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APISSEQ
Sisimiut – Greenland

-1st winter survey 2011-

TECHICAL
UNIVERSITY OF
DENMARK

Report nr. SR 11-01
DTU BYG
March 2011

Apisseq
Sisimiut – Greenland

-1st winter survey 2011-

Authors:

Martin Kotol

Preface

This report summarizes the very first survey of the engineering dormitory Apisseq in Sisimiut, Greenland. The dormitory was inaugurated in August 2010 and the survey was performed in March 2011. The experienced problems and their possible causes are explained in the report. Furthermore possible solutions are suggested.

March 2011
Technical University of Denmark

Contents

1 Introduction

Apisseq is a dormitory for engineering students built in 2010 in Sisimiut, Greenland. It is an energy efficient building in which the low energy technologies, not commonly used in the Arctic, are installed. The aim of the sophisticated technologies is to minimize the energy consumption and provide the occupants of the building with good indoor environment.

The Technical University of Denmark has donated DKK 500.000 for the advanced monitoring system which will document the performance of the building. The system monitors the energy consumption of the building as well as the indoor air quality (IAQ), outdoor conditions and conditions inside the constructions.

1.1 Key data of the dormitory

Inauguration of Apisseq was on 18th of August 2010 and on 20th of November 2010

1.1.1 Space solution

Net living area: 957 m^2 (living net area for apartments) and
131 m^2 (glazed atrium with staircase) and
94.3 m^2 (common room and washing room)

Gross heated area: 1,414 m^2 (heated area including atrium, janitor´s office and technical room)

Number of occupants: 40

There are 33 single units, 3 three room apartments and 1 two room apartment for handicapped person in the building.

Table 1 - Types of apartments in Apisseq

Apartment	Rooms	Net area [m^2]
Single	Room	16.8
	Entrance	3.3
	Bathroom	2.8
	Total	**22,9**
Two room (for handicapped)	Room	22.5
	Bedroom	15.8
	Entrance	5.8
	Bathroom	6.2
	Total	**50,3**
Three-room	Room	24.0
	Bedroom 1	10.6
	Bedroom 2	7.7
	Entrance	4.6
	Bathroom	3.3
	Total	**50,2**

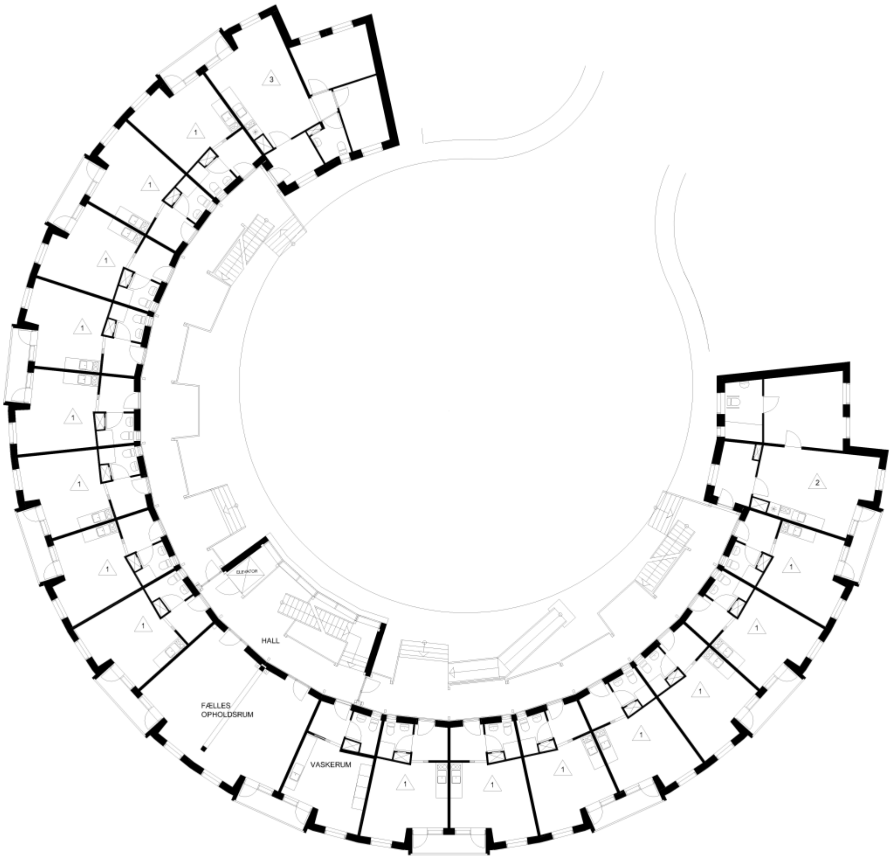

Figure 1 - 1st floor plan

1.1.2 Constructions

The foundations and the bearing walls and ceilings are made of concrete. The insulated envelope consists of wooden beams and thermal insulation. The outer surface is made of wooden cladding.

Table 2 - U-values for constructions

Construction	Insulation thickness [mm]	U-value [W/(m²·K)]
Floor	50+200	0.13
Wall	290	0.15
Roof/ceiling	150+150	0.13
Windows/door	-	1.80

1.1.3 Heating and ventilation system

The building is primarily heated by the radiators in the living rooms and floor heating in the entrances and bath rooms. Main source of the heat is the district heating but the system is designed so, that the heat from solar tanks could be used for space heating in periods with sufficient solar gain.

Proper ventilation of the spaces is ensured by two ventilation units VEX 160 from the company Exhausto. Both are equipped with heat recovery and additional heating coils connected to heating system.

1.1.4 Solar collectors

Type of collectors:	38 evacuated tubular collectors (12 tubes each)
Expected efficiency:	71.2%
Solar tank:	2 x 2,000 litres

1.1.5 Estimated consumption and production

Heating:	160,000 kWh/a
Hot water:	80,000 kWh/a
Solar heating:	400 kWh/ ($m^2 \cdot a$) of solar collector

1.2 Survey purposes and subjects

The survey was performed in March 2011. The purpose of the survey was to examine some of the technical issues such as:

- U-values of the window glazing
- Air tightness of the building
- Thermal bridges in the insulated envelope
- Ventilation units

These issues are often sources of problems when buildings in arctic regions are considered.

2 Methods

2.1 U-value of the windows

The large three pane window in the living room of the single unit number 2.17 (right next to the balcony door) and the 40 m^2 glazed facade in the atrium were chosen for the measurements.

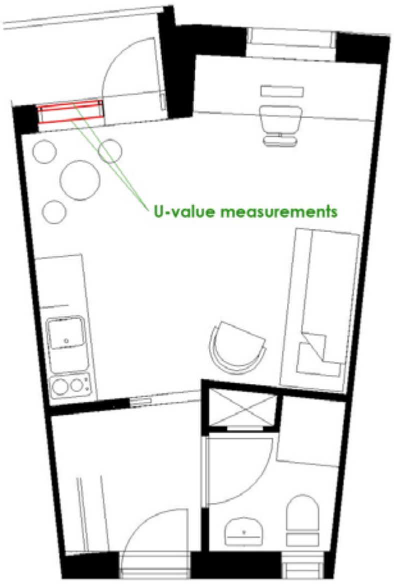

Figure 2 - U-value in single unit

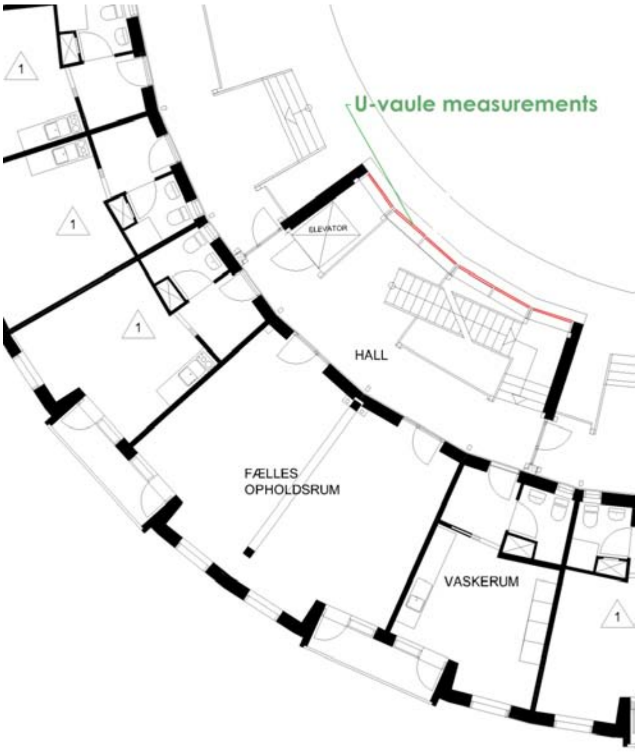

Figure 3 - Glazed atrium, U-value measurements

Two heat flux sensors (HFP01) were used for measuring the heat flux through the glass panes. Final heat flux was calculated as an average of the two sensors. The temperatures (indoors and outdoors) were measured with thermocouples. The logging time was set to 10 minutes. The first two hours of the logging weren't taken into consideration because the heat flux sensors were adapting to the actual conditions. The formula for calculating the U-value was derived from equation (1.):

(1.)

Where:

q	is the heat flux through the window	[W/m^2]
U	is the heat transfer coefficient of the glazing	[$W/(m^2 \cdot K)$]
t_{in}	is the indoor temperature	[ºC]
t_{out}	is the outdoor temperature	[ºC]

This gives the following formula:

(2.)

To estimate the overall annual energy loss of the glazed wall in the atrium, the heating degree days (HDD) were calculated from the formula (3.).

$$HDD = \sum \left(t_{in} - t_{out,m}\right) \cdot d_m \qquad (3.)$$

Where:

HDD	is number of heating degree days	[-]
$t_{out,m}$	is monthly mean ambient temperature	[ºC]
	(The average temperature measured in particular month over last five years)	
d_m	is number of days throughout month	[-]

The annual energy loss is then:

(4.)

Where:

E	is total annual energy loss of the glazing	[Wh]
A	is the area of the glazing	[m^2]

The heat loss was then calculated for different indoor temperatures to see how much energy could be saved by decreasing the temperature in the atrium.

2.2 Blower door test of the single unit

The building design doesn't allow to test the entire building at once. The only possibility is to test the separate units. Therefore the unit 2.17 was chosen to undergo the blower door. During the test the air flow through the ventilator sufficient to keep 50 Pa pressure difference was measured. The kitchen hood as well as the other air terminal devices were sealed with tape. The ventilator was attached to the entrance door. Both, pressurisation and depressurisation tests were performed. The air change rate at 50 Pa pressure difference n_{50}, air permeability q_{50} and specific leakage rate w_{50}, were calculated according to the standard EN13829. There is not the limit value for specific leakage rate in the actual Greenlandic building regulation, but the Danish building regulation sets the maximum leakage rate to 1.5 $l/(s \cdot m^2)$ of heated floor area. The measured values were compared with this value.

2.3 Thermo graphic survey

Thermo graphic pictures of the facade were taken to see if there are any serious thermal bridges in the insulated envelope. Thermal camera NEC TH7700 was used.

2.4 Survey of the ventilation units

The two ventilation units were stopped and opened. Pictures of the insides were taken with digital camera. The special attention was paid to eventual accumulation of the snow inside the unit and to frost formation on the heat exchanger. Air flows, ventilator speeds, air properties (T, RH) and pressure losses are being logged continuously by thee installed monitoring system.

3 Results and discussion

3.1 U-values

The measured U-values of the glazing are as follows:

Table 3 - U-values of the monitored windows

Type	U-value of the glazing [W/(m^2·K)]
Glazed facade	1,00
Single room	0,95

The average temperature measured inside the atrium was 15°C which results in 5958,33 HDD (based on the average outdoor temperatures within last 4 years). Heat losses as a result of different temperatures in the atrium are presented in Figure 4.

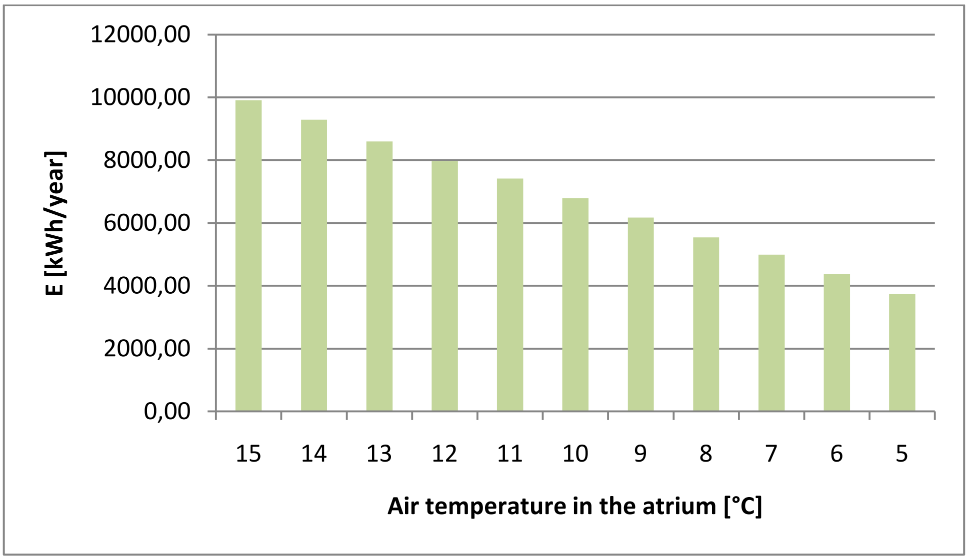

Figure 4 - Heat loss from the glazed facade (different indoor temperatures)

Comments on U-values

The U-value of the glazing in the atrium (double glazed panels) is reasonably low. But considering the large area of the glazing, it results in fairly large heat loss. It is therefore recommended to decrease the heating set point or skip the heating of the atrium at all. Since there aren't any moisture sources in the atrium, there shouldn't be a risk of any condensation problems. To investigate the actual heat consumption of the entire atrium, some calorimeters could be installed on the two radiators in the ground floor.

3.2 Blower door test

Table 4 - Results of the blower door test of unit 2.17

	Depressurisation	Pressurisation	Avg.	DBR 10
Air flow at 50 Pa, V_{50} [l/s]	45,55	52,50	**49,03**	
Air changes at 50 Pa, n_{50} [/h]	2,735	3,150	**2,943**	
Permeability at 50 Pa, q_{50} [l/s.m^2]	1,674	1,928	**1,801**	
Specific leakage at 50 Pa, w_{50} [l/s.m^2]	1,98	2,28	**2,13**	**1,50**

Thermo pictures taken during depressurisation test showing places where cold air is being sucked to the space due to under pressure are shown below.

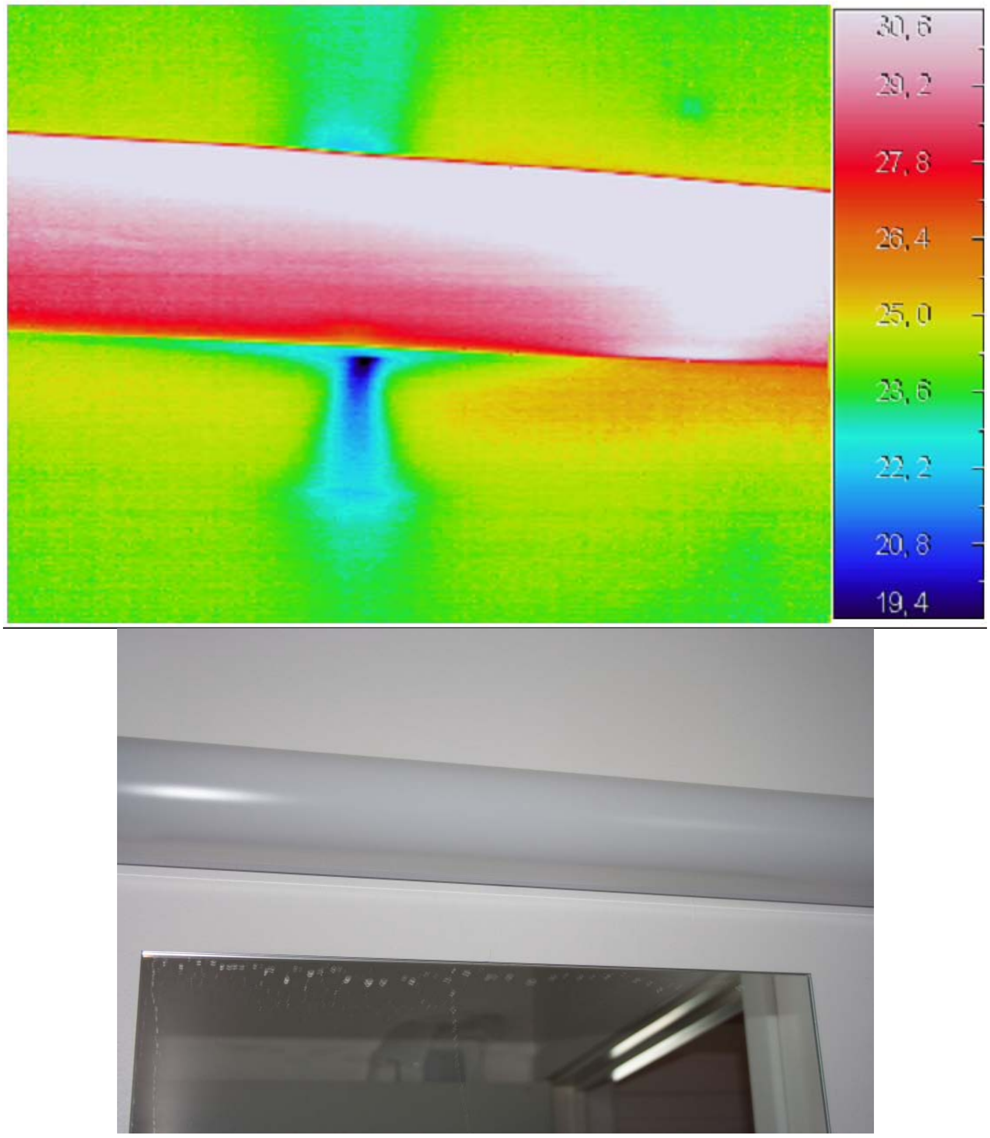

Figure 5 - Air leakage from behind the light in the bath room

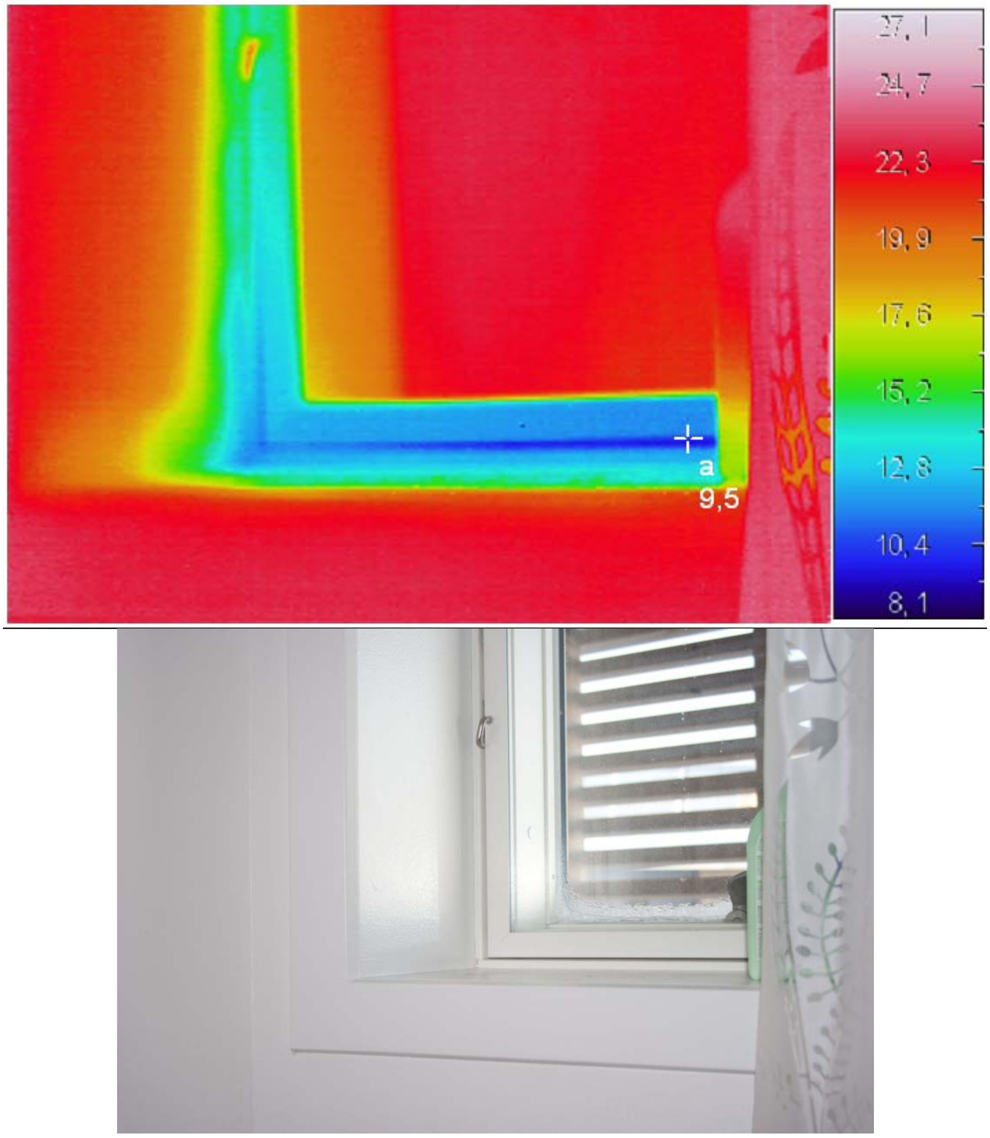

Figure 6 - Leakage around the bath room window

Figure 7 - Condensation and frost formation on the window pane in the bath room

Figure 6 displays the insufficient sealing of the crack between the third removable glass pane and the window frame. This untightness also causes penetration of the moisture from bathroom to the window gap and its condensation and freezing on the middle glass pane (see Figure 7).

Comments on air tightness

The air tightness of the unit doesn't fulfil the Danish requirements. Part of the air is probably leaking to/from the adjacent heated units and thus doesn't make any heat loss, but the rest is from/to the exterior and thus increases the overall heat losses.

The amount of air leaking to/from the different spaces (adjacent rooms/exterior) should be examined by means of tracer gas measurements.

In the Figure 5 the leakage from behind the wall-mounted light, shows most likely the penetration of the vapour barrier by the electricity cable, or mounting screw.

The third removable glass panes should be sealed and attached to the frames properly so the exfiltration of the air from the space to the window gap will be avoided.

3.3 Thermo graphic survey

The pictures of the facade show, that the significant thermal bridges are created mainly by the window frames of the large windows/balcony doors. They are larger in case of balcony doors compare to the fixed windows (see Figure 8 and Figure 9).

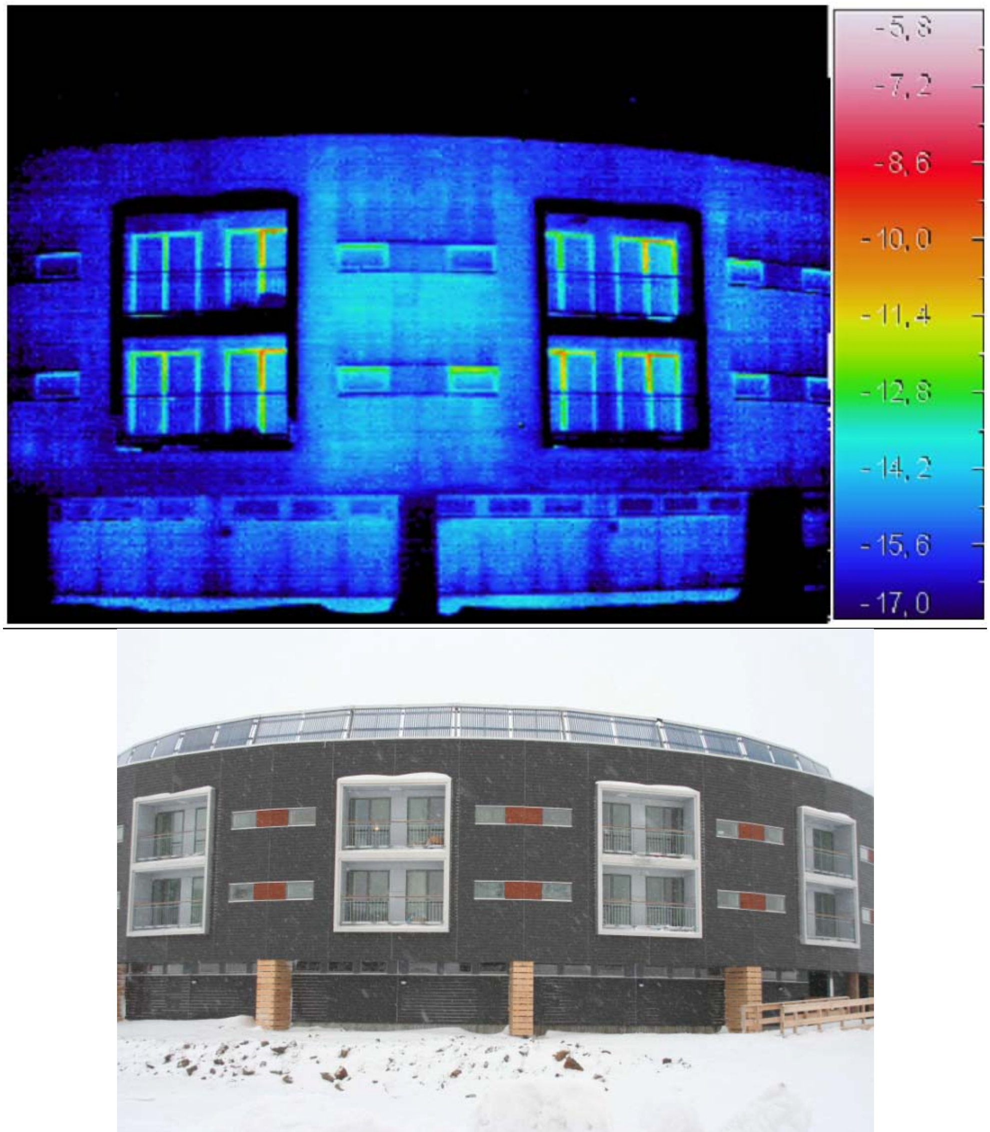

Figure 8 – South-western facade

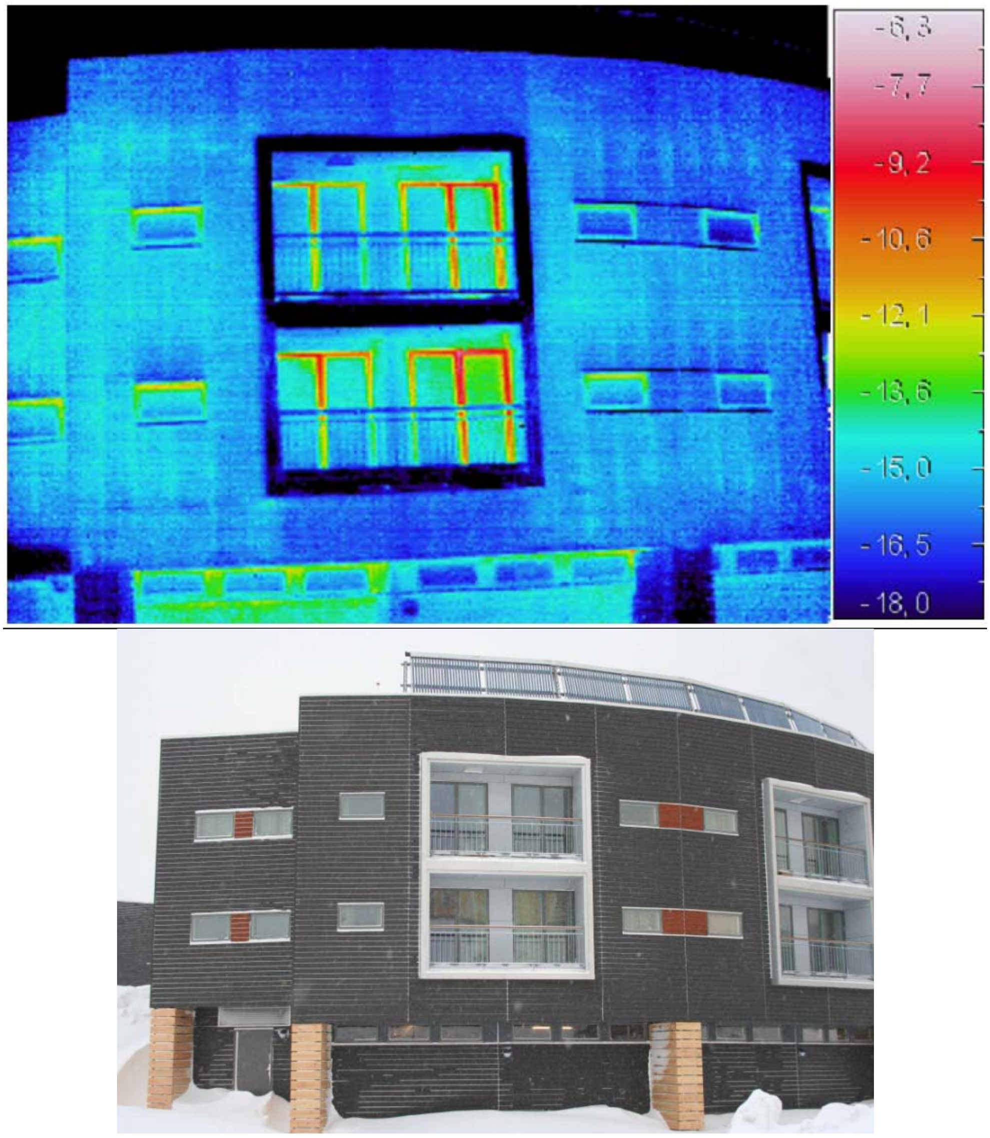

Figure 9 – Western facade

In Figure 9 it is possible to see the warmer facade (meaning higher heat loss) from the technical room (down left) with the ventilation unit. It is caused by the lack of insulation of this room and insufficiently insulated ventilation ducts in that room. The heat loss from the ducts heats up the room. Higher room temperature then increases the heat loss through the uninsulated facade. As a result of this phenomenon the fresh supply air which was heated in the ventilation unit is being cooled before it is delivered to the space.

In section 3.1 the heat loss from the glazed part of the atrium was estimated. From Figure 10 it is obvious that the actual heat loss will be even higher due to thermal bridges of the window frames.

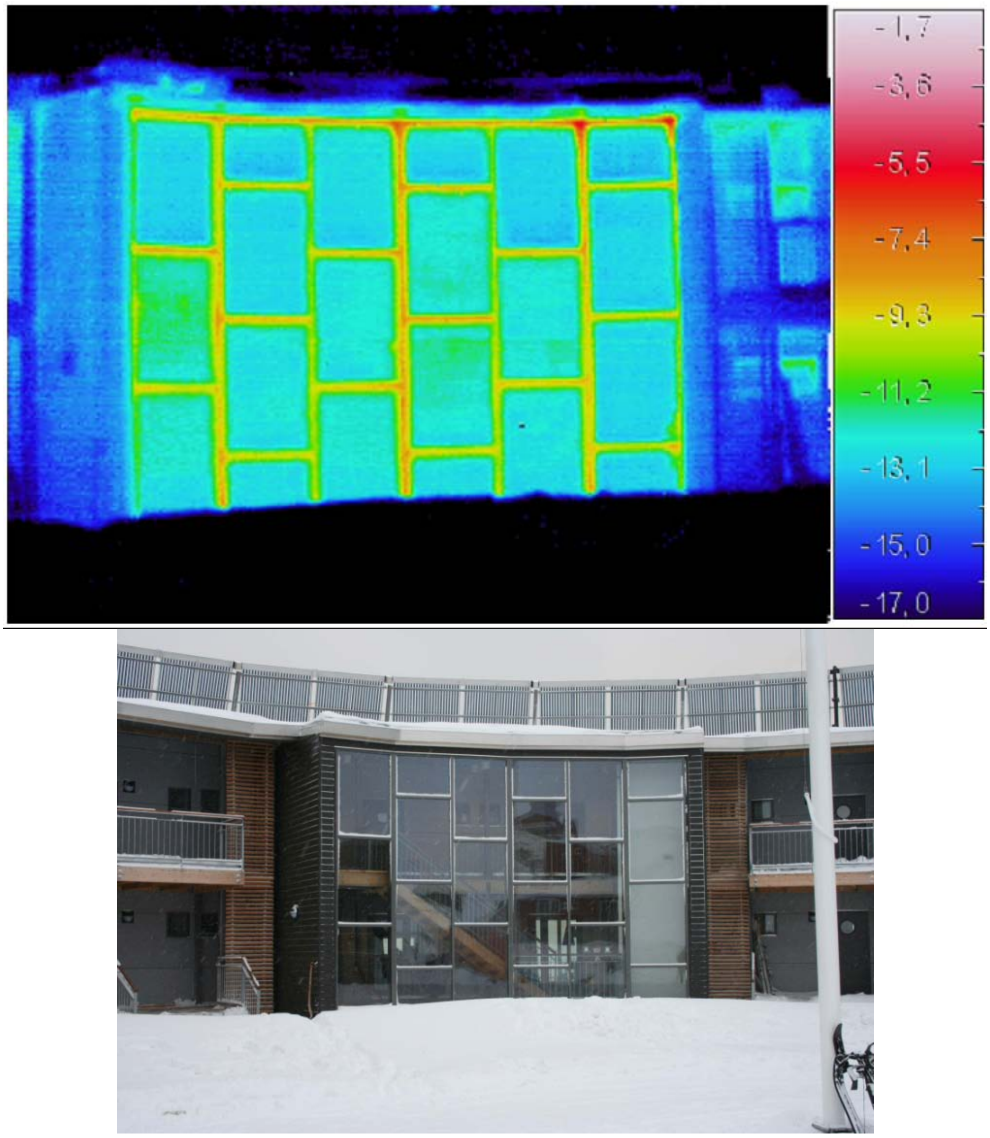

Figure 10 - Glazed atrium facing north

Comments on thermal bridges

It seems that the insulated envelope doesn’t have any significant thermal bridges, the only problem are the window frames. This is however quiet common problem.

The technical rooms with ventilation units should be additionally insulated to avoid extra heat losses.

3.4 Ventilation units

During the survey some problems with the ventilation units were explored.

3.4.1 Snow accumulation

In the Figure 11 and Figure 12 the identical chamber could be seen before it started snowing and after 24 hours of light snowing outside. Significant amount of snow was sucked with the supply air into the unit during that period.

Figure 11 - Ventilation unit - snow accumulation in the supply air chamber – before it started snowing

Figure 12 - Ventilation unit - snow accumulation in the supply air chamber – after 1 day of light snowing (10 cm of snow/day)

There is a risk that in case of long lasting snowing the chamber will be filled with snow which may affect the air flows or in the worst case put the unit out of order until the snow melts. The other risk is the water accumulation inside the chamber after the snow melts. The unit has a metal tray for collecting the liquid condensate and draining it out of the unit, but it is only placed under the exhaust chamber (see Figure 12). After the snow in the tight supply chamber melts, the water will create a small lake where the bacteria could start to grow.

3.4.2 Frost formation on the heat exchanger

The units are equipped with the by-pass of the cold supply air in cases that freezing appears. The by-pass damper however doesn't take any action even in cases where the frost formation is obvious (see Figure 13). It is probably caused by the wrong setup of the unit.

Figure 13 - Cross flow heat exchanger with frost formation

3.4.3 Too low supply air temperature

The set point temperature for the supply air is as low as 15 °C. When taking into account heat losses from the ducts before the air reaches the space, it is even colder than 15 °C. This causes discomfort of the occupants and may lead to their tendency to block the air terminal devices.

3.4.4 Constant air flows

The units are set to operate with constant air flows over time. Even in periods when the dormitory is empty (day time) the units supply (and extract) around 300 l/s which requires quiet some energy consumption and there are no benefits of such strategy.

Comments on ventilation

The intake on the facade should be better protected from the snow and the drainage of the melted snow from the unit should be enabled.

The defrosting strategy of the heat exchangers should be checked and adjusted so the by-pass damper opens when it is suppose to. It should be controlled by the pressure loss of the heat exchanger possibly in combination with the outdoor temperature. In case that the temperature of the incoming air is below freezing point and the pressure loss increases without increase of the air flow, the frost is most likely blocking parts of the heat exchanger. It means, that the defrosting function should be activated.

The ducts in the technical (unheated) rooms should be insulated with at least 100 mm of thermal insulation to avoid heat losses and the air supplied to the rooms should have a temperature of 20 °C

The time profile of the units should be set so they run on lower power during unoccupied hours when the air exchange is not needed.

4 Conclusion

After the first winter of operation some problems with the systems have been discovered, but most of them might be solved by proper adjustment of these systems.

Further investigation and improvements of the ventilation system are required for better understanding to problematic of ventilation systems in arctic climates.

Unfortunately the monitoring system of the dormitory has not been completely working yet, but after its launch deeper and continuous investigation of the performance and IAQ will start.