IEA EBC Annex 62 The IEA project on ventilative cooling

EBC

venticool the international platform for ventilative cooling

AIVC

QUALICHeCK Towards better quality and compliance

Some key aspects to consider ventilative cooling in energy performance regulations

WS 15 : Perspectives for assessing ventilative cooling potential in Energy Performance regulations

François Rémi Carrié, ICEE
Valérie Leprince, PLEIAQ
Maria Kapsalaki, INIVE

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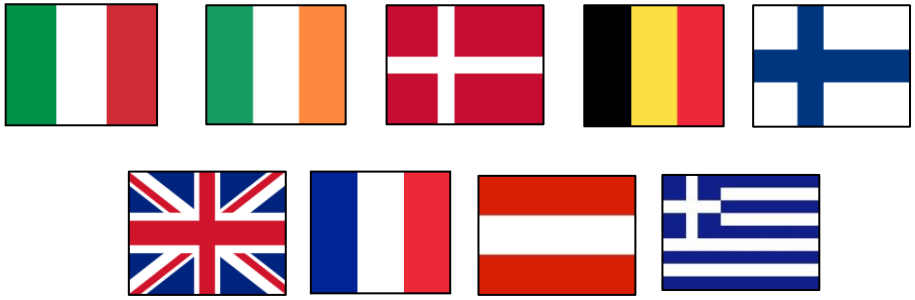
Ventilative cooling

What is it?	• Cool a building by means of ventilation rates higher than hygienic ones
How?	• Induce additional external air flowrate when appropriate to cool the building
Means?	• Naturally by windows • Naturally by specific devices (louvers, vent, passive ducts) • Mechanical
What is the impact?	• Decrease cooling load • Decrease indoor temperatures/ Increase thermal comfort

Outline

- Key outcomes of a survey amongst 9 countries
- Approach to ventilative cooling with the new set of EPBD standards
- What's new in the EPBD standard FprEN 16798-7 to calculate airflow rates?
- What is critical for compliance checks?

KEY OUTCOMES OF A SURVEY AMONGST 9 COUNTRIES



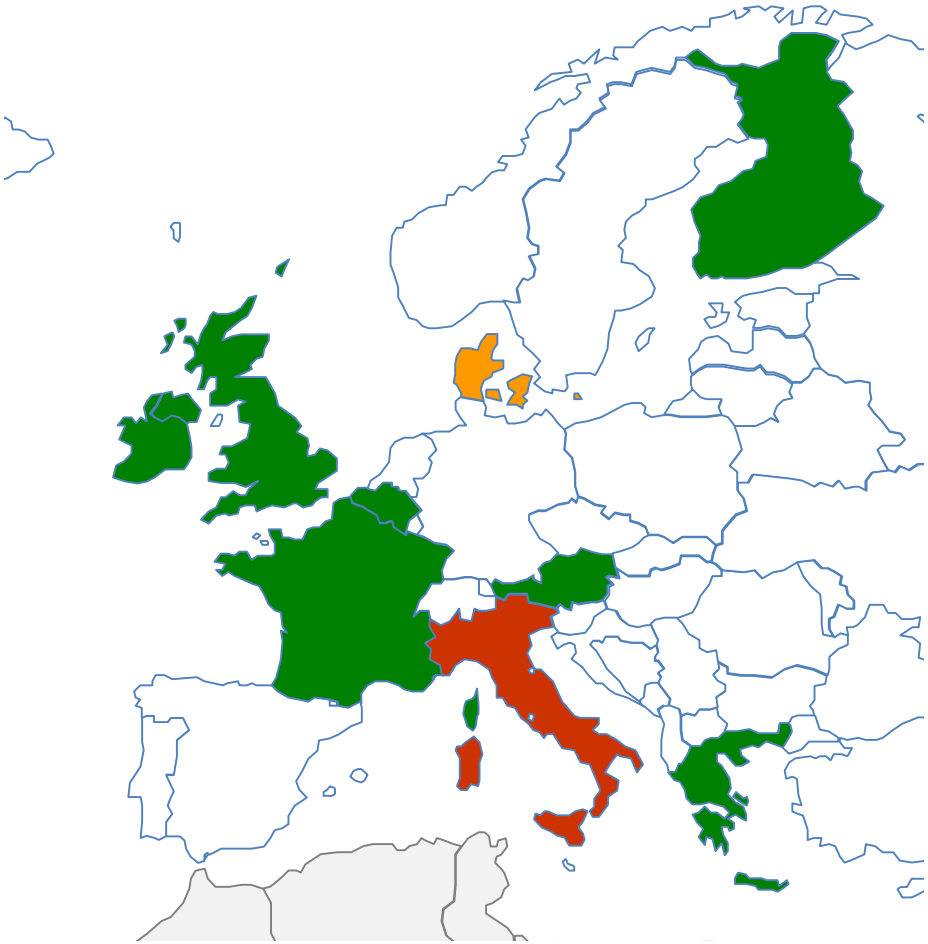
ARE EP-REGULATION IN EUROPE ABLE TO IMPLEMENT VENTILATIVE COOLING?

4 key questions:

- Is there a thermal comfort criteria?
- Is at least one ventilative cooling technique taken into account?
- What is the calculation time step?
- How are natural ventilation air flow rates assessed ?

Respondents

Thermal comfort criteria?



Yes

No

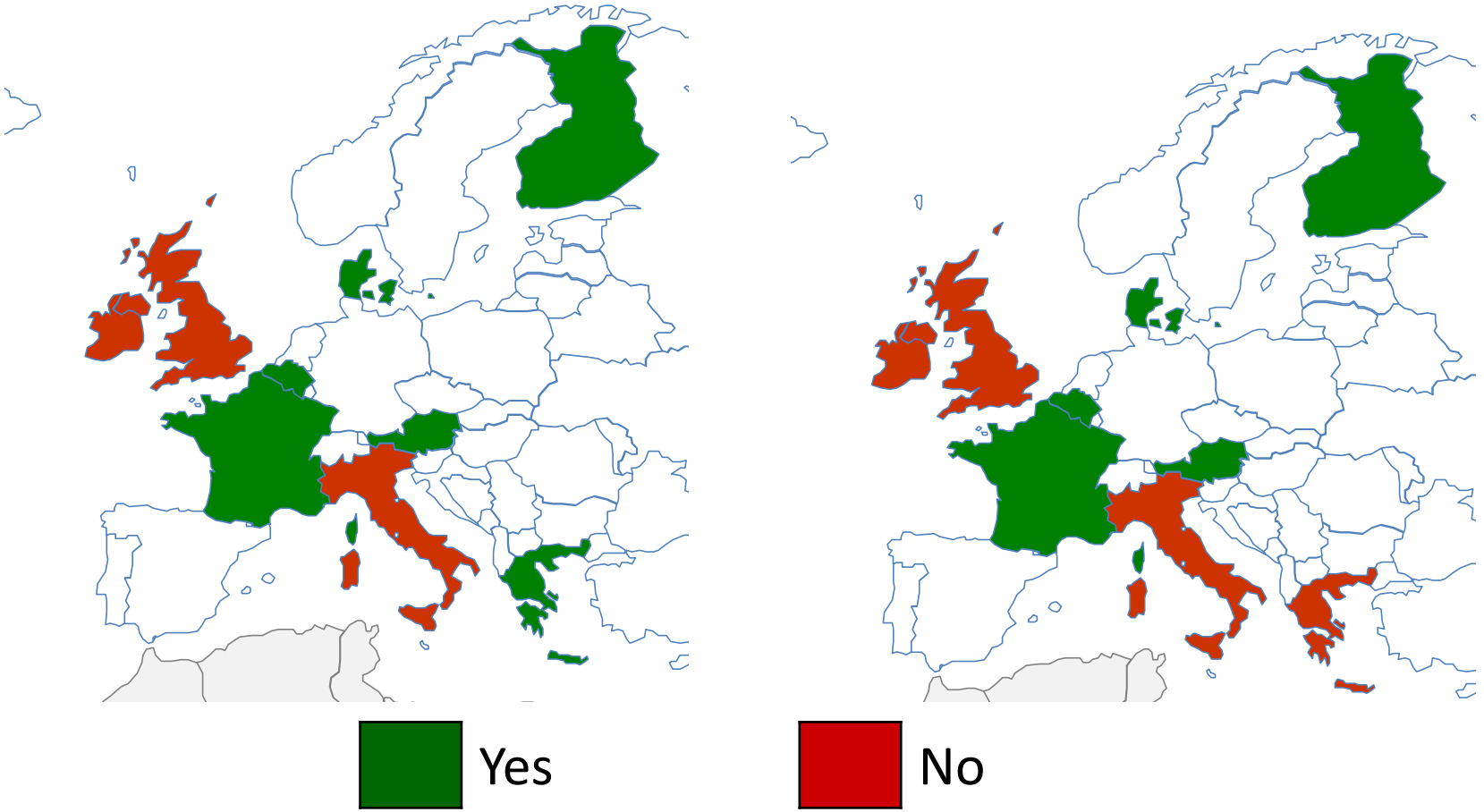
In the future

Source: Venticool report 2015, Provisions for ventilative cooling, Kapsalaki M. and venticool webinars

At least one ventilative cooling technique taken into account?

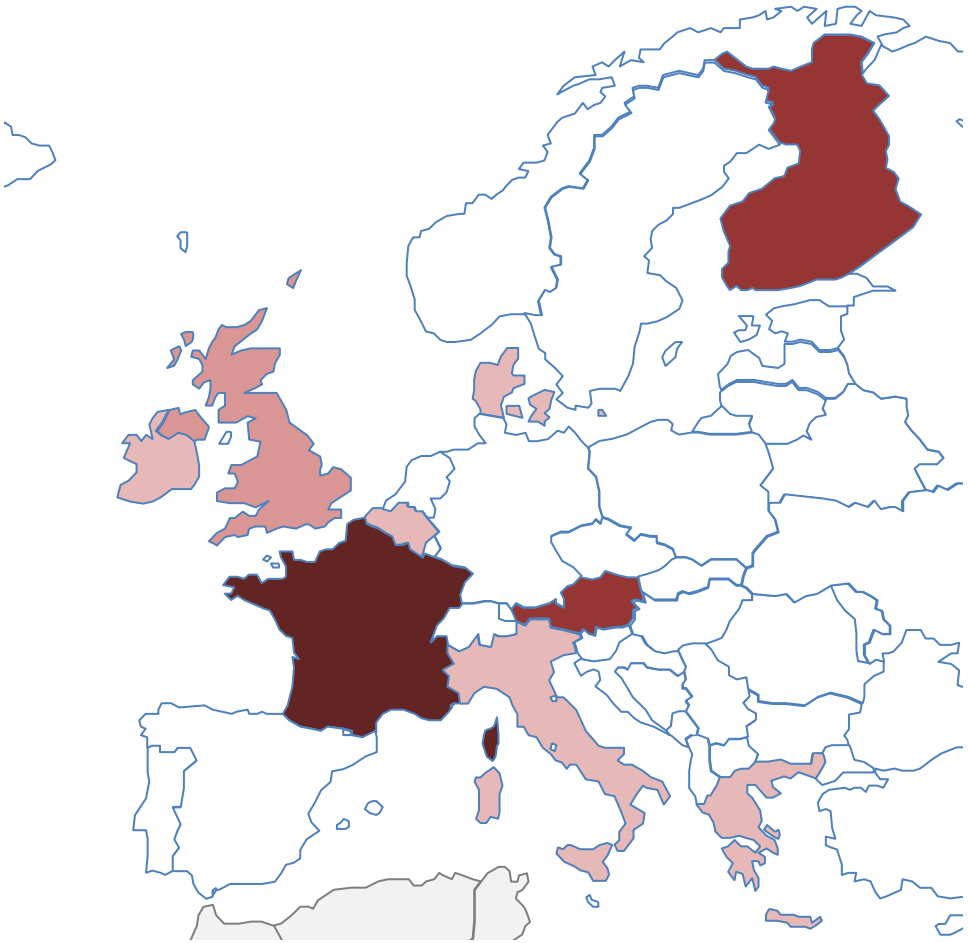
Residential

Non-residential



Source: Venticool report 2015, Provisions for ventilative cooling, Kapsalaki M. and venticool webinars

Monthly vs hourly calculation



- Why monthly calculation fails to model ventilative cooling?
  - Averaging the need for cooling in both time and space underestimates the need for cooling
  - No correlation between cooling need with simplified method and number of hours with elevated temperature

Monthly calculation

Monthly calculation, simplified hourly for specific buildings

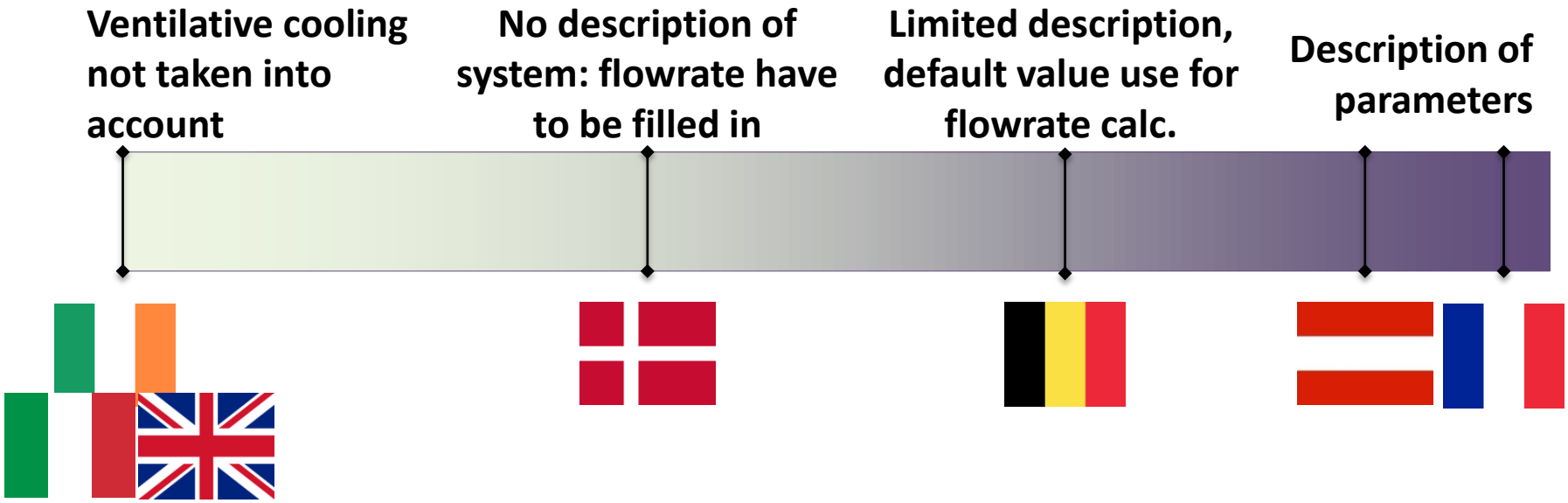
Monthly calculation for heating load, simplified hourly for summer comfort

Hourly calculation

Source: Venticool report 2015, Provisions for ventilative cooling, Kapsalaki M. and venticool webinars

Natural ventilation air flow rates

- Most countries do not have airflow model based on building parameters such as windows size, vents characteristics, etc.



Source: Venticool report 2015, Provisions for ventilative cooling, Kapsalaki M. and venticool webinars

Which of the following methods seems more appropriate to take into account ventilative cooling in energy performance regulations?

1. Hourly

75%

2. Monthly, but with a simplified hourly method for summer comfort

25%

3. Monthly

0%

4. Other

0%

Please vote!

APPROACH TO VENTILATIVE COOLING WITH THE NEW SET OF EPBD STANDARDS

How to take ventilative cooling into account? … the ‘perfect’ software

Description

It allows describing any system within the building including **control options**

Windows	Vents	Passive duct	Mechanical	Internal partitions

Hypothesis

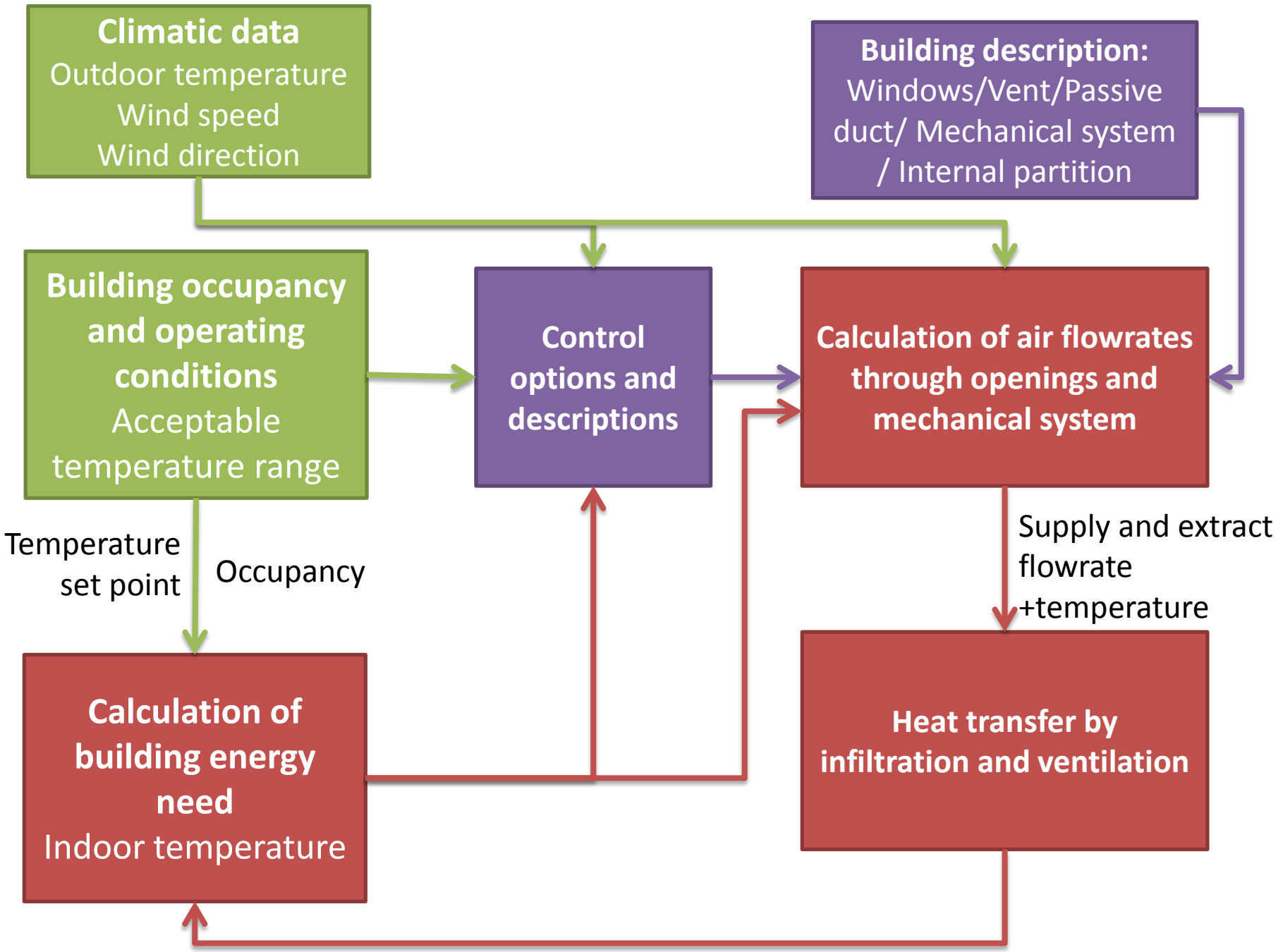
It takes into account external/internal conditions

Indoor/outdoor climate	Occupant behaviour

Calculation

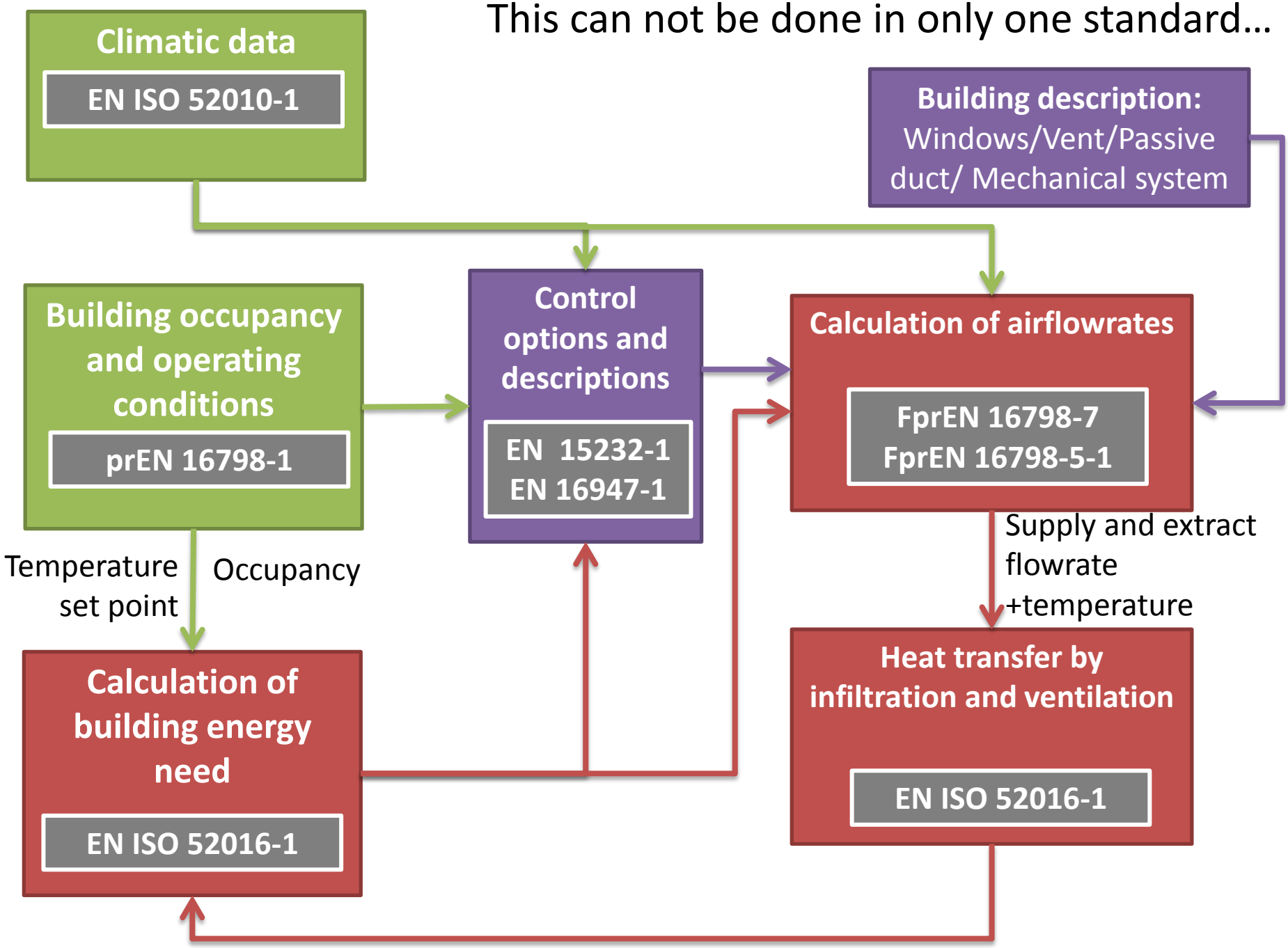
It calculates air flowrates and their impact

On internal temperatures	On comfort	On cooling load



Source: inspired by prCEN/TR 16798-10 (PE draft, 2015)

This can not be done in only one standard…



Source: inspired by prCEN/T 16798-10 (PE Draft, 2015)

What works …

- Description and calculation of:
  - Natural airflow rates through vents / leakage / passive ducts / windows
  - Mechanical airflow rates
- Use of climatic data
- Instantaneous comfort criteria (see EN 16798-1) and long term comfort indices (see prCEN/TR 16798-2)
- …

Major elements missing to implement ventilative cooling in regulations

- Guidelines, depending on system type, to distinguish:
  - Key input parameters that should be described accurately
  - Input parameters for which default values are proposed (but other values can be used)
  - Input parameters for which conventional values are defined (other values cannot be used)
  - Other parameters not critical for ventilative cooling
- Effective heat exchange between surfaces and air flowing through the building
- Air speed calculation for draught rate
- Control algorithms, in particular to obtain the window opening ratio
- Guidelines to set limits for long term comfort criteria (long term comfort indices exist, see prCEN/TR 16798-2)

Focus in next slides

Draught rate

- FprEN 16798-1

Table B1.3. – Local thermal discomfort design criteria

Draught	Vertical air temperature difference (head-ankle)	Range of floor temperature

	Draught		
	DR (Draught Rate) [%]	Maximum air velocity [a] Winter [m/s]	summer [m/s]
Category I	10	0,10	0,12 [c]
Category II	20	0,16	0,19 [c]
Category III	30	0,21	0,24 [c]

If indoor operative temperature > 25°C

Table B1.4 – Indoor operative temperature correction ($\Delta\Theta_o$) applicable for buildings equipped with fans or personal systems providing building occupants with personal control over air speed at occupant level.

Average Air Speed (V_a) 0.6 m/s	Average Air Speed (V_a) 0.9 m/s	Average Air Speed (V_a) 1.2 m/s
1.2°C	1.8°C	2.2°C

Note to entry: An air speed over 0,8 m/s moves the normal office paper from the desk.

Draught rate

- FprEN 16798-1 allows one to consider increased air velocities above T_{op} = 25°C
- No standard gives keys to calculate air speed

Do you think draught should be taken into account in energy performance regulation ?

1 Yes, with rough estimates of air speeds in rooms

28%

2 Yes, roughly (e.g., assume closed windows above wind speeds of 3 m/s)

33%

3 No, not possible/useful to take into account in an EP regulation tool

22%

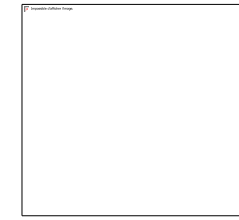
4 Other

17%

Please vote!

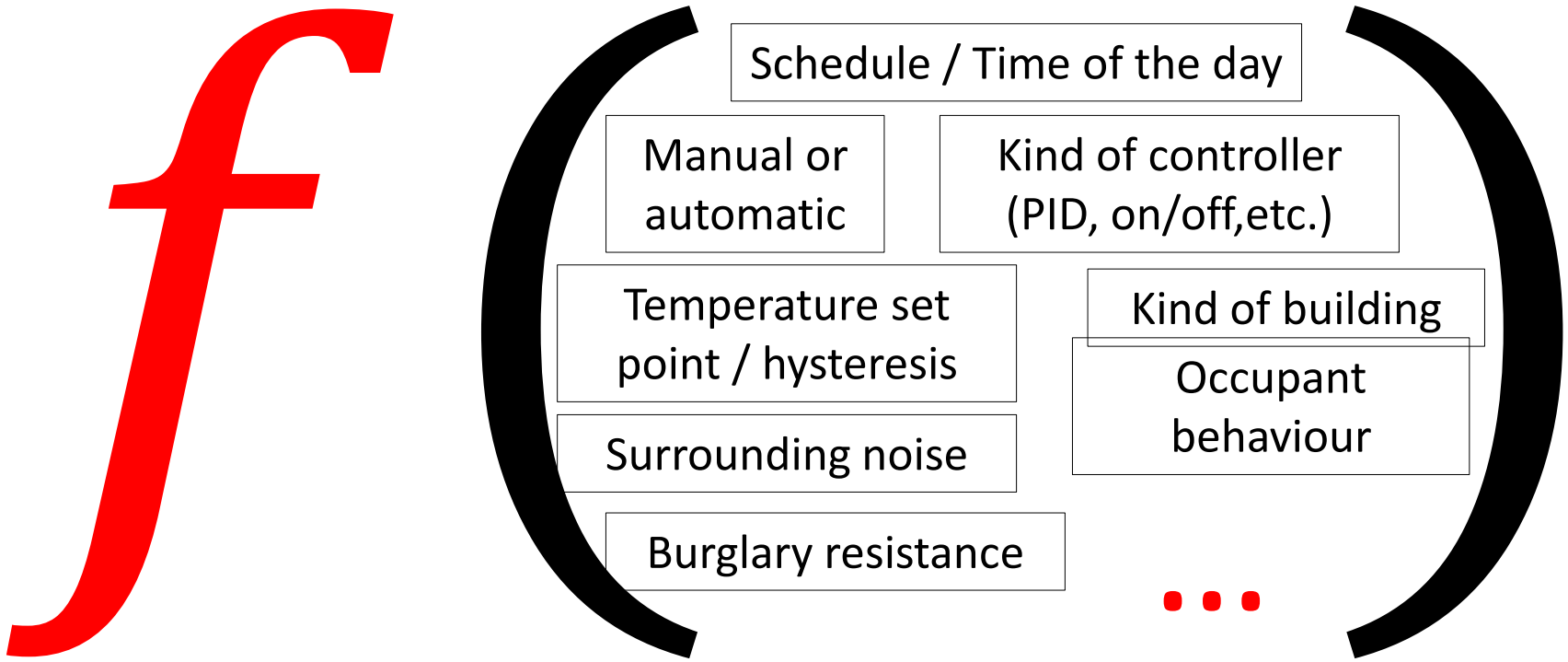
What is the issue with controls?

- The calculation tool shall determine at a given time “t”:
  - The flowrate due through each ventilative cooling component:
    - Flowrate through windows, through ventilation system, etc.
  - The operating conditions for each ventilative cooling component:
    - Is a window open or partly open?
    - Is the fan on?
    - Etc.



What is the issue with controls?

- Operating conditions depend on



What is "*f*" and "…"?

What do we need?

- List of parameters that may have an impact on the operation of a technique
- Identifiers
  - For each parameter
- *f* () that determines the operating conditions of the system depending on identifiers

What do we have? Some identifiers

		15232-1 16947-1
Included systems	Control of mechanical /hybrid system	
	Control of natural flowrate	
	Control of windows opening	
Parameters	Automatic/manual	
	Indoor set point, outdoor set point and temperature difference set point	
	Type of controller, on/off, proportional, PID etc.	
	Various scenarios (night cooling, free-cooling, etc.)	
	Burglary resistance of windows	
	Surrounding noise (impact on windows opening)	
	Impact of adaptive comfort	
	Occupation	

Yes

No

To be set by user

Do you think window opening scenarios and algorithms should be?

1 Set by default for all buildings

0,0%

2 Set by default depending on building type

21,4%

3 Set using a pick list of 10 identifiers (defining major control types)

57,1%

4 Left open

7,1%

5 Not clear

14,3%

Please vote!

Impact of ventilative cooling

- The thermal/comfort criteria is key to enhance ventilative cooling
- As many indicators as countries
  - Most current: number of hour above a certain temperature (or equivalent) Denmark , Finland, Ireland, UK
  - In France conventional indoor building temperature

  => Does not take into account adaptive comfort theory
- In standard
  - **prEN 16798-1 gives comfort categories**
    - Possible to take into account adaptive comfort theory
  - ISO/DIS 52016-1 gives calculation of cooling need

Comfort indices (long term evaluation)

- 3 options in prCEN/TR 16798-2
  - Percentage of time outside the range
    - % of occupied hours when PMV or T_{op} are outside a specified range
  - Degree hours
    - Time during which $T_{op} > T_{op;specified}$, weighted by a factor depending on how many degrees it exceeds
  - PPD weighted
    - Time during which PMV exceeds comfort boundaries weighed by a factor depending on PPD

How should we consider overheating in national building regulations?

1 Penalties on the calculation energy in case of overheating

20%

2 Temperature limits, fixed

7%

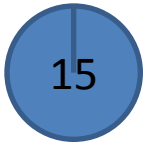
3 Temperature limits, adaptive comfort

60%

4 Other

13%

Please vote!



Do you think your country will use the new set of standards to implement ventilative cooling in the energy performance regulation?

1 Probably yes, at least partially

63%

2 Probably no, the new standards are not relevant for my country

26%

3 Probably no, nobody cares

11%

Please vote!

WHAT'S NEW IN THE EPBD STANDARD FprEN 16798-7 TO CALCULATE AIRFLOW RATES?

What's new in the EPBD standard FprEN 16798-7 to calculate airflows?

- Changes in EN:
  - Calculation of airflows thought windows
  - Calculation of mass balance (instead of volume balance)
  - More details on passive duct calculation (implicit equation included)
  - Required airflow rates can take into account heating/cooling needs (if applicable)
  - Required supply temperature can be calculated (if applicable)
- Moved to TR:
  - Information on multi-zone modelling
  - Use of window openings depending on ext. temperature and wind
- Removed
  - Explicit calculation to calculate total airflow rates

What's new in the EPBD standard FprEN 16798-7 to calculate airflow?

Major changes on airing (i.e., natural airflow rates through windows)

- Airing
  - Flowrate depends on:
    - Wind speed
    - Thermal draft
    - Windows area and height
  - Or simplified method
    - Directly proportional to hygienic flowrate
- Specific § for summer comfort
  - No method described
  - Cross ventilation « has to be taken into account »

EN 15242 (old)

- No distinction between airing and summer comfort
- Calculation for **cross-ventilation** included in the standard
- 3 proposed methods
  - Simplified calculation (idem)
  - Explicit calculation
    - Single sided and **cross-ventilation**
  - **Implicit calculation**

FprEN 16798-7 (new)

What's new in the EPBD standard FprEN 16798-7 to calculate airflow?

Major changes on airing (i.e., natural airflow rates through windows)

Single-sided ventilation

EN 15242 (old)

$$q_{vairing} = 3.6 \,.\, 500\, Aow\, V^{0,5}$$

$$V = Ct + Cw \,.\, Vmet^{2} + Cst \,.\, Hwindow \,.\, \text{abs}\,(\theta i - \theta e)$$

FprEN 16798-7 (new)

$$q_{V;arg;in} = 3600 \times \frac{\rho_{a;ref}}{\rho_{a;e}} \cdot \frac{A_{w;tot}}{2} \cdot \max\left(C_{wnd} \cdot u^{2}_{10;site}; C_{st} \cdot h_{w;st} \cdot abs\left(T_z - T_e\right)\right)^{0,5}$$

=> Only **main driving force** is taken into account (wind or thermal draft)

What's new in the EPBD standard FprEN 16798-7 to calculate airflow?

Major changes on airing (i.e., natural airflow rates through windows)

Cross ventilation

FprEN 16798-7 (new)

$$q_{V;arg;in} = 3600 \times \frac{\rho_{a;ref}}{\rho_{a;e}} \cdot \max\left(C_{D;w} \cdot A_{w;cros} \min\left(u_{10;site}; u_{10;site;max}\right) \cdot \left(\Delta C_p\right)^{0,5}; \frac{A_{w;tot}}{2} \cdot \left(C_{st} \cdot h_{w;st} \cdot abs\left(T_z - T_e\right)\right)^{0,5} \right)$$

$A_{w;cros}$ represents an equivalent area that has to be crossed by the airflow
It is estimated by averaging the equivalent area for 4 wind directions
The standard provides an algorithm to estimate $A_{w;cros}$

Only **main driving force** is taken into account (wind or thermal draft)

What's new in the EPBD standard FprEN 16798-7 to calculate airflow?

Major changes on airing (i.e., natural airflow rates through windows)

Implicit equation

FprEN 16798-7 (new)

Possible to use orifice-flow equations to calculate windows airflow rates (then linked to the mass balance equation to determine internal pressure of the zone)

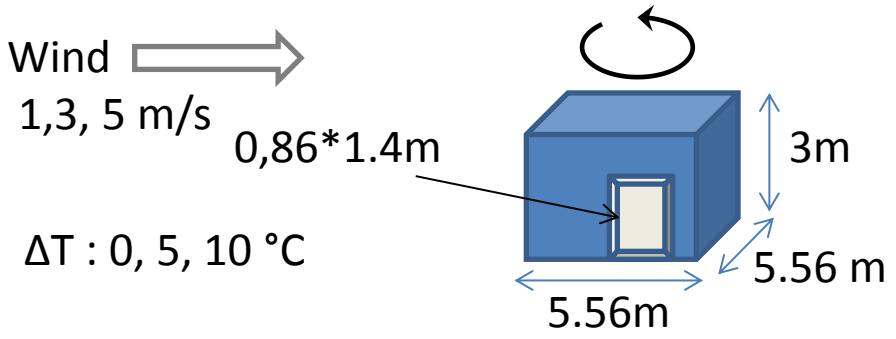
$$q_{V;w;div;path,i,j} = \frac{C_{w;path,i}}{N_{w;div} + 1} \cdot sign\left(\Delta p_{w;div;path,i,j}\right) \cdot \left|\Delta p_{w;div;path,i,j}\right|^{n_w}$$

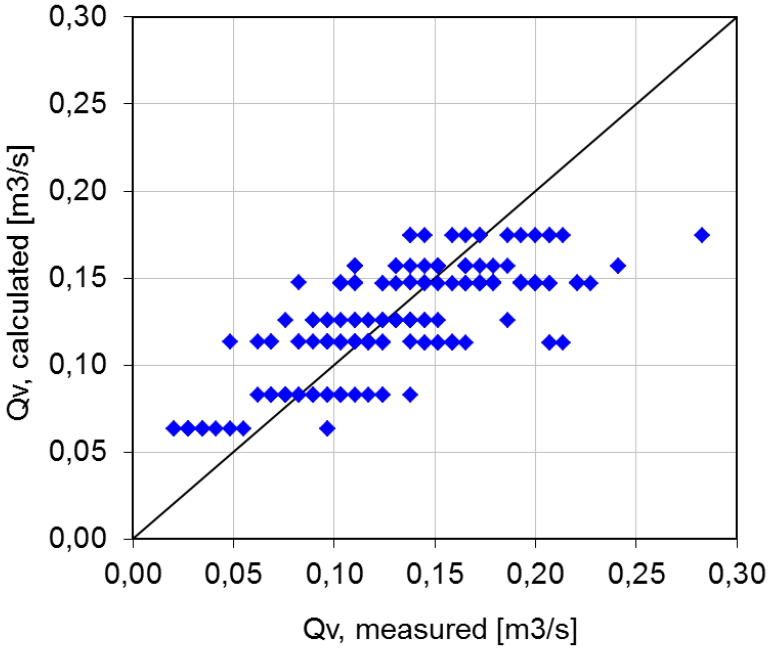
Testing those formulae

- Comparison with wind tunnels and on-site measurements
  - See Tine Steen Larsen's paper presented in session SS-18
- Comparison between methods and with Contam
  - See Valérie Leprince's paper presented in session SS-18

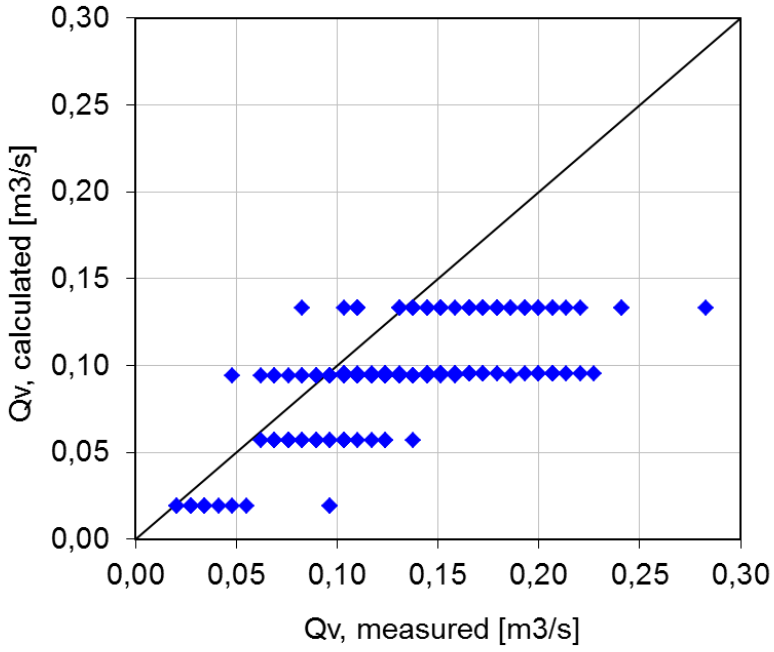
Comparison with measurement data

- Wind tunnel





De Gids & Phaff, prEN formula

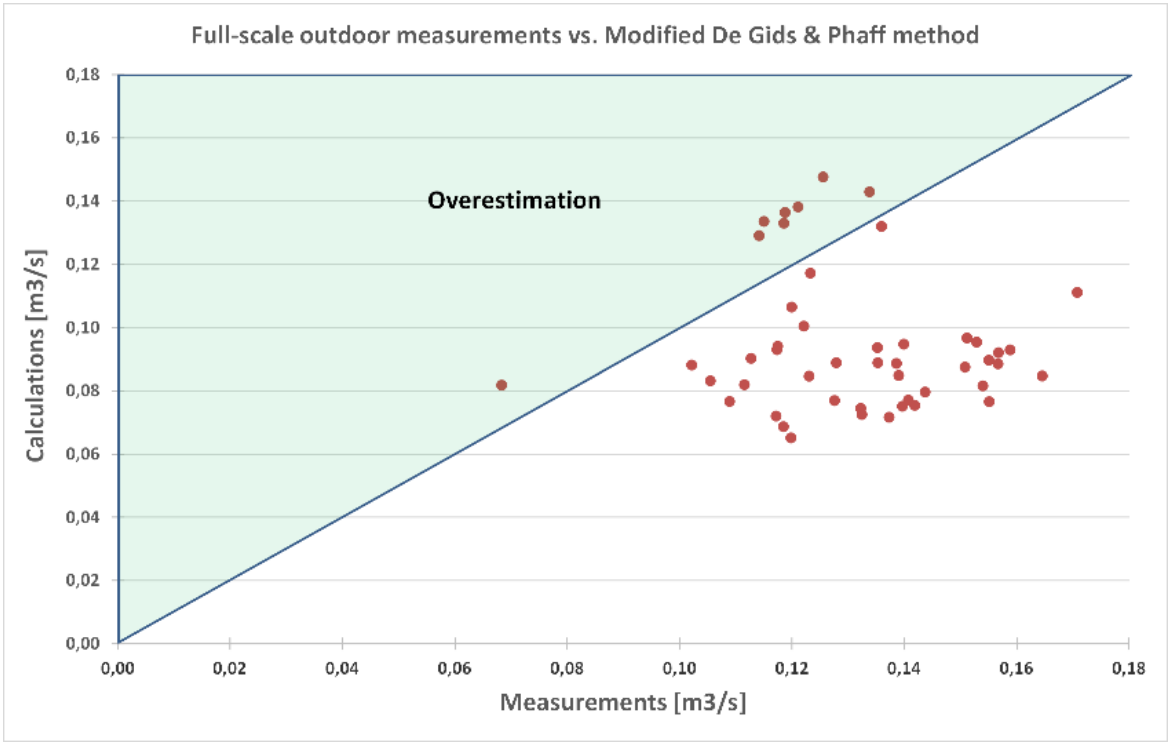


Modified De Gids & Phaff, FprEN formula

See Tine Steen Larsen's presented in session SS-18

Comparison with measurement data

- Full scale outdoor measurement in an office



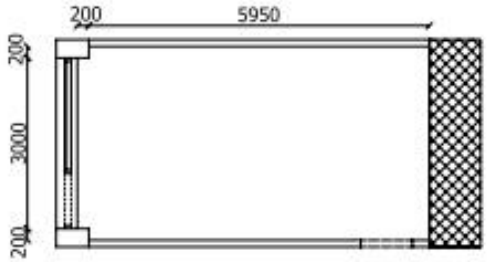


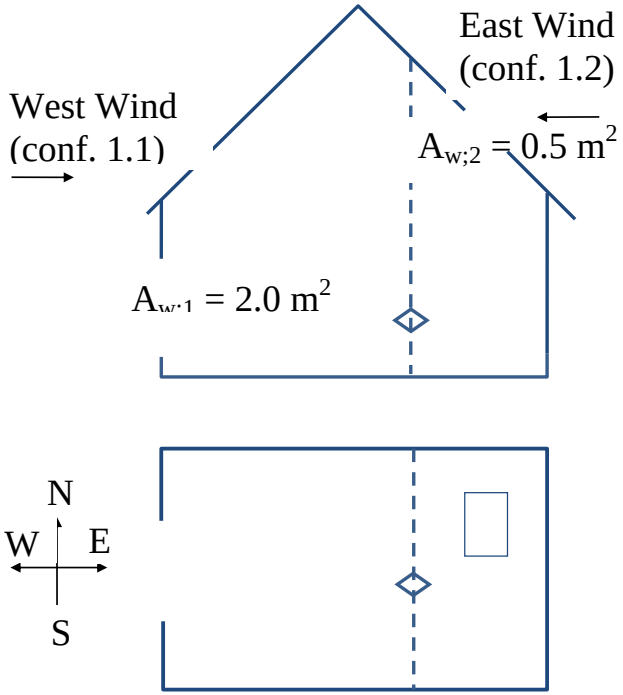
Figure 4.19. *Plan of the test office. Dimensions in mm.*

Figure 4.20. *Position of the opening in the wall.*

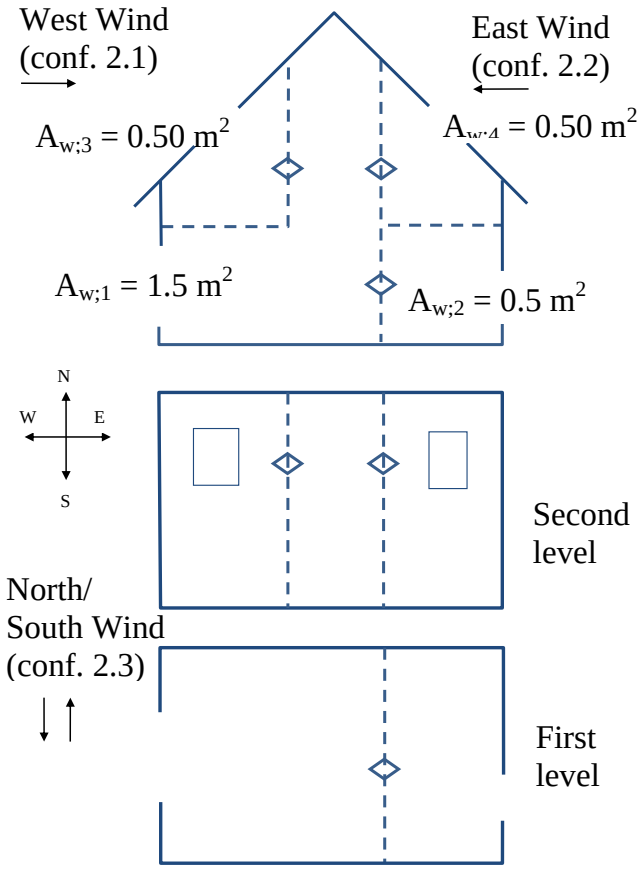
See Christoffer Plesner presentation in IA2016, Tine Steen Larsen Ph. D. thesis

Comparison between methods and with CONTAM

See Valérie Leprince's paper presented in session SS-18



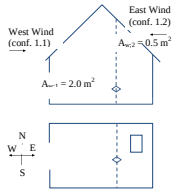
- Wind speed : 0 to 5m/s
- ΔT : 0 K to 15 K



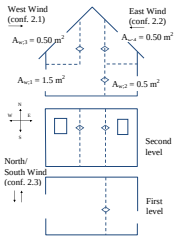
Configuration 1

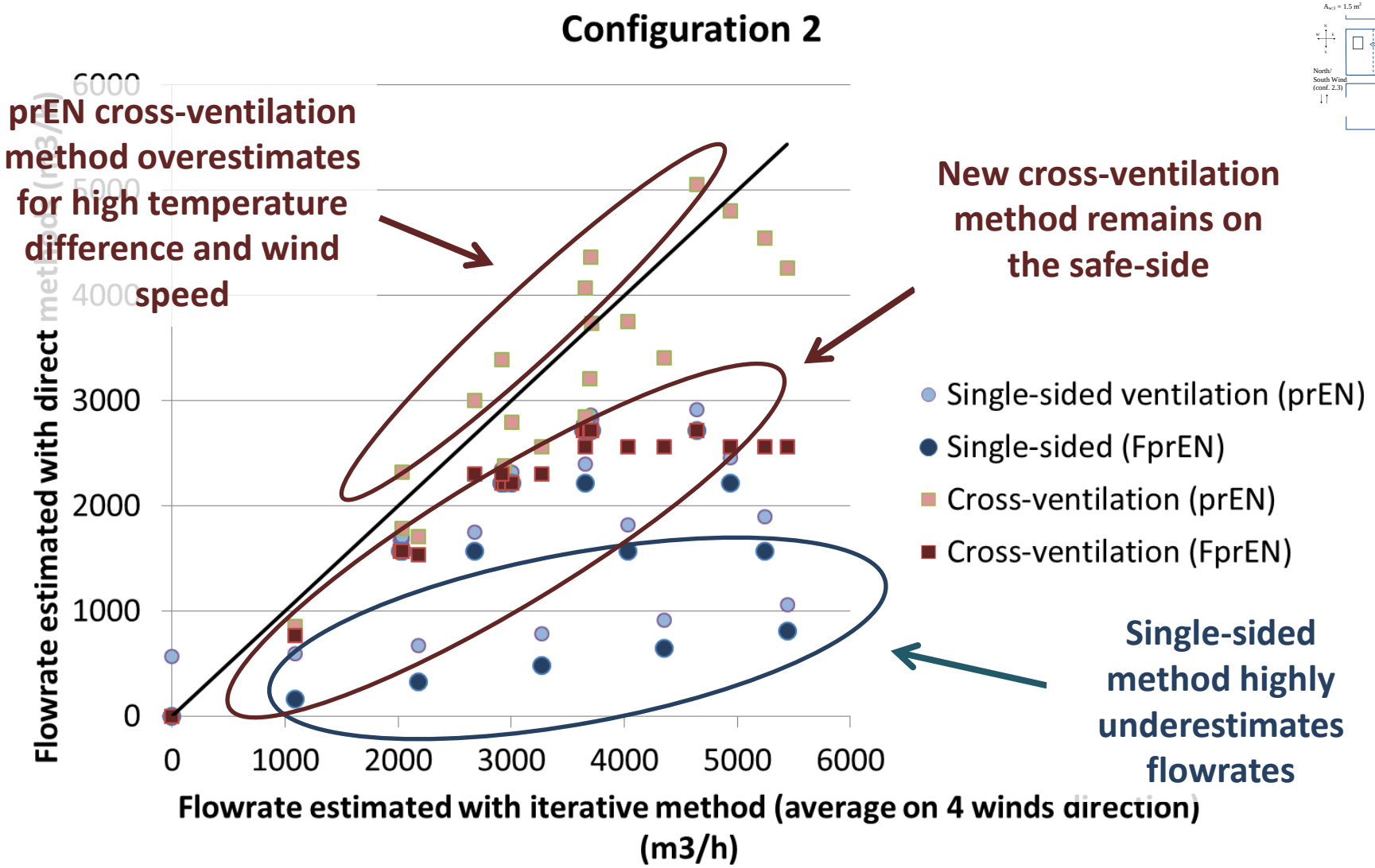
Configuration 2

Comparison between methods



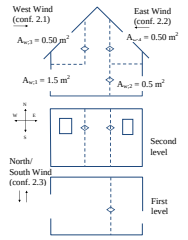
Comparison between methods

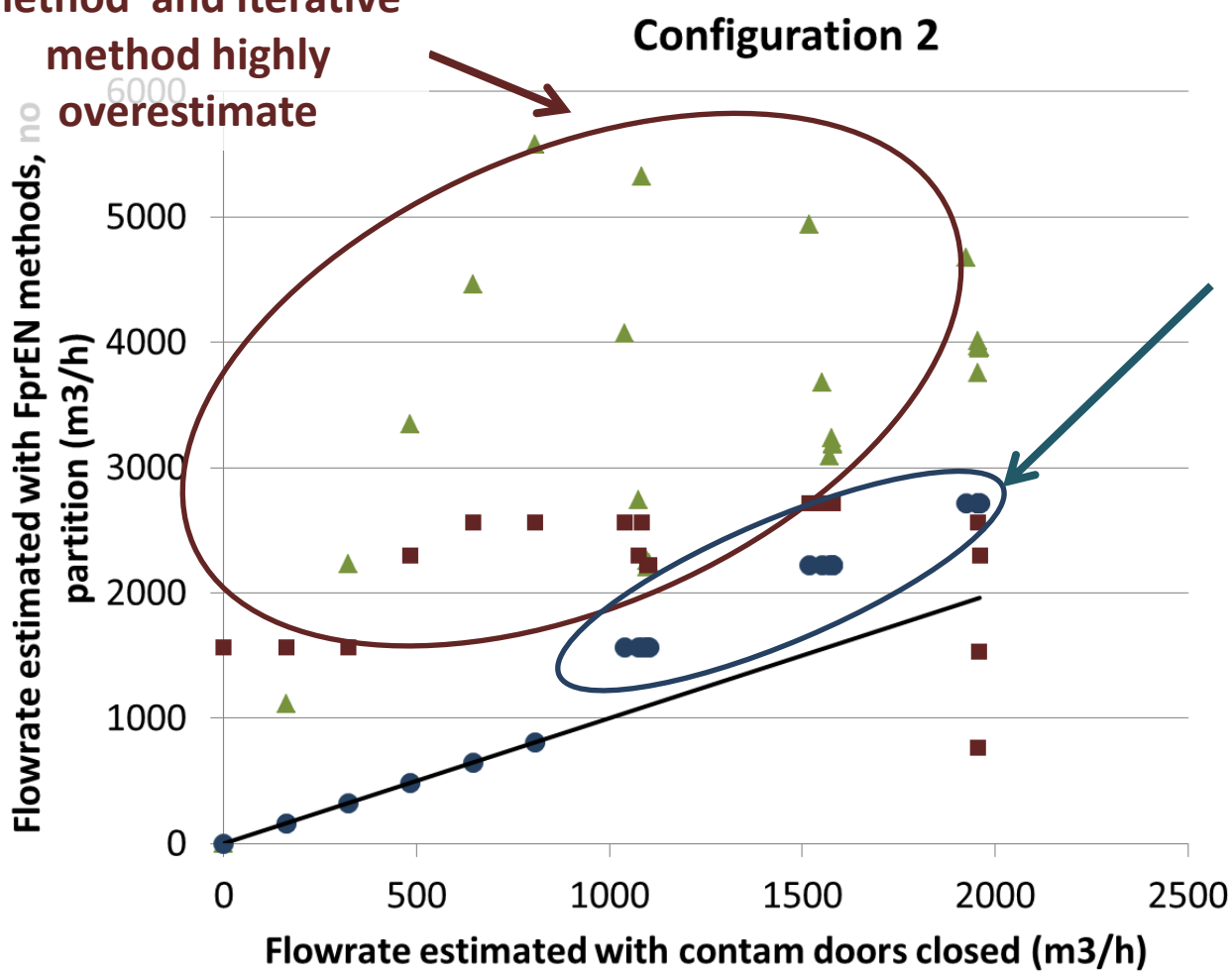




Closed doors, comparison with Contam

Cross-ventilation method and iterative method highly overestimate

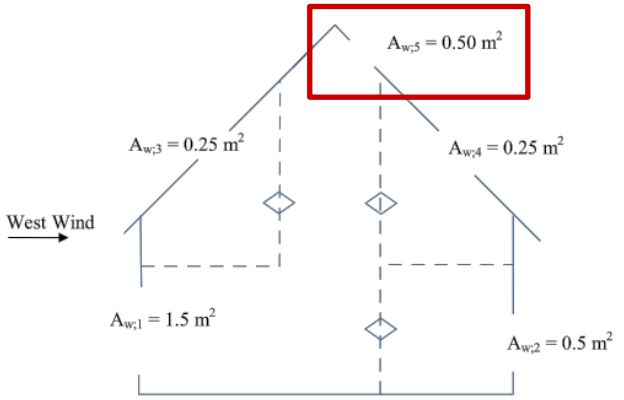


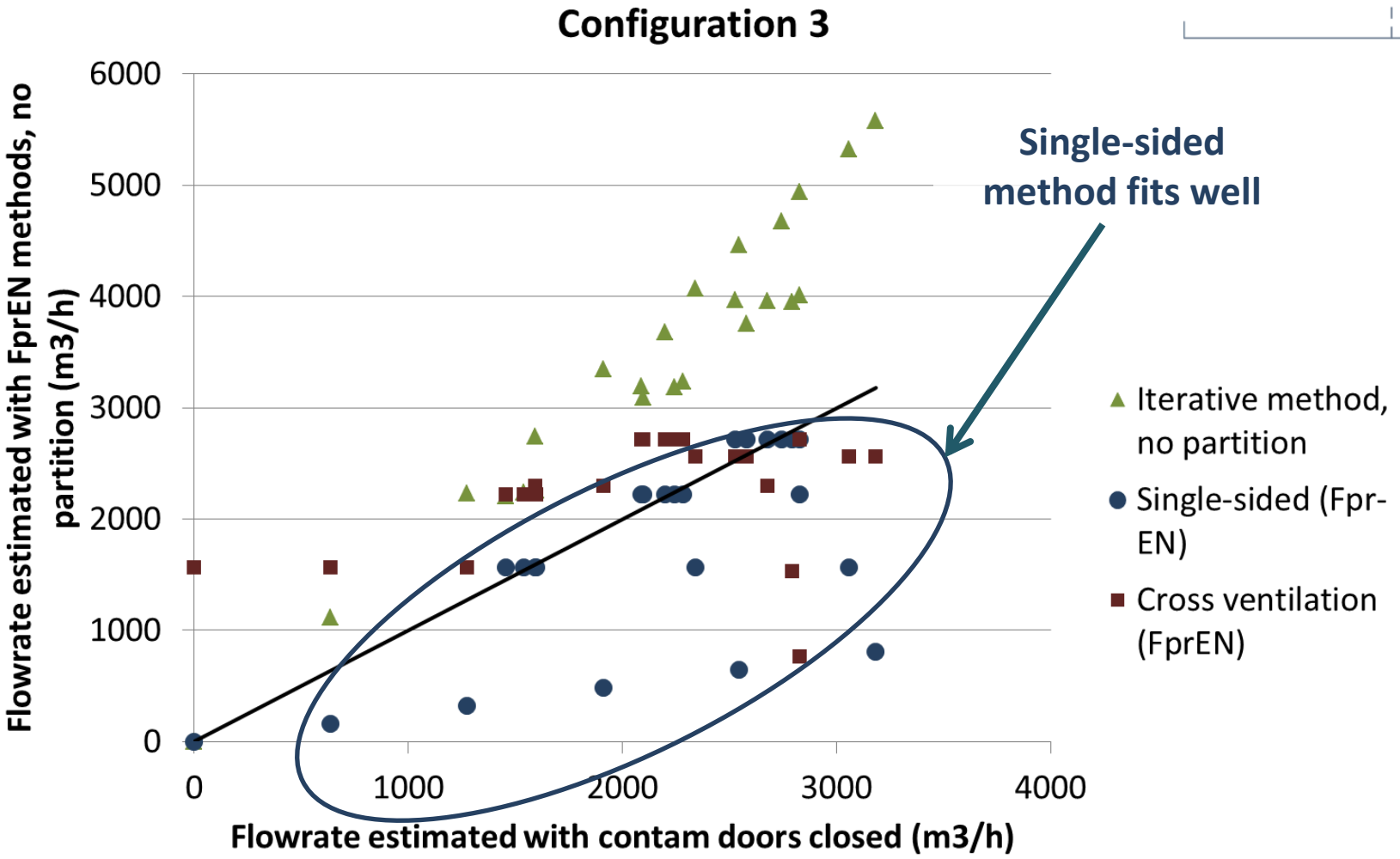


Single-sided method over estimates when ΔT>0

- Iterative method, no partition
- Single-sided (Fpr-EN)
- Cross ventilation (FprEN)

Closed doors, but **open staircase** comparison with Contam





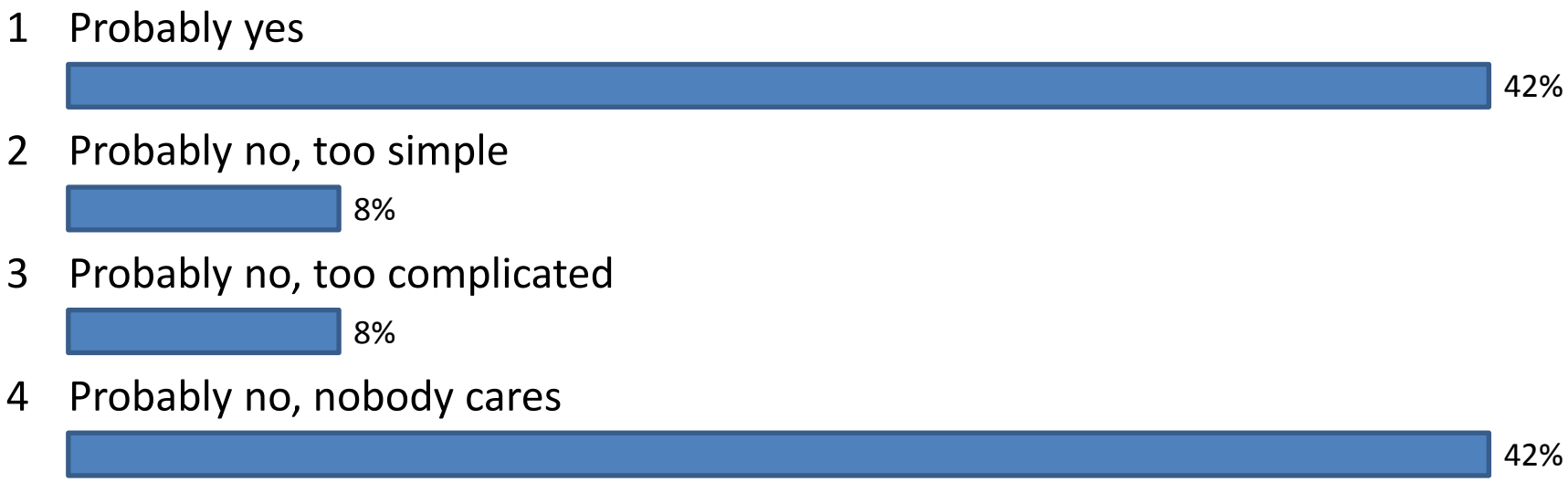
Methods for windows opening

- Iterative method assumes a zone to be at a constant pressure (at the floor level), this supposes internal doors do not create pressure drop inside the dwelling.
  - Unsuitable for important flowrates due to windows airing.
  - $\Rightarrow$ Use explicit method for each subzone

- Other limit of iterative method:
  - Can not apply to ventilation zones where the only airflows considered are due to single-sided ventilation (instability)
  - Flowrate through windows can be much more important than flowrate through vents, leaks or ventilation system. Include windows in the mass balance flowrate could create convergence problem (to solve the implicit equation) and lead to foolish results.

$\Rightarrow$ Use of explicit method for windows and implicit for others flowrate

Do you think your country will use FprEN 16798-7 to calculate ventilative cooling through airing?



Please vote!

Are we missing standards on design of natural ventilative cooling systems?

1 Yes, European standard

45%

2 Yes, national standard

20%

3 No, but guidelines would be useful

35%

4 No

0%

Please vote!

Do you think there are sufficient trainings available for designers to improve their skills to design ventilative cooling systems in your country?

Please vote!

WHAT IS CRITICAL FOR COMPLIANCE CHECKS?

Compliance checks

- In our context:
  - Compliance = Fact of conforming with EPC procedures
- Implies:
  - Someone will check the EPC
  - He has to be able to unambiguously say if the EPC is compliant or not, based on
  - Rules that are defined, inc.:
    - Technical rules to determine the EPC input data
    - Organisational requirements (e.g., requirements for certification, etc.)
    - Rules to show evidence of compliance

Some evidence of issues

- Denmark
  - Airflow rates are directly entered, but there is no rule to calculate these airflow rates, therefore…
  - Input parameters (natural airflow rates) can be checked neither with technical documents nor with measurements
  - Strong barrier for designers to implement ventilative cooling
  - Difficult to show evidence of (non) compliance
- Estonia
  - Open calculation method
  - Input parameters that have to be considered are not defined
  - Results can differ considerably depending on hypotheses and methods used
  - Difficult to show evidence of (non) compliance

What can be verified?

- Mostly (only ?) input parameters
- Key input parameters have to be highlighted
- It should be clear:
  - How to define these key input parameters
  - How the characteristics can be verified, either:
    - Technical documentation, preferably based on a product standard
    - Measurement, preferably based on test standard
  - The tolerance for deviation when the characteristics are verified
  - How to show evidence that the characteristics are in accordance with the input parameters

What's in FprEN 16798-7?

- All EPBD standards have tables with input/output values in a common format (see presentation by J. Hogeling)

Name	Symbol	Unit	Range	Origin Module	Varying
Topography coefficient depending on the local environment of the meteorological station	$C_{top;met}$	-	0 to ∞	ISO 15927-1	No
Topography coefficient depending on the local environment of the building site at building height	$C_{top;site}$	-	0 to ∞	ISO 15927-1	No
Topography coefficient depending on the local environment of the building site at height of 10m	$C_{top;10;site}$	-	0 to ∞	ISO 15927-1	No
Airing factor (see B.3.3.8)	f_{arg}	-	0 to 3	Local	No
Cross-ventilation factor	F_{cros}	-	0 or 1	Local	No
Control factor	f_{ctrl}	-	0 to 1	Local	Yes
Supply outdoor air fraction	f_{ODA}	-	0 to 1	M5-6	Yes
Operation requirement signal (combustion appliance)	$f_{op;comb}$	-	0 or 1	Local	Yes
Operation requirement signal (ventilation) (0 = fan					

What's in FprEN 16798-7?

- Checklist for quality control and compliance check

8 Quality control

The calculation report shall:

- state the calculation interval, methods and options used for the calculation
- list all input data
- list all output data of Table 4 transferred to other modules
- besides the output values of Table 4 transferred to other modules, include the values of the total volume air flow rates are $q_{v;tot;in}$ and $q_{v;tot;out}$

9 Compliance check

Compliance check performed in the context of an energy performance regulation may be based on checks performed on a selection of input data, in particular those for which a minimum requirement is set at national level, and/or those that have a significant weight on the calculated energy use.

When checks are performed on-site, they shall include the following verifications:

- Ventilation system type
- Location and characteristics of air terminal devices used for passive ducts*
  - Location, C_{ATD}, A_{ATD}
- Location and characteristics of cowls

Summary

- In most European countries EP-calculation tools do not fairly consider ventilative cooling
- The new EPBD set of standard gives models to implement ventilative cooling. Missing information are mainly with:
  - Control of systems
  - Guidance on parameters that shall be defined by the user or taken as default
  - Guidance for long-term thermal comfort criteria
- Windows openings is better considered in FprEN 16798-7, in particular cross-ventilation
- Unambiguous definition of input parameters and ways to checks those input parameters are pre-requisites for compliance checks

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Thank you, please give back your voting unit