

Technical University of Denmark



Low-energy house in Sisimiut

Annual report of Low-energy house performance July 2009 to June 2010

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LOW-ENERGY HOUSE IN SISIMIUT

Annual report of Low-energy house performance
July 2009 to June 2010



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Preface

This Annual Report 5 of the low-energy house (LEH) in Sisimiut - Greenland, summarizes data of the measurements collected from 1st July 2009 to 30th June 2010. The report's layout and structure is identical with the previous annual reports of the LEH [1-4]. The report begins with a brief description of the house and the reference simulation used for evaluation/comparison of the estimated annual heat consumption. The report also presents results of the measurements from the house as well as the adjustments done within the mentioned period. Suggestions and plans for further actions are included in each chapter.

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Content

1	INTRODUCTION.....	1
1.1	KEY DATA FOR THE LOW-ENERGY HOUSE.....	1
1.2	LAYOUT AND CROSS-SECTION	2
1.3	SIMULATED ENERGY CONSUMPTION FOR HEATING	3
1.4	OBJECTIVES FOR ENERGY CONSUMPTION FOR HEATING	4
2	OVERVIEW OF MEASUREMENTS.....	5
3	PRESENTATION OF MEASUREMENTS.....	7
3.1	INDOOR TEMPERATURE AND HUMIDITY	7
3.2	AMBIENT TEMPERATURE AND HEATING DEGREE HOURS.....	8
3.3	OIL CONSUMPTION	10
3.4	HEATING DEMANDS	12
3.5	DOMESTIC HOT WATER CONSUMPTION	14
3.6	SOLAR ENERGY	15
3.7	SOLAR HEATING	17
3.8	ELECTRICITY CONSUMPTION	19
3.9	VENTILATION	20
4	AIR TIGHTNESS	23
5	COMMENTS ON LOW-ENERGY PERFORMANCE IN YEAR 5.....	24
6	LOW-ENERGY HOUSES' TECHNICAL JOURNAL.....	26
	REFERENCES	28
	ANNEX 1 – PHOTOS OF LOW-ENERGY HOUSE 2009/2010.....	29

1 Introduction

In year 2001, BYG•DTU, represented by the Arctic Technology Centre (ARTEK), Technical University of Denmark, has applied for a donation of 5 million DKK for the construction of a low-energy house in Sisimiut in Greenland.

The low-energy house was designed by Erik Møller Arkitekter A/S, together with research team from the Technical University of Denmark. In Greenland, the house was designed by Rambøll A/S and built by Arctic Sanasut ApS.

The low-energy house is built as a semi detached house with total floor area of 197 m² consisting of two symmetrical units (apartments), separated by a common central section with the entrance and the technical room/scullery. One of the apartments has been used as an ordinary dwelling inhabited by a Greenlandic family and the other as an exhibition for visitors and occasionally as a guest apartment.

The residents moved in February 2005, and in April 2005 the low-energy house was officially inaugurated/opened. During the five years of its operation there has been many research and measurements done. The outcomes were presented in scientific papers as well as at the conferences. Some of the findings were implemented into the building in order to improve its performance which has been higher than expected since the very beginning.

The aim of this report is to summarize results of the measurements and the adjustments (done and planned to be done) during the last year.

1.1 Key data for the low-energy house

Net area of house: 197 m²
Number of occupants: 2-3 adults

Constructions

Table 1 U-values for construction

Construction	Insulation thickness [mm]	U-value [W/m ² K]
Floor	350	0.14
Wall	300	0.15
Roof/ceiling	350	0.13
Windows	-	1.0 – 1.1

Ventilation

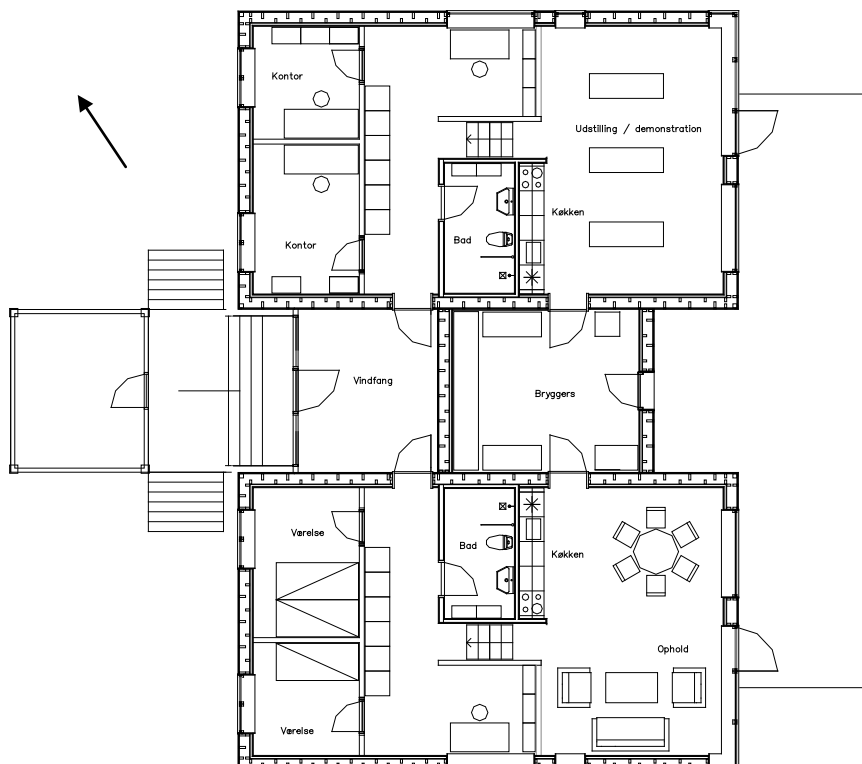
The ventilation system consists of two low energy ventilators, a heat exchanger, additional heating coil, air terminal devices and circular ducts. The fans are standard box fans from the company Exhausto type BESB 250-4-1 MGE equipped with frequency converter. A new type of HE was developed for the low-energy house in order to avoid freezing problems during cold periods. It consists of two aluminium counter flow plate heat exchangers Klingenburg GS 45/300 coupled in a serial connection.

Solar collectors

Area of collectors:	8.1 m ²
Tilting of collectors:	70°
Orientation of collectors:	Compass direction -56° (South = 0°, negative to East)
Solar tank:	257 liters

1.2 Layout and cross-section

Figure 1 shows the floor plan of the low-energy house and a vertical cross section through one of the apartments.



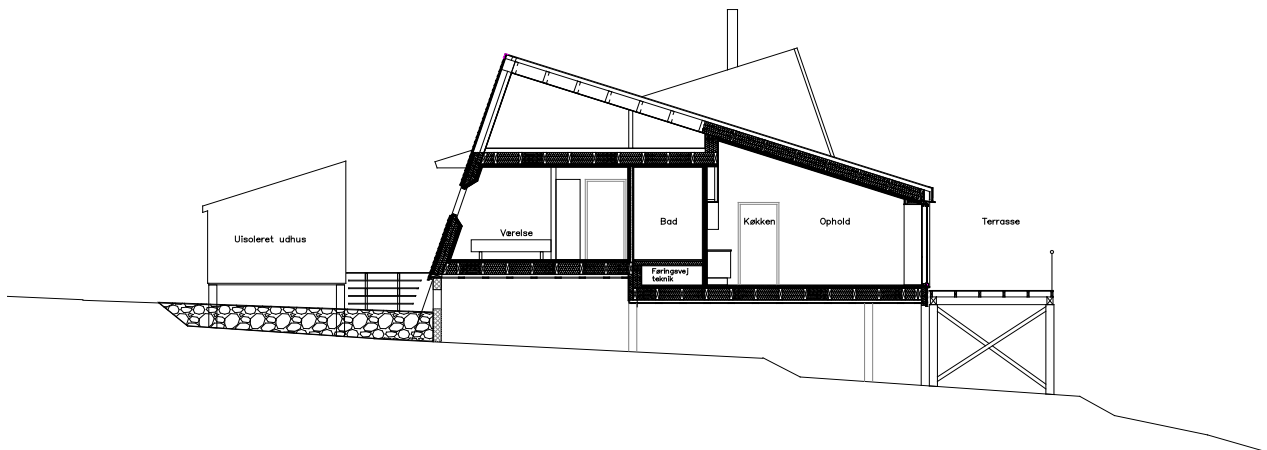


Figure 1 Low-energy house layout and cross section. The house is divided in two apartments, one serves as accommodation for a family and the other one as exhibition / guest house.

1.3 Simulated energy consumption for heating

A simulation model of half of the low-energy house was created in the building energy analysis program BSim [5]. For the simulation of ambient temperature the annual weather data of Sisimiut (test reference year - TRY) was used. Figure 2 shows the simulation model BSim. The simulation model is described in detail in [6].

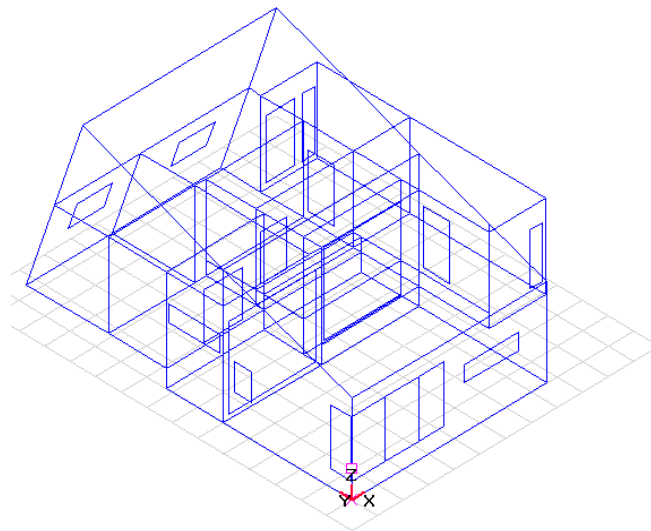


Figure 2 Simulated model from BSim

Figure 3 shows simulated annual energy consumption for heating per square meter as a function of interior temperature.

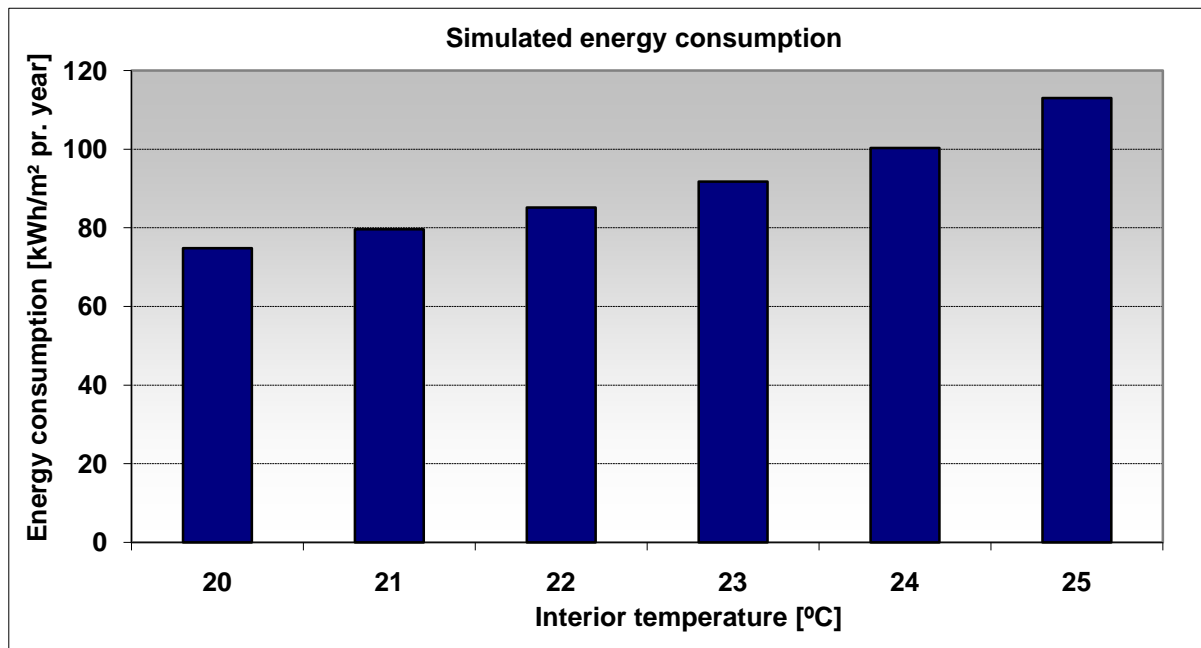


Figure 3 Simulated annual energy consumption (theoretical) for heating as a function of the interior temperature

It can be seen that the set point of interior temperature has a decisive influence on the energy consumption for heating. It is therefore necessary to know this when assessing whether the low-energy house lives up to the target in terms of energy consumption for heating.

1.4 Objectives for energy consumption for heating

According to the Greenlandic Building Code the energy frame for a single storey house which is built north of the Arctic Circle is 830 MJ/ (m²·year), equivalent to approx. 230 kWh/ (m²·year). The energy frame is based on the assumption that ventilation with heat recovery cannot yet be introduced in Greenlandic buildings, since experiences with the use of heat recovery system in buildings in the Arctic are still very limited. However, a standard Greenlandic detached house would probably be able to achieve a 50% reduction of its ventilation loss if a ventilation system with heat recovery were used. If demands for ventilation with heat recovery were introduced in the Greenlandic building code, the energy frame would likely be set to approximately 160 kWh/ (m²·year) for the part of Greenland north of the Arctic Circle.

A low-energy house is historically defined as a house that needs at most 50% of the energy for heating which is permissible according to the Building Code. Since furthermore the low-energy house in Sisimiut was planned to be equipped with a ventilation system with an optimized heat recovery unit, the goal was set at annual energy consumption for heating of 80 kWh/(m²·year).

Compared to the Danish energy frame, the requirement is equal to a low-energy class 2 house in the Danish Building Code. The comparison is made by correcting for the total number of heating degree hours. The Danish and Greenland energy framework calculation differs also in terms of energy consumption for hot water. This is contained in the Danish energy framework and it's corrected with a typical consumption of 15-20 kWh/m² per year for a dwelling.

2 Overview of measurements

All major energy flows in the low-energy house are logged. Some of these measurements can be found online at: <http://www.energyguard.dk> (User name: DTU4, Password: sisimiut).

An overview of the measurements is shown below:

Oil

- Total oil consumption

Heating

- Floor heating energy
- Energy for heating coil in ventilation system
- Hot water consumption

Electrical energy

- Electricity consumption (Unit 1 – empty apartment)
- Electricity consumption (Unit 2 - guest apartment)
- Electricity consumption for technical room (common area)
- Electricity consumption of the el. panel in isolated box with heat exchanger

Solar energy

- Transferred solar energy to solar tank
- Transferred solar energy to space-heating

Ventilation

- The volume flow rate of exhaust air (HOBO data logger)
- The volume flow rate of supply air (HOBO data logger)
- Temperature of exhaust air before HE (HOBO data logger)
- Temperature of exhaust air after HE (HOBO data logger)
- Temperature of supply air before HE (HOBO data logger)
- Temperature of supply air after HE (HOBO data logger)

Indoor climate

- Indoor temperature (Sensirion sensors and data logger)
- Indoor relative humidity (Sensirion sensors and data logger)
- Temperature and moisture in constructions (Sensirion sensors and data logger)

External measurements

- Outdoor climate in Sisimiut (DMI)
- Solar radiation (ASIAQ)[7]

3 Presentation of measurements

The following chapter presents the collected measurements of the low-energy house performance. The measurement period is chosen from 2009 July 1st to 2010 June 30th (cut off period).

3.1 Indoor temperature and humidity

As shown in Figure 3, the indoor temperature in the house has a large effect on the energy consumed for heating. Therefore it is interesting to see what temperature level has been inside the house through the year. Figure 4 shows the measured indoor temperatures in the kitchens. Figure 5 shows the measured relative humidity in the kitchens. The average temperatures in the kitchens were 23.9°C for the inhabited apartment (South-western apartment) and 22.7°C for the guest apartment (North-eastern apartment). The average relative humidity was 29.0% and 28.5 %. The devices were placed in the kitchens / living rooms of each apartment (Sensirion: T18, T20, RH18, RH20).

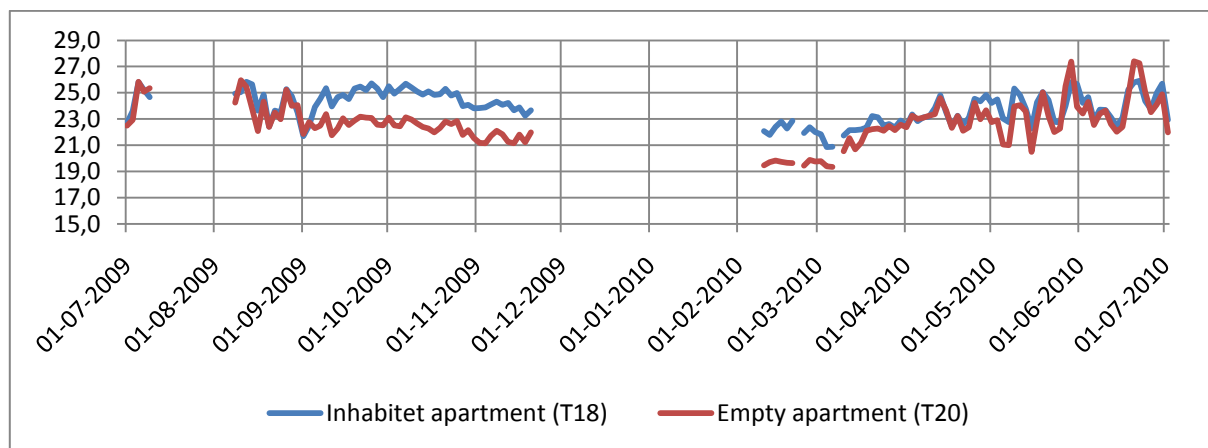


Figure 4 Measured air temperature in kitchens/living rooms from July 2009 to June 2010

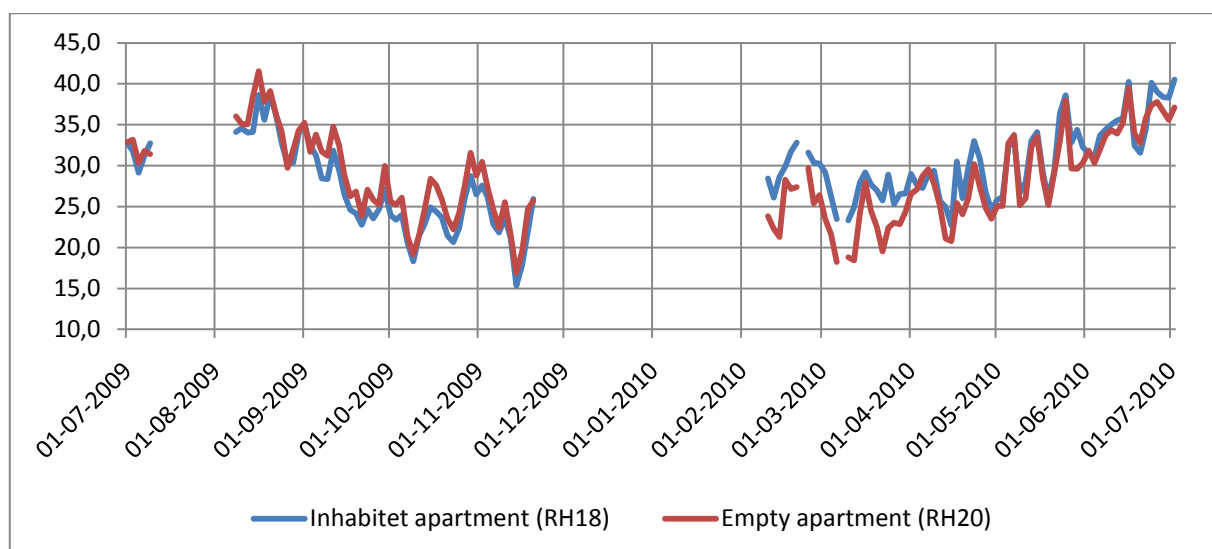


Figure 5 Measured relative humidity in kitchens/living rooms from July 2009 to June 2010

Comments on the indoor temperature measurements

The average temperature in the inhabited apartment has been rather high. Also the measurements from previous years showed the same phenomena. It is probably caused by the different demands of the people living in the arctic. However it might also be caused by the improper control of the heating and ventilation system where in case that the temperature in the space is above the set point, the after heater in the ventilation system should heat the air up to lower temperature.

As expected, the relative humidity is seen to be lower than normal for Danish conditions.

Unfortunately there has been a huge amount of data missing. It was caused by the breakdown of the UPS unit and inability of the logging computer to turn on by itself after the power cut. Therefore it has been out of order for more than 2 months just because nobody turned it on.

Recommendations for further improvements

- Investigate what temperature the inhabitants prefer to have in different seasons.
- Based on the results adjust the heating set points.
- Control the heating coil in the ventilation based on these set points to avoid unnecessary overheating.

3.2 Ambient temperature and heating degree hours

In order to have a better correlation and comparison for the low-energy house every year, it is necessary to know the outside temperature throughout the year. From DMI's weather archives, these data can be drawn for Sisimiut.

Data of ambient outside temperature are also compared to a test reference year (TRY), which has been designed for detailed simulation of the annual energy need for heating the house. The TRY is composed of 12 "typical" months, found by statistical analysis of at least 10 years of measured weather data.

The temperatures of the TRY together with the real temperatures during last five years are presented in Figure 6.

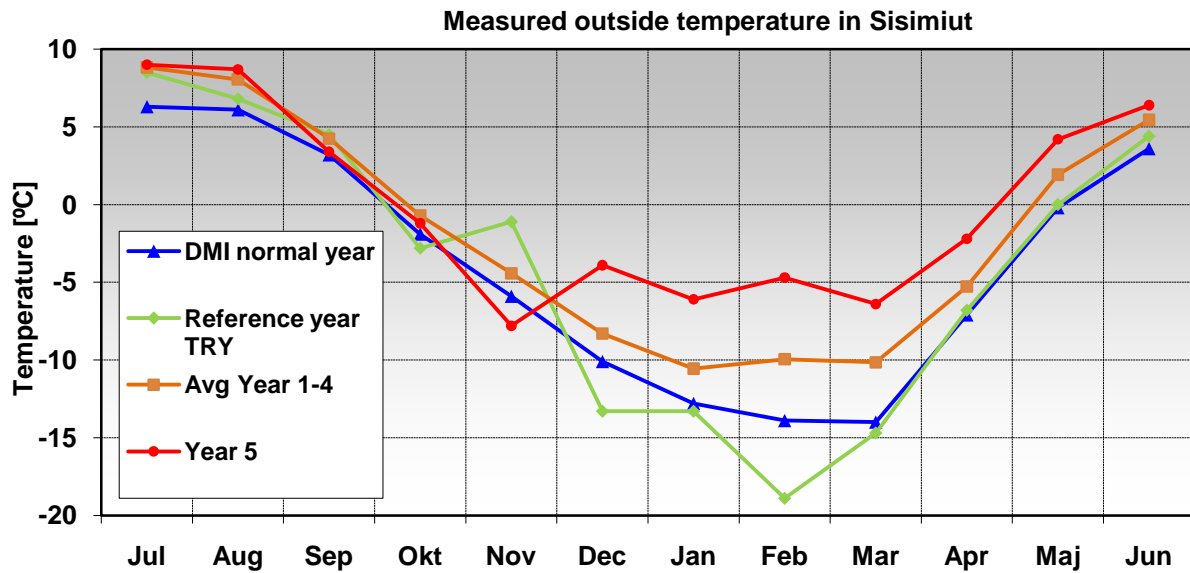


Figure 6 Measured outside temperature in Sisimiut. DMI normal year from www.dmi.dk. Data for reference year (TRY) from ASIAQ.

Degree hours

Based on an indoor temperature of 20°C the monthly degree hours are calculated as:

$$Gd_m = \sum (20 - T_{out,m}) \cdot t_m \quad (1)$$

Where:

Gd_m	number of degree hours per month	[Kh]
$T_{out,m}$	monthly mean ambient temperature	[°C]
t_m	number of hours throughout month	[-]

Figure 7 shows the estimated total annual number of degree hours. These values are compared with DMI's normal year and reference year (TRY).

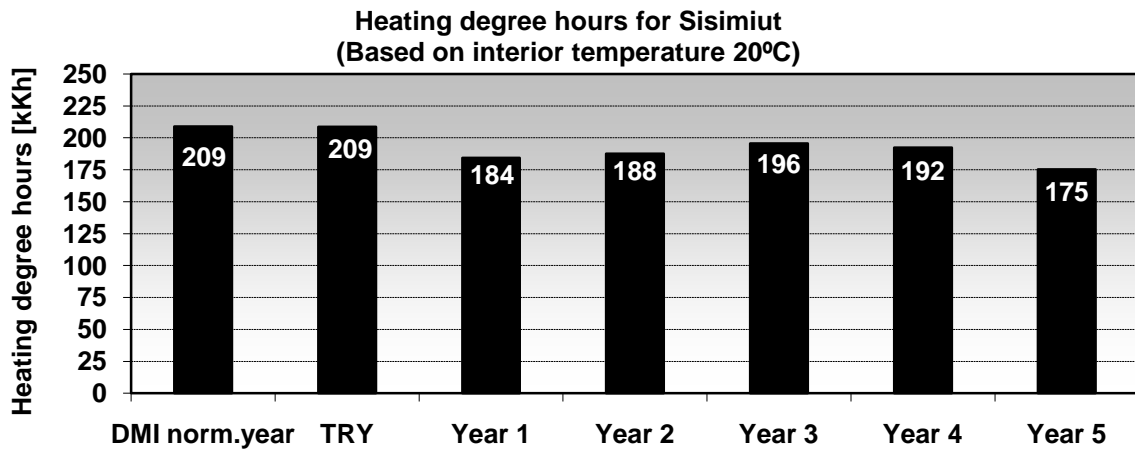


Figure 7 Calculated heating degree hours with interior temperature 20°C.

Comments on the outside temperature

Compared to the first four years of operation and to TRY data, the year 5 was milder. The number of heating degree hours in the year 5 was 10% lower than the coldest year 3 and 16% lower than the TRY.

3.3 Oil consumption

Figure 8 shows the measured oil consumption spread over the months of the year.

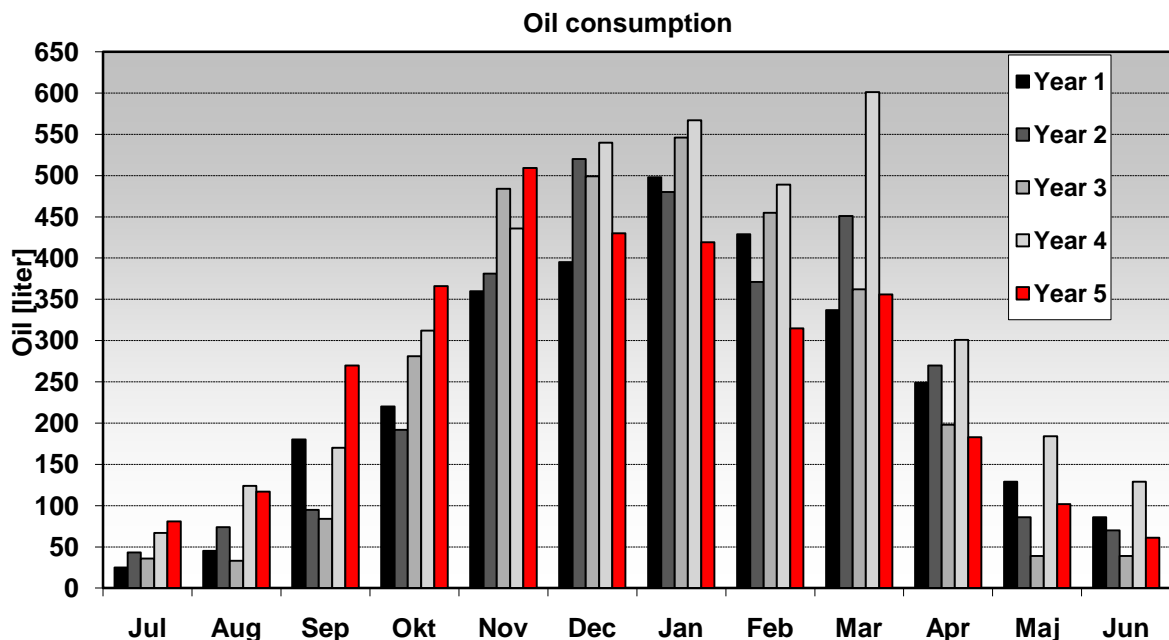


Figure 8 Oil consumption throughout the years

Figure 9 shows the total annual oil consumption.

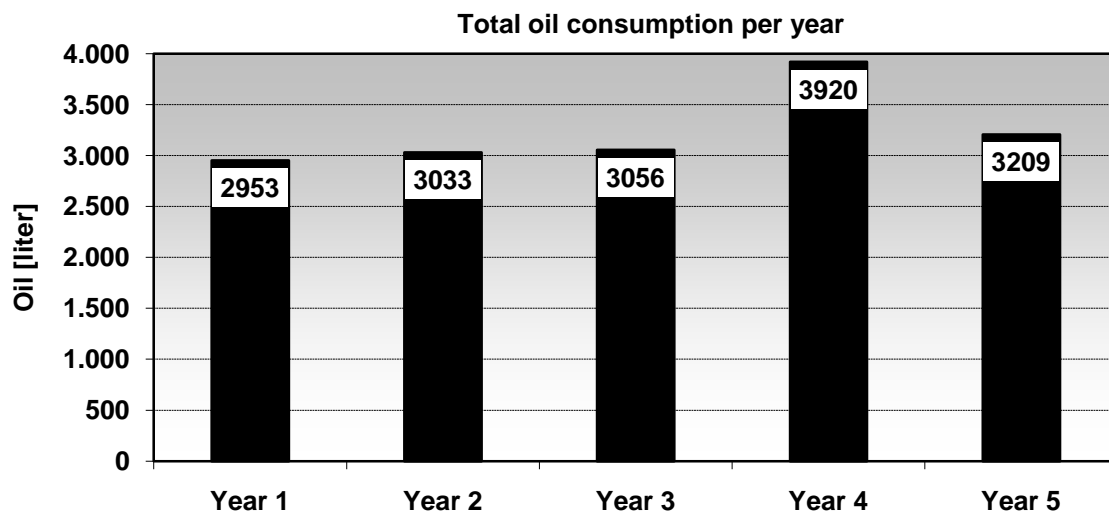


Figure 9 Annual oil consumption

Comments on the oil consumption

The oil consumption has decreased by 20% when compared to year 4. Part of this savings is caused by milder winter (app. 50%) and the rest is probably caused by fixing the broken damper in the heat exchanger in December 2009. After the damper has started working, the efficiency of the heat exchanger has increased¹.

However the consumption has still been higher than in the years 1-3 which is caused by higher indoor temperature during last two years and by the fact that there were freezing problems of the heat exchanger during the first years so the ventilation system was often put out of order and thus there was no energy consumption of the heating coil.

It is expected that if the indoor temperature could be decreased, the oil consumption will be even lower.

¹ More about the heat exchanger in the chapter 3.9

3.4 Heating demands

Figure 10 shows the measured heating demands spread over the months throughout measured years. Heating is excl. domestic hot water.

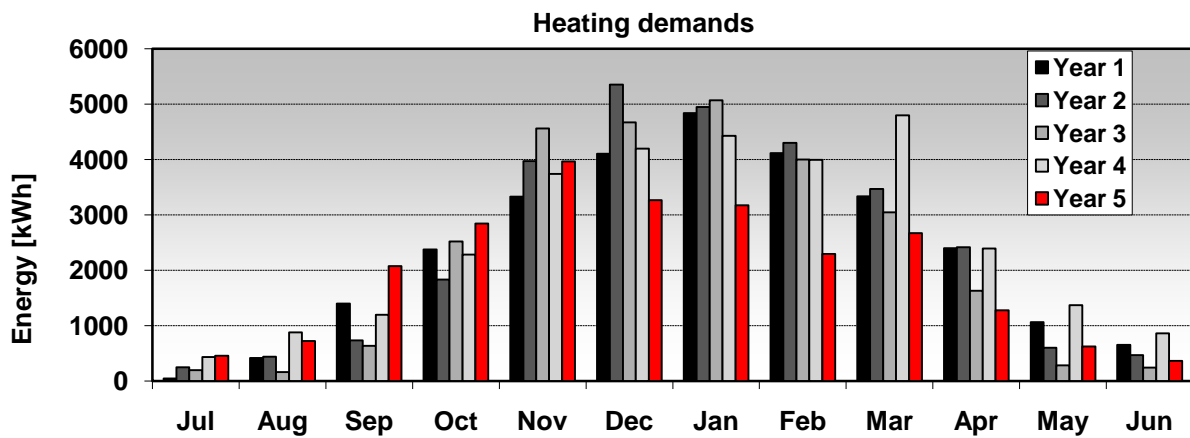


Figure 10 Heat distribution through the years

Figure 11 shows comparison of the annual heating consumption for each year and the targeted heating consumption.

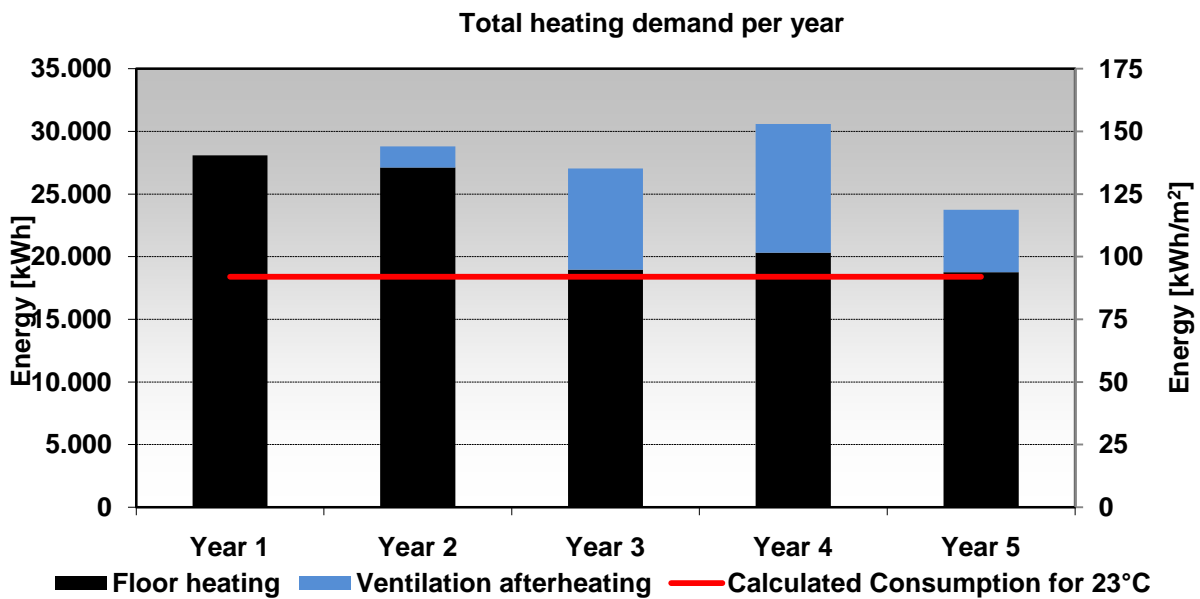


Figure 11 Comparison of heating consumption for each year

Figure 12 shows how the heat is distributed between the after heating of the ventilation air and floor heating.

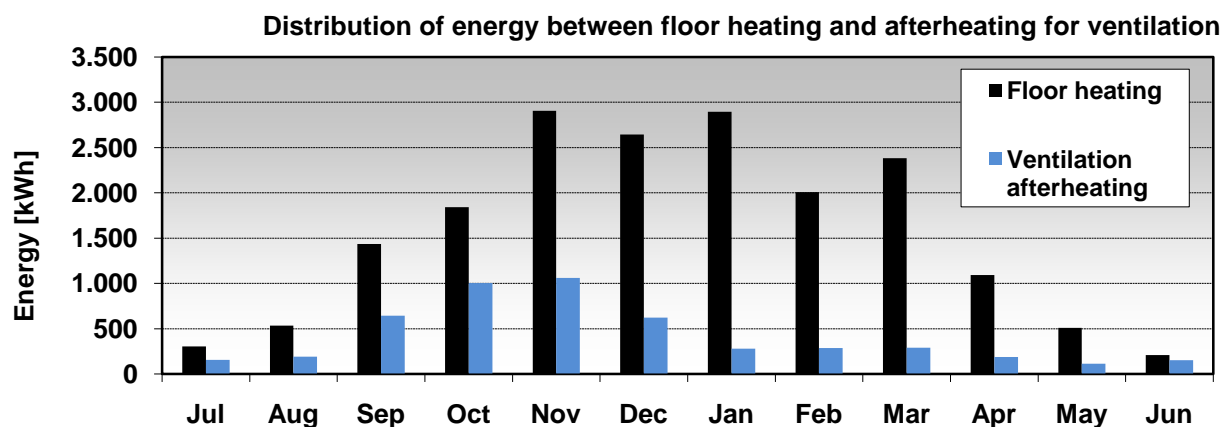


Figure 12 The distribution of heat between the after-heating for ventilation and floor heating

Comments on the heating demands

As it could be seen from the Figure 11 the energy demand of the floor heating has been more or less identical for last three years. The only thing what has varied is the ventilation energy demand.

It is obvious that after the following adjustments being done in December 2009:

- Putting up an extra 100 mm of insulation on the ventilation ducts
- Fixing the broken damper
- Mending the controller of the heating coil so the air is being heated up to 20°C instead of 40°C

The energy demand of the ventilation has decreased significantly.

3.5 Domestic hot water consumption

Figure 13 shows the measured energy needed for domestic hot water.

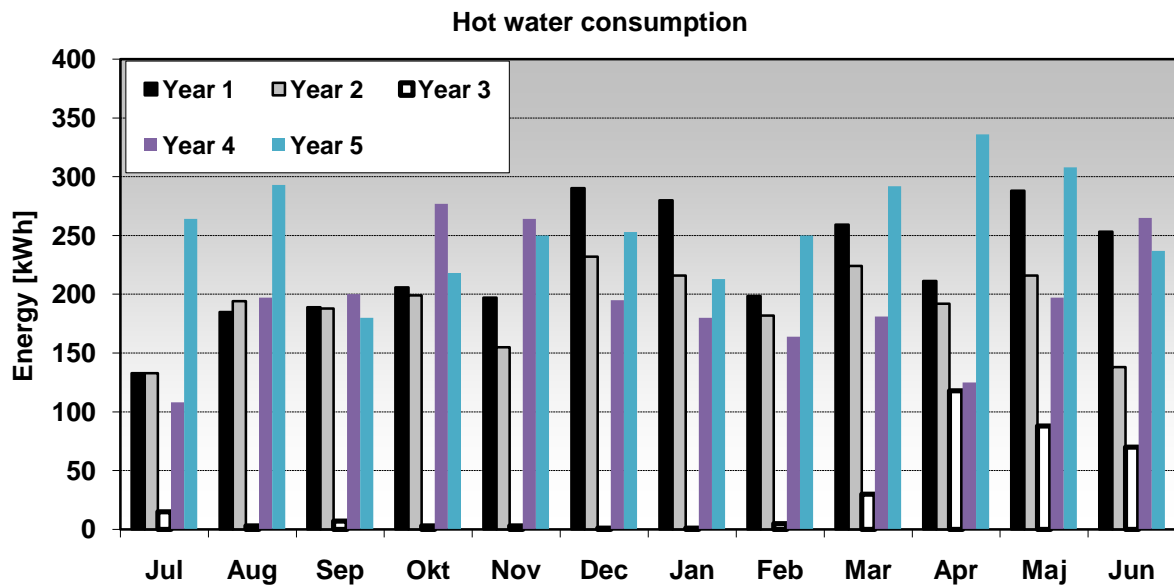


Figure 13 Measured energy consumption for hot water

Figure 14 shows the annual energy consumption for hot water is obtained from the hot water tank.

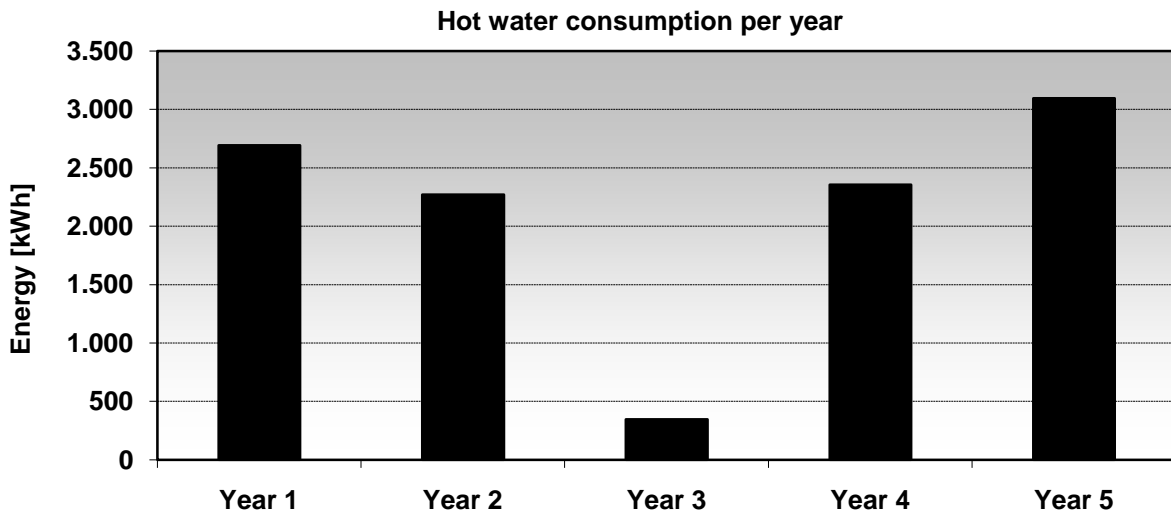


Figure 14 Annual collected energy for hot water

Comments on domestic hot water consumption

Hot water consumption in year 5 is higher than during previous years which might be caused by higher occupancy of the guest apartment.

3.6 Solar energy

Solar radiation is important both for the solar gain collected by solar panels and for the solar gain received by windows. Figure 15 shows a comparison of monthly global radiation for reference year and for measurement (measured horizontally) made by ASIAQ [7].

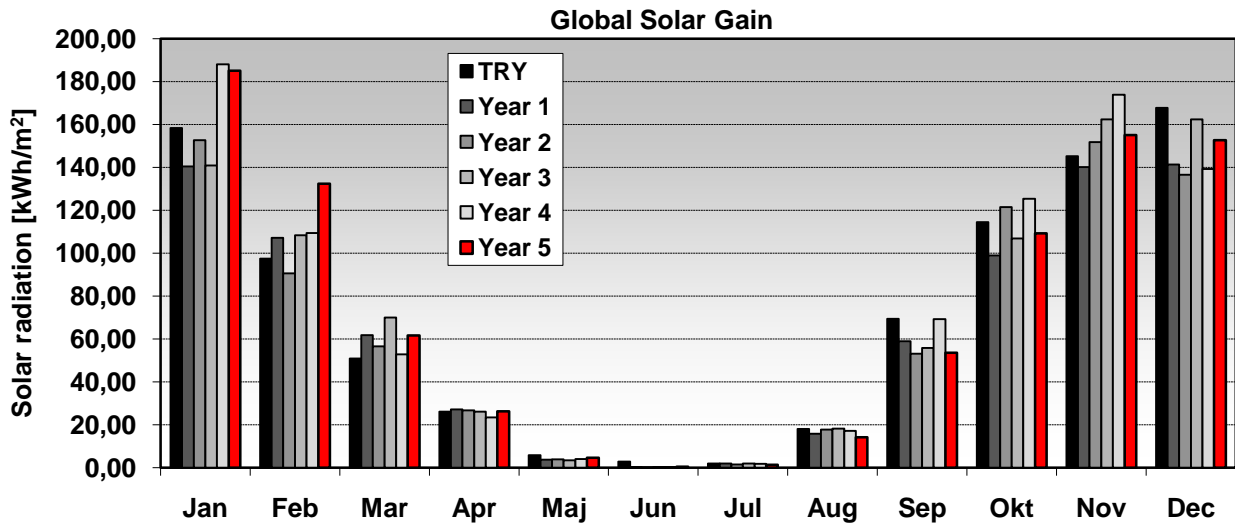


Figure 15 Comparison of reference year and measured global solar radiation

Solar radiation perpendicular to the South, East, West and North measured also by ASIAQ every 5 minutes was done in 2005/5006 only. These data have been used to make an analysis of the solar radiation through the windows for each month. Each window is included with orientation, size and g-value to calculate the transmitted sun, as shown below:

$$Simulated = Q_{sol,referenceyear} \cdot A_{window} \cdot g_v$$

$$Measured = Q_{sol,measured} \cdot A_{window} \cdot g_v$$

Figure 16 shows the monthly values of radiation on vertical surface for measured values in 2005/2006 and for simulated values (DRY).

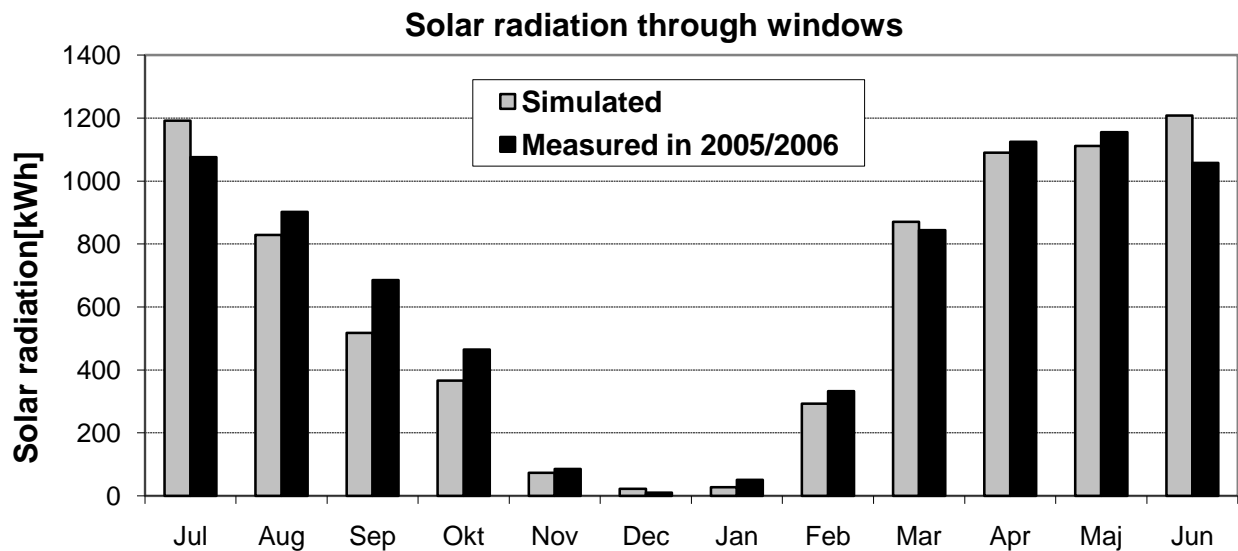


Figure 16 Solar radiation through the windows of the low-energy house

Comments on solar radiation

Global solar radiation in year 4 and 5 is nearly the same (904 and 896 kWh/m²) which is about 4% higher than the reference year (860 kWh/m²). It can be seen that the solar gain through the windows (simulated and measured) is not quite the same, but nevertheless in an appropriate level. The reason for the difference between measured and simulated solar gain on vertical surface is partly due to the fact that solar radiation in the reference year has collection of different year variations.

The Solhat measurement on vertical surface is not working since the year 2007, therefore the solar radiation on vertical face cannot be calculated for current year (Figure 16).

3.7 Solar heating

The annual projected thermal performance of the solar heating system is influenced by the hot water consumption. In [8] the net utilized solar energy for the solar heating system is calculated to be approx. 1700 kWh assuming a hot water consumption of 3000 kWh (corresponds to 150 l/day).

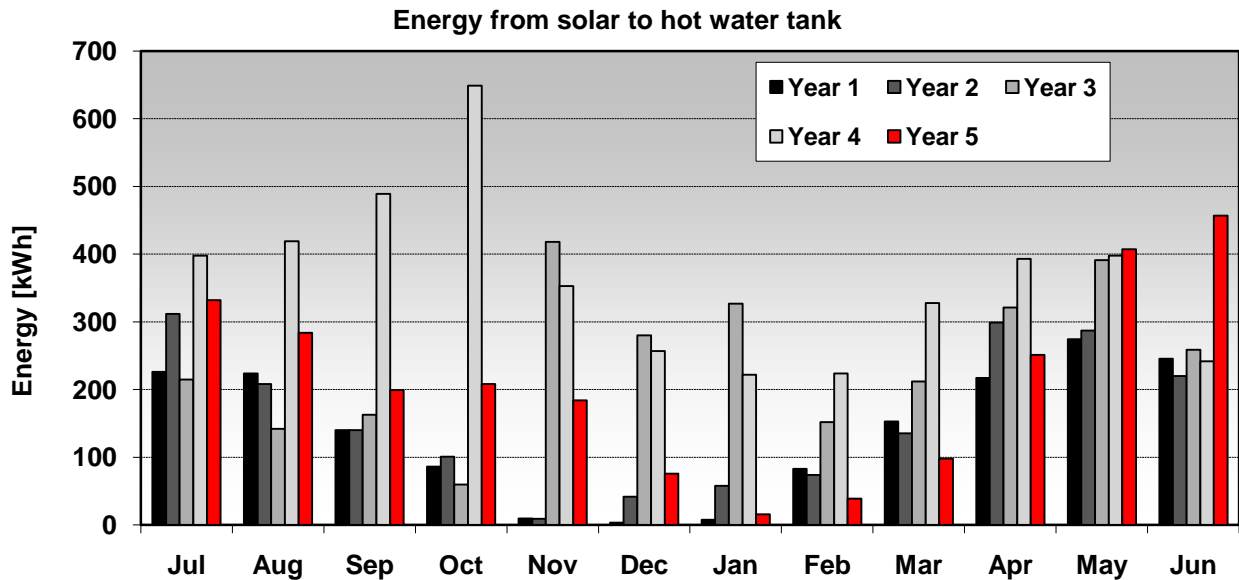


Figure 17 Energy supplied by solar panels for hot water tank

Besides the solar heat transferred from the solar collectors to the hot water tank, the excess solar heat has been from the spring 2009 also transferred to a separate radiator in the house. In sunny periods where the temperature in the hot water tank is high enough heat is transferred from the solar collectors to the radiator. The energy transferred from the solar collectors to the radiator is shown in Figure 18.

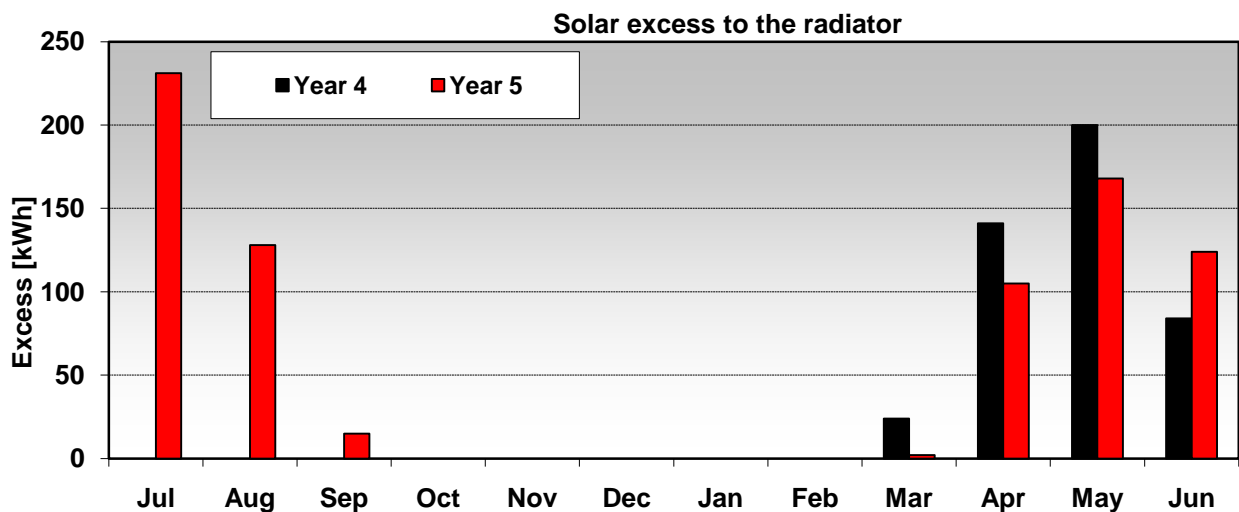


Figure 18 Energy transferred from solar collectors to separate radiator

Figure 19 shows the annual energy transferred from collectors to hot water tank.

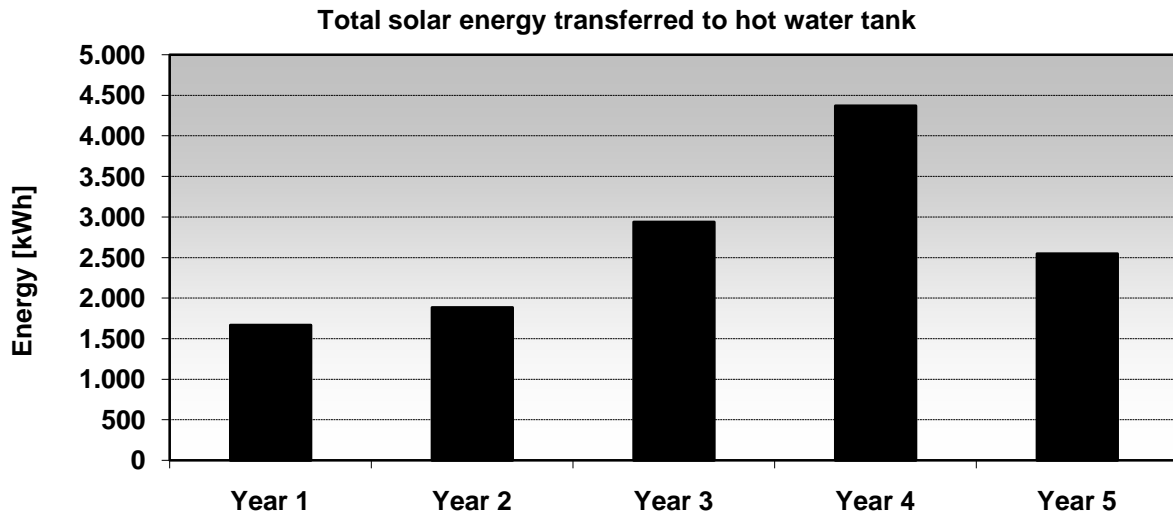


Figure 19 Total annual energy production transferred from the collector to hot water tank

Comments on the solar heating system

After installation of magnetic valve in December 2009 the thermosyphoning effect was prevented and losing of the energy from the tank (which was by the energy meters considered to be energy gain) was eliminated.

Return and forward pipes in solar collector loop to the domestic hot water tank (which is a mantle tank) were until May 2010 placed wrongly, so that the inlet to the mantle was placed at the lower part of the mantle and the outlet was placed at the top part of the mantle. This problem was fixed in May 2010.

Separate radiator was moved outdoors in May 2010. This was done to avoid too high indoor temperatures.

3.8 Electricity consumption

Figure 20 shows the monthly electricity consumption through the year. The low-energy house has two meters that log consumption in each unit of the house and one electric meter that log consumption in technical room and the other common electrical energy.

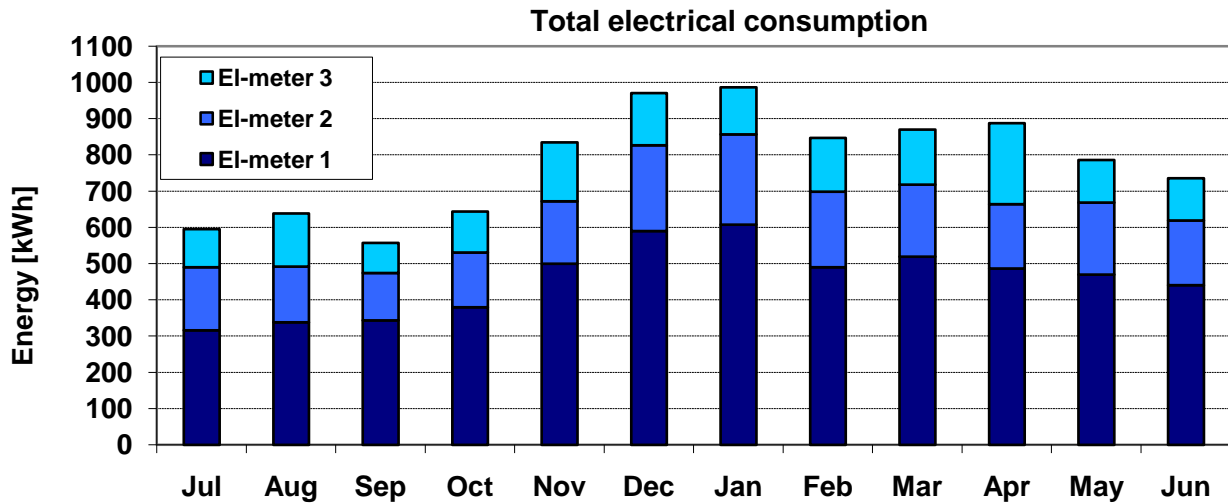


Figure 20 The distribution of electricity consumption throughout the year. El-meter 1 is for the common areas, el-meter 2 is for inhabited apartment and el-meter 3 is for guest part of the house

In Figure 21 the total electricity consumption is presented

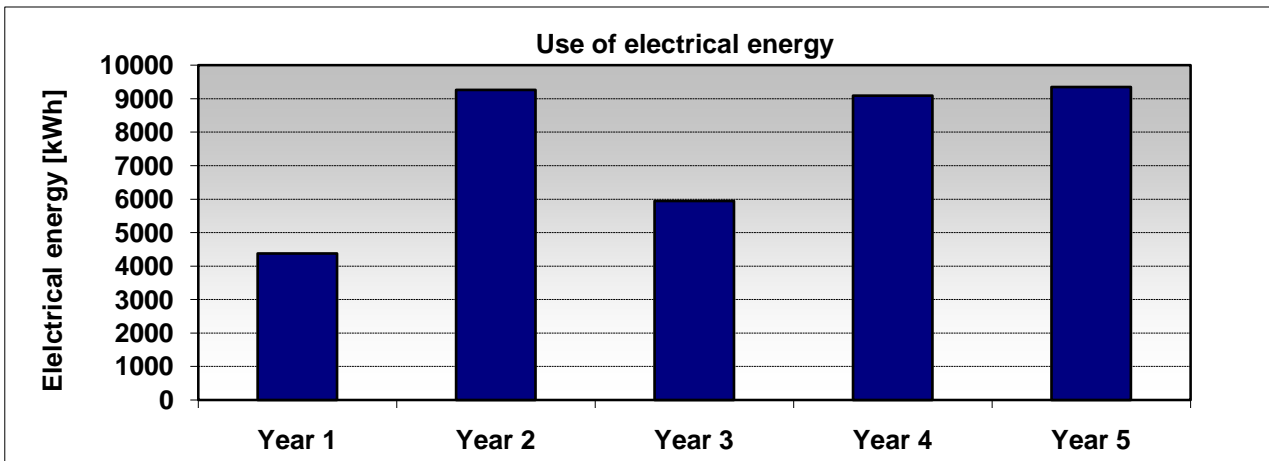


Figure 21 Total yearly electricity consumption

Commenting on electricity consumption

The electricity consumption is almost the same as in the years 2 and 4 when the house was occupied and the frost protection of the sewer pipes was active during winters. It might be expected that the consumption will be decreased by adjusting the ventilation system to operate only when needed.

3.9 Ventilation

Ventilation of the dwellings in a cold climate is both energy-consuming and problematic because draught may cause discomfort for the residents. To reduce energy consumption a heat recovery system with heat exchanger (HE) can be used in which the energy in the warm exhaust air is used for preheating the cold supply air. In cold climate there is a risk of ice formation inside the heat exchanger. When the warm humid room air is brought in contact with the cold surfaces of the exchanger (cooled by the outside air); the moisture in the exhaust air condensates in the heat exchanger and due to very low temperatures can freeze and thus block the entire heat exchanger. In the low-energy house a prototype of a HE with a unique defrosting function is installed. More about the HE and ventilation system in LEH could be read in [9].

In December 2009 the revision of the HE was made. The revision discovered that the mechanical damper inside the HE was broken. Due to this failure the defrosting function didn't work and therefore there were so many freezing problems with the HE in the past. After fixing the problem the efficiency of the HE has increased. In Figure 22 the temperatures and thermal efficiency of the HE for the period from 28th March 2010 until 28th April 2010 is presented.

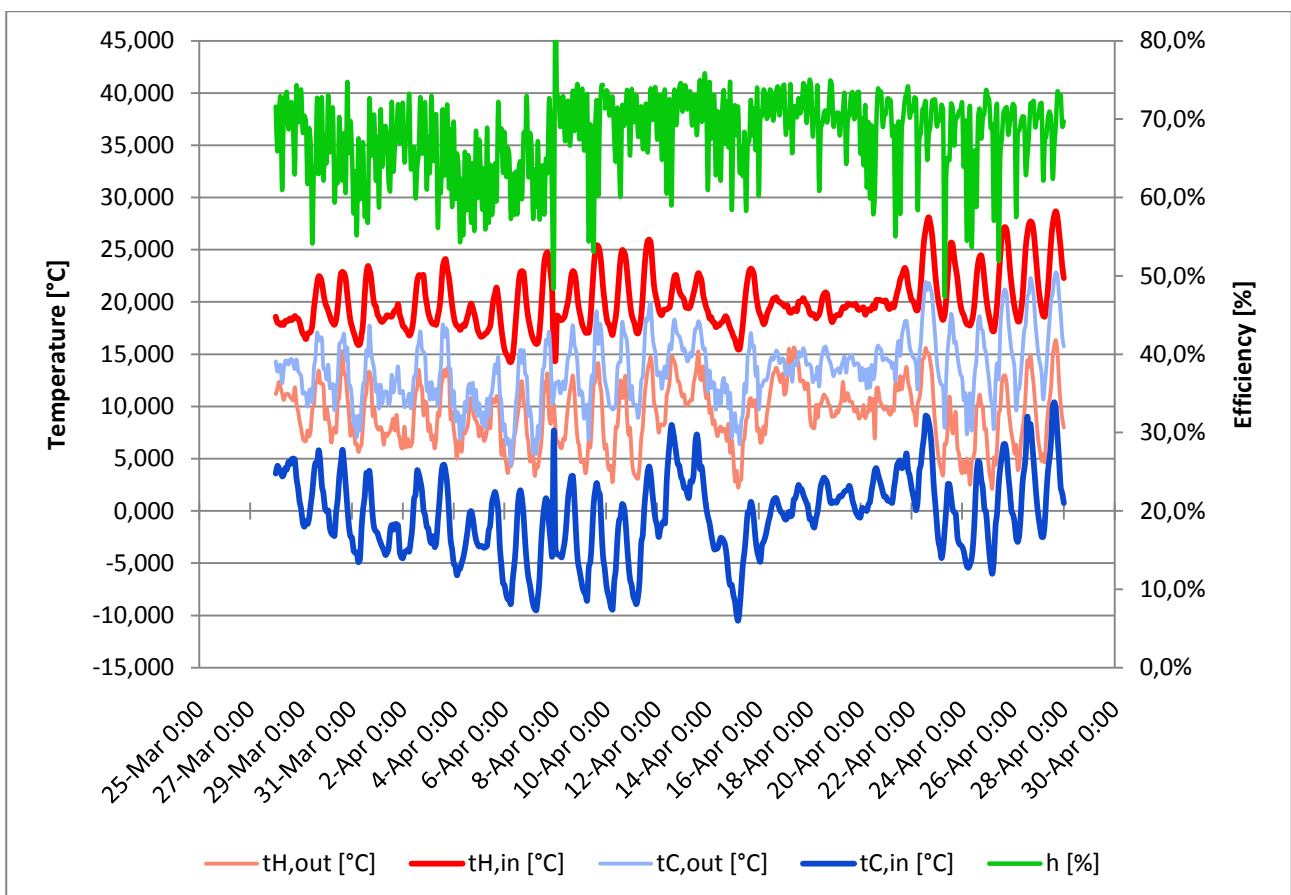


Figure 22 Temperatures and thermal efficiency of the HE

The air flows and pressure loss on the exhaust side of the HE are presented in Figure 23.

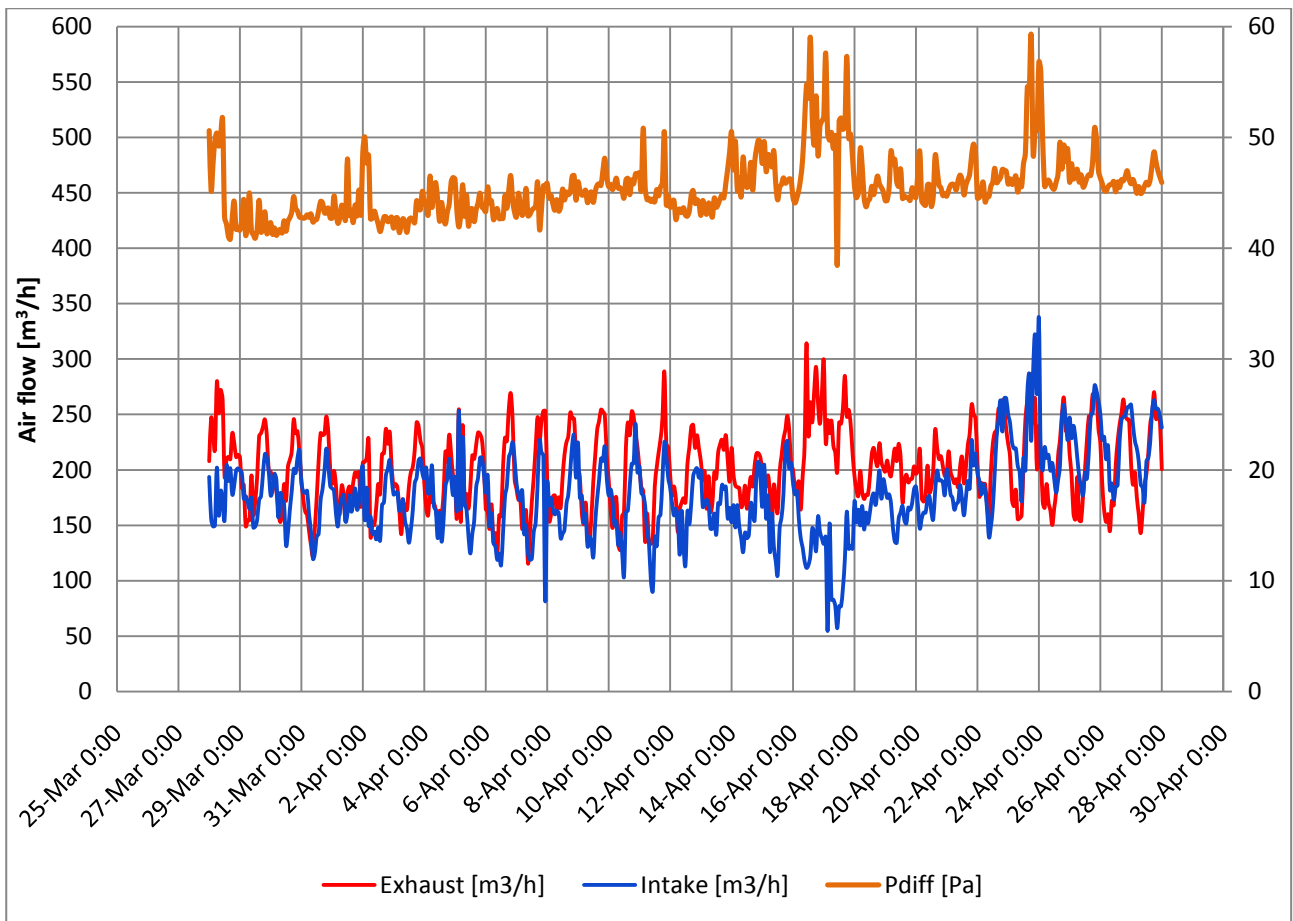


Figure 23 Air flows and pressure loss over the HE on the exhaust side

During December 2009 the extra insulation was put on ventilation ducts

Commenting on ventilation

The efficiency of the HE is after fixing the broken damper significantly higher than in previous years but still lower than expected. It might be caused by untightness of the damper or by imbalanced flows as described in [9]. The fact that the air is supplied equally to both apartments even though that the one is almost all year long unoccupied and thus its ventilation is not needed is very surprising. Also the way of air distribution is untraditional, normally the air is supplied to the bed rooms and extracted from the corridors, bathrooms and kitchens but in case of LEH the fresh air is supplied to the corridor and living room and then extracted from bedrooms, bathroom and from kitchen by use of kitchen hood. This setup may cause that the polluted air from kitchen is being sucked through the bed rooms in case of kitchen hood being turned off.

Recommendations for further improvements

For the improvement of the HE's efficiency it is recommended to:

- Check the air tightness of the HE.
- The damper should only be active during the freezing period.

For the improvement of the ventilation system's performance it is recommended to:

- Control the air flow to the separate apartments separately by means of dampers.
- Control the air flow based on occupancy or indoor air quality.

4 Air tightness

In April 2010 a blower-door test was performed to measure the air-tightness of the building envelope and to compare the results with the test done in February 2009 [10]. The results are presented in Table 2.

Table 2 Blower-door tests results

	Corrected flow	Air changes	Leakage rate
	V₅₀ [m³/h]	n₅₀ [h⁻¹]	q₅₀ [l/(s·m²)]
Test April 2010	1568	3.07	2.10
Test February 2009	1706	3.35	2.28

As it is seen the results from April 2010 are app. 10% better than from February 2009.

Commenting on air tightness

According to requirements which are to be implemented in the Greenlandic standards in 2011, the maximum q₅₀ value is 1.5 l/(sm²). This condition will need to be fulfilled for a certain percentage of newly built buildings. The actual measured air tightness of the LEH is about 46% worst than the planned regulation.

During summer 2010, the renovation of the façade was done which beside the other things should have improved the air tightness of the LEH. The other blower-door tests are therefore planned for January 2011. They will show how successful the renovation was.

5 Comments on Low-energy performance in year 5

Low-energy house in general

The low-energy house has been inhabited during the whole year, i.e. the South-western apartment was inhabited, and the North-eastern apartment was used as occasional guest house during the year.

The energy consumption was **118 kWh/m²** which is app. 23% less than previous year. It is partly caused by milder winter 2009/2010 but also the adjustments of the ventilation system had a significant effect on it.

Ventilation

After fixing the broken damper in the HE, its efficiency increased and there were no freezing problems recorded during the winter 2009/2010. The extra insulation of the ducts has decreased the heat losses significantly. However the ventilation strategy might be improved in order to decrease the energy consumption even more.

The solar heating system

The magnetic valve which prevents thermosyphoning was installed to the system. Also the right connection of the mantle tank was done.

Façade

During the summer 2010 the wooden cladding on the façade was partly removed and the leakages of the wind barrier by the windows and corners were sealed after the cladding was back in place the new paint was applied on the entire outer surface. It is expected that the air tightness has been improved which will be tested by the blower-door test.

Further improvements and savings

For the further improvements it is recommended to do the following actions:

<u>Heat consumption today</u>	<u>118 kWh/m²</u>
Possible savings by air tightening the house to fulfil the upcoming Building Regulation (GBR 2010/2011)	11.5 kWh/m ²
Optimization of the ventilation system in terms of air flow control (estimate)	5-10 kWh/m ²
Improving the HE's efficiency by 10% (estimate)	3 kWh/m ²
Possible saving by various other improvements, e.g. user behaviour (estimate)	10 kWh/m ²

It is not realistic to assume that all these savings can be achieved simultaneously.

6 Low-energy houses' technical journal

Below are listed dates and descriptions of major changes that could affect the registration of Low-energy house performance.

Date	Description
April 2005	Inauguration of low-energy house
16. Jan 2006	Three meters coupled to keep focus system
Marts 2006	Insulation of pipes in technical room
August 2006	Internal regulation of solar heating
August 2006	Logging of ventilator inoperative
October 2006	Insulated box around the exchanger
November 2006	Measuring the differential in the fan and the air temperature at home and take at vex'en. Measurements made with Hobo data logger,
November 2006	To fix the frosting between panels in terrace windows the holes have been drilled to avoid frost and condensation
Forår 2007	Logging of Sensirion system inoperative for long periods.
1 July. 2007	1. rents of low-energy house move out
Dec. 2007	Setting up the wall in front of washroom facilities
Feb – Mar 2008	Renovation wood flooring
1. April 2008	2. tenant moves in. (Larseraaq - switching)
February 2009	Blower-door test
March 2009	Replacement of parts in the air heating system
July 2009	Fixing of leaking windows in inclined wall
August 2009	Current 30 mm was increased for extra 50 mm of insulation on ventilation ducts in the attic (total thickness of insulation is 80 mm)
December 2009	Extra 70 mm of insulation on top of the 80 mm (total thickness of insulation is 150 mm)
December 2009	Mending of after-heating
December 2009	Fixing of the broken damper in the Heat Exchanger
December 2009	Installation of the magnetic valve in the solar collector loop
May 2010	Swapping return and forward pipes in solar collector loop to the domestic hot water tank
May 2010	Separate radiator charged by solar excess was moved outdoors to avoid too high indoor temperatures
July 2010	Improving of the air tightness by sealing the leakages in the facade of the LEH

July 2010	The cracks in the paving were sealed
July 2010	Large holes in the window frames which were drilled before in order to ventilate the windows were sealed now because the holes were found to be too large

References

- [1] P Vladykova, E Borchersen, C Rode, S Furbo, Low-energy house in Sisimiut : Annual report of Low-energy house performance July 2008 to June 2009, (2009).
- [2] J Kragh, Lavenergihuset i Sisimiut : Arsrapport for lavenergihusets ydeevne juli 2007-juni 2008, (2007).
- [3] C Rode, E Borchersen, J Fan, S Furbo, J Kragh, Lavenergihuset i Sisimiut : Arsrapport for Lavenergihusets ydeevne juli 2006 til juni 2007, (2007).
- [4] C Rode, E Borchersen, J Fan, S Furbo, J Kragh, Lavenergihuset i Sisimiut : Arsrapport for lavenergihusets ydeevne. Juli 2005 til juni 2006, (2006).
- [5] Aalborg University, Danish Building Research Institute, BSim,.
- [6] J Kragh, S Svendsen, Lavenergihus i Sisimiut. : Beregnet varmebehov,.
- [7] ASIAQ, Asiaq,.
- [8] S Furbo, LJ Shah, Lavenergihus i Sisimiut - solvarmeanl'g. Baggrund og forslag, (2002).
- [9] M Kotol, Mechanical Ventilation in Cold Climates, (2010).
- [10] LN Jensen, M Marencokova, Blower door test and thermo graphic investigation of Low Energy House in Sisimiut, (2010).

Annex 1 – Photos of Low-energy house 2009/2010



Improving the air tightness (summer 2010)



Improving the air tightness (summer 2010)



Improving the air tightness (summer 2010). The gap between wind barrier and wall has been sealed by silicon



Mending the damper of the heat exchanger. The arm was welded to the servomotor.



Insulated ducts and the additional heating coil.



Insulated ducts in the cold attic.



Sealed holes in the window frames.

