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Högsbo 20:22

Energy efficiency improvements according to the Total Concept method

STEP 3 – MEASUREMENT AND FOLLOW-UP

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Version: Final

Date: 2017-02-28

This document has been developed 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. Contract number: IEE/13/613/SI2.675832

Project webpage: www.totalconcept.info

February 2017

Co-funded by the Intelligent Energy Europe Programme of the European Union

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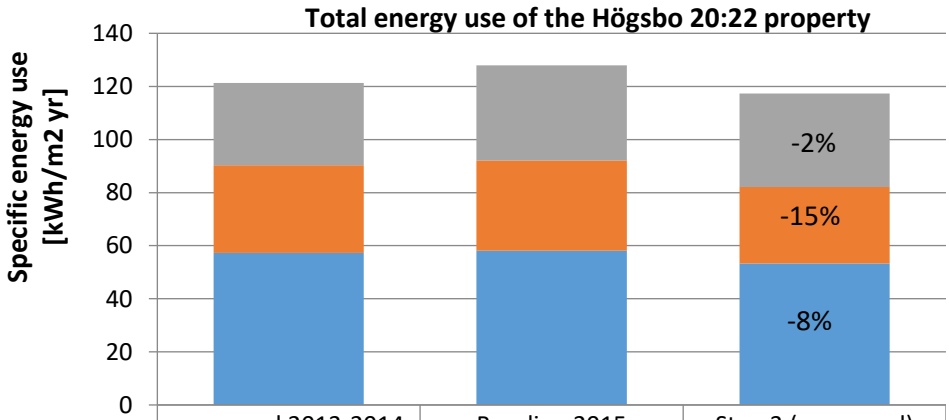
SUMMARY

An action package with five energy efficiency improvement measures based on the Total Concept method has been carried out in Högsbo 20:22 office building as part of the general upgrade of the building. Due to planned tenant adjustments in one of the building sections 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.

With the formed action package the total building energy use was estimated to decrease about 7 % compared to the new baseline. The measurement and follow-up in Step 3 shows the savings to be about 8 %. The total specific energy use of the Högsbo 20:22 property after renovations is about 117 kWh/m^2 per year. The total specific energy use for building operations (excl. tenants' electricity) decreased about 11 % compared to the baseline and is about 82 kWh/m^2 per year.

The measurement outcomes in Step 3 compared to estimated baseline in Step 1 are presented in Figure 1.



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

***Figure 1**. Specific energy use before and after carrying out the energy efficiency measures in the action package for Högsbo 20:22 office building. Energy savings are based on the new baseline for the energy performance of the building.*

The estimated profitability of the action package in Step 2 was about 5 %.The calculated actual profitability of the action package in Step 3 is about 8 % and fulfils property owners profitability demands. The action package resulted in annual savings about 169 tkr/year and required an investment about 1807 tkr.

BACKGROUND

This report presents the outcomes of the energy efficiency improvements in Högsbo 20:22 office building based on the Total Concept method. 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. This project is part of an international project *"The Total Concept method for major reduction of energy use in non-residential buildings",* supported by Intelligent Energy Europe Programme.

Step 1 of the Total Concept method (forming an action package) was carried out in the buildings in autumn 2014 and the proposed measures were implemented (Step 2) in spring-summer 2015. Measurements and follow-up (Step 3) has been carried out from **October 2015 until September 2016**. The following persons have been involved in the measurements and follow-up work in Step 3 of the Total Concept method:

Participant	**Contact**
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Installation of meters and sensors by Harry Sjögren AB. Data reading from meters and sensors by Harry Sjögren AB and CIT Energy Management. Collection and analysis of data by CIT Energy Management. Follow-up of costs in Step 2 has been done by Harry Sjögren AB.

Deviations from the measurement plan

Measurements and follow-up work in Step 3 has been carried out in accordance to the measurement and follow up plan made in Step 2. The existing energy meters and sensors were primarily used for monitoring the energy use of the buildings. However, the heat meter for Section C has not been functioning properly during the measurement period and unfortunately it was not possible to replace it. Therefore the measurement of district heating use in Section C has not been reported separately. The results are presented separately for Sections A,B,C and Sections D.

New sub-meters were installed for the new air handling unit in Section C and for the chiller and cooling system pumps in Sections C and D. The electricity meter for chiller was installed in spring 2016. Therefore only about 8 months monitoring has been possible.

MEASURES CARRIED OUT IN STEP 2

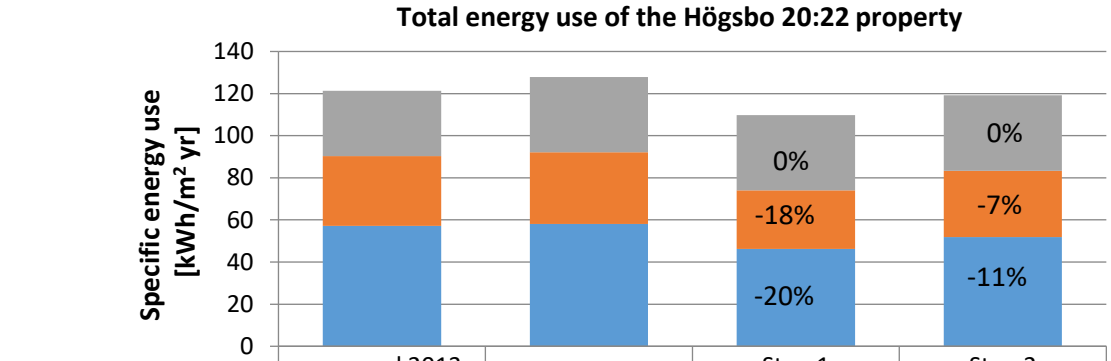
The proposed action package in Step 1 is summarized in appendix 1. The action package contained 6 energy saving measures for building Sections C and D, which were planned to be carried out as part of the upcoming renovation for the tenant adjustments. A number of adjustments were made to the action package in Step 2. The changes included the following:

- *Measure 3* (Replace the units 102 and 103 in Section C) has been carried out as planned.
- *Measure 4* (Replace the chiller in Sections C and D) has been carried out as planned.
- *Measure 5* (Replace the units 104 and 105 in Section D) will probably be implemented during 2017.
- *Measure 6* (Install VAV-dampers to ventilation in Sections C and D) have only been implemented in Section C.
- *Measure 8* (New pumps in the heating system in Section D) has been carried out as planned.
- *Measure 10* (Hydronic balancing of the heating system in Sections C and D) has been implemented in Section D. Section C is on hold until further notice.

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 Tables 1 and figure 2.

***Table 1**. Summary of the action package for the Högsbo 20_22 office buildings in Step 1 and Step 2. Presented savings are compared to the new baseline.*

	Step 1	**Step 2**
Total annual energy savings:	14 %	7 %
Total annual energy savings for building operations (BBR):	20 %	9 %
Calculated energy savings – district heating:	173 MWh/yr	90 MWh/yr
Calculated power savings – district heating:	103 kW	79 kW
Calculated energy savings – electricity:	91 MWh/yr	37 MWh/yr
Calculated power savings – electricity:	46 kW	50 kW
Total annual cost savings:	217 kSEK/yr	125 kSEK/yr
Energy investment cost:	2938 kSEK (28%)	1807 kSEK
Internal rate of return for the package:	5,5 %	4,8%



	measured 2013-2014	Baseline 2015	Step 1 (calculated)	Step 2 (calculated)
Electricity for tenants	31	36	36	36
Electricity for building operation	33	34	28	31
District heating	57	58	46	52

***Figure 2**. Specific energy use before and after carrying out the energy efficiency measures in the action package for Högsbo 20:22 office building in Step 1 and Step 2. Energy saving potential is estimated based on the new baseline for the energy performance of the building.*

Total measured energy use before renovations was 121 kWh/m^2 yr (including tenants' electricity). Due to planned tenant adjustments in Section C the energy use of the building was estimated to increase to about 128 kWh/m^2 yr. This was set as a new baseline for energy efficiency measures.

According the adjusted action package in Step 2 the calculations show that the action package will result the same total energy use as before measures, about 119 kWh/m^2 yr. However, 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 83 kWh/m^2 yr. Total saving potential with the action package will be about 7 % based on the new baseline.

The design values and measured values for technical systems and components included to the action package in Step 2 are shown in appendix 2.

RESULTS OF MEASUREMENTS AND FOLLOW-UP IN STEP 3

The use of the building and operation of the technical systems after renovation

The Högsbo 20:22 property consists of two office buildings divided into four building sections: A, B, C and D. According to the planned tenant adjustments empty premises in Section C was planned to be rented out in 2015. This was used as input for baseline calculations.

The use of the building, internal loads from the people, lighting and equipment has been followed up and is in accordance to the planned use of the building in Step 1 and Step 2.

Operating times and control set point values of the different systems and components were monitored continuously during the measurement period. No major changes has been indicated compared to the estimations done in Step 1 and Step 2.

Indoor climate

Room temperatures were monitored both in Section C and Section D during the monitoring period. The outcomes are summarized in Table 2 below. The measured values are compared with the input data used in energy calculations in Step 1 and Step 2.

Property owner´s indoor temperature requirements set for the office premises are: winter time +21°C and summer time +23°C. The monitoring results show that these requirements are met. However, the indoor temperatures during winter time in Section D were somewhat higher than required and as estimated in the calculations. Section C had somewhat lower indoor temperatures at summer time compared to the estimation.

Table 2. Measured room temperatures in the Högsbo 20:22 property during the measurement period in Step 3. The outcomes are compared with the estimations done in Step 1 and 2.

	Energy calculations Step 1 and Step 2			Measured in Step 3	
	Section A,B	**Section C**	**Section D**	**Section C**	**Section D**
Min indoor temperature day (heating)	21	21	21	21,1	22,4
Min indoor temperature night (heating)	20,5	20,5	20,5	21,1	22,6
Set point comfort cooling day	23	22,8	22,8	21,6	23,3
Set point comfort cooling night	23	23	23	21,8	23,4
Max indoor temperature day	24	24	24	24,4	27,0
Max indoor temperature night	24	24	24	24,4	27,6

Building energy use after renovations

Figures 3 and 4 below show of the measured total district heating use and total electricity use for building operation in the Högsbo 20:22 property (all building sections) during the period of October 2015 to November 2016. The monthly values for district heating use are corrected to normal year. The values are compared to the measured energy use before renovation (mean for 2013-2014) and calculated values for after renovation (Step 2). Also measured outdoor temperature and outdoor temperature used in the calculations is presented for comparison.

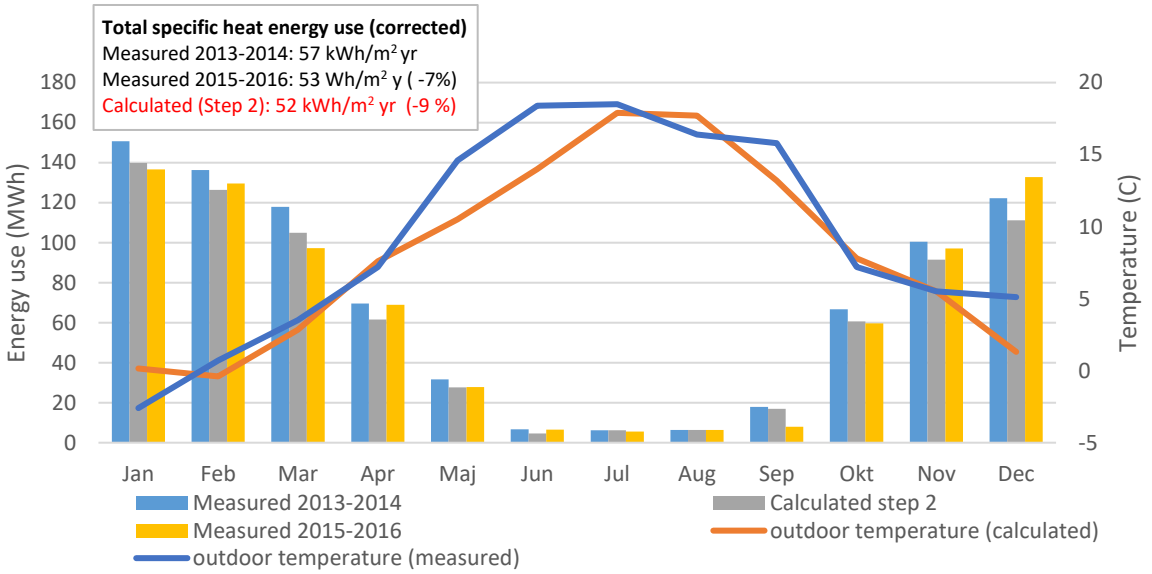


***Figure 3**. Measured total heat energy use (district heating) in the Högsbo 20:22 property compared to calculated values (Step 2). The monthly values have been corrected to normal year.*

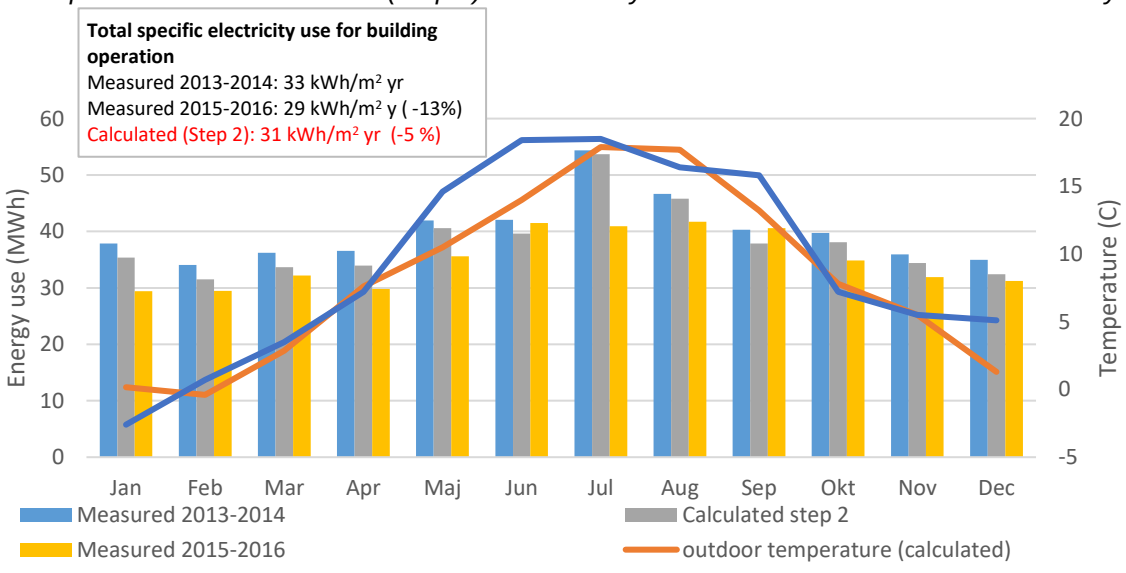


***Figure 4**. Measured total electricity use for building operation in the Högsbo 20:22 property compared to calculated values (Step 2).*

More detailed measurement outcomes from Step 3 are summarized in table 3 below and presented in Appendix 3. The measurement outcomes are compared with calculated values in Step 2 and measured energy use before renovation.

Table 3. Measured energy use for building operation in the Högsbo 20:22 property in Step 3 compared to the Step 1 and 2 outcomes.

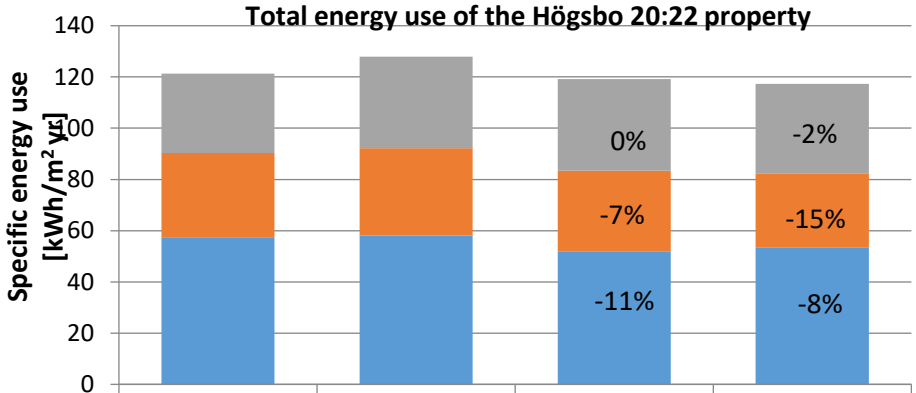
		Before	Step 2		Step 3	
Energy type	Unit	Measured 2013-2014 (mean)	Calculated	*Diff. measured Step 1*	Measured 2015-2016	*Diff. measured Step 1*
Total district heating use (corrected)	MWh	833	755	*-9%*	776	*-7%*
Sections A, B, C	MWh	*441*	*383*	*-13%*	*398*	*-10%*
Sections D	MWh	*391*	*372*	*-5%*	*378*	*-3%*
Total electricity for building operation	MWh	481	458	*-5%*	419	*-13%*
Sections A, B	MWh	*106*	*105*	*0%*	*103*	*-3%*
Sections C	MWh	*81*	*81*	*0%*	*77*	*-5%*
Sections D	MWh	*294*	*272*	*-7%*	*239*	*-19%*
Total annual energy use (excl tenants)	**MWh**	**1314**	**1213**	***-8%***	**1195**	***-9%***
Total annual energy use (excl tenants)	**kWh/m²yr**	**90**	**83**	***-8%***	**82**	***-9%***
Total electricity use for tenants	MWh	451	520	*+15%*	512	*+14%*
Total annual energy use (incl. tenants)	**MWh**	**1765**	**1733**	***-2%***	**1707**	***-3%***
Total annual energy use (incl. tenants)	**kWh/m²yr**	**121**	**119**	***-2%***	**117**	***-3%***

According to the measurement outcomes of Step 3 the total specific energy use of the Högsbo 20:22 property after renovations is about 117 kWh/m^2 per year. The outcomes are mostly in accordance with the estimations done in Step 2. The total heat energy use after renovations is about 53 kWh/m^2 per year. The estimation in Step 2 was about 52 kWh/m^2 per year. Minor deviations can be connected to the slight deviations in the indoor temperatures in some sections.

The total electricity use for building operation was 29 kWh/m^2 per year, which was slightly lower compared to the estimation done in Step 2, 31 kWh/m^2 per year. Somewhat higher savings achieved can be accounted for by more energy efficient chiller and cooling system pumps installed in the cooling system for Sections C and D.

The total electricity use for tenants was 35 kWh/m^2 per year during the measurement period. The estimation made in Step 2 was about 36 kWh/m^2 per year.

Figure 5 presents the measurement outcomes compared to estimated baseline in Step 1 and calculated values in Step 2.



	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

***Figure 5**. Specific energy use before and after carrying out the energy efficiency measures in the action package for Högsbo 20:22 office building. Energy saving are based on the new baseline for the energy performance of the building.*

Due to tenant adjustments in Section C the total energy use of the building was estimated to increase about 5 % due to higher occupancy rate and due to new ventilation unit with increased design airflow rates. However, with the action package carried in Step 2 the total building energy use was estimated to decrease about 7 % compared to the new baseline and about 2 % compared to the energy use before renovation. The measured outcomes in Step 3 show the savings to be about 8 % and 3 % respectively. The energy use for building operation (BBR) decreased about 11 % compared to the baseline and about 9 % compared to measured energy use before renovation.

This means that regardless the increased occupancy and tenant adjustments (increased cooling load and ventilation air flow rates) the energy efficiency measures lead to decreased energy use of the building.

Power savings

According to the measured hourly values for district heating and electricity use for building operation the total power demand has decreased by about 52 kW for heating and about 9 kW for electricity (annual mean power demand) in comparison with the measured values before the renovation. Compared to the estimated new baseline the power demand has decreased by about 86 kW for heating and about 38 kW of electricity. Estimated power savings for district heating is based on the average of the three highest power demand during the measurement period January 2016 - September 2016. Estimated power savings for electricity is based on the highest measured power demand during each month between October 2016 - September 2016.

Measurement and follow-up of the technical systems

According to *Measure 3* the existing ventilation units in Section C were replaced with a single unit LB03 with a built-in heat pump for supply air heating and cooling. The new unit has also higher design airflow rates in order to accommodate the increased occupancy in Section C. Additionally, according to *Measure 6* VAV-dampers were installed in Section C to vary the airflow rates in the rooms when not occupied.

In Step 2 new sub-meters were installed for the new air handling unit in Section C in order to follow up the performance of the unit. The outcomes of the measurements are summarized in the table 4 below.

Table 4. Measured airflow rates and energy performance of the air-handling unit LB03 installed in Section C. The measurement results are compared to the before renovation and Step 2 outcomes.

	Before renovation		After renovation	
	Measured/ estimated	**Baseline (calculated)**	**Calculated**	**Measured**
Max supply airflow rate (m3/s)	4,1	6,2	4,8	4,8
Max exhaust airflow rate (m3/s)	2,8	6,2	5,1	5,6
Mean supply airflow rate (m3/s)	3,4	6,2	4,3	4,5
Mean exhaust airflow rate (m3/s)	3,0	6,2	4,8	5,1
SFP (kW/(m3/s)	2,8	2,0	2,0	2,1
Heat recovery efficiency %	75	50	78,0	>78
Heat energy use (kWh/yr)	25000	72000	2400*	4263*
Cooling energy (Electricity) (kWh/yr)	1700	6000		
Electricity for fans (kWh/yr)	32000	37000	26000	28582
Total energy use (kWh/yr)	***58700***	***115 000***	***28400***	***32845***

** electricity for heat pump*

According to the follow-up in Step 3, the air handling unit was using more energy than estimated in Step 2. This is partly due to the higher airflow rates than calculated. The mean airflow rates during operation time were higher than expected. Also, the heat pump performance was lower than calculated.

During the follow-up in Step 3 also the new chiller performance (*Measure 4*) was monitored separately. New sub-meters were installed for the chiller KM1 and cooling system pumps in Sections C and D. However, the electricity meter for the chiller KM1 was installed in spring 2016. Therefore only about 8 months monitoring has been possible. The outcomes of the measurements are summarized in table 5 below.

Table 5. Measured energy performance of the chiller KM1 in Section D and cooling system pumps KB1 and KB2. The measurement results are compared to the before renovation and Step 2 outcomes.

	Before renovation (calculated)	Step 2 (Calculated)	Measured Step 3
Chiller KM1 compressor operation time (hours)	8760	6260	1413
Chiller KM1 cooling energy produced (kWh/yr)	241500	144000	863
Chiller KM1 electrical energy use (kWh/yr)	80500	57600	37869*
Section C KB1 pump operation time (h)	8760	6260	2921
Section C KB1 pump energy use (kWh/yr)	9500	6700	1091
Section D KB2 pump operation time (h)	8760	6260	3161
Section D KB2 pump energy use (kWh/yr)	9500	6700	2286

** measured 8 months, from feb 2016- sept 2016*

Since the new installed chiller has a free cooling function then the compressor operation times were rather low. However, the outcomes from the energy meter measuring the cooling energy produced by the chiller did not show any reliable result. The inaccuracy of the measurement of the energy meter is strongly influenced by the temperature difference on the secondary side. The inaccuracy is increasing considerably when the difference between the return and supply water temperature is low, which has occurred during the times of low demand.

It is strongly recommended to check the possibilities to optimize the cooling system operation in order to increase the temperature difference.

PROFITABILITY RESULTS OF THE ACTION PACKAGE

For assessing the actual outcomes of the Total Concept project the figures from the measured energy use in Step 3 and the approved final costs for the action package from Step 2 are used. Control of energy prices and power tariffs has been made for the calculation of the annual cost savings. The energy prices are shown in Appendix 1.

The actual profitability outcome is calculated in the form of internal rate of return for the whole action package. This is then compared with the internal rate of return calculated in Step 2. The outcomes are summarized in the table 7 and presented on the figure 6 below.

The diagram on figure 6 shows the calculated profitability for the action package in Step 2 together with the true profitability that was calculated after Step 3. The calculated profitability for the package in Step 2 was 4,8 %. The actual profitability based on the outcomes in Step 3 is about 8 %, which is in accordance with property owners profitability demands.

***Table 7**. Summary of the outcomes of the action package carried out in Högsbo 20:22 office buildings. Presented savings are compared to the new baseline.*

	Compared to baseline	Compared to measured before
Total annual energy savings:	8 %	3 %
Total annual energy savings for building operations (BBR):	11 %	9 %
Calculated energy savings – district heating:	70 MWh/yr	57 MWh/yr
Calculated power savings – district heating:	86 kW	52 kW
Calculated energy savings – electricity:	75 MWh/yr	62 MWh/yr
Calculated power savings – electricity:	38 kW	9 kW
Total annual cost savings:	169 kSEK/yr	116 kSEK/yr
Energy investment cost:	1807 kSEK	-
Internal rate of return for the package:	8 %	-

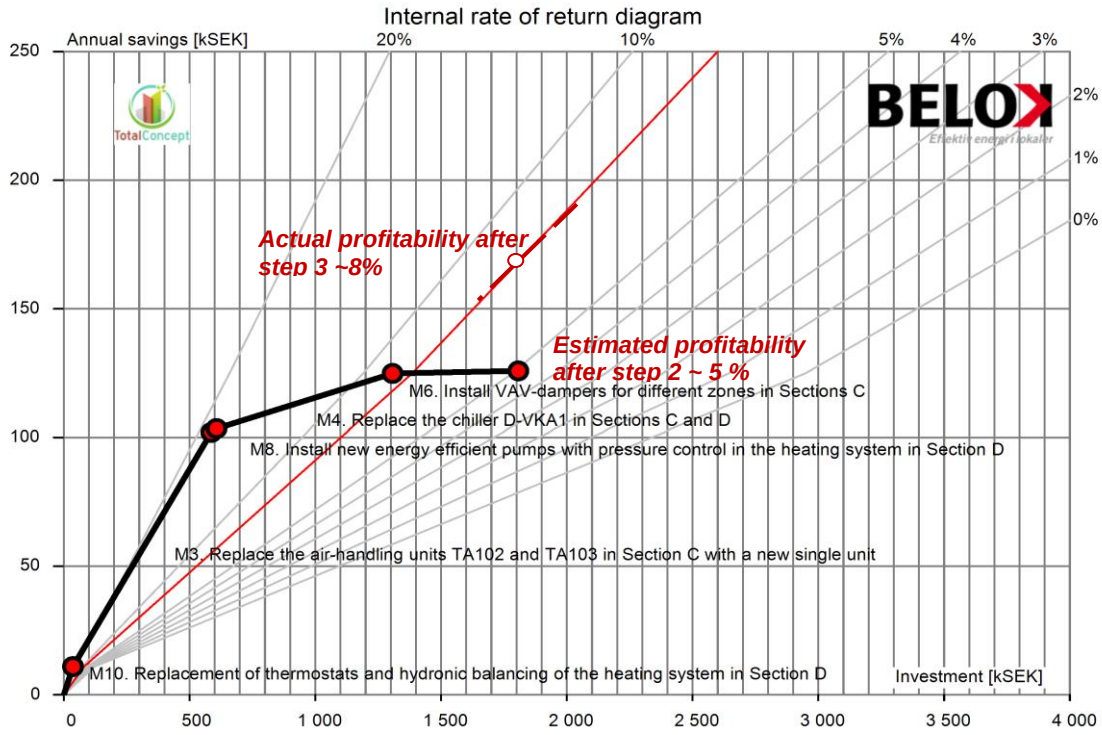


***Figure 6**. Outcomes of the profitability of the action package carried out in the Högsbo 20:22 office building presented in an internal rate of return diagram. Actual internal rate of return for the action package is approx. 8 %.*

APPENDIX 1. OVERVIEW OF THE ACTION PACKAGE IN STEP 1 AND STEP 2

Table B1.1. Summary of the measures included to the *Action package* in Step 1

Action package from Step 1

No	Description of the measure	Heat energy saving			Electricity saving			Other saving	Total savings	Invest-ment	Economic calculation period
		MWh/yr	kW	kSEK/yr	MWh/yr	kW	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	60	87	7	0	3	0	90	550	20
10	Replacement of thermostats and hydronic balancing of the heating systems in Section C and	21	4	11	0	0	0	0	11	65	10
5	Replace the air-handling units TA104 and TA105 in Section D with a new single unit	28	26	30	42	14	32	0	62	602	20
8	Install new energy efficient pumps with pressure control in the heating system in Section D	0	0	0	2	0	1	0	1	21	15
4	Replace the chiller D-VKA1 in Sections C and D and optimizing pump operation	0	0	0	30	22	28	0	28	700	20
6	Install VAV-dampers for different zones in Sections C and D	16	13	16	10	10	8	0	24	1000	15
	Total	**173**	**103**	**144**	**91**	**46**	**73**	**0**	**217**	**2938**	

Table B1.2. Summary of the measures included to the *Action package* in Step 2

No	Description of the measure	Heat energy saving			Electricity saving			Other saving	Total savings	Invest-ment	Economic calculation period
		MWh/yr	kW	kSEK/yr	MWh/yr	kW	kSEK/yr	kSEK/yr	kSEK/yr	kSEK	Years
3	Replace the air-handling units TA102 and TA103 in Section C	72	75	82	8	28	9	0	91	550	20
10	Replacement of thermostats and hydronic balancing of the	18	4	10	0	0	0	0	10	37	10
8	Install new energy efficient pumps with pressure control in the heating system in Section D	0	0	0	2	0	1,5	0	1,5	21	15
4	Replace the chiller D-VKA1 in Sections C and D and optimizing	0	0	0	26	20	21	0	21	700	20
6	Install VAV-dampers for different zones in Sections C	0	0	0	1	2	1	0	1	500	15
	Total	**90**	**79**	**92**	**37**	**50**	**32**	**0**	**125**	**1807**	

Following input data has been used for profitability calculations in Step 1 and in Step 3:

Energy and power tariffs	**Step 1[1)]**	**Step 3[2)]**
Mean energy price for district heating	0,45 kr/kWh	0,45 kr/kWh
Power tariff for district heating (> 100 kW)	663 kr/kW, yr	678 kr/kW, yr
Mean energy price for electricity	0,73 kr/kWh	0,72 kr/kWh
Power tariff for electricity	475 kr/kW, yr	494 kr/kW, yr

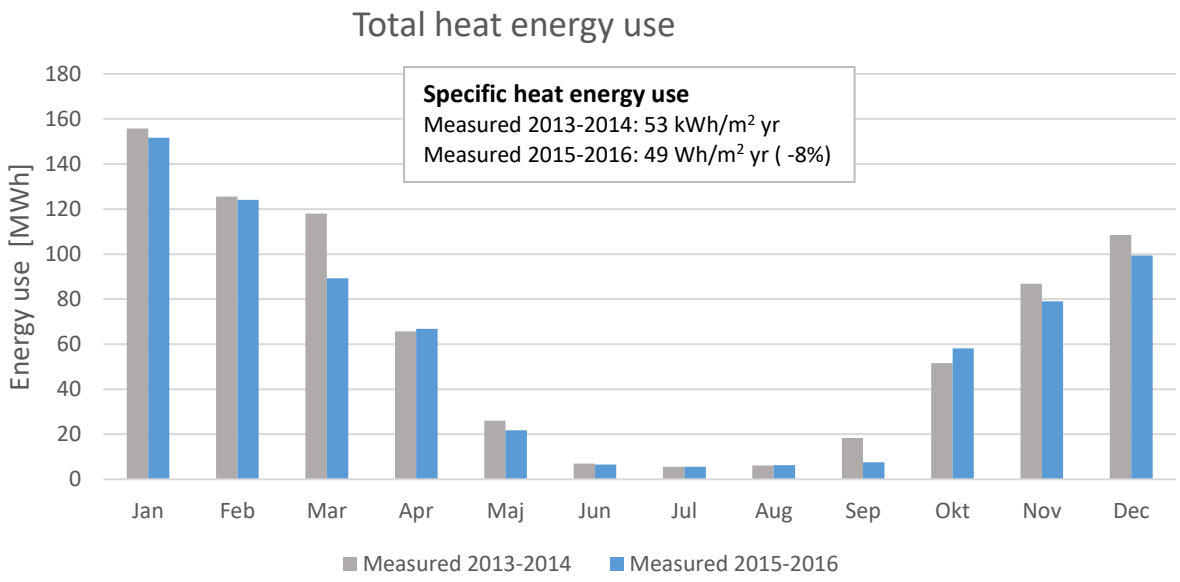
1) According to year 2013 data 2) According to year 2016 data

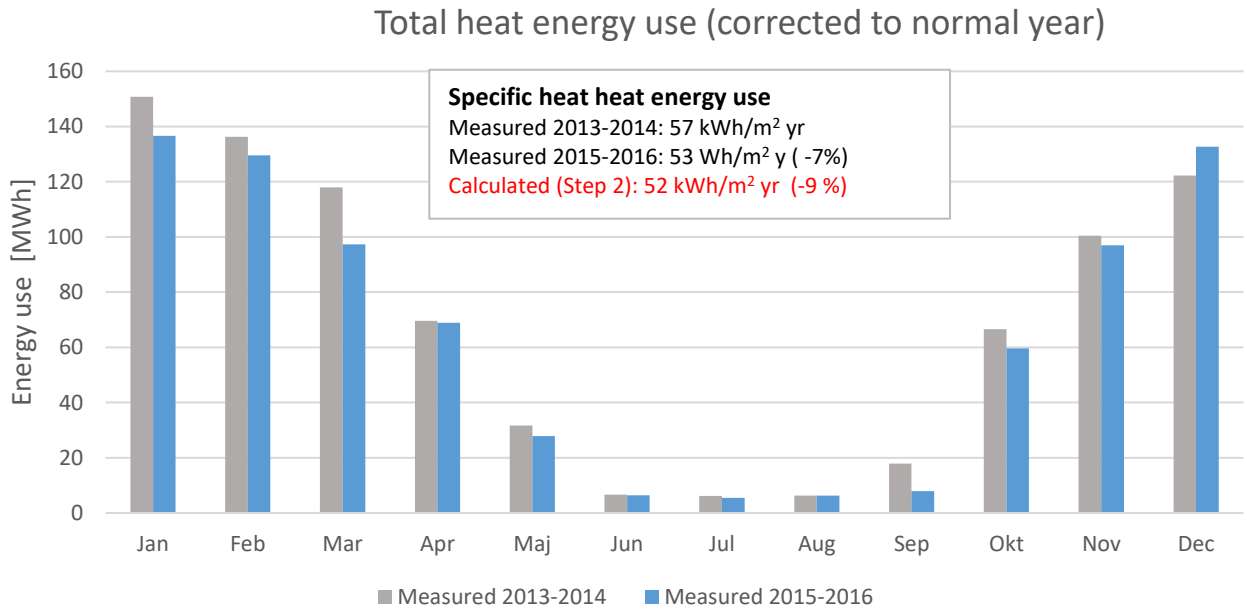
APPENDIX 2. CALCULATED AND DESIGNED VALUES FOR SYSTEMS AND COMPONENTS

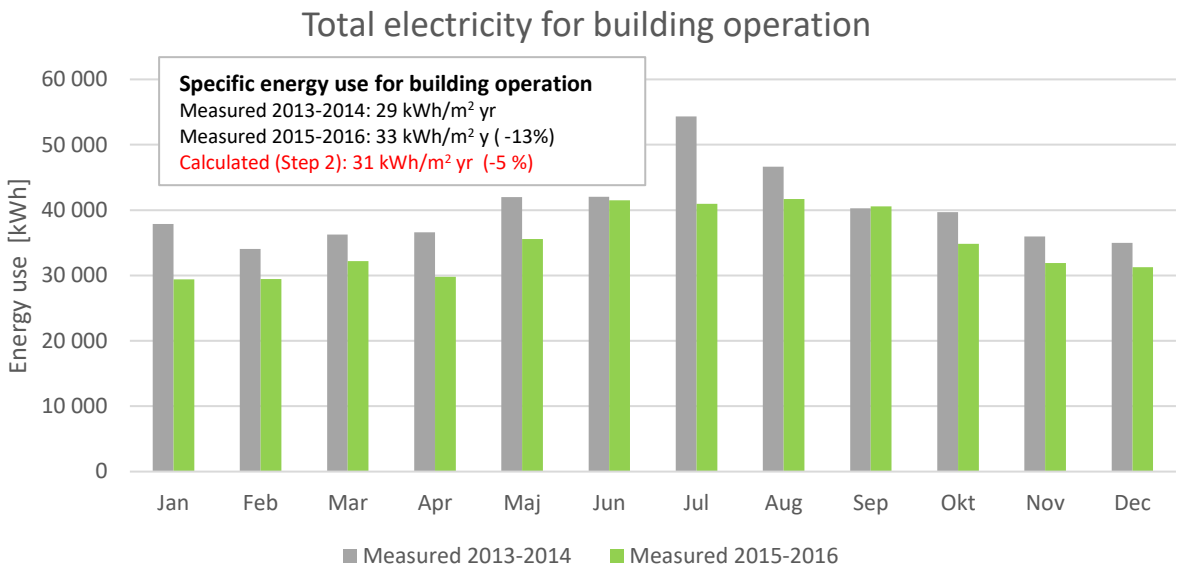
Table B2.1. Calculated and designed values for systems and components in Step 1 and Step 2 and measured values in Step 3.

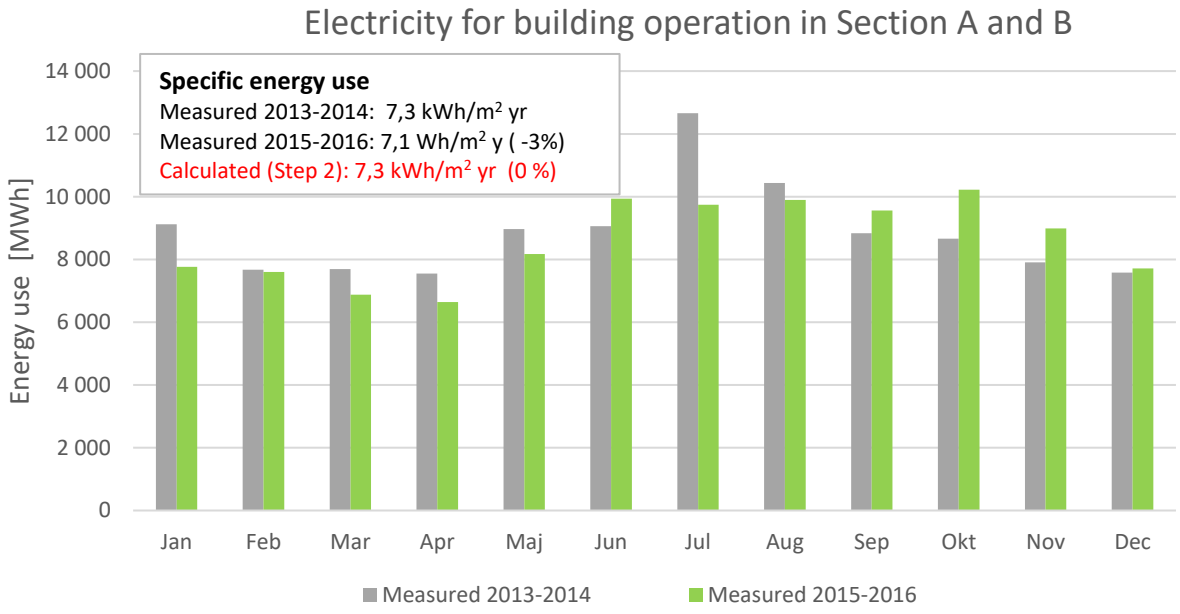
Measure nr	System	Description	Technical properties (Step 1)			Results of Step 2	Technical properties	
			Parameter	Before	After (calculated)		Steg 2	Steg 3
3	TA102	Replace the air-handling units TA102 and TA103 in Section C with a new single unit	Airflow rate SF/EF m3/s	3,4 / 3,0	6,2/6,2	New ventilation unit LB03 with built-in heat pump for heating and cooling	4,8/5,1	4,6/4,9
	TA103		temp. efficiency %	70	78		78	100 (at -16 C)
			Design power SF/EF	7.5/7.5	7.5/11		7,5/11	8,5 (mean total)
			SFP kW/(m3/s)	2,8	2		2	2,1
			Supply temp. Control	20/20C at 20/-20C	18/19C at 20/-20C		room temp	room temp
			Operation time	6:40-18:00 M-F	6:40-18:00 M-F		6:30-18:00 M-F	6:30-18:00 M-F
			COP cooling	n/a	5,3		5,3	5,3
			COP heating	n/a	19,6		19,6	19,6
10	RAD:D	Replacement of thermostats and hydronic balancing of the heating systems in Section C and D	*Room temperatures*			Hydronic balancing in Section D (primary and secondary) side.		
	D-RAD:S		Winter day	+ 21C	+ 21C		+ 21C	+ 22,5C
	D-RAD:N		Winder night	+ 20,5C	+ 20,5C		+ 20,5C	+ 22C
	C-RAD:S		Pump stop >	12C	12C		13C	13C
	C-RAD:N		Supply temp. control	20/70C at 20/-20C	20/70C at 20/-20C		20/70C vid 20/-20C	20/70C vid 20/-20C
5	TA104	Replace the air-handling units TA104 and TA105 in Section D with a new single unit	Airflow rate SF/EF m3/s	11,9/12,1	10/10	Measure is planned to be carried out in 2017		
	TA105		temp. efficiency %	70	75			
			SFP kW/(m3/s)	3,3	2,5			
			Supply temp. Control	0/20C at 20,4/-20C	18/19C at 20/-20C			
			Operation time	6:40-18:00 M-F	6:40-18:00 M-F			
8	RAD:D-P1:1	Install new energy efficient pumps in the heating system in Section D	Power RAD:D-P1:1 (kW)	0,43	0,2	Replacement of pumps RAD:D-P1:1 and D-RAD:N-P1	0,025-0,49	0,025-0,49
	D-RAD:N-P1		operation time RAD:D-P1:1 (h/yr)	6209	6209		6500	6500
			Power D-RAD:N-P1 (kW)	0,275	0,1		0,012-0,31	0,012-0,31
			operation time D-RAD:N-P1 (h/yr)	6209	6209		6500	6500
4	D-VKA1	Replace the chiller D-VKA1 in Sections C and D and optimizing pump operation	Power	275	578	Replacement of the chiller D-KM1 in Sections C and D. New machine has free cooling and increased power. Replacement of pumps in the cooling system and optimizing pump operation (no central cooling of server rooms).	578	578
	D-VKA1-P1		COP cooling	2,5	3		3	3
	D-VKA1-P2		Pump design power	7,5	5,9		3,2/5,6	3,2/5,6
			operation time	8760	6260		6260	1400h for chiller, 3100/2900 h for pumps in the cooling system
			System temperatures				Winter 12/15.5, summer 7/12.5	Winter 10/12, summer 7,5/15
			Room temperatures					
			Summer day	+ 22,8C	+ 22,8C		+ 23C	+ 23C (mean)
			Summer night	+ 22,8C	+ 22,8C		+ 23C	+ 27C (max)
6	TA102	Install VAV-dampers for different zones in Sections C and D	Full airflow rate SF/EF m3/s			Open/closed dampers are installed on supply and return air ducts on different floors in Section C.		
	TA103		Section C	3,4 / 3,0	5,7/5,7		4,3/4,6	4,5/5,1
	TA104		Section D	11,9/12,1	9/9			
	TA105							

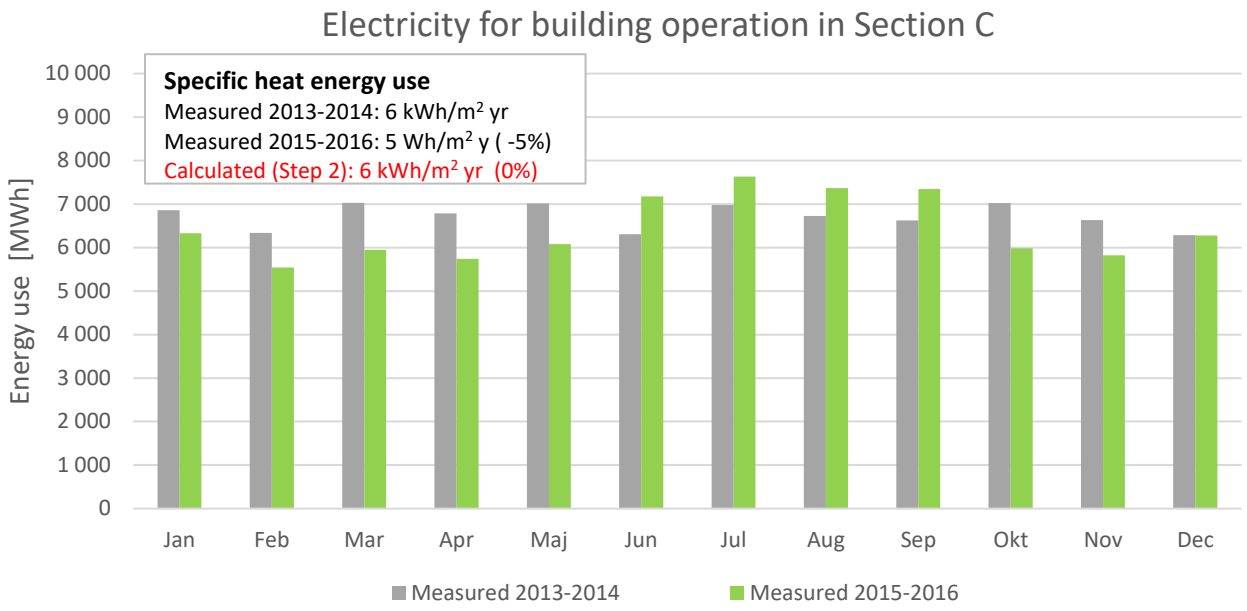
APPENDIX 3. RESULTS OF MEASUREMENTS AND FOLLOW-UP

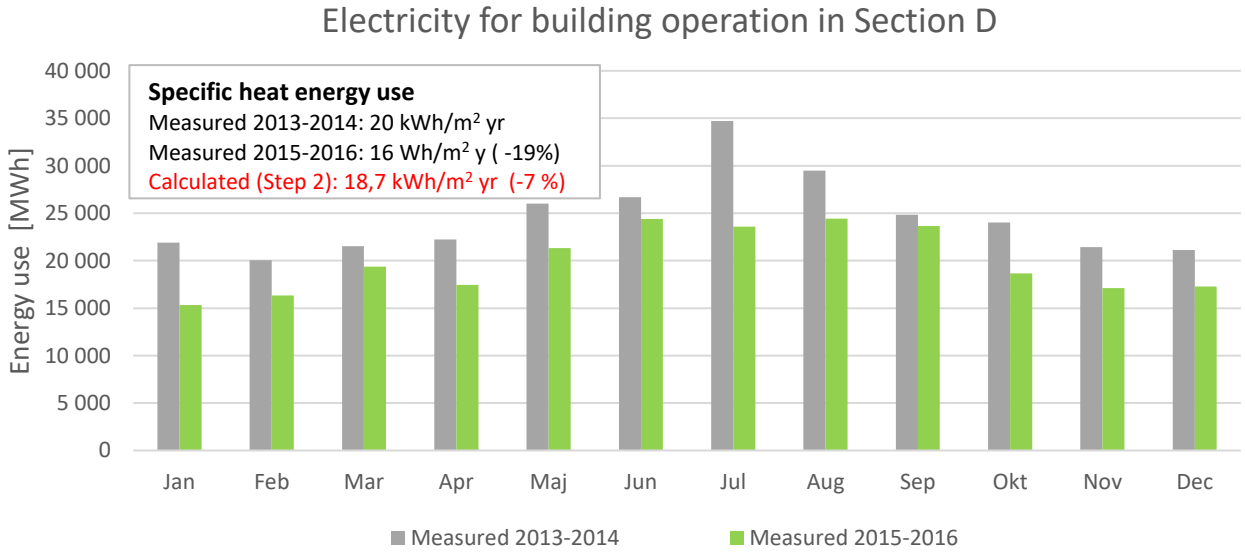


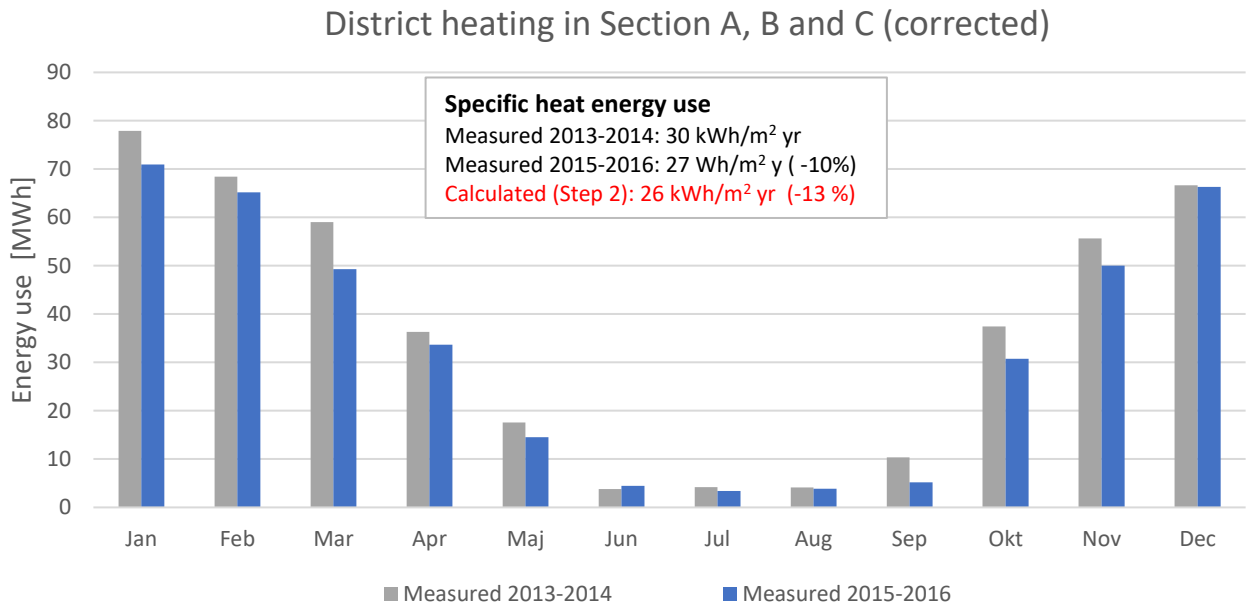


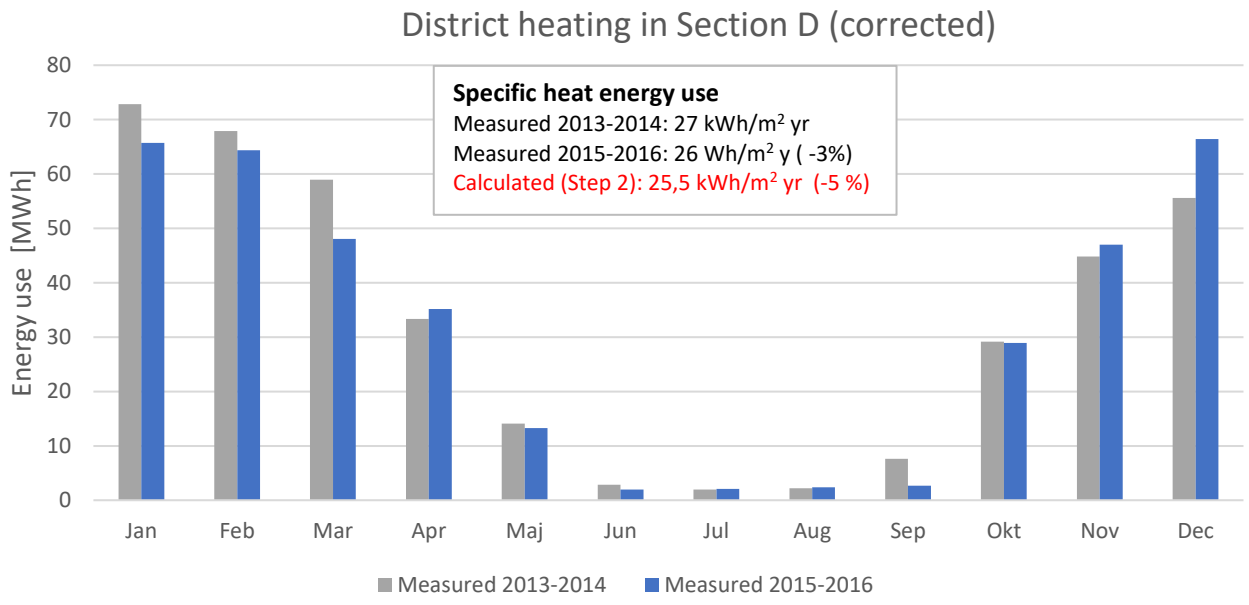

Total electricity for building operation
Specific energy use for building operation
Measured 2013-2014: 29 kWh/m² yr
Measured 2015-2016: 33 kWh/m² y (-13%)
Calculated (Step 2): 31 kWh/m² yr (-5 %)
Energy use [kWh]
60 000
50 000
40 000
30 000
20 000
10 000
0
Jan
Feb
Mar
Apr
Maj
Jun
Jul
Aug
Sep
Okt
Nov
Dec
Measured 2013-2014
Measured 2015-2016

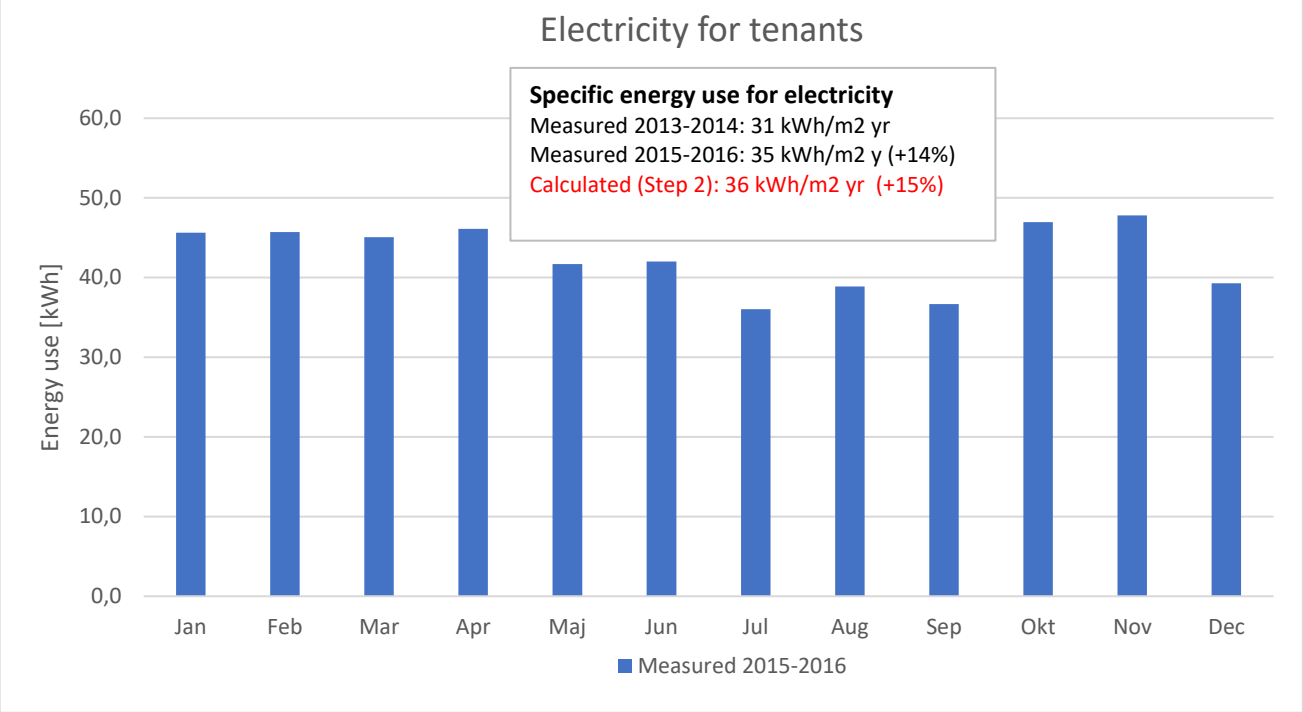

Electricity for building operation in Section A and B
Specific energy use
Measured 2013-2014: 7,3 kWh/m² yr
Measured 2015-2016: 7,1 Wh/m² y (-3%)
Calculated (Step 2): 7,3 kWh/m² yr (0 %)
Energy use [MWh]
14 000
12 000
10 000
8 000
6 000
4 000
2 000
0
Jan
Feb
Mar
Apr
Maj
Jun
Jul
Aug
Sep
Okt
Nov
Dec
Measured 2013-2014
Measured 2015-2016


Electricity for building operation in Section C
Specific heat energy use
Measured 2013-2014: 6 kWh/m² yr
Measured 2015-2016: 5 Wh/m² y (-5%)
Calculated (Step 2): 6 kWh/m² yr (0%)
Energy use [MWh]
10 000
9 000
8 000
7 000
6 000
5 000
4 000
3 000
2 000
1 000
0
Jan
Feb
Mar
Apr
Maj
Jun
Jul
Aug
Sep
Okt
Nov
Dec
Measured 2013-2014
Measured 2015-2016


Electricity for building operation in Section D
Specific heat energy use
Measured 2013-2014: 20 kWh/m² yr
Measured 2015-2016: 16 Wh/m² y (-19%)
Calculated (Step 2): 18,7 kWh/m² yr (-7 %)
Energy use [MWh]
40 000
35 000
30 000
25 000
20 000
15 000
10 000
5 000
0
Jan
Feb
Mar
Apr
Maj
Jun
Jul
Aug
Sep
Okt
Nov
Dec
Measured 2013-2014
Measured 2015-2016


District heating in Section A, B and C (corrected)
Specific heat energy use
Measured 2013-2014: 30 kWh/m² yr
Measured 2015-2016: 27 Wh/m² y (-10%)
Calculated (Step 2): 26 kWh/m² yr (-13 %)
Energy use [MWh]
0
10
20
30
40
50
60
70
80
90
Jan
Feb
Mar
Apr
Maj
Jun
Jul
Aug
Sep
Okt
Nov
Dec
Measured 2013-2014
Measured 2015-2016


District heating in Section D (corrected)
Specific heat energy use
Measured 2013-2014: 27 kWh/m² yr
Measured 2015-2016: 26 Wh/m² y (-3%)
Calculated (Step 2): 25,5 kWh/m² yr (-5 %)
Energy use [MWh]
0
10
20
30
40
50
60
70
80
Jan
Feb
Mar
Apr
Maj
Jun
Jul
Aug
Sep
Okt
Nov
Dec
Measured 2013-2014
Measured 2015-2016


Electricity for tenants
Specific energy use for electricity
Measured 2013-2014: 31 kWh/m2 yr
Measured 2015-2016: 35 kWh/m2 y (+14%)
Calculated (Step 2): 36 kWh/m2 yr (+15%)
Energy use [kWh]
60,0
50,0
40,0
30,0
20,0
10,0
0,0
Jan
Feb
Mar
Apr
Maj
Jun
Jul
Aug
Sep
Okt
Nov
Dec
Measured 2015-2016