Definition of the indoor environmental quality

Final VERSION

Used for Net Zero Energy Buildings (NetZEB)
in

strategic research centre for
ZERO ENERGY BUILDINGS

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Contents

Scope

The scope of this document is in relation to the Strategic Research Centre for Zero Energy Buildings (ZEB) to define method and procedures for describing and evaluating the indoor environmental quality in new and existing residential and office buildings. The document includes criteria for design, dimensioning and operation of buildings. Methods and concepts for evaluation of and describing the performance of buildings by building simulation, physical measurements and subjective measurements are defined.

Working group

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1. Introduction

To be able to compare the different activities within the ZEB centre where the indoor environment is specified or evaluated, there is a need for defining some common criteria and concepts. Wherever possible the criteria and methods should be based on existing international standards. If needed additional criteria and concepts will be explained in the present document.

The indoor environment shall be evaluated on a room by room basis. Typically 1-4 rooms in a building must be evaluated taken into account the following factors:

- Individual office
- Landscaped office
- Bedroom
- Living room
- Location in the building (south-north, corner, number of external surfaces)

Design and dimensioning

The design must take into account the criteria for thermal comfort, indoor air quality (ventilation), illumination and acoustic.

2. Thermal environment

For design of buildings and dimensioning of room conditioning systems the thermal comfort criteria (minimum room temperature in winter, maximum room temperature in summer) shall be used as input for heating load (EN12831) and cooling load calculations. This will guarantee that a minimum-maximum room temperature can be obtained at design outdoor conditions and design internal loads. Ventilation rates that are used for sizing the equipment shall be specified in design

Instead of using temperature as the design criterion the PMV-PPD index can be used directly. In this way the effect of increased air velocity will be taken into account.

The project must specify to what extent the occupant's are able to individually adjust or control their personal indoor environment (personal ventilation devices, set point for room temperature, opening of windows, control of blinds, and electrical light .

In Denmark and several other countries there is a requirement for individual room control of the heating system. The possibility to individually control room heating, solar shading, electric light and open able windows improves the satisfaction with the indoor environment

For the purpose of the ZEB centre we are only dealing with rooms for mainly sedentary activity (1.2 met) and two levels of clothing, 0.5 clo for summer and 1.0 clo for winter. In special projects other clothing/activity values maybe used; but the corresponding criteria must then be specified.

As a default it is recommended to use category II for design and dimensioning. All categories shall however be used for the evaluation of the building performance (see later).

Mechanically ventilated buildings

Table 1. Example criteria for PMV-PPD, operative temperature and ventilation (CO_2) for typical spaces with sedentary activity in mechanically ventilated or air conditioned buildings. (EN15251, 2007)

Class	Thermal requirements Comfort		Operative Temperature range	
	PPD	PMV	Winter 1.0clo/1.2met	Summer 0.5clo/1.2 met
	[%]	[/]	[°C]	[°C]
I	< 6	-0.2 < PMV < + 0.2	21.0-23.0	23.5-25.5
II	< 10	-0.5 < PMV < + 0.5	20.0-24.0	23.0-26.0
III	< 15	-0.7 <PMV < + 0.7	19.0-25.0	22.0-27.0
IV	> 15	PMV > ± 0.7	< 19.0-25.0<	<22.0-27.0<

Note: In standards like EN ISO 7730 and CR 1752 categories or classes are also used; but may be named different (A, B, C or 1, 2, 3 etc.).

The corresponding temperature ranges in Table 1 are based on the assumed activity and clothing listed and these further assumptions: Air velocity < 0,15m/s, RH (relative humidity) in summer 60%; in winter 40%. For other conditions corresponding temperature intervals can be calculated using the PMV-index (ISO EN 7730).

Naturally ventilated buildings

The criteria for the thermal environment in natural ventilated buildings without mechanical cooling may be specified differently from those with mechanical cooling during the warm season due to the different expectations of the building occupants and their adaptation to warmer conditions. The level of adaptation and expectation is strongly related to outdoor climatic conditions.

In summer most naturally ventilated buildings are free-running so there is no mechanical cooling system to dimension and the criteria for the categories are based on indoor temperature. Summer temperatures are mainly used to design for the provision of passive thermal controls (e.g. solar shading, thermal capacity of building, design, orientation and opening of windows etc) to avoid over heating of the building.

Recommended criteria for the indoor temperature are given in Figure 1 based on a weekly running mean outside temperature.

The operative temperatures (room temperatures) presented in Figure 1 are valid for

- office buildings and other buildings of similar type used mainly for human occupancy with mainly sedentary activities
- dwellings, where there is easy access to operable windows and where occupants may freely adapt their clothing to the indoor and/or outdoor thermal conditions.

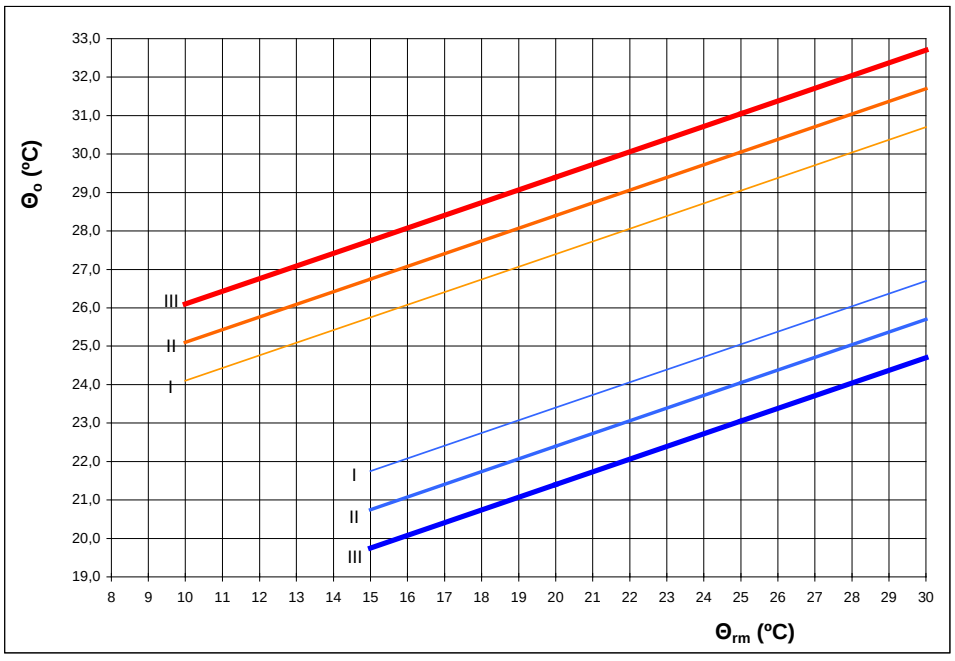


Figure 1. Design values for the indoor operative temperature for buildings without mechanical cooling systems as a function of the exponentially-weighted running mean of the outdoor temperature . [EN15251]

Θ_0 = Operative temperature ^{o}C.

Θ_{rm} = Outdoor Running mean temperature ^{o}C.

Θ_{rm} = (Θed-1 + 0,8 Θed-2 + 0,6 Θed-3 + 0,5 Θed-4 + 0,4 Θed-5 + 0,3 Θed-6 + 0,2 Θed-7)/3,8

Where

Θed-1 = the daily mean external temperature for the previous day

Θed-2 = the daily mean external temperature for the day before etc

The temperature limits only apply when the thermal conditions in the spaces at hand are regulated primarily by the occupants through opening and closing of windows. Several field experiments have shown that occupants' thermal responses in such spaces depends in part on the outdoor climate, and differ from the thermal responses of occupants in buildings with HVAC systems, mainly because of differences in thermal experience, availability of control and shifts in occupants' expectations.

In order for this optional method to apply, the spaces in question must be equipped with operable windows which open to the outdoors and which can be readily opened and adjusted by the occupants of the spaces.

There must be no mechanical cooling in operation in the space. Mechanical ventilation with unconditioned air (in summer) may be utilized, but opening and closing of windows must be of primary importance as a means of regulating thermal conditions in the space. There may in addition be other low-energy methods of personally controlling the indoor environment such as fans, shutters, night ventilation etc. The spaces may be provided by a heating system, but this optional method does not apply during times of the year when the heating system is in operation when the method of Table 1 applies.

This optional method only applies to spaces where the occupants are engaged in near sedentary physical activities with metabolic rates ranging from 1,0 to 1,3 met. It is also important that strict clothing policies inside the building are avoided, in order to allow occupants to freely adapt their clothing insulation.

The (summer) temperature limits presented here are primarily based on studies in office buildings. Nevertheless, based on general knowledge on thermal comfort and human responses, the assumption can be made that the limits may apply to other (comparable) buildings with mainly sedentary activities like residential buildings. Especially in residential buildings the opportunities for (behavioral) adaptation are relatively wide: one is relatively free to adjust metabolism and the amount of clothing worn dependent on outside weather conditions and indoor temperatures.

The temperature limits in Figure 1 are based on comfort studies in offices, which did not take peoples work performance into account.

In landscaped (open plan) offices most occupants have only limited access to operable windows and therefore poor control over natural ventilation. Therefore: the temperature limits presented in Figure 1 may not always apply in such situations.

Local thermal comfort

For design purposes also the criteria for local thermal comfort in Table 2 (draught, vertical air temperature differences, radiant asymmetry, floor surface temperatures, EN ISO 7730) may influence the dimensioning of facades and heating, cooling and ventilation systems.

Table 2. Recommended categories for local thermal discomfort parameters (reference: EN7730)

Category	Vertical airTemp. diff. K	Floor surface C	Radiant temp. asymmetry (K)				Mean air velocity m/s	
			Warm Ceiling	Cool ceiling	Cool wall	Warm Wall	Cooling season Summer	Heating season Winter
I	2	19-29	5	14	10	23	0.18	0.15
II	3	19-29	5	14	10	23	0.22	0.18
III	4	17-31	7	18	13	35	0.25	0.21
IV	>4	<17;>31	>7	>18	>13	>35	>0.25	>0.21

3. Indoor Air Quality (ventilation)

The indoor air quality shall in the ZEB centre be specified as required ventilation rate or required maximum levels of CO_2.

In buildings with varying occupancy, demand-controlled ventilation can be used to achieve the required indoor air quality at a minimum energy demand.

Table 3. Examples of recommended CO_2 concentrations above outdoor concentration. Applies to all building types within the scope of this document. (EN15251, 2007)

Class	Ventilation CO_2 Above outdoor [ppm]
I	0-350
II	350-500
III	500-800
IV	800<

Note: In standards like EN ISO 7730 and CR 1752 categories or classes are also used; but may be named different (A, B, C or 1, 2, 3 etc.).

Table 3 give in a simplified way recommended levels of CO_2.

In Table4a more detailed values for the recommended ventilation rates in non-residential buildings are given depending on type of space and occupancy density (EN15251). Table 4b give the corresponding levels of CO_2. In accordance with EN15251 Table 5 give recommended ventilation rates for residential buildings.

Table 4a. Examples of recommended ventilation rates for non-residential buildings with default occupant density for three categories of pollution from building itself.

Type of building or space	Category	Floor area m^2/person	q_p	q_B	q_{tot}	q_B	q_{tot}	q_B	q_{tot}
			l/s, m^2 occupancy	l/s,m^2 very low-polluted building		l/s,m^2 low-polluted building		l/s,m^2 non-low polluted building	
Single office	I	10	1,0	0,5	1,5	1,0	2,0	2,0	3,0
	II	**10**	**0,7**	**0,3**	**1,0**	**0,7**	**1,4**	**1,4**	**2,1**
	III	10	0,4	0,2	0,6	0,4	0,8	0,8	1,2
Land-scaped office	I	15	0,7	0,5	1,2	1,0	1,7	2,0	2,7
	II	**15**	**0,5**	**0,3**	**0,8**	**0,7**	**1,2**	**1,4**	**1,9**
	III	15	0,3	0,2	0,5	0,4	0,7	0,8	1,1
Conference room	I	2	5,0	0,5	5,5	1,0	6,0	2,0	7,0
	II	**2**	**3,5**	**0,3**	**3,8**	**0,7**	**4,2**	**1,4**	**4,9**
	III	2	2,0	0,2	2,2	0,4	2,4	0,8	2,8
Auditorium	I	0,75	15	0,5	15,5	1,0	16	2,0	17
	II	**0,75**	**10,5**	**0,3**	**10,8**	**0,7**	**11,2**	**1,4**	**11,9**
	III	0,75	6,0	0,2	0,8	0,4	6,4	0,8	6,8
Restaurant	I	1,5	7,0	0,5	7,5	1,0	8,0	2,0	9,0
	II	**1,5**	**4,9**	**0,3**	**5,2**	**0,7**	**5,6**	**1,4**	**6,3**
	III	1,5	2,8	0,2	3,0	0,4	3,2	0,8	3,6
Class room	I	2,0	5,0	0,5	5,5	1,0	6,0	2,0	7,0
	II	**2,0**	**3,5**	**0,3**	**3,8**	**0,7**	**4,2**	**1,4**	**4,9**
	III	2,0	2,0	0,2	2,2	0,4	2,4	0,8	2,8
Kinder garten	I	2,0	6,0	0,5	6,5	1,0	7,0	2,0	8,0
	II	**2,0**	**4,2**	**0,3**	**4,5**	**0,7**	**4,9**	**1,4**	**5,8**
	III	2,0	2,4	0,2	2,6	0,4	2,8	0,8	3,2
Department store	I	7	2,1	1,0	3,1	2,0	4,1	3,0	5,1
	II	**7**	**1,5**	**0,7**	**2,2**	**1,4**	**2,9**	**2,1**	**3,6**
	III	7	0,9	0,4	1,3	0,8	1,7	1,2	2,1

Tabel 4b — Examples of CO2 criteria for similar spaces and occupancy as in Table 4a.

		Very low polluted	Low polluted	Not low polluted
Building type or space	Category	ΔCO_2 [ppm]	ΔCO_2 [ppm]	ΔCO_2 [ppm]
Single office	I	375	280	190
	II	560	400	265
	III	930	695	465
Landscaped office	I	310	220	140
	II	465	310	195
	III	745	530	340
Conference room	I	510	465	400
	II	735	665	570
	III	1265	1160	995
Auditorium	I	480	465	440
	II	690	665	625
	III	1195	1160	1090
Restaurant	I	495	465	415
	II	715	665	590
	III	1235	1160	1030
Class room	I	510	465	400
	II	735	665	570
	III	1265	1160	995
Kindergarten	I	430	400	350
	II	620	570	500
	III	1070	995	870
Department store	I	260	195	160
	II	365	275	225
	III	615	470	380

Table 4. Ventilation rates for residential buildings with mechanical ventilation. Continuous operation of ventilation during occupied hours. Complete mixing. EN15251

Category	Air change rate [1)]		Living room and bedrooms, mainly outdoor air flow		Exhaust air flow, l/s		
	l/s,m^2 (1)	ach	l/s, pers[2)] (2)	l/s/m^2 (3)	Kitchen (4a)	Bathrooms (4b)	Toilets (4)
I	0,49	0,7	10	1,4	28	20	14
II	0,42	0,6	7	1,0	20	15	10
III	0,35	0,5	4	0,6	14	10	7

[1)] The air change rates expressed in l/sm^2 and ach correspond to each other when the ceiling height is 2,5 m

[2)]The number of occupants in a residence can be estimated from the number of bedrooms. The assumptions made at national level have to be used when existing, they may vary for energy and for IAQ calculations.

The ventilation rates specified in Table 4 and 5 can be converted to equivalent CO_2-levels.

In Denmark the minimum requirement is 0.3 l/s/m² in residential buildings.

Illumination

The criteria in EN 15251 shall be used. The following additional criteria for daylight factor, solar shading and seasonal affective disorder (SAD) should be evaluated.

For rooms that are used during the day (work places, living rooms, dining rooms, kitchens, or child's play rooms) the minimum daylight factor is:

	I	II	III
Daylight factor	> 5% on average	> 3% on average	> 2% on average

Residential buildings

To reduce the prevalence of SAD (seasonal Affective Disorder; "winter depression"), high light levels are particularly important during winter. For minimum one of the main habitable rooms in residential buildings direct sunlight should be available from fall to spring equinox:

	I	II	III
Direct sunlight availability, percentage of probable sunlight hours[1]	> 10%	> 7,5%	> 5%

[1]The direct sunlight availability can be determined by software tools or hand calculation methods. The evaluation is made according to British Standard BS 8206-2:2008 ”Lighting for buildings - Part 2: Code of practice for daylight”. The percentage of probable sunlight hours are calculated as the annual probable sunlight hours available at the reference point compared to the total available sunlight hours.

Office buildings

Solar shading is important to block unwanted direct sunlight. For office rooms and rooms with similar activities in non-domestic buildings the solar shading criteria are:

	I	II	III
Solar shading in rooms facing south (+/- 150°)	Adjustable and retractable shading device, able to block direct sunlight with automatic and manual control, maintain some view to outside	Adjustable and retractable shading device, able to block direct sunlight with automatic and manual control	Adjustable and retractable shading device, able to block direct sunlight with manual control
Solar shading in rooms facing north (+/- 30°)	Retractable shading device, able to block bright skylight and direct sunlight, maintain some view to outside	Retractable shading device, able to block bright skylight and direct sunlight	Retractable shading device, able to block bright skylight

4. Acoustics

The criteria in EN15251 shall be used for the design

Vedvarende støj fra byningens ventilationsanlæg kan genere brugerne. Støjniveauet i et rum kan evalueres med et A-vægtet, ekvivalent lydtrykniveau. Tabel B6 indeholder kriterier for lydtrykniveauer fra bygningsinstallationer for forskellige rum.

Tabel 6 Examples of A-weighted criteria for the sound level from installations (EN15251)

Building	**Room**	**Sound level [dB(A)]**	
		Typical interval	**Recommended level for design**
Residential	Living room	25 to 40	32
	Bed room	20 to 35	26
Institutionsr	Kindergarten	30 to 45	40
Public spaces	Auditorium	30 to 35	33
	Bibliotec	28 to 35	30
	Cinema	30 to 35	33
	Court room	30 to 40	35
	Museum	28 to 35	30
Offices	Single office	30 to 40	35
	Meeting room	30 to 40	35
	Landscaped room	35 to 45	40
Schools	Class room	30 to 40	35
	Corridor	35 to 50	40
	Gymnasium	35 to 45	40
	Meeting room	30 to 40	35

Revebreation time in residential and office buildings should be 0,5.

5. Building simulations

Dynamic simulations must be used to evaluate the performance of a building during a time period (week, month, summer, winter). The simulations must be based on 1-hour input values for weather, building data and the resulting indoor parameters. The output parameters are normally air and operative temperatures, CO_2 concentrations or ventilation rates, humidity, and energy consumption. Besides this daylight factors must be evaluated. The used simulation tool must be specified.

The results must be presented as specified in the following section on long term assessment.

Operation

The operation schedule for the building must be specified. This include schedules for time of occupancy, internal loads, temperature set-points, ventilation (demand controlled), solar shading, artificial lighting (demand controlled) etc.

Furthermore the control concept must be specified. Either the space is controlled by a set-point or the space can float within a specified temperature range.

Default schedule for an office and residential building are included in annex 1.

6. Physical measurements

The indoor environmental quality in existing buildings can be evaluated by physical measurements of the indoor environmental parameters. This can be done as spot measurements, long term measurements and using data from the building management system.

The measuring positions and used instrumentations for measurement of the thermal environment must follow the requirements in EN ISO 7726. Accuracy of the used instruments must be specified.

The presentation of long term measurements is specified in a following section.

Spot measurements

These measurements are used to characterize individual work places and evaluate the uniformity of a space. The measurement locations shall represent the position of the occupants. In a larger room it is recommended to measure at a minimum of three locations: the center of the room, 1 m from the façade and a location in the interior zone away from the façade.

Operative temperature is measured at the middle of a person (0.6m sedentary, 1.1m standing). Draught risk and vertical air temperature differences are measured at head and feet level (0.1m and 1.1m sedentary or 1.7m standing). In ZEB it is normally not necessary to measure radiant asymmetry since the low U-values used for the construction will make sure that all surfaced are almost equal temperature. Humidity can be measured anywhere except position with direct sunlight. CO_2 concentrations are measured at breathing level. Values for daylight factors are measured at desk level. The measurements of daylight must follow the guideline in SBi 219 - Dagslys i rum og bygninger or equal standards.

Spot measurements are often combined with on-site subjective measurements.

Long term measurements

The indoor environment will vary over time due to change in outdoor environment and use of space. Therefore it is recommended to also make long term measurements for at least a week (7 days) both for summer, winter and spring or autumn conditions. As a minimum it is recommended to measure operative temperature, air temperature, humidity, CO_2 level and illumination (Lux) at the center of a space.

For seasonal (summer, winter, whole year) evaluations a location representing the space without disturbing the occupants must be selected. The same parameters as mentioned above should be measured.

Long term measurements should also include the outside climate (air temperature, humidity, CO_2 concentration, solar radiation).

The position of the measuring sensors must be clearly documented.

Building management systems

It is always best to measure with calibrated equipment, but in larger buildings the building management system will record (but not always save) several parameters, which are also used for control of the building and HVAC systems. This system might be used for analysis of the indoor environment. Normally measurements to evaluate the performance of a building should be separate from the sensors used for control, but it will be acceptable to use the build in sensors for evaluating the indoor environment. The location and type of sensors used must be clearly specified in the measuring report. Besides this a control of the building sensors must be made in order to find any large deviations between building sensors and true values.

7. Subjective measurements

The indoor environmental quality can also be evaluated based on subjective measurements. The methods are either on-site spot measurements for a momentarily evaluation or a general measurement.

Spot measurements

In a spot measurement the occupants are asked how they feel exactly now. It is recommended to combine this with a spot measurement of the physical environment. This measurement can also be done on a frequent basis (like once a week) using an online questionnaire through internet or intranet. An example of a short questionnaire is shown Annex 3.

General measurement

An overall questionnaire which includes several back ground questions and questions about the occupants' general evaluation of the indoor environment. This is not related to a specific moment in time but based on a seasonal evaluation. An general example is shown in Annex 2. A specific example from from a Danish low energy house project is shown in Annex 4.

8. Long term assessment of indoor environmental quality

To evaluate the comfort conditions over time (season, year) a summation of parameters must be made based on data measured in real buildings or dynamic computer simulations. Besides a timeline of the data must be shown.

Timeline of parameter

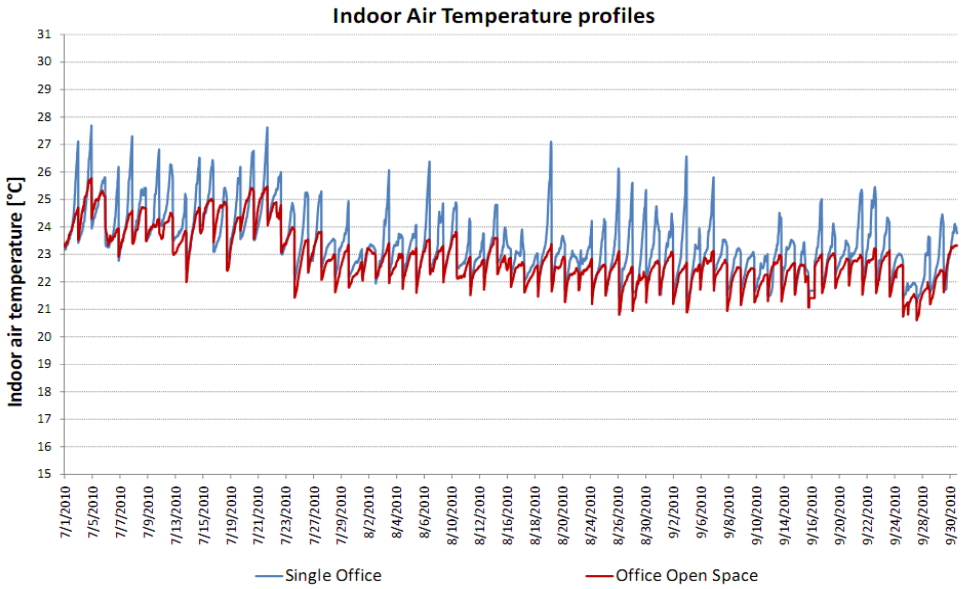


Figure 2. Example of timeline from measurement during a summer period.

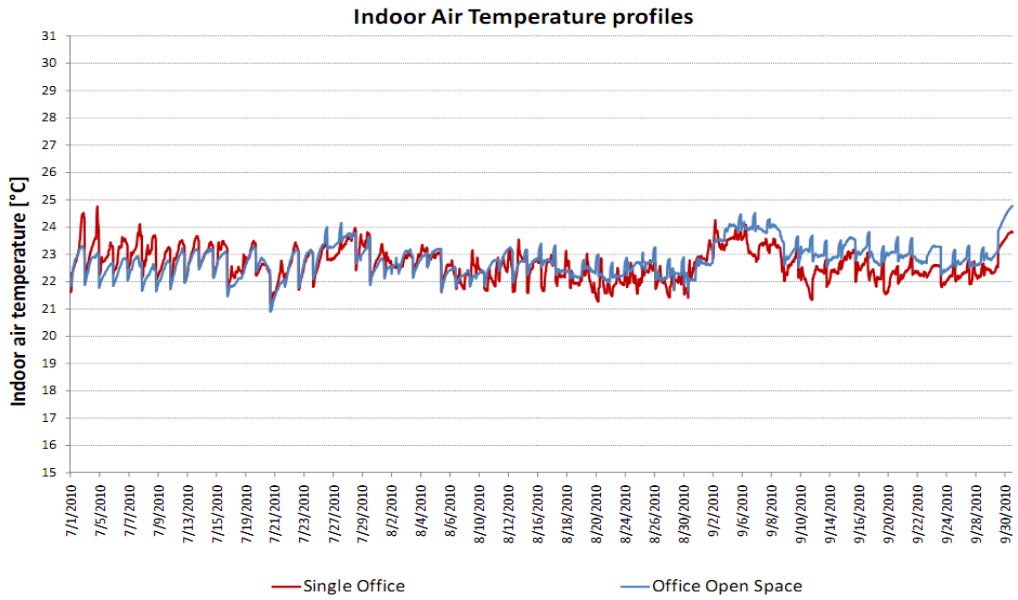


Figure 3. Example of timeline from measurement during a winter period.

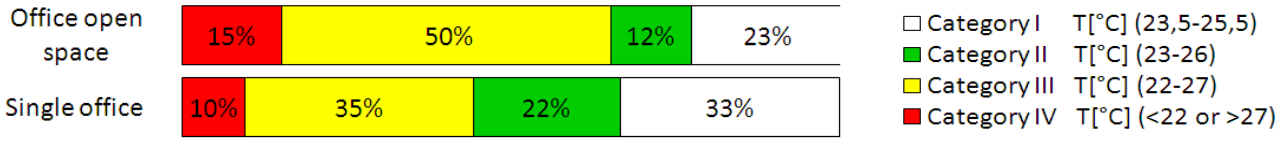
Distribution in categories

Calculate the number or % of occupied hours (those during which the building is occupied) when the parameter (PMV, operative temperature, air temperature, CO_2

concentration above outdoor, ventilation level, illumination, acoustic) is within the different categories. For thermal comfort the % time in category IV is shown separated in warm and cold side (Figur 4)

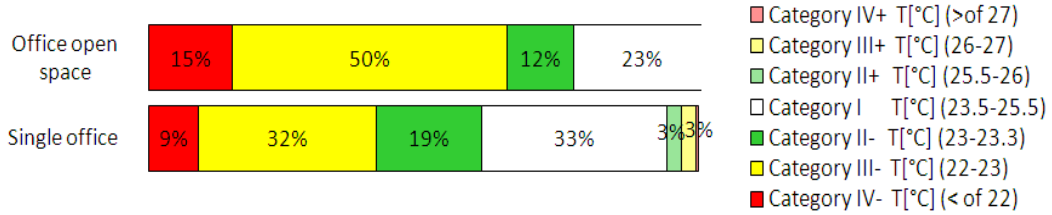
Figr 4 Example of air temperature distribution

Summer

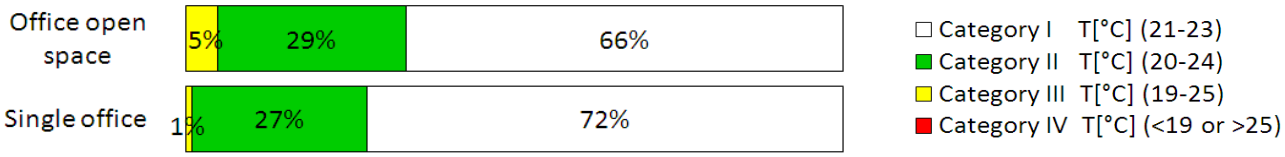


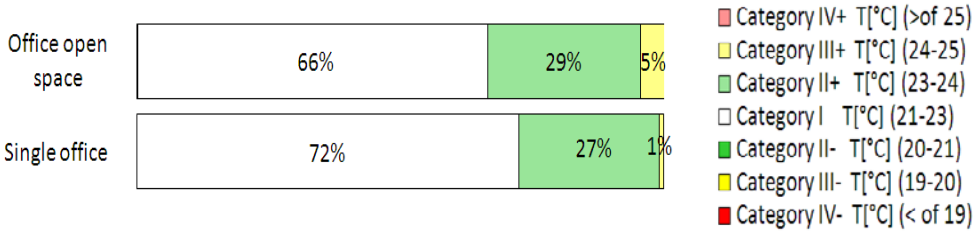
Note: The figure must be changed to show + or – for category I

Alternative with above and below temperature range



Winter





For a natural ventilated building the air (operative) temperature is presented like the following diagrams (Figur 5)

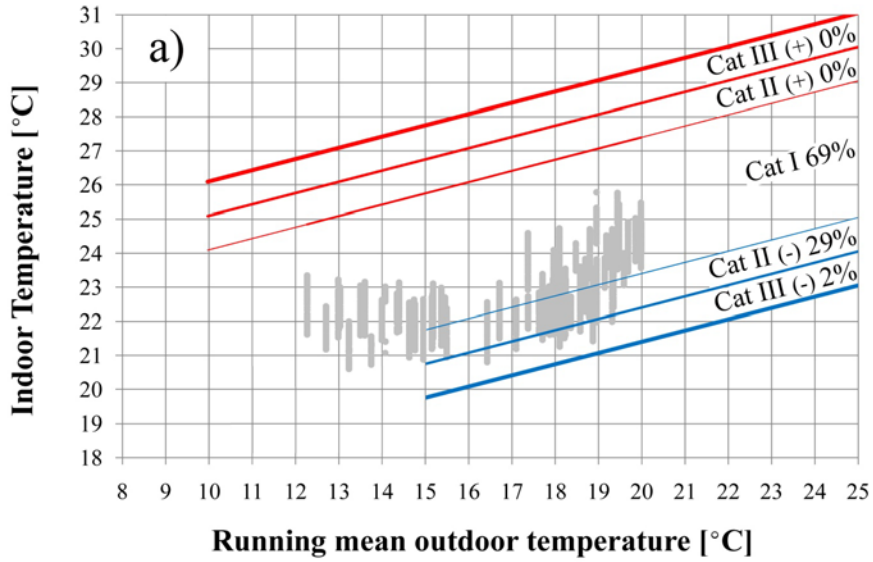


Figure 5a. Presentation of indoor temperature as a function of the running mean outdoor temperature for a landscape office.

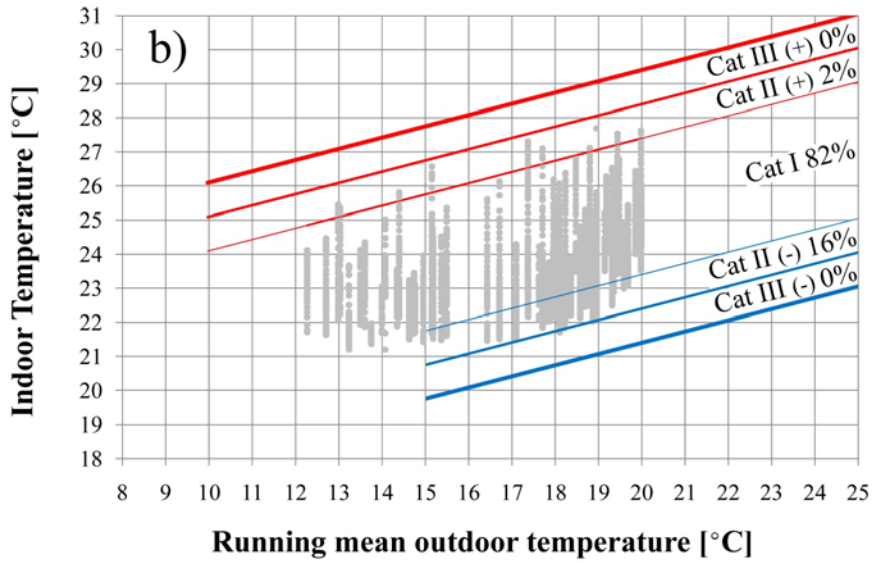
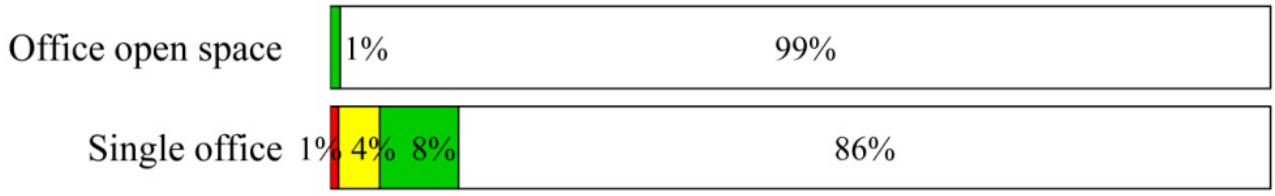


Figure 5b. Presentation of indoor temperature as a function of the running mean outdoor temperature for a single office.

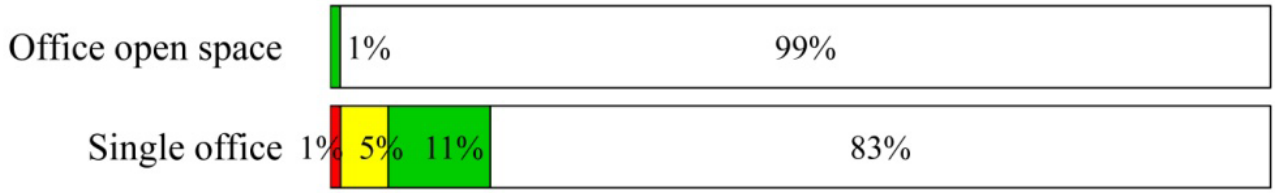
In a similar way the indoor air quality can be shown as a distribution of CO_2 levels (Figure 6)

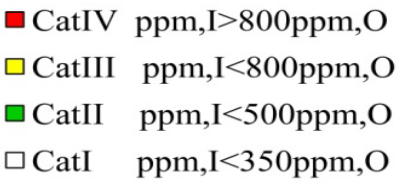
Figure 6 Example of CO2 distribution

Summer



Winter





Degree hours

The time during which the actual operative temperature is above or below the specified temperature set-point during the occupied hours is weighted by a factor which is a function depending on by how many degrees, the range has been exceeded.

The weighing factor, wf, equals 0 for $\Theta_o = \Theta_{o,setpoint}$

Where $\Theta_{o,setpoint}$ is the optimal temperature for the specified activity and clothing level. In ZEB we look at spaces for mainly sedentary occupants e.g. 22.0°C for winter and 24.5°C for summer.

The weighing factor, wf, is calculated as $wf = \Theta_o - \Theta_{o,setpoint}$

For a characteristic period during a year, the product of the weighting factor and time is summed. The summation of the product has the unit of hours:

Warm period: Σ wf · time for $\Theta_o > \Theta_{o,setpoint}$

Cold period: Σ wf · time for $\Theta_o < \Theta_{o,setpoint}$

Table 5. Example of calculation of degree hours

Optimal temperature		24,5°C				22°C			
Period of time		Summer	Jul	Aug	Sep	Winter	Oct	Nov	Dec
Single office	Deg*h (-)	826	135	318	372	20	3	12	5
	Deg*h (+)	92	74	12	6	435	196	93	145
Open space office	Deg*h (-)	1099	171	435	493	8	7	1	0
	Deg*h (+)	26	26	0	0	533	152	120	261

9. References

EN 15251, 2007. Indoor environmental input parameters for design and assessment of energy performance of buildings- addressing indoor air quality, thermal environment, lighting and acoustics. Brussels.

ISO EN 7730, 2007 Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort. Brussels.

ISO EN 10551, Ergonomics of the thermal environment – Assessment of the influence of the thermal environment using subjective judgment scales.

Annex 1 – Example of schedule for occupancy in an office and residential buildings.

Day	Office		Residential 1		Residential 2	
	Occupied	Un-occupied	Occupied	Un-occupied	Occupied	Un-occupied
Monday Tuesday Wednesday Thursday Friday	8:00-12:00 13:00-17:00	00:00-8:00 12:00-13:00 17:00-24:00	00:00-08:00 15:00-24:00	08:00-15:00	00:00-24:00	
Saturday		00:00-24:00		00:00-24:00		00:00-24:00
Sunday		00:00-24:00		00:00-24:00		00:00-24:00

Annex 2 - General background questionnaire.

BACKGROUND CHARACTERISTICS Log off

(1) What is your age? ☐ Years

(2) What is your gender? ○ Female ○ Male

(3) Which is your job category?

- Technical ○
- Administrative ○
- Management ○
- Other, please specify: ☐

(4) Do you use glasses or contact lenses?

Glasses Yes ○ No ○ Contact lenses Yes ○ No ○

(5) How long have you been working in this room? ☐ Years ☐ Months

(6) On average, how many hours per day do you spend at your work desk? ☐ Hours

Continue

HEALTH CHARACTERISTICS Log off

(7) Do you suffer from asthma or allergy? ○ Yes ○ No

(8) Do you suffer from eczema? ○ Yes ○ No

(9) Do you smoke? ○ Yes ○ No

if "YES", on average, how many cigarettes do you smoke per day? ☐ cigaretter

Continue

HEALTH CHARACTERISTICS

Log off

(10) During the LAST THREE MONTHS have you had any (one or more) of the following symptoms while at work? (Please, answer every question even if you have not had any symptoms)

	No, never	Yes, sometimes	Yes often (every week)	Yes, daily
a. Fatigue	○	◉	○	○
Do you believe it is better when you are not in the building?		○ Yes	○ No	
	No, never	**Yes, sometimes**	**Yes often (every week)**	**Yes, daily**
b. Feeling heavy-headed	○	◉	○	○
Do you believe it is better when you are not in the building?		○ Yes	○ No	
	No, never	**Yes, sometimes**	**Yes often (every week)**	**Yes, daily**
c. Headache	○	◉	○	○
Do you believe it is better when you are not in the building?		○ Yes	○ No	
	No, never	**Yes, sometimes**	**Yes often (every week)**	**Yes, daily**
d. Nausea/dizziness	○	◉	○	○
Do you believe it is better when you are not in the building?		○ Yes	○ No	
	No, never	**Yes, sometimes**	**Yes often (every week)**	**Yes, daily**
e. Difficult to concentrate	○	◉	○	○
Do you believe it is better when you are not in the building?		○ Yes	○ No	

Continue

HEALTH CHARACTERISTICS

Log off

(10) During the LAST THREE MONTHS have you had any (one or more) of the following symptoms while at work? (Please, answer every question even if you have not had any symptoms)

	No, never	Yes, sometimes	Yes often (every week)	Yes, daily
f. Difficult to breathe	○	◉	○	○
Do you believe it is better when you are not in the building?		○ **Yes**	○ **No**	
	No, never	**Yes, sometimes**	**Yes often (every week)**	**Yes, daily**
g. Trouble focusing eyes	◉	○	○	○
	No, never	**Yes, sometimes**	**Yes often (every week)**	**Yes, daily**
h. Itching, burning or irritation in eyes	○	◉	○	○
Do you believe it is better when you are not in the building?		○ **Yes**	○ **No**	
	No, never	**Yes, sometimes**	**Yes often (every week)**	**Yes, daily**
i. Irritated, stuffy or runny nose	○	◉	○	○
Do you believe it is better when you are not in the building?		○ **Yes**	○ **No**	
	No, never	**Yes, sometimes**	**Yes often (every week)**	**Yes, daily**
j. Hoarse, dry throat	◉	○	○	○

Continue

HEALTH CHARACTERISTICS

Log off

(10) During the LAST THREE MONTHS have you had any (one or more) of the following symptoms while at work? (Please, answer every question even if you have not had any symptoms)

	No, never	Yes, sometimes	Yes often (every week)	Yes, daily
k. Cough	○	◉	○	○

Do you believe it is better when you are not in the building? ○ Yes ○ No

	No, never	Yes, sometimes	Yes often (every week)	Yes, daily
l. Dry or flushed facial skin	◉	○	○	○

	No, never	Yes, sometimes	Yes often (every week)	Yes, daily
m. Scaling/itching scalp or ears	◉	○	○	○

	No, never	Yes, sometimes	Yes often (every week)	Yes, daily
n. Dry, itchy, red hands' skin	○	◉	○	○

Do you believe it is better when you are not in the building? ○ Yes ○ No

	No, never	Yes, sometimes	Yes often (every week)	Yes, daily
o. Other	○	◉	○	○

Please specify: [ ]

Do you believe it is better when you are not in the building? ○ Yes ○ No

PERSONAL COMFORT

Log off

(11) Have you been bothered during THE LAST THREE MONTHS by any of the following factors at your work place? (Please, answer every question even if you have not been bothered)

	No, never	Yes, sometimes	Yes, often (every week)	Yes, daily
a. Room temperature too high	○	○	○	○
b. Varying room temperature	○	○	○	○
c. Room temperature too low	○	○	○	○
d. Draught	○	○	○	○
e. Stuffy ("bad") air	○	○	○	○
f. Dry air	○	○	○	○
g. Noise	○	○	○	○
h. Light that is dim or causes glare or reflections	○	○	○	○

(12) How satisfied are you with the environmental conditions in your office?

Clearly dissatisfied	Just dissatisfied	Just satisfied	Clearly satisfied
○	○	○	○

Continue

PERSONAL CONTROL

Log off

(13) To which degree do you feel you control the thermal conditions of your workspace?

No control	Slight degree	High degreee	Complete control
○	○	○	○

(14) How satisfied are you with your level of control?

Dissatisfied	Slightly dissatisfied	Slightly satisfied	Satisfied
○	○	○	○

(15) Can you exercise any of the following options to adjust the thermal environment at your workspace?

	Yes	No	Partially
a. Open or close a window	○	○	○
b. Open or close a door to the outside	○	○	○
c. Open or close a door to an interior space	○	○	○
d. Adjust a thermostat	○	○	○
e. Adjust the drapes or blinds	○	○	○
f. Turn a local space heater on or off	○	○	○
g. Turn a local fan on or off	○	○	○

Continue

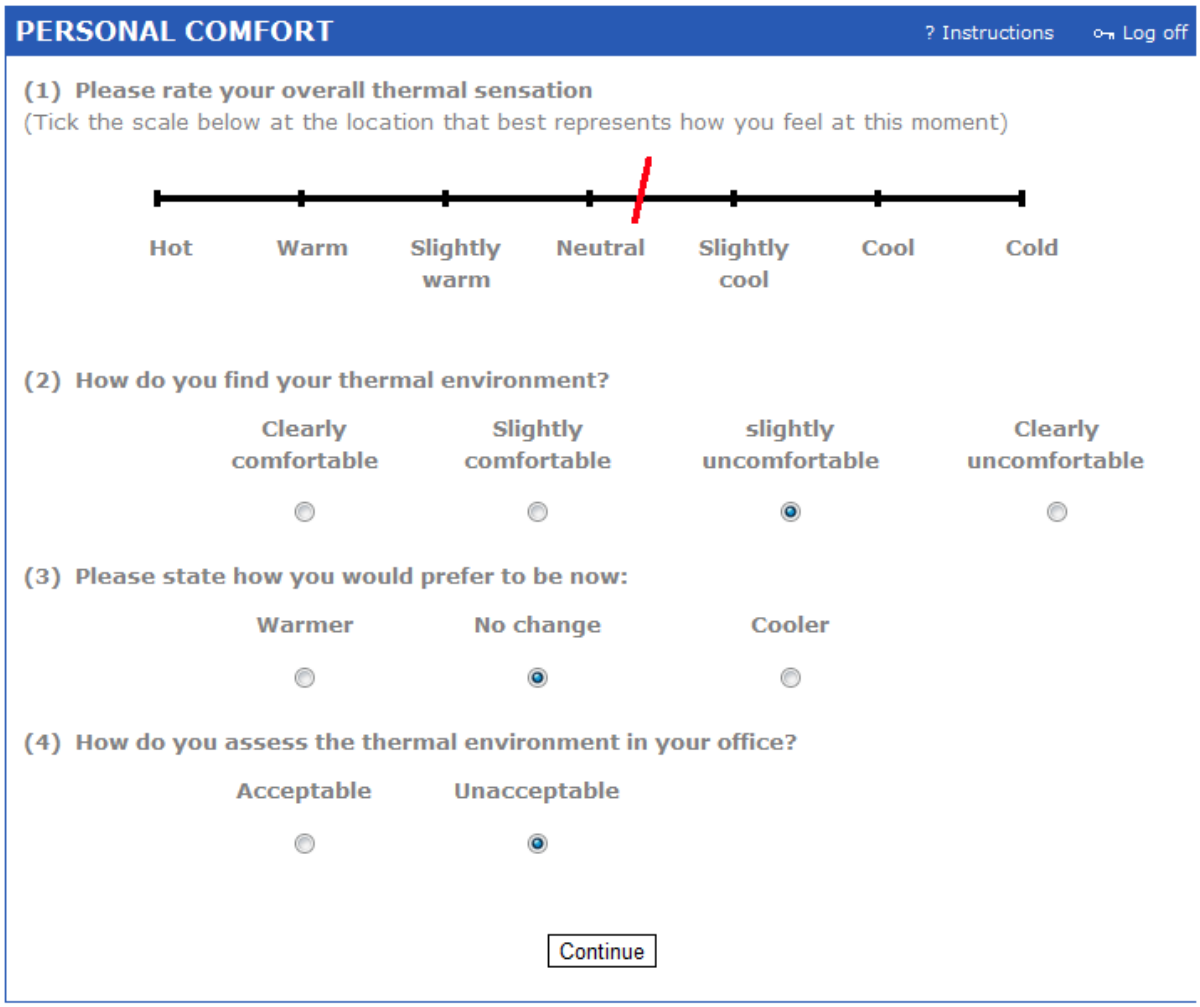
Log off

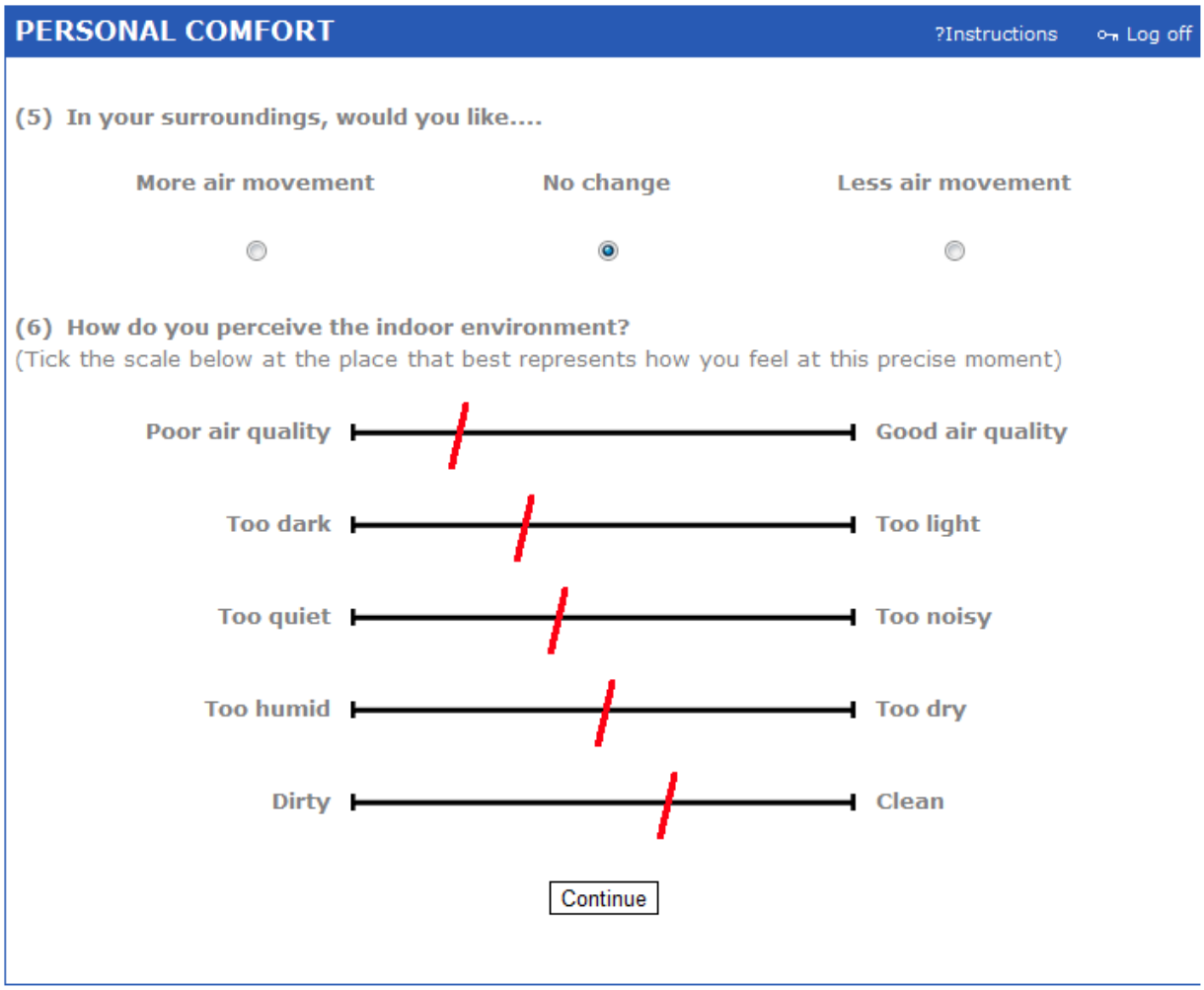
This questionnaire has now been completed.

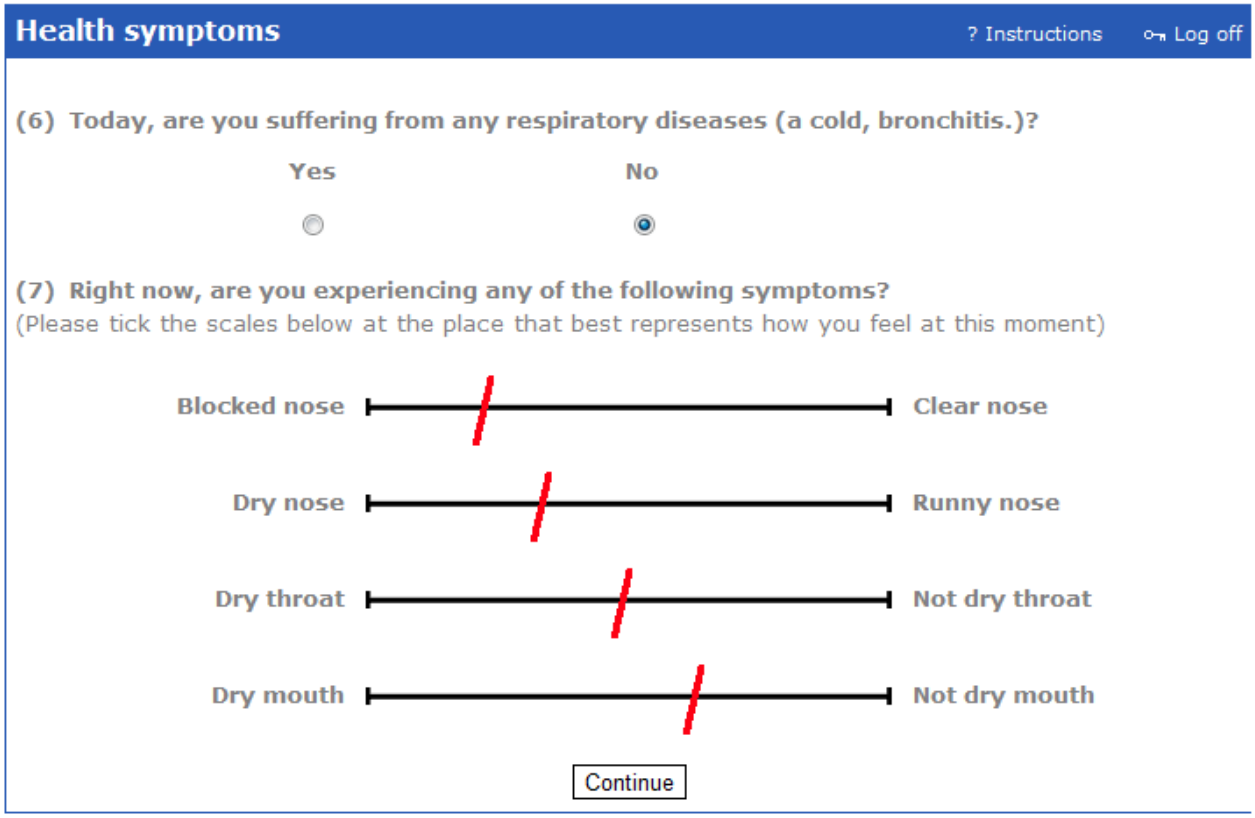
Thank you for your time and co-operation.

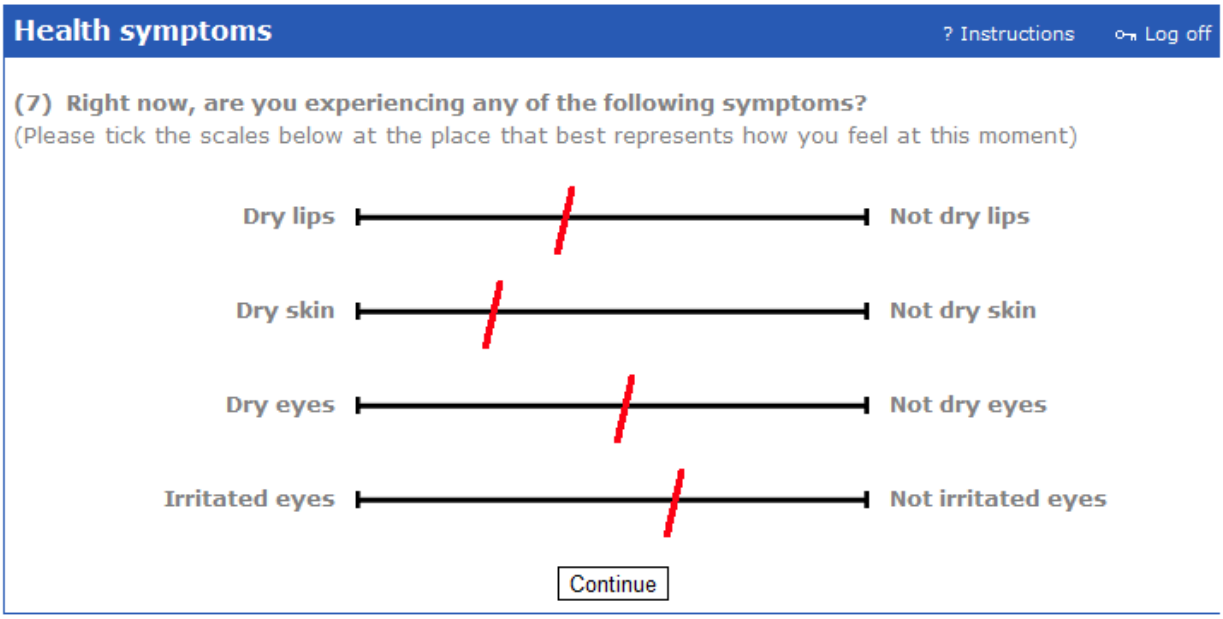
End

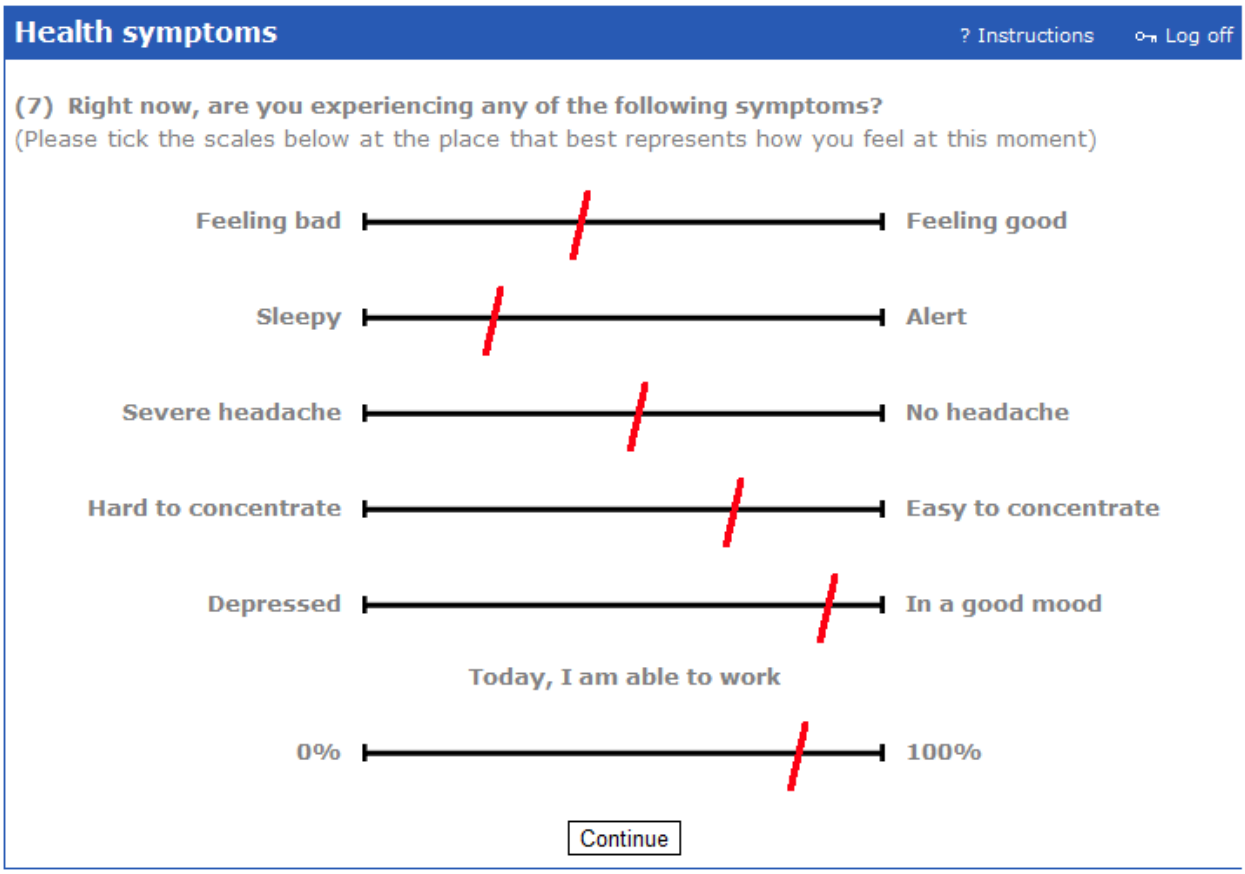
Annex 3 - Spot Questionnaire

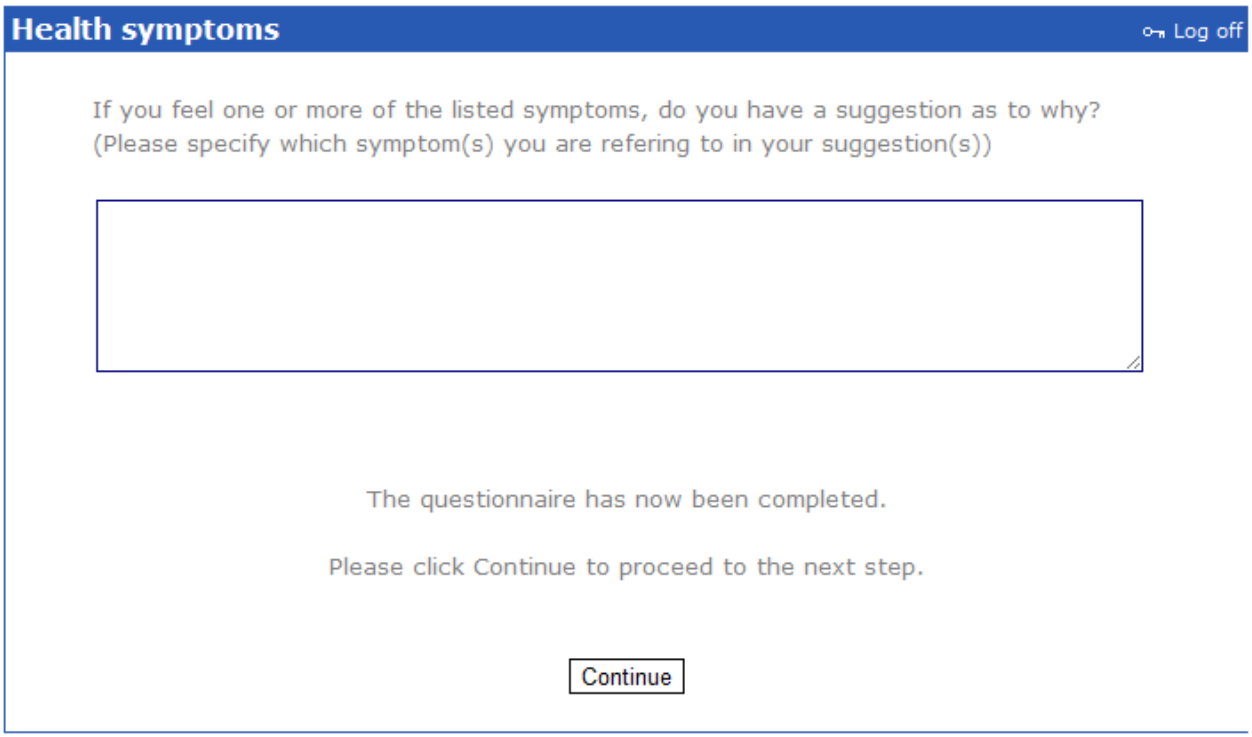



PERSONAL COMFORT
?Instructions
Log off
(5) In your surroundings, would you like....
More air movement
No change
Less air movement
(6) How do you perceive the indoor environment?
(Tick the scale below at the place that best represents how you feel at this precise moment)
Poor air quality
Good air quality
Too dark
Too light
Too quiet
Too noisy
Too humid
Too dry
Dirty
Clean
Continue


Health symptoms
? Instructions
Log off
(6) Today, are you suffering from any respiratory diseases (a cold, bronchitis.)?
Yes
No
(7) Right now, are you experiencing any of the following symptoms?
(Please tick the scales below at the place that best represents how you feel at this moment)
Blocked nose
Clear nose
Dry nose
Runny nose
Dry throat
Not dry throat
Dry mouth
Not dry mouth
Continue


Health symptoms
? Instructions
Log off
(7) Right now, are you experiencing any of the following symptoms?
(Please tick the scales below at the place that best represents how you feel at this moment)
Dry lips
Not dry lips
Dry skin
Not dry skin
Dry eyes
Not dry eyes
Irritated eyes
Not irritated eyes
Continue


Health symptoms
? Instructions
Log off
(7) Right now, are you experiencing any of the following symptoms?
(Please tick the scales below at the place that best represents how you feel at this moment)
Feeling bad
Feeling good
Sleepy
Alert
Severe headache
No headache
Hard to concentrate
Easy to concentrate
Depressed
In a good mood
Today, I am able to work
0%
100%
Continue


Health symptoms
Log off
If you feel one or more of the listed symptoms, do you have a suggestion as to why?
(Please specify which symptom(s) you are refering to in your suggestion(s))
The questionnaire has now been completed.
Please click Continue to proceed to the next step.
Continue

Annex 4 – Example on questionnaire from a low energy house project

Institut for Byggeri og Anlæg

AALBORG UNIVERSITET

Undersøgelse af indeklima i KOMFORHUSENE

Du har nu boet i et af de ti KOMFORTHUSE i Vejle i et år Husene indgår alle i et måleprogram styret af Aalborg Universitet, som skal dokumentere energi og indeklima-forholdene i husene samt kontrollere om husene har nået passivhus-standard. Til denne dokumentation har vi brug for din mening om forholdene i netop din bolig, og vi håber derfor, at du vil hjælpe os med at udfylde nedenstående spørgeskema.

Som supplement til dette spørgeskema vil vi bruge målinger af temperatur-, CO_2 og fugtforhold i boligen. Målingerne har kørt løbende siden du flyttede ind i huset, og data fra målingerne vil blive sammenholdt med din mening om forholdene.

Da du til daglig opholder dig i boligen og derfor er den rette til at vurdere indeklimaforhold, er det vigtigt for os at opnå viden om din mening om indeklimaet, ventilationssystemet og styringen af dette. Dette er dels for at kunne vurdere den aktuelle situation i dit hus, men også for fremover at kunne fremme eller forbedre de ting, du mener er henholdsvis funktionelle eller uhensigtsmæssige i din bolig

Vi håber, at du kan afse ca. 5 minutter til at besvare dette spørgeskema. Du bedes besvare spørgsmålene ud fra *din personlige mening* og med tanke på forholdene i boligen på de *pågældende tidspunkter* angivet i spørgsmålene.

Besvarelsen returneres på dagen, hvor interviewet (jf. følgebrev) vil finde sted.

Baggrundsinformation

(1.1) Hvad er din alder, og hvad er dit køn? ..... Alder: _____ Mand ☐ Kvinde ☐

(1.2) Hvor mange år og måneder har du ca. boet i denne bolig? ..... _____år _____ mdr.

(1.3) Uddannelse: ..... Kort ☐ Mellemlang ☐ Lang ☐

(1.4) Stilling/beskæftigelse_____

(1.5) Har du arbejdsplads hjemme? ..... Ja ☐ Nej ☐

(1.6) Hvor mange timer på en normal arbejds*dag* tilbringer du i boligen? ..... _____ timer pr. dag

(1.7) Hvor mange timer på en normal weekend*dag* tilbringer du i boligen? ..... _____ timer pr. dag

(1.8) Hvor mange biler har du/I i husstanden..... _____

(1.9) Bliver der røget dagligt i boligen ..... Ja ☐ Nej ☐

(1.10) Er du optaget af at passe på miljøet..... Ja ☐ Nej ☐
Hvis ja, graduér ved at sætte et X i en af kasserne svarende til din mening

Lidt ☐ ☐ ☐ ☐ ☐ Meget

(1.11) Er du optaget af at spare på energien..... Ja ☐ Nej ☐
Hvis ja, graduér ved at sætte et X i en af kasserne svarende til din mening

Lidt ☐ ☐ ☐ ☐ ☐ Meget

Indeklimaet i boligen *om sommeren*?

Hvordan vil du beskrive *typiske* indeklimamæssige tilstande i din bolig *om sommeren?*

(Anbring et X i en af kasserne svarende til din mening og sæt – om nødvendigt – ét eller flere krydser i kasserne med beskrivelse af oplevede problemer)

(2.1) Temperatur: Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

Oplevede du problemer med, at der var…
☐ For varmt
☐ For koldt
☐ For varierende temperaturer
☐ Andet
Hvis andet, beskriv gerne problemet nedenfor

_____

_____

(2.2) Luftbevægelse: Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

Oplevede du problemer med, at der var…
☐ Stillestående luft
☐ Træk
☐ Andet
Hvis andet, beskriv gerne problemet nedenfor

_____

_____

(2.3) Luftkvalitet: Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

Oplevede du problemer med, at der var…
☐ Indelukket
☐ Ubehagelig lugt
☐ Andet
Hvis andet, beskriv gerne problemet nedenfor

_____

_____

(2.4) Dagslys: Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

Oplevede du problemer med, at der var…
☐ For meget dagslys
☐ For lidt dagslys
☐ Blænding fra sol og himmel
☐ Andet
Hvis andet, beskriv gerne problemet nedenfor

_____

_____

(2.5) Er der nogle rum i din bolig, hvor du kunne tænke dig at have mere eller mindre dagslys om sommeren?
(Sæt gerne flere krydser)

Soveværelse	Mere ☐	Mindre ☐
Dagligstue	Mere ☐	Mindre ☐
Køkken	Mere ☐	Mindre ☐
Badeværelse	Mere ☐	Mindre ☐
Andet rum (hvilket_____)	Mere ☐	Mindre ☐
Andet rum (hvilket_____)	Mere ☐	Mindre ☐

(2.6) Støjniveau: Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

Oplevede du problemer med, at der var…
☐ Støj udefra, fx trafikstøj
☐ Støj fra aktivitet inde i bygningen
☐ Støj fra de tekniske installationer
☐ Andet
Hvis andet, beskriv gerne problemet nedenfor

_____

_____

Indeklimaet i boligen *om vinteren*?

Hvordan vil du beskrive *typiske* indeklimamæssige tilstande i din bolig *om vinteren?*

(Anbring et X i en af kasserne svarende til din mening og sæt – om nødvendigt – ét eller flere krydser i kasserne med beskrivelse af oplevede problemer)

(3.1) Temperatur: Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

Oplevede du problemer med, at der var…
☐ For varmt
☐ For koldt
☐ For varierende temperaturer
☐ Andet
Hvis andet, beskriv gerne problemet nedenfor

_____

_____

(3.2) Luftbevægelse: Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

Oplevede du problemer med, at der var…
☐ Stillestående luft
☐ Træk
☐ Andet
Hvis andet, beskriv gerne problemet nedenfor

_____

_____

(3.3) Luftkvalitet: Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

Oplevede du problemer med, at der var…
☐ Indelukket
☐ Ubehagelig lugt
☐ Andet
Hvis andet, beskriv gerne problemet nedenfor

_____

_____

(3.4) Dagslys: Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

Oplevede du problemer med, at der var…
☐ For meget dagslys
☐ For lidt dagslys
☐ Blænding fra sol og himmel
☐ Andet
Hvis andet, beskriv gerne problemet nedenfor

_____

_____

(3.5) Er der nogle rum i din bolig, hvor du kunne tænke dig at have mere eller mindre dagslys om vinteren?
(Sæt gerne flere krydser)

Soveværelse.....	Mere ☐	Mindre ☐
Dagligstue	Mere ☐	Mindre ☐
Køkken	Mere ☐	Mindre ☐
Badeværelse	Mere ☐	Mindre ☐
Andet rum (hvilket_____)	Mere ☐	Mindre ☐
Andet rum (hvilket_____)	Mere ☐	Mindre ☐

(3.6) Støjniveau: Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

Oplevede du problemer med, at der var…
☐ Støj udefra, fx trafikstøj
☐ Støj fra aktivitet inde i bygningen
☐ Støj fra de tekniske installationer
☐ Andet
Hvis andet, beskriv gerne problemet nedenfor

_____

_____

Indeklimaet i din bolig *generelt*

(4.1) Alt taget i betragtning, hvordan vil du *generelt set* vurdere indeklimaet i din bolig *om sommeren*?
(Anbring et X i en af kasserne svarende til din mening)

Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

(4.2) Alt taget i betragtning, hvordan vil du *generelt set* vurdere indeklimaet i din bolig *om vinteren*?
(Anbring et X i en af kasserne svarende til din mening)

Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

(4.3) Hvordan opleves luftkvaliteten i din nye bolig i forhold til din tidligere bolig?

Bedre ☐ Det samme ☐ Dårligere ☐

(4.4) Oplever du mere komfortable temperaturer i din nye bolig end den bolig du kom fra?

Ja ☐ Ingen ændring ☐ Nej ☐

(4.5) Imødekommer din boligs indretning *generelt set* dine behov?

Nej, slet ikke ☐ ☐ ☐ ☐ ☐ Ja, helt bestemt

(4.6) Er der ofte fugt på grund af kondens på indersiden af ruderne om vinteren?..... Ja ☐ Nej ☐

(4.7) Er der ofte fugt på grund af kondens på ydersiden af ruderne?..... Ja ☐ Nej ☐

(4.8) Er der typiske situationer eller tidspunkter, hvor du *ikke* er tilfreds med indeklimaet i din bolig?..... Ja ☐ Nej ☐

Hvis du har svaret "ja" bedes du uddybe svaret her.

_____

_____

_____

_____

Regulering af indeklimaet generelt *over året?*

Sommersituation

(5.1) Åbner du, eller andre i husstanden, jævnligt vinduerne om dagen? ..... Ja ☐ Nej ☐

(5.2) Åbner du, eller andre i husstanden, jævnligt vinduerne om natten? ..... Ja ☐ Nej ☐

Vintersituation

(5.3) Åbner du, eller andre i husstanden, jævnligt vinduerne om dagen?..... Ja ☐ Nej ☐

(5.4) Åbner du, eller andre i husstanden, jævnligt vinduerne om natten? ..... Ja ☐ Nej ☐

I hvor høj grad føler du, at *du personligt* har *muligheden* for at regulere og tilpasse følgende:
(Anbring et X i en af kasserne svarende til din mening)

(5.5)	Rumtemperaturen:	Ingen mulighed for *personligt* at regulere	☐	☐	☐	☐	☐	Fuld *personlig* regule-ringsmulighed
(5.6)	Ventilationen:	Ingen mulighed for *personligt* at regulere	☐	☐	☐	☐	☐	Fuld *personlig* regule-ringsmulighed
(5.7)	Solafskærmningen:	Ingen mulighed for *personligt* at regulere	☐	☐	☐	☐	☐	Fuld *personlig* regule-ringsmulighed

Føler du, at du har behov for at kunne regulere på:

(5.8)	Rumtemperaturen:	Nej, aldrig	☐	☐	☐	☐	☐	Ja, meget ofte
(5.9)	Ventilationen:	Nej, aldrig	☐	☐	☐	☐	☐	Ja, meget ofte
(5.10)	Solafskærmningen:	Nej, aldrig	☐	☐	☐	☐	☐	Ja, meget ofte

Hvis du har muligheden, hvor *hurtigt* sker der så en ændring på indeklimaet, hvis du regulerer på:

(5.11)	Rumtemperaturen:	Meget langsomt	☐	☐	☐	☐	☐	Meget hurtigt
(5.12)	Ventilationen:	Meget langsomt	☐	☐	☐	☐	☐	Meget hurtigt
(5.13)	Solafskærmningen:	Meget langsomt	☐	☐	☐	☐	☐	Meget hurtigt

Er der typiske situationer eller tidspunkter, hvor du *ikke* er tilfreds med:

(5.14) a) den *automatiske* regulering af indeklimaet i boligen?..... Ja ☐ Nej ☐

(5.15) b) dine *personlige* reguleringsmuligheder? ..... Ja ☐ Nej ☐

Hvis du har svaret "ja" til a) og/eller b) bedes du uddybe svaret her.

Information og opfølgning

(6.1) Har du og andre i husstanden modtaget information om, hvordan de automatiske reguleringssystemer fungerer, og hvad I kan gøre for at forbedre indeklimaforholdene i boligen, hvis I synes de er utilfredsstillende? ..... Ja ☐ Nej ☐

Hvis "ja" – hvad er din mening om informationen:

(6.2) Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

hvad mangler, hvis det var ikke tilfredsstillende

_____

_____

(6.3) Har der været indkøringsproblemer med boligens tekniske installationer i sommerperioden?

Ja ☐ Nej ☐

Hvis "ja" – angiv hvilke problemer:

_____

_____

_____

_____

(6.4) Har der været indkøringsproblemer med boligens tekniske installationer i vinterperioden?

Ja ☐ Nej ☐

Hvis "ja" – angiv hvilke problemer:

_____

_____

_____

(6.5) Har du, eller andre i din husstand, nogensinde udtrykt ønske om af få ændret på styringen af den mekaniske ventilation?..... Ja ☐ Nej ☐

(6.6) Hvis "ja" – overfor hvem er det blevet udtrykt?

_____

(6.7) Hvis "ja" – har det medført, at der er foretaget ændringer? ..... Ja ☐ Nej ☐

(6.8) Hvis "ja" – hvad er din mening om resultatet af ændringerne:

Utilfredsstillende ☐ ☐ ☐ ☐ ☐ Tilfredsstillende

Tak fordi du tog dig tid til at besvare spørgeskemaet