Project Acronym: **NEXT-Buildings**

Reference EU: **ENER/FP7/284533/NEXT-BUILDINGS**

DELIVERABLE

Number: D6.2

Title: Technical monitoring data and results from Kv. Isbanan, Helsingborg, Sweden

Nature[1]: O

Dissemination level[2]: PU

Date of issue: November 14, 2017 (M71)

Responsible contractor: COWI

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1 **R** = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other

2 **PU** = Public
PP = Restricted to other program participants (including the Commission Services)
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European Commission

NEXT-Buildings is co-funded by the Energy-Efficient Buildings PPP of the EU

Executive summary

This deliverable describes the monitoring results for 3 new demonstration buildings constructed in Helsingborg, Sweden. The monitoring includes a year of monitoring 2016 and an update for 2017. The report shows that the building fulfils the demand specification of max 42 kWh/m² in yearly energy use for a normal year, and shows a reasonable economic payback period. The building is well insulated, tight and has a compact geometry without large window percentage. These passive means are the main reasons for achieving low energy consumption. The building is further equipped with active elements in the form of efficient balanced ventilation with a high degree of heat recovery, PV and solar thermal panels on the roof and waste water heat recovery, as well as 2-way individual meters, where the tenants can follow their consumption on the building owners website. Further, there is display of RES production in the foyer. The project is a success and the results is a model for other construction projects in Helsingborg. Results are disseminated and discussed in various for fora.

Summary and conclusion

Three new energy efficient buildings of altogether **10,704 m²** were erected in the neighbourhood of Kv. Isbanan in **Helsingborg, Sweden**.

Both passive energy savings features (well insulated façade, roof and ground floor, 3 layer windows, heat recovery on the ventilation, LED lighting in common areas) and active energy savings features (waste water heat recovery, solar heaters, PV system) were successfully implemented. Apart from that, a number of other sustainable features were implemented such as waste sorting, rain water collection and charging station for vehicles.

Measurements on the energy consumption confirmed a total average energy consumption (before subtracting the RES contribution) for the three buildings of **32 kWh/m²/year** - 25% lower compared to the targeted energy consumption of **42 kWh/m²/year.**

The low energy consumption result in low net CO_2emissions (Gross emission minus CO_2displacement from RES) – only **9.8 tonnes/year**, which is 7% lower compared to the BEST target of 10.5 tonnes/year

Extra costs for energy saving measures and sustainability was in total **1.127.434 EUR or 105 EUR/m² incl. VAT**. The simple payback time for the investment in energy efficient measures excl. the RES is **12.1 years** and for the entire project incl. RES, it is **15.6 years** before EU grant and **8.2 years** including the EU grant.

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NOVEMBER 2017

NEXT-BUILDINGS – NEXT ZERO ENERGY BUILDINGS AT LOWEST COST BY USING COMPETITIVE SUSTAINABLE TECHNOLOGY

D.6.2 TECHNICAL MONITORING DATA AND RESULTS FROM ISBANAN

REPORT

PROJECT NO.	DOCUMENT NO.
A024314	D.6.2

VERSION	DATE OF ISSUE	DESCRIPTION	PREPARED	CHECKED	APPROVED
1.0 D	14.11.2017	-	MGCH/MNSC	RMH	RMH

CONTENTS

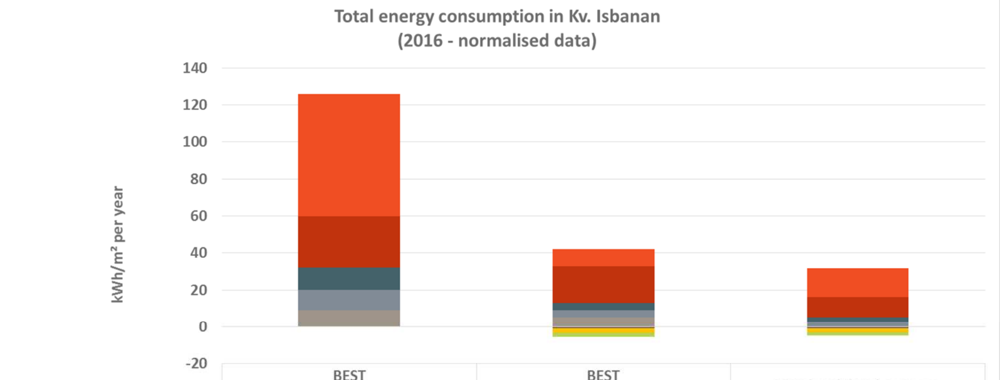
1 Resumé

This report, *D.6.2 Technical monitoring data and results from Isbanan* contains monitoring data and analyses from a new built neighbourhood of three multifamily houses of 10,704 m² in total in Helsingborg, Sweden. The report is a deliverable in the EU-funded NEXT-Buildings-project.

The monitoring data and analyses covers energy consumption, environmental impact, economics and socio-economics.

Energy consumption

The contractual energy consumption targets from 2008 for the buildings was 42 kWh/m² per year. In 2016, the total area weighted normalised average energy consumption for the three buildings was 32 kWh/m², which corresponds to the target, see Figure 1.



	BEST Reference	BEST Target values	Total weighted average
Space heating	66	9	15,8
DHW incl. pipe losses	28	20	11,2
Ventilation	12	4	2,4
Lighting	11	4	2,4
Other electricity (ex. lifts)	9	5	0,3
Solar thermal - flat plate	0	-2,3	-1,7
PV installation	0	-2,2	-2,0
Waste water heat recovery	0	-1	-0,9

Figure 1: Total normalised energy consumption for Kv. Isbanan, reference, target and actual normalised values.

CO_2 savings

The energy savings in 2016 (before subtracting the contribution from RES) was 1.056 MWh or 78 % compared to the reference consumption and it corresponds

to 235 tons/year[3] or in total 11,750 tons in a lifetime of 50 years. Figure 2 illustrates the total CO_2 balance of the Kv. Isbanan.

Two solar thermal plants and one PV plant on top of the buildings and a wastewater heat recovery system in each of the buildings produced in total 49,918 kWh in 2016. This amount of energy saved the environment of 16 tons CO_2

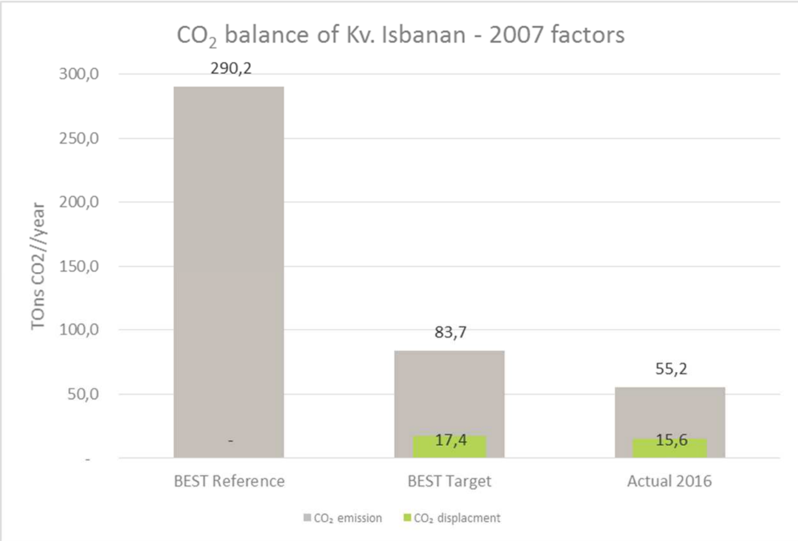


Figure 2: CO_2 balance of Kv. Isbanan in reference, target and actual situation (2007-factors)

Feasibility

The investment costs of the total Kv. Isbanan construction project was 21,500,000 EUR incl. VAT including contractor and developer expenses with an exchange rate of 9.54 SEK/EUR.

Extra costs for energy saving measures and sustainability was in total 1.127.434 EUR or 105 EUR/m² incl. VAT. As Table 1 shows, the simple payback time for the investment in energy efficient measures excl. the RES is 12.1 years and for the entire project, it is 15.6 years before EU grant and 8.2 years including the EU grant.

Table 1: Investment costs, savings and simple payback time (Incl. VAT)

		Demonstration building ekskl. RES (Total]	Demonstration building (building envelope) - Heat savings	Demonstration building (installations) - Mainly electricity savings	RES: Waste water heat recovery	RES: Solar thermal panels	RES: Photovoltaics	Total inkl. RES
Costs	SEK	8.010.000	6.277.000	1.733.000	350.000	1.200.000	1.200.000	**10.760.000**
Investment costs	EUR	839.288	657.704	181.584	36.673	125.736	125.736	**1.127.434**
Production 2016	kWh/year	-	-	-	10.090	18.673	21.155	**49.918**
Extra O&M costs	EUR/year	10.209	6.577	3.632	-	80	629	**10.917**
Annual savings	kWh/year	1.006.411	717.620	288.791	10.090	18.673	21.155	**1.056.329**
Annual savings	EUR/year	79.676	47.321	32.356	456	625	2.258	**83.015**
Simple Payback Time	Years	12,1	16,1	6,3	80	231	77	**15,6**
EU grant	EUR	535.200	-	-	-	-	-	**535.200**
Simple Payback Time	Years	4,4	-	-	-	-	-	**8,2**

[3] CO_2 emission factor (2007 UCTE-mix): 630 g CO_2 / kWh

2 Summary and conclusion

Three energy efficient buildings of altogether **10,704 m²** were erected in the neighbourhood of Kv. Isbanan in **Helsingborg, Sweden**.

Both passive energy savings features (well insulated façade, roof and ground floor, 3 layer windows, heat recovery on the ventilation, LED lighting in common areas) and active energy savings features (waste water heat recovery, solar heaters, PV system) were successfully implemented. Apart from that a number of other sustainable features were implemented such as waste sorting, rain water collection and charging station for vehicles.

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Extra costs for energy saving measures and sustainability was in total **1.127.434 EUR or 105 EUR/m² incl. VAT**. The simple payback time for the investment in energy efficient measures excl. the RES is **12.1 years** and for the entire project incl. RES, it is **15.6 years** before EU grant and **8.2 years** including the EU grant.

3 Introduction to monitoring in Helsingborg

The results of this deliverable D.6.2 Technical monitoring data and results from Isbanan is to report the results, findings and conclusions from the monitoring activities in the NEXT-Buildings project in Helsingborg, Sweden. The report is a draft version of the final deliverable including at least 12 months of monitoring data.

The objective of WP6 is to monitor the overall energy, carbon and social impact of the NEXT-Buildings-project, as well as to monitor the energy performance in all relevant buildings and plants.

The monitored buildings in Helsingborg are the three fill-in multi-storey houses in the neighbourhood called Kv. Isbanan (Isbanan Quarter), see Figure 3 and Table 2. The municipal housing company Helsingborgshem developed, built, owns and operates the new houses, which were built on a site with existing houses from 1950'es, also administrated by Helsingborgshem.

Figure 3: Aerial photo of the total Kv. Isbanan and existing Elineberg

Table 2: General information on the three demonstration buildings.

	Address	House no.	Storeys	GFA, m²	Completed
House 1	Liebäckskroken 6	14	8	2,993	December 2015
House 2	Harlyckegatan 1	16	8	2,993	February 2016
House 3	Liebäckskroken 8	15	11	4,718	March 2016

3.1 Building description

3.1.1 Constructions

For a complete description of implemented technologies, please see deliverable *D.4.6 Catalogue of eco-measures to be implemented.*

Windows

The windows in Kv. Isbanan comes from the Swedish window manufacturer Elitfönster[4] and are triple-glazed windows with a total U-value for the entire window of 0.9 W/m²K. See specifications in Figure 4.

Daylight, solar factor, sound and U-values. Light transmission (LT) indicates the percentage of sunlight that passes through the glass. Solar factor (g) indicates the percentage of thermal radiation passing through the glass.

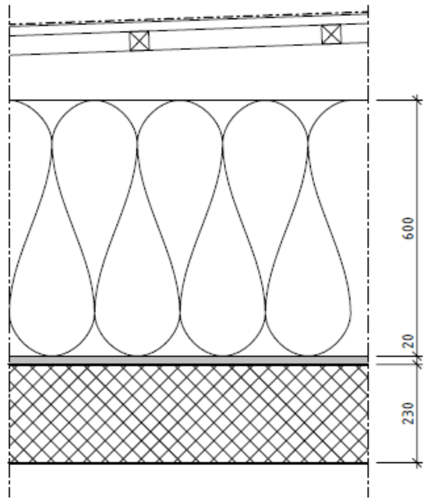
Sound value				U-value 0,9		U-value 1,0		U-value 1,2	
Rw (dB)	Rw+C (dB)	Rw+Ctr (dB)	Rw+Ctr (dB) 50-3150	Lt-value (%)	G-value (%)	Lt-value (%)	G-value (%)	Lt-value (%)	G-value (%)
34	33	29	29	71	50	71	50	73	57
39	38	35	34	70	48	70	48	72	54
41	40	37	36	69	45	69	45	71	53

Figure 4: Technical specifications of the Elitfönster-window used in Kv. Isbanan.

Roof

The Roof is "flat" but has a roof top house for storage and installations. The U-Value of the roofs is 0.07 W/m²K. See Figure 5.

[4] http://www.elitfonster.se/fonster-altandorrar/original-alu/sidhangt/

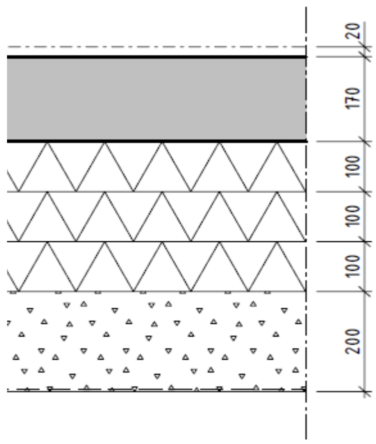


Roof construction (outside to inside)	
Layer	*Thickness [mm]*
Waterproofing	-
Tongue and groove	22
Ventilated air gap	45
Upholstered roof chair	-
Ceiling footboard with wind board	195
Mineral wool	400
Smoothing	20
Concrete slab	230

Figure 5: Roof section with 400 mm insulation.

Ground floor

The ground floor has a U-value of 0.11 W/m²K and includes 300 mm insulation. See Figure 6.

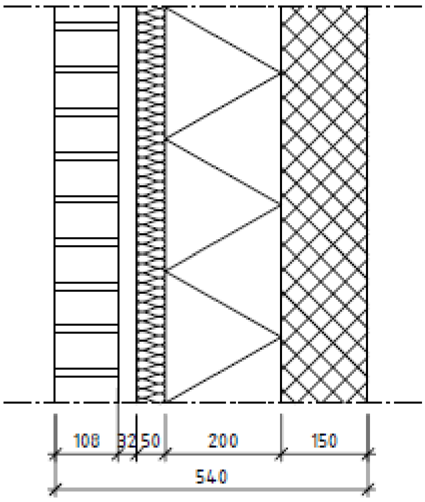


Floor construction (inside to outside)	
Layer	*Thickness [mm]*
Armed concrete	22
Hard foam insulation	300
Macadam	200
Cover	-

Figure 6: Section of the ground floor construction with 300 mm insulation.

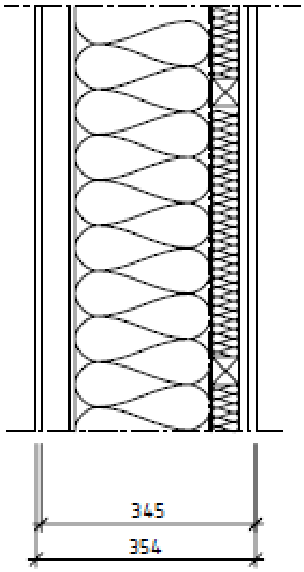
Façade

The façade construction has a U-value of 0.14 W/m² K and consists of bricks, see sections in Figure 7 - Figure 9



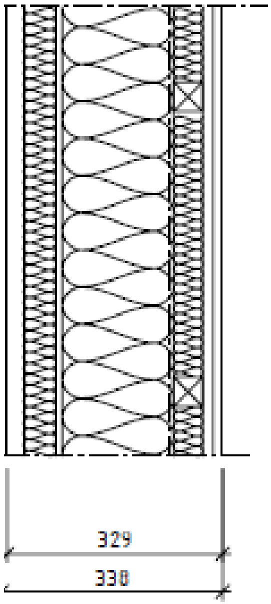
Wall construction 1 (outside to inside)	
Layer	*Thickness [mm]*
Bricks	108
Air gap	32
Stone Wool Insulation	50
Hard foam insulation	200
Concrete	150

Figure 7: Cross section of wall construction 1.



Wall construction 2 (outside to inside)	
Layer	*Thickness [mm]*
Façade panel	8
Air gap	45
Glassroc wind cover	10
Mineral wool	220
Plast foil	-
Mineral wool	45
Gypsum board (2 boards x 13 mm)	26

Figure 8: Cross section of wall construction 2.



Wall construction 1 (outside to inside)	
Layer	*Thickness [mm]*
Façade panel	8
Air gap	25
Façade insulation	50
Glassroc wind cover	10
Mineral wool	170
Plast foil	-
Mineral wool	45
Gypsum board (2 boards x 13 mm)	26

Figure 9: Cross section of wall construction 3.

3.1.2 Installations and RES

Ventilation

The ventilation unit used in Kv. Isbanan are supplied and manufactured by System Air, a company based in Sweden. The ventilation unit the project is called DV25 and Figure 10 shows the technical data.

Air/Fan data	**Supply air**	**Exhaust air**
Air flow rate (1,205 kg/m³)	1,00	1,50 m³/s
Air velocity inside the unit	1,19	1,79 m/s
External pressure loss	200	400 Pa
Fan speed	1625	2204 r/m
Motor	1,80	1,80 kW
Voltage	3x400	3x400 V
Current, nameplate	3,8	3,8 A

Air/Fan data	**Supply air**	
Air flow rate (1,205 kg/m³)	1,00	1,00 m³/s
Air velocity inside the unit	1,19	1,19 m/s
External pressure loss	200	200 Pa
Fan speed	1625	1567 r/m
Motor	1,80	1,80 kW
Voltage	3x400	3x400 V
Current, nameplate	3,8	3,8 A

Air handling unit data

Width	1420 mm
Weight	1231 kg
Filter	Supply air F7 - Exhaust air, intake M5
Heat recovery	0,838
SFP_V with clean filter, frequency converter included	1,23 kW/(m³/s)
Heating battery Air	20,5kW - 3,0/20°C
Water	55/35°C - 0,9kPa - 0,25 l/s - 3/4" Pipe connection

Figure 10: Technical data of the DV25 ventilation unit

Solar thermal panels

The solar panels are supplied and manufactured by Green One Tec, a company based in Austria and one of the largest suppliers in the world. The model that is used at Kv. Isbanan is called "GK3102".

The two solar thermal plants are located on top of the two 8-storey buildings and has an area of 2 x 30 m² and a slope of 45° S-SE. The expected annual heat production from the systems is calculated to 2 x 12,300 kWh = 24,600 kWh which is approx. 410 kWh/m² per year.

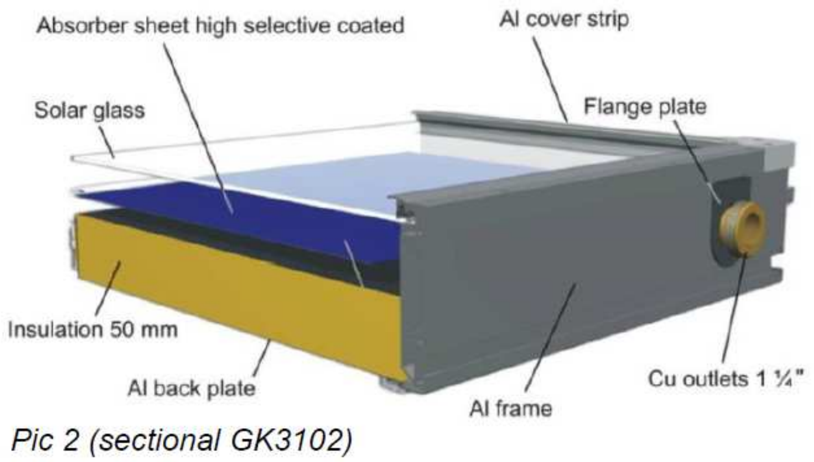


Figure 11: Illustration of solar thermal panel. Source: http://www.greenonetec.com/home/produkte/gk-3000-serie/

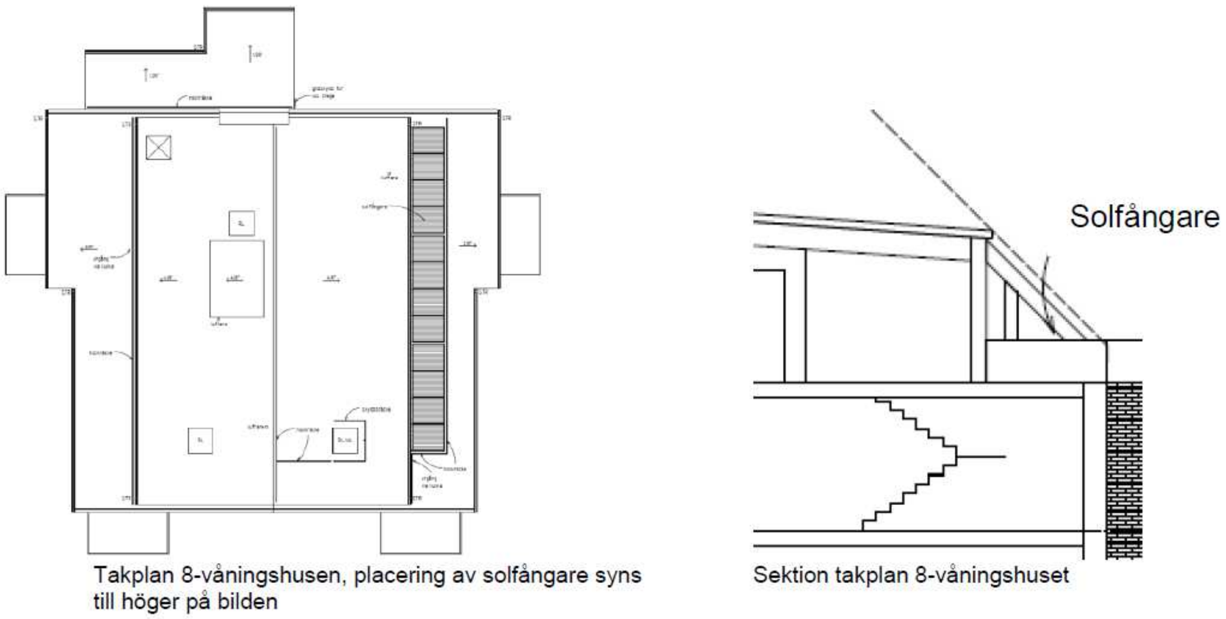


Figure 12: Location of the solar thermal panels on the rooftop of the 8-storey houses (House 1 and 2).

Please see deliverable *D.4.7 Design and specification of solar and wind technologies used* for further information.

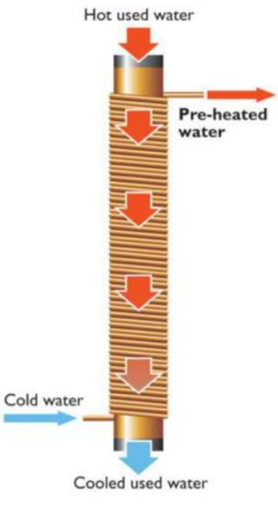
Photovoltaics (PV)

The photovoltaics come from the German supplier SolarWorld AG, a company with its own production, strong power of innovation along with long experience. SolarWorld AG guarantees that the real output from their PV modules is at least 97% of factory tested power output during the first year after installation. Starting with the second year until the twenty-fifth year of operation it is guaranteed that the real output does not drop further by more than 0.7% per year. The model that is used at Kv. Isbanan is called "Sunmodule Plus SW280 mono"[5] and are listed below with photos, performance information and specific product benefits.

The PV plant is located on top of the 11-storey house (Liebäckskroken 8) and has an area of 148 m². The expected annual electricity production is approx. 23,600 kWh. The maximum power per module is 280 Wp – altogether 22 kWp installed capacity.

Wastewater heat recovery

A collective heat exchanger is used in each of all three houses. The ThermoDrain™ heat exchanger works under the principle of gravity film exchange. Due to the superficial tension present in liquids, the wastewater clings in a film-like fashion to the inside wall of the drain pipe as it undergoes gravity flow in the open drain. This greatly improves the effectiveness of heat transfer from the falling drain water to the water inside the copper coils that winds around the central pipe. The heat exchange is thus completed with no contamination risk to the incoming cold water.



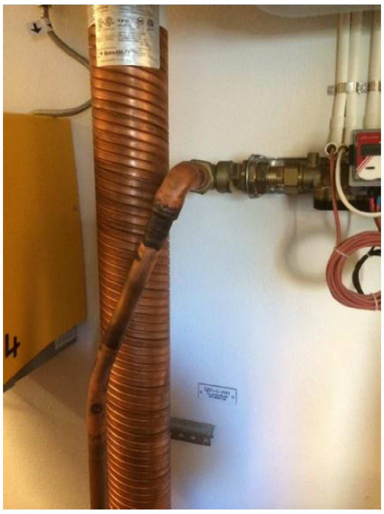


Figure 13: Left: Illustration of wastewater heat recovery exchanger. Source: [http://ecoinnovation.ca/technicalguide/.](http://ecoinnovation.ca/technicalguide/) Right: Photo from technical room in building block.

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[5] http://www.solarworld.de/en/products/products/solar-modules/overview/

3.1.3 Other sustainable building features

Underground waste handling

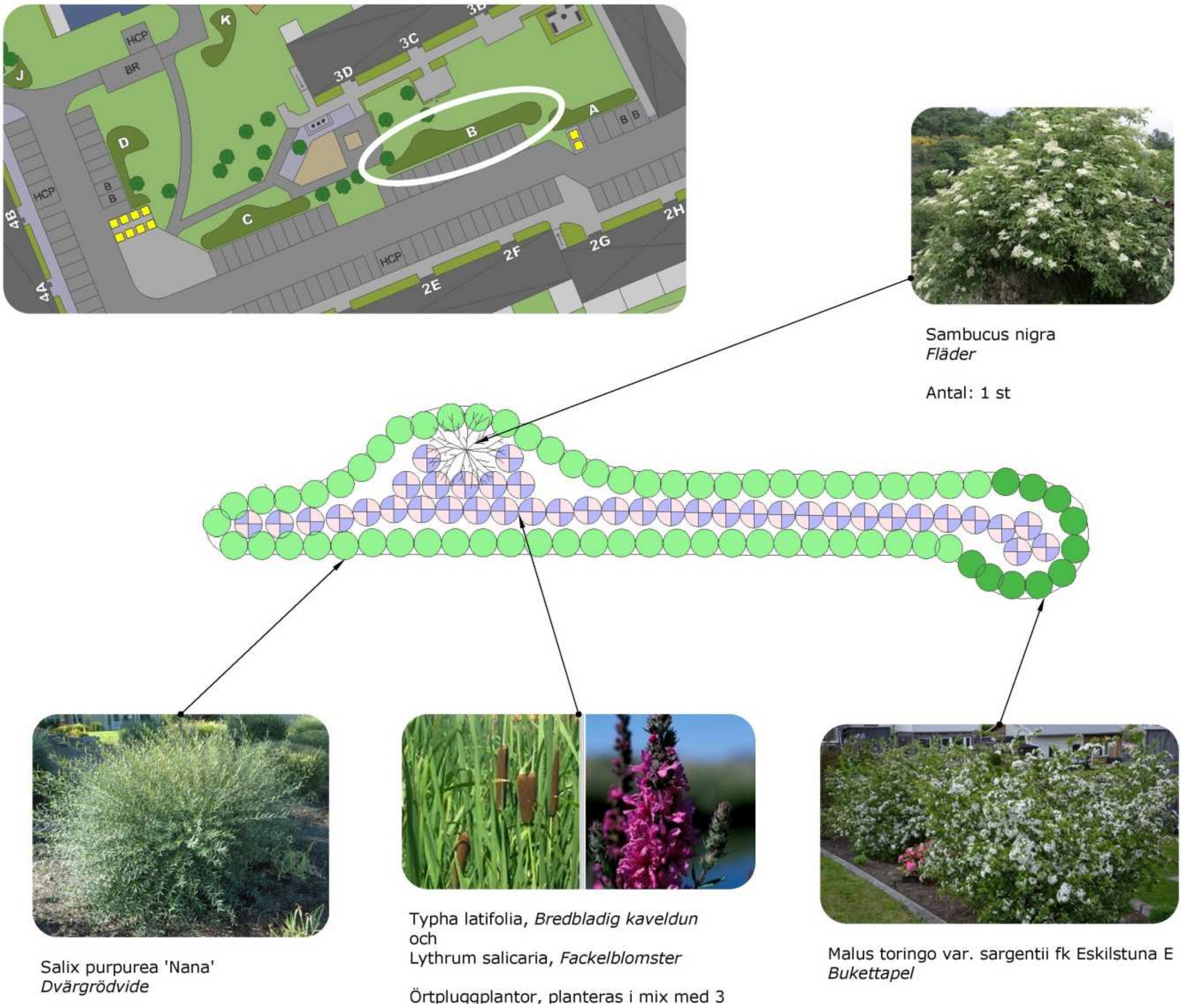
An underground waste disposal system is located central in the area. See illustration in Figure 14. The containers are installed below the ground and only the throw-peak is visible above the ground. The system has nine different waste fractions, which is organic, coloured and colourless glass, cardboard packaging, soft plastic, hard plastic, papers, metal, batteries and residual waste. The waste handling system is available for both the residents in the existing and the new neighbourhood.

The system is popular among the residents, including the local children, who finds it great fun to go and sort the waste. The open design with no canopy, high visibility from the buildings and a central location in the parking lot leads to greater security for the residents and results in less maintenance as the area is kept clean.

Figure 14: Illustration of the waste handling station.

Rain water collection

The area has established several rainwater retention basins for prevention of flooding. The basins moreover have a recreational value to the building surroundings.



Available space beyond the apartment

In the buildings there are an extra apartment available in the ground floor, which the residents have the possibility to book and rent for guests that they cannot host in the apartment. Moreover, the residents have a right of disposal of a dining room in the ground floor of two of the buildings, which they can book for parties etc.

EV chargers

The area has EV charging stations for electrical vehicles.

Figure 15: EV charger at Kv. Isbanan.

4 Methodology of energy monitoring

4.1 Monitored energy parameters

The "Smart Cities Information System - Technical Monitoring Guide"[6] prepared by Smart Cities Information System (SCIS), is the basis of the methodology of the monitoring of energy consumption. In the monitored parameters, all energy meters are included in order to document the total final energy consumption of the building or production of the energy plant. Monitoring data was collected as monthly values during a period of at least one year.

Levels of details

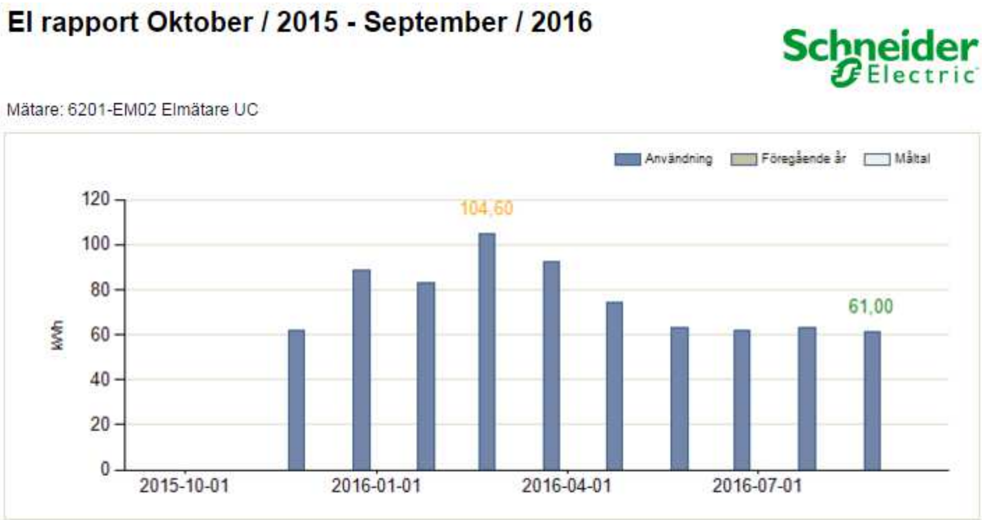
Two levels of details on metering were performed on the demonstration buildings, see Table 3.

Table 3: List of metering points for the buildings at Isbanan.

Level 1 – Building level		Level 2 – Individual level	
Space heating	kWh	Mean indoor air temperature	°C
Domestic Hot Water	kWh and m³	Space heating for selected apartments –	kWh
Electricity for common functions	kWh	Electricity for households in groups of app. 20 apartments – kWh	kWh
Electricity for ventilation in apartments	kWh		
Electricity for ventilation in residents common room	kWh		
Electricity for technical rooms	kWh		
Production from solar thermal panels	kWh		
Production from PV panels	kWh		
Energy recovered from waste water	kWh		
Cold water	m³		

[6] http://www.smartcities-infosystem.eu/sites/default/files/document/technical-monitoring-guide_2016.pdf

Schneider Electric, see example of monitoring data output in Figure 16, provides the energy monitoring system for Helsingborgshem.



Tid	Användning [kWh]	Föregående år [kWh]	Måltal [kWh]	Förändrings [%]
10/2015				0,00%
11/2015				0,00%
12/2015	62,10			0,00%
1/2016	88,50			0,00%
2/2016	83,10			0,00%
3/2016	104,60			0,00%
4/2016	92,10			0,00%
5/2016	74,10			0,00%
6/2016	63,20			0,00%
7/2016	61,80			0,00%
8/2016	63,20			0,00%
9/2016	61,00			0,00%
Summa	753,70			0,00%

Figure 16: Example of monitoring data output from Schneider Electric.

4.2 Conventions

4.2.1 Floor area and volume definition

In the Monitoring Data sheets, the SCIS floor area definitions for gross area are used in order to enable comparison of the energy performance indicators between buildings from different EU countries. Denmark uses the same definition of floor area as defined by SCIS.

Gross Floor Area and Volume

Gross Floor Area and Volume are calculated according to the SCIS conventions. According to these conventions, the outside borders of the building and building envelope define the gross floor area and volume. All floor areas in all levels including secondary rooms and external walls are considered and the building volume including all these areas and external walls are considered. The area of balconies, patios and parking spaces is excluded.

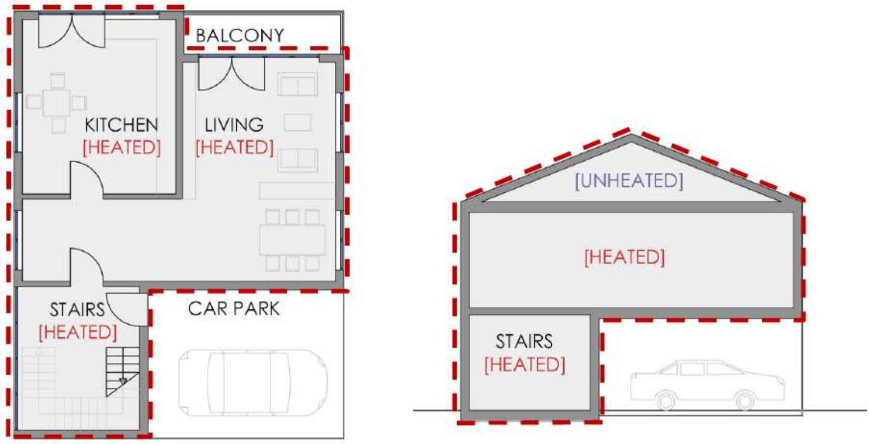


Figure 17: Gross Floor Area and Volume conventions example.

4.3 Normalisation of energy consumption

4.3.1 Normalisation to weather conditions: Definition and collection of degree-days

Normalisation of the heat energy consumption corresponding to that of an average climate year is necessary when one want to compare the consumption of a building from different years. This report compares the energy consumption in a monitored period with the energy consumption stated in the BEST (Building Energy Specification Table) and must therefore be normalised. Normalisation of data follows a standard normalisation technique. The heating data is normalised using the official Danish degree-days, as they are comparative to the number of annual degree-days in a reference year that the BEST states (see Appendix A – BEST (Building Energy Specification Table). In 2011, the reference year was of 2906 degree days (2900 in BEST), while the Swedish was 3963 because it is calculated using a different method and covers a larger area of central part of Southern Sweden. Helsingborg is located at the sea towards Øresund like Copenhagen. It is therefore normal practice to use the climatic data of Copenhagen.

The Danish degree-days are measured and managed by Danish Technological Institute (DTI) at a monitoring station at Landbohøjskolen in Copenhagen. The list of degree-days is available on the website: http://www.teknologisk.dk/graddage/pressemeddelelse/492?cms.query=graddage

Definition of degree-days

According to DTI, who is national contact point on degree-day information:

> *"One degree-day is an expression of the difference of 1°C between the presumed indoor average temperature of 17°C and the outdoor average temperature in one day and night."*[7]

[7] http://www.teknologisk.dk/graddage/hvad-er-graddage/492,3

The temperature of 17°C is used as it is assumed, that the internal heat load contributes with the last 3°C up to the reference temperature of 20°C, which is the design indoor design temperature in Denmark. Moreover, the prerequisite of 20°C indoor temperature was used to define the energy consumption targets in the BESTs in the contract as it is the temperature used in the Danish Energy Labelling System and in the documentation of energy frames according to the Danish Building Regulations, valid for the actual buildings.

Example (indoor temperature 20 °C):
+2°C outdoor temperature gives 17-2 °C x 1 day=15 degree-days per day
-5°C outdoor temperature gives 17-(-5) °C x 1 day = 22 degree-days per day

If the indoor air temperature is higher than 20°C, for instance 22°C, then a normalisation back to reference temperature is necessary as explained in section 4.3.2 'Normalisation to indoor reference temperature: Definition of indoor temperatures'.

DRY and new normal year

The official Danish Design Reference Year (DRY) was performed by Danish Technological University and is based upon 20°C indoor temperature. It consists of an average of data collected in the period 1941-1980 and contains many parameters such as outdoor temperature, relative humidity, wind speed and direction, hours of sunshine etc. The DRY has 2,906 degree-days. Because of climate changes, the average of degree-days in the period 2001-2016 has only been 2,529 degree-days, see Figure 18. After a period of voluntariness, it is now mandatory in Denmark since 2015 by the Danish Building Regulations to use updated climate data starting in 2001. This means that the old DRY is not used anymore.

The monitoring data from Kv. Isbanan is normalised according to the average of 2001-2016 in order to produce as realistic values as possible.

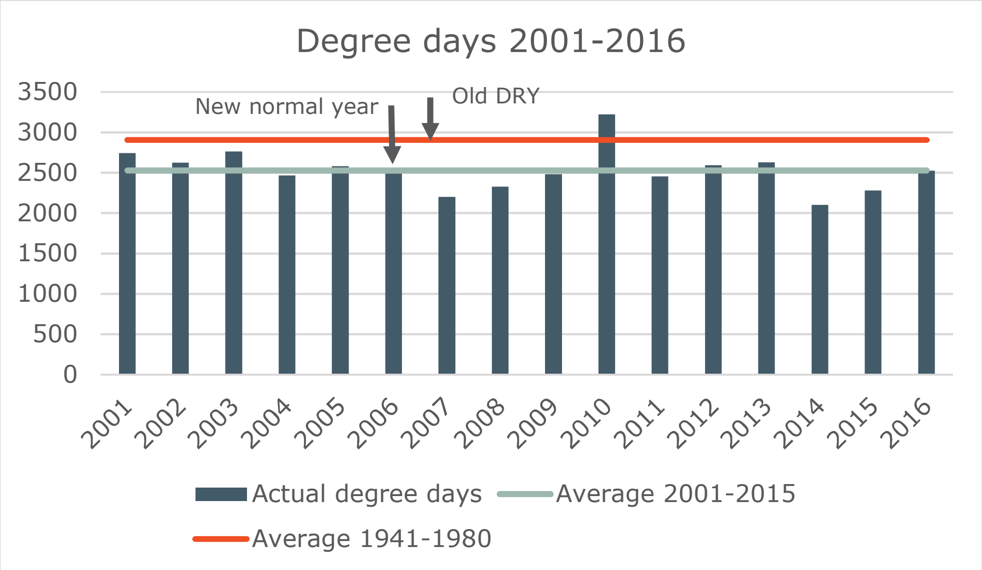


Figure 18: Degree-days measured by Danish Technological Institute in the period 2001-2016. The lines are the Danish Reference Year (1940-1982) in red and the new reference based on average of the last 16 years in yellow.

Normalisation to weather conditions – Example:

The normalisation of heat energy consumption in relation to the outdoor climate is carried out as shown in the example below. Only one year is presented in the fact sheets and only this year is normalised.

Space heating consumption, 2016: 100 kWh/m² (metered value)

Degree-days normal year (20°C): 2529 (2001-2016)*

Actual degree-days in 2016 (20°C): 2526 (see Figure 18)*

Normalisation, space heating:

100 kWh/m² / 2526 * 2529 = 100.12 kWh/m²

* (from DTI's monitoring station in Copenhagen)

4.3.2 Normalisation to indoor reference temperature: Definition of indoor temperatures

The normalisation of heat energy consumption in relation to the outdoor climate presumes an indoor air temperature of 20°C see section 4.3.1. Experience shows, that inhabitants often have more than 20°C in actual room temperature, especially when they live in a low energy house. To investigate and support this fact, the indoor air temperature was logged in all apartments in the three houses of Kv. Isbanan, see Figure 19.

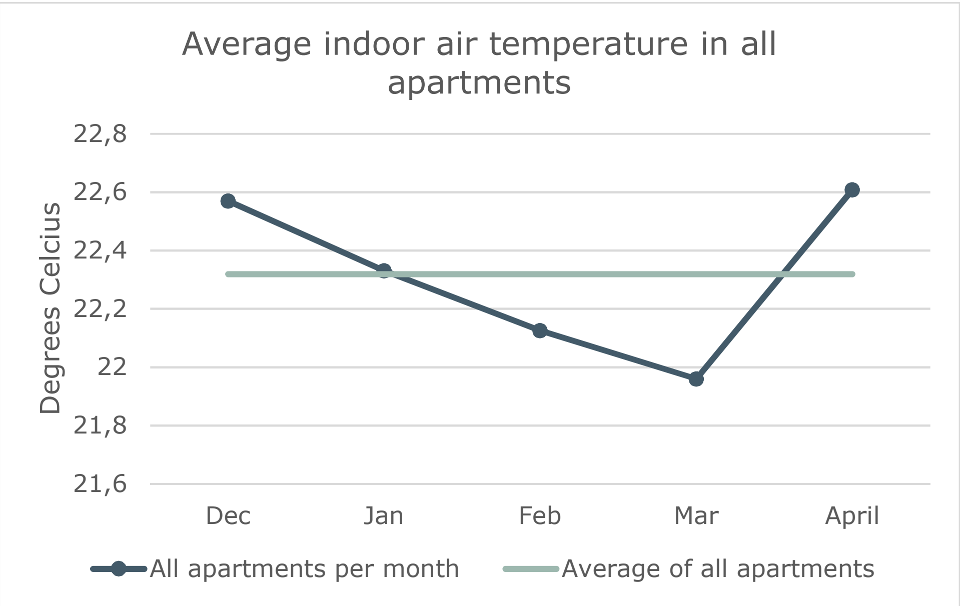


Figure 19: Plot of measured indoor air temperature in all apartments in Kv. Isbanan per month and as an average.

Calculating degree-days

The consequence of keeping such a high indoor temperature is a higher energy consumption than calculated. For every degree, a resident keeps the average indoor temperature above 20°C in the heating season, the number of total degree days will rise equally, approximately by 5% pr. degree. The energy consumption is therefore approx. 15% higher when keeping 23°C instead of 20°C. To compare the actual heating consumption with the contractual heating consumption, the additional heating consumption caused by higher indoor temperature must be normalised. The method for this is to add one degree-day per day for every degree the indoor temperature is higher than 20°C. See example:

<u>Example (indoor temperature of 22˚C):</u>
+2˚C outdoor temperature gives 17+2-2 °C x 1 day= 17 degree-days per day.
-5˚C outdoor temperature gives 17+2-(-5) °C x 1 day = 24 degree-days per day.

As the example shows, the number of degree-days increases with increased temperature. Table 4 shows a list of the Danish Reference Year compared with degree-days from 2016 at indoor temperatures from 20-24˚C. Specifically, 1 degree-day per day in the month was added when adjusting the year from 20°C to 21°C, 2 degree-days per day in the month at 22°C, etc.

Table 4: The old Danish Reference Year 1941-1980 (DRY), the new normal year 2001-2016 and the annual degree-days from Danish Technological Institute including additional degree-days at higher indoor temperatures.

	Normalisation to weather conditions			Normalisation to reference indoor temperature (extra degree-days/month)			
	DRY 1941 -1980	Normal year 2001 -2016	2016 (20˚C)	2016 (21˚C)	2016 (22˚C)	2016 (23˚C)	2016 (24˚C)
January	525	477	506	31	62	93	124
February	480	437	406	28	56	84	112
March	460	408	388	31	62	93	124
April	302	229	275	30	60	90	120
May	79	31	0	31	62	93	124
June	1	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0
September	36	15	0	30	60	90	120
October	219	189	221	31	62	93	124

November	349	315	359	30	60	90	120
December	455	427	371	31	62	93	124
Total	**2906**	**2.529**	**2.526**	**273**	**546**	**819**	**1092**

Normalisation to indoor reference temperature – Example:

The normalisation of heat energy consumption in relation to the indoor reference temperature is carried out as the following example shows:

Space heating consumption, 2016: 100 kWh/m² (metered value)

Degree-days normal year (20°C): 2529 (2001-2016)*

Additional actual degree-days in 2016 (22°C): 546 (see Table 4)*

Normalisation, space heating:

100 kWh/m² / (2526+546) * 2529 = 82.3 kWh/m²

* (from DTI's monitoring station in Copenhagen)

4.4 Example from Liebäckskroken 6

To clarify the method for normalising the heating consumption a complete example will follow from the building block at Liebäckskroken 6. The monitored data consists of values from direct meter readings and values that derives from meter readings (more information on derived data later). The building is supplied from with district heating has nine meters:

- DH for total heating, kWh
- DH for hot water, kWh
- Cold water meter, m³
- Hot water meter, m³
- Electricity for common functions, kWh
- Electricity for ventilation in apartments, kWh
- Electricity for ventilation in communal premises, kWh
- Electricity for pumps and technical room, kWh

Presentation of data

The data are presented in the appendix with fact sheets like the example in Figure 20 shows – more data are available in the monitoring spreadsheets. The red boxes and black text highlights directly read monitored data from meters and the other data are either normalisations, summarisations or subtractions.

Liebäckskroken 6, 256 58 Helsingborg

Address	Liebäkskroken 6
Typology of Dwelling	High rise
Occupants number	60
Occupants type	Mixed families
Ownership	Renting
Gross floor area (m²)	2.993

Monitoring Period	Energy Total kWh	Total/m² kWh/m²	Total heating kWh	Hot water kWh	Heat losses space heating kWh	Space heating kWh	Space heating (Normalized) kWh	Total electricity consumption kWh	Common Lighting	Vent. (appt.) kWh	Vent. (communal premises) kWh	Pumps	Water: Cold water m³	Hot water from DH kWh	Hot water m³	RES: Local heat producti kWh
jan-16	**21.260**	7,1	19.540	2.750	648	16.703	**13.968**	1.720	791	815	16,1	88,5	161	2.190	56,8	560
feb-16	**14.222**	4,7	12.850	2.820	648	10.083	**9.539**	1.372	657	618	4,4	83,1	153	2.120	56,1	700
mar-16	**12.332**	4,1	10.910	3.400	648	7.933	**7.227**	1.422	688	615	4,5	104,6	177	2.330	66,0	1070
apr-16	**8.931**	2,9	7.570	3.030	648	5.243	**3.521**	1.361	670	579	10,1	92,1	168	1.680	60,2	1350
maj-16	**4.340**	1,4	3.000	3.130	648	1.233	**0**	1.340	718	533	5,4	74,1	188	1.120	63,9	2010
jun-16	**3.299**	1,1	1.670	2.450	690	690	**0**	1.629	704	846	6,1	63,2	172	980	51,6	1470
jul-16	**2.841**	0,9	1.590	2.380	470	470	**0**	1.251	692	482	5,1	61,8	173	1120	55,6	1260
aug-16	**2.894**	0,9	1.530	2.080	680	680	**0**	1.364	727	560	4,7	63,2	163	850	49,5	1230
sep-16	**2.892**	0,9	1.600	2.140	750	750	**0**	1.292	750	466	5,1	61,0	180	850	52,5	1290
okt-16	**10.033**	3,3	8.600	2.430	648	6.183	**4.085**	1.433	795	533	4,8	90,9	186	1770	59,7	660
nov-16	**12.907**	4,3	11.500	2.660	648	8.933	**6.651**	1.407	802	501	4,9	89,3	175	1920	55,6	740
dec-16	**13.098**	4,3	11.700	3.030	648	8.693	**8.652**	1.398	782	508	5,1	93,3	182	2360	67,9	670
TOTAL	**109.049**	3	92.060	32.300	7.770	67.590	**53.645**	16.989	8.775	7.055	76	965	2.079	19.290	696	13.010

Figure 20: Table of monitoring data from Liebäckskroken 6. Red boxes highlights the directly read monitoring data. Other data are normalisations, summarisations or subtractions.

Derivation of data

Figure 21 illustrates the total energy consumption and how it is obtained from the different energy categories. The total heating consumption, which is read from the district heating meter, includes both space heating, heating of domestic hot water and heat losses from distribution pipes. As only the space-heating share is subject to normalisation to weather and reference temperature, this must be identified, see procedure after the figure.

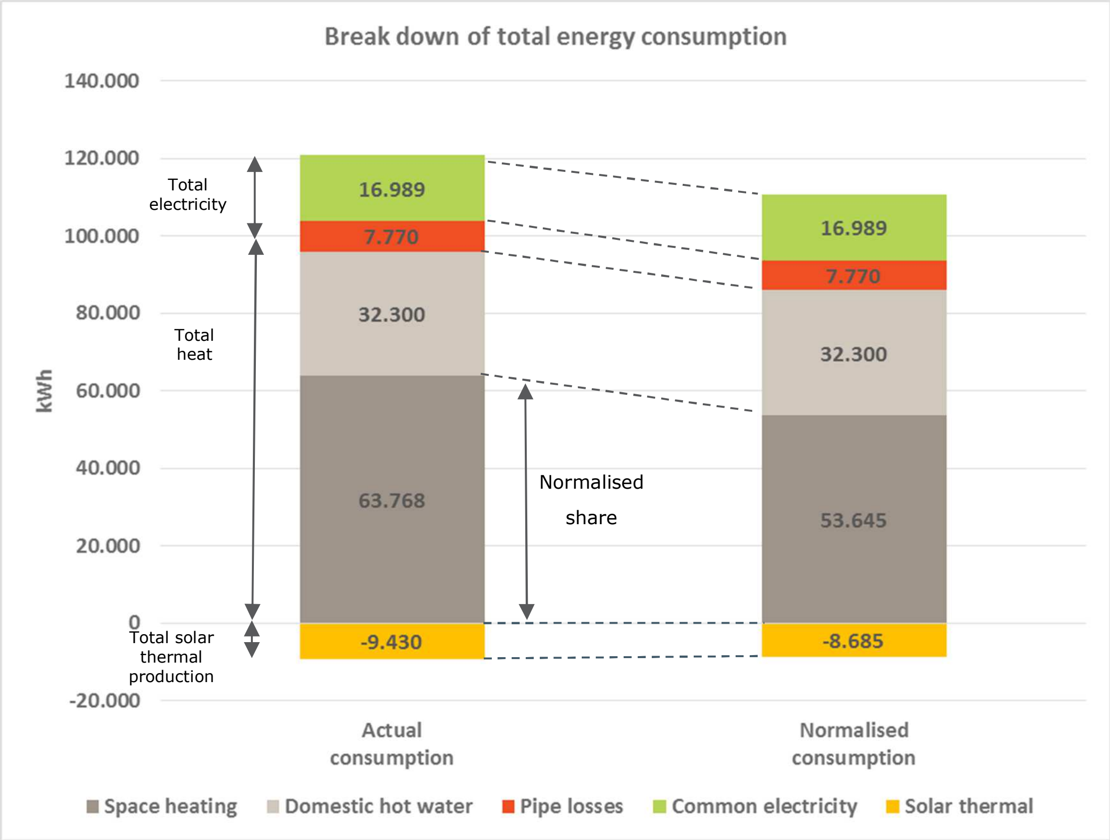


Figure 21: Breakdown of total energy consumption (electricity and heat) into categories: Space heating, domestic hot water and pipe heat losses.

The derivation of data follows this principle:

1 Total heating – heating for DHW = Space heating incl. pipe heat losses
2 Space heating incl. pipe heat losses – pipe heat losses = Space heating

Space heating

The monitored data consists of values from <u>direct meter readings</u> and values that <u>derives from meter readings</u>. I.e. if:

A + B = C and

C is a direct meter reading of **total heating**
B is a direct meter of **domestic hot water** (kWh or m³)

then

A is **space heating** and <u>derives</u> from monitored data.

The data derivation and analysis included normalisation of the heating consumption. Only the heating energy consumption needs to be normalised as it can be assumed that the domestic hot water consumption and pipe losses are approximately equal for every month – summer as winter.

Domestic hot water

The hot water consumption is metered directly and have not undergone any adjustments.

Pipe losses

The pipe heat losses are the remaining heat consumption that can't be ascribed to either space heating or domestic hot water consumption. Therefore, the pipe losses can be identified from the three summer months where there is no space heating demand. The heat losses from pipes are almost constant during the year as hot water circulates constantly. In wintertime, the heat loss from pipes may contribute to heating of the building, depending on the location of pipes and is not a complete loss, but in summertime, the heat cannot be utilised and losses can be significant.

Detailed derivation of monthly data

When pipe losses are identified, the final conversion and normalisation of data can be conducted. In general, the conversion, derivation and normalisation of data in all three buildings follows this example of method, month by month (data derives from Figure 20):

Processing of monitored data per month (For instance January)

<u>Total district heating – heating of hot water:</u>
19,540 kWh – 2,190 kWh = 17,350 kWh

<u>Domestic hot water:</u> 2,190 kWh

<u>Pipe losses (average of Jun-Aug):</u> 613 kWh

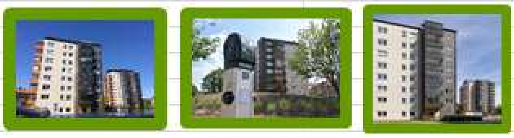
<u>Actual space heating:</u>
Actual space heating = Total heating – Domestic hot water – Pipe losses
(19,540 – 2,190 – 613) kWh = 16,737 kWh

<u>Normalised space heating:</u>
Normalised space heating = Actual space heating / (degree-days in January 2015 + additional degree-days for indoor temperature) x degree-days in January in normal year
16,737 kWh / (506 + 62) x 475 = 13,996 kWh

4.5 Guide to monitoring fact sheets in appendix

The appendix of this report consists of a 1-2 page monitoring fact sheet for each of the three building blocks and one per renewables and integration. In front of the appendix, the reader will find a table of content. The fact sheets present in a visual easy way all the relevant information of the demonstration such as general data, building characteristics and key energy figures. To each building fact sheet belongs an overview table of the monitored data and the procession hereof.

No.	Content
1	General data (Address, area, year of construction, investment costs etc.)
2	Short description of the performed measures (Insulation thickness, glazing type etc.)
3	U-values defined in BEST tables, target figures and actual obtained U-values
4	Information on the energy system
5	Calculation prerequisites such as used indoor temperature and degree-days for the specific period
6	Reference energy consumption according to BEST
7	Target energy consumption according to BEST-table and calculated design values.
8	Actual monitored values per m² gross heated area in the specific period and the same values normalised for 2016 and 2017



NEXT buildings

Kv. Isbanan (SE1)

Liebäckskroken 6, 256 58 Helsingborg

General Data

Refurbished Building	Isbanan - house 1
Year built	2015
Year refurbished	n.a.
Address	Liebäkskroken 6
Building function	Multifamily building
Building type	High rise
Number of Apartments	30
Number of Occupants	60
Gross Floor Area (m²)	**2.993**
Gross Volume (m³)	8.081
Net Heated/Cooled Area (m²)	2.676
Net Heated/Cooled Volume (m³)	7.225
Basement Type	No basement
Attic Type	Flat roof
Total Investment cost [Euro/m2]	105

Building Features

Building Features		Unit		Normal practice	BEST Target	Design (calc)	Actual (2015)
External walls		W/m²K		0,40	0,15	0,14	0,14
Roof		W/m²K		0,25	0,12	0,07	0,07
Ground floor		W/m²K		0,30	[illegible]	0,11	0,11
Windows (frame & glass)		W/m²K		-	[illegible]	0,90	0,90
Average U-value of glazings		W/m²K		2,00	[illegible]	-	-
Average g-value of glazings		-			0,5-0,6	-	-
Ventilation Flow Rate average		l/s/m²		0,36		0,35	
Thermal Bridges	0,03 W/m² K						
Air tightness & n50 air change rate	0,25 l/s/m²						
Ventilation system type	Balanced ventilation with heat recovery						
Energy saving measures	Insulation, windows, heat recovery, solar energy						
Water saving measures							
Special building materials							
Type of Shading	No shading						

Energy Systems

Energy Systems	
District Heating connection	Yes
Photovoltaic - grid connected	No
Solar thermal - flat plate	Yes
Heat pump	No
Boiler	No

Calculation prerequsites

Calculation prerequsites		
Indoor air temperature	22	°C
Degree days (2001-2014)	2.528	days
Degree days (2016)	2.526	days

Key Energy figures

Key Energy figures	kWh/year/m² gross area	Normal practice	BEST target	Design		2016 (Normalized	2017
Total Energy Demand		**126,0**	**36,5**	**41,7**		**32,5**	**39,5**
Total heat		94,0	29,0	32,4		31,2	32,5
Space heating		66,0	9,0	10,4		17,9	16,4
Domestic hot water		28,0	20,0	22,0		10,8	13,9
Pipe heat losses		incl.	incl.	incl		2,6	2,2
Total electricity		32,0	13,0	14,9		5,6	5,6
Ventilation		[illegible]	[illegible]	[illegible]		2,4	1,9
Other electricity (ex. lifts)		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Pumps		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Lighting (Shared space)		11,0	4,0	[illegible]		2,9	3,1
Energy - total		0,0	-5,5	-5,6		-4,3	1,4
PV installation		0,0	-2,2	0,0		0,0	0,0
Solar thermal - flat plate		0,0	-2,3	-4,6		-3,2	3,0
Heat recovery from waste water		0,0	-1,0	-1,0		-1,2	-1,6
Electricity for appliances (indication, costs not eligible)		35,0	24,0	n.a.		33,9	33,9
Lift						0,04	0,04

Figure 22: *Guide to understanding the monitoring fact sheets for one selected building. Se explanation of numbering in list above. Year 2017 are based on 8 months meter readings and projected to a full normalized year.*

4.6 Other calculation prerequisites

4.6.1 PV systems

PV efficiency is calculated on monthly basis as metered PV output at the AC side of inverter per m² PV array, divided by global solar radiation per m² on horizontal level:

$$PV\ system\ efficiency = \frac{PV\ electricity\ produced, kWh}{Global\ radiation\ x\ F_{area}, kWh}$$

where: F_{area} is a factor of efficient PV area (approximately 0.9)

It is an overall <u>system efficiency</u> for the actual installation so therefore no correction is made for shade, orientation or tilt (tilt is with a few exceptions very low i.e. 10-20 deg.)

Normalisation to a standard year is made on monthly basis by multiplying the heat produced with a normalization factor

$$Normalisation\ factor\ = \frac{Standard\ global\ radiation \frac{kWh}{m2} month}{Actual\ global\ insolation \frac{kWh}{m2} month}$$

4.6.2 Solar thermal systems

The output of solar thermal plants are monitored as heat to storage or district heating per m² collector vs global solar insulation per m² horizontal:

$$Thermal\ system\ efficiency = \frac{Solar\ heat\ produced, kWh}{Global\ radiation\ x\ F_{area}, kWh}$$

where: F_{area} is a factor of efficient panel area (approximately 0.9)

It is an overall <u>system efficiency</u> for the actual installation so therefore no correction is made for shade, orientation or tilt. Power for circulation pump is minor and therefore not monitored separately.

Normalisation to a standard year is made on monthly basis by multiplying the heat produced with a normalization factor

$$Normalisation\ factor\ = \frac{Standard\ global\ radiation \frac{kWh}{m2} month}{Actual\ global\ insolation \frac{kWh}{m2} month}$$

5 Energy performance targets from Building Energy Specification Table

In the Building Energy Performance Table (BEST) from the contract all prerequisites, requirements and performance targets for Kv. Isbanan are given.

The BEST no is SE-1. The project includes 10,704 m² new construction.

Local climate

The prerequisites of the local climate is summarized in Table 5.

Table 5: Local climate conditions

Local Climate		January average outside temperature	°C	0
		August average outside temperature	°C	16
Climatic Zone	Temperate	Average global horizontal radiation	kWh/m^2 yr	1000
(national definition)	Sweden SE	Annual heating degree days [3]	°Cd/yr	2900

Maximum requirements of building envelope

Maximum U-values and other key figures are given in Table 6.

Table 6: Maximum requirements of building envelope

Maximum requirements of building fabric			Existing building [5]	National regulation for new built [6]	**suggested** specification [7]	Energy savings [%] [8]
Façade/wall	U	W / m2K	n.a.	0,4	0,15	62,5
Roof	U	W / m2K	n.a.	0,25	0,12	52
Ground floor	U	W / m2K	n.a.	0,3	0,12	60
Glazing	U_g	W / m2K	n.a.	2	0,8	60
Average U-value	U_{av}	W / m2K	n.a.	n.a.	0,5	n.a.
Glazing	g	total solar energy transmittance of glazing [%	n.a.	none	0,3-0,6	n.a.
Shading	Fs	Shading correction factor	n.a.	none	external	n.a.
Ventilation rate [4]		air changes/hr	n.a.	126 m3/h /dwel.	0,3-0,5	n.a.

Building energy performance

The BEST also includes the target values for the energy consumption of the buildings see Table 7. The energy consumption is distributed on the parameters space heating, cooling, ventilation, lighting, hot water and common electricity and the table includes the energy performance for both an existing building, national regulations and the suggested specification.

The total energy performance target excl. appliances of the buildings is **42 kWh/m²** excluding electricity for households.

Table 7: Building energy performance divided into categories before and after refurbishment.

energy carrier existing building	**suggested energy carrier**		specify energy efficiency measures [13]	Existing building [5]	National regulation / normal practice for new built (2006) [6]*	**suggested** specification [7]	% Energy savings [8]
Heating + ventilation							
District Heat	Water	kWh/m²yr	Insulation + heat recovery + accumulation	132	66	9	86
Cooling + ventilation							
-	Air	kWh/m²yr	Sunshading	0	5	0	100
Ventilation (if separate from heating/cooling)							
Air	Air	kWh/m²yr	Demand control	8	7	4	43
Lighting							
	Photo Voltaic	kWh/m²yr	Daylight access + LED + controls only in public circulation area	15	11	4	64
Domestic Hot Water (DHW)							
District Heat	-	kWh/m²yr	Saving fixtures	33	28	20	29
Other energy demand							
	Electricity	kWh/m²yr	Freq. control. , red. idle load, a+labeled excl lifts	7	9	5	44
		kWh/m²yr	Subtotal sum of energy demand	195	126	42	67

Renewable energy sources

The energy consumption of the buildings are supplied with several renewable energy sources such as photovoltaics (PV), solar thermal, waste and biomass based district heating, waste water heat recovery and electricity from wind turbines, see Table 8.

Table 8: Contribution of renewable energy, kWh/m²/year

total production kWh/yr	m² installed	kW installed	specify RES measures	Existing building [5]	National regulation / normal practice for new built	**suggested** specification [7]	RES contribution [%][8]
23600	148	25	Building Integrated Photo Voltaic	0	0	2,2	5
24600	60	30	Solar heat interaction with DH	0	0	2,3	5
306176	n.a.	245	Green electricity from future windturbines	0	0	28,5	68
10743	n.a.	4	Wastewater heat recovery	0	0	1	2
257832	n.a.	n.a.	Additional waste & biobased DH 90% RES	n.a.	0	24	57
		kWh/m²yr	Subtotal sum of RES contribution	0	0	58,0	138

6 Monitoring of energy consumption

6.1 Monitoring period

In order to have the most accurate monitoring data, the data should be available for at least 1-2 years for all demonstration projects, which in the case of Kv. Isbanan is 14-16 months at June 2017. The three houses was finalised and inhabited with a few months in between why the one 8-storey house has monitoring data from December 2015 and the two other houses from February 2016.

For new buildings as well as refurbished buildings it takes approximately one or two years for the energy consumption to stabilise. There are several reasons for this and one is that the building (if it a residential building) typically is not 100% occupied from the beginning and therefore the first periods energy consumption can be misleading. Another reason is that the new installations requires a period of running in and optimisation of controls and operation. The energy consumption will also include energy for drying out of the building, which is very energy demanding in a concrete building.

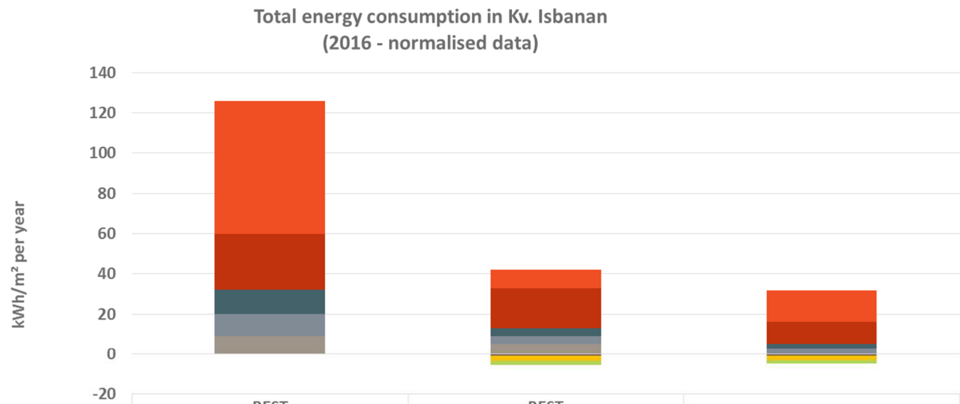
In the specific project, the tenants moreover have had a period of heating billing where the heating consumption is included in the rent. The reason for this is, that the housing company, Helsingborgshem, are planning to introduce a new energy management system, where the tenant will be accounted for the heating consumption through indoor temperature measurements. This is not fully in operation yet and therefore the heating is included in rent as a start.

6.2 Results of monitoring

Figure 23 shows an overview of the results from the monitoring of energy consumption and presents the reference consumption as from BEST, the BEST-target and the final actual consumption in 2016 as a normalised weighted average of the three buildings.

The monitoring objective was to go below the reference consumption of 126 kWh/m² per year to the target consumption of 42 kWh/m² per year and a reduction of 67 % according to BEST in Annex 1. The reduction of the actual normalised energy consumption compared to the reference is approximately 75% in 2016 corresponding to a final consumption of **32.0 kWh/m²**, which is well below the target. Including the contribution from RES, the resulting energy consumption is **27.3 kWh/m²**

The continued monitoring during 2017 shows that the projected energy consumption for 2017 will be app. 35 kWh/m². Including the contribution from the RES, the resulting energy consumption will be app. 30 kWh/m².



	BEST Reference	BEST Target values	Total weighted average
Space heating	66	9	15,8
DHW incl. pipe losses	28	20	11,2
Ventilation	12	4	2,4
Lighting	11	4	2,4
Other electricity (ex. lifts)	9	5	0,3
Solar thermal - flat plate	0	-2,3	-1,7
PV installation	0	-2,2	-2,0
Waste water heat recovery	0	-1	-0,9

Figure 23: Total energy consumption in Kv. Isbanan including reference consumption, BEST target values and normalised actual weighted average of the three buildings. Space heating the first year is above expected due to the drying out of the concrete.

In total, the actual energy consumption excl. RES is 24% lower compared to the target, which is very satisfying and a little unusual for new buildings. Most often new buildings go beyond the expected energy consumption due to the before mentioned reasons as running in of installations and drying out of the building.

As the results in Figure 23 show, the space heating is higher than expected. That can be attributed to two factors:

- The drying out of the concrete takes a significant amount of energy
- Based on experience with similar projects in Denmark with enclosed balconies, the occupants will often use the enclosed balconies as an extension of the living space – sometimes as a storage area. Hence the door to the enclosed balconies will often be open leading to an increased space heating consumption.

The energy used for heating of domestic hot water is however very low. Common electricity includes also lighting and is very close to the target value. This is also the fact for the renewable energy production, i.e. the solar thermal and the PV production and the heat recovery from the wastewater.

Domestic hot water supply

The supply of the domestic hot water comes from the RES based district heating (75 %), the solar thermal panels (16 %) and the wastewater heat recovery (10 %), see Figure 24. The annual correlation between the consumption, heat recovery, solar thermal production and district heating supply is illustrated in Figure 25. The hot water consumption is as expected decreasing in the summer period where tenants in general are less at home. The solar thermal plants produces most energy in the summer as expected and the waste water heat recovery is almost constant during the year.

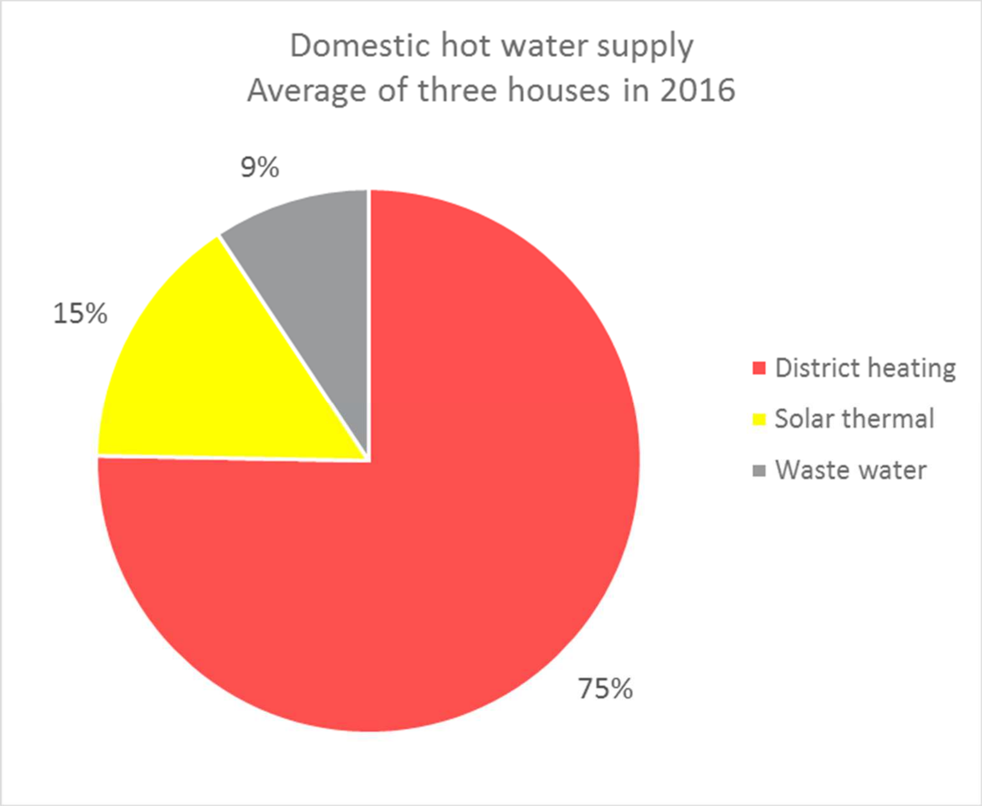


Figure 24: Sources of domestic hot water supply of Kv. Isbanan

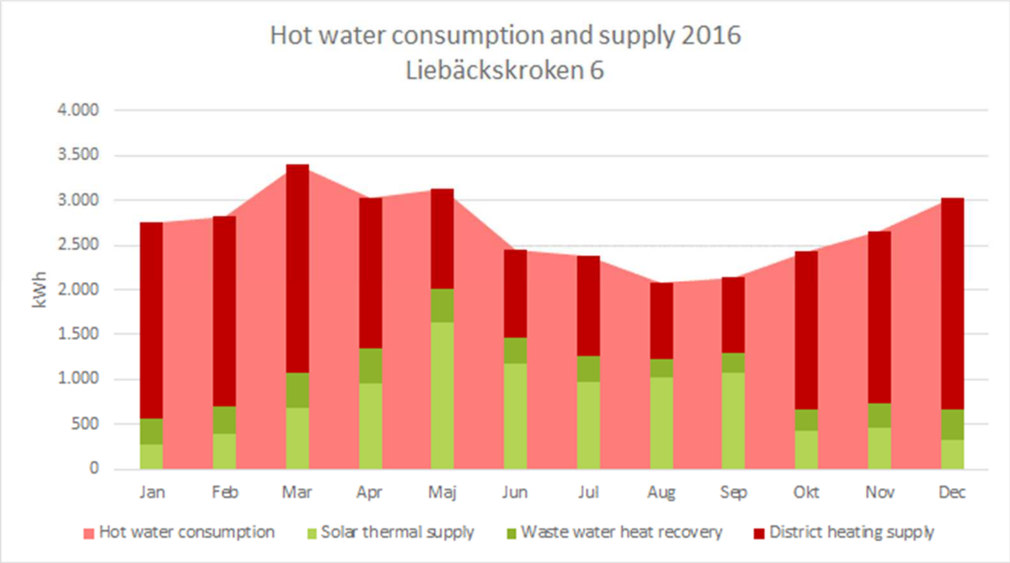


Figure 25: Annual correlation between domestic hot water consumption and supply for Liebäckskroken 6. (House 1 in Table 2)

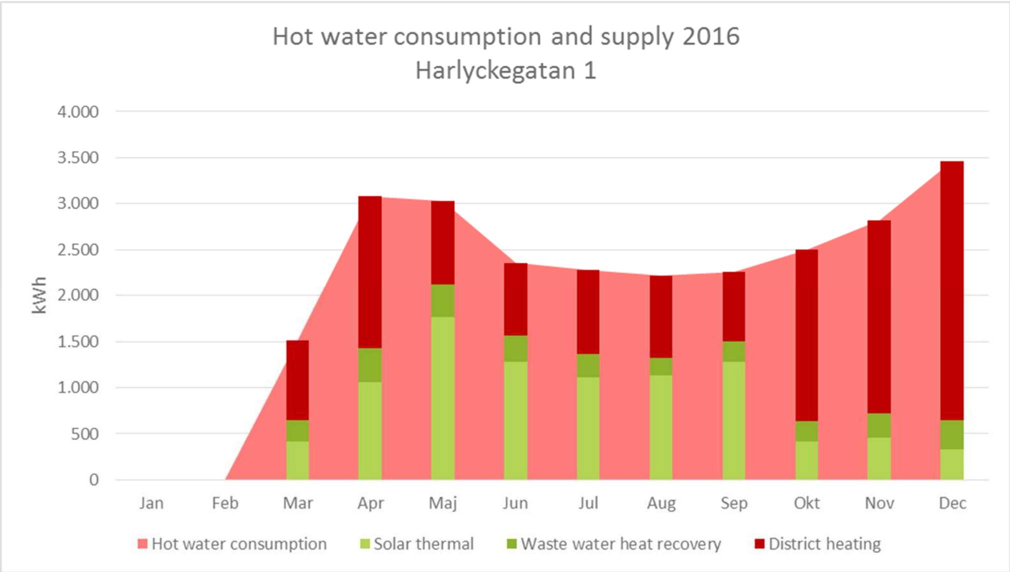


Figure 26: Annual correlation between domestic hot water consumption and supply for Harlyckegatan 1. (House 2 in Table 2)

PV

The correlation between the production of the PV plant and the electricity consumption from the 11-storey house is illustrated in Figure 27. The figures show that a large share of the electricity consumption in summer period is covered by own production.

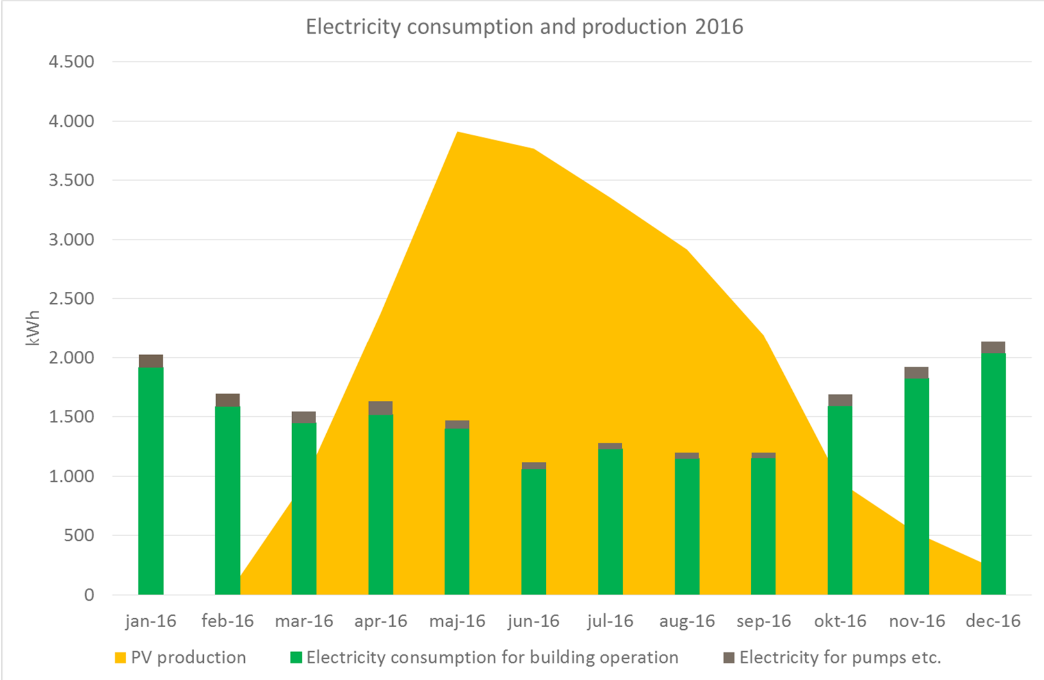


Figure 27: Correlation between PV production and electricity consumption. (House 3 in Table 2)

7 Environmental impact

7.1 CO_2 emission basis and targets

Annex 1 describes the baseline for the CO_2 monitoring compared with investment costs and energy savings see Table 9.

The basis for the CO2 calculation is UCTE mix 2007 for marginal electricity consumption (629 g CO_2/kWh) and Swedish average in 2008 for district heating (74 g CO_2/kWh) as the system is exchanging energy in/out of the city.

Table 9: Key figures from Description of Work (DOW) on energy savings and CO_2 savings.

Saved prim. energy	Saved CO2	**CO2 footprint**	Lifespan	**Total saved CO2**	**Cost**
KWh/m2/y	kg/m2/y	**kg/m2/y**	Years	**kg/m2 in life**	**EUR/ ton CO2**
114	31	**-4,12**	>50	**1562**	**-161**
		negative i.e. CO2 reducing			**negative!**

For the 10400 m2 in Helsingborg project:

Saved prim. energy	Saved CO2	**CO2 footprint**	Lifespan	**Total saved CO2**	**Cost**
MWh/y	ton/y	**ton/y**	Years	**ton/m2 in life**	**EUR/ ton CO2**
1186	325	**-43**	>50	16241	**-161**

7.2 CO_2-emission factors

Electricity

At the energy supply company in Helsingborg, the customers can choose between the regular electricity and electricity based on 100 % renewable energy. In 2015, the regular mix of fuels for the electricity production was 21 % from fossil fuels, 20 % from nuclear power and 59 % from renewable energy sources (mainly waste-to-energy and biomass), see Figure 28. Today, in 2017, only approx. 4 % of the fuels comes from fossil sources.

Helsingborgshem are one those clients that are receiving electricity based on 100 % renewable energy sources. For that reason, the calculation prerequisite for the CO_2 emission is based on an emission factor of **0 g/kWh**.

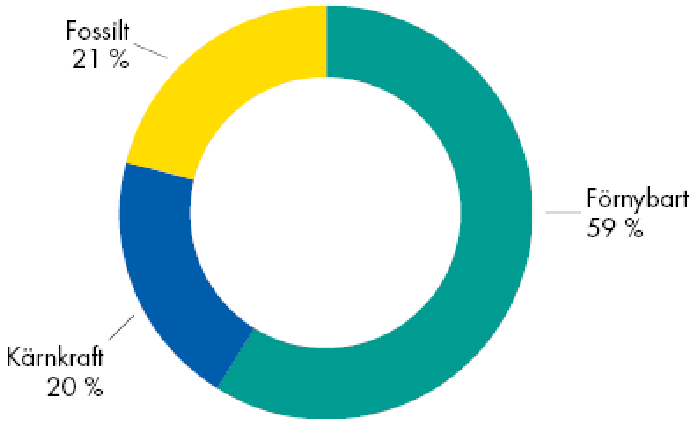


Figure 28: Distribution of Öresundskrafts electricity production in 2015. 21 % fossil fuel, 20 % nuclear power and 59 % renewable (waste and biomass). (Fossilt = fossil, kärnkraft = nuclear, förnybart = renewable) (https://oresundskraft.se/privat/produkter-tjaenster/elhandel/ursprungsmaerkning/)

District heating

The district heating for KV. Isbanan is also supplied by Öresundskraft. Table 10 shows the CO_2 emission factor and the share of fossil fuels in the production of the district heating in 2015 and 2016.

Table 10: Environmental factors of the district heating production in Helsingborg

District heating in Helsingborg	2015	2016
CO_2 emission	39 g CO_2 eqv./kWh	38 g CO_2 eqv./kWh
Share of fossil fuels	0.4 %	0.5 %

7.3 CO_2 emission results

The extensive energy savings that are a result of the NEXT-Buildings project, has led to corresponding wide CO_2 emission savings. See Figure 29 and Figure 30 for the overall impact the NEXT-Buildings-project. The figures are based on 2016-figures for energy consumption and production and 2008 and 2016 CO_2-emission factors, respectively. The figures compare the emission from the year of project application (2008) and the reference energy consumption at this time with the actual emission at the project end for the actual energy consumption.

The CO_2 emission from the demonstration buildings built according to building regulations and the reference consumption according to 2008 would have been **290 tons/year**. This number is now only **55 tons/year** when calculated with 2007 emission factors, which is CO_2-savings of 235 tons/year or 22 kg/m²/year. In fact, the true emission in 2016 was only **11 tons/year** when calculated with 2016 emission factors. This corresponds to a reduction of 81 % when using 2007 factors or 96 % when using 2016 factors compared to original 2007 reference.

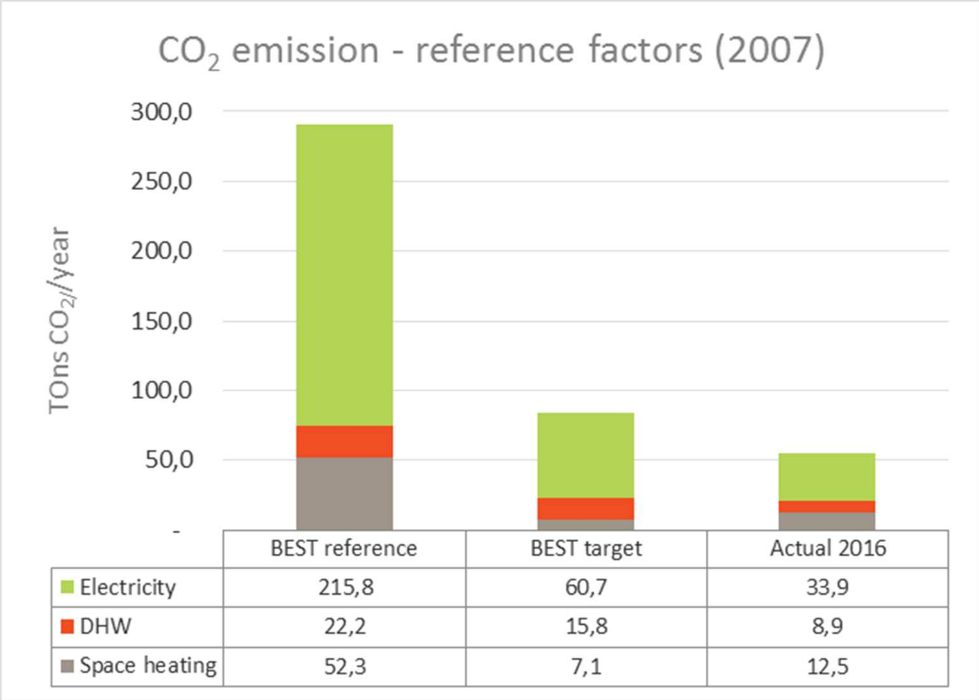


Figure 29: CO_2 emission from KV. Isbanan in Helsingborg based on energy consumption and production figures from 2016 and reference CO_2 emission factors from 2007 (Ref. DoW).

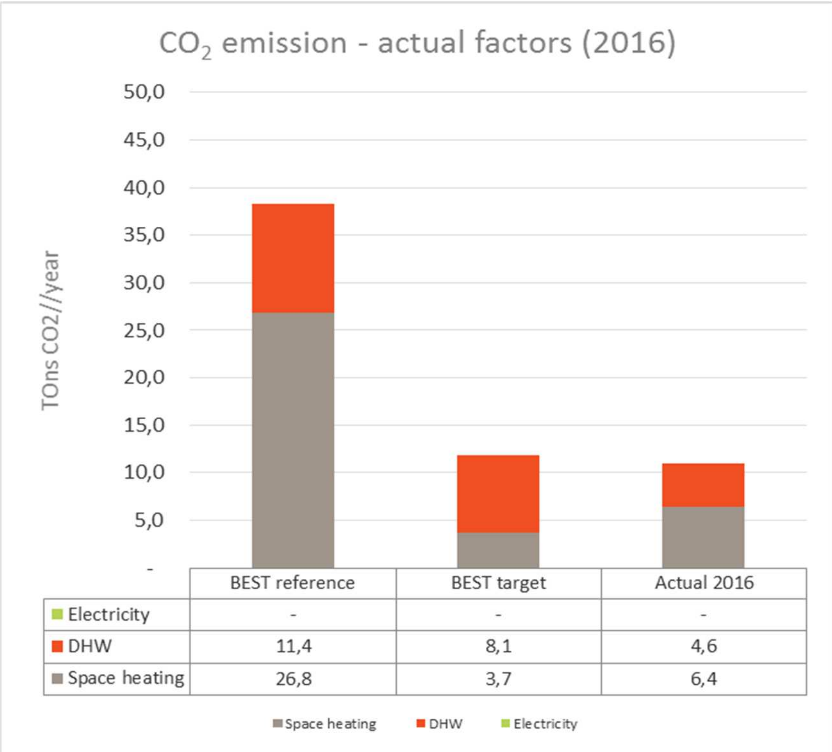


Figure 30: CO_2 emission from KV. Isbanan in Helsingborg based on energy consumption and production figures and actual CO_2 emission factors from 2016 (latest available).

7.4 CO_2 displacement

The renewable energy plants at Kv. Isbanan produced 38,534 kWh in 2016 (normalised) and the wastewater heat recovery system recovered 11,774 kWh in the same period, see Table 11. The BEST-scheme indicates that 28.5 kWh/m² was supposed to come from a wind turbine, but this wind turbine was not realised and has been omitted from the project. The district heating in Helsingborg is running on waste and biofuel (96 %) as indicated in the BEST scheme, but is not included in the Table 11. The actual production is very close to the target.

Table 11: Total production of renewable energy systems at Kv. Isbanan in 2016.

Renewable Energy System	Reference		Actual	
Production 2016	kWh/m²	kWh	kWh/m²	kWh
Solar thermal plant	2.3	24,619	2.0	18,673
PV plant	2.2	23,549	2.0	21,155
Waste water heat recovery	1.0	10,704	0.9	10.090
Total	**5.5**	**58,872**	**4.7**	**49,918**

The energy production from RES converted into CO_2 savings result in a total CO_2 saving of **15.6 tons/year** if using 2007-factors, see Figure 31, which corresponds to a reduction of 28.4 % compared to the emission without the RES contribution. Using 2016-factors, the CO_2 displacement from the local RES is **1.2 tons/year,** see Figure 32, which corresponds to a reduction of 10.9 %.

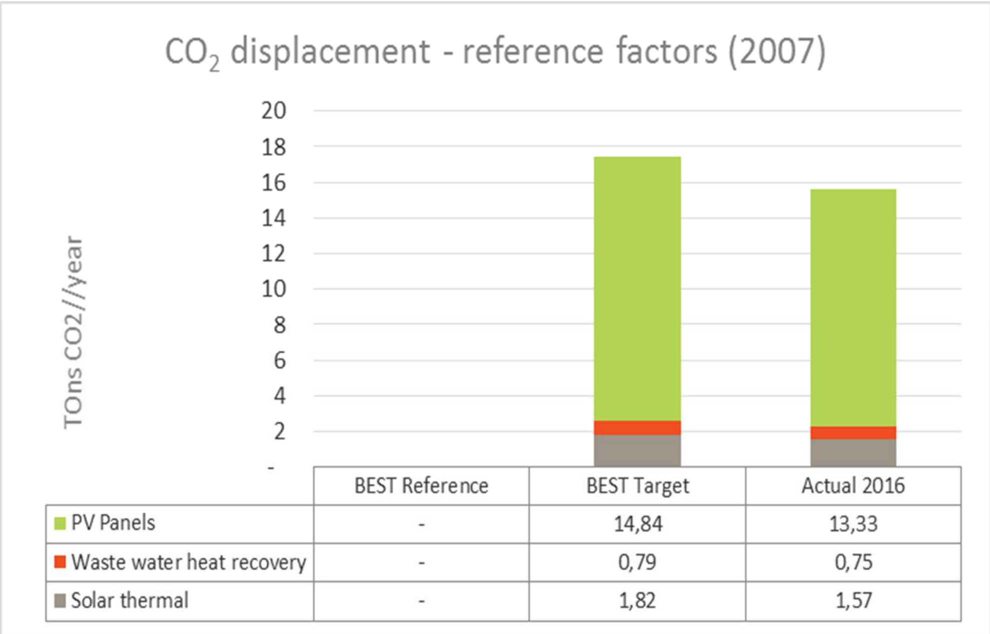


Figure 31: CO_2 displacement of renewable energy systems in 2016 in a reference situation and the actual situation (2007-factors)

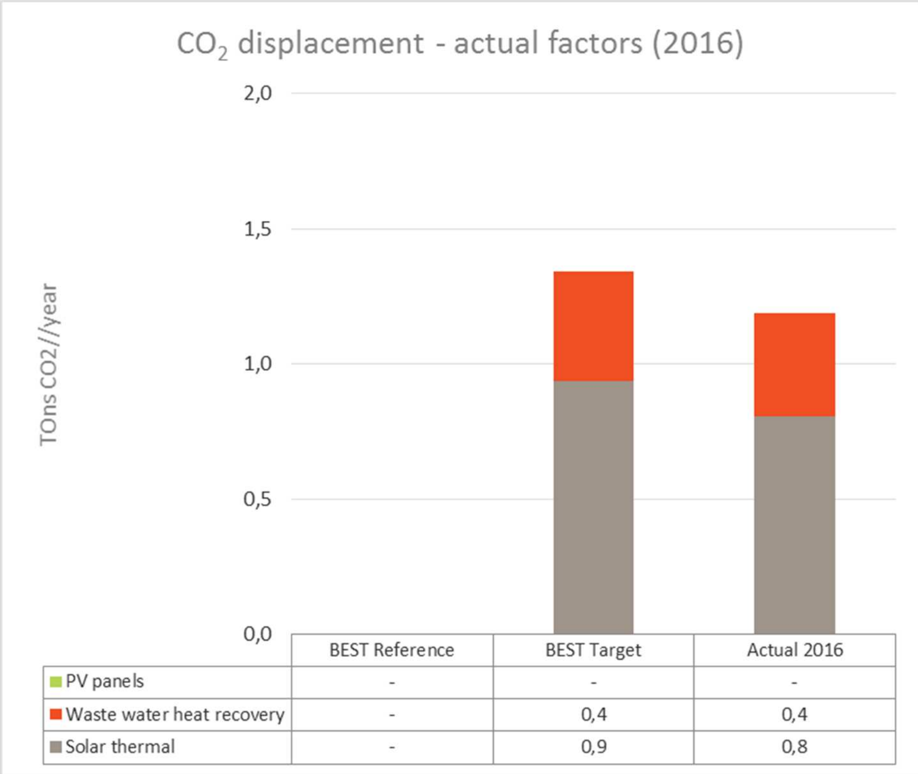


Figure 32: CO_2 displacement of renewable energy systems in 2016 in a reference situation and the actual situation (2016-factors).

7.5 CO_2 balance

The total CO_2 balance is the difference between emitted and displaced CO_2. Figure 33 and Figure 34 shows the CO_2 balance of the three scenarios: Reference, target and actual situation using both 2007 and 2016 CO_2-emission factors. In Figure 33, the actual CO_2 balance is lower than the target due to significant savings on almost all energy consumption except room heating

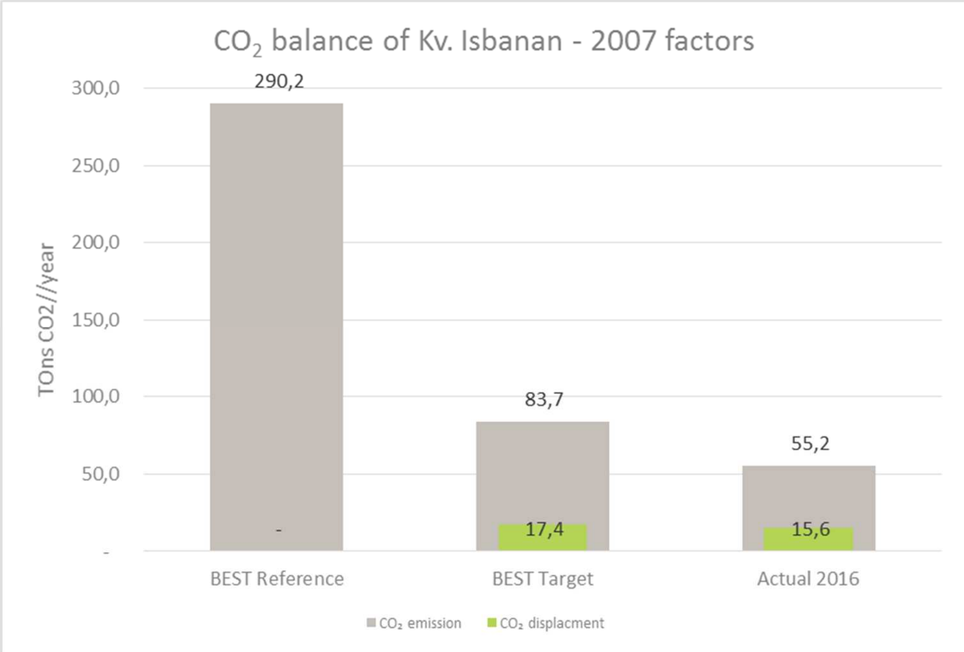


Figure 33: *CO_2 balance of Kv. Isbanan in reference, target and actual situation (2007-factors)*

When using 2016-factors, the actual CO_2 emission is slightly lower than the target.

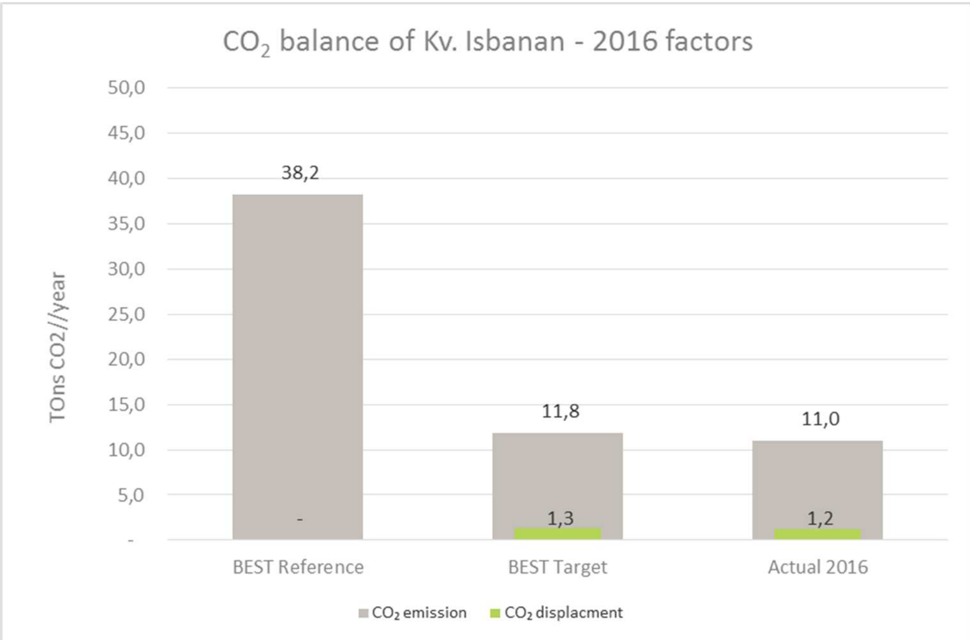


Figure 34: *CO_2 balance of Kv. Isbanan target and actual situation (2016-factors) compared with BEST reference excl. electricity*

The key figures from the Annex 1 of energy savings, CO_2 and investment costs are summarized in Table 12 and

Table 13. Basis for the calculations are:

- Area: 10,704 m²
- Total extra investment costs for the building and RES: 1.127.434 EUR
- Primary energy factor for electricity and district heating: 1.0

Table 12: Specific energy and CO_2 savings figures, target and actual.

	Saved primary energy	Saved CO_2	CO_2 foot print	Life span	Total saved CO_2	Cost
	kWh/m²/year	Kg/m²/year	Kg/m²/year	Years	kg/m² in life	EUR/ton CO_2
Target, Annex 1	114	31	-4.12	50	1562	-161
Actual	94	22	3.70	50	1098	1.1

Table 13: Energy and CO_2 savings figures, target and actual.

	Saved primary energy	Saved CO_2	CO_2 foot print	Life span	Total saved CO_2	Cost
	MWh/year	Tons/year	Tons/year	Years	Tons in life	EUR/ton CO_2
Target, Annex 1	1186	325	-43	50	16,241	-161
Actual	1026	235	40	50	11.752	1.1

8 Economic analysis

8.1 Definition of simple payback time

Energy savings and hence CO_2 savings are great advantages for the climate and usually they lead to economical savings. The most common financial indicator used to evaluate energy savings is the simple payback time.

As the name indicates, the simple payback time is a simple calculation of the number of years before the investment has been paid back only due to the annual energy savings. This calculation method does not take into account the inflation, interests, technical lifetime of the installed measures or changes in the energy prices. On the other hand, it is a term that is easy to understand. However, there is a risk that a simple payback time of more than 10-15 years easily can sound unattractive even though the technical lifetime of the measure is 20 years or more.

The simple payback period is calculated as:

$$Payback\ period\ = \frac{Investment}{Annual\ savings\ in\ energy\ costs - O\&M\ costs}$$

Where O&M costs are costs for operation and maintenance.

8.2 Investment costs and energy savings

8.2.1 Investment costs

The investment costs of the total Kv. Isbanan construction project was 21,500,000 EUR including contractor and developer expenses. Extra costs for energy saving measures and sustainability was in total 1.127.434 EUR, see Table 14.

Annex 1 states, that the expected extra costs for the buildings was 108 EUR/m² back in 2008 and turned out to be 105 EUR/m². The local RES was expected to lead to extra costs of 28 EUR/m², which is close to the actual costs of 27 EUR/m². The lower construction costs are most likely caused by the general development in the construction sector, where prices on construction materials follow the demand in the market and the tightening of the building regulations.

Table 14: Investment costs for Kv. Isbanan. Exchange rate: 9.5438 SEK/EUR

Extra costs for energy efficiency	Costs (SEK)	Costs (EUR)
User interface for energy monitoring	2.540.000	266.141
Building envelope	1.650.000	172.887
Ventilation	170.000	17.813
Solar thermal panels	1.200.000	125.736
Photovoltaics	1.200.000	125.736
Waste water heat recovery	350.000	36.673
Detailed design/energy concept	1.030.000	107.923
Energy efficient installations (LED etc.)	620.000	64.964
Measurements	1.100.000	115.258
User interface in staircases	100.000	10.478
Electrical chargers for EV's	50.000	5.239
Sustainable underground waste handling (10 fractions)	600.000	62.868
Rainwater collection and treatment	150.000	15.717
Total	**10.760.000**	**1.127.434**

8.2.2 Energy savings

The energy savings of the project was calculated separately for the three houses and converted into economical savings based on energy prices from Öresundskraft. Energy prices for the district heating supply of Öresundskraft including VAT was in 2016:

- Winter (Nov-Mar): 0.074 EUR/kWh
- Spring/autumn (Apr-May + Sep-Oct): 0.043 EUR/kWh
- Summer (Jun-Aug): 0.013 EUR/kWh

Energy prices including VAT for the electricity supply of Öresundskraft was in 2016:

- Supply fee: 0.047 EUR/kWh
- Transmission: 0.018 EUR/kWh
- Energy tax: 0.039 EUR/kWh
- Total: 0.104 EUR/kWh

Table 15 includes energy consumption data for the reference situation, the actual consumption and the normalised actual consumption. Table 16 includes the energy consumption converted into energy costs in SEK for the three situations. VAT is 25%. Both are included contribution from RES.

Table 15: Net energy consumption of the three houses for the reference situation, the actual measured data and the normalised actual data.

Energy consumption		BEST REF	**REFERENCE**				**ACTUAL 2016**				**ACTUAL Normalised**			
			B14	B15	B16	Total	B14	B15	B16	**Total**	B14	B15	B16	Total
Space heating		kWh/m²	kWh	kWh	kWh	kWh	kWh	kWh	kWh	**kWh**	kWh	kWh	kWh	kWh
Consumption (January)	January		51.434	64.360	41.871	**157.666**	16.703	14.920	12.553	**44.176**	13.968	13.052	10.981	**38.001**
Consumption (February)	February		35.127	57.821	37.162	**130.110**	10.083	12.420	10.323	**32.826**	9.539	11.726	9.746	**31.011**
Consumption (March)	March		26.614	63.664	31.088	**121.366**	7.933	14.170	8.993	**31.095**	7.227	12.910	8.153	**28.291**
Consumption (November)	November		24.493	37.252	26.924	**88.669**	8.933	10.145	9.393	**28.470**	6.651	7.554	7.061	**21.267**
Consumption (December)	December		31.861	44.340	31.858	**108.058**	8.693	9.033	8.473	**26.198**	8.652	8.992	8.355	**25.999**
Consumption (April)	April		12.966	25.883	13.274	**52.123**	5.243	7.815	5.093	**18.150**	3.521	5.249	3.481	**12.251**
Consumption (May)	May		-	-	-	**0**	-	-	-	**0**	0	0	0	**0**
Consumption summer (Jun-Aug)	Jun-Aug		-	-	-	**0**	-	-	-	**0**	0	0	0	**0**
Consumption (September)	September		-	-	-	**0**	-	-	-	**0**	0	0	0	**0**
Consumption (October)	October		15.043	18.068	15.362	**48.473**	6.183	5.545	6.033	**17.760**	4.085	3.664	4.029	**11.778**
Total		66	**197.538**	**311.388**	**197.538**	**706.464**	**63.768**	**74.048**	**60.859**	**198.675**	**53.645**	**63.146**	**51.807**	**168.598**
DHW from DH			kWh	kWh	kWh	**kWh**	kWh	kWh	kWh	kWh	kWh	kWh	kWh	**kWh**
Consumption winter			35.490	66.544	25.329	**127.363**	10.920	20.475	7.793	**39.188**	10.920	20.475	7.793	**39.188**
Consumption spring/autumn			17.615	48.360	16.835	**82.811**	5.420	14.880	5.180	**25.480**	5.420	14.880	5.180	**25.480**
Consumption summer			9.588	36.010	8.515	**54.113**	2.950	11.080	2.620	**16.650**	2.950	11.080	2.620	**16.650**
Pipe loss summer			10.522	15.031	9.872	**35.425**	3.238	4.625	3.038	**10.900**	3.238	4.625	3.038	**10.900**
Total		28	**73.215**	**165.946**	**60.551**	**299.712**	**22.528**	**51.060**	**18.631**	**92.218**	**22.528**	**51.060**	**18.631**	**92.218**
Electricity			kWh	kWh	kWh	**kWh**	kWh	kWh	kWh	**kWh**	kWh	kWh	kWh	**kWh**
Total electricity			95.776	150.976	95.776	**342.528**	16.989	17.886	-3.086	**31.789**	16.989	17.886	-3.086	**31.789**
Total		32	**95.776**	**150.976**	**95.776**	**342.528**	**16.989**	**17.886**	**-3.086**	**31.789**	**16.989**	**17.886**	**-3.086**	**31.789**
						1.348.704	5,7	3,8	-1,0	**322.682**				292.605

Table 16: Net energy costs of the three houses for the reference situation, the actual measured data and the normalised actual data.

Energy prices			**REFERENCE**				**ACTUAL 2016**				**ACTUAL Normalised**			
District heating	öre/kWh		SEK	SEK	SEK	SEK	SEK	SEK	SEK	SEK	SEK	SEK	SEK	SEK
Winter	70,9		120.111	189.479	119.668	**429.258**	37.085	42.998	35.237	**115.319**	32.618	38.424	31.384	**102.427**
Spring/autumn	40,8		11.428	17.932	11.683	**41.043**	4.661	5.451	4.539	**14.651**	3.103	3.636	3.064	**9.804**
Summer	12,4		0	0	0	**-**	0	0	0	**-**	0	0	0	**-**
Total			131.539	207.411	131.351	**470.301**	41.746	48.449	39.776	**129.970**	35.721	42.061	34.448	**112.231**
DHW from DH	öre/kWh		SEK	SEK	SEK	**SEK**	SEK	SEK	SEK	**SEK**	SEK	SEK	SEK	**SEK**
Consumption winter	70,9		25.145	47.147	17.945	**90.237**	7.737	14.507	5.522	**27.765**	7.737	14.507	5.522	**27.765**
Consumption spring/autumn	40,8		7.187	19.731	6.869	**33.787**	2.211	6.071	2.113	**10.396**	2.211	6.071	2.113	**10.396**
Consumption summer	12,4		1.189	4.465	1.056	**6.710**	366	1.374	325	**2.065**	366	1.374	325	**2.065**
Pipe loss summer	12,4		1.305	1.864	1.224	**4.393**	401	574	377	**1.352**	401	574	377	**1.352**
Total			34.825	73.207	27.094	**135.126**	10.715	22.525	8.337	**41.577**	10.715	22.525	8.337	**41.577**
Electricity	SEK/kWh		SEK	SEK	SEK	**SEK**	SEK	SEK	SEK	**SEK**	SEK	SEK	SEK	**SEK**
Electricity transmission fee	0,18		16.761	26.421	16.761	**59.942**	2.973	3.130	-540	**5.563**	2.973	3.130	-540	**5.563**
Energy taxes	0,45		43.099	67.939	43.099	**154.138**	7.645	8.049	-1.389	**14.305**	7.645	8.049	-1.389	**14.305**
Electricity supply fee	0,37		35.317	55.672	35.317	**126.307**	6.265	6.595	-1.138	**11.722**	6.265	6.595	-1.138	**11.722**
Total	0,99		**95.177**	**150.032**	**95.177**	**340.387**	**16.883**	**17.774**	**-3.067**	**31.590**	**16.883**	**17.774**	**-3.067**	**31.590**

Table 17 presents the total energy savings (kWh and EUR) of the three buildings incl. RES. The energy savings figures used for the economic analysis is the difference between **the reference consumption and the normalised actual consumption.**

Table 17: Total energy consumption of the three buildings incl. RES

	Unit	REFERENCE	ACTUAL 2016	Normalised 2016
Area	m²	10.704	10.704	10.704
Energy consumption HEATING	kWh/m² per year	94	26	24
Energy consumption ELECTRICITY	kWh/m² per year	32	3	3
Total energy consumption	**kWh/m² per year**	**126**	**29**	**27**
Energy consumption HEATING	kWh	1.006.176	279.883	259.793
Energy consumption ELECTRICITY	kWh	342.528	32.582	32.582
Total energy consumption	**kWh**	**1.348.704**	312.465	292.375
Energy costs HEATING (Exc. fixed fee)	SEK	605.427	171.547	153.808
Energy costs ELECTRICITY	SEK	340.387	31.590	31.590
Total energy costs	**SEK**	**945.814**	203.138	185.398

8.2.3 Payback period

In Table 18, the investment costs are separated into measures related to the construction of the building envelope, the installations and the renewable energy systems. Measures not leading to direct energy savings such as EV chargers and waste handling stations was not included in the calculations. Annual costs for operation and maintenance is, based on usual practice, assumed to be 1% of the investment costs for the building envelope and 2% for the electrical installations (excl. the RES installations).

For the wastewater heat recovery system, the O+M costs are set to 0 EUR/year, as there are no moving parts in the system and hence no reason for maintenance costs. For the photovoltaic system, the O+M costs are equivalent to the changing of the inverters every 10 years. For the solar thermal system, the O+M costs are equivalent to the cost of electricity for the circulation pumps.

Payback time BUILDING

Table 18: Investment costs, savings and simple payback time incl. VAT

		Demonstration building ekskl. RES (Total]	Demonstration building (building envelope) - Heat savings	Demonstration building (installations) - Mainly electricity savings	RES: Waste water heat recovery	RES: Solar thermal panels	RES: Photovoltaics	Total inkl. RES
Costs	SEK	8.010.000	6.277.000	1.733.000	350.000	1.200.000	1.200.000	**10.760.000**
Investment costs	EUR	839.288	657.704	181.584	36.673	125.736	125.736	**1.127.434**
Production 2016	kWh/year	-	-	-	10.090	18.673	21.155	**49.918**
Extra O&M costs	EUR/year	10.209	6.577	3.632	-	80	629	**10.917**
Annual savings	kWh/year	1.006.411	717.620	288.791	10.090	18.673	21.155	**1.056.329**
Annual savings	EUR/year	79.676	47.321	32.356	456	625	2.258	**83.015**
Simple Payback Time	Years	12,1	16,1	6,3	80	231	77	**15,6**
EU grant	EUR	535.200	-	-	-	-	-	**535.200**
Simple Payback Time	Years	4,4	-	-	-	-	-	**8,2**

The total payback time for the building (extra costs to reach the target of 42 kWh/m²) is **15.6 years** and **8.2 years** including the EU grant. The building design uses passive energy saving technologies such as a very compact volume, balconies to avoid solar heat gain and the construction is robust. Overall, this construction method results in great energy savings.

As the table shows, the simple payback time for the investment only related to the building envelope (heating savings) is **16.1 years** while it is **6.3 years** for the costs related to the installations (electricity savings).

Payback time RES

The payback period for the photovoltaics and the solar thermal systems seems very high with 231 years for solar thermal due to seasonal tariff structure on district heating and 77 years for PV. This is for the solar thermal system caused by the very low summer tariff of the displaced district heating

For the photovoltaics, the long payback period is caused by unusual high investment costs.

When selling to the grid, Kv. Isbanan receive 0.073 EUR/kWh incl. VAT from the local electricity provider and 0.063 EUR/kWh in tax refund – altogether 0.136 EUR/kWh incl. VAT. Hence, it is slightly more beneficial to sell the electricity to the grid than using the electricity internally when comparing with the total electricity price listed above

Moreover, the investment costs are remarkably high for both the photovoltaic system and the solar thermal collectors. The table lists up the prices used in this project compared with the market prices as of July 2017:

Table 19: Price in project compared to market price incl. VAT

	Price in project	Unit	Market price 2017	Unit	Actual payback period [Years]	Payback period with market price 2017 [Years]
Photovoltaics	5750	EUR/kWp	1400	EUR/kWp	77	19
Solar thermal	2096	EUR/m²	764	EUR/m²	231	84

As described in Table 19, the present market price for photovoltaic systems (medium size) is app. 4 times lower compared to the price paid and hence the payback period for future plants can be significantly reduced.

The economic analysis shows that due to energy tariffs in Helsingborg, it is not economical feasible to invest in solar heating. The investment costs are high and the energy price for district heating and the corresponding CO_2 savings are very low.

9 Socio-economic data

The city quarter Elineberg is located in the Southern and Eastern part of Helsingborgshem. The major part of the quarter was built between 1957 and 1965. The buildings around the three new houses at Kv. Isbanan is characteristic with its yellow brick walls and red tiled roof.

At the beginning, the three new houses was not popular among the inhabitants of the existing area at Elineberg, but this perception has changed since. The three houses contains 111 apartments in total and have had a very high occupancy rate right from the finalisation of the construction phase.

The inhabitants consists of a mix in age, family size and geographical origin. Thirty-five percent of the tenants have another ethnical background than Swedish and the age of the tenants distributes as shown in Figure 35. The average age is 47 years, but includes only the people stated in the tenancy agreement. Other residents are not registered. The average age of 47 years might be the reason why the domestic hot water consumption for these buildings is quite low (14 kWh/m² per year) compared to similar residential buildings. Elderly people have from experience a slightly lower consumption of domestic hot water than younger residents do. Only eleven of the 111 households in total have children, which distributes as in Figure 36.

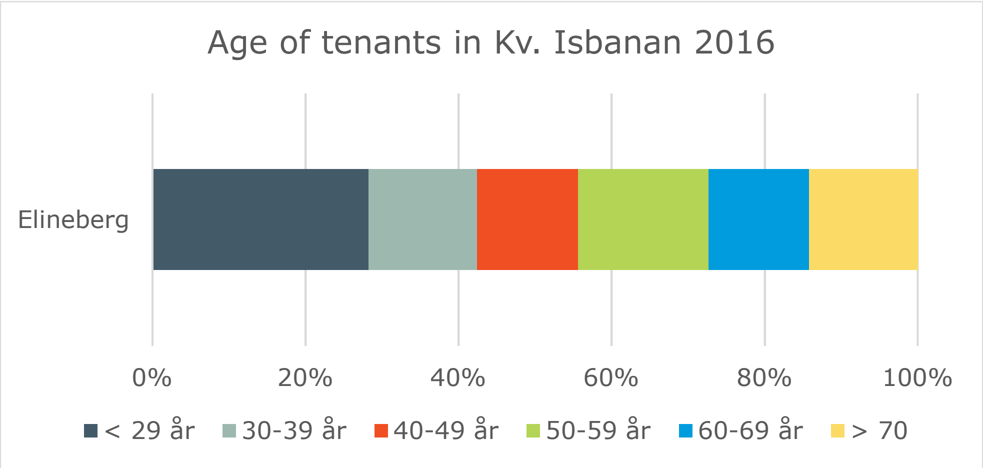


Figure 35 Distribution of age of residents in Kv. Isbanan.

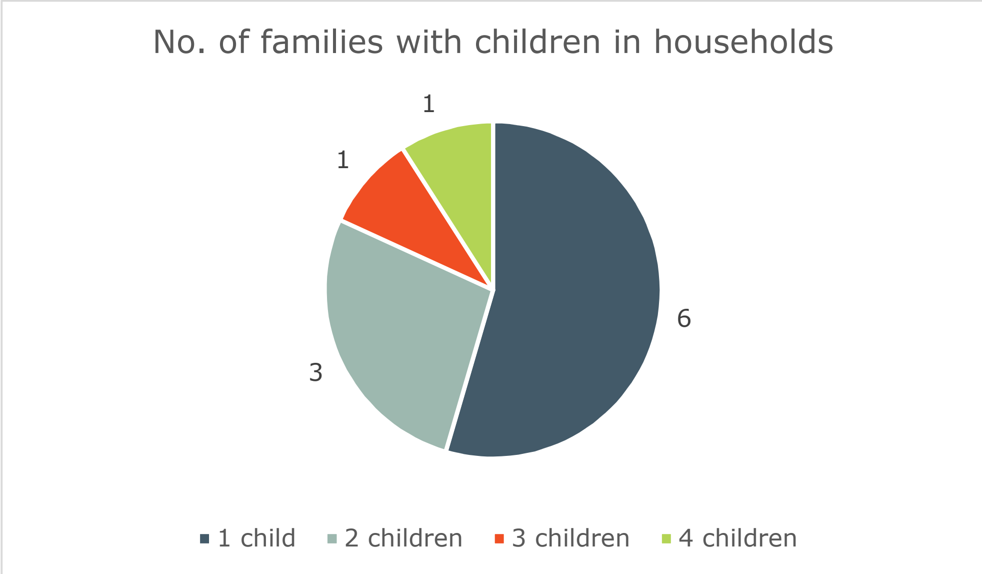


Figure 36: Number of families with children in Kv. Isbanan. Only 11 of 111 households have children.

The houses are located very centrally and has good facilities incl. lifts and a high safety. The rent for the new houses is higher than for the existing neighbourhood but this apparently has less influence at the popularity, see Figure 37. The new houses have a positive effect on the neighbourhood as they attract resourceful residents with a higher income than the rest of the Elineberg neighbourhood, see Table 20.

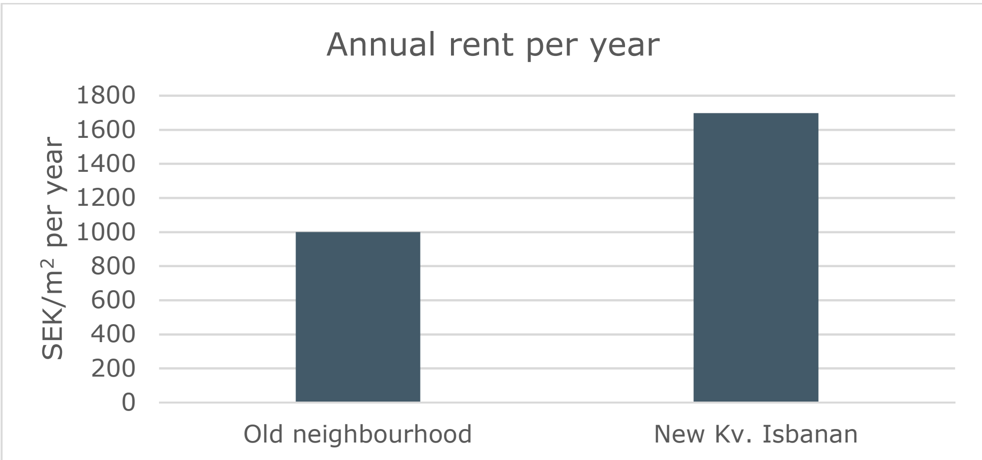


Figure 37: Annual rent per m² in SEK in existing neighbourhood and the new Kv: Isbanan.

Table 20: Mean value of available income in households in SEK/year

	Single	Cohabitants	Other	Total average
Quarter Elineberg	201 773	360 510	458 476	255 267

Total Helsingborg	240 785	570 919	551 624	411 005

10 Appendix A – Monitoring data sheets



NEXT buildings

Kv. Isbanan (SE1)

Liebäckskroken 6, 256 58 Helsingborg

General Data

Refurbished Building	Isbanan - house 1
Year built	2015
Year refurbished	n.a.
Address	Liebäkskroken 6
Building function	Multifamily building
Building type	High rise
Number of Apartments	30
Number of Occupants	60
Gross Floor Area (m²)	**2.993**
Gross Volume (m³)	8.081
Net Heated/Cooled Area (m²)	2.676
Net Heated/Cooled Volume (m³)	7.225
Basement Type	No basement
Attic Type	Flat roof
Total Investment cost [Euro/m2]	105

Building Features				Normal practice	BEST Target	Design (calc)	Actual (2015)
External walls		W/m²K		0,40	0,15	0,14	0,14
Roof		W/m²K		0,25	0,12	0,07	0,07
Ground floor		W/m²K		0,30	0,12	0,11	0,11
Windows (frame & glass)	3 layers	W/m²K		-	-	0,90	0,90
Average U-value of glazings		W/m²K		2,00	0,80	-	-
Average g-value of glazings		-			0,3-0,6	-	-
Ventilation Flow Rate average		l/s/m²		0,36		0,35	
Thermal Bridges	0,03 W/m² K						
Air tightness & n50 air change rate	0,25 l/s/m²						
Ventilation system type	Balanced ventilation with heat recovery						
Energy saving measures	Insulation, windows, heat recovery, solar energy						
Water saving measures							
Special building materials							
Type of Shading	No shading						

Energy Systems		Calculation prerequsites		
District Heating connection	Yes	Indoor air temperature	22	°C
Photovoltaic - grid connected	No	Degree days (2001-2014)	2.528	days
Solar thermal - flat plate	Yes	Degree days (2016)	2.526	days
Heat pump	No			
Boiler	No			

Key Energy figures	kWh/year/m² gross area	Normal practice	BEST target	Design		2016 (Normalized)	2017 (Normalized to full year)
Total Energy Demand		**126,0**	**36,5**	**41,7**		**32,6**	**33,4**
Total heat		94,0	29,0	32,4		31,3	32,5
Space heating		66,0	9,0	10,4		17,9	16,4
Domestic hot water		28,0	20,0	22,0		10,8	13,9
Pipe heat losses		incl.	incl.	incl		2,6	2,2
Total electricity		32,0	13,0	14,9		5,6	5,6
Ventilation		12,0	4,0	4,4		2,4	1,9
Other electricity (ex. lifts)		9,0	5,0	9,7		0,3	0,3
Pumps		incl.	incl.	0,8		0,3	0,3
Lighting (Shared space)		11,0	4,0	incl.		2,9	3,1
Energy - total		0,0	-5,5	-5,6		-4,3	-4,6
PV installation		0,0	-2,2	0,0		0,0	0,0
Solar thermal - flat plate		0,0	-2,3	-4,6		-3,2	-3,0
Heat recovery from waste water		0,0	-1,0	-1,0		-1,2	-1,6
Electricity for appliances (indication, costs not eligible)		35,0	24,0	n.a.		33,9	33,87
Lift						0,04	0,04

Liebäckskroken 6, 256 58 Helsingborg

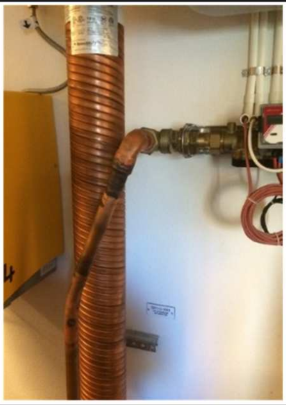
Address	Liebäkskroken 6
Typology of Dwelling	High rise
Occupants number	60
Occupants type	Mixed families
Ownership	Renting
Gross floor area (m²)	2.993

Monito-ring Period	Energy Total (kWh)	Total/m² (kWh/m²)	Total heating (kWh)	Hot water (kWh)	Heat losses space heating (kWh)	Space heating (kWh)	Space heating (Normalized) (kWh)	Total electricity consumption (kWh)	Common Lighting	Vent. (appt.) (kWh)	Vent. (storage) (kWh)	Pumps	Water: Cold water (m³)	Hot water from DH (kWh)	Hot water (m³)	RES: Local heat producti (kWh)
jan-16	**21.260**	7,10	19.540	2.750	648	16.703	**13.968**	1.720	791	815	16,1	88,5	161	2.190	56,8	560
feb-16	**14.222**	4,75	12.850	2.820	648	10.083	**9.539**	1.372	657	618	4,4	83,1	153	2.120	56,1	700
mar-16	**12.332**	4,12	10.910	3.400	648	7.933	**7.227**	1.422	688	615	4,5	104,6	177	2.330	66,0	1070
apr-16	**8.931**	2,98	7.570	3.030	648	5.243	**3.521**	1.361	670	579	10,1	92,1	168	1.680	60,2	1350
maj-16	**4.340**	1,45	3.000	3.130	648	1.233	**0**	1.340	718	533	5,4	74,1	188	1.120	63,9	2010
jun-16	**3.299**	1,10	1.670	2.450	690	690	**0**	1.629	704	846	6,1	63,2	172	980	51,6	1470
jul-16	**2.841**	0,95	1.590	2.380	470	470	**0**	1.251	692	482	5,1	61,8	173	1120	55,6	1260
aug-16	**2.894**	0,97	1.530	2.080	680	680	**0**	1.364	727	560	4,7	63,2	163	850	49,5	1230
sep-16	**2.892**	0,97	1.600	2.140	750	750	**0**	1.292	750	466	5,1	61,0	180	850	52,5	1290
okt-16	**10.033**	3,35	8.600	2.430	648	6.183	**4.085**	1.433	795	533	4,8	90,9	186	1770	59,7	660
nov-16	**12.907**	4,31	11.500	2.660	648	8.933	**6.651**	1.407	802	501	4,9	89,3	175	1920	55,6	740
dec-16	**13.098**	4,38	11.700	3.030	648	8.693	**8.652**	1.398	782	508	5,1	93,3	182	2360	67,9	670
TOTAL	**109.049**	36	92.060	32.300	7.770	67.590	**53.645**	16.989	8.775	7.055	76	965	2.079	19.290	696	13.010

Wastewater heat recovery

General Data — Liebäckskroken 6, 256 58 Helsingborg

New RES	Heat recovery from waste water
Year installed	2015
Installation type	Heat recovery unit
Address	Liebäckskroken 6
Installed capacity [kWp]	n.a.
Quantity [pieces]	1
Area [m²]	n.a.
Slope [°]	n.a.
Orientation	n.a.
Est. annual prod. [kWh]	3500
Annual CO_2-savings [tons]	0,29
Total Investment cost [€]	7090



Monitoring Period	Heat recovered kWh
jan-16	290
feb-16	310
mar-16	380
apr-16	390
maj-16	370
jun-16	290
jul-16	280
aug-16	210
sep-16	210
okt-16	230
nov-16	280
dec-16	340
TOTAL	**3580**
jan-17	380
feb-17	390
mar-17	460
apr-17	430
maj-17	430
jun-17	430
jul-17	360
aug-17	330
sep-17	330
okt-17	
nov-17	
dec-17	
TOTAL	**3540**

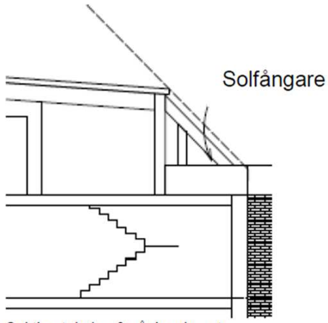
Only summed for January – August 2017

Solar thermal plant

General Data

Liebäckskroken 6, 256 58 Helsingborg

New RES	Solar thermal system
Year installed	2015
Installation type	Solar thermal system
Address	Liebäckskroken 6
Installed capacity [kWp]	n.a.
Quantity [pieces]	n.a.
Area [m²]	30
Slope [°]	45
Orientation	S-SE
Est. annual prod. [kWh]	12300
Annual CO_2-savings [tons]	0,83
Total Investment cost [€]	66483



Sektion takplan 8-våningshuset

	Heat		Climate		Performance
	Heat produced				
	Actual	Normal.	Global solar radiation (actual)	Global solar radiation (normal year)	**Efficiency**
Monitoring Period	**kWh**	**kWh**	**kWh/m²**	**kWh/m²**	**%**
jan-16	**270**	259	***14***	**14**	**63%**
feb-16	**390**	379	***31***	**30**	**42%**
mar-16	**690**	644	***69***	**65**	**33%**
apr-16	**960**	999	***105***	**109**	**30%**
maj-16	**1.640**	1.353	***189***	**156**	**29%**
jun-16	**1.180**	1.122	***173***	**165**	**23%**
jul-16	**980**	956	***159***	**155**	**21%**
aug-16	**1.020**	981	***135***	**130**	**25%**
sep-16	**1.080**	854	***101***	**80**	**36%**
okt-16	**430**	454	***40***	**42**	**36%**
nov-16	**460**	351	***23***	**17**	**67%**
dec-16	**330**	333	***10***	**10**	**109%**
TOTAL	**9.430**	8.685	**1.050**	**973**	**30%**
jan-17	**330**	310	***15***	**14**	**75%**
feb-17	**520**	606	***26***	**30**	**67%**
mar-17	**720**	764	***61***	**65**	**39%**
apr-17	**1.250**	1.257	***109***	**109**	**38%**
maj-17	**1.570**	1.560	***157***	**156**	**33%**
jun-17	**1.180**	1.247	***156***	**165**	**25%**
jul-17	**1.250**	1.363	***142***	**155**	**29%**
aug-17	**1.200**	1.205	***129***	**130**	**31%**
sep-17			***71***	**80**	
okt-17			***0***	**42**	
nov-17			***0***	**17**	
dec-17			***0***	**10**	
TOTAL	**8.020**	**8.310**	**866**	**973**	

Only summed for January – August 2017



NEXT buildings

Kv. Isbanan (SE1)

Harlyckegatan 1, 256 58 Helsingborg

General Data

Refurbished Building	Isbanan - house 2
Year built	2015
Year refurbished	n.a.
Address	Harlyckegatan 1
Building function	Multifamily building
Building type	High rise
Number of Apartments	30
Number of Occupants	60
Gross Floor Area (m^2)	2.993
Gross Volume (m^3)	8.081
Net Heated/Cooled Area (m^2)	2.676
Net Heated/Cooled Volume (m^3)	7.225
Basement Type	No basement
Attic Type	Flat roof
Total Investment cost [Euro/m2]	105

Building Features

Building Features				Normal practice	BEST Target	Design (calc)	Actual (2015)
External walls		W/m^2K		0,40	0,15	0,14	0,14
Roof		W/m^2K		0,25	0,12	0,07	0,07
Ground floor		W/m^2K		0,30	0,12	0,11	0,11
Windows (frame & glass)	3 layers	W/m^2K		-	-	0,90	0,90
Average U-value of glazings		W/m^2K		2,00	0,80		
Average g-value of glazings		-			0,3-0,6		
Ventilation Flow Rate average		$l/s/m^2$		0,36		0,35	
Thermal Bridges	0,03 W/m^2K						
Air tightness & n50 air change rate	0,25 $l/s/m^2$						
Ventilation system type	Balanced ventilation with heat recovery						
Energy saving measures	Insulation, windows, heat recovery, solar energy						
Water saving measures							
Special building materials							
Type of Shading	No shading						

Energy Systems

Energy Systems		Calculation prerequisites		
District Heating connection	Yes	Indoor air temperature	22	°C
Photovoltaic - grid connected	No	Degree days (2001-2014)	2.528	days
Solar thermal - flat plate	Yes	Degree days (2016)	2.526	days
Heat pump	No			
Boiler	No			

Key Energy figures

Key Energy figures	kWh/year/m^2 gross area	Normal practice	BEST target	Design		2016 (Normalized)	2017 (Normalized to full year)
Total Energy Demand		126,0	36,5	42,7		33,2	33,3
Total heat		94,0	29,0	32,4		30,8	33,1
Space heating		66,0	9,0	10,4		17,3	16,7
Domestic hot water		28,0	20,0	22,0		11,0	14,1
Pipe heat losses		incl.	incl.	incl		2,4	2,3
Total electricity		32,0	13,0	14,9		6,4	5,2
Ventilation		12,0	4,0	4,4		2,7	1,8
Other electricity (ex. lifts)		9,0	5,0	9,7		0,4	0,2
Pumps		incl.	incl.	0,8		0,4	0,2
Lighting		11,0	4,0	incl.		3,3	2,9
Energy production		0,0	-5,5	-4,6		-4,0	-4,9
PV installation		0,0	-2,2	0,0		0,0	0,0
Solar thermal - flat plate		0,0	-2,3	-4,6		-3,1	-3,5
Heat recovery from waste water		0,0	-1,0	0,0		-0,9	-1,4
Electricity for appliances (indication, costs not eligible)		35,0	24,0	n.a.		22,4	22,4
Lift						0,04	0,04

Harlyckegatan 1, 256 58 Helsingborg



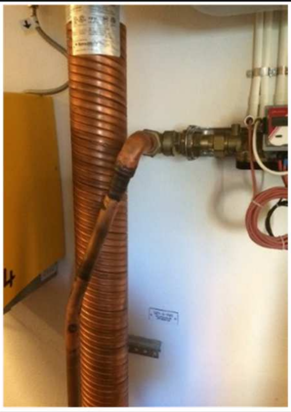
Address	a		
Typology of Dwelling			
Occupants number			
Occupants type	M		
Ownership		Lift pr. month	
Gross floor area (m²)	2.993		9,75

Monito-ring Period	Energy												Water			RES
	Total	Total/m²	Total heating	Hot water	Heat losses	Space heating	Space heating (correct.)	Total	Common lighting	Vent. (appt.)	Vent. (Storage room)	Pumps	Cold water	Hot water from DH	Hot water	Local heat producti
	kWh	kWh/m²	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh		m³	kWh	m³	kWh
jan-16	**1.264**	0,42	0	0	608	0	6.959	1264	710	516	28	75	165	0	54	0
feb-16	**1.174**	0,39	0	0	608	0	5.583	1174	353	783	28	140	165	0	54	0
mar-16	**12.448**	4,16	10.460	1.510	608	8.993	**8.153**	1.988	1171	779	28	177	103	860	33,8	650
apr-16	**8.956**	2,99	7.350	3.080	608	5.093	**3.481**	1.606	835	734	28	156	173	1.650	62,9	1430
maj-16	**5.060**	1,69	3.060	3.030	608	1.543	**0**	2.000	1287	675	28	125	183	910	62,8	2120
jun-16	**3.036**	1,01	1.470	2.360	*670*	670	**0**	1.566	457	1071	28	107	182	800	53,3	1560
jul-16	**3.293**	1,10	1.500	2.280	*580*	580	**0**	1.793	1144	611	28	105	172	920	54,6	1360
aug-16	**3.015**	1,01	1.540	2.220	*640*	640	**0**	1.475	729	709	28	107	167	900	54,7	1320
sep-16	**2.579**	0,86	1.300	2.260	*540*	540	**0**	1.279	775	466	28	61	178	760	55,1	1500
okt-16	**9.841**	3,29	8.500	2.500	608	6.033	**4.029**	1.341	770	533	28	91	180	1860	65,3	640
nov-16	**13.373**	4,47	12.100	2.820	608	9.393	**7.061**	1.273	773	479	11	70	179	2100	65,7	720
dec-16	**13.210**	4,41	11.900	3.463	608	8.473	**8.355**	1.310	808	481	12	74	197	2820	76,7	643
TOTAL	**77.249**	26	59.180	33.003	7.290	41.955	**43.621**	**18.069**	**9.813**	7.837	302	1.287	2.044	13.580	693	11.943
jan-17	**17.464**	5,83	16.200	3.780	567	12.553	**10.981**	1.264	774	468	12	77	199	3080	81,0	700
feb-17	**14.974**	5,00	13.800	3.700	567	10.323	**9.746**	1.174	702	452	11	70	187	2910	76,7	790
mar-17	**12.433**	4,15	11.100	4.050	567	7.643	**7.551**	1.333	834	478	12	79	206	2890	85,1	1160
apr-17	**8.666**	2,90	7.500	3.710	567	4.833	**3.189**	1.166	715	429	12	77	188	2100	76,6	1610
maj-17	**4.642**	1,55	3.500	3.600	567	1.223	**0**	1.142	690	430	12	60	191	1710	72,5	1890
jun-17	**3.226**	1,08	2.100	2.990	660	660	**0**	1.126	644	461	11	43	185	1440	72,0	1550
jul-17	**3.123**	1,04	2.000	3.090	420	420	**0**	1.123	697	405	12	45	200	1580	65,4	1510
aug-17	**3.297**	1,10	2.200	3.210	620	620	**0**	1.097	671	404	12	45	221	1580	81,7	1630
sep-17	**0**	0,00		0	567	0	**0**									0
okt-17	**0**	0,00		0	567	0	**3.754**									0
nov-17	**0**	0,00		0	567	0	**6.272**									0
dec-17	**0**	0,00		0	567	0	**8.496**									0
TOTAL	**67.825**	23	58.400	28.130	6.800	38.277	**49.990**	9.425		3.527	93		1.575		611	10.840

Wastewater heat recovery

General Data — Harlyckegatan 1, 256 58 Helsingborg

New RES	Heat recovery from waste water
Year installed	2015
Installation type	Heat recovery unit
Address	Liebäckskroken 6
Installed capacity [kWp]	n.a.
Quantity [pieces]	1
Area [m²]	n.a.
Slope [°]	n.a.
Orientation	n.a.
Est. annual prod. [kWh]	2700
Annual CO_2-savings [tons]	0,29
Total Investment cost [€]	7090



Monitoring Period	Heat recovered kWh
jan-16	
feb-16	
mar-16	240
apr-16	370
maj-16	360
jun-16	280
jul-16	250
aug-16	190
sep-16	220
okt-16	220
nov-16	260
dec-16	310
TOTAL	**2700**
jan-17	310
feb-17	330
mar-17	440
apr-17	360
maj-17	380
jun-17	300
jul-17	330
aug-17	300
sep-17	
okt-17	
nov-17	
dec-17	
TOTAL	**2750**

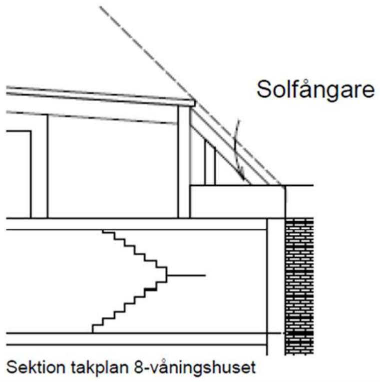
Only summed for January – August 2017

Solar thermal plant

General Data

Harlyckegatan 1, 256 58 Helsingborg

New RES	Solar thermal system
Year installed	2015
Installation type	Solar thermal system
Address	Liebäckskroken 6
Installed capacity [kWp]	n.a.
Quantity [pieces]	n.a.
Area [m²]	30
Slope [°]	45
Orientation	S-SE
Est. annual prod. [kWh]	12300
Annual CO_2-savings [tons]	0,83
Total Investment cost [€]	66483



	Heat		Climate		Performa
	Heat produced		Global solar radiation (actual)	Global solar radiation (normal year)	Nominal Efficiency
Monitori	kWh		kWh/m²	kWh/m²	%
jan-16		0	*14*	**14**	
feb-16		0	*31*	**30**	
mar-16	**410**	383	*69*	**65**	**20%**
apr-16	**1.060**	1.103	*105*	**109**	**34%**
maj-16	**1.760**	1.452	*189*	**156**	**31%**
jun-16	**1.280**	1.217	*173*	**165**	**25%**
jul-16	**1.110**	1.083	*159*	**155**	**23%**
aug-16	**1.130**	1.087	*135*	**130**	**28%**
sep-16	**1.280**	1.013	*101*	**80**	**42%**
okt-16	**420**	443	*40*	**42**	**35%**
nov-16	**460**	351	*23*	**17**	**67%**
dec-16	**333**	168	*20*	**10**	**55%**
TOTAL	**9.243**	8.300	**1.060**	**973**	**29%**
jan-17	**390**	366	*15*	**14**	**89%**
feb-17	**460**	536	*26*	**30**	**59%**
mar-17	**720**	764	*61*	**65**	**39%**
apr-17	**1.250**	1.257	*109*	**109**	**38%**
maj-17	**1.510**	**1.500**	*157*	**156**	**32%**
jun-17	**1.250**	**1.321**	*156*	**165**	**27%**
jul-17	**1.180**	**1.286**	*142*	**155**	**28%**
aug-17	**1.330**	**1.335**	*129*	**130**	**34%**
sep-17			*71*	**80**	
okt-17			*0*	**42**	
nov-17			*0*	**17**	
dec-17			*0*	**10**	
TOTAL	**8.090**	**8.365**	**866**	**973**	

Only summed for January – August 2017



NEXT buildings

Kv. Isbanan (SE1)

Liebäckskroken 8, 256 58 Helsingborg

General Data

Refurbished Building	Isbanan - house 3
Year built	2015
Year refurbished	n.a.
Address	Liebäkskroken 8
Building function	Multifamily building
Building type	High rise
Number of Apartments	51
Number of Occupants	90
Gross Floor Area (m²)	**4.718**
Gross Volume (m³)	12.739
Net Heated/Cooled Area (m²)	4.231
Net Heated/Cooled Volume (m³)	11.424
Basement Type	No basement
Attic Type	Flat roof
Total Investment cost [Euro/m2]	105

Building Features

			Normal practice	BEST Target	Design (calc)	Actual (2015)
External walls		W/m²K	0,40	0,15	0,14	0,14
Roof		W/m²K	0,25	0,12	0,07	0,04
Ground floor		W/m²K	0,30	0,12	0,11	0,11
Windows (frame & glass)	3 layers	W/m²K	-	-	0,90	0,90
Average U-value of glazings		W/m²K	2,00	0,80		
Average g-value of glazings		-		0,3-0,6		
Ventilation Flow Rate average		l/s/m²	0,36		0,35	
Thermal Bridges	0,03 W/m² K					
Air tightness & n50 air change rate	0,25 l/s/m²					
Ventilation system type	Constant Air Volume					
Energy saving measures	Balanced ventilation with heat recovery					
Water saving measures						
Special building materials						
Type of Shading	No shading					

Energy Systems

District Heating connection	Yes
Photovoltaic - grid connected	Yes
Solar thermal - flat plate	No
Heat pump	No
Boiler	No

Calculation prerequsites

Indoor air temperature	22	°C
Degree days (2001-2014)	2.528	days
Degree days (2016)	2.526	days

Key Energy figures

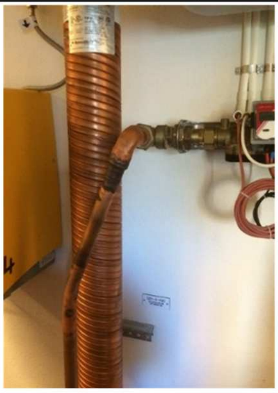
	kWh/year/m² gross area	Normal practice	BEST target	Design		2016	2017 (Normalized for full year)
Total Energy Demand		**126,0**	**36,5**	**40,9**		**25,8**	**26,3**
Total heat		94,0	29,0	32,0		27,3	28,4
Space heating		66,0	9,0	9,7		13,4	13,0
Domestic hot water		28,0	20,0	22,3		11,6	13,1
Pipe heat losses		incl.	incl.	incl.		2,4	2,3
Total electricity		32,0	13,0	14,5		3,7	3,3
Ventilation		12,0	4,0	4,1		2,1	1,8
Other electricity (ex. lifts)		9,0	5,0	9,8		0,2	0,2
Pumps		incl.	incl.	0,6		0,2	0,2
Lighting		11,0	4,0	incl.		1,4	1,1
Energy production		0,0	-5,5	-5,6		-5,3	-5,4
PV installation		0,0	-2,2	-5,6		-4,5	-4,3
Solar thermal - flat plate		0,0	-2,3	0,0		0,0	0,0
Heat recovery from waste water		0,0	-1,0	0,0		-0,8	-1,1
Electricity for appliances (indication, costs not eligible)		35,0	24,0	n.a.		22,2	22,2
Lift						0,1	0,1

Wastewater heat recovery

General Data

Liebäckskroken 8, 256 58 Helsingborg

New RES	Heat recovery from waste water
Year installed	2015
Installation type	Heat recovery unit
Address	Liebäckskroken 8, 256 58 Helsingborg
Installed capacity [kWp]	n.a.
Quantity [pieces]	1
Area [m²]	n.a.
Slope [°]	n.a.
Orientation	n.a.
Est. annual prod. [kWh]	3800
Annual CO_2-savings [tons]	0,29
Total Investment cost [€]	7090



Monitoring Period	Heat recovered kWh
jan-16	
feb-16	
mar-16	10
apr-16	300
maj-16	540
jun-16	450
jul-16	400
aug-16	390
sep-16	360
okt-16	410
nov-16	460
dec-16	490
TOTAL	**3810**
jan-17	540
feb-17	560
mar-17	560
apr-17	520
maj-17	520
jun-17	460
jul-17	430
aug-17	460
sep-17	
okt-17	
nov-17	
dec-17	
TOTAL	4050

Only summed for January – August 2017

Photovoltaics

General Data	Liebäckskroken 8, 256 58 Helsingborg
New RES	Photovoltaic system
Year installed	2016
Installation type	Photovoltaic system
Address	Liebäckskroken 8
Installed capacity [kWp]	22
Quantity [pieces]	n.a.
Area [m²]	148
Slope [°]	45
Orientation	S-SE
Est. annual prod. [kWh]	21000
Annual CO_2-savings [tons]	10,12
Total Investment cost [€]	117563

Period	Electricity		Climate		Performanc
	Electricity produced		**Global solar radiation (actual)**	**Global solar radiation (normal year)**	***Efficiency***
	Plant 1 kWh	**Plant 2** kWh	kWh/m²	kWh/m²	*%*
jan-16			*14*	30	0%
feb-16			*31*	65	0%
mar-16	389	555	*69*	109	9%
apr-16	954	1.422	*105*	156	15%
maj-16	1.592	2.320	*189*	165	14%
jun-16	1.524	2.244	*173*	155	15%
jul-16	1.348	2.005	*159*	130	14%
aug-16	1.183	1.732	*135*	80	15%
sep-16	927	1.264	*101*	42	15%
okt-16	391	559	*40*	17	16%
nov-16	203	317	*23*	10	15%
dec-16	85	142	*10*	14	15%
TOTAL	**8.595**	**12.560**	***1.004***	**973**	14%
jan-17	125	200	*26*	30	8%
feb-17	220	333	*61*	65	6%
mar-17	636	892	*109*	109	9%
apr-17	849	1.220	*157*	156	9%
maj-17	1.026	1.512	*156*	165	11%
jun-17	1.391	2.037	*142*	155	16%
jul-17	1.273	1.903	*129*	130	17%
aug-17	1.177	1.754	*71*	80	28%
sep-17			*0*	42	
okt-17			*0*	17	
nov-17			*0*	10	
dec-17			*0*	0	
TOTAL	**16.546**	**10.700**	**851**	**959**	

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