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Monitoring system in new dormitory APISSEQ Sisimiut - Greenland

TECHICAL UNIVERSITY OF DENMARK

Report SR xx-10
BYG·DTU
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Monitoring system in new dormitory
Apisseq
Sisimiut - Greenland

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Preface

The report on “Monitoring system in new dormitory Apisseq in Sisimiut, Greenland” contains the information and data about the system that has been selected for the monitoring of Apisseq. The report begins with brief description of the dormitory and list of sensors used for monitoring the indoor climate, energy consumption and temperature and moisture inside the construction. The report presents the locations of sensors and aspects around the sensors with relevant manuals, technical description, calibration lists and list of contacts.

March 2011
Technical University of Denmark

Content

1 Introduction

The new dormitory Apisseq is an energy efficient building and the monitoring system was designed to measure consumed and produced energy as well as the quality of indoor environment. The initial design goal of minimizing operating and maintenance costs will be documented by using the monitoring system.

The Technical University of Denmark (DTU) has donated DKK 500,000 for the monitoring system that would be suitable to measure all important aspects concerning energy, indoor air quality (IAQ) and built-in moisture. The Technical University of Denmark (ARTEK, BYG and Building 101) has also donated money for the project where the selection of sensors and placement was decided.

DTU is responsible only for instalment of the monitoring system, setting up of the sensors and running the monitoring system. DTU has not been involved in the design process of the dormitory or in the actual construction of the dormitory.

1.1 Objectives

The objectives of the monitoring system are as follows:

- monitoring of overall performance of the dormitory with focus on detailed key measurements
- continuous and autonomic solution for data collection (accessible online)
- continuous logging of:
    - IAQ (temperature, relative humidity, CO_2)
    - opening of the windows/doors and temperature close to them
    - total building consumption of energy (electricity, heat)
    - fractions of different sources to heating (district heating, solar energy)
    - solar production and use of hot water
    - situation inside the structure (temperature and moisture content)
- each sensor will have unique name and number for identification, the name consists of shortcut for type of the sensor and its particular number
- each sensor will be supplied with calibration certificate to exactly calculate the required values

1.2 Key-data for the dormitory

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

1.2.1 Space solution

The building has a circular shape and a partially heated ground floor and two upper floors. Main technical room and janitor´s office are in the heated part of the ground floor and small storage compartments (one for each apartment) are in the unheated part together with smaller technical rooms with ventilation units. The 1st and 2nd floor consist of identical flats. There is a common room with a kitchen and a laundry room on the first floor (Fig. 1**Error! Reference source not found.** shows the floor plans). On the second floor, the common room and laundry are replaced with flats. In the centre of the building is a glazed atrium with a staircase.

Most of the flats are meant to accommodate one person. Each flat has an entrance, bathroom and living room with a kitchenette. At the gables of the building are four bigger apartments for families and handicapped.

Fig. 1. Floor plans

The rooms are specified in Table 1.

Table 1 - Types of flats 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**

1.2.2 Constructions

The foundations and the inner load bearing walls and ceilings are made of solid concrete. The insulated envelope consists of wooden timber construction and thermal insulation. The construction is made with a vapour barrier on the warm side of the insulation. The outer surfaces comprise of wind barrier and wooden or cement-based cladding. Windows are gas-filled double-glazed with an additional third pane of glass on the indoor side of the windows. The large balcony window/door is triple-glazed and the non-openable parts have a fourth glass pane. See **Error! Reference source not found.** for calculated U-values.

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	-	1.10

1.2.3 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 heat is 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.

1.2.4 Solar collectors

Type of collectors:	38 evacuated tubular collectors (24 tubes each)
Expected efficiency:	71.2%
Solar tank:	2 x 2,000 litres

1.2.5 Estimated consumption and production

Heating:	160,000 kWh/a
Domestic hot water:	80,000 kWh/a
Solar heating:	400 kWh/ (m^2·a) of solar collector

2 Monitoring system for Apisseq

2.1 LONBOX system

The web server and data logger, Lonbox Series model PID 4000 (Fig. 2) was chosen for monitoring in Apisseq. Thanks to an on line access the latest data can be reached from any computer. For long term data collection the server placed at DTU is used. The data are stored in an SQL database.

In original proposal it was designed to have the cables for 25 analog and 25 digital signals (or 50 digital) located at required positions to measure the required data. Cables for 50 measuring positions with 2*2*0.6 PTS cables with expected connections of 50 sensors (analog or digital) have been used. Average length of each cable is 25 meters. The set up boxes for 4 channels are installed to accommodate 50 signals. Further in the project it was decided to have more sensors and therefore the adjustments have been made. The PID4000 has 200 channels for connection of sensors

Fig. 2. Web server type PID4000

Type of sensors had to be selected depending on the available products/sensors which can work with LonWorks. Lonbox requires: “20 kΩ NTC” (NTC = negative temperature coefficient) to get the most accurate reading over long distance cable and a 0-10 Vdc signal for other sensors.

The embedded WEB server is a software function used for serving Web pages and these pages can be viewed with a standard WEB browser as the Microsoft Explorer. When reading the data from the unit, the request is sent as a computer file. The used file is the standard XML format including the self-description inside the file.

2.2 Access information

The following chapter is short list of important aspects and information from user guide for Lonbox PID4000 [http://www.prolon.dk/products].

Internet access

Server address:	http://194.177.254.118/home.htm
Username:	Apisseq
Password:	Sisimiut

Web data queries

Logged data is available in two XML formats: one contains the current values for all active channels and one containing the series of readings from a single channel. Use the nvfetch data query to read actual real-time data. To view current values, use the "nvfetch.xml" page and specify the device id and optionally a network variable index as parameters. The detailed instructions can be found on http://194.177.254.118/datause.htm.

For access to long term data collection please contact Martin Kotol (mrko@byg.dtu.dk) or Carsten Rode (car@byg.dtu.dk).

3 The summary of measuring sensors: numbering, labelling and location

3.1 Space temperature and humidity sensors

Table 3 - Sensors for temperature and relative humidity in rooms, bathrooms and outdoors

Type of sensor	Channel ID	Labelling	Description of sensors / location	Note / location
Honeywell H7012A	30	HON1 - Temperature	**Flat 1.02** facing North (in a living room)	Fig. 4. First floor (level 1) Fig. 6. Unit for placing indoor climate measurement
	31	HON1 - Relative humidity		
	32	HON2 - Temperature	**Flat 1.02** facing North (in a bathroom)	
	33	HON2 - Relative humidity		
	60	HON3 - Temperature	**Flat 1.07** facing North (in a living room)	
	61	HON3 - Relative humidity		
	62	HON4 - Temperature	**Flat 1.07** facing North (in a bathroom)	
	63	HON4 - Relative humidity		
	72	HON5 - Temperature	**Flat 1.10** facing North (in a living room)	
	73	HON5 - Relative humidity		
	74	HON6 - Temperature	**Flat 1.10** facing North (in a bathroom)	
	75	HON6 - Relative humidity		
	80	HON7 - Temperature	**Flat 1.16** facing North (in a living room)	
	81	HON7 - Relative humidity		
	82	HON8 - Temperature	**Flat 1.16** facing North (in a bathroom)	
	83	HON8 - Relative humidity		
	48	HON10 - Temperature	**Flat 2.02** facing North (in a living room)	Fig. 5. Second floor (level 2)
	49	HON10 - Relative humidity		
	50	HON11 - Temperature	**Flat 2.02** facing North (in a bathroom)	
	51	HON11 - Relative humidity		
Honeywell H7508A	76	HON9 - Temperature	**Outdoors** below roof-deck, covered	Fig. 4. First floor (level 1)
	77	HON9 - Relative humidity		

Units of measurements are: temperature (°C), relative humidity (%)

3.2 CO_2 sensors

Table 4 - Sensors for indoor CO_2 concentration (in rooms)

Type of sensor	Channel ID	Labelling	Description of sensors / location	Note / location
Vaisala CARBOCAP® GMW20	23	CAR1 - CO_2	**Flat 1.02** facing North (in a living room)	**Error! Reference source not found.** **Error! Reference source not found.** **Error! Reference source not found.**
	24	CAR2 - CO_2	**Flat 1.07** facing North (in a living room)	
	25	CAR3 - CO_2	**Flat 1.10** facing North (in a living room)	
	26	CAR4 - CO_2	**Flat 1.16** facing North (in a living room)	
	27	CAR5 - CO_2	**Flat 2.02** facing North (in a living room)	

Units of measurements are: CO_2 (ppm)

Note: Honeywell and CO_2 sensors have the same location in the rooms.

3.3 Opening & temperature sensors

Table 5 – Opening and temperature sensors

Type of sensor	Channel ID	Labelling	Description of sensors / location	Note / location
Honeywell T7412A Magnetic valve DC101	28	TEW 1	**Flat 1.02** V1(single window)	**Error! Reference source not found.** **Error! Reference source not found.** **Error! Reference source not found.**
	29	OPW 1		
	30	TEW 2	**Flat 1.02** V2(balcony windoor)	
	31	OPW 2		
	32	TEW 3	**Flat 1.02** V3 (bath window)	
	33	OPW 3		
	34	TEW 4	**Flat 1.02** D1 (entrance door)	
	35	OPW 4		
	36	TEW 5	**Flat 1.07** V1(balcony windoor)	
	37	OPW 5		
	38	TEW 6	**Flat 1.07** V2 (single window)	
	39	OPW 6		
	40	TEW 7	**Flat 1.07** V3 (bath window)	
	41	OPW 7		
	42	TEW 8	**Flat 1.07** D1 (entrance door)	
	43	OPW 8		
	44	TEW 9	**Flat 2.02** V1(single window)	
	45	OPW 9		
	46	TEW 10	**Flat 2.02** V2(balcony windoor)	
	47	OPW 10		
	48	TEW 11	**Flat 2.02** V3 (bath window)	
	49	OPW 11		
	50	TEW 12	**Flat 2.02** D1 (entrance door)	
	51	OPW 12		

Units of measurements are: state of the window/door (close =0, open=1, time of opening/closing in seconds); temperature (°C)

3.4 Built in sensors

Table 6 - Built-in sensors for temperature and humidity (in walls, floors, attic)

Type of sensor	Channel ID	Labelling	Description of sensors / location	Note / location
Vaisala HMT100	0	DTU1 – Temperature	Unit facing North (module line 3-4)	Fig. 13. Detail 1 - sensor 1,2&3
	1	DTU1 – Humidity		
	2	DTU2 – Temperature		
	3	DTU2 – Humidity		
	4	DTU3 – Temperature		
	5	DTU3 – Humidity		
	6	DTU4 – Temperature		Fig. 19. Detail 2 - sensor 4
	7	DTU4 – Humidity		
	8	DTU5 – Temperature		Fig. 22. Detail 3 - sensor 5&6
	9	DTU5 – Humidity		
	10	DTU6 – Temperature		
	11	DTU6 – Humidity		
	12	DTU7 – Temperature		Fig. 27. Detail 4 - sensor 7, 8 & 9
	13	DTU7 – Humidity		
	14	DTU8 – Temperature		
	15	DTU8 – Humidity		
	16	DTU9 – Temperature		
	17	DTU9 – Humidity		
	18	DTU10 – Temperature	Ventilation shaft	Fig. 32. Detail 5 - sensor 10
	19	DTU10 – Humidity		
	20	DTU11 – Temperature	Bathroom (module line 3-4)	Fig. 33. Detail 6 - sensor 11
	21	DTU11 – Humidity		
	22	DTU12 – Temperature	Room (module line 3-4)	Fig. 37. Detail 7 - sensor 12&13
	23	DTU12 – Humidity		
	24	DTU13 – Temperature		
	25	DTU13 – Humidity		
	26	DTU14 – Temperature	Attic	Fig. 40. Detail 8 - sensor 14&15
	27	DTU14 – Humidity		
	28	DTU15 – Temperature		
	29	DTU15 – Humidity		

Units of measurements are: temperature (°C) and relative humidity (%)

3.5 Energy meters

Table 7 – List of energy meters

Type of sensor	Channel ID	Labelling	Description of sensors / location	Note / location
	112	EM1- Solar energy	Solar output	**Error! Reference source not found.**
	113	EM1- Solar flow		
	155	EM1 - Volume		
	156	EM1 - Temperature 1		
	157	EM1 - Temperature 2		
	114	EM2 - Solar Tank energy	From solar to accumulation tanks	
	115	EM2 - Solar Tank flow		
	159	EM2 - Volume		
	160	EM2 - Temperature 1		
	161	EM2 - Temperature 2		
	116	EM3 - Tank Hot energy	From tanks to DHW preheating	
	117	EM3 - Tank Hot flow		
	163	EM3 - Volume		
	164	EM3 - Temperature 1		
	165	EM3 - Temperature 2		
	118	EM4 - Hot water energy	DHW circulation energy	
	119	EM4 - Hot water flow		
	167	EM4 - Volume		
	168	EM4 - Temperature 1		
	169	EM4 - Temperature 2		
	120	EM5 - Circulation energy	DHW preheating by solar	
	121	EM5 - Circulation flow		
	171	EM5 - Volume		
	172	EM5 - Temperature 1		
	173	EM5 - Temperature 2		
	122	EM6 - Hot Heating energy	District heating to DHW	
	123	EM6 - Hot Heating flow		
	175	EM6 - Volume		
	176	EM6 - Temperature 1		
	177	EM6 - Temperature 2		
	124	EM7 - District energy	District heating total	
	125	EM7 - District flow		
	179	EM7 - Volume		
	180	EM7 - Temperature 1		
	181	EM7 - Temperature 2		
	126	EM8 - Tank Heating energy	From tanks to space heating	
	127	EM8 - Tank Heating flow		
	183	EM8 - Volume		
	184	EM8 - Temperature 1		
	185	EM8 - Temperature 2		

	128	EM9 - Total energy	Total energy for space heating	
	129	EM9 - Total flow		
	187	EM9 - Volume		
	188	EM9 - Temperature 1		
	189	EM9 - Temperature 2		
	150	EM10 – HE 1 energy	Heating coil in ventilation unit VEX 1	
	151	EM10 – HE 1 flow		
	191	EM10 - Volume		
	192	EM10 - Temperature 1		
	193	EM10 - Temperature 2		
	152	EM11 – HE 2 energy	Heating coil in ventilation unit VEX 2	
	153	EM11 – HE 2 flow		
	195	EM11 - Volume		
	196	EM11 - Temperature 1		
	197	EM11 - Temperature 2		

Units of measurements are: energy (kWh); flow (m^3/h); volume (m^3) and temperature (°C)

3.6 Heat exchangers

Table 8 - Heat exchanger monitoring (unit nr.1)

Type of sensor	Channel ID	Labelling	Description of sensors / location	Note / location
AFC100 HE 1	130	HR1 - Extract air flow		nvoExtAirFlow
	131	HR2 - Supply air flow		nvoSupAirFlow
VEX 160 VK mode 160FC-2	132	HR3 - Inlet Air before HE	Outside temperature – air entering the ventilation unit	nvoOutdoorTemp
	133	HR4 - Exhaust Air after HE	Temperature of outlet air – coming from ventilation unit and leaving the building	nvoExhaustTemp
	134	HR5 - Exhaust Air before HE	Temperature of exhaust air coming from rooms before entering ventilation unit	nvoExtractTemp
	135	HR6 - Inlet Air after HE	Temperature supply air – leaving the unit and going to rooms	nvoSupplyTemp
	136	HR7 - Speed Extract Fan	The actual fan speed of the extract fan	nvoFanSpeedExt
	137	HR8 - Speed Supply Fan	The actual fan speed of the supply fan	nvoFanSpeedSup
	138	HR9 - Extract Air Duct Pressure	The measured pressure in the extract duct	nvoExtAirPress
	139	HR10 - Supply Air Duct Pressure	The measured pressure in the supply duct	nvoSupAirPress
HK sensor (ENOTECH DPT 2500 R8)	40	HR11 - Pressure drop over the HE	The pressure difference over the exhaust side of the HE.	connected with a plastic tube with the plastic top
Vaisala HUMICAP®	41	HR12 - Humidity inlet before HE		
	42	HR13 - Humidity exhaust after HE		
	43	HR14 - Humidity exhaust before HR		
	44	HR15 - Humidity inlet after HE		

Units of measurements are: for heat exchanger are volume (m^3); temperature (°C); pressure (Pa); humidity (%); flow (l/s)

Table 9 - Heat exchanger monitoring (unit nr.2)

Type of sensor	Channel ID	Labelling	Description of sensors / location	Note / location
AFC100 HE 2	140	HR16 - Extract air flow		nvoExtAirFlow
	141	HR17 - Supply air flow		nvoSupAirFlow
VEX 160 VK mode 160FC-2	142	HR18 - Inlet Air before HE	Outside temperature – air entering the ventilation unit	nvoOutdoorTemp
	143	HR19 - Exhaust Air after HE	Temperature of outlet air – coming from ventilation unit and leaving the building	nvoExhaustTemp
	144	HR20 - Exhaust Air before HE	Temperature of exhaust air coming from rooms before entering ventilation unit	nvoExtractTemp
	145	HR21 - Inlet Air after HE	Temperature supply air – leaving the unit and going to rooms	nvoSupplyTemp
	146	HR22 - Speed Extract Fan	The actual fan speed of the extract fan	nvoFanSpeedExt
	147	HR23 - Speed Supply Fan	The actual fan speed of the supply fan	nvoFanSpeedSup
	148	HR24 - Extract Air Duct Pressure	The measured pressure in the extract duct	nvoExtAirPress
	149	HR25 - Supply Air Duct Pressure	The measured pressure in the supply duct	nvoSupAirPress
HK sensor (ENOTECH DPT 2500 R8)	85	HR26 - Pressure drop over the unit on exhaust site	The pressure difference over the exhaust side of the HE.	connected with a plastic tube with the plastic top
Vaisala HUMICAP®	86	HR27 - Humidity inlet before HE		
	87	HR28 - Humidity exhaust after HE		
	88	HR29 - Humidity exhaust before HR		
	89	HR30 - Humidity inlet after HE		

Units of measurements are: for heat exchanger are volume (m^3); temperature (°C); pressure (Pa); humidity (%); flow (l/s)

3.7 Other meters

Table 10 - Other sensors

Type of sensor	Channel ID	Labelling	Description of sensors / location	Note / location
	109	EL2 - Electricity consumption – Cold water frost protection		
	110	EL1 – Total electricity consumption		

Unit of measurements are: electricity (kWh)

4 Details of sensors - description and location

4.1 Honeywell sensors

Objective

- 4 single flats with different site orientation on the first floor of building (level 1) and 1 single flat facing North with Vaisala built-in sensors on the second floor of building (level 2)
- 10x Honeywell sensors in the building and 1x sensor outside the building (as a reference value the outdoor climate)
- one sensor will be located in room, and one sensor in bathroom
- the temperatures in entrance hall are expected to be the same as in rooms (no zoning)
- each sensor will measure temperature and relative humidity

Location

- according the mounting instruction, e.g. no direct sun, away from windows/doors and heat sources, sufficient air circulation, etc.
- outside sensor has to be also protected from rain, direct sunshine, etc.

Calibration

- calibration scale for channel 1 for relative humidity was set up to 5…95% and temperature for channel 2 in range -30 °C…+50 °C (for outdoor climate, based on Sisimiut climate conditions), and for indoor climate 0..+50 °C

Table 11 - Indoor climate sensors - Honeywell

	Temperature sensing range	Accuracy	Relative humidity sensing range	Accuracy
H7012A,B	0…50 °C	±0.3 K	5…95%	±3% at RH 30…70%, ±5% else
H7508A	-30…50 °C	±0.3 K	5…95%	±3% at RH 30…70%, ±5% else

Fig. 3. Honeywell sensor H7012A,B

4.1.1 On floor level - layout

Level 1

	Section	Flat nr.
Flat 1:	3-4	1.02
Flat 2:	8-9	1.07
Flat 3:	14-15	1.10
Flat 4:	20-21	1.16

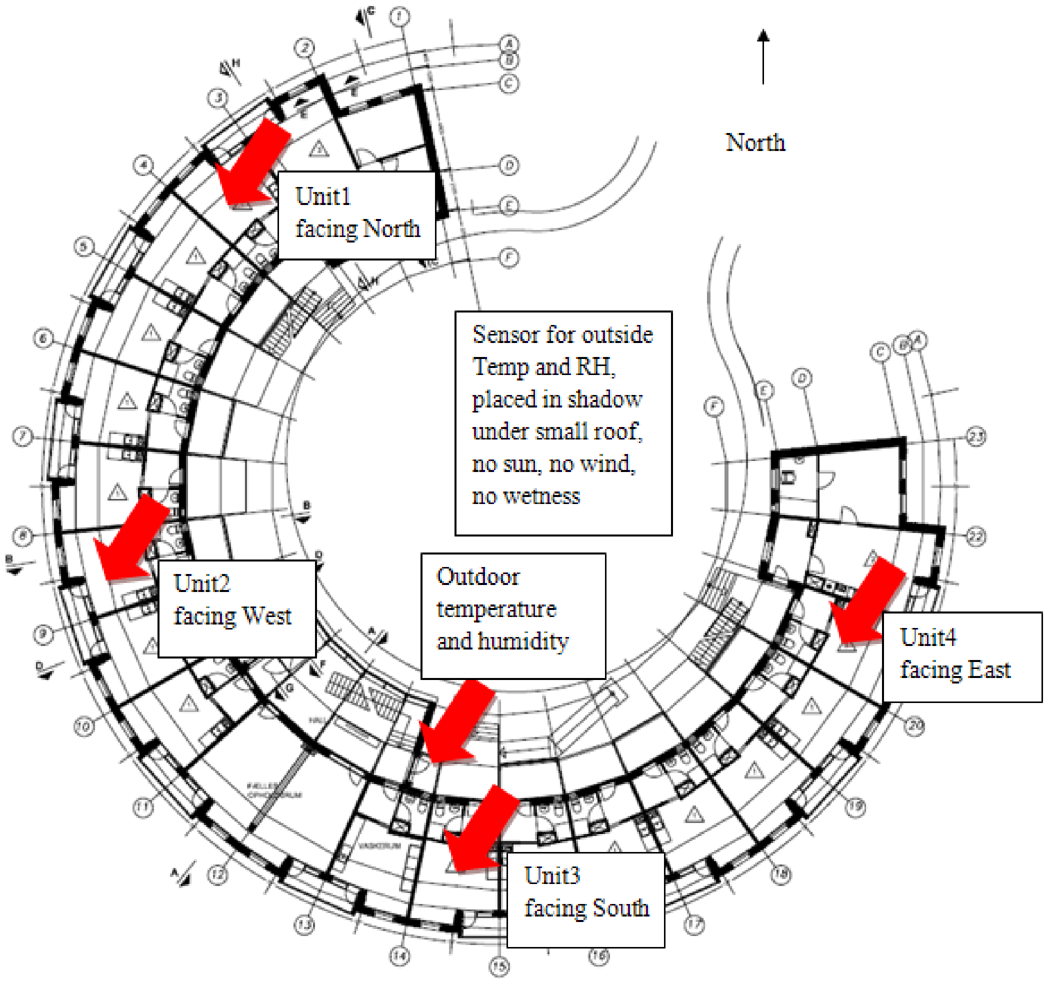

Fig. 4. First floor (level 1)

Level 2

	Section	Flat nr.
Flat 5:	3-4	2.02

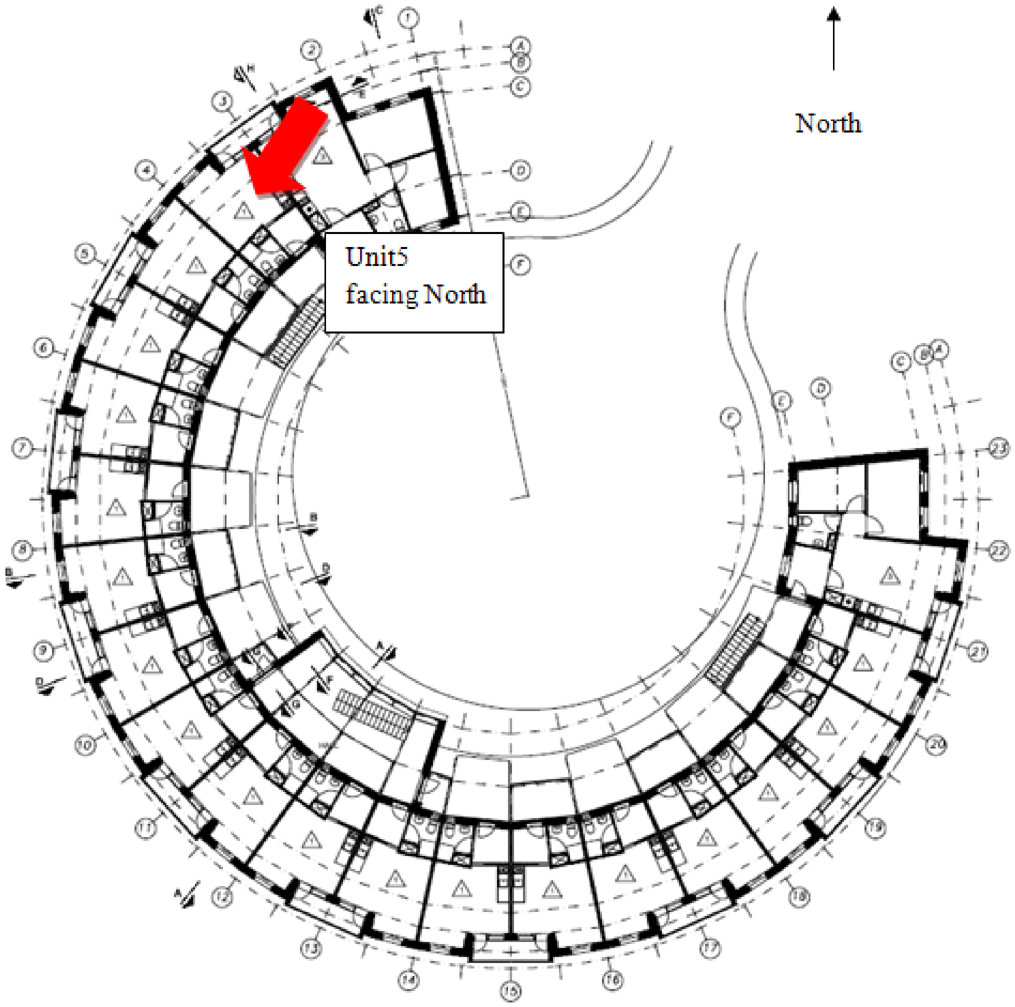

Fig. 5. Second floor (level 2)

4.1.2 On room level - single unit

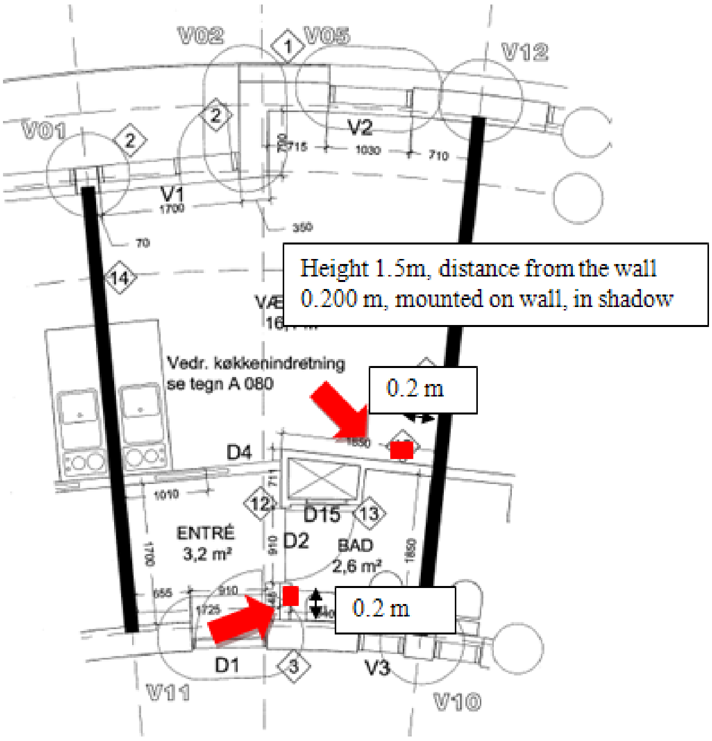

Fig. 6. Unit for placing indoor climate measurement

4.2 CO_2 sensors

Objective

- to register the level of CO_2 concentration
- Vaisala CARBOCAP® Carbon Dioxide Transmitter Series GMW20 (wall mounted) with no display

Location

- as for indoor climate Honeywell sensors in living rooms
- wall mounted (GMW)

Calibration

- before delivery: 0…5,000 ppm
- after 5 years

Fig. 7. CO_2 transmitter for demand

4.3 Opening and temperature sensors

Objective

- in 3 single units
- two sensors will be located in room, one sensor in bathroom and one in entrance
- each sensor will measure the state of opening of a window / door (0=closed, 1=open) and time duration (in seconds)
- each sensor will be accompanied with a temperature sensor

Location

- according the mounting instruction
- balcony door (right side) and single window in a room, bathroom window, entrance door

Calibration

- not needed

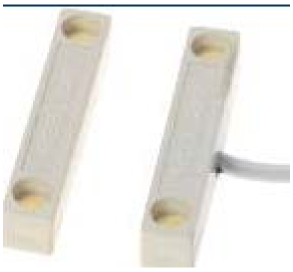

Fig. 8. Magnetic valve DC101

4.4 Build in sensors

Objective

- to measure moisture content in construction
- in most demanding places
- to measure varying content of moisture (leads to shrinking or swelling of wood) or high moisture content (growth of mould, fungi)
- built-in moisture and moisture transfer from in/out
- cheap yet reliable sensors
- timber structure with insulation with concrete load bearing structure and steel additional structure
- the protection cap will be from steel

Location

- biggest risk of condensation
- location close to outside of the insulation are worse (better to measure)
- North orientation is more critical than South orientation
- position with moisture sensible materials (e.g. wood or other organic materials) are more important to measure than positions with less sensible materials (e.g. concrete)
- positions around cold bridges might be interesting, but also positions away from cold bridges
- potential cold spots are probably more interesting than potential warm spots
- positions where there is a risk that there could be an air flow, e.g. risk that warm humid air from inside could penetrate and pass by
- steel structure holding the solar collectors (top of concrete/below insulation)
- between concrete and roof insulation away from the structure that holds the solar collectors

Calibration

- calibrated according the best usage in Arctic climate
- if the temperature goes below -40 °C, the sensor will log a value “-40 °C”; when the temperature rise over -40 °C the actual value will be shown
- calibration scale for channel 1 (temperature) -40 °C to +40 °C (0...10 V) and for channel 2 (humidity) 0..100%

Table 12

Moisture and temperature built-in sensors - Vaisala

	Temperature measurement range	Accuracy	Relative humidity sensing range	Accuracy
HMT100	-40 …+80 °C	±0.2 at 20 °C	0…100%	<2.5% RH dependent on temp.

Fig. 9. Vaisala HMT100 remote probe with wall mount model

Table 13

List of sensors and why they are placed in a location

Detail 1	DTU1 – Temperature & Relative humidity	To log temperature in critical place between inside gypsum and concrete wall. Could point out an air-tight problem.
	DTU2 – Temperature & Relative humidity	Critical place between concrete and insulation. Could show problem of condensation influenced from outside temperature and interior concrete.
	DTU3- Temperature & Relative humidity	Temperature and RH on almost exterior surface. Sensors in detail1 are facing North.
Detail 2	DTU4 – Temperature & Relative humidity	Temperature and RH close to internal surface. Could show a problem with condensation. Sensor is facing closed circle of dormitory.
Detail 3	DTU5 – Temperature & Relative humidity	Risk of condensation on inner surface in window corner. Located on second floor and facing North.
	DTU6 – Temperature & Relative humidity	Measurement of almost outside surface of construction. Facing North and on second floor close to ceiling.
Detail 3	DTU7 – Temperature & Relative humidity	Measurement of temperature on inner face of concrete, possible risk of condensation of air coming from outside and touching of concrete. Mould growth.
	DTU8 – Temperature & Relative humidity	Connection between suspended balcony and concrete-load bearing structure. Possible transfer of heat to the building.
	DTU9 – Temperature & Relative humidity	Possible transfer of heat from outside to inside beneath a wooden detail below window. Facing North and between first and second floor.
Detail 5	DTU10 – Temperature & Relative humidity	Temperature and RH in shaft were the ducts for ventilation are placed.
Detail 6	DTU11 – Temperature & Relative humidity	Difficult place close to outside temperature, transfer of heat. Facing closed circle of Dormitory.
Detail 7	DTU12 - 13 – Temperature & Relative humidity	Typical detail of small window facing North. Transfer heat in detail of window mounting.
Detail 8	DTU14 – Temperature & Relative humidity	Protruding of steel structure holding solar support. Possible risk of condensation and cold bridge.
	DTU15 – Temperature & Relative humidity	Temperature and RH of attic, close to outside.

4.4.1 On floor level - layout and cross section

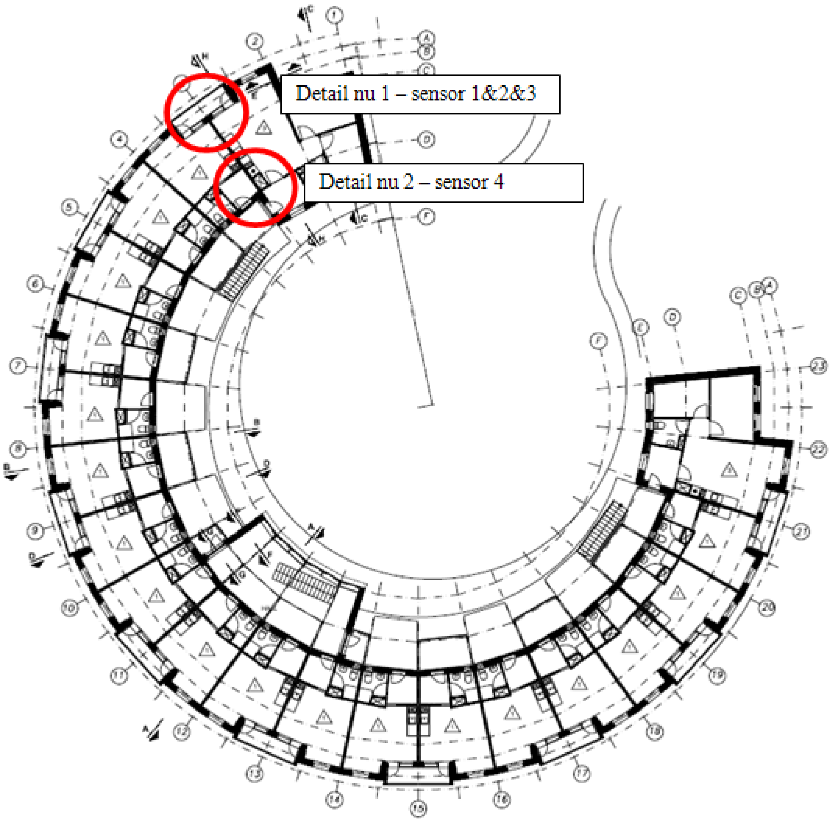

Fig. 10. Second floor (level 2)

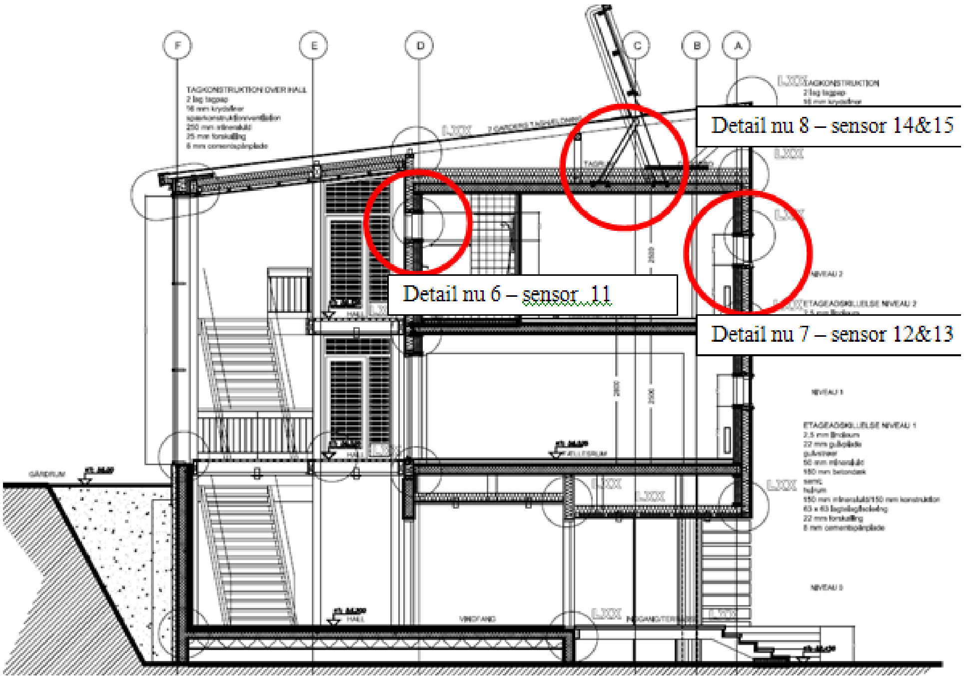

Fig. 11. Cross-section I (module line 3-4)

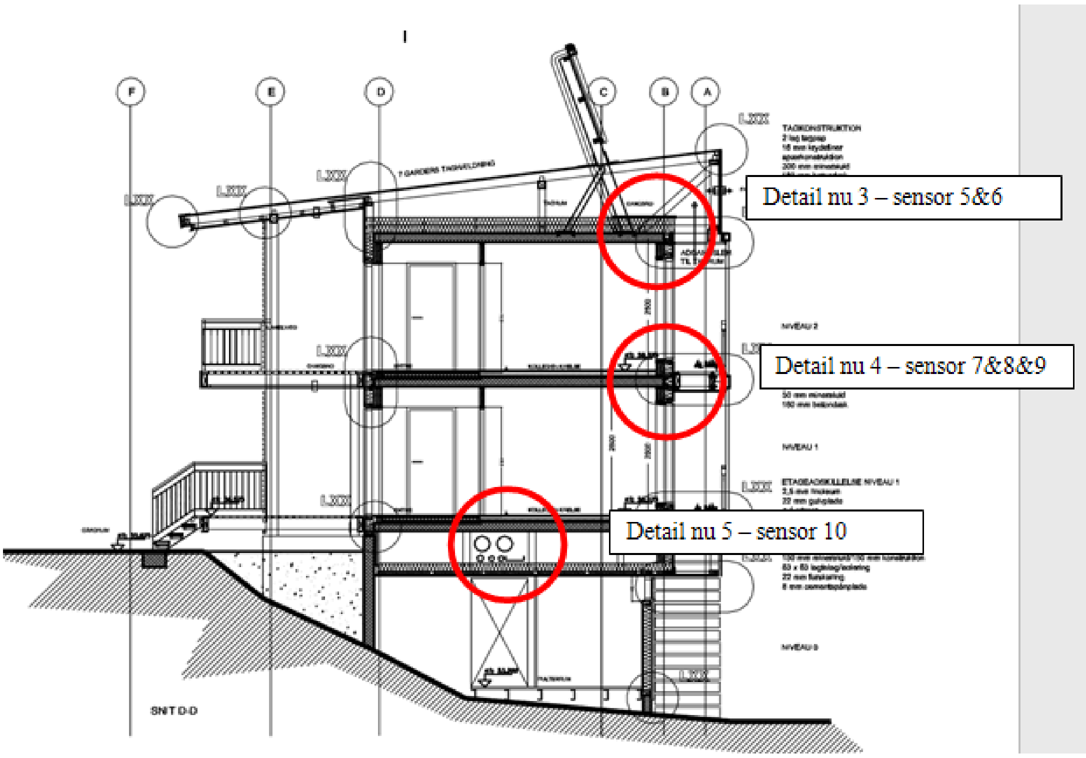

Fig. 12. Cross section II (module line 3-4)

4.4.2 On room level - walls, floors, attic

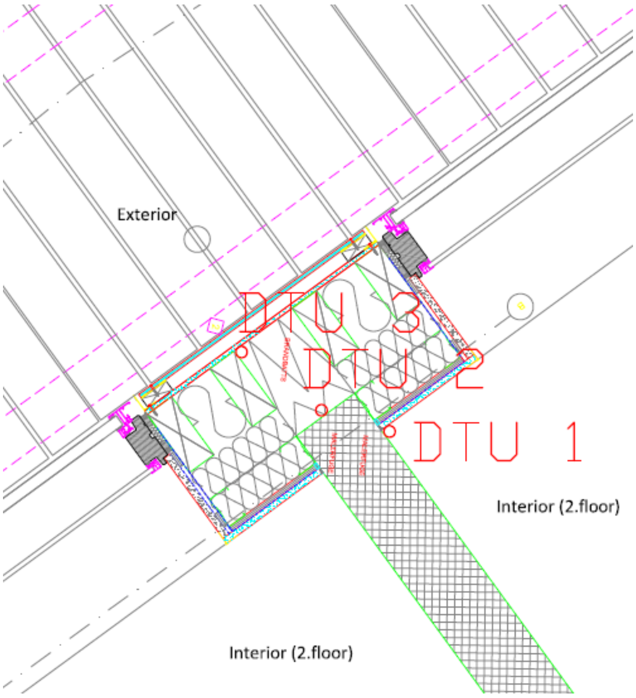

Fig. 13. Detail 1 - sensor 1,2&3

Fig. 14. Vaisala sensors, module line 3-4, DTU1 and DTU2, from inside

Fig. 15. Vaisala sensors, module line 3-4, DTU1, from inside

Fig. 16. Vaisala sensors, module line 3-4, DTU2, from inside

Fig. 17. Vaisala sensors, module line 3-4, DTU3 and DTU8 from outside

Fig. 18. Vaisala sensors, module line 3-4, DTU3 from outside

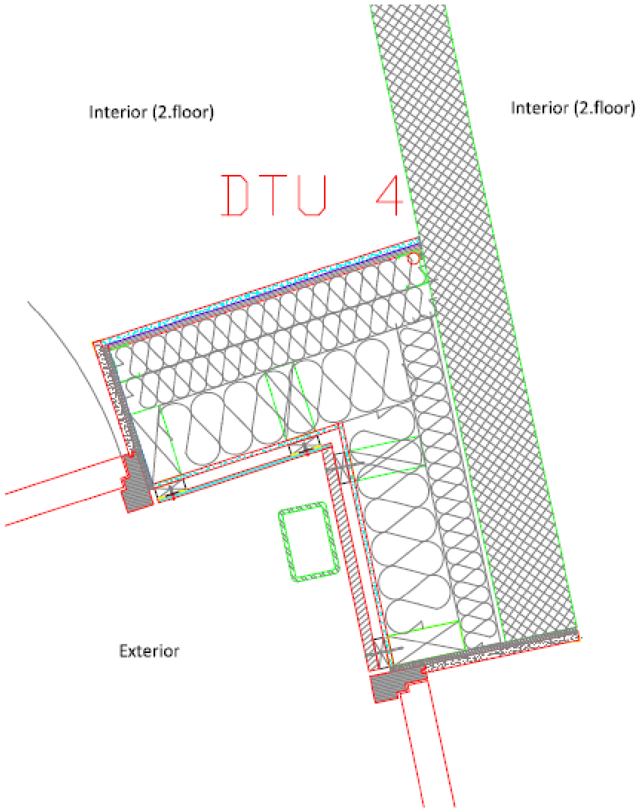

Fig. 19. Detail 2 - sensor 4

Fig. 20. Vaisala sensors, module line 3-4, DTU4 from inside

Fig. 21. Vaisala sensors, module line 3-4, DTU4 from inside, close-up

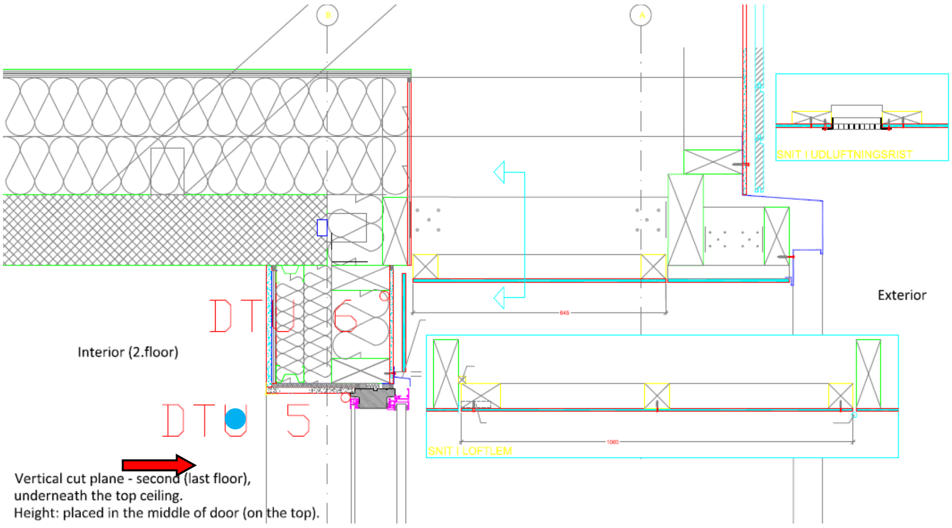

Fig. 22. Detail 3 - sensor 5&6

Fig. 23. Vaisala sensors, module line 3-4, DTU5 and DTU6 from inside

Fig. 24. Vaisala sensors, module line 3-4, DTU5 from inside, close-up

Fig. 25. Vaisala sensors, module line 3-4, DTU6 from inside

Fig. 26. Vaisala sensors, module line 3-4, DTU6 from inside, close-up

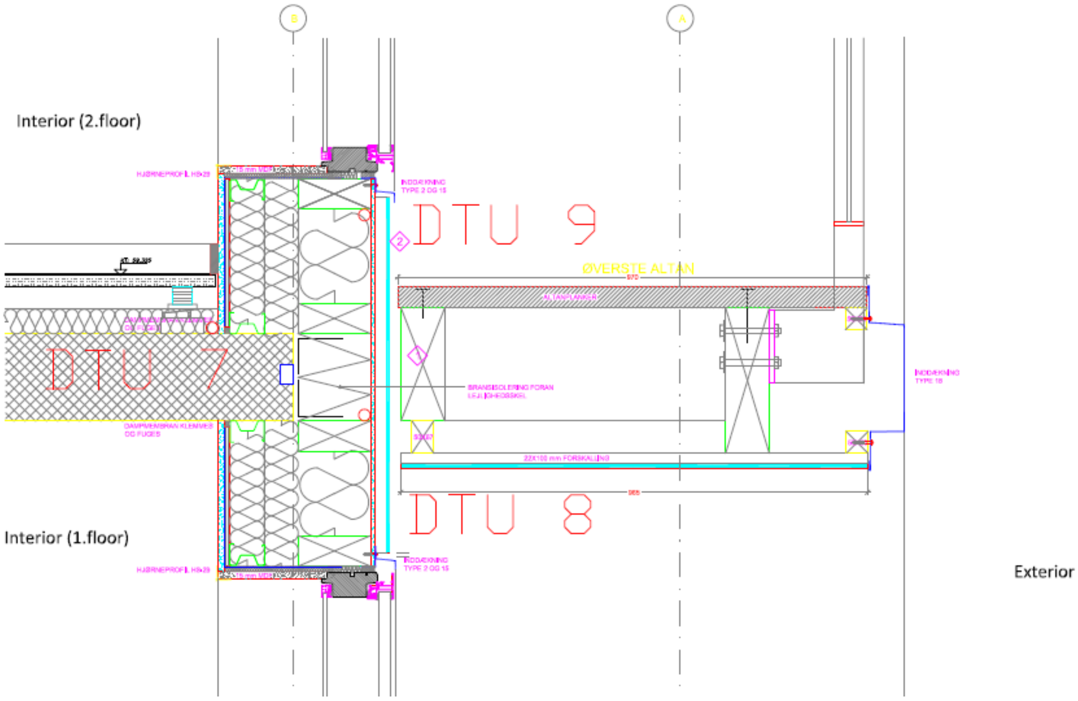

Fig. 27. Detail 4 - sensor 7, 8 & 9

Fig. 28. Vaisala sensors, module line 3-4, DTU3 (left) and DTU8 (right), from outside

Fig. 29. Vaisala sensors, module line 3-4, DTU8 from outside, close-up

Fig. 30. Vaisala sensors, module line 3-4, DTU9 from inside

Fig. 31. Vaisala sensors, module line 3-4, DTU9 from inside, close-up

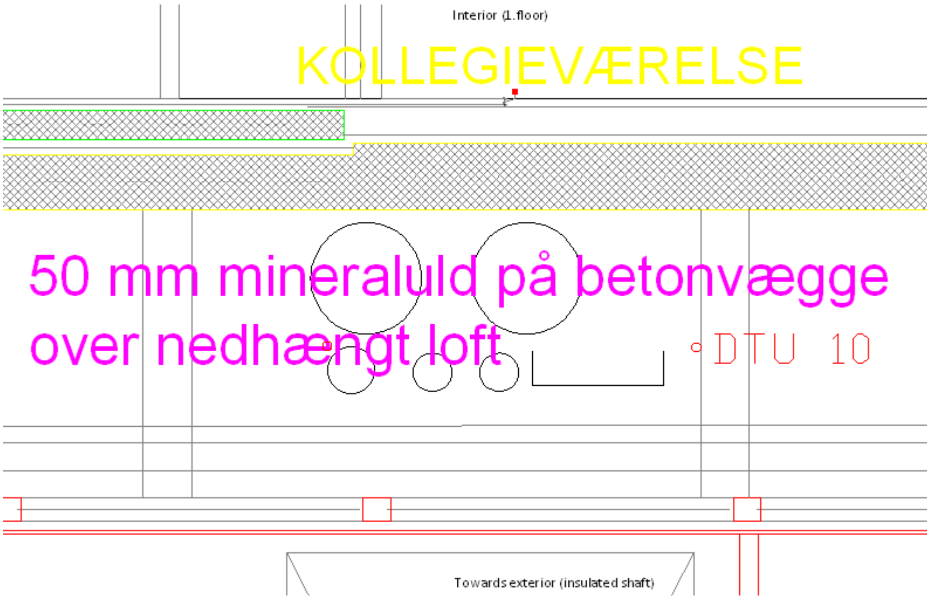

Fig. 32. Detail 5 - sensor 10

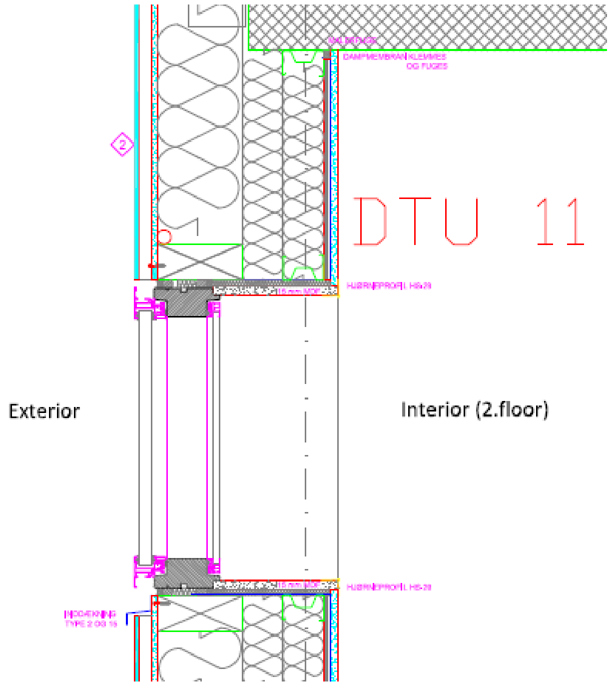

Fig. 33. Detail 6 - sensor 11

Fig. 34. Vaisala sensors, module line 3-4, DTU11 from inside

Fig. 35. Vaisala sensors, module line 3-4, DTU11 from inside, close-up

Fig. 36. Vaisala sensors, module line 3-4, DTU11 from inside, close-up 2

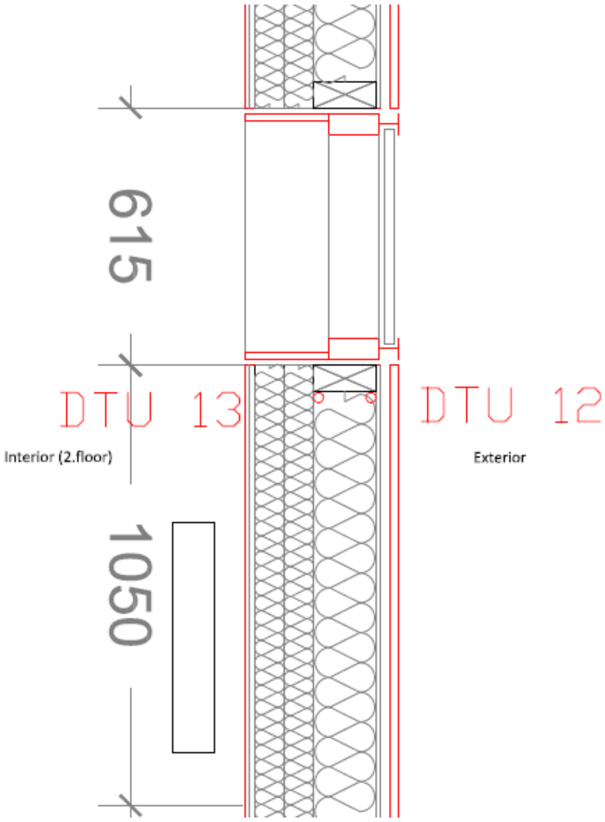

Fig. 37. Detail 7 - sensor 12&13

Fig. 38. Vaisala sensors, module line 3-4, DTU12 (back) and DTU13 (front) from inside

Fig. 39. Vaisala sensors, module line 3-4, DTU12 (back) and DTU13 (front) from inside, close-up

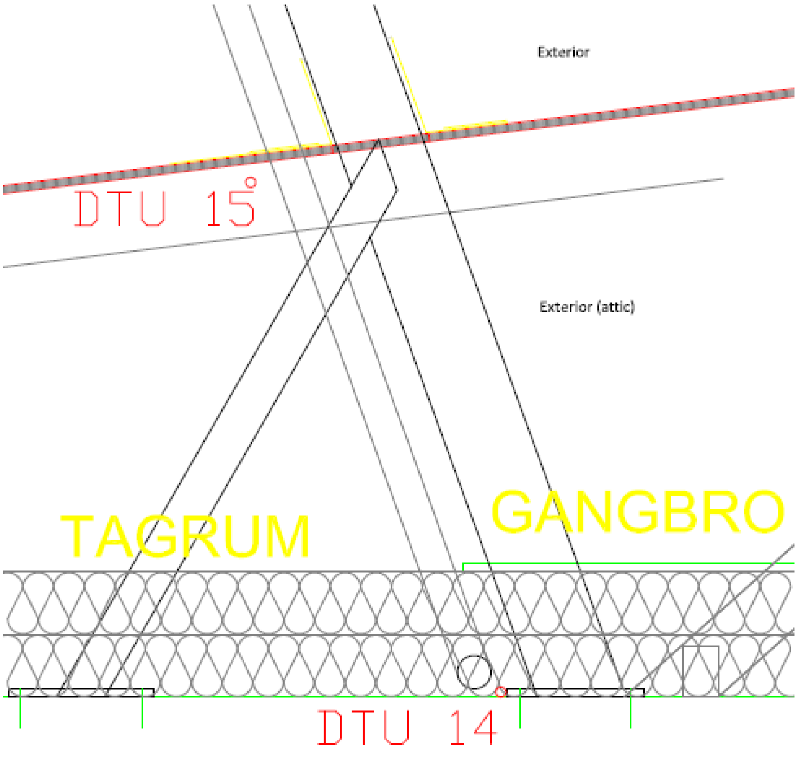

Fig. 40. Detail 8 - sensor 14&15

4.5 Energy meters

Objective

- to measure various consumptions and flows, and be able to measure/calculate the total heating consumption
- identify the heat loss in case of circumpolar heat loss or escape of energy
- Kamstrup Multical 601 based on the diameter of the ducts and on the flow

Location

- According to drawing in Fig. 42.

Calibration

- Calibrated from factory

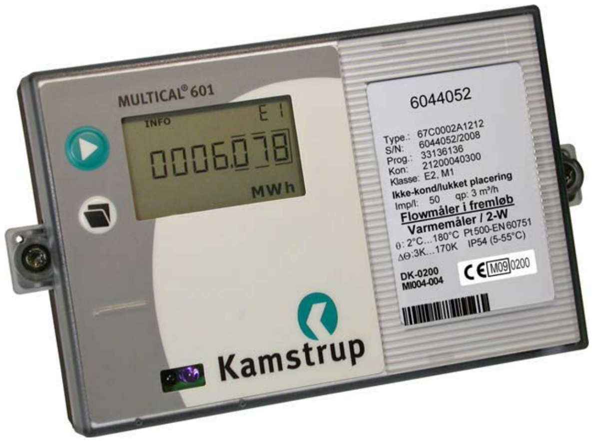

Fig. 41. Energy meter Kamstrup Multical 601

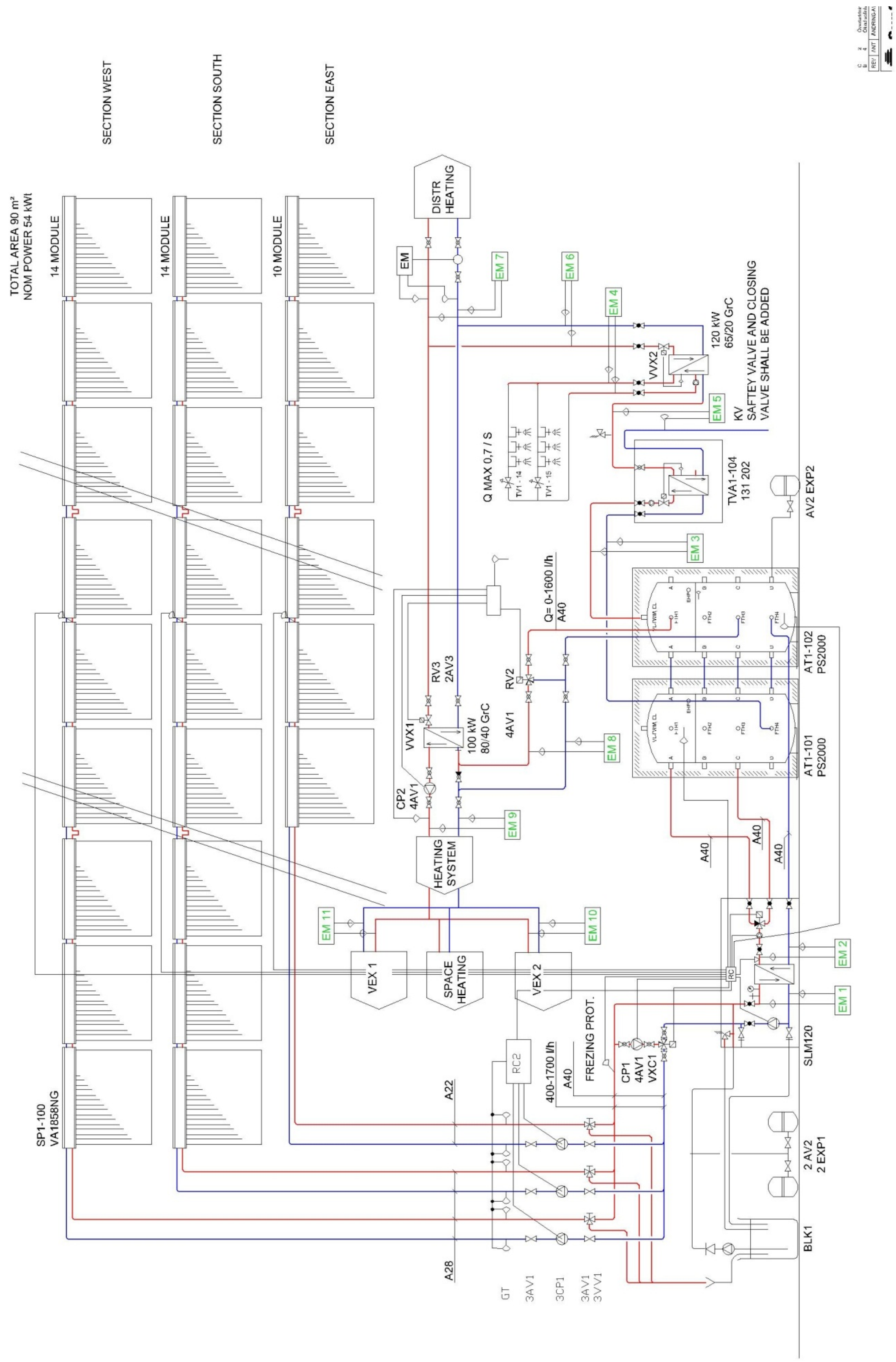

Fig. 42. Technical room scheme and energy meter placement

4.6 Ventilation

Objective

- Evaluation of ventilation unit's performance
- IAQ measurements

Location

- Inside the ventilation units

Calibration

- Calibrated from manufacturer

4.6.1 AFC100

- to measure the air flow from extract and supply air

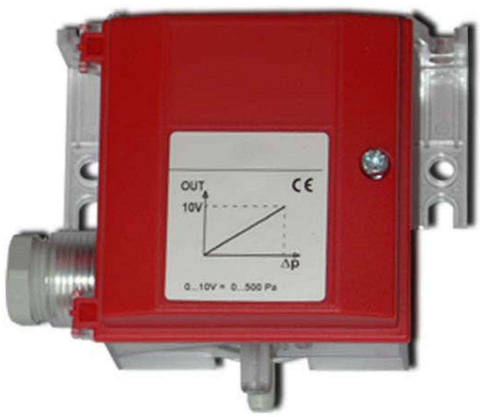

Fig. 43. AFC100 for heat exchanger

4.6.2 VEX 160FC

- delivered with VEX
- to measure: inlet air before HE, exhaust air after HE, exhaust air before HE, inlet air after HE, speed of extract and supply fan, pressure of extract and supply air duct
- description in file

4.6.3 HK sensors

- to measure pressure loss of / over the unit, where air flow is measured based on the pressure difference
- to monitor what is the pressure difference on exhaust before and after the unit, to be able to see if the pressure loss of unit increases when there is freezing of a unit

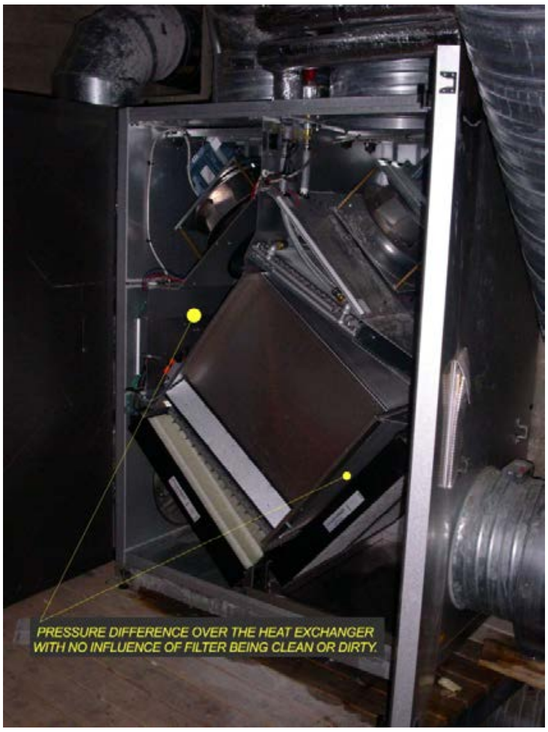

Fig. 44. Location of HK sensors

4.6.4 Humidity sensors

- to monitor the relative humidity of: inlet before HE, exhaust after HE, exhaust before HR and inlet after HE

Fig. 45. Vaisala Humicap HMT100 with duct installation mounting kit

5 Contact list

5.1 Monitoring system

Name	Contact information	Position in the project
Petra Vladykova Ph.D. student	Technical University of Denmark Brovej 118, 2800 Kgs. Lyngby, Denmark pev@byg.dtu.dk +45 45 25 18 62 +45 60 83 21 55 www.dtu.dk	Design of the monitoring system and selection of sensors
Martin Kotol Ph.D. student	Technical University of Denmark Brovej 118, 2800 Kgs. Lyngby, Denmark mrko@byg.dtu.dk	System operation, data analysis, trouble shooting, building experiments
Stefan Hammer Electricity Installer	Kaataq El ApS, Aqqusinersuaq 81, Postboks 465, 3911 Sisimiut, Greenland Stefan@kae.gl +299 86 56 86 www.kaataqel.gl	Installation and selection of sensors Setting up of Lonbox system
Martin Gredsted Building site supervisor (Projektleder)	TNT NUUK +299 48 74 01 mg@tntnuuk.gl	Building site manager for Apisseq

5.2 Sensors

Name	Contact information	Position in the project
Jan Olsen	Brdr. Jørgensen Instruments A/S Hanne Nielsens Vej 10, 2840 Holte jo@brj.dk +45 45 47 30 44 www.brj.dk	Ordering, calibration and delivery of Vaisala sensors
Anders Møller	Automatikcentret ApS Strandvejen 42, Saksild, 8300 Odder am@automaticenteret.dk +45 86 62 63 64 rt@automatikcentret.dk	Ordering and delivery of Honeywell sensors
Thomas Maltesen	Prolon A/S Denmark, www.prolon.dk tm@prolon.dk	Provider of PID 4000
Jesper Gram Hansen Servicechef	EXHAUSTO DK Odensevej 76 DK-5550 Langeskov www.exhausto.dk jgh@exhausto.dk	Provider of ventilation unit VEX160
Gabi Lars Løvendahl	Broendum +299 525913 gla@broendum.gl lal@broendum.gl	Supplier and mounting of EM 4-9 for heating system
Lars Weiss	VVS Service Sisimiut A/S Box 237 3911 Sisimiut +299 864924 lars@vvsservice.gl	Supplier and mounting of EM 1,2,3 for solar heating

5.3 Technical University of Denmark

Name	Contact information	Position in the project
Arne Villumsen	av@byg.dtu.dk	Project supervisor for monitoring system
Carsten Rode	car@byg.dtu.dk	Decision making and advice on the monitoring system
Simon Furbo	sf@byg.dtu.dk	Solar system monitoring advisor
Janne Dragsted		Solar system monitoring advisor

5.4 Dormitory

Name	Contact information	Position in the project
Jørn Hansen Akademiingeniør	Rambøll, Sisimiut afd. Postboks 426, 3911 Sisimiut, Grønland joha@ramboll.gl	Involved in dormitory Representative from the employer (building owner)
Sten Kryger Andersen Architect, Engineer	Inuplan A/S Postbox 1024, 3900 Nuuk +299 34 37 01 ska@inuplan.gl	Design of the dormitory Energy calculation
Robert Sundquist	Exoheat robert@exoheat.se +46 (0) 43 17 89 90	Design of heating system
Flemming Berger	TNT Nuuk +299 32 12 56 fb@tntnuuk.gl	Project team leader
Ole Lennert	SARFAA Ingengeniørit siunnersuisartut. Postboks 561, Saqqarlernut 28, 3900 Nuuk ole@sarfaa.gl +299 34 81 00	Member of project team Data Acquisition Equipment
Peter Poulsen	TNT Nuuk a/s Hellerupvej 8, baghuset, 2900 Hellerup pp@tntnuuk.gl	Design of Apisseq Architectural expression