years |

Description of the measure

According to this measure the existing chiller A-VKA1, supporting Sections A and B, will be replaced with a new chiller, example type Carrier Aquaforce 30XA. The design power is 210 kW, which includes also increased cooling capacity due to potential future tenant adjustments. The existing pump on the primary side is replaced with a new pump. The pump on the secondary side (A-KB1-P1) can be controlled after the outside temperature, whereas the most suitable set points for pump stop need to be tested on site. The pump on the primary side (pump A-VKA1- P1) can be operated in sequence after the distribution pump on the secondary side.

Energy- and cost savings

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- Estimated COP value for the new chiller is 3.0
- New pump has better efficiency leading to reduced power demand by about 30%.
- Reduction of the operating time of the distribution pump in the cooling systems with about 2500 h/year.

Investment cost

The total investment cost for this measure has been estimated to be about 1 000 kSEK. The cost estimate includes the dismantling and building costs, installation of a new chiller, new pipes and new pump on the primary side, electrical wiring, control and connections to the BMS system, and design costs. **This measure can be considered also as a maintenance measure. Therefore 50% of the total costs have been included to the costs for energy efficiency improvement.** Economic lifetime of the investment is estimated to be 20 years.

## 6.3 Measure 3. Replace the air-handling units TA102 and TA103 in Section C with a new single unit

| | |
|---|---|
| Type of measure | Technical installations |
| Calculated energy savings - District heating | 108 MWh/yr |
| Calculated energy savings - Electricity | 7 MWh/yr |
| Calculated power savings - District heating | 60 kW |
| Calculated power savings - Electricity | - |
| Calculated other savings (SEK/yr): | - |
| Total annual cost savings: | 90 kSEK/yr |
| Energy investment cost: | 550 kSEK (20% of the total cost) |
| Economic calculation period: | 20 years |

Description of the measure

According to the property owner a number of tenant adjustments are planned for Section C next year and the ventilation airflow rates need to be increased. A new single unit is designed to replace TA102 and TA103. The basic options for tenant adjustments would be installation of a new ventilation unit with a basic indirect recuperative heat recovery. According to this measure the new unit that replaces TA102 and TA103 shall have a regenerative heat exchanger and built-in heat pump for heating and cooling supply air. Example type of unit: FläktWoods EQ -072. The fans will be controlled by a constant pressure in the duct system. After-heating/cooling coils will be removed from the main ducts. New mixing station and pipes will be installed for the coils in the unit.

Energy- and cost savings

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- New unit has a regenerative heat exchangers with a temperature efficiency of approximately 78%, COP of the heat pump for cooling 5.3 and for heating 19.6.
- New supply air temperature control set points are + 18 °C/+ 19°C at 20°C/ -20°C outdoor temperature.
- The operating time of the unit will remain the same 6:40-18:00 M-F

The design airflow rate of the new unit 6.2 $m^3/s$ and SFP value of 2.0 $kW/(m^3/s)$ have been included in the calculation of the new baseline for energy efficiency improvements.

Investment cost

The total investment cost for this measure has been estimated to be about 2 750 kSEK. The cost estimate includes the dismantling and building costs, installation of a new unit and new mixing station with new pipes for the coils, balancing of the airflow rates, electrical wiring, control and connections to the BMS system, and design costs. **This measure is carried out together with the upcoming renovation for tenant adjustments and can be considered also as a maintenance measure. Therefore 20% of the total costs have been included to the costs for energy efficiency improvement.** Economic lifetime of the investment is estimated to be 20 years.

## 6.4 Measure 4. Replace the chiller D-VKA1 in Sections C and D and optimizing pump operation

| | |
|---|---|
| Type of measure | Technical installations |
| Calculated energy savings - District heating | - |
| Calculated energy savings - Electricity | 30 MWh/yr |
| Calculated power savings - District heating | - |
| Calculated power savings - Electricity | 22 kW |
| Calculated other savings (SEK/yr): | - |
| Total annual cost savings: | 28 kSEK/yr |
| Energy investment cost: | 700 kSEK (20% of the total cost) |
| Economic calculation period: | 20 years |

Description of the measure

According to this measure the existing chiller A-VKA1 will be replaced with a new chiller, example type Carrier Aquaforce 30XA. The design power is 585 kW, which includes also increased cooling capacity due to future tenant adjustments. The existing pumps on the primary side will be replaced with new pumps.

Additionally, local DX cooling units will be installed in the server rooms in Sections C and D, which have chilled beams. Number of such rooms where local cooling is needed should be specified on site together with the tenants, but the estimated number of such rooms is two. After local cooling has been installed to all server rooms the chiller D-VKA1 can be switched off during the winter time, when no cooling demand prevails in the office areas. For example, the pumps on the distribution side (pumps D-KB2-P01 and C-KB2-P01) can be controlled after the outside temperature, whereas the most suitable set points for pump stop need to be tested on site. Pumps on the primary side (pumps VKA1- P1 and VKA1-P2) can then be operated in sequence after distribution pumps on the secondary side.

Energy- and cost savings

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- Estimated COP value for the new chiller is 3.0
- New pump has better efficiency leading to reduced power demand by about 30%.
- Reduction of the operating time of the pumps in the cooling systems with about 2500 h/year.
- The savings potential of this measure is affected by Measures 3 and 5, which has been taken into account in the calculations.

Investment cost

The total investment cost for this measure has been estimated to be about 3 500 kSEK. The cost estimate includes the dismantling and building costs, installation of a new chiller, new pipes and new pumps on the primary side, electrical wiring, control and connections to the

BMS system, and design costs. **This measure is carried out together with the upcoming renovation for the tenant adjustments and for system maintenance. Therefore 20% of the total costs have been included to the costs for energy efficiency improvement.** Economic lifetime of the investment is estimated to be 20 years.

## 6.5 Measure 5. Replace the air-handling units TA104 and TA105 in Section D with a new single unit

| | |
|---|---|
| Type of measure | Technical installations |
| Calculated energy savings - District heating | 28 MWh/yr |
| Calculated energy savings - Electricity | 42 MWh/yr |
| Calculated power savings - District heating | 26 kW |
| Calculated power savings - Electricity | 14 kW |
| Calculated other savings (SEK/yr): | - |
| Total annual cost savings: | 62 kSEK/yr |
| Energy investment cost: | 602 kSEK (20% of the total cost) |
| Economic calculation period: | 20 years |

Description of the measure

According to this measure, the TA104 and TA105 air-handling units will be replaced with one single air-handling unit with advanced indirect recuperative heat recovery, heating and cooling coils and frequency-controlled direct drive fans. Example type of unit: FläktWoods EQ-062 with Econet heat recovery. The design airflow rate of the new unit 10/10 $m^3/s$, design SFP value approx 2.5 kW/($m^3$/s). The fans will be controlled by a constant pressure in the duct system. After-heating/cooling coils will be removed from the main ducts. New mixing station and pipes will be installed for the heating coils in the unit.

Energy- and cost savings

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- New unit has a design airflow rate 10, /10 $m^3/s$ regenerative heat exchangers with a temperature efficiency of approximately 75%, SFP value 2.5 kW/($m^3$/s)
- New supply air temperature control set points are + 18 °C/+ 19°C at 20°C/-20°C outdoor temperature.
- The operating time of the unit will remain the same: 6:40-18:00 M-F

Investment cost

The total investment cost for this measure has been estimated to be about 3 010 kSEK. The cost estimate includes the dismantling and building costs, installation of a new unit and new mixing station with new pipes for the coils, balancing of the airflow rates, electrical wiring, control and connections to the BMS system, and design costs. **This measure is carried out for the upcoming renovation for the tenant adjustments as well as for system maintenance. Therefore 20% of the total costs have been included to the**

**costs for energy efficiency improvement.** Economic lifetime of the investment is estimated to be 20 years.

## 6.6 Measure 6. Install VAV-dampers for different zones in Sections C and D

| | |
|---|---|
| Type of measure | Technical installations |
| Calculated energy savings - District heating | 16 MWh/yr |
| Calculated energy savings - Electricity | 10 MWh/yr |
| Calculated power savings - District heating | 13 kW |
| Calculated power savings - Electricity | 10 kW |
| Calculated other savings (SEK/yr): | - |
| Total annual cost savings: | 24 kSEK/yr |
| Energy investment cost: | 1 000 kSEK (100% of the total cost) |
| Economic calculation period: | 15 years |

Description of the measure

There will be some office premises in Sections C and D which will be vacant even in the future. The entire ventilation system is built as a CAV system, which means all premises are continuously ventilated even if they are not in use. According to this measure, the ventilation system in Sections C and D will be divided into subsections so that it is possible to decrease/increase the airflow rates to different zones. VAV- dampers will be installed on the supply and exhaust air branch ducts connected to each tenants. This measure requires reconstruction in the duct system and it is assumed that this reconstruction will be made at the same time with the tenant adjustments in these building sections.

Energy- and cost savings

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- The average air flow in the Section C will be reduced by 0.5 $m^3/s$ and in Section D by 1.0 $m^3/s$.
- Reduction of air flow will result in reduced indoor temperatures in empty premises, because these premises are mainly heated with the supply air. In the calculations, the weighted average indoor temperature for Sections C and D is estimated to be about + 20 °C.
- The savings potential of this measure is affected by Measures 3, 4 and 5, which has been taken into account in the calculations.

Investment cost

The total investment cost for this measure has been estimated to be about 1 000 kSEK. The cost estimate includes installation of VAV-dampers, electrical wiring, control and connections to the BMS system, reconstruction of some of the air ducts in the shafts and design costs. There are some uncertainties associated with the costs for installation of VAV-dampers in Section D, because the premises around the shafts are rented out and extra construction costs may occur. This needs to be assessed in detail in the design stage. **Since this measure is carried out mainly for energy savings then the entire investment cost will be included to the costs for energy efficiency improvement.** Economic lifetime of the investment is estimated to be 15 years.

## 6.7 Measure 7. Install new energy efficient pumps with pressure control in the heating system in Sections A, B and C

| | |
|---|---|
| Type of measure | Technical installations |
| Calculated energy savings - District heating | - |
| Calculated energy savings - Electricity | 2 MWh/yr |
| Calculated power savings - District heating | - |
| Calculated power savings - Electricity | - |
| Calculated other savings (SEK/yr): | - |
| Total annual cost savings: | 1,5 kSEK/yr |
| Energy investment cost: | 55 kSEK (50% of the total cost) |
| Economic calculation period: | 15 years |

<u>Description of the measure</u>

According to this measure, the pumps in the heating systems in Sections A, B and C will be replaced with new energy efficient pumps with integrated pressure control. In total two pumps will be replaced on the primary side and five pumps on the secondary side. This measure should be carried out together with the Measure 9 and 10 (replacement of thermostats and hydronic balancing of the heating systems).

<u>Energy- and cost savings</u>

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- Better efficiency and pressure control of new pumps will lead to reduced power demand by about 30%.

<u>Investment cost</u>

The total investment cost for this measure has been estimated to be about 110 kSEK. The investment cost estimate includes dismantling and construction costs, installation of new pumps, electrical wiring, control and connections to the BMS system, and design costs. **This measure can also be considered as a maintenance measure. Therefore 50% of the total costs have been included to the costs for energy efficiency improvement.** Economic lifetime of the investment is estimated to be 15 years.

## 6.8 Measure 8. Install new energy efficient pumps with pressure control in the heating system in Section D

| | |
|---|---|
| Type of measure | Technical installations |
| Calculated energy savings - District heating | - |
| Calculated energy savings - Electricity | 2 MWh/yr |
| Calculated power savings - District heating | - |
| Calculated power savings - Electricity | - |
| Calculated other savings (SEK/yr): | - |
| Total annual cost savings: | 1,5 kSEK/yr |
| Energy investment cost: | 20,5 kSEK (50% of the total cost) |
| Economic calculation period: | 15 years |

Description of the measure

According to this measure, the pumps in the heating system in Section D will be replaced with new energy efficient pumps with integrated pressure control. In total one pump will be replaced on the primary side and one pump on the secondary side. This measure should be carried out together with the Measure 10 (replacement of thermostats and hydronic balancing of the heating systems).

Energy- and cost savings

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- Better efficiency and pressure control of new pumps will lead to reduced power demand by about 30%.

Investment cost

The total investment cost for this measure has been estimated to be about 41 kSEK. The investment cost estimate includes dismantling and construction costs, installation of new pumps, electrical wiring, control and connections to the BMS system, and design costs. **This measure can also be considered as a maintenance measure. Therefore 50% of the total costs have been included to the costs for energy efficiency improvement.** Economic lifetime of the investment is estimated to be 15 years.

## 6.9 Measure 9. Replacement of thermostats and hydronic balancing of the heating systems in Sections A and B

| | |
|---|---|
| Type of measure | Technical installations |
| Calculated energy savings - District heating | 10 MWh/yr |
| Calculated energy savings - Electricity | - |
| Calculated power savings - District heating | 2 kW |
| Calculated power savings - Electricity | - |
| Calculated other savings (SEK/yr): | - |
| Total annual cost savings: | 6 kSEK/yr (20% of the total cost) |
| Energy investment cost: | 32 kSEK |
| Economic calculation period: | 10 years |

Description of the measure

According to this measure the old thermostats on the radiators will be replaced with new ones and hydronic balancing will be carried out in the entire heating system in Sections A and B. Number of radiator thermostats to be replaced is estimated to be approx 320. Number of mixing stations that will be balanced is 3.

Energy- and cost savings

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- Reductions of mean room temperatures during winter time in Sections A and B by about 0.5 °C.

Investment cost

The total investment cost for this measure has been estimated to be about 158 kSEK. The cost estimate includes installation of new thermostats, hydronic balancing of the radiator circuits and the primary side of the heating systems. T**his measure can be considered also as a maintenance measure and will be carried out together with the upcoming renovation for the tenant adjustments. Therefore 20% of the total costs have been included to the costs for energy efficiency improvement.** Economic life of the investment is estimated at 20 years.

## 6.10 Measure 10. Replacement of thermostats and hydronic balancing of the heating systems in Sections C and D

| | |
|---|---|
| Type of measure | Technical installations |
| Calculated energy savings - District heating | 21 MWh/yr |
| Calculated energy savings - Electricity | - |
| Calculated power savings - District heating | 4 kW |
| Calculated power savings - Electricity | - |
| Calculated other savings (SEK/yr): | - |
| Total annual cost savings: | 11 kSEK/yr (20% of the total cost) |
| Energy investment cost: | 65 kSEK |
| Economic calculation period: | 10 years |

Description of the measure

According to this measure the old thermostats on the radiators will be replaced with new ones and hydronic balancing will be carried out in the entire heating system in Sections C and D. Number of radiator thermostats to be replaced is estimated to be approx 680. Number of mixing stations that will be balanced is 4.

Energy- and cost savings

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- Reductions of mean room temperatures during winter time in Sections C and D by about 0.5 °C.

Investment cost

The total investment cost for this measure has been estimated to be about 327 kSEK. The cost estimate includes installation of new thermostats, hydronic balancing of the radiator circuits and the primary side of the heating systems. T**his measure can be considered also as a maintenance measure and will be carried out together with the upcoming renovation for the tenant adjustments. Therefore 20% of the total costs have been included to the costs for energy efficiency improvement.** Economic life of the investment is estimated at 20 years.

## 6.11 Measure 11. Replacement of windows

| | |
|---|---|
| Type of measure | Building envelope |
| Calculated energy savings - District heating | 90 MWh/yr |
| Calculated energy savings - Electricity | 20 MWh/yr |
| Calculated power savings - District heating | 30 kW |
| Calculated power savings - Electricity | - |
| Calculated other savings (SEK/yr): | - |
| Total annual cost savings: | 70 kSEK/yr |
| Energy investment cost: | 6 500 kSEK (50 % of the total cost) |
| Economic calculation period: | 30 years |

Description of the measure

Majority of the windows are triple pane wooden windows. Estimated U-value is 2.0 $W/m^2 \cdot K$, which is considered to be rather high according to today's standards. All windows are original from the 80s, except for part of the lunch restaurant section, which was built in the early 2000s. According to this measure the existing windows from the 80s will be replaced with new windows with triple pane insulating glass and with energy deposition. Example characteristics of new windows: U-value of about 1,2 $W/m^2K$, solar factor 0.39. Detailed selection of the windows must be made during the design stage.

Energy- and cost savings

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- Reduction of the U-value from 2.0 $W/m^2K$ to 1.2 $W/m^2K$ and solar factor from 0.67 to 0.39.
- The savings potential of this measure is affected by Measure 9 and 10, which has been taken into account in the calculations.

Investment cost

The total investment cost for this measure has been estimated based on the standard values from cost books (Sektionsfakta) and previous windows investigations and is about 13 000 kSEK. The investment cost includes construction costs, installation of new windows and design costs. **This measure can also be considered as a maintenance measure. Therefore 50% of the total costs have been included to the costs for energy efficiency improvement.** Economic lifetime of the investment is estimated to be 30 years.

## 6.12 Measure 12. Installation of PV panels

| | |
|---|---|
| Type of measure | Technical installations |
| Calculated energy savings - District heating | - |
| Calculated energy savings - Electricity | 270 MWh/yr |
| Calculated power savings - District heating | - |
| Calculated power savings - Electricity | upp till 150 kW[1)] |
| Calculated other savings (SEK/yr): | - 24 kSEK/yr[2)] |
| Total annual cost savings: | 200 kSEK/yr |
| Energy investment cost: | 6 206 kSEK (100 % of the total cost) |
| Economic calculation period: | 25 år |

*1) During the summer period*
*2) Other costs include estimated maintenance costs, which is approximately 0.075% of the total investment costs and revenues from sales of excess electricity.*

<u>Current status</u>
The main energy end-users of the electricity for building operation is comfort cooling, with about 30% (including electricity for chillers and pumps in the cooling system), and fan operation, about 46%. How the buildings' energy demand for building operation (excl. tenants) varies during the year is shown in Figure 14 below. The data is based on the new baseline calculations.

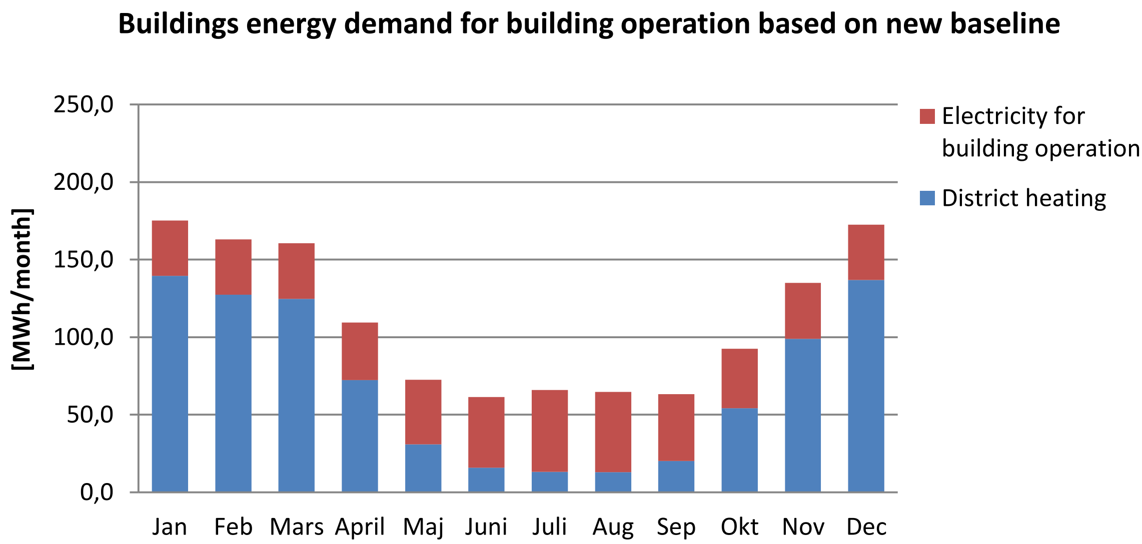



**Figure 14.** The Högsbo 20:22 property's monthly energy demand for building operation (excl. tenants) based on the calculations for the new baseline for energy performance.

The property has very good potential for installing solar electricity systems to cover the electricity demand for building operation during summer period, late spring and early fall. Both buildings in the Högsbo 20:22 property have flat roofs which provides good conditions for the installation of solar panels.

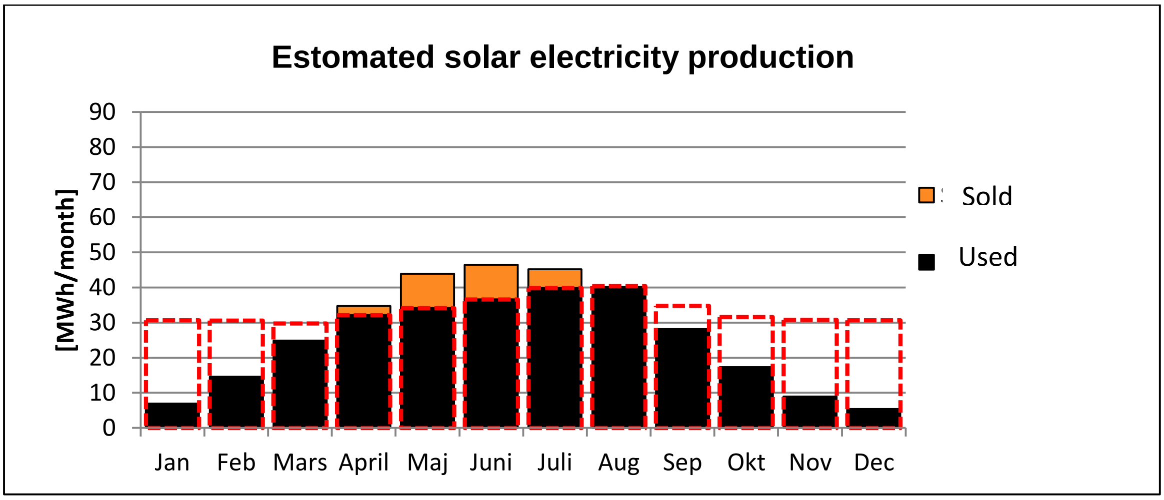
Description of the measure

According to this measure solar electricity system will be installed to the site to decrease the amount of bought electricity from the grid. Solar panels will be installed on the roofs of the two buildings of the Högsbo 20:22 property. Estimated roof area for installation of PV cells is in Section A and B to 800 $m^2$, in Section C 900 $m^2$ and in Section D 1400 $m^2$. Detailed placement and design of photovoltaic system shall be decided during the design phase.

Energy- and cost savings

The above-reported energy saving potential is calculated based on the following estimates/changes in the systems:

- Total roof area available for installation of PV panels is approximately 3100 $m^2$
- The PV panels will be tilted by about 5 ° angle.
- The estimated electricity production of the solar system is illustrated in Figure 15 below. The total cost saving potential of this measure is affected by other measures which have been taken into account in the calculation.
- Specific power for PV cells is 130 $W/m^2$, the energy production of 0.9 kWh/W per year.
- Electricity price to sell to the grid is 0.4 SEK/kWh.




**Figur 15.** Calculated solar electricity production from the solar system.

Investment cost

The total investment cost for this measure has been estimated based on the estimated price of 14 SEK/W and will be about 6 206 kSEK in total. Additional 10% of the total investment has been added for the design cost. The investment cost does not take into account any subsidies from the government, which right now is undecided. Economic lifetime of the investment is estimated to be 25 years.

# 7 Action package based on the Total Concept method

## 7.1 Input data for the profitability calculations

The following input data has been used for profitability calculations:

- The property owner's profitability requirement: real calculation interest rate is 8%.
- Estimated annual relative energy price increase 2%.
- Economic calculation period for energy saving measures corresponds to their economic lifetimes.
- Energy and resource prices and power tariffs are based on the invoices received from Harry Sjögren and are summarized in the tables below.

| Energy price for district heating | Price |
|---|---|
| Energy price summer, may-sept | 99 kr/MWh |
| Energy price spring/autumn: april, oct, nov | 360 kr/MWh |
| Energy price winter: jan-march, dec | 525 kr/MWh |
| Power tariff (at over 100 kW) | 663 kr/kW, yr |
| Grid connection tariff 101-250 kW | 11750 kr/yr |
| High return temperature fee MWh*dT | 4 kr/MWh, grad C |

| Energipris for fastighetsel | Price |
|---|---|
| Energy price 50 % fixed (incl renewable energy fee) | 0,40 kr/kWh |
| Energy price 50 % spot (incl renewable energy fee) | 0,36- 0,47 kr/kWh[1)] |
| Energy tax | 0,29 kr/kWh |
| Grid charge | 0,07 kr/kWh |
| Power tariff | 475,2 kr/kW, yr |
| Grid connection tariff | 4700 kr/yr |

*1) According to year 2013 data*

Calculated mean annual price for district heating is 0.45 SEK/kWh and for electricity is 0.73 SEK/kWh.

## 7.2 Results

According to the Total Concept method an action package will be formed that as whole must fulfill a property owner’s profitability demands. It is up to the property owner to decide which measures will be carried out. According to the discussions with the property owner of the Högsbo 20_22 office buildings the energy saving measures for the building Sections C and D will be prioritized first and carried out at the same time as the upcoming renovation for the tenant adjustments and maintenance in these sections.

Therefore, two alternative packages of measures have been put together to show the saving potential and profitability with the specific measures:

- *Action package 1*, which contains those measures that most probably will be implemented as part of the upcoming renovation for the tenant adjustments and maintenance in Sections C and D.
- *Action package 2*, which meets the profitability requirements according to the Total Concept method.

It must also be noted that in the presented action packages there are some measures providing internal rate of interest less than 0%. According Total Concept method these measures are included to the package, since there are a number of profitable measures "supporting" the less profitable measures and the overall package can still be profitable. It's up to the property owner to determine if these measures will be included.

**Summary of the Action package 1**

| | |
|---|---|
| Total annual cost savings: | 217  kSEK/yr |
| Energy investment cost: | 2 938 kSEK (28 % of the total cost) |
| Internal rate of return for the package | 5.5 % |
| Calculated energy savings -  District heating | 173 MWh/yr |
| Calculated energy savings -  Electricity | 91 MWh/yr |

List of measures included in the *Action package 1* are summarized in Table B2.2 in Appendix 2. The profitability of the *Action package 1* plotted on an internal rate of return diagram is shown in Figure 17.  The whole package will provide about 5.5 % internal rate of return. The last measure in the Action package 1 is *Measure 6 "Install VAV-dampers for different zones in Sections C and D"* where the full investment cost of the measure has been included to the costs for energy efficiency improvement. Since a number of air ducts in the main shafts will be replaced in Section C during the upcoming renovation work for tenant adjustments, then there are great opportunities to optimize the costs for this measure and increase the profitability of the whole action package.

Figure 18 gives the energy saving potential with the *Action package 1*. Total energy use of the property will be about 74 kWh/m$^2$ when excluding tenants' electricity and about 111 kWh/m$^2$ when including tenants' electricity.

Due to higher uncertainties for the investment cost for *Measure 3*, a sensitivity analysis have been carried out to analyse its impact on the results. The results show that ±20 % changes in the energy investment cost for *Measure 3* (approx. ±550 kSEK of the total investment cost for *Measure 3*) the internal rate of return for the action package will be in between 5.0 % and 6.0 %.

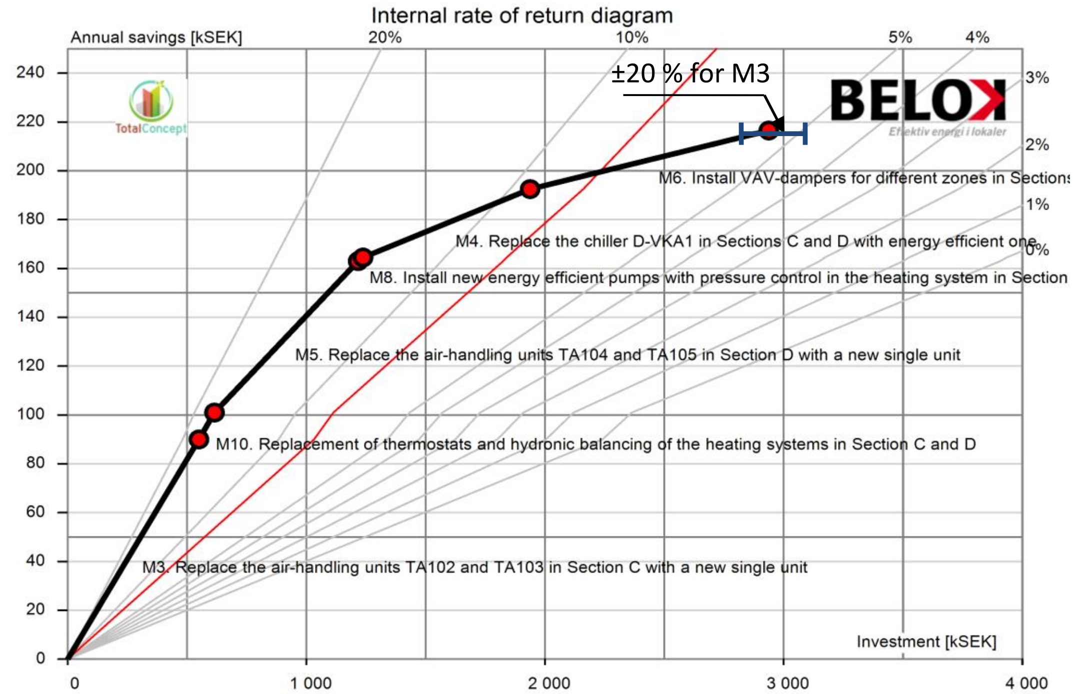



**Figure 17.** Profitability of the ”*Action package 1*” presented in an internal rate of return diagram. The property owner´s profitability requirement is 8 % and the estimated relative energy price increase is 2 %. Internal rate of return for the action package is 5.5 %. If the energy investment cost for Measure 3 will change ±20 % the internal rate of return for the action package will be in between 5.0 % and 6.0 %.

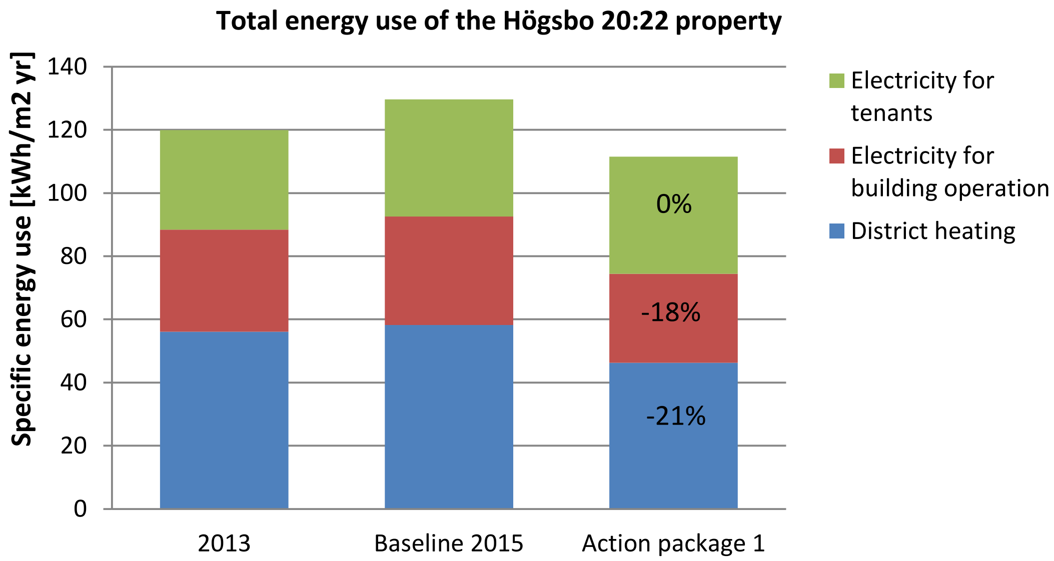



**Figure 18.** Specific energy use before and after carrying out the measures in ”*Action package 1*” for Högsbo 20:22. Energy saving potential is estimated based on the new baseline for the energy performance of the building. With ”*Action package 1*” the heat demand can be reduced by about 21% and the electricity demand for building operation by about 18%.

**Summary of the Action package 2**

| | |
|---|---|
| Total annual cost savings: | 200 kSEK/yr |
| Energy investment cost: | 2 025 kSEK (28 % of the total cost) |
| Internal rate of return for the package | 9.2 % |
| Calculated energy savings - District heating | 167 MWh/yr |
| Calculated energy savings - Electricity | 83 MWh/yr |

List of measures included in the *Action package 2* are summarized in Table B2.3 in Appendix 2. The profitability of the *Action package 2* plotted on an internal rate of return diagram is shown in Figure 19. The whole package will provide about 9 % internal rate of return.

Figure 20 gives the energy saving potential with the *Action package 2.* Total energy use of the property would be about 75 kWh/m$^2$ when excluding tenants' electricity and about 112 kWh/m$^2$ when including tenants' electricity.

The results of the sensitivity analysis show that ±20 % changes in the energy investment cost for *Measure 3* (approx. ±550 kSEK of the total investment cost for *Measure 3*) the internal rate of return for the *Action package 2* will be in between 8.5 % and 10.0 %.

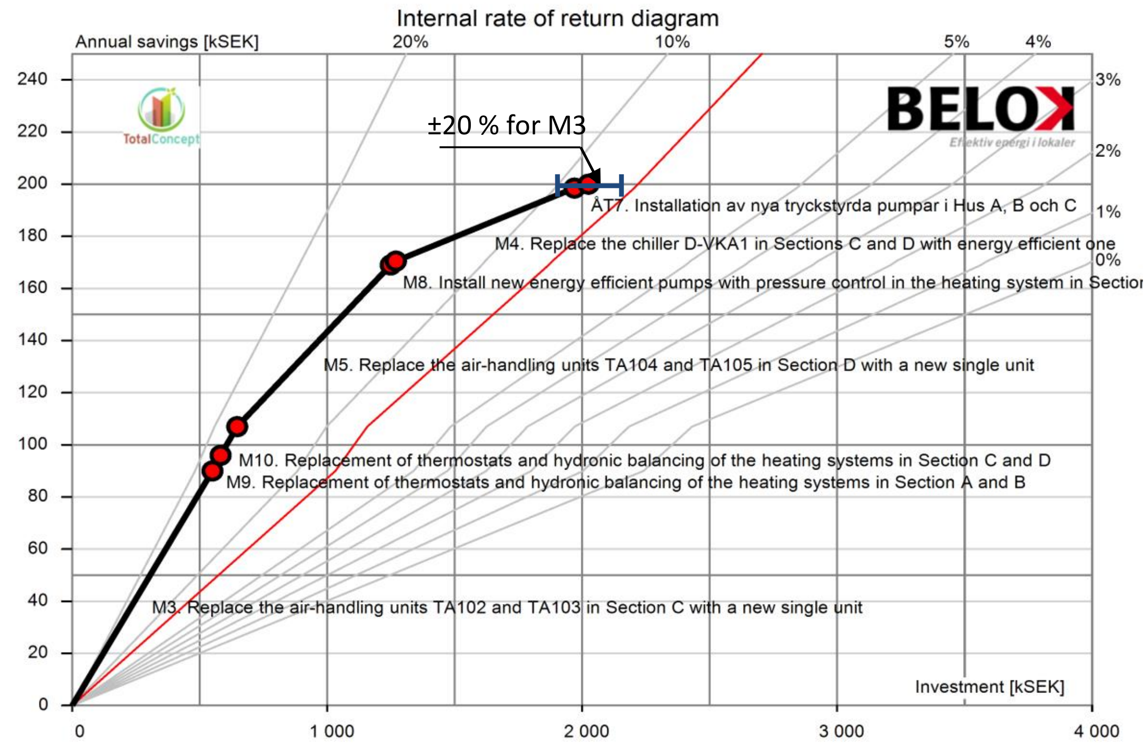



**Figure 19.** Profitability of the "*Action package 2*" presented in an internal rate of return diagram. The property owner´s profitability requirement is 8 % and the estimated relative energy price increase is 2 %. Internal rate of return for the action package is approx 9 %. If the energy investment cost for Measure 3 will change ±20 % the internal rate of return for the action package will be in between 8.5 % and 10.0 %.

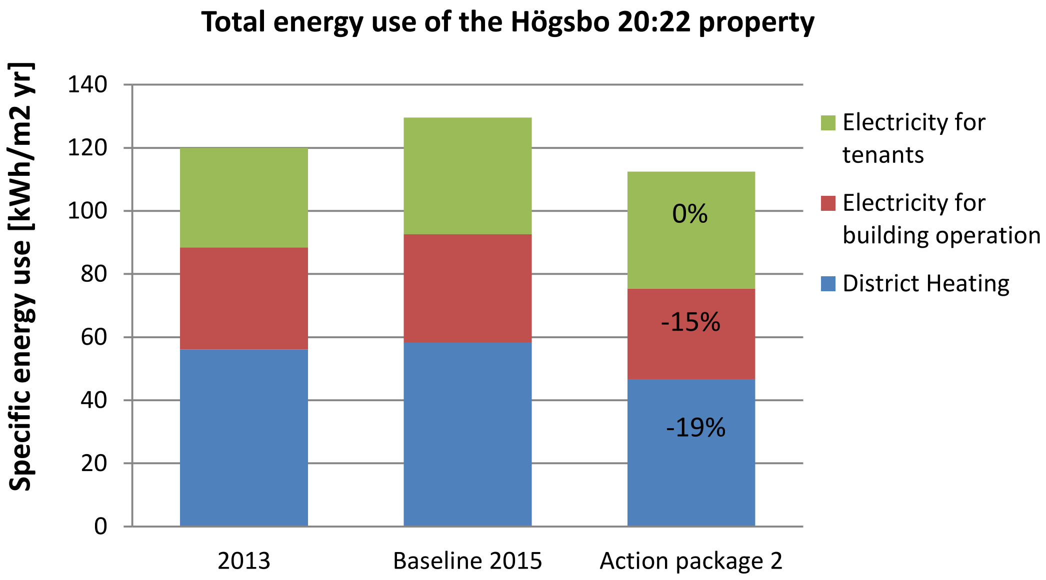



**Figure 20.** Specific energy use before and after carrying out the measures in ”*Action package 2*” for Högsbo 20:22. Energy saving potential is estimated based on the new baseline for the energy performance of the building. With ”*Action package 2*” the heat demand can be reduced by about 19% and the electricity demand for building operation by about 15%.

Summary of all identified measures and results of the profitability calculations can be found in Appendix 2. If all of the identified measures would be carried out then the heat demand will be reduced by about 33% and purchased electricity for building operation by about 82%. Total energy use of the property (bought energy) would be about 44 kWh/m$^2$ when excluding tenants' electricity and about 81 kWh/m$^2$ when including tenants' electricity. However profitability of such an action package will be close to 0 % of internal rate of return and will not meet the property owner's profitability requirement. Some measures are simply not cost-effective from the energy saving point of view.

# 8 Conclusions

The aim of this project has been to carry out Step 1 of the Total Concept method[4] and form a package of measures for energy efficiency improvements in the Högsbo 20:22 office building. The Högsbo 20:22 property has today very low energy consumption compared to similar existing office buildings in Sweden. The total specific energy use of the property was only about 120 kWh/m$^2$ in 2013. This low energy use can be explained by the relatively high vacancy level in the buildings and low occupancy rate in the used premises. About 60 % out of the total heated area ($A_{temp}$) of the property was rented out in year 2013 and about 70 % has been rented out in year 2014. Also, the property is managed by quite

[4] Details of the Total Concept method can be found from: ”The Total Concept method. Guidebook for implementation and quality assurance”. 2014, www.totalconcept.info

skilled operational staff, who continually works to optimize the operational performance of the technical systems in the buildings in order to reduce energy use.

According to the property owner a number of tenant adjustments are planned for the year 2015, which will lead to increased energy use in the building. Therefore a new baseline for the property's energy consumption was calculated by using the calibrated energy simulation model, which shows that the total energy use will increase to about 130 kWh/m².

In order to improve the energy performance of the Högsbo 20:22 buildings, which already have rather low energy use, more extensive measures will be required, where the focus should be on the air-handling systems and on the building envelope. Twelve energy saving measures have been identified and analyzed in this report. Some of the measures will be carried out as part of the upcoming renovation for the tenant adjustments. It has also been taken into account in the performed calculations that a number of building services systems and building construction parts are old. Therefore most of the proposed measures can be considered also as maintenance measures and only part of the investment cost is included to the investment costs for energy efficiency improvement.

Two alternative packages of measures have been presented in this report. The aim has been to include even those measures that most probably will be implemented as part of the upcoming renovation for the tenant adjustments and maintenance in Sections C and D. It is up to the owner to decide what the final package will be.

With the action package that includes only measures for Sections C and D, *Action package 1*, the total energy saving potential is approximately 14% compared to the new baseline. Profitability of such an action package will be about 5.5 % internal rate of return. District heating use can be reduced by about 173 MWh/year and electricity use by about 91 MWh/yr. Several proposed measures contribute also to reduction in power demand and reduced power costs. In total the operating costs can be reduced by approx. 217 kSEK/yr. Energy investment costs for such an action package would be about 2 938 kSEK.

With the action package that meets the profitability requirement 8% internal rate of return, *Action package 2*, the total energy saving potential is approximately 13% compared to the new baseline. District heating use can be reduced by about 167 MWh/yr and electricity use by about 83 MWh/year. Total operating costs can be reduced by approx 200 kSEK/yr and energy investment costs for such an action package would be about 8400 kSEK.

The results show also that it is possible to reduce the total amount of bought energy up to 37% when all the measures would be carried out. However, to achieve this saving is so expensive that with given profitability demands and energy prices it will not be profitable.

# Appendix 1. Input data for energy simulations

The specification of the input data used for the energy calculations is given in the tables below.

### 1. Location and climate

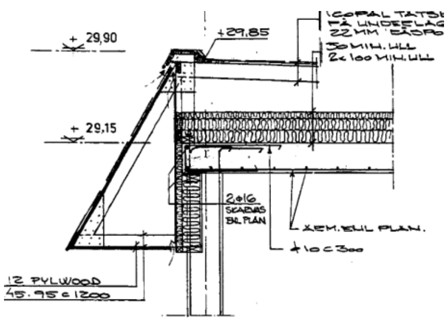
| General information about the buildings | | Information source |
|---|---|---|
| Location | Göteborgs kommun | 3 |
| Climate file for energy calculations | Göteborg Säve, Meteotest-Meteonorm 4.0 | 5 |
| Total area (Atemp) | 14543 m2 | 3 |
| *Sections A and B (Atemp)* | 4038 m2 | 3 |
| *Section C (Atemp)* | 4055 m2 | 3 |
| *Section D (Atemp)* | 6450 m2 | 3 |
| Building orientation | | |
| *Section A and B (Atemp)* | South facade is towards south-west approx 45 deg | 1 |
| *Section C (Atemp)* | South facade is towards south-west approx 50 deg | 1 |
| *Section D (Atemp)* | South facade is towards south-west approx 10 deg | 1 |

*Information source:*
*1) From drawings and building permit documents*
*2) Estimated*
*3) Information from the property owner*
*4) Information from the audit*
*5) Energy simulation tool*

### 2. Technical properties of the building envelope

| Construction part | Description | U-value [W/m²K] | Information source |
|---|---|---|---|
| Façade 1 | 120 bricks; 30 air gap; 120 insulation; 150 concrete | 0.26 | 1,2 |
| Façade 2 | metal sheet; 9 gypsum; 50 insulation; 45x45 joists; 145 insulation; 45x145 joists; 0,2 plastic sheet; 13 gypsum | 0.24 | 1,2 |
| Roof | 250 concrete; 250 insulation; timber rafters c/c 1200; wooden surface; 2-layer roof cover | 0.2 | 1,2 |
| Ground slab | 350 concrete; 50 sundolitt; 150 makadam | 0.36 | 1,2 |
| Window 1 | triple pane wooden windows | 2.0 | 1,2 |
| Window 2 (restaurant) | triple pane wooden windows | 1.8 | 1,2 |
| Entrance door 1 | aluminum framed glass doors | 1.8 | 1,2 |
| Entrance door 2 | steel doors | 1 | 1,2 |

There are two different kinds of solid external solar shadings on windows facing south and partly also on east, west and even north (mainly upper floors). Type 1 is built in to the building facade construction above the windows on the upper floors and Type 2 is wall mounted solid homogenous solar shading (see figure below).



## Section A and B

| | Facade | | Window | | | | | | External solar shading coefficients | | | | Doors | | Info source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | External solar shading | | Winter | | Summer | | | | |
| | Area [m²] | U-value [W/m²K] | Area [m²] | U-value [W/m²K] | Window share [%] | g [-] | Exists | share [%] | Direct | Diffuse | Direct | Diffuse | Area [m²] | U-value [W/m²K] | |
| South | 680,0 | 0,24 | 220,5 | 2,0 | 95,0 | 0,7 | yes | 89,2 | 0,9 | 0,5 | 0,6 | 0,5 | 5,2 | 1,8 | 1 |
| East | 319,0 | 0,24 | 90,9 | 2,0 | 95,0 | 0,7 | yes | 82,2 | 0,9 | 0,6 | 0,7 | 0,5 | 9,8 | 1,8 | 1 |
| West | 299,0 | 0,24 | 59,3 | 2,0 | 95,0 | 0,7 | yes | 72,2 | 1,0 | 0,7 | 0,7 | 0,6 | 7,8 | 1,8 | 1 |
| North | 415,0 | 0,24 | 123,8 | 2,0 | 95,0 | 0,7 | yes | 64,0 | 0,8 | 0,5 | 0,8 | 0,5 | 8,2 | 1,7 | 1 |

| Summary | Area [m2] | Weighted U-value [W/m²K] | U*A [W/K] | % of total (U*A) | Information source |
|---|---|---|---|---|---|
| Facade | 1188 | 0,24 | 289 | 14% | 1 |
| Window | 494 | 2,0 | 983 | 46% | 1 |
| Entrance doors | 31 | 1,77 | 55 | 3% | 1 |
| Roof | 1232 | 0,20 | 246 | 12% | 1 |
| Ground slab | 1232 | 0,36 | 444 | 21% | 1 |
| Thermal bridges | | | 102 | 5% | 1,2 |
| Total | 4177 | | 2118 | 100% | |

| General information about the buildings | Properties | Information source |
|---|---|---|
| Thermal mass (Internal) | medium | 1 |
| Thermal mass (facade) | medium | 1 |
| Thermal mass (roof) | medium | 1 |
| Thermal mass (m3) | 11912 | 1 |
| Air infiltration based on tightness of the building | ≤ 0,20 ACH | 2 |
| Air infiltration due to thermal driving forces | ≤ 0,20 ACH | 2 |

**Section C**

| | Facade | | Window | | | | | | External solar shading coefficients | | | | Doors | | Info source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Window share | g | External solar shading | | Winter | | Summer | | | | |
| | Area [m²] | U-value [W/m²K] | Area [m²] | U-value [W/m²K] | [%] | [-] | Exists | share [%] | Direct | Diffuse | Direct | Diffuse | Area [m²] | U-value [W/m²K] | |
| South | 756,0 | 0,24 | 200,0 | 2,0 | 90,0 | 0,7 | yes | 100,0 | 1,0 | 0,6 | 0,6 | 0,5 | 7,5 | 1,3 | 1 |
| East | 270,0 | 0,24 | 45,0 | 2,0 | 90,0 | 0,7 | yes | 25,0 | 1,0 | 1,0 | 1,0 | 1,0 | 11,2 | 1,4 | 1 |
| West | 0,0 | - | 0,0 | - | - | - | no | - | - | - | - | - | 0,0 | - | 1 |
| North | 756,0 | 0,24 | 184,0 | 2,0 | 90,0 | 0,7 | yes | 25,0 | 1,0 | 1,0 | 1,0 | 1,0 | 5,0 | 1,0 | 1 |

| Summary | Area [m2] | Weighted U-value [W/m²K] | U*A [W/K] | % of total (U*A) | Information source |
|---|---|---|---|---|---|
| Facade | 1329 | 0,24 | 322 | 16% | 1 |
| Window | 429 | 2,0 | 858 | 43% | 1 |
| Entrance doors | 24 | 1,26 | 30 | 1% | 1 |
| Roof | 1274,0 | 0,20 | 255 | 13% | 1 |
| Ground slab | 1274,0 | 0,36 | 459 | 23% | 1 |
| Thermal bridges | | | 86 | 4% | 1,2 |
| Total | 4330 | | 2009 | 100% | |

| General information about the buildings | Properties | Information source |
|---|---|---|
| Thermal mass (Internal) | medium | 1 |
| Thermal mass (facade) | medium | 1 |
| Thermal mass (roof) | medium | 1 |
| Thermal mass (m3) | 11692 | 1 |
| Air infiltration based on tightness of the building | ≤ 0,20 ACH | 2 |
| Air infiltration due to thermal driving forces | ≤ 0,20 ACH | 2 |

**Section D**

| | Facade | | Window | | | | | | External solar shading coefficients | | | | Doors | | Info source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area [m²] | U-value [W/m²K] | Area [m²] | U-value [W/m²K] | Window share [%] | g [-] | External solar shading Exists | External solar shading share [%] | Winter Direct | Winter Diffuse | Summer Direct | Summer Diffuse | Area [m²] | U-value [W/m²K] | |
| South | 549,0 | 0,24 | 181,0 | 2,0 | 90,0 | 0,7 | yes | 100,0 | 1,0 | 0,6 | 0,6 | 0,5 | 4,5 | 1,8 | 1 |
| East | 618,0 | 0,24 | 173,0 | 2,0 | 90,0 | 0,7 | yes | 25,0 | 1,0 | 1,0 | 1,0 | 1,0 | 0,0 | - | 1 |
| West | 757,0 | 0,24 | 219,0 | 2,0 | 90,0 | 0,7 | yes | 25,0 | 1,0 | 1,0 | 1,0 | 1,0 | 8,0 | 1,8 | 1 |
| North | 729,0 | 0,24 | 201,0 | 2,0 | 90,0 | 0,7 | yes | 25,0 | 1,0 | 1,0 | 1,0 | 1,0 | 25,0 | 1,0 | 1 |

| Summary | Area [m2] | Weighted U-value [W/m²K] | U*A [W/K] | % of total (U*A) | Information source |
|---|---|---|---|---|---|
| Facade | 1842 | 0,24 | 446 | 14% | 1 |
| Window | 774 | 2,0 | 1548 | 50% | 1 |
| Entrance doors | 38 | 1,27 | 48 | 2% | 1 |
| Roof | 1700,0 | 0,20 | 340 | 11% | 1 |
| Ground slab | 1700,0 | 0,36 | 612 | 20% | 1 |
| Thermal bridges | | | 127 | 4% | 1,2 |
| Total | 6053 | | 3121 | 100% | |

| General information about the buildings | Properties | Information source |
|---|---|---|
| Thermal mass (Internal) | medium | 1 |
| Thermal mass (facade) | medium | 1 |
| Thermal mass (roof) | medium | 1 |
| Thermal mass (m3) | 19027 | 1 |
| Air infiltration based on tightness of the building | ≤ 0,20 ACH | 2 |
| Air infiltration due to thermal driving forces | ≤ 0,20 ACH | 2 |

## 3. Building services systems

### Control parameters for HVAC systems

| | Section A&B | Section C | Section D | Garage | Information source |
|---|---|---|---|---|---|
| Min indoor temperature day (heating) | 21 | 21 | 21 | 10 | 2,4 |
| Min indoor temperature night (heating) | 20,5 | 20,5 | 20,5 | 7 | 2,4 |
| Set point comfort cooling day | 23 | 22,8 | 22,8 | - | 2,4 |
| Set point comfort cooling night | 23 | 22,8 | 22,8 | - | 2,4 |
| Max indoor temperature day | 24 | 24 | 24 | - | 2,4 |
| Max indoor temperature night | 24 | 24 | 24 | - | 2,4 |

### Ventilation

Building ventilation systems are simplified in the calculations. For detailed information about ventilation systems see the table at the end of Appendix 1.

| Building section | Type of climate control | Airflow rate [m3/s] | | Operating time | Temperature control | Supply air temperature | | SFP [kW/m3/s] | Heat recovery [%] | Cooling recovery |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Supply | Exhaust | | | Set point [C] | Outdoor/room temp [C] | | | |
| Section A and B | CAV with water cooling | 5,8 | 5,6 | 6:40-18:30 M-F | Outdoor temp | 19,0 | 20 | 3,5 | 67 | yes |
| | | | | | | 20,0 | -20 | | | |
| Section A and B restaurant | CAV | 0,3 | 1,0 | 6:30-14:00 M-F | room temp | max 18 | 14 | 1,9 | 85 | no |
| Section C | CAV with water cooling | 3,4 | 3,0 | 6:40-18:00 M-F | Outdoor temp | 20 | 20 | 2,8 | 70 | no |
| | | | | | | 20 | -20 | | | |
| Section D | CAV with water cooling | 11,9 | 12,1 | 6:40-18:00 M-F | Outdoor temp | 19,9 | 20 | 3,3 | 70 | yes |
| | | | | | | 20,4 | -20 | | | |

### Heating and comfort cooling

Heating and comfort cooling are simulated with are simulated with infinite supply of power. Efficiency of the heat production is set to 98% in order to take into account losses in the production and distribution.  Estimated COP value for the chillers is 2.5.

Pump energy: Estimated total power demand is based on measured values or design values. Operating times are taken from the BMS system.

| Building section | System | Total power [kW] | Mean operating time [h/yr] | Energy use [MWh/yr] |
|---|---|---|---|---|
| Section A and B | Heating system | 0,7 | 5900 | 4 |
| | Chiller VKA1 | 2,0 | 5900 | 12 |
| | Chilled beams | 0,6 | 8760 | 5 |
| Section C | Heating system | 0,3 | 6000 | 2 |
| | Chiller VKA1 | - | - | - |
| | Chilled beams | 1,1 | 8760 | 10 |
| Section D | Heating system | 0,9 | 6400 | 5 |
| | Chiller VKA1 | 5,3 | 8760 | 47 |
| | Chilled beams | 1,1 | 8760 | 10 |

Domestic hot water use: 100 MWh/year for year 2013 is calculated based on the energy statistics; 140 MWh/year for calculating the new baseline for energy use. Distribution losses about 30% of the total energy use.

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## 4. Internal heat loads and additional electricity users

### Section A and B

| Building section/tenant | Area [m2] | People [W/m2] | | Lighting [W/m2] | | | Machines [W/m2] | | | Information source |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Occupancy times | Scheme | Occupancy times | Other times | Scheme | Occupancy times | Other times | Scheme | |
| Tenant 6 | 721 | 0,7 | 08-18 M-F | 6,4 | 0,4 | 08-18 M-F | 2,0 | 0,7 | 08-18 M-F | 4 |
| Tenant 3 | 145 | 3,0 | 08-18 M-F | 5,0 | 0,0 | 08-18 M-F | 3,9 | 1,6 | 08-18 M-F | 4 |
| Tenant 7 | 550 | 4,9 | 08-18 M-F | 6,1 | 0,0 | 08-18 M-F | 4,6 | 2,3 | 08-18 M-F | 4 |
| Tenant 8 | 478 | 2,9 | 08-18 M-F | 9,8 | 0,5 | 08-18 M-F | 6,3 | 2,5 | 08-18 M-F | 4 |
| Tenant 2 | 520 | 1,0 | 08-18 M-F | 5,8 | 0,1 | 08-18 M-F | 2,2 | 0,6 | 08-18 M-F | 4 |
| Tenant 10 | 325 | 8,2 | 07-15 M-F | 9,1 | 0,0 | 07-15 M-F | 55,0 | 10,0 | 07-15 M-F | 4 |
| Tenant 9 | 257 | 2,1 | 08-18 M-F | 7,4 | 0,2 | 08-18 M-F | 4,1 | 1,6 | 08-18 M-F | 4 |
| Tenant 11 | 520 | 3,1 | 08-18 M-F | 6,2 | 0,0 | 08-18 M-F | 1,3 | 0,5 | 08-18 M-F | 4 |
| Empty office (B) | 450 | 0 | 08-18 M-F | 0 | 0 | 08-18 M-F | 0 | 0 | 08-18 M-F | 4 |
| Bi-areas A&B | 72 | 0 | 08-18 M-F | 8,0 | 5,6 | 08-18 M-F | 5,0 | 5,0 | 08-18 M-F | 4 |
| ***Total*** | ***4038*** | | | | | | | | | |

### Section C

| Building section/tenant | Area [m2] | People [W/m2] | | Lighting [W/m2] | | | Machines [W/m2] | | | Information source |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Occupancy times | Scheme | Occupancy times | Other times | Scheme | Occupancy times | Other times | Scheme | |
| Tenant 12 | 860 | 1,3 | 08-18 M-F | 6,1 | 2,0 | 08-18 M-F | 10,7 | 5,5 | 08-18 M-F | 4 |
| Tenant 13 | 750 | 1,2 | 08-18 M-F | 6,2 | 0,4 | 08-18 M-F | 4,5 | 3,2 | 08-18 M-F | 4 |
| Tenant 4 | 300 | 1,8 | 08-18 M-F | 5,9 | 0,0 | 08-18 M-F | 4,4 | 3,6 | 08-18 M-F | 4 |
| Emtpy office - uthyrd 2015 | 1245 | 6,1 | 08-18 M-F | 7,6 | 1,1 | 08-18 M-F | 9,9 | 2,1 | 08-18 M-F | SVEBY |
| Empty office (C) | 845 | 0,0 | 08-18 M-F | 0,0 | 0,0 | 08-18 M-F | 0,0 | 0,0 | 08-18 M-F | 4 |
| Bi-areas C | 55 | 0,0 | 08-18 M-F | 11,1 | 6,1 | 08-18 M-F | 5,0 | 5,0 | 08-18 M-F | 4 |
| ***Total*** | ***4055*** | | | | | | | | | |

## Section D

| Building section/tenant | Area [m2] | People [W/m2] | | Lighting [W/m2] | | | Machines [W/m2] | | | Information source |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Occupancy times | Scheme | Occupancy times | Other times | Scheme | Occupancy times | Other times | Scheme | |
| Tenant 4B | 853 | 1,9 | 08-18 M-F | 4,2 | 0,9 | 08-18 M-F | 7,6 | 4,3 | 08-18 M-F | 4 |
| Tenant 17 | 800 | 0,7 | 08-18 M-F | 5,8 | 0,6 | 08-18 M-F | 1,9 | 0,8 | 08-18 M-F | 4 |
| Tenant 14 | 405 | 2,7 | 08-18 M-F | 4,7 | 0,1 | 08-18 M-F | 3,6 | 1,5 | 08-18 M-F | 4 |
| Tenant 5 | 902 | 5,4 | 08-18 M-F | 8,5 | 0,0 | 08-18 M-F | 6,6 | 2,3 | 08-18 M-F | 4 |
| Gym in Section D | 100 | 2,2 | 08-18 M-F | 15,6 | 0,0 | 08-18 M-F | 0,9 | 0,0 | 08-18 M-F | 4 |
| Tenant 4A | 280 | 2,7 | 07-15 M-F | 7,3 | 0,5 | 07-15 M-F | 55,0 | 10,0 | 07-15 M-F | 4 |
| Tenant 16 | 150 | 0,7 | 08-18 M-F | 7,1 | 0,0 | 08-18 M-F | 2,4 | 0,8 | 08-18 M-F | 4 |
| Tenant 15 | 346 | 0,0 | 08-18 M-F | 0,0 | 0,0 | 08-18 M-F | 0,3 | 0,3 | 08-18 M-F | 4 |
| Empty office (D) | 860 | 0 | 08-18 M-F | 0 | 0 | 08-18 M-F | 0 | 0 | 08-18 M-F | 4 |
| Dorma (4-D) | 910 | 2,4 | 08-18 M-F | 6,7 | 0,1 | 08-18 M-F | 2,3 | 0,5 | 08-18 M-F | 4 |
| Tenant 1 | 770 | 1,7 | 08-18 M-F | 7,0 | 0,6 | 08-18 M-F | 2,5 | 1,4 | 08-18 M-F | 4 |
| Bi-areas D | 74 | 0 | 08-18 M-F | 11,2 | 7,9 | 08-18 M-F | 5,0 | 5,0 | 08-18 M-F | 4 |
| | *6450* | | | | | | | | | |

## Additional electricity users

| Energy user | Nr of units | Total power (W) | Operation time [h/yr] | Annual energy use [kWh/yr] |
|---|---|---|---|---|
| Outdoor lighting (common) | | 4000 | 4300 | 17200 |
| Outdoor lighting tenants | 13 | 5000 | 4300 | 21500 |
| Garage lighting | | 3200 | 3700 | 11840 |
| Elevators | 6 | | | 33000 |

# Ventilation systems

The specification of ventilations systems at Högsbo 20:22 buildings. The technical data has been obtained from the BMS system july-oct 2014, Mandatory Ventilation Inspection report, auditing on site and based on calculations/estimations.

| System / Air handling unit | Area supported | Section | Fan speed control | Supply air fan | | | | Exhaust air fan | | | | Supply air | | Exhaust air | | Heat recovery [%] | Operation time | Operation time [h/week] | Estimated SFP [kW/m3/s] | Calculated electrical energy [kWh/yr] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Rated airflow [m3/s] | Rated power [kW] | Measured airflow [m3/s] | Measured power [kW] | Rated airflow [m3/s] | Rated power [kW] | Measured airflow [m3/s] | Measured power [kW] | Set point [C] | Measured [C] | Set point [C] | Measured [C] | | | | | |
| LA1- TF01/FF01 | Restaurant, Section B | Section A&B | frequency inverter | 0,9/0,45 | 1,5 | 0,3 | 1,125 | 0,75/0,3 | 1,5 | 0,5 | 1,125 | max 18 | 15,9 | 14 | 21,3 | 85 | M-F 06:30-14:00 FF01 | 37,5 | 1,9 | 3 |
| LA1- FF2 | Restaurant exhaust hood | Section A&B | frequency inverter | | | | | 0,5 | 0,84 | | | | | | | | M-F 06:45-14:00 FF2 | 36,3 | 1,2 | 1 |
| TA1-TF1/FF1 | Offices floor 1, 2, 3, section A+B | Section A&B | constant speed | 4,8 | 20 | 4,0 | 10,3 | 4,8 | 11 | 3,97 | 6,4 | 19,5/20 | 22,5 | | 23,3 | 63 | M-F 6:40-18:30 | 59,0 | 4,2 | 51 |
| *TA1-EVB1* | Offices north part of Section A+B | Section A&B | | | | | | | | | | 19,5/20 | 20 | | | | | | | |
| *TA1-EVB2* | Offices middle part of Section A+B | Section A&B | | | | | | | | | | 19,5/20 | 20,4 | | | | | | | |
| *TA1-EVB3* | Offices middle part of Section A+B | Section A&B | | | | | | | | | | 19,5/20 | 20,2 | | | | | | | |
| TA1-FF3 | Attic Section A | Section A&B | stepwise control | | | | | 0,2 | | | 0,1 | | | | | | ? | 168,0 | 0,5 | 1 |
| TA1-FF4 | Attic Section B | Section A&B | stepwise control | | | | | 0,2 | | | 0,2 | | | | | | ? | 168,0 | 1,0 | 2 |
| TA2-TF2/FF2 | Offices floor 4, Section A+B | Section A&B | constant speed | 2 | 4 | 1,82 | 3,07 | 1,64 | 3 | 1,08 | 0,57 | 18/21 | 18,7 | | 21,6 | 75 | M-F 6:40-18:00 | 56,5 | 2,0 | 11 |
| *TA2-EVB1* | Offices north part, fl 4 of Section A+B | Section A&B | | | | | | | | | | 17/19,5 | | 21/20 | 22,3 | | | | | |
| *TA2-EVB2* | Offices middle part fl 4 of Section A+B | Section A&B | | | | | | | | | | 17/19,5 | | 21/20 | 22,2 | | | | | |
| TA102- TF102/FF102 | Offices in Section C | Section C | constant speed | 2,1 | 7,5 | 1,38 | 3,67 | 1,4 | 7,5 | 1,58 | 1,7 | 20/20 | 20,2 | | 22,8 | 75 | M-F 6:35-18:00 | 57,0 | 3,4 | 16 |
| *TA102-EVB1* | Offices north part, Section C | Section C | | 7,5 | | | | | | | | 20/20 | 19,9 | | | | | | | |
| *TA102-EVB2* | Offices south part Section C | Section C | | | | | | | | | | 20/20 | 19,7 | | | | | | | |
| TA103- TF103/FF103 | Offices in Section C | Section C | | 2,1 | 7,5 | | 3,43 | 1,4 | 7,5 | | 2,12 | 19,6/20,6 | 21,2 | | 22,3 | 65 | M-F 6:40-18:00 | 56,5 | 2,3 | 16 |
| *TA103-EVB1* | Offices north part, Section C | Section C | | | | | | | | | | 20/20 | 20,9 | | | | | | | |
| *TA103-EVB2* | Offices south part Section C | Section C | | | | | | | | | | 20/20 | 20,8 | | | | | | | |
| FF2 | Attic Section C | Section C | constant speed | | | | | 0,2 | | | 0,2 | | | | | | ? | 168,0 | 1,0 | 2 |
| FF3 | Attic Section C | Section C | constant speed | | | | | 0,2 | | | 0,2 | | | | | | ? | 168,0 | 1,0 | 2 |

The specification of ventilations systems at Högsbo 20:22 buildings (*continues*).

| System / Air handling unit | Area supported | Section | Fan speed control | *Supply air fan* | | | | *Exhaust air fan* | | | | *Supply air* | | *Exhaust air* | | Heat recovery [%] | Operation time | Operation time [h/week] | Estimated SFP [kW/m3/s] | Calculated electrical energy [kWh/yr] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Rated airflow [m3/s] | Rated power [kW] | Measured airflow [m3/s] | Measured power [kW] | Rated airflow [m3/s] | Rated power [kW] | Measured airflow [m3/s] | Measured power [kW] | Set point [C] | Measured [C] | Set point [C] | Measured [C] | | | | | |
| TA104- TA104/FA104 | Offices in Section D | Section D | constant speed | 10,9/12,9 | 22 | | 21,7 | 8,5/9,3 | 15 | | 8,3 | 19,5/20 | 21,5 | | | 60 | M-F 6:40-18:00 | 56,5 | 3,3 | 88 |
| *TA105-TA105/FA105* | Offices in Section D | Section D | constant speed | | 4 | | 3,3 | 3,2 | 5,5 | | 3,32 | | | | | 72 | M-F 6:40-18:00 | 56,5 | | 19 |
| *TA104-EVB1* | Offices north part Section D | Section D | | | | | | | | | | 19,9/20,4 | 21,9 | | 21,5 | | | | | |
| *TA104-EVB2* | Offices middle part Section D | Section D | | | | | | | | | | 19,9/20,4 | 21,9 | | | | | | | |
| *TA104-EVB3* | Offices south part Section D | Section D | | | | | | | | | | 19,9/20,4 | 22 | | | | | | | |
| FF1 | Attic Section D | Section D | constant speed | | | | | 0,2 | | | 0,2 | | | | | | | 168,0 | 1,0 | 2 |
| FF2 | Attic Section D | Section D | constant speed | | | | | 0,2 | | | 0,2 | | | | | | | | 1,0 | 0 |
| FF3 | Stairway A, Section D | Section D | constant speed | | | | | 0,2 | | | 0,2 | | | | | | | | 1,0 | 0,06 |
| FF4 | Stairway B, Section D | Section D | constant speed | | | | | 0,2 | | | 0,2 | | | | | | | | 1,0 | 0,06 |
| FF5 | Stairway C, Section D | Section D | constant speed | | | | | 0,2 | | | 0,2 | | | | | | | | 1,0 | 0,06 |
| TA106-TF1/FF1 | Garage in Section D | Section D | constant speed | 3 | | | 3,5 | 3 | | | 3,5 | | 21,3 | | 21 | | M-F 7:15-8:30; M-F 11:45-12:45 | 11,5 | 2,3 | 4 |

## Specification about the input data used in the new baseline calculations

The following estimates have been made when calculating the new baseline for the property's energy use before the energy measures:

- In Sections A and B the use of the premises will remain unchanged and about 3300 $m^2$ will be rented out in total. The premises on the $4^{th}$ floor will remain vacant.
- In Section C approx 3200 $m^2$ will be rented out in total. Approximately 100 people will be working on about 1250 $m^2$ of premises that are vacant today, with an estimated occupancy rate of 0.7.
- Ventilation airflow rates in Section C will be increased to adapt to new tenants. The basic alternative for the tenant adjustments is to install a new larger ventilation unit with indirect recuperative heat recovery. Technical characteristics of the new unit: Airflow rate 6.2 $m^3/s$; SFP = 2.0 $kW/(m^3/s)$; temperature efficiency of about 50%.
- In Section D, about 5600 $m^2$ will be rented out in total, with the same occupancy profiles that has been estimated previously.
- The average indoor temperatures in all sections: + 21ºC daytime; + 20.5ºC nighttime.

# Appendix 2. Summary of the energy saving measures

Summary of all of the identified measures is given in table B2.1 and presented in Figures B2.1-2.2. Tables B2.2-2.3 present the measures included to the different proposed action packages.

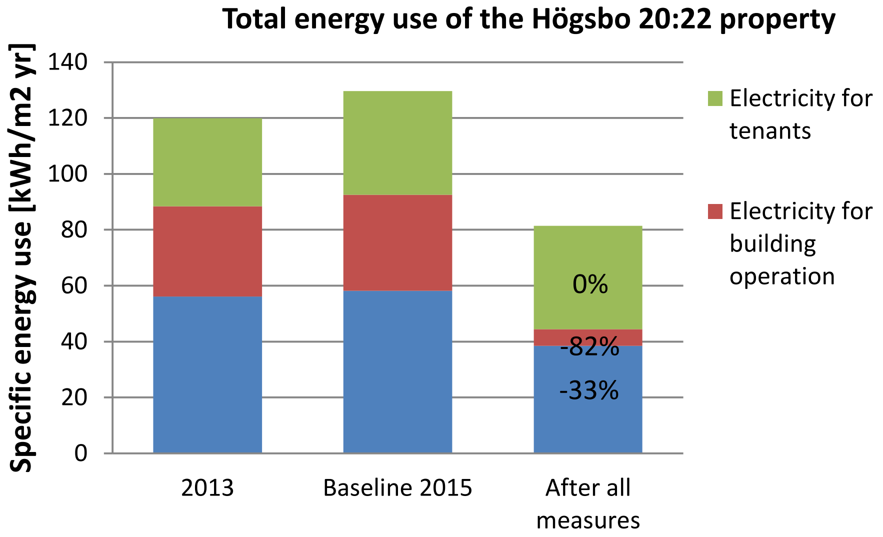


**Figure B2.1** Specific energy use before and after carrying out all of the identified measures for Högsbo 20:22. The heat demand can be reduced by about 33 % and bought electricity for building operation by about 82 % compared to the new baseline.

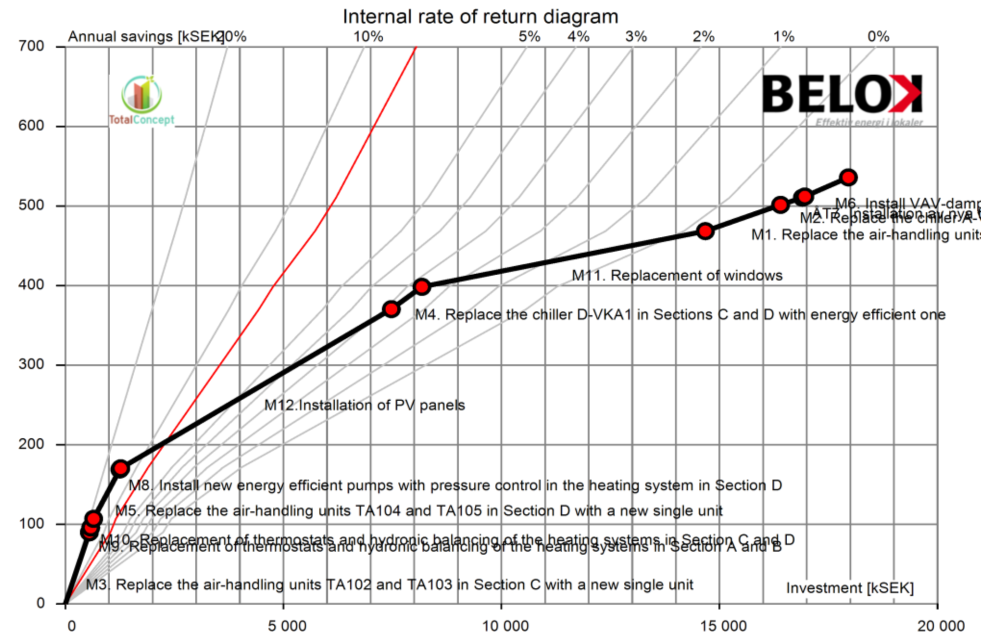


**Figure B2.2.** Profitability of the action package including all of the identified measures presented in an internal rate of return diagram. The property owner´s profitability requirement is 8 % and the estimated relative energy price increase is 2 %. Internal rate of return of the action package is approx -0,75 %.

**Tabell B2.1.** Summary of all of the identified measures, ranked after profitability. Cost savings for *Measure 12* are based on the new energy demand (after all the rest of the measures have been carried out).

| Measure nr | Description of the measure | Heat energy saving | | Electricity saving | | Other saving | Total savings | Investment | Economic calculation period |
|---|---|---|---|---|---|---|---|---|---|
| | | MWh/yr | kSEK/yr | MWh/yr | kSEK/yr | kSEK/yr | kSEK/yr | kSEK | Years |
| 3 | Replace the air-handling units TA102 and TA103 in Section C with a new single unit | 108 | 87 | 7 | 3 | 0 | 90 | 550 | 20 |
| 9 | Replacement of thermostats and hydronic balancing of the heating systems in Section A and B | 10 | 6 | 0 | 0 | 0 | 6 | 32 | 10 |
| 10 | Replacement of thermostats and hydronic balancing of the heating systems in Section C and D | 21 | 11 | 0 | 0 | 0 | 11 | 65 | 10 |
| 5 | Replace the air-handling units TA104 and TA105 in Section D with a | 28 | 30 | 42 | 32 | 0 | 62 | 602 | 20 |
| 8 | Install new energy efficient pumps with pressure control in the heating system in Section D | 0 | 0 | 2 | 1 | 0 | 1,5 | 21 | 15 |
| 4 | Replace the chiller D-VKA1 in Sections C and D and optimizing pump operation | 0 | 0 | 30 | 28 | 0 | 28 | 700 | 20 |
| 7 | Install new energy efficient pumps with pressure control in the heating system in Section A, B and C | 0 | 0 | 2 | 1 | 0 | 1 | 55 | 15 |
| 11 | Replacement of windows | 90 | 55 | 20 | 15 | 0 | 70 | 6500 | 30 |
| 1 | Replace the air-handling units TA1 and TA2 in Section A&B with a new single unit | 13 | 13 | 25 | 20 | 0 | 33 | 1725 | 20 |
| 2 | Replace the chiller A-VKA1 in Sections A and B and optimizing pump operation | 0 | 0 | 7 | 9 | 0 | 9 | 500 | 20 |
| 6 | Install VAV-dampers for different zones in Sections C and D | 16 | 16 | 10 | 8 | 0 | 24 | 1000 | 15 |
| 12 | Installation of PV panels | 0 | 0 | 270 | 224 | -24 | 200 | 6206 | 25 |
| | ***Totalt*** | **286** | **217** | **415** | **343** | | **536** | **17956** | |

**Table B2.2.** Summary of the measures included to the *Action package 1*, ranked after profitability

| Measure nr | Description of the measure | Heat energy saving | | Electricity saving | | Other saving | Total savings | Investment | Economic calculation period |
|---|---|---|---|---|---|---|---|---|---|
| | | MWh/yr | kSEK/yr | MWh/yr | kSEK/yr | kSEK/yr | kSEK/yr | kSEK | Years |
| 3 | Replace the air-handling units TA102 and TA103 in Section C with a new single unit | 108 | 87 | 7 | 3 | 0 | 90 | 550 | 20 |
| 10 | Replacement of thermostats and hydronic balancing of the heating systems in Section C and D | 21 | 11 | 0 | 0 | 0 | 11 | 65 | 10 |
| 5 | Replace the air-handling units TA104 and TA105 in Section D with a new single unit | 28 | 30 | 42 | 32 | 0 | 62 | 602 | 20 |
| 8 | Install new energy efficient pumps with pressure control in the heating system in Section D | 0 | 0 | 2 | 1 | 0 | 1 | 21 | 15 |
| 4 | Replace the chiller D-VKA1 in Sections C and D and optimizing pump operation | 0 | 0 | 30 | 28 | 0 | 28 | 700 | 20 |
| 6 | Install VAV-dampers for different zones in Sections C and D | 16 | 16 | 10 | 8 | 0 | 24 | 1000 | 15 |
| | ***Total*** | **173** | **144** | **91** | **73** | | **217** | **2938** | |

**Table B2.3.** Summary of the measures included to the *Action package 2*, ranked after profitability

| Measure nr | Description of the measure | Heat energy saving | | Electricity saving | | Other saving | Total savings | Investment | Economic calculation period |
|---|---|---|---|---|---|---|---|---|---|
| | | MWh/yr | kSEK/yr | MWh/yr | kSEK/yr | kSEK/yr | kSEK/yr | kSEK | Years |
| 3 | Replace the air-handling units TA102 and TA103 in Section C with a new single unit | 108 | 87 | 7 | 3 | 0 | 90 | 550 | 20 |
| 9 | Replacement of thermostats and hydronic balancing of the heating systems in Section A and B | 10 | 6 | 0 | 0 | 0 | 6 | 31,6 | 10 |
| 10 | Replacement of thermostats and hydronic balancing of the heating systems in Section C and D | 21 | 11 | 0 | 0 | 0 | 11 | 65,4 | 10 |
| 5 | Replace the air-handling units TA104 and TA105 in Section D with a new single unit | 28 | 30 | 42 | 32 | 0 | 62 | 602 | 20 |
| 8 | Install new energy efficient pumps with pressure control in the heating system in Section D | 0 | 0 | 2 | 1 | 0 | 1 | 21 | 15 |
| 4 | Replace the chiller D-VKA1 in Sections C and D and optimizing pump operation | 0 | 0 | 30 | 28 | 0 | 28 | 700 | 20 |
| 7 | Install new energy efficient pumps with pressure control in the heating system in Section A, B and C | 0 | 0 | 2 | 1 | 0 | 1 | 55 | 15 |
| | ***Totalt*** | **167** | **134** | **83** | **66** | | **200** | **2025** | |