D3 – Appendix 6: ST4 – First common exercise. Instructions and template for collection

December 2025

Authors

Gaëlle Guyot & Baptiste Poirier, Cerema, France
Jakub Kolarik, Technical University of Denmark (DTU), Denmark
Daniela Mortari, Cerema, Université Savoie Mont Blanc, PUCPR, France-Brasil
Yu Wang, BRANZ, New Zealand
Julie Soriano & Laure Mouradian, CETIAT, France

Preface

The International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster international cooperation among the 30 IEA participating countries and to increase energy security through energy research, development and demonstration in the fields of technologies for energy efficiency and renewable energy sources.

The IEA Energy in Buildings and Communities Programme

The IEA co-ordinates international energy research and development (R&D) activities through a comprehensive portfolio of Technology Collaboration Programmes (TCPs). The mission of the IEA Energy in Buildings and Communities (IEA EBC) TCP is to support the acceleration of the transformation of the built environment towards more energy efficient and sustainable buildings and communities, by the development and dissemination of knowledge, technologies and processes and other solutions through international collaborative research and open innovation. (Until 2013, the IEA EBC Programme was known as the IEA Energy Conservation in Buildings and Community Systems Programme, ECBCS.).

The high priority research themes in the EBC Strategic Plan 2019-2024 are based on research drivers, national programmes within the EBC participating countries, the Future Buildings Forum (FBF) Think Tank Workshop held in Singapore in October 2017 and a Strategy Planning Workshop held at the EBC Executive Committee Meeting in November 2017. The research themes represent a collective input of the Executive Committee members and Operating Agents to exploit technological and other opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy technologies, systems and processes. Future EBC collaborative research and innovation work should have its focus on these themes.

At the Strategy Planning Workshop in 2017, some 40 research themes were developed. From those 40 themes, 10 themes of special high priority have been extracted, taking into consideration a score that was given to each theme at the workshop. The 10 high priority themes can be separated in two types namely 'Objectives' and 'Means'. These two groups are distinguished for a better understanding of the different themes.

Objectives: The strategic objectives of the EBC TCP are as follows:
– reinforcing the technical and economic basis for refurbishment of existing buildings, including financing, engagement of stakeholders and promotion of co-benefits;
– improvement of planning, construction and management processes to reduce the performance gap between design stage assessments and real-world operation;
– the creation of 'low tech', robust and affordable technologies;
– the further development of energy efficient cooling in hot and humid, or dry climates, avoiding mechanical cooling if possible; the creation of holistic solution sets for district level systems taking into account energy grids, overall performance, business models, engagement of stakeholders, and transport energy system implications.

Means: The strategic objectives of the EBC TCP will be achieved by the means listed below:
– the creation of tools for supporting design and construction through to operations and maintenance, including building energy standards and life cycle analysis (LCA);
– benefitting from 'living labs' to provide experience of and overcome barriers to adoption of energy efficiency measures;
– improving smart control of building services technical installations, including occupant and operator interfaces;
– addressing data issues in buildings, including non-intrusive and secure data collection;
– the development of building information modelling (BIM) as a game changer, from design and construction through to operations and maintenance.

The themes in both groups can be the subject for new Annexes, but what distinguishes them is that the 'objectives' themes are final goals or solutions (or part of) for an energy efficient built environment, while the 'means' themes are instruments or enablers to reach such a goal. These themes are explained in more detail in the EBC Strategic Plan 2019-2024.

The Executive Committee

Overall control of the IEA EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA EBC Implementing Agreement. At the present time, the

following projects have been initiated by the IEA EBC Executive Committee, with completed projects identified by (*) and joint projects with the IEA Solar Heating and Cooling Technology Collaboration Programme by (☼):

Annex 1: Load Energy Determination of Buildings (*)
Annex 2: Ekistics and Advanced Community Energy Systems (*)
Annex 3: Energy Conservation in Residential Buildings (*)
Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)
Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)
Annex 20: Air Flow Patterns within Buildings (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: ☼ Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: ☼ Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: ☼ Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
Annex 52: ☼ Towards Net Zero Energy Solar Buildings (*)

Table of content

First common exercise. Instructions and template for collection

ST4 smart ventilation - 1ˢᵗ common exercise

Instructions & Template for data collection from the common exercise

"Rating existing smart ventilation strategies"

By Gaëlle Guyot, Jakub Kolarik, Hilde Breesch, Klaas De Jonge, Baptiste Poirier, Douaa Al Assaad, Maria Justo Alonso

Instructions

1.1. Context and objectives

Each country has its specific approach regarding design of residential ventilation. This includes both "standard" ventilation strategies and "smart"[1] ventilation strategies. In this common exercise, we would like (1) to show how different performance-based approaches using different performance indicators can be used to assess performance of "smart" ventilation strategies in different countries and (2) to compare these "smart" strategies with the traditional/standard ones.

The objectives of this exercise are:

- To demonstrate the application of performance-based approach for the assessment of residential ventilation performance, including smart as well as traditional ventilation strategies, across the participating countries.
- To form a basis for creation of generally acceptable rating scheme for performance-based assessment of residential ventilation.
- To investigate its applicability in different countries, design contexts, with different simulation software, smart ventilation strategies, building geometries, etc.
- To conduct a qualitative assessment, identifying the challenges, barriers, advantages and disadvantages regarding application of performance-based evaluation in the context of different countries, their building codes and design-construction traditions. Consequently, to define common trends regarding challenges & barriers as well as benefits.

1.2. The workflow

For the common exercise, you are free to use an existing simulation case (uilding geometry, software, weather data, etc…). We would like you to conduct a performance analysis of the (smart) ventilation strategy in this simulation case study and use the performance indicators and methods described below. You can choose "smart" ventilation strategy/strategies; as well as the standard strategy for a reference. What we use in common are the performance indicators. You do the comparison to a "reference case", which has a country specific relevance, and we, as a group, do the qualitative analysis of the usability of performance-based approaches and associated performance indicators. This analysis will include a synthesis of experiences, observations, identified barriers and challenges reported by all involved participants.

---

[1] According to the AIVC: "Smart ventilation is a process to continually adjust the ventilation system in time, and optionally by location, to provide the desired IAQ benefits while minimizing energy consumption, utility bills and other non-IAQ costs (such as thermal discomfort or noise). (…)".

1.3.   Contaminants

To be able to produce the desired outputs, the following contaminants should be included (**those marked with (*) are optional, but we strongly encourage simulating as many as possible**):

- CO_2 (human breathing)
- Humidity (human breathing, events)
- $PM_{2.5}$ (Outdoor concentration, events)
- Formaldehyde (Indoor sources, events)
- Fictive pollutant constantly and continuously emitted in each zone (Cf ASHRAE 62.2) [*]

1.4.   We need to collect as output data:

1. **The concentrations profiles** (Raw time-series data), at least: CO_2 and relative humidity
   - Preferably In all the rooms
   - at least in
     - the bedroom with the highest occupancy
     - the living room
     - the kitchen
2. **The exposure concentrations profiles** (Raw time-series data), at least:
   - $PM_{2.5}$
   - formaldehyde
   - fictive pollutant

   At least for two occupants (as occupants should differ in their presence patterns in particular rooms).

3. Following performance indicators should be determined (**those marked with (*) are optional, but we strongly encourage determining as many as possible**) (Formulas in Annex 2):
   - DALY (chose one of calculation methods from the Annex 2)
   - CE_{CO2}: cumulative CO2 exposure when exposure concentrations are higher than a threshold ppm in a room
   - P_{CO2}: 95th percentile
   - T_{RH}: % of time spent out of the range [25-60%][2]
   - E_{HCHO}: cumulative occupant exposure
   - $E_{fictive}$: cumulative occupant exposure
   - $E_{PM2.5}$: cumulative occupant exposure
   - E_{HCHO_acute}: maximum of the cumulative occupant exposure over 1hour
   - $E_{fictive\_acute}$: maximum of the cumulative occupant exposure over 1hour
   - $E_{PM2.5\_acute}$: maximum of the cumulative occupant exposure over 1hour
   - ACH: Average building ACH due to ventilation
   - If possible (voluntary), for the ones who can/are interested in (it will be further investigated for the second exercise in one-two years):
     - Energy losses due to ACH ventilation [*]
     - Fan electric consumption over the year [*]
     - Exposure to a pollutant emitted only in toilets (odor) [*]
     - 30 day average RH on a thermal bridge [*]
     - Thermal discomfort indicator [*]
4. **Calculation period**: the whole ventilation operating period depending the contexts:
   - Typical Heating period where there is no cooling with outdoor air supply. The heating period can extend to the "fee floating" period where neither heating nor cooling is used.
   - Whole year if there is a cooling system with outdoor air supply and heating system
   - Typical cooling period where there is no heating period
5. **Time step**: If possible 10-15 min (max. 1 hour).

---

[2] EN 16798 category II

1.5. We need that you fill out the tables of Annex 1

Annex 1 - Tables to use for gathering the data (one table 2.a and one table 2.b per case study):

Contributor (name, country, Institute, date) :
………………………..……………………………………
………
………………...

Case Study (name, short description, sim. software used, reference for more details) :
………………………..……………………………………………………………………………
…………………………………
………
………………...

Inputs

Occupancy patterns : who is where when ?	*Example :*			
		Room	**Occupant 1**	**Occupant 2**	**Occupant3**

Room	Occupant 1	Occupant 2	Occupant3
Bedroom	21h00-6h20	21h00-6h20	21h00-6h20
Bathroom	6h20-7h00	7h00-7h40	20h20-21h00
Kitchen	7h00-7h20 / 12h00-12h40 / 19h00-20h10	6h20-6h40 / 12h00-12h40 / 19h00-20h10	6h20-6h40 / 12h00-12h40 / 19h00-20h10
Livingroom	7h20-8h30 / 12h40-14h00 / 20h10-21h00	6h40-7h00 / 7h40-8h30 / 12h40-14h00 / 20h10-21h00	6h40-8h30 / 12h40-14h00 / 20h10-20h20

Emission scenarios for CO2	*Example : CO_2 awake / asleep: 18 / 15 L.h^{-1}*
Emission scenarios for humidity	*Example : H_2O awake / asleep: 55 / 40 g.h^{-1}* *Breakfast / lunch / dinner: 1512 / 2268 / 2844 g.h^{-1}* *During 15 / 30 / 40 minutes*
Emission scenarios for HCHO	*Example : In each room 12µg.h^{-1}.m^2 (m² floor area)*
Emission scenarios for PM	*Example : Cooking event: 1.91 mg.min^{-1} During 28 minutes, at 12:00 and 18:00*
Emission scenarios for fictive	*Example : In each room 10 µg.h^{-1}.m^2 (m² floor area)*
Weather file used	*Example : London TRY weather file*

Simulation period	*Example : Heating period from October 15, 00:00 a.m to April 14, 12:00 p.m (French one)*
Outdoor pollution	*Example : We assumed a constant outdoor concentration of CO_2 at 400 ppm; 2.6 $\mu g.m^{-3}$ for formaldehyde based on average concentration in European cities (Bruinen de Bruin et al. 2008) and 10.6 $\mu g.m^{-3}$ yearly average concentration for $PM_{2.5}$ in Copenhagen between 2015 and 2020 calculated from weather data measurement (« Annual AQ statistics » s. d.).*
Air leakage distribution	*Example :* *envelope airleakage of $n_{50}=1.5h^{-1}$, evenly distributed over the envelope depending the ratio of external surfaces,* *evenly distributed airleakage on internal partition walls: $q_{50}=1.2\ m^3.h^{-1}.m^{-2}$ (from Guyot et al. 2016 for heavy structures)*
Position of internal doors	*Example : all closed, an undercut of 1 cm² is modelled*
Position of windows	*Example : All closed*
…	
…	

Modelling data

	Model	Associated parameters asumptions / schedules
Moisture absorption/desorption		
PM deposition/resuspension Penetration factor		
HCHO dependence to T°C and RH		
Position of doors and associated models		
Position of windows and associated models		
Wind pressure / microclimate around the building		
Airflows through natural ventilation components		
…		
…		
…		
…		
…		
…		

Description of the ventilation strategies and components

Type of ventilation (whole house ?, mechanical exhaust-only/balanced/supply only, windows-based, etc.)	

Type of control parameter (humidity, CO_2, VOC, outdoor conditions, a combination, etc.)	
Amount of sensors	
Location of sensors (rooms – which rooms?, ducts, …)	
Type of measuring technology for sensors (Ex : CO2 : NDIR), or reference and name of producer, and associated accuracy and range of measurement	
Type of control and components that are controlled (mechanical or electronic of inlets and outlets cross-sectional area, direct control of fan speed, of dampers, …)	
Control algorithm (value of set points + associated airflows + rules, etc…)	
Airflows through mechanical exhaust vents	
Airflows through mechanical suppliers	

Qualitative Feedbacks

Feedback on proposed metrics o What did you like, what didn't you like and why? o Are some of these metrics used in your country? Which ones ? Are they required/incorporated in the building code? o To what extent are these metric relevant given the context you work in. o Are these metric relevant for practice in your country? Will there be expertise and tools available among the practitioners? o Suggestions for expanding the framework? (other IAQ aspects, non-IAQ costs?) o Suggestion for simplification?	*Free answer ….*
List of barriers and problems met during the exercise	*Free answer ….*
List of warnings	*Free answer ….*
List of advantages	*Free answer ….*
Conclusions on the applicability of the method	*Free answer ….*
Major needs	*Free answer ….*
Other important comments	*Free answer ….*

Annex 2 – Formulas for the calculation of performance indicators

Remember the calculation period and time-step are described in 1. Instruction [d]

DALYs

The long-term health effects of indoor air contaminant exposure can be quantified using Dynamic Disability-Adjusted Life Years (DALYs)[3]. The total health impact is the sum of all DALYs, regardless of the method used to calculate the DALYs. Dynamic DALYs can be calculated as:

$$DALYs(t) = \int_{t_0}^{t} \frac{DALYs}{time}(t)$$

$$\frac{DALYs}{time}(t) = EF_{marginal} * IR(t)$$

$$IR(t) = V_{br}(t).C_{exp}(t)$$

Where

- $DALYs(t)$ is the cumulative Dynamic DALYs function
- IR(t) [kg/s] is the Intake rate
- $V_{br}(t)$ is the breathing rate over time, default a value of 16m³/day may be assumed [4] (this parameter can be varied based on the occupant's metabolism).
- $C_{exp}(t)$ is exposure concentration profile
- EF [DALY/kg] is the Effect factor[5] (From ST1, this function is made easier, linear and independent of ID or IND method).

		95% Confidence interval (CI)	
	EF marginal (median) [DALY/kg]	CI_2.5% [DALY/kg]	CI_97.5% [DALY/kg]
PM2.5	118.6111038	28.32760334	502.3125065
Formaldehyde	18.0350555	3.518138613	94.1348335

E_CO2: normalized cumulative exposure when concentrations are higher than 1000 ppm in a room

For rooms *r* in the building:

---

[3] 2022/08 - Unpublished so must be treated confidential until correct reference can be made.

[4] U.S. EPA. Exposure Factors Handbook 2011 Edition (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-09/052F, 2011, https://www.nrc.gov/docs/ML1400/ML14007A666.pdf.

[5] P. Fantke *et al.*, "Global Effect Factors for Exposure to Fine Particulate Matter," *Environ Sci Technol*, vol. 53, no. 12, pp. 6855–6868, Jun. 2019, doi: 10.1021/acs.est.9b01800.

$$E_{CO2\_r} = \frac{\sum_{t=0,occupied\ hours}^{d}(C_{CO2\_r}(t) - 1000).\Delta t}{d}$$

Equation 1

With $C_{CO2\_r}(t)$ the CO$_2$ exposure concentration (only when the room is occupied) in *[ppm]* in the room *r* at time step *t* , *d* the total duration of the simulation, and Δt the time step of simulation.

P$_{CO2}$: 95th percentile

The 95th percentile must be calculated of the CO2 exposure concentrations (only when the room is occupied).

E$_{RH}$: % of time spent out of the range [25-60%]

For rooms *r* in the building:

$$E_{RH\_r} = \frac{100}{d}\sum_{t=0}^{d}\Delta t \begin{cases} if\ RH\_r(t) > 60\% \\ if\ RH\_r(t) < 25\% \end{cases}$$

Equation 2

With $RH_{\_r}(t)$ the relative humidity in *[%] of* the room *r* at time step *t*, *d* the total duration of the simulation, and Δt the time step of simulation.

E$_{HCHO}$: cumulative occupant exposure

For occupants *o* in the building:

$$E_{HCHO\_o} = \sum_{t=0}^{d} C_{HCHO\_r,o}(t).\Delta t$$

Equation 3

With $C_{HCHO\_r,o}(t)$ the HCHO concentration in *[µg.m^{-3}] of* the room *r* where the occupant *o* is at time step *t*, *d* the total duration of the simulation, and Δt the time step of simulation.

E$_{fictive}$: cumulative occupant exposure

For occupants *o* in the building:

$$E_{fictive\_o} = \sum_{t=0}^{d} C_{fictive\_r,o}(t).\Delta t$$

Equation 4

With $C_{fictive\_r,o}(t)$ the fictive pollutant concentration in *[µg.m^{-3}] of* the room *r* where the occupant *o* is at time step *t*, *d* the total duration of the simulation, and Δt the time step of simulation.

E$_{PM2.5}$: cumulative occupant exposure

For occupants o in the building:

$$E_{PM2.5\_o} = \sum_{t=0}^{d} C_{PM2.5\_r,o}(t).\Delta t$$

Equation 5

With $C_{PM2.5\_r,o}(t)$ the HCHO concentration in *[µg.m^{-3}] of* the room r where the occupant o is at time step t, d the total duration of the simulation, and Δt the time step of simulation.

E$_{HCHO\_acute}$: maximum of the cumulative occupant exposure over 1hour

For occupants o in the building:

$$E_{HCHO_{acute}\_o} = max\left(\sum_{t=0}^{1h} C_{HCHO\_r,o}(t).\Delta t\right)$$

Equation 6

With $C_{HCHO\_r,o}(t)$ the HCHO concentration in *[µg.m^{-3}] of* the room r where the occupant o is at time step t, and Δt the time step of simulation.

E$_{fictive\_acute}$: maximum of the cumulative occupant exposure over 1hour

For occupants o in the building:

$$E_{fictive\_acute\_o} = max\left(\sum_{t=0}^{1h} C_{fictive\_r,o}(t).\Delta t\right)$$

Equation 7

With $C_{fictive\_r,o}(t)$ the fictive concentration in *[µg.m^{-3}] of* the room r where the occupant o is at time step t, and Δt the time step of simulation.

E$_{PM2.5\_acute}$: maximum of the cumulative occupant exposure over 1hour

For occupants o in the building:

$$E_{PM2.5\_acute\_o} = max\left(\sum_{t=0}^{1h} C_{PM2.5\_r,o}(t).\Delta t\right)$$

Equation 8

With $C_{PM2.5\_r,o}(t)$ the PM$_{2.5}$ concentration in *[µg.m^{-3}] of* the room r where the occupant o is at time step t, and Δt the time step of simulation.

ACH: Average building ACH due to ventilation

Energy losses due to ACH ventilation (voluntary)

Calculation ventilation heat loss for the time when heating (or mechanical cooling) system is in operation.

From (Abadie et al. 2017)[6]:

$$Q_{heat\_loss} = C_{p_m} . q_m . \left(1 - \varepsilon_{heat_{ex}}\right) . (T_{in} - T_{ex}) \; [kJ]$$
Equation 9

With q_m the total exhaust mass airflows in *[kg.s⁻¹]*, C_{pm} the thermal mass capacity of air (we used 1 $kJ.kg^{-1}. °C^{-1}$), $\varepsilon_{heat_{ex}}$ the heat exchanger efficiency. We can use for example a constant theoretical efficiency rate of 0.8 for ventilation with heat recovery and 0 with no heat recovery and this value can be adjusted depending on the systems design. T_{in} the zone temperature where the air is extracted, and T_{ex} the external temperature *[°C]*.

Optionally, it is also possible to provide results as total energy consumption for particular simulated cases including heating/ cooling consumption.

Fan electric consumption over the simulation period (voluntary)

According to ASHRAE Standard 90.1 :

$$P_{fan}(t) = P_{fan} . P_{nom}$$
Equation 10

$$P_{nom} = Qmax . SFP$$
Equation 11

$$P_{fan} = 0.0013 + 0.1470 . PLR_{fan} + 0.9506 . PLR_{fan}^2 - 0.0998 . PLR_{fan}^3$$
Equation 12

$$PLR_{fan} = Q(t) / Qmax$$
Equation 13

With P_{nom} the nominal power of the fan, Qmax the maximal design aiflow, SFP the specific fan power and Q(t) the current total exhaust (or supply) airflow.

Exposure to a pollutant emitted only in toilets (odours) (voluntary)

For occupants *o* in the building:

$$E_{odour\_o} = \sum_{t=0}^{d} C_{odour\_r,o}(t) . \Delta t$$

Equation 14

With $C_{odour\_r,o}$ *(t)* the fictive pollutant representing odours concentration in *[µg.m⁻³]* of the room *r* where the occupant *o* is at time step *t*, *d* the total duration of the simulation, and Δt the time step of simulation.

---

[6] Abadie, M. Wargocki, P. Rode, C. Rojas, G. Kolarik, J. Laverge, J. Cony, L. Qin, M. et Blondeau, P. (2017). Indoor Air Quality Design and Control in Low-energy Residential Building Subtask 1: Defining the metrics. IEA Annex 68

30 day average RH on a thermal bridge (voluntary)

The **30 day average relative humidity on a typical thermal bridge** of a well designed and constructed building should be smaller than 80% RH:

$$30\ day\ average\ RH_{si} < 80\%$$

$$RH_{si} = \frac{P_w}{P_{w,sat}(\theta_{si})}$$

Equation 15

With

RH_{si}	The local relative humidity on the thermal bridge
P_w	The room vapor pressure
$P_{w,sat}(\theta_{si})$	The local saturation vapor pressure
θ_{si}	The surface temperature on the cold-bridge

The surface temperature on the cold-bridge **could be a direct output of a BES model. Another approach is the use of the** temperature factor (f_h) to estimate the surface temperature on the cold-bridge.

A typical thermal bridge of a well-designed and well-constructed building should have a relatively high temperature factor (f_h). This means that the surface temperature lies closer to the indoor air temperature then the outdoor air temperature in steady-state conditions.

This factor can be country specific, depending on local legislation. For Belgium, a minimum temperature factor of 0.7 is required.

$$f_h = \frac{\theta_{si} - \theta_e}{\theta_i - \theta_e}$$

Equation 16

With

f_h	The dimensionless temperature factor of a cold bridge
θ_{si}	The surface temperature on the cold-bridge
θ_e	The exterior temperature
θ_i	The interior temperature

With equation 14 and 15. For each timestep, the RH_{si} can be calculated.

The **running 30-day average** of this output should not exceed 80%. Be careful to also include the analysis for data going past the full year (e.g. 15/dec to 15/Jan)

Thermal comfort indicator (voluntary)

The percentage of time when the thermal comfort ranges for indoor environmental category II (IEQ$_{II}$) according to EN 16798-1:2019 and CEN/TR 16798-2:2019 are exceeded during the simulation period. For yearly simulations the exceedance during maximum 6% time is considered acceptable.

The thermal comfort ranges are defined differently for buildings with and without mechanical cooling.

- Buildings without mechanical cooling - Adaptive thermal comfort model according to EN 16798-1:2019, Annex B, section B.2.2

Key
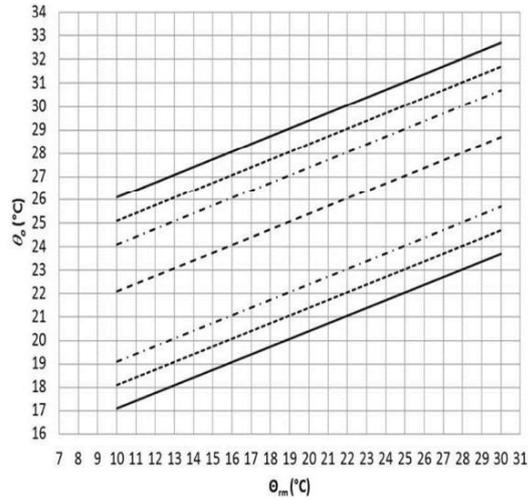
θ_o = indoor operative temperature, °C

Θ_{rm} = running mean outdoor temperature °C

Cat. III upper limit
Cat. II upper limit
Cat. I upper limit
Comfort temperature
Cat. I lower limit
Cat. II lower limit
Cat. III lower limit

Figure 1 – Default design values for the indoor operative temperature for buildings without mechanical cooling as a function of the exponentially-weighted running mean of the outdoor temperature (Figure B.1 from EN 16798-1:2019)

See also additional explanation in CEN/TR 16798-2:2019 section 6.3.2.

The following approximate Formula (1) can be used where records of daily mean external temperature are available:

$$\Theta_{rm} = \frac{(\Theta_{ed-1} + 0,8\Theta_{ed-2} + 0,6\Theta_{ed-3} + 0,5\Theta_{ed-4} + 0,4\Theta_{ed-5} + 0,3\Theta_{ed-6} + 0,2\Theta_{ed-7})}{3,8} \tag{1}$$

Θ_{ed-i} = daily mean outdoor air temperature for the *i-th* previous day

- In buildings with mechanical cooling, the thermal comfort range is determined using PMV/PPD model – see EN 16798-1:2019 section B.2.1

In the case that the simulation tool does not calculate thermal comfort indices directly, they can be calculated using the CBE Thermal Comfort Tool (https://comfort.cbe.berkeley.edu/; Tartarini, F., Schiavon, S., Cheung, T., Hoyt, T., 2020. CBE Thermal Comfort Tool : online tool for thermal comfort calculations and visualizations. SoftwareX 12, 100563. https://doi.org/10.1016/j.softx.2020.100563)

Contributors

Marcos Batistetlla, Université Savoie Mont Blanc, PUCPR, France-Brasil

Nathan Mendes, PUCPR, France-Brasil

Klaas De Jonge, UGent, Belgium

Jelle Laverge, UGent, Belgium

Douaa Al Assaad, KU Leuven, Belgium

Quinten Carton, KU Leuven, Belgium

Hilde Bressche, KU Leuven, Belgium

Sébastien Pecceu, Buildwise, Belgium

Valérie Leprince, Cerema, France

Markus Wirnsberger, UIBK - University of Innsbruck, Austria

Gabriel Rojas, UIBK - University of Innsbruck, Austria

Anna Maria Belleri, EURAC Research, Italy

Irene Laraibeas, EURAC Research, Italy

Evangelos Belias, EPFL, Switzerland

Dusan Licina, EPFL, Switzerland

Maria Justo Alonso, SINTEF, Norway

Iain Walker, LBNL, USA

Marcel Loomans, Eindhoven university of Technology, The Netherlands

Pilar Linares, CSIC, Spain

Sonia Garcia, CSIC, Spain

Manfred Plagmann, BRANZ, New Zealand

www.iea-ebc.org