Property name: Högsbo 20:22 office
Property owner: Harry Sjögren
Consultants: CIT Energy Management

Total Concept method

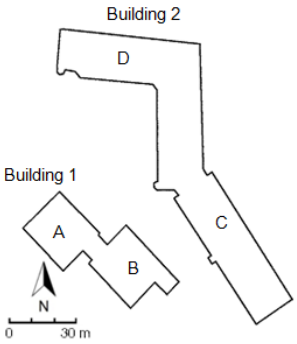
Step 3. Follow-up

Building and its use

Year built: 1982 (A, B, C): 1986 (D)
Area: 14543 m² Heated area
Type of building: Office building

The Högsbo 20:22 property is locating in Gothenburg and consists of two office buildings divided into four building sections: A, B, C and D. Sections A and B are part of Building 1 and Sections C and D are part of Building 2. All of the building sections have four floors and incorporate mainly office rooms, but there are also some storage rooms on the ground floor. There is a lunch restaurant (ca 325 m²) in Section B, open from 11:00-13:30 during working days and has ca 190 places in total. Section D has an underground garage.

About 60-70 % out of the total heated area (A_{temp}) of the property was rented out before the renovation in 2013-2014. In average there were approx 170 persons working in the buildings during normal occupancy hours, from 8:00 to 18:00 from Monday to Friday. The aim of the property owner was to decrease the vacancy level to 15%, which was used as a new baseline for calculations. The main objective of the renovation in Högsbo 20:22 was to incorporate energy performance improvements to the general upgrade of the building for upcoming tenant adjustments in Building sections C and D.



Indoor climate

Indoor climate requirements set for the office premises are the same as commonly set for the office environment in Sweden: minimum room temperature winter time +21°C and summer time +23°C; minimum airflow rates 7 l/s per person + 0,35 l/s m². Before the renovation some office areas were experienced to be too cold winter time and in some zones even summer temperatures.

Room temperatures were monitored both in Section C and Section D during the monitoring period in Step 3 (Oct 2015 - Sept 2016). The monitoring results show that indoor climate requirements are generally met. Mean indoor temperatures during winter time were about +21°C in Section C. However, in Section D winter temperatures were somewhat higher than required and as estimated in the calculations in Step 1 and 2. The mean temperatures were about +22.4°C. Mean summer temperature in Section C was somewhat lower than estimated, about +21.6°C. In Section D the mean room temperatures in summer time were +23.3°C.

The status of the building and its technical systems before measures

Building envelope

The building envelope is in a rather good condition. Both of the buildings are similar in construction: the frame is set on concrete pillars and the floor frames are made of concrete structure. The ground floor facade consists of concrete, insulation and brick wall outside. Estimated total U-value is ca 0,26 W/m^{2}K. The upper facades are made of light construction with the metal sheet outside and have estimated total U-value is ca 0,24 W/m^{2}K. The buildings have flat roofs made of concrete structure (insulation ca 250 mm). Majority of the windows are triple pane wooden windows (U-value is ca 2.0 W/m^{2}K). All windows are original, from 80ies, except for part of the lunch restaurant section.

Heating

The buildings have district heating, distributed via two substations: one locating in Section A, supporting sections A, B and C and one locating in Section D, supporting only Section D. The rooms are heated via 1-pipe radiator system. Distribution pumps are from 80ies as well as most of the radiator thermostats. The radiators are functioning poorly, especially in Section D and are step-by-step replaced with new ones when premises are renovated for the new tenants. The primary side of the heating systems was balanced in 2012, no hydronic balancing has been made in the radiator circuits. The garage has air heaters with recirculation air, operating only during the extreme cold weather.

Ventilation

There are totally 8 air handling units installed. The units for the office areas operate from 6:40 to 18:00 M-F and the unit for the lunch restaurant from 6:40 to 14:00 M-F. Majority of the units are from the 80-ies and show signs of wear. All ventilation units have heat recovery, whereas four units have regenerative heat exchangers (temperature efficiency varying 63 % - 75 %) and other units use return air for heat recovery (temperature efficiency 63 % - 75 %). All office systems are equipped with after heating and/or after cooling coils on the main ducts. The supply air temperatures are varying in between +19.5 °C to +20.5 °C at outdoor temperatures of +20°C to -20°C. The ventilation systems have quite high SFP values, for some systems up to 4.0 kW/(m^3/s). All offices premises are ventilated with constant air volume flow (CAV). Total airflow rate 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. The airflows in Section C needs to be increased to adapt to the new tenants.

Cooling

About 75 % of the office premises have hydronic comfort cooling system with chilled beams. Chilled water is produced with two chillers locating on the roofs of Section A and D. The chillers are from 1995, estimated COP value 2.5. The chiller for Sections C and D has problems with compressors, which need to be replaced. Cooling system in Section D and C is in operation all year around, due some server rooms that are connected to the central cooling system.

Lighting

FTL lighting fixtures with T5 and T8 tubes are installed in the buildings. Most of the office areas have modern lighting, installed during recent years. In the common areas low energy light bulbs are installed. All lighting is manually controlled, except in the garage (occupancy sensors) and outdoor lighting (astronomical clock).

Equipment

There is standard office equipment used in the premises. Each tenant has a separate kitchenette. Lunch restaurant has typical restaurant kitchen equipment (frying plates, ovens, blenders, etc) for preparing food on site.

Control and monitoring system(s)

All of the technical systems are connected to the central building management system from KTC, installed in 2007.

Other systems

Domestic hot water is produced by district heating via separate heat exchangers.

Energy and resource use before renovation and baseline for energy savings

	Measured before	*Baseline*
Total specific energy use before measures	121 kWh/m^2,yr	128 kWh/m^2,yr
Whereas,		
Heat energy	57 kWh/m^2,yr	58 kWh/m^2,yr
Electricity for building operation	33 kWh/m^2,yr	34 kWh/m^2,yr
Electricity for tenants	31 kWh/m^2,yr	36 kWh/m^2,yr

Based on measured data in 2013-2014 the total specific energy use for the Högsbo 20:22 property was 90 kWh/m² yr excl. tenants (corrected to normal year) and 121 kWh/m² yr incl. tenants. This is rather low energy use compared to other similar office buildings in Sweden and can be explained by the relatively high vacancy level in the buildings and low occupancy rate in the used premises. Since a number of tenant adjustments were planned in Section C as part of the renovations a new baseline for the property's energy use was calculated by using the calibrated energy simulation model. Establishing of a new baseline was needed for assessing correctly the potential with the identified energy efficiency measures. Due to planned tenant adjustments the energy use of the building was estimated to increase about 5 %, to about 128 kWh/m^2 yr (new baseline). This is due to increased use of tenant´s electricity, increased cooling demand and increased ventilation airflow rates.

Identified energy saving measures

Since the Högsbo 20:22 property already has rather low energy use, more extensive measures will be required to decrease the energy use even more. Twelve energy saving measures were identified during the auditing, whereas six measures were included to the proposed action package in Step 1. The proposed action package for improving energy efficiency in the buildings included measures for Sections C and D, as these sections were prioritized first due to upcoming renovation for the tenant adjustments. Several proposed measures contribute also to reduction in power demand and reduced power costs. In the calculations only part of the investment cost was included to the costs for energy efficiency improvements since a number of measures are carried out also for maintenance reasons.

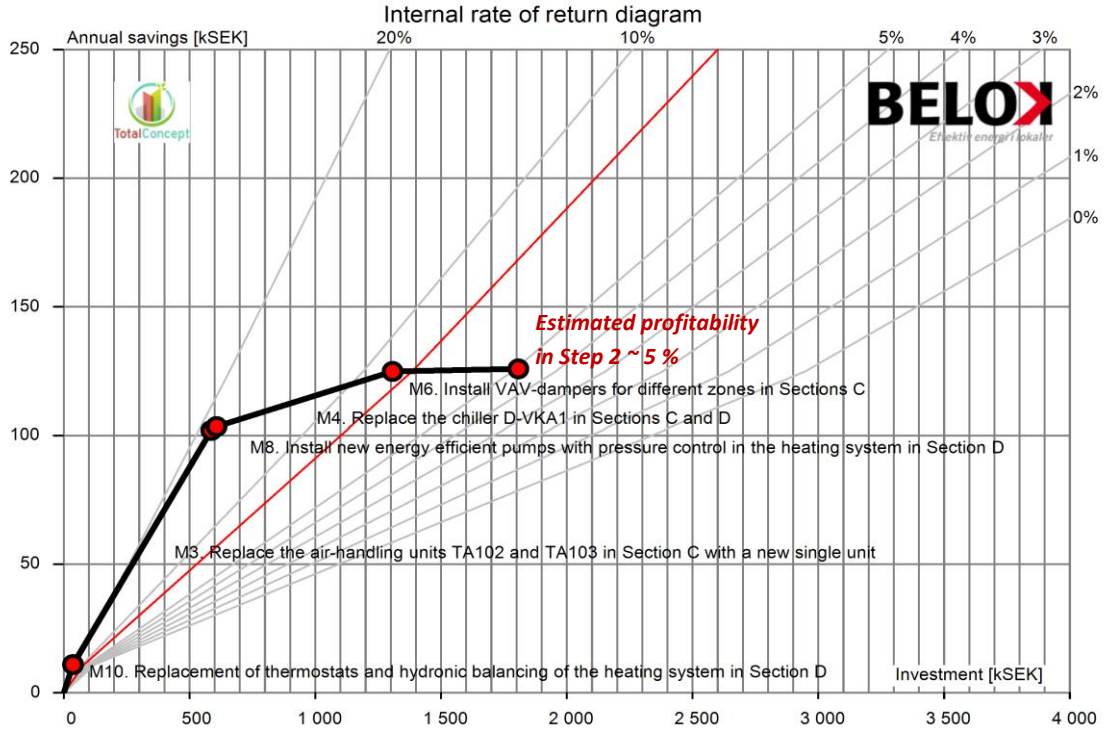
It is proposed to replace the existing air-handling units with more energy efficient ones. Also, installing VAV-dampers on the main ducts connecting the different zones in Sections C and D is suggested to minimize the airflow rates in unoccupied spaces. Additionally, replacement of chillers and optimizing the pump operation in the cooling system is proposed. In the heating systems new thermostats on the radiators and hydronic balancing of the entire system is recommended as well as installation of energy efficient pumps with pressure control.

Summary of the measures carried out in the action package

A number of adjustments were made to the action package in Step 2. Measures 3 (*Replace the units 102 and 103 in Section C*), Measure 4 (*Replace the chiller in Sections C and D*) and Measure 8 (*New pumps in the heating system in Section D*) has been carried out as planned. Measure 6 (*Install VAV-dampers to ventilation in Sections C and D*) was carried out in Section C only and Measure 10 (*Hydronic balancing of the heating system in Sections C and D*) was carried out in Section D only. Measure 5 will be carried out in the future. Calculated total energy and cost saving potential and profitability of the action package carried out in Step 2 compared to the proposal in Step 1 are presented in the table below.

According the adjusted action package in Step 2 the calculations show that the despite the tenant adjustments the energy efficiency improvement action package will result the same total energy use as before measures, about 120 kWh/m^2 yr. The estimated energy use for building operations (excl. tenants' electricity) will be about 9 % lower compared to the measured values before and will be about 84 kWh/m^2 yr. Annual district heating use can be reduced by about 11% and electricity use by about 7% compared to the new baseline. Total annual costs savings will be about 125 kSEK/yr. The total saving potential with the updated action package is about 7% based on the new baseline. The proposed action package in Step 1 would have led to total savings approx. 14% compared to the new baseline.

	Measure	Step 1			Step 2		
		Investment cost kSEK	Cost saving kSEK/yr	Total energy saving MWh/yr	Investment cost kSEK	Cost saving kSEK/yr	Total energy saving MWh/yr
1	M3. Replace the air-handling units TA102 and TA103 in Section C with a new single unit	550	90	115	550	91	80
2	M10. Replacement of thermostats and hydronic balancing of the heating systems in Sections C and D	65	11	21	37	10	18
3	M5. Replace the air-handling units TA104 and TA105 in Section D with a new single unit	602	62	70	-	-	-
4	M8. Install new energy efficient pumps with pressure control in the heating system in Section D	21	1	2	21	1,5	2
5	M4. Replace the chiller D-VKA1 in Sections C and D with energy efficient one	700	28	30	700	21	26
6	M6. Install VAV-dampers for different zones in Sections C and D	1000	24	26	500	1	1
	Sum	2938	217	264	1807	125	127

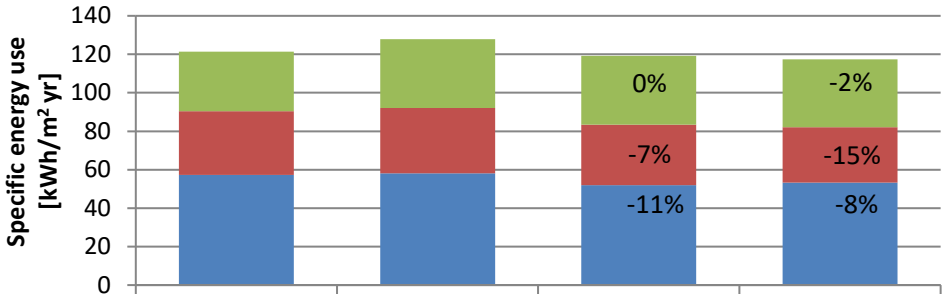


The internal rate of return of the updated action package in Step 2 is 4.8 %, which is somewhat lower than the property owner's profitability demand. This is due to the fact that the last measure in the action package (M6) is exceeding the profitability line, but was included to the package as it was planned to be carried out by the property owner anyway. The calculated profitability of the proposed action package in Step 1 was about 5.5 %. The estimated relative energy price increase 2 % is taken into account in the calculations.

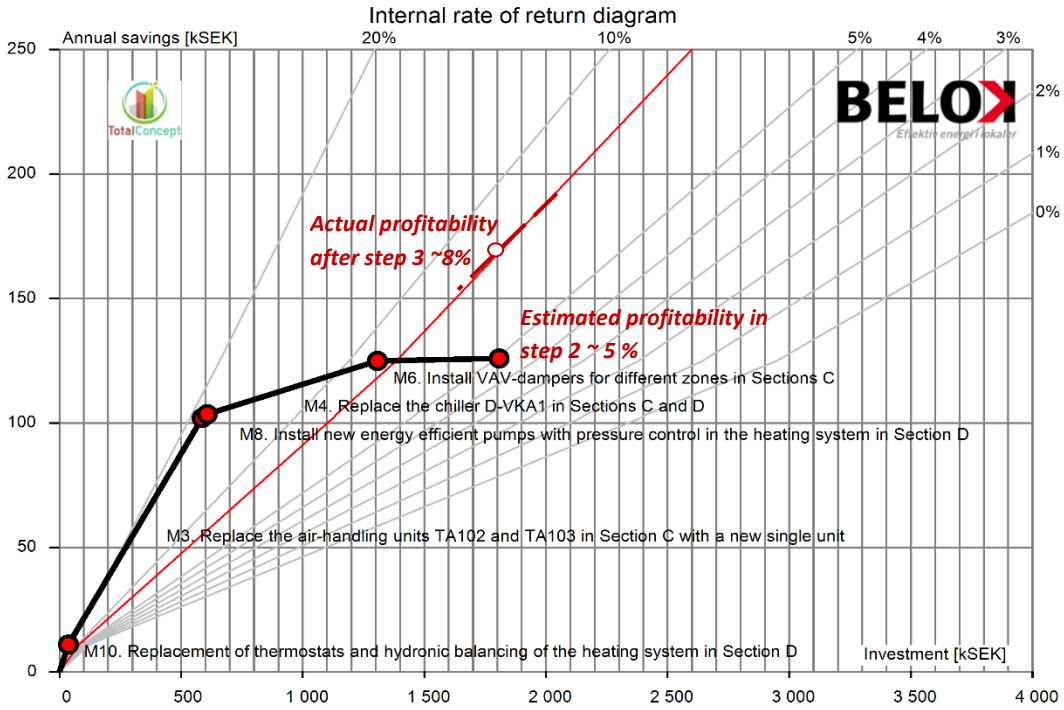
Summary of the outcome of measurement and follow-up in Step 3

The proposed measures were implemented (Step 2) in spring-summer 2015. Measurements and follow-up (Step 3) was carried out from October 2015 until September 2016. According to the measurement outcomes of Step 3 the action package decreased the total energy use of the building about 8 % compared to the new baseline and about 3 % compared to the energy use before renovation. The total specific energy use of the Högsbo 20:22 property after renovations is about 117 kWh/m^2 per year. The energy use for building operation (BBR) is about 82 kWh/m^2 per year, which is 11 % lower compared to the baseline and about 9% lower compared to measured energy use before renovation. The measured outcomes are mostly in accordance with the estimations done in Step 2. The total electricity use was slightly lower compared to the estimation done in Step 2, which can be accounted for by more energy efficient chiller and cooling system pumps installed in the cooling system for Sections C and D.

Total energy use of the Högsbo 20:22 property



	measured 2013-2014	Baseline 2015	Step 2 (calculated)	Step 3 (measured)
Electricity for tenants	31	36	36	35
Electricity for building operation	33	34	31	29
District heating	57	58	52	53



The actual profitability of the action package carried out in Step 2 is about 8 %, which is in accordance with the property owner's profitability demand. Total annual costs savings are about 169 kSEK/yr based on the estimated baseline and about 116 kSEK/yr based on the measured energy use before renovation.