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the international platform for ventilative cooling

STATUS AND RECOMMENDATIONS FOR BETTER IMPLEMENTATION OF VENTILATIVE COOLING IN STANDARDS, LEGISLATION AND COMPLIANCE TOOLS (Background report)

A publication in the context of IEA EBC Annex 62 ventilative cooling

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Executive summary

Introduction

Overheating in buildings is an emerging challenge at the design stage and during operation. This is due to a number of reasons including high performance standards to reduce heating demand by high insulation levels, and restriction of infiltration in heating dominated climatic regions; the occurrence of higher external temperatures during the cooling season due to changing climate and urban climate is not usually considered at the design stage, and changes in internal heat gains during operation are not factored in the design. Such factors have resulted in significant deviations in energy use during operation which is usually termed 'performance gap'. In most energy performance comparative studies energy use is higher than predictions, and in most post-occupancy studies overheating is a frequently reported problem.

As previously mentioned, a major challenge is the increased need for cooling arising in the highly insulated and airtight buildings. The cooling demand depends less on the outdoor temperature, and more on solar radiation and internal heat gains. This normally provides more opportunities for the use of ventilative cooling technologies, because the cooling need is not only during the summer time, but actually all year round.

What is ventilative cooling?

Ventilative cooling is a way to cool indoor spaces through the use of natural ventilation (i.e. natural ventilative cooling), mechanical ventilation strategies (i.e. mechanical ventilative cooling) or a combination (i.e. hybrid ventilative cooling). Ventilative cooling uses outside air to cool indoor spaces, mitigating overheating in both existing and new buildings. Ventilative cooling can save cooling energy and give more flexibility and design options for buildings, enabling a broader range of design solutions to fulfil building energy legislations. But for ventilative cooling to become a more widely used solution, it needs to be well integrated into standards, legislation and compliance tools. This background report will evaluate if this is the case or not.

Objectives and contents of the background report for recommendations

The overall objective of this background report is to describe the current status and future recommendations for better implementation of ventilative cooling in standards, legislation and compliance tools. The basis for this background report is the current implementation of ventilative cooling in EN standards, ISO standards and national standards, as well as national legislation and national compliance tools. This information is obtained through questionnaires answered by experts in 11 countries, all of which participate in IEA EBC Annex 62 (see Table 2). Also, another objective is to evaluate if new Technical documents on ventilative cooling (e.g. European standards (EN), Technical specifications (TS) or Technical reports (TR)) should be considered at European level (in CEN).

Detailed information on the evaluation of missing parameters in standards, legislation and compliance tools as regards ventilative cooling is available in the completed questionnaires of Annex A (missing ventilative cooling aspects in standards) to Annex C (missing ventilative cooling aspects in compliance tools), used as background information for the answers provided in the separate chapters on standards, legislation and compliance tools of this report.

Scope and target group for the background report on recommendations

The introduced status and recommendations for better implementation of ventilative cooling in standards, legislation and compliance tools address residential and non-residential buildings as well as natural, mechanical and hybrid ventilative cooling systems.

The background report on recommendations is intended for building designers, builders and experts working with building energy performance standards, legislations and compliance tools. It aims at helping these target groups with concrete recommendations for a better future implementation of ventilative cooling.

The first part of the background report presents the status of ventilative cooling, followed by recommendations at national level and beyond (included in section 5 Main recommendations per topic for standards, legislation and compliance tools - for better implementation of ventilative cooling).

Main results

The background report on recommendations deals with the status and recommendations for better implementation of ventilative cooling in standards, legislation and compliance tools. The report reveals that ventilative cooling is not well-integrated in standards, legislation and compliance tools. However, it also reveals that there is a broad field of evaluation methods for ventilative cooling, ranging from simple to detailed, which can support a better integration of ventilative cooling in the near future.

Even though the benefits of ventilative cooling are widely acknowledged, its use by e.g. designers or architects strongly depends on a few intertwined challenges:

- The adequate modeling of natural ventilation and especially of air flows
- The share of the energy for cooling for summer comfort and to avoid overheating risks, which is close to becoming equivalent to the energy consumption for heating in winter, depending on the climate
- The adequate prediction of the expected "thermal comfort and cooling requirements", as well as the "energy performance" when using ventilative cooling in buildings (this could e.g. be based on Static models (e.g. Fanger PMV model) or Adaptive models (e.g. adaptive comfort model))

Although the first point can be handled by the use of adequate air flow models, the second point requires national ambitions and targets to be set up in building regulations and standards. Finally, the third point requires that both static and adaptive comfort models are supported in standards, building legislation and compliance tools.

The split of roles and responsibilities between legislation, standards and compliance tools differ from country to country. The collective task is to set up targets for certain parameters and methods to evaluate if these targets have been met. The targets are assumed to be defined in the legislation, and the methods to evaluate if the targets are met are defined in standards and/or national compliance tools.

The main results for standards, legislation and compliance tools are summarized below, some with specific examples in different countries, showing what evaluation methods are used for ventilative cooling. Each section presents several important parameters which should be taken into account, to ensure a more fair and better implementation of ventilative cooling in future standards, legislation and compliance tools.

Main recommendations for standards and other technical documents

Regarding national standards, the conclusion drawn was that overall ventilative cooling is not integrated in the standards of most of the evaluated countries e.g. in the United Kingdom, Italy and China. For instance, in Italy, standard user behaviours are assumed in reference ventilation; ventilation is principally considered for IAQ purposes and hence the suggested minimal air change rates of 0.5 h^{-1} for residential (point D5.1 UNI EN 12831:2006) and for industrial/artisan buildings are not sufficient for pursuing cooling through the use of ventilative cooling strategies.

As regards European Standards and other Technical Documents, there are European Technical reports in CEN (TR's) which cover to some extent some of the "system design" aspects of natural ventilative cooling in a building by mentioning natural ventilation systems (not ventilative cooling) namely CEN/TR 16798-4:2017 (TR to EN 16798-3:2017) and CEN/TR 14788:2006. However, European EN standards as well as ISO standards covering this sufficiently, are missing. The aforementioned standards CEN/TR 14788:2006, EN 16798-3:2017 and CEN/TR 16798-4:2017 are all under revision.

To allow for ventilative cooling to be treated better in standards both at the design stage, where initial calculations of e.g. the natural forces are made, as well as at more detailed stages where more detailed calculations are needed, it is important that several parameters are taken into account, such as:

- Assessment of overheating, e.g.:
    - Utilizing thermal comfort indicators, including adaptive temperature sensation
    - Utilizing energy performance indicators
- Assessment of natural and mechanical ventilative cooling
- Assessment of night cooling
- Calculation methods that fairly treat natural ventilative cooling for determination of air flow rates including e.g. the dynamics of varying ventilation and the effects of location, area and control of openings

When revising standards with respect to calculation and design of ventilative cooling systems, specific technologies shouldn't be favoured and emerging technologies such as hybrid systems should be considered. Among other things, the determination of air flow rates in buildings is important to consider for ventilative cooling. Calculation methods can be found in e.g. calculation standard; EN 16798-7:2017 for both mechanical and natural ventilation, enabling the designer to choose the level of detail needed for the given purpose and stage of the construction [1].

It is recommended that the full effects of ventilative cooling are evaluated reflecting the real conditions for the building, control, use and climate. This should include in particular the actual building physics and geometry, supporting a fair evaluation of natural ventilation (e.g. stack effects, cross ventilation), mechanical ventilation, control system, night/day ventilation and summer/winter ventilation.

Lastly it is recommended to use the Key Performance Indicators for "thermal comfort" and "energy performance" used in the IEA EBC Annex 62 "Ventilative cooling design guide" [2], for:

- "Thermal comfort" indicator: supports either the static Fanger model (PMV evaluation) or the Adaptive comfort model, using the Percentage outside the range (POR). POR evaluates the percentage of occupied hours when PMV/Operative temperature is outside the range, and the Degree-hours criterion (DhC) which evaluates the time the operative temperature is above the range during occupied hours.
- "Energy performance" indicator: using the Cooling Reduction Requirement (CRR), and the Ventilative Cooling Seasonal Energy Efficiency Ratio (SEER) defined as the cooling requirement saving divided by the electrical consumption of the ventilation system.

Main recommendations in legislation

The research conducted has revealed that the control of ventilation (air flow rate) for ventilative cooling and its effect on thermal comfort and on cooling demand reduction is not clear [1] - generally being too simplified or even missing in legislation and compliance tools. In many national building codes and energy performance regulations, ventilative cooling is not explicitly referred to as a cooling option for meeting requirements of energy performance and thermal comfort.

Generally, the calculation of air flow rates in buildings and their control is not sufficiently reflecting the real conditions such as the actual building design, physics, geometry and operation, thereby underestimating the potential of ventilative cooling. A better integration of ventilative cooling is possible in Switzerland, Norway and Austria where legislation supports hourly time step calculations for thermal comfort, which better support the adaptive comfort model and the prediction of need for cooling in the building and hereby also the overheating, instead of less precise, monthly calculations. In this sense, these countries could be seen as pioneers.

To allow for ventilative cooling to be treated better in building performance evaluations in legislation, several parameters are necessary to consider in the building regulation, such as:

- Assessment of overheating e.g.:
  - Requirements to thermal comfort, including adaptive temperature sensation
  - Requirements to energy performance including cooling
- Acknowledgement of natural and mechanical ventilative cooling
- Support to evaluation methods considering the dynamics of varying ventilation
- Support to evaluation methods considering the effects of location, area and control of openings

Overheating is highly dynamic and so are the effects of ventilative cooling and overheating prevention measures such as solar shading. Luckily, calculation methods and tools are available to deal with these dynamics. To assess the resulting performance with respect to both thermal comfort and energy use for cooling, it is clearly recommended for legislation to require overheating effects to be assessed by means of detailed assessment methods. These be detailed add-on modules accompanying existing simplified tools (as in e.g. Denmark) or (preferred) added features in a more detailed tool, capable of taking dynamics into account (as in e.g. Switzerland).

Main recommendations in Compliance Tools

Several building simulation tools are available today around the world, which allow architects or engineers to assess buildings with a high accuracy on energy performance or indoor climate. Some of them are already implementing modules to consider natural ventilation or natural ventilative cooling through windows and its effect on thermal summer comfort.

In particular, natural ventilative cooling is difficult to assess in most existing compliance tools, reflecting what's stated in the national legislation. Since compliance tools are the only evaluation tools used in many cases, it is recommended to secure the implementation of ventilative cooling in compliance tools, allowing the evaluation of overheating issues at the earliest stage of the design process when decisions on e.g. windows location or orientation can still be taken.

The recommendations from the report show that, even though simulation tools today are available on the market, the critical channel to spread the rational assessment of over-heating and the use of ventilative cooling remains in compliance tools on which building legislation is based.

Therefore, depending on the national context and the progress made on these compliance tools, it is recommended to aim at solutions considering ventilative cooling in a realistic and efficient way. For example, an effort should be made to implement hourly calculation time steps for both thermal comfort and energy performance evaluations in more compliance tools (currently available in just a few countries), instead of less precise monthly calculations, to better support the adaptive comfort model and consider the dynamic nature of ventilative cooling. Advanced calculation methods like e.g. dynamic simulations based on hourly time-steps are usually closer to reality and lead to more realistic air change rates. Moreover, hourly calculations have the capability to predict the cooling loads in the building and hereby assess the overheating more precisely compared to monthly calculations; this is crucial for today's buildings.

The main recommendations from the IEA EBC Annex 62 are summarised below, covering all investigated compliance tools.

To allow for ventilative cooling to be better considered in compliance tools' evaluations, several parameters should be considered, such as:

1. Assessment of overheating, e.g.:
    a. Thermal comfort indicators, should be implemented in compliance tools, considering air flow rates when evaluating internal temperature and adaptive temperature sensation
    b. Energy performance indicators, are either an alternative or a complementary solution to be used for evaluating the benefits of ventilative cooling (by acknowledging the reduction of cooling needs)
2. Assessment of increased air flows when efficient ventilative cooling systems are used:

   a. Differentiation should be made i.e. between cross- or stack ventilation vs. single-sided ventilation, automated systems vs. manual control, large vs. small opening areas
   b. Associated airflows should preferably be based on building physics e.g. dynamic tools (using pressure equations) or – as a simpler solution - “coefficients” which increase air flows based on the chosen system
3. Implementation of different levels of approaches to the evaluation of ventilative cooling, depending on the level of detail needed for the given purpose and stage of the construction.
   a. **Simplified approach:**
      Using national compliance tools based on monthly calculations with specific assumptions on input air flows for natural ventilation and ventilative cooling (like e.g. in Belgium, Flanders).
      The main benefit of this method is its direct applicability towards most existing compliance tools.
      It allows modelling of ventilative cooling via the use of constant air flows over a given period and can, like in Belgium, promote the gradual use of openable windows, stack effect, cross-ventilation and even control systems.
      Its simplicity will of course lower the air flows and tends to reduce the impact of ventilative cooling on thermal summer comfort.
   b. **Intermediary approach** (combining simplified and detailed approach):

      Using national compliance tools based on monthly calculations + using an add-on tool or plugin to address thermal summer comfort and ventilative cooling in a more accurate way (like e.g. in Denmark for residential buildings).

      The main benefit of this approach is to keep the existing compliance tool, but could be less accurate (and then less beneficial to ventilative cooling) due to the reduced number of parameters that can be used by the add-on tool (in several cases, this tool will usually be using the same input parameters as the main compliance tool)

   c. **Detailed approach**:
      i. Using national compliance tools based on full dynamic calculations (e.g. like in Switzerland, where several simulation tools from the market are allowed)
      ii. Using national compliance tool based on simplified hourly calculations (like e.g. in France or in The Netherlands)

      These tools can support the modelling of natural ventilation and do not require the integration of environmental parameters (outdoor temperature, wind speed, wind direction, solar radiation…) over a given period (e.g. no pre-calculation should be performed to evaluate an average outdoor night temperature over the summer period).

      These tools can therefore fully use the evaluation method given in EN 16798-7:2017 (modelling of air flows through windows via discharge coefficients (Cd)) and also allow the use of control strategies like e.g. sensor-based systems.

References

[1] State-of-the-art-review, IEA Annex 62, 2015, accessible on http://venticool.eu/wp-content/uploads/2013/09/SOTAR-Annex-62-FINAL.pdf

[2] IEA EBC Annex 62 deliverable "Ventilative cooling design guide", http://venticool.eu/wp-content/uploads/2016/11/VC-Design-Guide-EBC-Annex-62-March-2018.pdf

Table of content

Acknowledgements

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Abbreviations

Table 1 - List of frequently used abbreviations

Abbreviations	Meaning
BPIE	Buildings Performance Institute Europe
CEN	European committee for standardization
CH	Switzerland
DK	Denmark
EN	European Norm
EPBD	Energy Performance of Buildings Directive
IEA-EBC	Energy in Buildings and Communities Programme of the International Energy Agency
ISO	International organization for standardization
NP	New Proposal
NV	Natural ventilation
NWI	New work item
NZEB	Nearly zero energy building or nearly zero emissions building
SOTAR	State of the are review
TC	Technical committee
TS	Technical specification
WG	Working group

1. Introduction

1.1. General context

IEA EBC Annex 62 on Ventilative Cooling was an international research project running from 2014 to 2017 [1]. The research focus of the annex was on the development of design methods and compliance tools related to predicting, evaluating and eliminating the cooling need and the risk of overheating in buildings as well as on the development of new attractive energy efficient ventilative cooling solutions.

The main goal was to make ventilative cooling an attractive and energy efficient cooling solution to avoid overheating of both new and renovated buildings. To fulfil its main goal, the Annex had the following targets for the research and development work:

- To develop and evaluate suitable design methods and tools for the prediction of cooling needs, ventilative cooling performance and risk of overheating in buildings;
- To develop guidelines for an energy-efficient reduction of the overheating risk using ventilative cooling solutions and for the design and operation of ventilative cooling in both residential and commercial buildings
- To develop guidelines for the integration of ventilative cooling in energy performance calculation methods and regulations including specification and verification of key performance indicators;
- To develop instructions for improvement of the ventilative cooling capacity of existing systems and for the development of new ventilative cooling solutions including their control strategies;
- To demonstrate the performance of ventilative cooling solutions through the analysis and evaluation of well-documented case studies.

IEA EBC Annex 62 included the participation of approximately 15 countries from Europe, Japan, China and the US, from universities, research centres and manufacturers and suppliers of ventilation equipment.

The research results are published in the following publications:

- Overview and state-of-the-art of ventilative cooling
- Status and recommendations for better implementation of ventilative cooling in standards, legislation and compliance tools
- Ventilative cooling source book
- Ventilative cooling case studies
- Ventilative cooling design guide

All publications can be found on www.iea-ebc.org [1].

1.2. Why ventilative cooling

Ventilative cooling is a way to cool indoor spaces using outside air, in this way mitigating overheating in both existing and new buildings - being both a sustainable and energy efficient solution. By using ventilative cooling, cooling energy can be saved and thereby the flexibility and design options for buildings is increased, enabling a broader range of design solutions to fulfil building energy legislations. Ventilative cooling may be split up into natural, mechanical and hybrid ventilative cooling, where natural ventilative cooling is e.g. the opening of windows, which is a very direct and fast method of influencing the thermal environment. An open window will cause increased air motion, and if the outdoor temperature is lower than indoors the temperature will fall. Even when the outdoor air temperature is slightly higher than the indoor, the elevated air speed due to increased airflow will increase the cooling of the body and reduce the thermal sensation.

1.3. Main Goals of Venticool platform

Venticool is the international ventilative cooling platform launched in October 2012 to accelerate the uptake of ventilative cooling by raising awareness, sharing experience and steering research and development efforts in the field of ventilative cooling [2]. The platform supports better guidance for the appropriate implementation of ventilative cooling strategies as well as adequate credit for such strategies in building regulations. The platform's philosophy is to pull resources together and to avoid duplicating efforts to maximize the impact of existing and new initiatives. Venticool joins forces with organizations with significant experience and/or well identified in the field of ventilation and thermal comfort like AIVC [3] and REHVA [4]. To grasp the potential of ventilative cooling to mitigate overheating problems in practice, venticool partners believe that this technology should be fairly accounted for in building regulations.

The main goal is to make ventilative cooling an attractive and energy efficient cooling solution to avoid overheating of both new and renovated buildings. Ventilation is already present in buildings through mechanical and/or natural systems and it can remove excess heat gains as well as increase air velocities and thereby also widen the thermal comfort range.

1.4. Purpose of the report

The overall purpose was to make a background report that describes the current status and provides recommendations for better implementation of ventilative cooling in standards, legislation and compliance tools. In order to present the status of how well ventilative cooling is implemented, experts in 11 countries, participating in IEA EBC Annex 62 (see Table 2), were asked to fill-in a questionnaire looking into which parameters influencing ventilative cooling are included in standards, legislation and compliance tools. Annex A (missing ventilative cooling aspects in standards), Annex B (missing ventilative cooling aspects in legislation) and Annex C (missing ventilative cooling aspects in compliance tools) of the report were used as background for the answers found in the “standards”, “legislation” and “compliance tools” sections of this report.

Based on the initial findings, another objective was to evaluate if new Technical documents on ventilative cooling (e.g. EN standards, technical specifications or technical reports) should be proposed in Europe, by evaluating if there was a critical lack of content in existing standards regarding ventilative cooling.

This report focuses on the status and recommendations specifically given for EN, ISO and national standards, national legislation and national compliance tools. IEA EBC Annex 62 sums up specific overall recommendations, given per topic as overall changes in standards, legislation and compliance tools to be used directly by the target group of this report (i.e. building designers, builders and experts working with building energy performance standards, legislations and compliance tools) for future revisions of these documents.

The sub-purpose is to ensure communication of the missing aspects found in EN standards, ISO standards, national standards, national legislations and national compliance tools regarding ventilative cooling.

To fulfil the main goal of the Annex, the following are the targets for the research and development work:

- To evaluate the status of how well ventilative cooling is integrated in EN standards and ISO standards
- To evaluate the status of how well ventilative cooling is integrated in national standards, national legislation and national compliance tools
- To evaluate if new standards on ventilative cooling should be proposed in Europe (in CEN), based on the initial findings, by evaluating if there was a sufficient lack of content in existing standards regarding ventilative cooling
- To give recommendations for better implementation of ventilative cooling in EN standards and ISO standards
- To give recommendations for better implementation of ventilative cooling in national standards, national legislation and national compliance tools
- To give overall recommendations to be proposed as overall changes in future standards, legislation and compliance tools

1.5. References

[1] www.iea-ebc.org

[2] http://venticool.eu/

[3] www.aivc.org

[4] www.rehva.eu

2. Foreword

This background report presents insights on recommendations into how ventilative cooling is integrated in EN standards, ISO standards, national standards, national legislation and national compliance tools. The information presented derives from feedback by IEA EBC Annex 62 experts of 11 countries (see Table 2) who have completed a questionnaire. This gives a high level of insight into the current status, and thereby the recommendations to be given on the basis of this knowledge. The background report on recommendations is the background for the IEA EBC Annex 62 summary report and should be seen as supplementary material for the State-of-the-Art Review (SOTAR). It is suggested to be used as a continuation of SOTAR and seen as an elaborated version of the SOTAR questionnaire, as seen in Annex D (State-of-the-art-review questionnaire).

Natural ventilative cooling, is difficult to assess in most existing compliance tools. Several building simulation tools are available today, allowing architects or engineers to assess buildings with a high accuracy on energy performance or indoor climate. Some of them are already implementing modules to consider natural ventilation through windows and its effect on thermal summer comfort. Nevertheless, even though some of these tools have reached an elevated level of user-friendliness, they are only occasionally used for building design as the compliance of a project with building regulation also requires the use of calculation tools. Therefore, these so-called “compliance tools” are usually preferred in the design process of a building to secure the performance of buildings and their compatibility with national regulations.

The background report on recommendations is oriented to building designers, builders and experts working with building energy performance standards, legislations and compliance tools. It aims to support them when making future revisions of these documents or tools dealing with passive cooling, where e.g. ventilative cooling is a sustainable choice when aiming to achieve energy neutral buildings (e.g. NZEB), alongside buildings with a good thermal comfort and reduced overheating issues.

A list of editors, authors and reviewers to this report are listed in Table 2, together with their affiliation (research institutes, universities to companies). The final report was edited by the Subtask A IEA EBC Annex 62 participant, Christoffer Plesner, with the help from Flourentzos Flourentzou, Guoqiang Zhang, Hilde Breesch, Per Heiselberg, Michał Pomianowski, Peter Holzer and Maria Kolokotroni.

Research participants worked together collaboratively under the umbrella of the IEA EBC framework to provide the information included in this background report.

Table 2 – Research participants helping with input to this report

Name	**Institute-Affiliation**	**Role in report**
Christoffer Plesner	VELUX A/S, Denmark	Author and editor
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Hilde Breesch	KU Leuven, Belgium	Author and reviewer
Per Heiselberg	Aalborg University, Denmark	Author and reviewer
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Annamaria Belleri	Eurac Research, Italy	Author and reviewer
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Paul D. O' Sullivan	Cork Institute of Technology (CIT), Ireland	Author
Toshihiro Nonaka	Lixil Corporation, Japan	Author

3. Status of ventilative cooling

This section evaluates how ventilative cooling is treated in EN, ISO and national standards, as well as other technical documents e.g. Technical reports. Furthermore, national legislation and national compliance tools are evaluated by seeing to which extent certain ventilative cooling parameters are integrated (e.g. cross ventilation or which calculation time step is used). One of the areas of interest are e.g. how to predict the expected "thermal comfort and cooling requirements", as well as the "energy performance" when using ventilative cooling in buildings. These may be predicted by using the so called “indicators”, which may be based on either Static models (e.g. Fanger PMV model) or Adaptive models (e.g. adaptive comfort model).

A more detailed evaluation of missing parameters in standards, legislation and compliance tools for ventilative cooling, is included in the completed questionnaires of Annex A (missing ventilative cooling aspects in standards), Annex B (missing ventilative cooling aspects in legislation) and Annex C (missing ventilative cooling aspects in compliance tools).

3.1. Status in standards and other technical documents

There are many types of standards (EN standards, ISO and national standards) in relation to ventilative cooling. Furthermore, other technical documents exist such as Technical reports, which are often more descriptive than typical standards (often describing the content of a standard or a topic). Technical reports are chosen to be part of this investigation as for example in the EPB package where there is one Technical report per standard, e.g. CEN/TR 16798-4:2017 (Technical Report) to EN 16798-3:2017 (EN Standard). Some examples of relevant EN and ISO standards are given below. Actually, a Technical Report is two steps below an EN standard in status. Some examples of relevant standards follow and could be split into different types, namely "system design” and “performance standards”. System design standards deal with how to design the ventilation system in regard to ventilative cooling, and performance standards have to do with either the calculations or the requirements. In this report, this division of "system design" vs. "performance" is only used for EN standards to easier distinguish EN standards’ main contents from one another - this division would e.g. not make sense for the status in national legislation.

Figure 1 provides an overview of the new EPBD standards relevant to ventilative cooling [1], and their significant differences in terms of content for example, prEN 16798-1:2017 (though not yet accepted in formal vote) deals with building occupancy and operating conditions e.g. including the adaptive comfort model used by natural ventilation (in buildings without mechanical cooling).

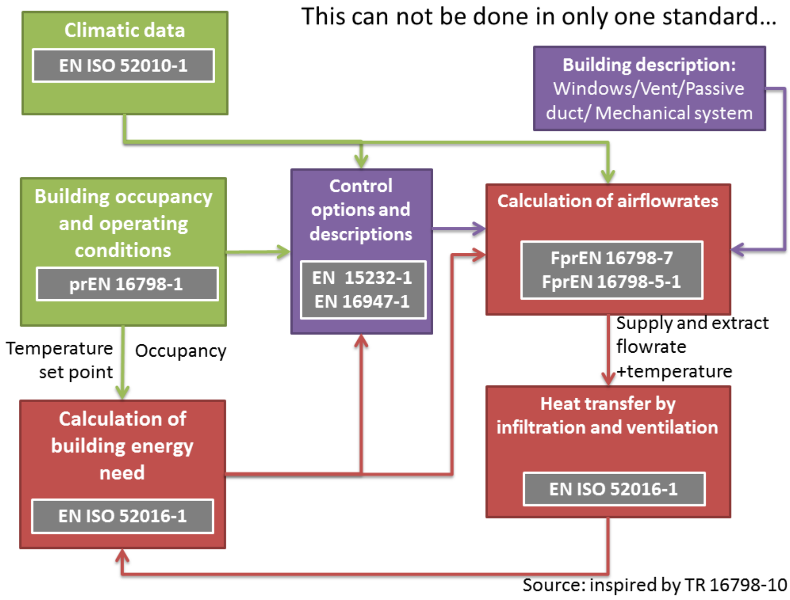

Figure 1 – Overview of new EPBD standards relevant to Ventilative cooling, inspired by CEN/TR 16798-10 (PE draft, 2015)

Within existing CEN standards, relevant to ventilative cooling, and used in energy performance legislations (EN 15242:2007, EN 15241, EN 15251:2007 and EN 13779:2007), there remain some critical limitations for these technologies. For example, how to properly reflect the effective cooling potential of outdoor air which varies within a single day, in seasonal or monthly methods.

The CENSE project includes a very useful site with summations of Energy Performance of Buildings Directive (EPBD) related EN standards [2].

3.1.1. European standards (EN) and other technical documents (status)

In this section, the status of relevant EN standards concerning ventilative cooling is evaluated.

In the previous years, many EN standards relating to the 2010 recast of the Energy Performance of Buildings Directive (EPBD) have been revised. In this background report, some of the important standards for ventilative cooling have been chosen for further elaboration; both new and old versions of the standards have been investigated in order to better understand the changes in the new revised versions. Some of the identified European standards are:

- EN 13779:2007 (EN 16798-3:2017)
- EN 15251:2007 (prEN 16798-1:2017), though not yet accepted in formal vote
- EN 15242:2007 (EN 16798-7:2017)

As briefly explained in the introduction, standards could be split into different types, namely “system design” and “performance” standards. In this report, only EN Standards use this division; “system design” standards deal with how to design the ventilation system, whereas “performance” standards concern calculations and/or requirements e.g. by looking at EPBD standards, among others. As mentioned in the beginning of this section, only EN standards use the division of "system design" vs. "performance" to easier distinguish the main contents from one another. Below is a short overview and examples of the different types.

System design (how to design ventilation systems and what to consider when designing):

- System design standards e.g. CEN/TR 14788:2006 (upcoming revision in 2018), EN 16798-3:2017 (under revision) and CEN/TR 16798-4:2017 (under revision))

Performance (performance aspects, e.g. calculation and requirement standards):

- Performance calculation (e.g. air flow rate calculations, e.g. EN 16798-7:2017 and CEN/TR 16798-10)
- Performance requirements (e.g. thermal comfort requirements, e.g. prEN 16798-1:2017 (in voting)) and EN 15665:2009 (upcoming revision in 2018)

3.1.1.1. System design

As mentioned there are different kinds of EN standards regarding the “system design” of ventilation systems. This section identifies European standards concerning “natural ventilative cooling” and more specifically those concerning the system design "ventilation systems” (there may be others also). Actually, the list that follows includes Technical reports and not EN standards; all documents are actually under revision in CEN or will become under revision in 2018:

- CEN/TR 14788:2006
- CEN/TR 16798-4:2017 (TR to EN 16798-3:2017, which is the revised version of EN 13779:2007)

In respect to European standards, there is a Technical Report called CEN/TR 14788:2006 which covers some of the aspects of natural ventilative cooling by mentioning stack effect and cross ventilation. This Technical Report informs readers on what to be aware of when designing a natural ventilation system. Unfortunately, CEN/TR 14788:2006 is not an EN standard, but “only” a Technical report, which is two steps below an EN standard in status. Actually CEN/TR 14788:2006 together with EN 15665:2009 is under upcoming revision in 2018, so the above information explains only the current content.

EN 16798-3:2017 concerns only mechanical ventilation systems with focus on filtration but has the accompanying Technical Report CEN/TR 16798-4:2017, where some natural ventilative cooling aspects regarding ventilation are mentioned, such as single-sided ventilation, stack effect and cross-ventilation. Actually, both EN 16798-3:2017 and CEN/TR 16798-4:2017 are currently under revision in 2018, so the above information explains only the current content.

Overall there are European Technical reports (TR’s) which to some extend cover some of the “system design” aspects of natural ventilative cooling in a building, such as CEN/TR 16798-4:2017 (TR to EN 16798-3:2017) and CEN/TR 14788:2006, but European EN standards covering this sufficiently are missing. As previously mentioned, standards CEN/TR 14788:2006, EN 16798-3:2017 and CEN/TR 16798-4:2017 are under revision.

Examples for inspiration, on how ventilative cooling may reduce overheating include e.g. the Japanese design guideline for ventilative cooling [3], CIBSE AM 10:2005 (first part of the guide (design) or in section “control of summer overheating”) [4], DS 447:2013 [5] and/or CIBSE TM 52 [6].

3.1.1.2. “Performance” standards

This sub-section looks into EN standards related to the “performance” of the ventilative cooling system, e.g. concerning air flow rates, control of systems and temperature calculations of the building. This has to do with the calculation or requirements to natural ventilative cooling in buildings, with a primary focus on ventilative cooling aspects.

A list of identified European standards (EN) concerning performance of ventilative cooling systems is given below:

- EN 16798-7:2017 (revised version of EN 15242:2007)
- EN 52016-1:2017 (previously EN ISO 13790:2008, EN ISO 13791:2012, EN ISO 13792:2012, EN 15255:2007 and EN 15265:2007)
- prEN 16798-1:2017 (revised version of EN 15251:2007), though not yet accepted in formal vote
- EN 52000-1:2017 (revised version of EN 15603:2008)
- EN 15665:2009 (upcoming revision in 2018)

All aforementioned standards are related to ventilative cooling, but some are more relevant than others. When looking at “natural ventilative cooling”, the coverage from standards depends on the kind of aspects investigated.

When looking at prEN 16798-1:2017 and EN 16798-7:2017 (updated version of EN 15242:2007), it is clear that there is good coverage of natural ventilative cooling. The former includes “adaptive comfort” which is a comfort (operative) temperature that varies depending on the mean outdoor running temperature, and not a fixed temperature range like for mechanical cooling, thus opening up for the use of natural ventilative cooling in buildings without mechanical cooling. The latter is a standard concerning the calculation of air flows in buildings where single-sided natural ventilation can be calculated by using the empirical formula from De Gids & Phaff (1982). Compared to the previous version EN 15242:2007, the new revision EN 16798-7:2017 includes a slightly revised single-sided ventilation formula, as well as cross ventilation which increases the relevance of the calculation of air flows using natural ventilative cooling in a more precise way than previously.

Some considerable work has been performed by Venticool on the “performance” aspect of EPBD standards, investigating and identifying missing aspects in regard to ventilative cooling [1].

Within this scope, EN 15665:2009 is a performance (requirement) standard referring to window opening by manual operation for airing and thermal summer comfort issues. It does not however, adequately cover performance criteria for naturally ventilated systems, and restricts to mere mentions that windows may be used in an informative Annex A. In the standard, three ways are given to calculate the ventilation air flow rates split into level 1, 2 and 3, where levels 2 and 3 calculate air flow rates according to EN 15242:2007.

Furthermore, there is no specific section on “summer comfort”, which is important to ventilative cooling. Actually, EN 15665:2009 is under upcoming revision in 2018, so the above information explains only the current content.

With the revisions of EN 15251:2007 (now prEN 16798-1:2017) and EN 15242:2007 (now EN 16798-7:2017) some aspects of natural ventilative cooling are covered. However, other aspects are still missing or lacking in content in different areas (e.g. as identified by venticool [1]). Some of these missing parameters in the existing standards are:

- Control of systems
- Internal partition of buildings
- Guidance on parameters that shall be defined by user or taken by default

The completed questionnaires in Annex A3: National standards, provide a more detailed evaluation of the missing parameters in EN standards for ventilative cooling.

3.1.2. ISO standards (status)

This section describes the status of relevant ISO standards concerning ventilative cooling.

There are many ISO standards which take into account ventilation, but few ISO standards evaluate the effect of natural ventilation on reducing cooling energy consumption or improving indoor thermal comfort. ISO 13153:2012 shows a framework of a design process for energy-saving in single-family residential buildings and small commercial buildings. The “Energy consumption ratio” is determined in the standard by the location of the building and the method(s) for taking cross ventilation into account. ISO 7730:2005 also describes the effect of air velocity which is relevant to indoor thermal comfort, but this standard is intended for steady-state rooms. Standards ISO 16890 series, specific use of room (ISO 7547, ISO 8304, ISO 8861, ISO 8862, ISO 8864, ISO 9099, ISO 9785, ISO 9943, ISO 11105 for ship and marine technology), the age of air (ISO 16000-8) and thermal insulation (ISO 8144-1, ISO 8144-2), are not directly relevant to ventilative cooling in buildings (although they do include mechanical ventilation). Nonetheless, they support the importance of ventilative cooling in other areas aside from buildings.

For a more detailed evaluation of the ISO standards, refer to the missing parameters of ventilative cooling in Annex A2: ISO standards.

3.1.3. National standards (status)

In this section, the status of relevant national standards concerning ventilative cooling is evaluated and described for different countries. The information presented is based on the filled in questionnaires found in Annex A3: National standards, covering different climates such as e.g. Denmark, Switzerland and Australia, providing a broad overview of how ventilative cooling is implemented in national standards.

Denmark

Overall there are very few Danish national standards concerning ventilative cooling. Actually, only one has been evaluated in this report, called DS 447:2013 which deals with the requirements for ventilation systems in buildings. It includes a very useful overview of requirements as well as information on what to include when designing and dimensioning ventilation systems, such as natural ventilation systems using passive techniques. In DS 447:2013 natural, mechanical and hybrid ventilation systems are defined; demand controlled ventilation and thermal summer comfort (e.g. ventilative cooling) are described.

For more standards, one must look into the EN standards lacking sufficient information on e.g. natural ventilative cooling systems.

For a more detailed evaluation of the Danish national standards, refer to the missing parameters of ventilative cooling in Annex A3.1: Denmark (standards).

Italy

The Italian Organization for standardization (UNI) has transposed the main European standards dealing with ventilation such as EN 12792, EN 15241, EN 15242 and EN 15251. Furthermore, UNI introduced a series of technical standards (UNI TS 11300) which define the energy performance of buildings calculation method. The application of UNI TS 11300 is mandatory for the EP calculation and the national compliance tools have to be certified by the Italian Thermo-technical committee (CTI) for compliance calculation, using this standard.

According to UNI TS 11300-1:2014, for design and standard evaluations, ventilation is considered for calculating:

- The thermal building performance – using the “reference” ventilation rate that considers in any case (even if mechanical systems are considered) natural ventilation (see further)
- The energy building performance – using the “effective” ventilation rate that includes the use of mechanical systems

In the “reference” condition, UNI TS 11300-1:2014 states that in residential buildings (class E.1) a standard air change rate of 0.5 h^{-1} should be considered (0.3 h^{-1} in the former version UNI TS 11300-1:2008). The average monthly ventilation air change rates for other building typologies shall refer to UNI 10339:1995, currently under review, including occupancy sub-zone areas and correction factors. When standard user behaviours are assumed in reference ventilation, ventilation is principally considered for IAQ purposes, hence, the suggested minimal air change rates of 0.5 h^{-1} for residential (point D5.1 UNI EN 12831:2006) and for industrial/artisan buildings are not sufficient for pursuing cooling purposes using ventilative cooling strategies. Similarly, for other building types minimal average monthly airflow rates are suggested to be calculated using UNI 10339 indications for the specific building typology (flowrate for person, for m^2…). Nevertheless, as suggested for the real user case, if a detailed calculation of natural ventilation is required, the Italian technical standard 11300-1:2014 refers to the UNI EN 13779 and UNI EN 15251 for the required airflow rate for IAQ, and to the UNI EN 15242 for a detailed calculation of the ventilation airflow rate. The possibility to include ventilative cooling solutions in further approaches, based for example on dynamic analyses, may overlap this gap.

In the “effective” condition, the ventilation rate is calculated for natural ventilated buildings using the same expression as for the “reference” rate. In the case of mechanical ventilation, the design airflow is considered, eventually multiplied by a contemporaneity factor which depends on vents use and system control (constant or variable airflow). Furthermore, when mechanical ventilation is considered, the “effective” rate also considers the effect of the average additional rate due to wind when the mechanical system is not operating. This value is calculated using tables. In the design phase, for hybrid ventilation, when the mechanical system is turned off, a natural averaged daily airflow rate value is assumed according to a table considering the exposed façade number, the envelope permeability, and protection classes. In this case, the ACH ranges from 0.5 to 1.2 h^{-1} for single residential houses and from 0.5 to 1.0 h^{-1} for other buildings according to the specific combination of variables. In the design phase, night cooling can be considered only if mechanical ventilation is considered, fixing a night ventilation (night is considered between 23:00 to 7:00) for all days of the cooling periods. No natural night ventilation is included in the energy performance calculations, even if a reference to the UNI EN 15232:2012 is included. Finally, it can be possible to consider mechanical ventilation combined with the cooling systems.

For a more detailed evaluation of the Italian national standards, refer to the missing parameters of ventilative cooling in Annex A3.2: Italy (standards).

United Kingdom

There is a British Standard on designing for natural ventilation BS 5925:1991 which includes good guidance for the calculation of natural ventilation air flow rates. Relevant EN standards are referred to within the Building Regulation Part F (Ventilation).

For a more detailed evaluation of the United Kingdom’s national standards, refer to the missing parameters of ventilative cooling in Annex A3.5: United Kingdom (standards).

Austria

As regards the energy demand calculation, there’s a set of standards defining the obligatory routines for calculating the annual energy demand for heating, cooling and lightning. These standards are ÖNORM B 8110-5 and -6, ÖNORM H 5055, 5056, 5057, 5058 and 5059. All together they are Austria’s answer to the EPBD requirements and Austria’s interpretation of EN ISO 13790.

The algorithms are precisely implemented in commercial software tools which are used as compliance tools.

For thermal summer comfort of rooms without technical cooling, compliance calculation is defined in ÖNORM B 8110-3. Its algorithms are closely linked to ISO 13791 and ISO 13792. What’s under discussion is the standard’s method of infinite repeated cooling design day as outdoor climate prerequisite. It gives comparable results, but it cuts off the beneficial effects of thermal mass and night ventilation in the beginning of heatwaves.

In ÖNORM 8110-3, night ventilation may be taken into account on an hourly basis, with ACH calculated from opening areas, temperature difference and stack effect. Wind effect may not be taken into account.

In ÖNORM B 8110-6, Ventilative Cooling may only be taken into account with the fixed value of 1,5 h^{-1}, with no sensitivity to design.

For a more detailed evaluation of the Austrian national standards, refer to the missing parameters of ventilative cooling in Annex A3.7: Austria (standards).

Belgium

There are no standards that guide the designers and promote the use of ventilative cooling. The standards NBN D50-001 for residential buildings and NBN EN 13779 for non-residential buildings define the required minimum fresh airflow rate in order to achieve good IAQ levels.

The Belgian organization for standardization has transposed the main European standards dealing with ventilation such as NBN EN 15241, NBN EN 15242 and NBN EN 15251.

For a more detailed evaluation of the Belgian national standards, refer to the missing parameters of ventilative cooling in Annex A3.8: Belgium (standards).

Switzerland

Swiss national standards offer a sufficient framework for thermal summer protection and thermal comfort taking into account solar protection, thermal mass and energy strategy.

For a more detailed evaluation of the national standards, refer to the missing parameters of ventilative cooling in Annex A3.3: Switzerland (standards).

Portugal

There is no Portuguese standard that guides the designers and promotes the use of the ventilative cooling systems. The existing buildings' standard only defines the required minimum fresh airflow rate calculation method (in order to achieve good IAQ levels) and sets the occupants thermal comfort limits.

Australia

Australian Standards 1668.2 and 1668.4 namely "The use of ventilation and air-conditioning in buildings. Part 2: Mechanical ventilation in buildings and Part 4: Natural ventilation of building" cover the requirements for mechanical and natural ventilation in occupied spaces. The objective of these two standards is to define the minimum ventilation rates per person or minimum window openings required for natural ventilation. They do not specifically address the design of ventilative cooling systems, nor the effect of using ventilation for cooling purposes. Only 1668.2 suggests that when a mechanical HVAC system is in place an economizer damper should be installed.

For a more detailed evaluation of the national standards, refer to the missing parameters of ventilative cooling in Annex A3.4: Australia (standards).

Japan

The Japanese national standard, “Energy saving standard for residential buildings, 2015” takes into account the effect of cross ventilation as a method for reducing the cooling energy consumption. The level of air-change rate (“none”, “5 ACH and more”, and “20 ACH and more”) is determined by the location of the building and the position arrangement of openings (windows and internal doors). The effect of natural ventilation has not yet been evaluated in the energy saving standard for non-residential buildings.

Norway

Overall there are very few Norwegian national standards concerning ventilative cooling. There is no standard that guides the designers and promotes the use of the ventilative cooling systems. The existing buildings standard defines the required minimum fresh airflow rate calculation method (in order to achieve good IAQ levels) and sets the occupants thermal comfort limits.

Norway has a standard that contains the description for calculations subject to legislation regarding energy demand for heating and cooling. The algorithms are implemented in software tools that are used as compliance tools.

The Norwegian Organization for standardization has transposed main European standards dealing with ventilation such as NS-EN 15241:2007, NS-EN 15242:2007 and NS-EN 15251:2007.

For a more detailed evaluation of the national standards, refer to the missing parameters of ventilative cooling in Annex A3.6: Norway (standards).

China

Relevant existing Chinese standards suggest the techniques for natural ventilation and ventilative cooling, but include no specifications for application.

There are 10 different national level standards which have clauses about Natural Ventilation. Most of these aim at Indoor Air Quality and only a few at ventilative cooling aspects. The following are clauses in the English translated, Chinese standards.

- GB 50736-2012: “Design code for heating ventilation and air conditioning of civil buildings”, gives some suggestions on the natural ventilation design of civil buildings
- GB/T 18883-2002: “Indoor air quality standard”, stipulates the ventilation efficiency of different types of buildings
- GB 50189-2015: “Design standard for energy efficiency of public buildings”, suggests making full use of natural ventilation, but includes no specific requirements
- GB 50368-2005: “Residential building code”, stipulates the opening area of the room with natural ventilation
- GB/T 50378-2006: “Assessment standard for green building”, recommends the opening area of green buildings with natural ventilation in different climate zones

For some of the important standards (mainly energy conservation and green building standards), there are provincial level standards of higher status than the national level ones. Some of these provincial level standards are:

Hunan province:

- DBJ 43/003-2010: “Design Standard for Energy Efficiency of Public Buildings in Hunan Province”, gives detailed energy saving principles for natural ventilation in public buildings
- DBCJ 002-2010: “Assessment standard for green building in Changsha”, presents higher requirements for natural ventilation of green buildings, such as requiring no less than 75% of the space to perform natural ventilation

Chongqing province:

- DBJ 50-071-2016: “Design standards on residential building energy saving 65% in Chongqing (green buildings)”, puts forward higher requirements for natural ventilation design, such as natural ventilation opening area ratio up to 8%, compared to the value of 5% included in the national standard
- BDJ 50-052-2013: “Design standards on public building energy saving in Chongqing” (green buildings), details the design points of natural ventilation of public buildings during transition season

The natural ventilation standards under development will include the specification to be used to in practical design.

3.2. Status in legislation

This section looks at the overall status and overview of legislation concerning ventilative cooling. Legislations could be divided into national and regional legislations. The type of legislation differs from country to country, as not all countries have regional legislations. Furthermore, the way ventilative cooling is treated in legislation is evaluated by looking into what extent certain ventilative cooling parameters are integrated nationally (e.g. cross ventilation or which calculation time step is used).

Legislation varies between countries. The current section aims to give an insight into how well ventilative cooling is “implemented”. The “recommendations” section highlights the “actions” that need to be taken in order to improve the overall relevance of ventilative cooling in national legislation e.g. by allowing higher air change rates during summer.

The authors of a BUILD UP article published in 2013 state that: *“Several countries - e.g. Austria, Denmark and France - have taken steps to integrate ventilative cooling into their building legislations, which is a positive development”* [7].

Below is an excerpt from an article containing an overview of provisions for ventilative cooling, based on answers from a questionnaire prepared jointly by venticool, the international platform for ventilative cooling and IEA-EBC Annex 62 [8]. Table 3 shows which countries have a thermal comfort criteria and if there are penalties on the calculation of energy use depending on the degree of overheating (overheating risk). This is one of many relevant aspects concerning ventilative cooling.

The table shows that e.g. only Italy doesn't have a criterion for thermal comfort or a penalty on the calculated energy use. Belgium, Denmark, and Finland use both criteria, while the rest only have thermal comfort criteria. Based on these findings there is work to be done nationally to better regard ventilative cooling for the penalty on the calculated energy use [8]; overheating criteria could also be used for this purpose.

Table 3 - Thermal comfort and overheating risk

Country	Are there a thermal comfort criteria for summer in the EP regulation?	Is there a penalty on the calculated energy use depending on the overheating risk?
Belgium (Flanders)	Yes already	Yes
Denmark	Yes in the future	Yes
Finland	Yes already	Yes
France	Yes already	No
Greece	Yes already	No
Ireland	Yes already	No
Italy	No	No
UK	Yes already	No

"*The responses to the survey confirm that energy performance legislations usually consider ventilative cooling in a rather simplified manner (when considered)"*. Furthermore, the conclusion of this previous study is that ***"****these methods do not seem to have been carefully evaluated. Further evaluation and research is needed to address the complexities of ventilative cooling in Energy performance legislations in a pragmatic way****"*** [8].

The status of relevant national legislation concerning ventilative cooling follows, based on results from previously published reports (e.g. looking at the national building codes through questionnaires).

"The state-of-the-art review has revealed that in many national building codes and energy performance regulations ventilative cooling is not explicitly referred to as a cooling option for achieving energy performance. Therefore, the treatment of ventilation (air flow rate) requirements for ventilative cooling and its effect on cooling demand reduction are not clear" [9].

"By 2020 many countries will impose the nearly or net zero energy requirement. Building airtightness will implicitly become a mandatory point of attention, as well as energy efficient ventilation systems will become mandatory. The use of natural ventilation to improve thermal comfort and/or reducing cooling need (ventilative cooling) and to assure indoor air quality will significantly increase. Existing CEN standards consider natural ventilation mainly as a measure to assure indoor air quality and not as a passive cooling strategy" [10].

Regarding legislation, a broad field of methods for ventilative cooling seem to be integrated, ranging from simple to detailed. For quite a few countries, among the reviewed ones, there is a lack of ventilative cooling integration in legislation and compliance tools e.g. in the United Kingdom, Italy and Japan. Generally, the calculation of air flow rates in buildings is not sufficiently reflecting the real conditions, being either the actual building design, physics or geometry, and thus undermining the full potential of ventilative cooling.

For a more detailed evaluation of missing parameters in legislation for ventilative cooling, see the filled in questionnaires in Annex B (missing ventilative cooling aspects in legislation).

Denmark

Since 2015, the Danish Building Institute – SBi, has implemented an additional feature to the official compliance tool to evaluate thermal comfort. This module is called "Summer comfort" and is used to document the thermal comfort in summer in residential buildings through hourly calculations (described as total number of hours above 27°C and 28°C). For many years the same compliance tool primarily served as documentation of energy performance which is still based on monthly calculations.

Ventilative cooling is not explicitly addressed in Danish Building Regulations. Minimum required ventilation air flow rates are defined for hygienic purposes (indoor air quality) and not thermal comfort. Thermal indoor comfort criteria with respect to the number of overheating hours are specifically addressed for residential buildings and are less specific for other building types. However, the way to achieve these criteria is not specified, although for residential buildings it is stated that if the building has openable windows that allow airing of the space then it should be possible to obtain these criteria. Yet, the ways to use the windows, night cooling possibilities, window control and automation are not mentioned.

Other statements found in Danish Building Regulations that could refer to ventilative cooling are:

- Air flow rates should be reduced when the need for ventilation is reduced
- In rooms with strongly variable loads it should be possible to adjust air flow rates to the needs
- Air recirculation is **not considered** as an alternative to heat recovery
- Building Regulation for ventilation systems specifically refer to DS 447 - "Ventilation in buildings – mechanical, natural and hybrid ventilation". This means that both natural and mechanical ventilation systems are considered as ventilation possibilities
- The Danish Building Regulation specifically defines indoor thermal comfort criteria for residential buildings and is less specific for other buildings. For residential buildings, Danish legislation permits a simplified calculation method to document that criteria are held. This method is not explicitly referred in the Building Regulation text but in fact it is the add-on module that was recently incorporated into the Danish compliance tool, namely "Summer Comfort" calculation. Calculation should be performed for the critical room with the highest risk of overheating. Moreover, calculation is hourly and is based on a simplified energy balance method that takes into account solar heat gains through the windows located in the critical room. Solar heat gains are taken into account for window area, window orientation, properties for solar gains and are specific for the calculated building. **Other loads are not included**. Design air flows are specified by the designer as fixed air change rates separately for winter and for summer with a distinction made between day and night for the summer case. In the case of naturally ventilated buildings, air flow calculation is estimated taking into account the ratio between effective window area and floor area. If the building is mechanically ventilated then maximum designed air flow rates should be applied both for day and night operation. **The calculation algorithm behind the method is not explained**. Outcome is provided as number of hours above 27°C and 28°C. **In practice, this calculation would often be the only one that documents indoor thermal comfort in new residential buildings**

- The thermal comfort calculation method for other than residential buildings requires the use of a dynamic tool which takes into account Danish Design Reference Year weather data sets. **Other criteria, such as validation agreement, are not stated**

For a more detailed evaluation of the national legislation, refer to the missing parameters of ventilative cooling in Annex B2: Denmark (legislation).

Italy

No Italian legislation explicitly tackles ventilative cooling e.g. by not having ventilation requirements nor recommending calculation methods for airflow or air velocity due to single sided ventilation, cross ventilation, stack ventilation, night cooling, ceiling fans, economiser, free cooling or hybrid systems. Some recommendations to limit the energy need for summer cooling and to prevent overheating are included in the **Presidential Decree 59/2009** which states that in case of new buildings and major renovations, the designer: evaluates and documents the efficacy of shading systems for glazed surfaces, either external or internal, so as to effectively reduce the solar heat gains; ensures enough thermal mass (>230 kg/m²) or periodic thermal transmittance (- a dynamic parameter introduced with the Standard UNI EN ISO 13786:2008, should be U < 0.12 W/m²K for external walls oriented SE/SW and U < 0.20 W/m²K for external walls oriented NE/NW); and **uses in the best way the external climate conditions and the internal space distribution in order to favour the natural ventilation of the building- in case this ventilation is not effective, the designer can use mechanical ventilation solutions**. The positive effects obtained by respecting the thresholds for the mass of the external walls and periodic thermal transmittance can be reached, as an alternative, by means of other techniques and materials (e.g. green roofs) which allow to contain the indoor temperature oscillations as a function of the solar irradiation.

However, calculation methods for the energy performance of buildings refer to the national standards mentioned in par. 3.1.3 and ventilative cooling performance cannot be evaluated using those calculation methods.

The current national regulation (Presidential Decree 74/2013) fixes the upper air temperature threshold for the heating period and the lower air temperature threshold for the cooling period. Specifically:

- During the heating period, the weighted mean of the air temperatures measured in the heated zones of each property cannot exceed 18°C + 2°C for buildings used for industry and manufacturing and 20°C + 2°C for all other buildings (residential, tertiary sector and others)
- During the cooling period, the weighted mean of the air temperatures measured in the heated zones of each property cannot be less than 26°C - 2°C for all buildings.

No upper air temperature threshold for the cooling period is fixed. Furthermore, the Italian national regulation does not address adaptive-model logics, nor the exploitation of devices to increase the indoor air velocity during the cooling season.

United Kingdom

In the UK, Ventilative cooling is partly included in the national regulations Part L (Conservation of Fuel and Power) and Part F (Ventilation). In the current building regulations, ventilation focusses on IAQ (including the provision for purge ventilation). Ventilative cooling could be included in the National Calculation Method for buildings other than dwellings; this could be part of the ‘Target CO_2 Emission Rate’ (TER).

Guidelines exist which can facilitate ventilative cooling such as CIBSE AM 10 (natural ventilation) for non-residential buildings [4], CIBSE TM 52: The limits of thermal comfort and TM 59 Design methodology for the assessment of overheating risk in homes. CIBSE AM 10 & TM 52 are less relevant to residential buildings, but CIBSE TM 59 can be used, although not referred to in Part F of the national regulation.

In the national legislation, cooling and ventilation are addressed in different parts of the regulation. Therefore, although ventilative cooling is usually considered as part of the ‘Target CO_2 Emission Rate’ calculation, there are no details on the calculation of air flow rates for natural ventilation within the regulation. However, standards and guidelines (thermal comfort, natural ventilation, overheating) exist which provide the calculations’ process.

For a more detailed evaluation of the national legislation, refer to the missing parameters of ventilative cooling in Annex B3: United Kingdom (legislation).

Austria

In Austria, there’s a set of guidelines which define the thresholds regarding energy demand for heating, cooling and lightning as well as thermal summer comfort. These guidelines are developed by the OIB (Österreichiches Institut für Bautechnik). Guideline Nr. 6 – reduction of energy-demand & heat insulation is relevant to Ventilative Cooling. The guidelines refer to the set of national standards, which define the calculation algorithms.

As regards legislation towards the energy demand for heating, there’s no correlation to Ventilative Cooling. As regards the energy demand for cooling, night ventilation may be implemented up to a ventilation rate of 1,5 h^{-1} and has an effect on lowering the cooling demand.

Furthermore, there’s a national code, the “Arbeitsstättenverordnung” which is mandatory for all permanent workplaces. It defines no calculation method but sets out thresholds for IEQ-parameters such as air temperature, air velocity, humidity, access to ventilation and daylight. These are defined in quite narrow bands, closely following ISO 7730 or even tighter. It is only through a broader interpretation that designers can push the limits.

For a more detailed evaluation of the national legislation, refer to the missing parameters of ventilative cooling in Annex B4: Austria (legislation).

Belgium

Ventilative cooling is not explicitly addressed in the Energy Order of the Government of Flanders. Minimum required ventilation air flow rates are defined for hygienic purposes (indoor air quality) and not thermal comfort.

There is a requirement for overheating risk in residential buildings. The compliance tool calculates an overheating indicator. The opening of windows is included in this calculation as extra ventilation heat losses.

The airflow rate depends on the potential for ventilative cooling (ranked from “No potential” to “Maximum potential”). This potential is based on a very simplified flowchart (see section 5.4).

For a more detailed evaluation of the national legislation, refer to the missing parameters of ventilative cooling in Annex B8: Belgium, Flanders region (legislation).

Switzerland

Legislation asks compliance with SIA 180 for thermal protection in the summer and fixes strict minimum requirements for air conditioning energy performance. In some regions air conditioning is allowed only in exceptional cases where particular conditions are fulfilled (process generating internal gains).

Legislation provides a sufficient framework to consider ventilative cooling by referring to SIA 180 for thermal protection and by taking into account the resulting air conditioning energy consumption for the energy label.

For a more detailed evaluation of the national legislation, refer to the missing parameters of ventilative cooling in Annex B5: Switzerland (legislation).

Portugal

There is no Portuguese legislation that promotes the use of the ventilative cooling systems. The existing building standard only defines the required minimum fresh airflow rate calculation method (in order to achieve good IAQ levels) and sets the occupants thermal comfort limits.

Australia

The Australian Construction Code refers to the standards 1668.2 and 1668.4 for ventilation. To meet the energy efficiency requirements, a building designer has two options; either to follow the “Deemed to Satisfy” construction requirement which does not consider the effect of ventilative cooling directly or, utilize a simulation software to benchmark the proposed building energy performance in comparison to a reference building simulated with the “Deemed to Satisfy” construction requirement. This process allows engineers and building designers to propose innovative solutions that could help reducing the overall building consumption in a different way compared to the “Deemed to Satisfy” requirements, achieving at least the same or better predicted annual energy consumption results. In the case of residential buildings, a certified rating simulation software needs to be utilized. The only relatively simple-to-use tool is BASIX (though only used in New South Wales for residential buildings), which is a multiple choice tool allowing the inputs of window areas, orientation, shading, etc. This tool only performs simple steady-state calculations, approximating gains and losses and seems to consider the effect of natural ventilative cooling on energy consumption. The software performs a full dynamic simulation of the building, taking into account wind and buoyancy effects when calculating infiltration and ventilation rates through openings, with generally optimistic assumptions on how the openings are operated. The effects of utilizing ventilative cooling are therefore considered in the total annual thermal energy demand of the building.

In the case of commercial buildings, the choice of an appropriate calculation method and any calculations performed, are the designer’s responsibility. Therefore, the choice of software must be made on the basis of the appropriateness of the calculations performed. Nevertheless, the software platform has to be accredited by the Australian Building Codes Board.

For a more detailed evaluation of the national legislation, refer to the missing parameters of ventilative cooling in Annex B6: Australia (legislation).

Japan

Japan does not have any legislation concerning ventilative cooling, but it will be an obligation to take into account the energy saving standard for residential buildings by the year 2020. The “Energy saving standard for residential buildings, 2015” takes into account the effect of cross ventilation.

Norway

The Norwegian legislation is general and states that *“the thermal indoor climate in rooms for permanent stays shall be arranged based on the consideration of health and satisfactory comfort in the intended use”*. Furthermore, the legislation includes some recommendations to limit the energy need for summer cooling and to prevent overheating which are listed below.

Passive measures that can help avoid overheating are e.g.:

- Reduced window area in sun-loaded facades
- Exposed thermal mass
- Exterior sun shielding
- Openable windows that allow for airing
- Placement of air intake or design of ventilation systems so that the temperature rise in the ventilation system due to high outdoor temperature will be minimal (<2°C)

In homes, users have the opportunity to adapt to high indoor temperatures, for example, by wearing light clothing and by airing the living zone. For residential buildings, the requirement for thermal indoor climate will usually be met if at least two of the above passive measures have been fulfilled. The prescription can be documented using different methods. The pre-assigned benefits shown below indicate one way, but there are national and international standards that are able to prove that the provision is met. These can open for an alternative approach, such as the use of an adaptive model for thermal comfort in homes. In the case of openable windows that allow for airing, there are no further requirements for the windows or their operation.

(The list of pre-accepted solutions is omitted here.) If these are implemented, the solution is said to fulfil the requirements in the legislation.

It is allowed to use mechanical cooling as long as the total maximum allowed energy consumption is not exceeded. Openable windows are in general mandatory, but there is no requirement that these should be a part of a well-designed natural ventilation solution.

For a more detailed evaluation of the national legislation, refer to the missing parameters of ventilative cooling in Annex B7: Norway (legislation).

China

National legislation may have different definitions in China compared to the EU countries.

There are 4 types of legislation documents, and their related clauses are:

Type 1:

- “Law of Energy Conservation”, signed by the Chairman of the country, emphasizes on building energy conservation but includes no special requirement for natural ventilation.
- “Law of Renewable Energy”, signed by the Chairman of the country, suggests that rural areas should make full use of natural wind and other renewable energy.

Type 2:

- Regulations of Energy Conservation in Non-Industrial Buildings signed by the Prime Minister - “Regulations on Energy Conservation for Civil Buildings” and “Regulations on Energy Conservation for Public Institutions” - both suggest that natural ventilation should be proritized in building ventilation.

Type 3:

- Policies issued by Ministries such as the Ministry of Construction promote green buildings. “Action Scheme of Green building”, considers natural ventilation as the key point to energy-saving retrofit and technology for green building.

Type 4:

- Regulations of Energy Conservation in non-industry buildings signed by governors of provinces - “Regulations on Energy Conservation for Civil Buildings in Hunan Province” and “Regulations on Energy Conservation for Civil Buildings in Chongqing”- both encourage that natural ventilation should be given priority in the construction and retrofit of civil buildings.

3.3. Status in compliance tools

This section looks into the overall status and overview of compliance tools concerning ventilative cooling. The degree of complexity among national compliance tools can vary a lot and it’s sometimes difficult to distinguish between national regulation and national compliance tools. The way ventilative cooling is considered in compliance tools is assessed by checking to what extent certain ventilative cooling parameters are integrated nationally (e.g. cross ventilation or which calculation time step is used). The national compliance tools for ventilative cooling are evaluated based on the findings from the filled in questionnaires found in Annex C (missing ventilative cooling aspects in compliance tools).

As regards compliance tools, a broad field of methods for ventilative cooling appears to be integrated, ranging from simple to detailed. Actually, for quite a few countries there was a lack of ventilative cooling integration e.g. in the United Kingdom, Italy and Japan. For example, in Italy, upper limits on indoor temperature (i.e. according to the adaptive thermal comfort model) and thermal comfort/overheating indicators are not included in the energy performance evaluation; this could be improved. Switzerland's, Norway's and Austria's legislation appear to better integrate ventilative cooling through hourly time step calculations which better support the adaptive comfort model, instead of the less precise, monthly calculations.

Denmark

Since 2015, the Danish Building Institute – SBi, has implemented an additional feature to the official compliance tool to evaluate thermal comfort. This module is called "Summer comfort" and is used to document the thermal comfort in summer in residential buildings through hourly calculations (described as total number of hours above 27°C and 28°C). For many years the same compliance tool primarily served as documentation of energy performance which is still based on monthly calculations. There are only some features of ventilative cooling considered in this add-on module, but it still allows the promotion of cross-ventilation, number of openable windows and geometrical free area of windows.

In the Danish compliance tool, ventilation air flow rates are defined as constant air flow rates. However, it can be specified if air flow is from a mechanical or natural ventilation system. Moreover, the air flow can be modified from summer to winter season and between day and night. Therefore, although air flow is given as a constant value, the tool is to some extent able to capture the dynamic character of ventilation performance. Selection between single sided and cross ventilation strategy is not possible directly through the software interface, but recommended air flow rates take into account these strategies recommending higher air flows for cross ventilation than single sided ventilation. Also, simple relations between air flow and openable window area are included in the help file of the tool (not in the interface). This is on the right track, even though air flow rates should reflect the real conditions to a higher degree, based on actual building physics and geometry and allowing for more flexibility e.g. higher air change rates allowed in unoccupied rooms during night time and lower if the rooms are occupied.

The Danish compliance tool performs 12 (steady-state) monthly calculations. This simplification is the primary reason why the compliance tool is not able to capture the dynamic character of ventilative cooling performance with adequate resolution.

Although the Danish national compliance tool reflects some flexibility to describe ventilative cooling, there is still place for improvement.

For a more detailed evaluation of the national compliance tools, refer to the missing parameters of ventilative cooling in Annex C1: Denmark (compliance tool).

Italy

In Italy, energy policies are regulated in two levels. The central government drafts the general framework and defines national guidelines by means of a Legislative Decree. Regions and autonomous provinces can define the principles of national standards and tailor it to their individual requirements. The requirements at regional level shall accomplish the national guidelines but could also adopt more stringent requirements.

The Italian government delayed the implementation of 2002/91 EPBD until 2005. Some regions took advantage of this legislation gap and developed their own procedures regarding the energy performance of buildings. Other regions have not implemented any certification scheme and decided to wait for the national guidelines. Therefore, the national panorama is quite fragmented [11].

For the provinces and regions which follow national guidelines, energy performance calculations can be performed by commercial software validated [12] by the Comitato Termotecnico Italiano (CTI), the technical Italian committee in charge of technical standards for the HVAC sector.

A simplified reference calculation tool, DOCET [13], was developed by ENEA (the Italian National Agency for New Technologies, Energy and the Sustainable Economic Development) together with ITC-CNR (Construction Technologies Institute- the Italian National Research Council) as a reference energy performance calculation method for residential buildings. DOCET has been recently updated according to the UNI/TS 11300 standards and it is based on a simplified monthly method.

The autonomous Province of Bolzano is part of those regions that took advantage of the legislation gap by developing its own procedure. Energy performance certificates have been mandatory since 2002. Despite its pioneering role at national level, the province of Bolzano has now aligned its legislation to the European guidelines. The ClimateHouse Agency is the competent public body for the energy performance of buildings. The ClimateHouse Agency developed an excel-based software, named ProCasaClima, to calculate the key performance indicators needed by the certification protocol, which is mandatory in South Tyrol but can be required also in other Italian regions. Since 2010, the certification protocol requires to verify air tightness by performing a Blower Door Test.

In ProCasaClima, mechanical ventilation can be activated only in winter or both summer and winter, with and without bypass. The user can set the airflow rate, the number of working hours per day, the heat recovery efficiencies in summer and winter and the ventilated volume. The ventilated volume can differ in summer and winter period depending on the mechanical ventilation settings. Natural ventilation is set by default as 0.30 1/hr for the building volume not ventilated through mechanical ventilation. Users cannot modify this data. The ProCasaClima tool has large room for improvement regarding ventilative cooling. Airflows are set as default constant values for natural ventilation. Mechanical free cooling is taken into account but no indicators are available on its effectiveness. Furthermore, it is not possible to set variable airflow rates or time schedules. Ventilation is therefore principally considered for IAQ purposes, hence, the suggested ACH of 0.3 1/hr is not sufficient for pursuing cooling purposes using ventilative cooling strategies.

A new version of the software ProCasaClima [14] is currently under development and the new software will include, among others, a natural ventilation design module and thermal comfort evaluation, going beyond the above stated limitations.

For a more detailed evaluation of the national compliance tools, refer to the missing parameters of ventilative cooling in Annex C6: Italy (compliance tool).

United Kingdom

Ventilative cooling for Residential Buildings is not specifically included in the SAP (Standard Assessment Procedure) although recent guidelines exist focusing on avoiding overheating in houses. SAP focuses on heat losses through the building envelope, airtightness, efficient heating systems and appliances and renewables. Ventilative cooling is better integrated for non-residential buildings because the National Calculation Method (NCM) allows the use of advanced thermal simulation models (steady-state and dynamic) which by default include features to calculate ventilative cooling.

Compliance tools for non-residential buildings calculate ventilative cooling.

For a more detailed evaluation of the national compliance tools, refer to the missing parameters of ventilative cooling in Annex C2: United Kingdom (compliance tool).

Austria

Ventilative Cooling may be taken into account in energy demand regulations for non-residential buildings due to night ventilation with the restricted air change rate of 1,5 h^{-1}. Ventilative Cooling is not taken into account in heating demand regulations for residential buildings. Cooling demand must not exist in Austrian residential homes. In this case, cooling demand calculations are replaced by thermal summer comfort calculations on an hourly basis, thus making Ventilative cooling a relevant factor.

For a more detailed evaluation of the national compliance tool, refer to the missing parameters of ventilative cooling in Annex C7: Austria (compliance tool).

Belgium

Ventilative cooling may be taken into account in the regional compliance tool in Flanders for office and school buildings. It is included in the calculation of the net cooling demand as an additional ventilation heat loss. Both natural and mechanical ventilation by day and night can be selected.

For residential buildings, the airflow caused by the opening of windows is taken into account in the monthly calculation of the overheating indicator. This causes an extra air change rate between 0,15 and 1,10 h^{-1}, depending on the potential for ventilative cooling.

For a more detailed evaluation of the national compliance tools, refer to the missing parameters of ventilative cooling in Annex C5: Belgium (compliance tool).

Switzerland

No status given.

For a more detailed evaluation of the national compliance tools, refer to the missing parameters of ventilative cooling in Annex C3: Switzerland (compliance tool).

Portugal

There is no Portuguese compliance tool that promotes the use of ventilative cooling systems.

Australia

The tools utilized at national level are generally quite flexible building dynamic simulation software and can take into account the effects of ventilative cooling into their calculations. The utilization of these tools to meet the building energy efficiency requirements is voluntary. Some assumptions in the operation of natural ventilation systems in residential buildings (windows are considered to be operable 24/7 and the logic of window opening is not modifiable, always opening windows when outdoor conditions are favourable) can be improved to better estimate the energy benefits of ventilative cooling equipment.

For a more detailed evaluation of the national compliance tools, refer to the missing parameters of ventilative cooling in Annex C4: Australia (compliance tool).

Japan

An online calculation compliance tool exists in Japan estimating the primary energy consumption in detached or apartment houses (Figure 2) [15]. This programme is based on the energy saving standard for residential buildings. The programme for non-residential buildings exists as well, but the effect of natural ventilation on (reducing) cooling demand has not been included so far.

The effect of natural ventilation can be evaluated by inputting the air-change rate of the house in the “envelope” tab as seen in Figure 3. The designer chooses the air-change rate of the habitable rooms from “none”, “5 ACH and more” or “20 ACH and more”. The higher the selected air-change rate, the lower the cooling demand.

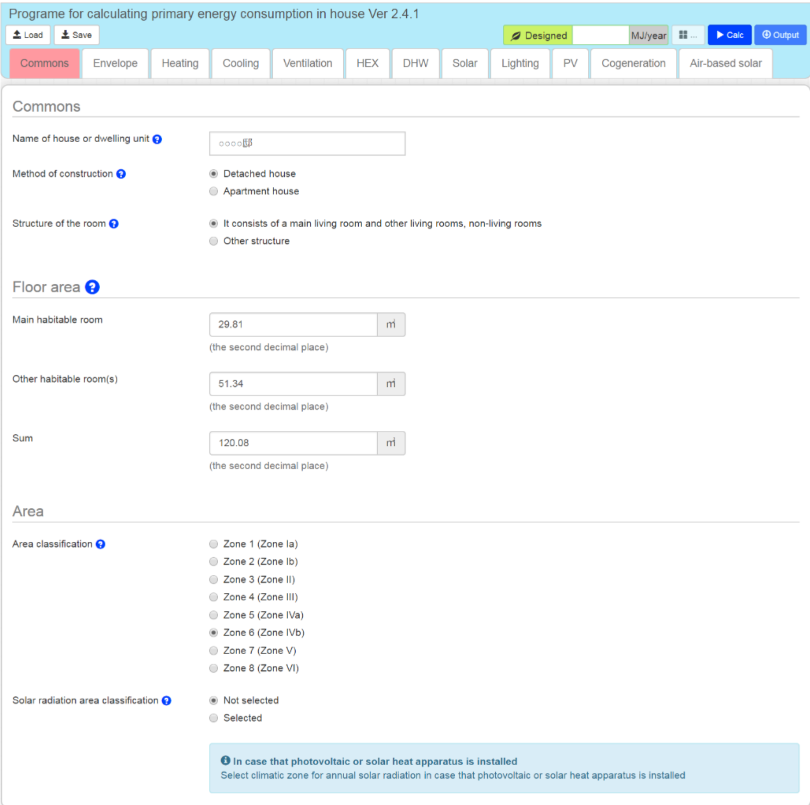

Figure 2 - Online calculation programme for houses

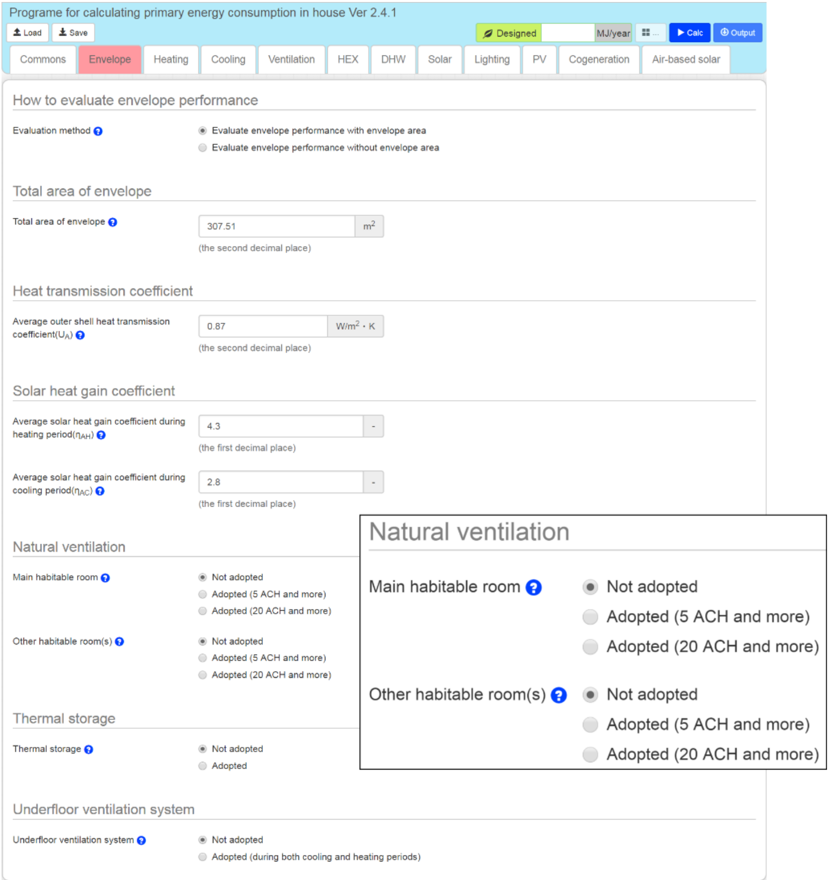

Figure 3 - Input screen of air-change rate

There are three ways to estimate the air-change rate. Cross ventilation is only available as natural ventilation:

1. By using tables
   a. The requirements of opening-to-floor area ratio for windows and internal doors are listed in tables
2. By using discriminant
   a. The value which is calculated from the discriminant should be equal to or less than a threshold value
3. By calculating the air flow rate

Norway

SIMIEN is the tool that is commonly used for compliance checks in Norway. However, SIMIEN is a simulation tool for indoor climate and energy use in buildings. It calculates energy consumption, power requirements and thermal comfort. It also includes modules for the evaluation against building regulations (TEK10/17) (works as a compliance control), the energy labelling of buildings and the evaluation against low energy-/passive house criteria. It is a dynamic tool using hourly calculations and one node for each zone. The compliance check is easy to perform if the buildings are already modelled, otherwise it is more complex.

Moreover, a programme called TEK-sjekk Energi (TEK Check Energy) exists which makes a compliance check: The building is checked against regulations: The building's heat loss budget, net energy demand and delivered energy are calculated according to NS 3031. The results of the calculation of energy requirements and key inputs are reported in accordance with NS 3031.

Indoor air quality:

- Thermal indoor climate and daylight conditions hour-by-hour for current local climate

Standard for passive houses and low energy buildings:

- Control against the criteria in NS 3700 (residential buildings)/NS 3701 (occupational buildings)

Energy label:

- The results are stored in an XML file that is uploaded to [16].

Other applications:

- The BIM applications DDS CAD, Autodesk Revit ([16] and [17]) and ArchiCAD offer their own export features that can be used in TEK Check Energy
- In addition, it is possible to import building geometry into the following DAK / BIM file formats: SketchUp COLLADA (.dae), Green Building gbXML (.xml) and IFC text files (.ifc)

China

In China, it is unclear how the calculation of Natural Ventilation is included in the design process. It seems that only some window opening areas and related Air Change Rates are defined in the standards.

DeST is a software platform for building environments and HVAC systems simulation developed by the Department of Building Science and Technology of Tsinghua University, China. DeST is not a software that is especially used for natural ventilation calculation. In China, it’s mainly used for building and system simulation and it’s similar to the energy consumption simulation software EnergyPlus. However, Ventplus, a natural ventilation simulation module integrated in DeST, could simulate natural ventilation.

Simulation software, Ventplus:

- Calculates the natural ventilation air flow rate
- Evaluates the influence caused by natural ventilation on building loads

The core algorithm used for the calculation of natural ventilation is a multi-regional network model, which is combined with the corresponding resistance models (such as the orifice model, the large opening model and the staircase channel model etc.) to calculate natural ventilation air flow rates. When calculating natural ventilation, DeST can take into account the indoor thermal environment in order to accurately simulate the effect of thermal buoyancy on natural ventilation. At the same time, DeST can output the result of the calculations to a building environment simulation module, able to accurately simulate the indoor thermal environment.

The resistance models in DeST can mainly be divided into two categories:

- Single-flow branch resistance model: Various architectural surface cracks, such as the door seam, window seam and the gap between the side wall and the roof both belong to the single flow branch. Small areas of the ventilation holes, ventilation pipes, chimneys also belong to the single-flow branch
- Double-flow branch resistance model: Large open branch for vertical section, such as opened doors, windows and so on

3.4. References

[1] Overview of advances and remaining challenges to implement ventilative cooling with the new EPBD standards", presented at Clima 2016, François Rémi Carrié, Valérie Leprince, Maria Kapsalaki. Accessible on venticool.eu

[2] http://www.iee-cense.eu/Events-and-publications/Publications

[3] Design guideline of window for outdoor air cooling, Northern regional building research institute, Japan, 2010

[4] CIBSE AM 10:2005 (Application manual, UK), "Natural Ventilation in Non Domestic Buildings", 2005 (under revision)

[5] DS 447:2013 (Danish standard), "Ventilation for buildings – Mechanical, natural and hybrid ventilation systems", 22013

[6] CIBSE TM 52:2013, "The limits of thermal comfort: avoiding overheating in European buildings",

[7] Ventilative cooling - Lowers energy consumption, BUILD-UP, INIVE, Aalborg university, 2013 (http://www.buildup.eu/sites/default/files/content/Overview%20article%20Ventilative%20cooling%2005092013.pdf)

[8] Overview of provisions for ventilative cooling within 8 European building energy performance legislations, Rémi Carrié et al, 2015

[9] State-of-the-art-review, IEA Annex 62, 2015, accessible on http://venticool.eu/wp-content/uploads/2013/09/SOTAR-Annex-62-FINAL.pdf

[10] Integrated design methods for natural ventilation, Annamaria Belleri, Doctoral thesis, 2013

[11] Comitato Termotecnico Italiano, Attuazione della certificazione degli edifici in Italia, Rapporto 2014 on CTI website at: (http://www.cti2000.eu/rapporto-ce-2014)

[12] A list of validated softwares is available on CTI website at: (http://www.cti2000.it/index.php?controller=sezioni&action=show&subid=34)

[13] DOCET available on website: (http://www.docet.itc.cnr.it)

[14] EFRE/FESR 2017 – BuildDOP project http://www.agenziacasaclima.it/it/progetti-di-ricerca/builddop-1701.html

[15] http://house.app.lowenergy.jp

[16] www.energimerkning.no

[17] www.nticad.no

4. Recommendations per country for standards, legislation and compliance tools - for better implementation of ventilative cooling

This section provides recommendations per country for standards, legislation and compliance tools for better implementation of ventilative cooling, based on the findings from the “status” section. In regard to legislation it is not always easy to align recommendations, due to the different ways ventilative cooling is included (or not) nationally and the differences in the use of calculation methods. Furthermore, this section discusses if new technical documents on ventilative cooling are needed, based on the findings from the filled-in questionnaires found in Annex A (missing ventilative cooling aspects in standards), Annex B (missing ventilative cooling aspects in legislation) and Annex C (missing ventilative cooling aspects in compliance tools).

All the recommendations that follow are important and may be used as input to regulators on how to improve the implementation of ventilative cooling in future standards, legislation and compliance tools.

Overall the background report has provided a lot of recommendations for both standards, legislation and compliance tools which vary depending on the type of document and country. To conclude on all these recommendations, it was chosen to make specific overall recommendations given per topic as proposed changes in standards, legislation and compliance tools (see Section 5), to be used directly by the target groups of this background report (building designers, builders and experts working with building energy performance standards, legislations and compliance tools) for future revisions of these documents.

This section only handles recommendations in EN, ISO and national standards (4.1), national legislation (4.2) and national compliance tools (4.3), whereas the "overall recommendations across all standards, legislation and compliance tools" can be found in Section 5.

4.1. Recommendations in standards and other technical documents

The recommendations for EN standards are given below, based on the findings from the filled in questionnaires, to be used directly by the target group of this report for future revisions of these documents.

4.1.1. European standards (EN) and other technical documents (recommendations)

This section describes recommendations to better implement ventilative cooling in relevant European standards (EN).

An example of recommendations for better inclusion of ventilative cooling in future EN standards is presented below. Previous work in the field, has also provided recommendations for summer comfort [1].

"In order to reduce the energy consumption for cooling and to promote the use of passive cooling concepts and strategies and in order to anticipate undesirable effects of global warming, it is strongly recommended to set:

- *Additional requirements limiting the cooling needs for air-conditioned buildings*
- *Additional requirements for non-air-conditioned buildings limiting the overheating risk or, in a complementary way, clear indicators that allow identifying the necessity (or not) of air conditioning (for both residential and non-residential buildings)*
- *If practically feasible in the context of the national EPB-legislation, the inclusion of such indicators about summer comfort should be based on hourly calculations of the indoor temperatures at a zone level, due to the huge temperature differences that can exist between zones of the same building"*

4.1.1.1. Evaluation of possible new technical documents on ventilative cooling in CEN

While working on the IEA EBC Annex 62 recommendation report to evaluate the status of ventilative cooling in existing standards, conclusions were drawn throughout the process, to act for better implementation.

One of the goals of the report was to evaluate if new Technical documents (e.g. EN standards, Technical specifications or Technical reports) on ventilative cooling should be proposed in Europe (in CEN), based on the initial findings, by evaluating if there was a sufficient lack of content in existing standards regarding ventilative cooling.

To sum up, there was an overall lack of ventilative cooling integration, in existing and revised European standards regarding "system design" and "performance" aspects of ventilative cooling, and therefore new work items (NWI's) relevant to ventilative cooling applications were proposed to the European Committee for Standardization (CEN). These new work items were approved and have now started up under CEN/TC 156 in various working groups (already launched at the time of writing of this report).

These new projects have the scope of making technical documents focusing on the design aspects of ventilative cooling and natural and hybrid ventilation systems in residential and non-residential buildings. There is good development in these recently launched projects, with a plan to coordinate to eliminate overlaps.

The following 3 projects relevant to ventilative cooling applications have begun:

- Ventilative cooling systems
    - Main focus: Thermal comfort (reduce cooling loads and prevent overheating)
    - Document type: A CEN Technical specification
    - Work started up in WG/21 in CEN/TC 156
- Natural and Hybrid ventilation systems in non-residential buildings
    - Main focus: Indoor air quality
    - Document type: A CEN Technical specification
    - Work started up in WG/20 in CEN/TC 156
- Design process of natural ventilation for reducing cooling demand in energy-efficient non-residential buildings
    - Main focus: Thermal comfort (design process to reduce cooling demands and/or overheating)
    - Document type: ISO standard
    - Work started up in WG/2 in ISO/TC 205

And, one project is upcoming:

- Expansion of Natural and Hybrid ventilation in residential buildings in upcoming "Revision of EN 15665:2009 and CEN/TR 14788:2006"
    - Main focus: Indoor air quality
    - Document type: Goal is to merge both documents into one document (e.g. EN standard)
    - Work started up in WG/2 in CEN/TC 156

The initiated projects are foreseen to be released as European Technical Specifications (normative documents of lower status than EN Standards) and as an EN standard under CEN/TC 156. The technical documents are a good opportunity to define the design aspects of ventilative cooling and natural and hybrid ventilation systems on the European and International scene e.g. by applying findings from the venticool platform [1] and the final deliverables of the IEA EBC Annex 62 reports [2].

Some more concrete recommendations to the future implementation of ventilative cooling in EN standards follow:

- The new projects in CEN could contain separate sections on thermal summer comfort which is very relevant to ventilative cooling, explaining how ventilative cooling may reduce overheating (as in e.g. Japanese design guideline for ventilative cooling [3], CIBSE AM 10:2005 (first part of the guide (design) or in section “control of summer overheating”) [4] and/or DS 447:2013 [5])
- The new projects in CEN could give guidance on how to design and dimension ventilative cooling and natural and hybrid ventilation systems in buildings
- In future standards “performance” aspects areas such as control of systems, internal partition of buildings and guidance on parameters that shall be defined by users, should be better integrated
- In future standards it should be considered that windows are not the only mean to provide ventilative cooling but there are other components already available on the market (i.e. louvre, operable opaque envelope parts, thermal chimneys, wind catchers, etc..) that can effectively contribute to overheating reduction

- Building designers, builders and experts need more information on how to design and calculate on ventilative cooling systems, instead of only being given requirements to follow or general information on natural forces
- Design of natural ventilative cooling systems should consider the effect of:
    - Height difference between windows or other opening types
    - Placement of windows or other opening types in regard to noise, outdoor air pollution and security
    - Placement of windows or other opening types (opposite sides of building/room) in regard to maximum cross ventilation (advantage using this)
    - Control strategies
    - Window operation management according to outdoor climate and pollution conditions
    - Simple calculation methods for ventilative cooling

The recommendations for ISO standards are given below, based on the findings from the filled in questionnaires, to be used directly by the target groups of this report for future revisions of these documents.

4.1.2. ISO standards (recommendations)

This section describes recommendations for better implementation of ventilative cooling in ISO standards.

As in CEN, New work items relevant to ventilative cooling applications have recently been proposed to the International Organization for Standardization (ISO) aiming at making a descriptive technical document focusing on the design process or aspects of natural ventilation systems.

One project has already started up:

- "Design process of natural ventilation for reducing cooling demand in energy-efficient non-residential buildings" (ISO/TC 205), NP 22511

The effect of cross ventilation on reducing cooling demand is described in ISO 13153:2012, but single-sided ventilation is excluded and buoyancy driven ventilation is not taken into account. This standard should be expanded to allowing to consider natural ventilation. This standard describes only the design process and thus the control strategy or methods for windows and cooling devices will be needed in other standards. No ISO standards for design methods of (large) non-residential buildings are available; hence, the new ISO standard NP 22511 (in progress) is being developed under ISO/TC 205.

4.1.3. National standards (recommendations)

Denmark

Overall the most important Danish national standard concerning ventilative cooling (DS 447:2013) and evaluated in this report, deals with requirements for ventilation systems in buildings and has a very good and useful overview of requirements and what to include when designing ventilation systems such as natural ventilation systems using passive techniques.

A recommendation could be to have a more “design specific” national standard on ventilative cooling, actually showing guidance on how to achieve well-functioning ventilative cooling systems by e.g. looking at the integration of ventilation components for natural ventilation/cooling like in CIBSE AM 10:2005, instead of focusing on the concrete requirements. This could be further investigated in future national standards, and the work of DS 447:2013 could be used as inspiration in the new work items starting up in CEN and ISO.

Italy

Current national standards propose a calculation methodology for both mechanical and natural airflow which is based on design airflow multiplied by correction factors listed in different tables. National standards should rely on more robust calculation methods and provide different calculation methods for natural and mechanical ventilation strategies, as well as predefined operation ranges (i.e. minimum/maximum outdoor temperature and humidity, maximum indoor/outdoor temperature difference, maximum wind speed) or control modes.

United Kingdom

Ventilative cooling is not included in the building regulations and standards in the United Kingdom; however natural ventilation is included mainly focusing on IAQ issues in buildings. Guidelines through professional bodies (CIBSE) exist which can facilitate the design of Ventilative cooling and this should be integrated in the regulations and standards.

Austria

It is recommended to take the next step and implement dynamic building energy and comfort modelling into Austrian standards. So far, this is only the case for thermal summer comfort calculations in residential buildings. Dynamic building energy modelling would not only allow Ventilative Cooling to be taken into account properly but would also be the basis for a realistic modelling of the effects of energy flexibility heating/cooling control. Furthermore, for residential buildings there’s the requirement to have operative temperature < 25°C in sleeping rooms from 10:00 in the evening and on. This is a bottleneck for ventilative cooling which is not justified and should be removed.

Belgium

As there is no standard for ventilative cooling in Belgium, it is recommended to have a standard that guides the designers and promotes the use of ventilative cooling.

Portugal

In fact, there is no Portuguese standard that guides the designers and promotes the use of the ventilative cooling systems, so this should be considered in future standards.

Australia

Ventilative cooling is not integrated in the national standards, but should be considered in the future. Australia could consider looking at the European countries as best practice examples.

Norway

Ventilative cooling is not integrated in the national standards, but should be considered in the future. The described calculation method is based on EN 15242:2007, but should be updated to EN 16798-7:2017.

Switzerland

Swiss national standards do not define energy strategies and the way night cooling is assessed. They recommend protected openings but they do not define minimum requirements to make night cooling realistic. In general night cooling is possible (and necessary to assure thermal comfort without air conditioning) but in practice it is not applied unless windows are automatic.

There is a need for recommendations for good ventilative cooling design.

China

In recent years, China has placed increasing emphasis on building energy conservation and has promulgated some standards that include natural ventilation. However, most are suggestive or encouraging principled standards, and there is no systematic guideline or reference index for natural ventilation design. The suggestions for Chinese standards on natural ventilation include the following, which will be included in the new standard, which is currently being written.

- Establish systematic guidelines for natural ventilation design for civil and public buildings, including potential estimation, flow rate calculation and suggestion of design of openings, flow path inside buildings, natural ventilation enhancing appliances and controlling systems
- Set reference indexes to assess the effect for natural ventilation utilization in different climatic regions in China
- Consider ventilative cooling

4.2. Recommendations in legislation

In this section recommendations to national and regional legislation concerning ventilative cooling are described. Aspects such as temperature limits, time steps, penalties on the calculation of energy use and type of ventilation are evaluated and discussed. These recommendations are important in order to improve the implementation in future legislation, among others.

In this section recommendations to national/regional legislation concerning ventilative cooling are described for various countries such as Denmark, Australia and Italy, among others.

An example of recommendations concerning the use of natural ventilation from a BPIE study follows:

"… there is an increasing risk of overheating which also has to be addressed. Thermal comfort should therefore be acknowledged in building legislations and the use of simple and efficient measures, e.g. solar

shading, solar protective glazing and ventilative cooling should be encouraged. In all surveyed countries, there are requirements in place relating to the thermal transmittance of external building elements, but only a few of them underline the co-benefits of thermal comfort" [6].

Another example is in Belgium, where openable windows in residential buildings have an impact on the overheating indicator. It is thus recommended to consider the impact of net cooling demand as well, to account for the extra ventilation heat losses caused by the opening of windows or more generally by increased ventilation.

Recommendations for national legislation (per country) are given below, based on the findings from the filled in questionnaires, to be used directly by the target groups of this report for future revisions of these documents.

4.2.1. National legislation (recommendations)

Denmark

Recommendations for national/regional legislation in Denmark include:

- Ventilative cooling should be explicitly addressed in Danish legislation (not at present).
- Cooling capabilities of natural and mechanical ventilation systems should be directly indicated.
- "Two complementary means could be used to introduce ventilative cooling into Danish compliance tool(s):
    - Using ventilative cooling to reduce the "virtual" cooling needs of the evaluated building, regardless of any cooling system installation
    - Using ventilative cooling to reduce overheating hours, meaning that room temperatures should be evaluated accurately
- Thermal comfort criteria with respect to overheating are established only for residential buildings.
- Thermal comfort criteria with respect to overheating in other types of buildings (e.g. offices, schools, day-care institutions) are still up to the investor. Here however, thermal comfort criteria for working spaces apply. Still when reading these criteria carefully, one would notice that they are not explicitly defined. **Therefore, thermal comfort criteria in other buildings should be sorted out.**
- Legislation text should be more specific with regard to ventilation strategies in order to cool/maintain acceptable thermal comfort.
- Natural ventilation strategies: single, cross, stack ventilation should be clearly identified with respect to ventilation capacities, application, other regulations (e.g. fire regulations).

Italy

A recommendation for national/regional legislation in Italy is to include upper limits on indoor temperature (i.e. according to the adaptive thermal comfort model) and thermal comfort/overheating indicators in the energy performance evaluation. More specifically:

- Consider the exploitation of devices (i.e. ceiling fans) to increase the indoor air velocity and therefore improve the thermal comfort sensation during the cooling season
- Include calculation methods for airflow due to single sided ventilation, cross ventilation, stack ventilation, night cooling, ceiling fans, economiser, free cooling or hybrid systems
- Include indicators for free cooling strategies' effectiveness

United Kingdom

Ventilative cooling needs to be specifically addressed in the regulation. At present, it is missing in both regulations, one concerning energy (Part L) and the other focusing mainly on IAQ concerning ventilation (Part F).

Austria

It is recommended to open the legally accepted range of comfort prediction tools to dynamic building simulation. Accompanied by a set of basic input parameters, a reasonable level of comparability of calculation outcomes could still be guaranteed. Another crucial point would be a revision of Austria's workplace ordinance. Today it defines very narrow bands of thermal comfort, including very low benchmarks for air movement. These benchmarks are clear obstacles against ventilative cooling and should be revised.

Belgium (Flanders)

It is recommended to add a requirement and calculation method for overheating in non-residential buildings.

Switzerland

There are gaps in the definition of the requirements for night cooling. There is no distinction between manual and automatic window opening (there is for blinds), and night cooling operation is not possible in practice. The possibility of window opening is not sufficient. Legislation should ask also the measures assuring the window opening (protection for intrusion, weather conditions, presence of automation).

Portugal

In fact, there is no Portuguese legislation that promotes the use of the ventilative cooling systems, so this should be considered in future legislation.

Australia

Ventilative cooling effects are only integrated when simulation software packages are utilized to meet the legislation requirements.

When the energy efficiency requirements of a building, residential or commercial, are met with "Deemed to Satisfy" requirements, ventilative cooling is only partially considered, given that the applicable standards are focused on ensuring ventilation rather than using ventilation for cooling purposes.

Australia would ideally include an extension to the current National Construction Code that allows to consider the benefits of a ventilative cooling system to meet the building's energy efficiency requirements.

Ireland

Ventilative cooling is not well defined in national building regulations. If there is no mechanical cooling then the legislation recommends a dynamic simulation to be completed in order to confirm there is no risk of overheating. CIBSE TM52 is the overarching document to which designers refer for guidance.

Ireland would ideally like to properly take into account the cooling contribution from single-sided ventilation and cross-ventilation strategies. Some calculation procedure that estimates the energy offset from using natural or mechanical ventilation for cooling purposes should be considered.

Currently there is no mechanism to calculate the required building geometry.

Some guidelines relating to ventilation for cooling are needed. Currently Part F of the building regulations covers minimum ventilation rates for moisture control, IAQ and local extract systems. However, it could be possible to provide guidance on recommended designs, for situations where Ventilative cooling was adopted.

Norway

Thermal comfort criteria with respect to overheating are established for both residential and non-residential buildings.

Natural and mechanical ventilation are specified as ventilation system possibilities. However, cooling capabilities of both are not indicated.

Night cooling is missing in the legislation's guideline for pre-accepted solutions. Openable windows are mandatory, but possibilities for single-sided, cross ventilation and stack ventilation should have been addressed in the guideline together with ventilative cooling.

China

By next year new standards for Natural Ventilation will be developed. An effort will be made to include the identified missing parameters in the upcoming standards.

Regarding legislation, China will try to suggest some clauses to different levels of legislation documents.

4.3. Recommendations in compliance tools

In this section recommendations for national compliance tools concerning ventilative cooling are described. It is essential that national compliance tools can interpret the legislation in a fair and correct manner so that the increased use of ventilative cooling becomes fully relevant in different countries.

Below are a few excerpts from previous reports on recommendations to compliance tools.

"The mandatory compliance tools to evaluate energy performance according to national EPBD transposition should to a larger extent reward and facilitate the use of energy efficient ventilation solutions and measures to prevent overheating" [6].

“Most countries have as their default a monthly energy calculation, which is not well suited for ventilative cooling. More complex calculations are generally possible in the energy performance calculations, but you need to be an expert and the complex calculations are time-consuming” [7].

In Italy and Switzerland, restrictions on the thermal mass can pose a threat to the relevance of ventilative cooling by influencing the time the maximum temperatures in buildings are reached [7]:

- Recommend removing restrictions for thermal mass in Italy and Switzerland

The recommendations for national compliance tools (per country) are given below, based on the findings from the filled in questionnaires, to be used directly by the target groups of this report for future revisions of these documents.

4.3.1. National compliance tools (recommendations)

Denmark

Recommendations for national compliance tools in Denmark for future updates are listed below:

- Possibility for variable air flow rates, ventilation time schedules and simple control strategies should be the first ones to be implemented for the ventilation strategy description (assuming that calculation is hourly and not monthly)
- Key performance indicators, such as Cooling Requirements Reduction (CRR) and Ventilative Cooling Seasonal Energy Efficiency Ratio (SEER) should be included in compliance tool calculations
- Calculation algorithm behind “Summer comfort” should be elaborated and explained in the tool help file
- There is a differentiation between day and night air flows and summer and winter seasonal air flows but still they are used as average values for very long time spans. Hence, more discretized time steps for ventilation descriptions should be used
- At present, real dynamic characteristics of ventilation and air based cooling capacities are not included in the compliance tool calculations, neither for mechanical nor natural ventilation. Therefore, compliance tool results should preferably be used as tools to compare one building performance to another, but not to draw conclusions on real building performance
- Air flows in natural ventilation systems are specified disregarding the window position in the building, the specific opening geometry and the characteristics and airflow paths to other openings. Therefore, the current version of the Danish compliance tool should not be used as a design tool at its present form (which is often done). At present, airflow calculation would be required to gain trust in natural ventilation performance and to use “more correct” average air flows in compliance tool calculations
- Proof constrains for automated controlled windows should be specifically addressed because they could have significant influence on building comfort and energy performance

Italy

Recommendations given for future updates of the national compliance tools in Italy include:

- Integrate equations for airflow prediction based on the opening area with predefined ventilation modes
- Key performance indicators, such as Cooling Requirements Reduction (CRR) and Ventilative Cooling Seasonal Energy Efficiency Ratio (SEER) should be included in compliance tool calculations
- Add predefined mechanical ventilation controls based on occupancy profiles
- Consider the adaptive thermal comfort model

United Kingdom

The compliance tool for residential buildings (SAP) focuses on energy and to some extend overlooks the resulting environmental conditions which can lead to overheating.

Austria

Austria's compliance tools closely follow the algorithms defined in the national standards. Thus, it is the standards which are the key to change. The compliance tools will follow as soon as the national standards are ready.

Belgium (Flanders)

Recommendations for national compliance tools for Flanders involve:

For non-residential buildings:

- Add a calculation method for thermal comfort which includes the impact of ventilative cooling
- Make it possible to combine different types of ventilative cooling (daytime and night-time, but also hybrid ventilation)
- Make it possible to select the natural ventilation strategy (buoyancy, single-sided, cross ventilation)

For residential buildings:

- Differentiate the use of ventilative cooling between day and night, but also the combination of both (hybrid)
- Increase the impact of intensive ventilation on the overheating indicator
- Add the impact of ventilative cooling on the net energy demand for cooling

Adapt the calculation method for thermal comfort in all types of buildings on an hourly basis and on room level.

Switzerland

Compliance tools are adequately applying the Swiss norms.

In the Swiss norms the window opening schedules and boundary conditions are not well defined, so the compliance tools themselves "invented" better natural ventilation strategies and they are different from one compliance tool to another. In some of the compliance tools, windows are set to open when the indoor temperature, Ti>26°C, and some of them when Ti>22°C and the outdoor temperature, Tout<26°C.

Portugal

In fact, there is no Portuguese compliance tool promoting the use of the ventilative cooling systems, so this should be considered in future compliance tools.

Australia

Recommendations include:

- The development and use of compliance tools which integrate ventilative cooling sufficiently as an energy consumption reduction strategy
- The use of these compliance tools should not be compulsory for fulfilling the energy efficiency requirements

Japan

A compliance tool for estimating primary energy consumption for non-residential buildings exists but the effect of natural ventilation on (reducing) cooling demand has not been included so far. Buoyancy driven ventilation and single-sided ventilation are excluded from the online calculation programme for residential buildings.

Norway

Air flows both for mechanical and natural ventilation are defined as fixed air flows per heated floor area.

It is possible to differentiate between day and night air flows and summer and winter seasonal air flows, but still they are used as average values for very long time spans.

Dynamic characteristics of ventilation and air based cooling capacities are captured in the compliance tool calculations, both for mechanical and natural ventilation.

The compliance tool does not have good enough models for window ventilation and natural ventilation. Air flows are specified disregarding the windows' position in the building, the specific opening geometry and the characteristics and airflow paths to other openings. This should be improved in future versions of the programme.

China

As the software DeST is not specifically designed for natural ventilation calculation, there are some inconveniences when using it. Recommendations for future updates of national compliance tools include:

- The natural ventilation module in DeST should be developed as a separate software, and a simple and operable software interface should be formed to facilitate the study and use by engineers.
- The prediction of the energy saving potential is an important prerequisite for the application of natural ventilation; hence, the energy saving potential should be calculated in the software.

- For automatically controlled windows, it should be able to accurately calculate the natural ventilation and ventilative cooling effect according to the control strategy and opening size of the window.
- The parameters representing the ventilative cooling effect should be output as the results of the calculation.
- The thermal comfort model under the condition of natural ventilation should be added into the tool

4.4. References

[1] http://venticool.eu/

[2] IEA EBC Annex 62 on "Ventilative cooling" – official deliverables, http://venticool.eu/annex-62-publications/deliverables/

[3] Design guideline of window for outdoor air cooling, Northern regional building research institute, Japan, 2010

[4] CIBSE AM 10:2005 (Application manual, UK), "Natural Ventilation in Non Domestic Buildings", 2005 (under revision)

[5] DS 447:2013 (Danish standard), "Ventilation for buildings – Mechanical, natural and hybrid ventilation systems", 2013

[6] BPIE, indoor air quality and thermal comfort, 2014

[7] State-of-the-art-review, IEA Annex 62, 2015, accessible on http://venticool.eu/wp-content/uploads/2013/09/SOTAR-Annex-62-FINAL.pdf

5. Main recommendations per topic for standards, legislation and compliance tools - for better implementation of ventilative cooling

Overall the report has provided a lot of recommendations for both standards, legislation and compliance tools which vary depending on the type of document and country.

The main recommendations from the IEA EBC Annex 62 on "Ventilative cooling" are given below, together with specific overall recommendations per topic covering all investigated legislations. The recommendations are listed as proposed changes in standards, legislation and compliance tools to be used directly by the target groups of this report (building designers, builders and experts working with building energy performance standards, legislations and compliance tools) for future revisions of these documents.

5.1. General

The split-up of roles and responsibilities between legislation, standards and compliance tools differ from country to country. The collective task is to set up targets for certain parameters and methods to evaluate if these targets have been met. In the following paragraphs, the targets are assumed to be defined in the legislation and the methods to evaluate if the targets are met are defined in standards and/or national compliance tools.

5.2. Overall recommendations in standards and other technical documents

The main recommendations across all investigated standards, summing up specific overall recommendations per topic are presented below. To allow for ventilative cooling to be treated better in standards both at the design stage, where initial calculations of e.g. the natural forces are made as well as, at more detailed stages where more detailed calculations are needed, it is important that several parameters are taken into account, such as:

- Assessment of overheating, e.g.:
    - Utilizing thermal comfort indicators, including adaptive temperature sensation
    - Utilizing energy performance indicators
- Assessment of natural and mechanical ventilative cooling

- Assessment of night cooling
- Calculation methods that fairly treat natural ventilative cooling for determination of air flow rates including e.g. the dynamics of varying ventilation and the effects of location, area and control of openings

When revising standards with respect to calculation and design of ventilative cooling systems ensure that the standards don't favour specific technologies and allow for emerging technologies such as hybrid systems and for components alternative to windows (i.e. louvers, thermal chimneys, wind catchers..). Among other things, the determination of air flow rates in buildings for e.g. natural ventilative cooling is important to consider, where both simplified and detailed calculation methods can be found in e.g. calculation standard; EN 16798-7:2017, enabling the designer to choose which level of detail is needed for the given purpose and stage of the construction.

It is recommended that the full effects of ventilative cooling are evaluated reflecting the real conditions for the building, control, use and climate. This should include in particular the actual building physics and geometry, supporting a fair evaluation of e.g. stack effects, cross ventilation, mechanical ventilation, control system, night/day ventilation and summer/winter ventilation.

Inspiration for recommendations in standards can be found in the recently published IEA EBC Annex 62 "Ventilative cooling design guide" [1], which gives information on how to design ventilative cooling systems by e.g. using Key performance indicators for "thermal comfort" and "energy performance" aspects. These key performance indicators are addressed in this section.

Air flow rate

Recommendation: Use main calculation standard, EN 16798-7:2017 for the calculation of air flow rates in buildings:

- We recommend using the standard, EN 16798-7:2017 for the calculation of air flow rates in buildings for ventilative cooling. The standard contains both simple direct methods and a detailed iterative method covering different needs and complexities. E.g. for quicker calculations, simple direct methods of calculation using wind velocity and temperature difference as input, can be used for single-sided and cross-ventilation, whereas for more detailed calculations, the detailed iterative mass-balance method calculation using internal reference pressure as input can be used.

Recommendation: Consider infiltration, natural and mechanical ventilation:

- A clear distinction between infiltration related air flow rates and natural ventilation airflow rates should be made. It must be clearly stated that infiltration airflow rate is the uncontrolled air flow while natural ventilation related air flow rate is controlled and may depend on several factors, such as, opening position, opening types, opening effective area, automation possibility, etc. If infiltration and natural ventilation airflow rates are not considered separately then high ventilation heat losses in the cold season would be observed since natural ventilation has no possibility for heat recovery and air flows should be significantly higher than for infiltration.

Recommendation: Flexibility allowing calculation of air flow rates based on real conditions:

- When revising standards with respect to calculation and design of ventilative cooling systems ensure that both day and night ventilation are taken into account, for various scenarios, including window openings. Generally, we recommend that standards reflect the real conditions based on actual building physics and geometry. This increases flexibility to reach the relevant air flows depending on room type and thermal loads.
- Air flow rates shall be adjustable depending on the ventilation need for: indoor air quality, overheating prevention, day/night and depending on season

Thermal comfort indicators (e.g. criteria for overheating)

- When revising standards with respect to the prediction of the expected thermal comfort and cooling requirements by using ventilative cooling, it is recommended to use a method that is based on the static Fanger model (PMV evaluation) (using mechanical ventilative cooling) or the Adaptive comfort model (using natural ventilative cooling)
- It is recommended to use Key Performance Indicators for "thermal comfort" that are used in the IEA EBC Annex 62 "Ventilative cooling design guide" (p. 33-34) [1]. A set of two indicators enable to properly evaluate of thermal comfort; the Percentage outside the range (POR) (see method A, in prCEN/TR 16798-2:2017) evaluating the percentage of occupied hours when PMV/Operative temperature is outside the range and; according to the Degree hours criterion (DhC) (see method B, in prCEN/TR 16798-2:2017), the time during which the actual operative temperature exceeds the specified range during the occupied hours is weighted by a factor which is a function depending on how many degrees the range has been exceeded.

Energy performance indicator (e.g. criteria for energy performance)

- It is recommended to use Key Performance Indicators for "energy performance" that are used in the IEA EBC Annex 62 "Ventilative cooling design guide" (see pages 34-36): the Cooling Reduction Requirement (CRR) evaluating the percentage of reduction of the cooling demand of a scenario, compared to a reference scenario and; the Ventilative Cooling Seasonal Energy Efficiency Ratio (SEER), which is defined as the cooling requirement saving divided by the electrical consumption of the ventilation system [1]
- Alternatively, give a "penalty" associated to the energy performance of the building if cooling is needed - like the method used in the Danish compliance tool. This penalty raises awareness for the necessity of cooling and encourages the implementation of an efficient ventilative cooling system. In southern Europe cooling need will occur anyway during summer period, so a penalty could be given if the building has a cooling need in the shoulder seasons.

Flexibility towards new/alternative technologies

- When revising standards with respect to calculation and design of ventilative cooling systems ensure that new and alternative technologies are allowed. It is recommended that technologies such as hybrid ventilation are supported where the full effect of natural ventilative cooling used during periods of overheating is evaluated reflecting on the real conditions based on actual building physics and geometry.

5.3. Overall recommendations in legislation

The main recommendations from the IEA EBC Annex 62 are given below together with specific overall recommendations per topic covering all investigated legislations. To allow for ventilative cooling to be treated in building performance evaluations, several parameters are necessary to take into account, such as:

- Assessment of overheating, e.g.:
  - Requirements to thermal comfort, including adaptive temperature sensation
  - Requirements to energy performance including cooling
- Acknowledgement of natural and mechanical ventilative cooling
- Support to evaluation methods considering the dynamics of varying ventilation and ventilation modes
- Support to evaluation methods considering the effects of location, area and control of openings

When revising legislation with respect to calculation and design of ventilative cooling systems, ensure that the legislation is technology neutral thereby not favouring specific technologies and allowing emerging technologies such as hybrid systems. It is recommended that the full effects of ventilative cooling are evaluated reflecting the real conditions for the building, control, use and climate. This should include in particular the actual building physics and geometry. Legislation should include or refer to guidelines, standards or compliance tools on how to calculate the cooling effect, resulting temperatures and the energy performance.

Thermal comfort indicator (e.g. criteria for overheating/overcooling)

- Methods for a long-term evaluation of thermal comfort conditions should be taken into consideration and used actively as a requirement in the national legislation as supported by prEN 16798-1:2017 and the associated Technical report, prCEN/TR 16798-2:2017. prCEN/TR 16798-2:2017 proposes different long-term evaluation methods e.g. the “Percentage Outside the Range Index” (method A) and the “Degree-hours Criterion” (method B) enabling the evaluation of both frequency and severity of overheating occurrences. The reference comfort temperature and the evaluation of overheating and overcooling can be derived from the Fanger model or the adaptive comfort model.

Available opening area for natural ventilative cooling

- Since natural ventilative cooling is highly dynamic, the legislation should support evaluation methods based on the actual building geometry, climatic conditions and actual use and control of the building. Necessary opening areas should be based on calculations where discharge coefficients of openings have been included.

Criteria for draught risk

- The legislation should require the use of draught rate calculation according to ISO 7730 by using one of the three categories (A, B or C) for the evaluation. Draught due to air inlets will be related to their position in the room and distance from the occupied area. A description should be given for the occupied zone which should fulfil the requirements. A deviation from the requirements could be suggested if the air velocity is under personal control e.g. by using openable windows, table- or ceiling fans. It should be noted, that under thermal summer comfort conditions with indoor operative temperatures above 25ºC, increased air velocity can be used to compensate for increased air temperatures if the increased air velocity is under personal control. The correction value depends on the air speed range of the appliance. Draught rate should include temperature, air velocity and turbulence intensity, meaning e.g. that with higher temperatures, higher air speed is accepted.

- In order to avoid other types of discomfort (e.g. flying papers, ingress of leaves, slamming doors etc.) in the occupied zone, one may set upper limits for air velocities different from the pure thermal draught assessment.

All day ventilation

- Legislation should require that ventilative cooling can be applied during both occupied and unoccupied periods, meaning all day if needed. For openings used for ventilation, legislation should require considerations on the need for burglary, noise, pollution, rain and mosquito proofing.

5.4. Overall recommendations in compliance tools

Several building simulation tools are today available around the world that allow architects or engineers to assess buildings with a high accuracy on energy performance or indoor climate. Some of them are already implementing modules to consider natural ventilation or natural ventilative cooling through windows and its effect on thermal summer comfort.

Especially natural ventilative cooling is difficult to assess in most existing compliance tools, which should reflect what is stated in the national legislation. Since compliance tools are the only evaluation tools used in many cases, it is recommended to secure the implementation of ventilative cooling in compliance tools, allowing the evaluation of over-heating issues at the earliest stage of design process when decisions on e.g. windows location or orientation can still be taken.

Despite the fact that some of these tools have reached an elevated level of user-friendliness, they are only occasionally used for building design as the compliance of a project with building regulation also requires the use of calculation tools. Therefore, these so-called “compliance tools” are usually preferred in the design process of a building to secure the performance of buildings and their compatibility with national regulations.

This background observation highlights the necessity of implementing ventilative cooling in compliance tools to promote its use, but also to secure that it is considered at the earliest stage of design process when decisions on e.g. windows location or orientation can still be taken.

The main recommendations from the IEA EBC Annex 62 across all investigated compliance tools follow. To allow for ventilative cooling to be treated in building performance evaluations, several parameters should be considered, such as:

- Assessment of overheating, e.g.:

  - Thermal comfort indicators, including adaptive temperature sensation
  - Energy performance indicators like e.g. virtual cooling needs, cooling consumptions etc.
- Assessment of increased air flows when efficient ventilative cooling systems are used:
  - Differentiation should be made i.e. for cross- or stack ventilation vs. single-sided ventilation, automated systems vs. manually controlled, large vs. small opening areas
  - Associated airflows should preferably be based on building physics for e.g. dynamic tools (using pressure equations) or - as a simpler solution - on “coefficients” which increase air flows based on the chosen system
- Implementation of different levels of approaches to the evaluation of ventilative cooling, depending on the level of detail needed for the given purpose and stage of construction:
  - **Simplified approach:**
    Using national compliance tools based on monthly calculations with specific assumptions on input air flows for natural ventilation and ventilative cooling (like e.g. in Belgium, Flanders).
    The main benefit of this method is its direct applicability towards most existing compliance tools.
    It allows modelling of ventilative cooling via the use of constant air flows over a given period, and can, like in Belgium, promote the gradual use of openable windows, stack effect, cross-ventilation and even control systems.
    Its simplicity will of course lower the air flows and tends to reduce the impact of ventilative cooling on thermal summer comfort.
  - **Intermediary approach** (combining simplified and detailed approach):
    Using national compliance tools based on monthly calculations + using an add-on tool or plugin to address thermal summer comfort and ventilative cooling in a more accurate way (like e.g. in Denmark).
    The main benefit of this approach is to keep the existing compliance tool, but could be less accurate (and then less beneficial to ventilative cooling) due to the reduced number of parameters (in several cases, this tool will usually be using the same input parameters as the main compliance tool)
  - **Detailed approach**:
    - Using national compliance tools based on full dynamic calculations (e.g. like in Switzerland, where several simulation tools from the market are allowed).
    - Using national compliance tools based on simplified hourly calculations (like e.g. in France or in The Netherlands).

Examples on different national evaluation approaches for ventilative cooling in compliance tools:

In most cases, simplified approaches underestimate the impact of ventilative cooling. Advanced calculation methods like e.g. dynamic simulations based on hourly time-steps are usually closer to reality and lead to more realistic air change rates. Examples of different "levels" of approaches to the evaluation of ventilative cooling in national legislation ranging from simplified to detailed, as explained in the above three bullet points, follow.

The three examples that follow show interesting national approaches used for compliance tools. These methods are using different ways to evaluate air flows and thermal summer comfort, by making use of the technical possibilities of each tool (e.g. static tool, hourly tool, dynamic hourly tool…).

Belgium: Simplified approach (To provide monthly inputs)

Since January 2018, the Belgian region Flanders, has introduced a new evaluation method for ventilative cooling in residential buildings to be used in the EPB compliance tool. It consists of a simple chart flow for designers, which identifies the potential for ventilative cooling (ranked from "No potential" to "Maximum potential") [2].

This approach is simple and promotes the use of ventilative cooling, by ranking solutions based on their efficiency potential (e.g. accessible from the outside, protected from the outside, possible adjustment of opening area, automatic control). The impact of ventilative cooling is then assessed according to its effect on the thermal comfort indicator but could also be implemented to energy cooling needs.

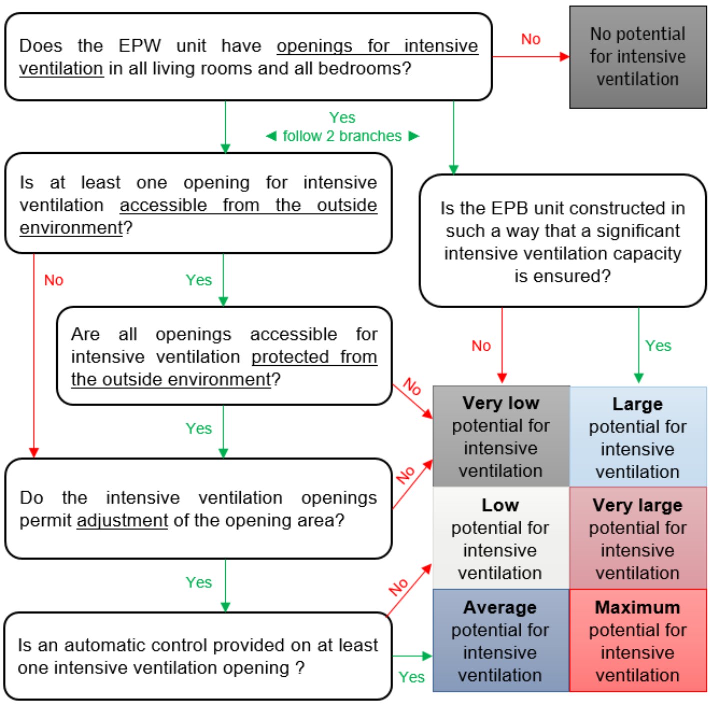

Figure 4 - Ventilative cooling potential (assessment flowchart)

Denmark: Intermediary approach (Add-on tool to improve the evaluation of thermal summer comfort)

Since 2015, the Danish Building Institute – SBi, has implemented an additional feature to the official compliance tool to evaluate thermal comfort. This module is called "Summer comfort" and is used to document the thermal comfort in summer in residential buildings through hourly calculations (described as total number of hours above 27°C and 28°C). Due to the limited number of parameters available in the main compliance tool, only some features of ventilative cooling can be considered in the add-on module, but it still allows the promotion of cross-ventilation, number of openable windows and geometrical free area of windows.

Even though these compliance tools are limited for the modeling of ventilative cooling, the Danish approach shows that more advanced simulation tools can be developed and connected to the existing compliance tool, without jeopardizing well-known approaches.

Switzerland: Detailed approach (Dynamic simulation software allowed)

The Swiss regulation MuKEn shows a specific approach for the energy calculation, and allows the use of several simulation tools available on the market.

This approach brings more flexibility regarding the use of ventilative cooling as most software are dynamic (hourly) simulation tools, which is the most accurate way of evaluating air flows (simplified methods usually tend to lower the impact of ventilative cooling in order to be conservative). Allowing several simulation tools could also lead to some disadvantages due to potential differences in input data if not standardized. Therefore, projects results might not be comparable with the results of other softwares. The use of software like e.g. DIAL+ promotes a realistic effect of ventilative cooling and considers influent parameters like e.g. window dimensions, stack effect, cross-ventilation or automatic control.

The main recommendations from the IEA EBC Annex 62 are given below together with specific overall recommendations per topic covering all investigated compliance tools; these are listed as proposed changes in compliance tools.

Air flow rate

Recommendation: Air flow rates to be used for ventilative cooling should be either assessed or at least provided as input value:

- When technically possible, air flow or air flow rates should be evaluated based on building features and climatic conditions
- When incompatible with national compliance tool(s), simplified approaches should be provided to building designers by e.g. providing fixed average air flow rates to be used for “cooling” purposes.
- When provided as input value, air flow rates should be divided into several levels to account for various systems efficiency (cross- or stack ventilation vs. of single-sided ventilation, automated systems vs. of manual control, large vs. of small opening areas)
- When air flow rates are accounted for via fixed values in compliance tools, the user must be able to specify different input values depending on the considered season (e.g. one value for winter, one value for summer). This is the only way to avoid a negative interaction between the heating and the cooling season, and to avoid that air flow rates associated with ventilative cooling are used all year long.

- Air flow rates shall be adjustable depending on the ventilation need and on occupied/not occupied time for indoor air quality or overheating prevention

Recommendation: Consider infiltration, Natural and Mechanical ventilation:

- Clear distinction between infiltration related air flow rates and natural ventilation airflow rates should be made. It must be clearly stated that infiltration airflow rate is the uncontrolled air flow while natural ventilation related air flow rate is controlled and may depend on several factors, such as, opening position, opening effective area, automation possibility, outdoor conditions etc. If infiltration and natural ventilation airflow rates are not considered separately then high ventilation heat losses in the cold season would be observed since natural ventilation has no possibility for heat recovery and air flows should be in general significantly higher than for infiltration.

Available opening area

- The compliance tool should - as an additional feature - be able to estimate air flow rates from a given list of predefined openings (inlets and outlets), for example “window top hinged”, “window side hinged” and “louvre” when they are fully opened, allowing for the possibility to overwrite this feature. In addition, it should introduce some interpolation of some intermediate openings. Discharge coefficients should be included in the predefined units. Based on this, the tool should confirm if the designed opening areas provide sufficient air flow rates.

Criteria for draught risk

- In modern airtight buildings, draught due to infiltration is almost non-existing in cold climates and reduced in warmer climates. Then draught is therefore mostly related to deliberately made inlets. Simple compliance tools are hardly designed or suitable for draught calculations and separate tools for evaluations are often necessary.

Flexibility towards new/alternative technologies

- Compliance tools should be updated regularly with respect to calculation of the new ventilative cooling technologies, such as diffuse ceiling ventilation for natural and mechanical ventilation, ventilation units accounting for heat/cold storage and utilization of phase change materials (PCMs), hybrid ventilation systems and others. Moreover, more effort should be made to integrate components promoting ventilative cooling in compliance tools, like wind chimneys, air vents, trickle vents, and many others. At present, these components are poorly or even not at all included in compliance calculation tools.

5.5. References

[1] IEA EBC Annex 62 deliverable "Ventilative cooling design guide", http://venticool.eu/wp-content/uploads/2016/11/VC-Design-Guide-EBC-Annex-62-March-2018.pdf

[2] Belgian EPB order (Annex V) "Method of determining the level of primary energy consumption for residential units", p.40-41

6. Conclusion

The overall purpose of the background report was to describe the current status and make recommendations for better implementation of ventilative cooling in standards, legislation and compliance tools.

In order to present the status of how well ventilative cooling is implemented, experts in 11 countries participating in IEA EBC Annex 62 (see Table 2) were asked to fill-in a questionnaire looking into which parameters influencing ventilative cooling are included in standards, legislation and compliance tools. Annex A (missing ventilative cooling aspects in standards), Annex B (missing ventilative cooling aspects in legislation) and Annex C (missing ventilative cooling aspects in compliance tools) of the report were used as background information for the answers found in the “standards”, “legislation” and “compliance tools” sections of this report.

The report reveals that ventilative cooling is not sufficiently integrated in standards, legislation and compliance tools. However, it also reveals that there is a broad field of evaluation methods for ventilative cooling, ranging from simple to detailed that can support a stronger integration of ventilative cooling in the near future.

Even though the benefits of ventilative are widely acknowledged, its use by e.g. designers or architects strongly depends on a few intertwined challenges:

- The adequate modelling of natural ventilation and especially of air flows
- The share of the energy used for cooling to provide summer comfort and avoid the overheating risk tends to become equivalent to the energy consumption for heating in winter, depending on the climate
- The adequate prediction of the expected "thermal comfort and cooling requirements", as well as the "energy performance" when using ventilative cooling in buildings (this could e.g. be based on Static models (e.g. Fanger PMV model) using mechanical ventilative cooling or on Adaptive models (e.g. adaptive comfort model)) using natural ventilative cooling

For an easier overview, the conclusions are split up into standards, legislation and compliance tools as seen below:

Standards and other technical documents:

There was generally a lack of ventilative cooling integration, in most of the evaluated countries e.g. United Kingdom, Belgium and China. In Japan, there is no legislation concerning ventilative cooling, but there will be an obligation to take into account an "energy saving standard" for residential buildings by the year 2020. The “Energy saving standard for residential buildings, 2015” takes into account the effect of cross ventilation.

Calculation of air flow rates in buildings should reflect the real conditions based on actual building physics and geometry. This allows for flexibility e.g. higher air change rates allowed in unoccupied rooms during night and lower when occupied. In conclusion, there was generally a lack of ventilative cooling integration, in existing and revised European standards regarding “system design” and “performance” aspects of ventilative cooling, and therefore new work items (NWI's) relevant to ventilative cooling applications were proposed in the European Committee for Standardization (CEN). These new work items were approved and have now started up under CEN/TC 156 in various working groups (already launched at the time of writing of this report).

To allow for ventilative cooling to be treated better in standards both at the design stage, where initial calculations of e.g. the natural forces are made as well as, at more detailed stages where more detailed calculations are needed, it is important that at least the following point is taken into account:

- The support of calculation methods that fairly treat natural ventilative cooling for the determination of air flow rates including e.g. the dynamics of varying ventilation and the effects of location, area and control of openings

Lastly it is also recommended to use the Key Performance Indicators used in the IEA EBC Annex 62 "Ventilative cooling design guide" for "Thermal comfort" (Percentage outsider range and the Degree hours criterion) and "Energy performance" (Cooling reduction requirement and the Ventilative cooling seasonal efficiency ratio.

Legislation:

Several countries have taken significant steps to better implement ventilative cooling, especially countries like Switzerland, Norway and Austria which allow hourly time steps for thermal comfort evaluations. This important decision generally allows for better inclusion of highly dynamic measures such as ventilative cooling. Also, e.g. Denmark has implemented an add-on module which supports the hourly approach for over-heating evaluation. This happens in a simplified module outside the monthly energy performance evaluation tool used in Denmark. This approach could potentially allow for a reasonable evaluation of the over-heating risk but is more difficult to be used in the energy performance evaluation.

Furthermore, in Switzerland, legislation provides a sufficient framework to consider ventilative cooling by referring to norm; SIA 180 for thermal protection which takes into account the resulting air conditioning energy consumption for the energy label.

To allow for ventilative cooling to be treated better in building performance evaluations in legislation, several parameters are necessary to be taken into account in the building regulation; it is thus important that at least the following point is considered:

- Assessment of overheating, e.g.:
    - Requirements to thermal comfort, including adaptive temperature sensation
    - Requirements to energy performance including cooling

Compliance tools:

Because of the dynamic nature of ventilative cooling, the recommendation is to implement hourly calculation time steps, instead of less precise monthly calculations, in more compliance tools for both thermal comfort and energy performance evaluations for a better support of adaptive comfort. The hourly calculations have the capability to predict the cooling loads in the building and hereby assess the overheating more precisely than the monthly calculations, which is crucial in many of the buildings nowadays.

To allow for ventilative cooling to be treated better in compliance tools evaluations, it is important that at least the following points are taken into account:

1. Assessment of increased air flows when efficient ventilative cooling systems are used:
    a. Differentiation should be made i.e. for cross- or stack ventilation vs. single-sided ventilation, automated systems vs. manual control, large vs. small opening areas
    b. Associated airflows should preferably be based on building physics for e.g. dynamic tools (using pressure equations) or - as a simpler solution - on “coefficients” which increase air flows based on the chosen system

Lastly it is important to evaluate if the current methodology for the evaluation of ventilative cooling in compliance tools is sufficient to assess overheating. In contrast to most European countries’- where compliance tools using the monthly average models for energy calculations can underestimate the cooling potential of Ventilative cooling - Denmark has been moving forward with the implementation of an additional feature to the official compliance tool to evaluate thermal comfort. The official compliance tool is based on monthly calculations, whereas the integrated module called "summer comfort" in the official compliance tool performs hourly calculations for thermal comfort in summer in residential buildings only. This method could be seen as an "intermediary" approach, in between the simplified monthly average models and the more dynamic hourly-based models. Although the "add-on" module method is a step forward, it is equally important that the calculated or allowed air change rates are high enough to actually achieve the needed cooling effect. Improvements in the "Danish" method are still needed - e.g. by ensuring the associated airflows are preferably based on building physics for e.g. dynamic tools (using pressure equations).

7. Annexes

This section describes in more detail the findings from this report. The Annexes are being referred to in the text. The annexes that follow include all the responses to the questionnaires provided by the different countries' representatives, evaluating how ventilative cooling is treated in EN standards, ISO standards, national standards, national legislation and national compliance tools by looking into what extent certain ventilative cooling parameters are integrated nationally (e.g. cross ventilation or which calculation time step is used).

The replies per county followed the same guidelines:

- If the scope did not necessarily cover certain parameters in the tables, "Not applicable" was inserted (i.e. not relevant in this document, nor necessarily excluded)
- If the scope covered the "field" of the parameter, but was not included in the document, "No" was inserted (or "Yes" otherwise)
- Finally, if there was a reference to a calculation method or method in the evaluated document, the reference of the standard/legislation/compliance tool was inserted.

7.1. Annex A (missing ventilative cooling aspects in standards)

This section compiles the replies from the countries regarding missing aspects concerning ventilative cooling found in EN standards, ISO standards and national standards e.g. by looking into which ventilative cooling aspects or parameters are included in standards.

7.1.1. A1: EN standards

Which EN standard(s) is relevant to ventilative cooling incl. short scope and type of document (system design/performance)?

- EN 15251:2007
  - How to establish optimal input parameters for building system design and energy performance calculations
  - The methods for long-term evaluation of the indoor environment obtained as a result of calculations or measurements
  - **Document type**: Performance (requirement)
- prEN 16798-1:2017 (revised EN 15251:2007, though not yet accepted in formal vote)
  - Deals with the indoor environmental parameters for thermal environment, indoor air quality, lighting and acoustic
  - Specifies how to establish indoor environmental input parameters for building system design and energy performance calculations

    - Includes design criteria for the local thermal discomfort factors, draught, radiant temperature asymmetry, vertical air temperature differences, floor surface temperature.
    - Does not prescribe design methods, but gives input parameters to the design of building envelope, heating, cooling, ventilation and lighting systems
    - **Document type**: Performance (requirement)
- EN 15665:2009 (upcoming revision)
    - Sets out criteria to assess the performance of residential ventilation systems (for new, existing and refurbished buildings) which serve single family, multi-family and apartment type dwellings through the year
    - These criteria are meant to be applied, in particular, to:
        - Window openings by manual operation for airing or summer comfort issues
        - Natural ventilation with stack effect of passive ducts
    - **Document type**: Performance (requirement)
- EN 16798-3:2017 (under revision)
    - Applies to the design, energy performance of buildings and implementation of ventilation, air conditioning and room conditioning systems for non-residential buildings subject to human occupancy, excluding applications like industrial processes. It focuses on the definitions of the various parameters that are relevant to such systems
    - Natural ventilation systems or natural parts of hybrid ventilation systems are not covered by this standard
    - **Document type**: System design
- CEN/TR 16798-4:2017 (Technical report to EN 16798-3:2017) (under revision)
    - Applies to the design and implementation of ventilation, air conditioning and room conditioning systems for non-residential buildings subject to human occupancy, excluding applications like industrial processes. It focuses on the definitions of the various parameters which are relevant to such systems
    - **Document type**: System design
- EN 16798-7:2017
    - This European Standard describes the methods to calculate the ventilation air flow rates for buildings to be used for energy calculations evaluation, heating and cooling loads.
    - This European Standard applies to buildings with one or more of the following characteristics:
        - Mechanical ventilation systems (mechanical exhaust, mechanical supply or balanced system)
        - Windows' openings (manual or automatic operation)
    - This European Standard is applicable to hybrid systems combining mechanical and passive duct ventilation systems in residential and low-rise non-residential buildings
    - **Document type**: Performance (calculation)
- EN ISO 52016-1:2017
    - This document specifies calculation methods for the assessment of:

        - The (sensible) energy need for heating and cooling, based on hourly or monthly calculations
        - The internal temperature, based on hourly calculations
        - The sensible heating and cooling load, based on hourly calculations
    - The calculation methods can be used for residential or non-residential buildings, or a part of it, referred to as "the building" or the "assessed object"
    - **Document type**: Performance (calculation)
- EN ISO 52017-1:2017
    - Specifies the general assumptions, boundary conditions and equations for the calculation under transient hourly or sub hourly conditions, of the internal temperatures (air and operative) and/or the heating, cooling and humidification and dehumidification loads to hold a specific (temperature, moisture) set point, in a single building zone
    - **Document type**: Performance (calculation)

How is the air flow rate determined for ventilative cooling in the EN standard(s)?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
    - EN 16798-7:2017: (simple single-sided ventilation method)
- More detailed calculation e.g. incl. window position and size in building (building design)
    - EN 16798-7:2017: (simple cross-ventilation method)

Are the effects of actual window position and geometry of the building included in the EN standard(s)? (E.g. orientation and height difference between windows in building?)

- EN 16798-7:2017: The window distribution has a significant impact on the calculated air flow rate obtained using the simple cross-ventilation method

State the name of the relevant EN standard concerning ventilative cooling and furthermore, indicate which parameters regarding ventilative cooling are included in the EN standard, below:

- e.g. EN 16798-7:2017

Table 4 - Ventilative cooling parameters in relevant European, EN standards for residential buildings

Parameters	**prEN 16798-1:2017 (in voting)**	**EN 16798-7:2017**	**EN 15665:2009 [1] & [3]**	**EN ISO 52016-1:2017**
Single-sided ventilation	Not applicable [1]	Yes	In scope yes, but No	Not applicable [2]
Cross ventilation	Not applicable [1]	Yes	In scope yes, but No	Not applicable [2]
Stack ventilation	Not applicable [1]	Yes	In scope yes, but No	Not applicable [2]

Night cooling	(Yes)	Yes	No	Yes
Free cooling	Yes	Yes	No	Yes
Hybrid systems	Yes	Yes	In scope yes, but No	Not applicable [2]
Position of windows in building	Yes	Yes	No	Not applicable [2]
Is wind included in your calculation?	Refers to EN 16798-7	Yes	Yes [4]	Not applicable [2]
Effect of having manual or automatic window operation	No	Not applicable [2]	No	Yes
Steady-state or dynamic calculation?	Refers to EN 16798-7	Steady state and dynamic calculation	(Yes) [4]	Steady state and dynamic calculation
Time-step (monthly or hourly)?	Refers to EN 16798-7	Monthly and hourly	Monthly and hourly [4]	Monthly and hourly
Indicate important issues not included in this table				

[1] = Performance requirement standard

[2] = Performance calculation standard

[3] = Upcoming revision in 2018

[4] = Refers to EN 15242:2007, doesn't directly deal with it, but seems to support both types

Table 5 - Ventilative cooling parameters in relevant European, EN standards for non-residential buildings

Parameters	**prEN 16798-1:2015**	**EN 16798-3:2017 [6]**	**CEN/TR 16798-4:2017 [7]**	
Single-sided ventilation	See above	Not applicable	Yes [8]	

Cross ventilation		Not applicable	Yes [8]	
Stack ventilation		Not applicable	Yes [8]	
Night cooling		Not applicable	Yes [8]	
Free cooling		Not applicable	Yes [8]	
Hybrid systems		Not applicable	Yes [8]	
Position of windows in building		Refers to CEN/TR 16798-4:2017 [5]	Yes	
Is wind included in your calculation?		Not applicable	Yes	
Effect of having manual or automatic window operation		Not applicable	Yes	
Steady-state or dynamic calculation?		Steady-state	Steady state and dynamic calculation	
Time-step (monthly or hourly)?		Monthly and hourly	Monthly and hourly	
Indicate important issues not included in this table				

[5] = Note in standard (voluntary)

[6] = Natural ventilation systems not part of scope. To be revised in 2018

[7] = An accompanying Technical Report to standard EN 16798-3; not an EN Standard, but part of the EPBD package explaining the contents of EN 16798-3. To be revised in 2018

[8] = Present in "informative Annex" of a Technical Report - undesirable place for important text to be located

7.1.2. A2: ISO standards

Table 6 - Ventilative cooling parameters in relevant ISO standards for residential buildings

Parameters	**ISO 13153:2012**	**ISO 7730:2005**		

Single-sided ventilation	Not applicable	No [9]		
Cross ventilation	Yes	No [9]		
Stack ventilation		No [9]		
Night cooling	Yes	No [9]		
Free cooling		No [9]		
Hybrid systems		No [9]		
Position of windows in building	Yes			
Is wind included in your calculation?	Yes			
Effect of having manual or automatic window operation				
Steady-state or dynamic calculation?	Dynamic calculation	Steady state		
Time-step (monthly or hourly)?	Hourly			
Indicate important issues not included in this table				

[9] Not applicable. This standard describes only the method of evaluating indoor thermal comfort (discomfort).

Table 7 - Ventilative cooling parameters in relevant ISO standards for non-residential buildings

Parameters	**ISO 13153:2012**	**ISO 7730:2005**		
Single-sided ventilation	Not applicable	No [10]		
Cross ventilation	Yes	No [10]		

Stack ventilation		No [10]		
Night cooling	Yes	No [10]		
Free cooling		No [10]		
Hybrid systems		No [10]		
Position of windows in building	Yes			
Is wind included in your calculation?	Yes			
Effect of having manual or automatic window operation				
Steady-state or dynamic calculation?	Dynamic calculation			
Time-step (monthly or hourly)?	Hourly			
Indicate important issues not included in this table				

[10] Not applicable. This standard describes only the method of evaluating indoor thermal comfort (discomfort).

7.1.3. A3: National standards

7.1.3.1. A3.1: Denmark (standards)

Which voluntary national standards/guidelines are relevant to ventilative cooling incl. short scope and type of document (system design/ performance)

- DS 447:2013 (Ventilation in buildings – Mechanical, natural and hybrid ventilation systems)
    - Specifies requirements to ventilation and ventilation systems in buildings, hereby residential buildings intended for human residence. The purpose of the standard is to ensure, that ventilation systems are organized, carried out and maintained in a technically and hygienically safe way, considering comfort and energy efficiency

How is the air flow rate determined for ventilative cooling in your national standards/guideline?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
  - Yes, DS 447:2013 (refers to simple manual calculation methods from EN 15242, which is now the updated EN 16798-7:2017)
- More detailed calculation e.g. incl. window position and size in building (building design)

Are the effects of actual window position and geometry of the building included in your national standards/guideline? (E.g. orientation and height difference between windows in building?)

- Yes, DS 447:2013 (refers both to EN 15242 (which is now the updated, EN 16798-7:2017), in which the window distribution has a significant impact on the calculated air flow rate obtained using the simple cross-ventilation method. Furthermore, for more SBI anvisning 202 is referred to for e.g. office buildings

State the name of relevant national standards/guidelines for your country and furthermore, indicate which parameters regarding ventilative cooling are included below:

Table 8 - Ventilative cooling parameters relevant to national standards/guidelines for residential buildings in Denmark

Parameters	**DS 447:2013**			
Single-sided ventilation	Yes			
Cross ventilation	Yes			
Stack ventilation	Yes			
Night cooling	Yes			
Free cooling	Yes			
Hybrid systems	Yes			
Position of windows in building	Yes			
Is wind included in your calculation?	Yes [11]			
Effect of having manual or automatic window operation	Yes			

Steady-state or dynamic calculation?	Steady state and dynamic calculation [11]			
Time-step (monthly or hourly)?	Monthly and hourly [11]			
Indicate important issues not included in this table				

[11] Note, in standard (voluntary): Refers to EN 16798-7:2017 and DS/EN ISO 13791 (Annex J)

Table 9 - Ventilative cooling parameters relevant to national standards/guidelines for non-residential buildings in Denmark

Parameters	**DS 447:2013**			
Single-sided ventilation	Yes			
Cross ventilation	Yes			
Stack ventilation	Yes			
Night cooling	Yes			
Free cooling	Yes			
Hybrid systems	Yes			
Position of windows in building	Yes			
Is wind included in your calculation?	Yes [12]			
Effect of having manual or automatic window operation	Yes			
Steady-state or dynamic calculation?	Steady state and dynamic calculation [12]			

Time-step (monthly or hourly)?	Monthly and hourly [12]			
Indicate important issues not included in this table				

[12] Note in standard (voluntary): Refers to SBi 202 (Danish document on “recommended practices” - e.g. used as basis for national compliance tool)

7.1.3.2. A3.2: Italy (standards)

Which voluntary national standards/guidelines are relevant to ventilative cooling incl. short scope and type of document (system design/performance)?

Energy Performance calculation methodologies refer to the National Standard UNI TS 11300, which is a national implementation of the European Standard EN ISO 13790:2008. Minimum ventilation requirements are calculated according to UNI 10339, currently under review.

How is the air flow rate determined for ventilative cooling in your national standards/guidelines?

- Fixed ACH [*]? (if, yes - what is it?)
    - Yes, for residential buildings only (0.3 ACH)
- Simple calculation e.g. excl. building design
    - According to UNI 10339
- More detailed calculation e.g. incl. window position and size in building (building design)

Are the effects of actual window position and geometry of the building included in your national standards/guidelines? (E.g. orientation and height difference between windows in building?)

State the name of relevant national standards/guidelines for your country and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 10 - Ventilative cooling parameters relevant to national standards/guidelines for residential buildings in Italy

Parameters	**National standard UNI TS 11300/1**			
Single-sided ventilation	In case of natural ventilation, airflow is assumed as 0.5			

	ACH (0.3 in former version)			
Cross ventilation	In case of natural ventilation, airflow is assumed as 0.5 ACH (0.3 in former version)			
Stack ventilation	In case of natural ventilation, airflow is assumed as 0.5 ACH (0.3 in former version)			
Night cooling	Can occur only if there is mechanical ventilation and it is evaluated according to section 9.4.3 of UNI EN ISO 13790:2008. Night free cooling may refer to UNI EN 15232:2012			
Free cooling	Same as night cooling			
Hybrid systems	No			
Position of windows in building	No			
Is wind included in your calculation?	No			
Effect of having manual or automatic window operation	No			
Steady-state or dynamic calculation?	Steady-state			

Time-step (monthly or hourly)?	Monthly			
Indicate important issues not included in this table				

Table 11 - Ventilative cooling parameters relevant to national standards/guidelines for non-residential buildings in Italy

Parameters	**National standard UNI TS 1300/1**	**National standard UNI TS 11300/1 for industrial and artisanal activities (E.8)**		
Single-sided ventilation	In case of natural ventilation, airflow is calculated as in UNI 10339	In case of natural ventilation, airflow is assumed as 0.5 ACH		
Cross ventilation	In case of natural ventilation, airflow is calculated as in UNI 10339	In case of natural ventilation, airflow is assumed as 0.5 ACH		
Stack ventilation	In case of natural ventilation, airflow is calculated as in UNI 10339	In case of natural ventilation, airflow is assumed as 0.5 ACH		
Night cooling	Can occur only if there is mechanical ventilation and it is evaluated according to section 9.4.3 of UNI EN ISO 13790:2008. Night free cooling may refer to UNI EN 15232:2012	Can occur only if there is mechanical ventilation and it is evaluated according to section 9.4.3 of UNI EN ISO 13790:2008. Night free cooling may refer to UNI EN 15232:2012		

Free cooling	Same as night cooling	Same as night cooling		
Hybrid systems	No	No		
Position of windows in building	No	No		
Is wind included in your calculation?	No	No		
Effect of having manual or automatic window operation	No	No		
Steady-state or dynamic calculation?	Steady-state	Steady-state		
Time-step (monthly or hourly)?	Monthly	Monthly		
Indicate important issues not included in this table				

7.1.3.3. A3.3: Switzerland (standards)

Which voluntary national standards/guidelines are relevant to ventilative cooling incl. short scope and type of document (system design/performance)?

- SIA 180 for thermal protection
    - This norm imposes the minimum conditions assuring sufficient thermal protection and thermal comfort in summer and determines if the use of air conditioning is justified
- SIA 382/1
    - This norm indicates how an air conditioning system should be designed.

Are the effects of actual window position and geometry of the building included in your national standards/guidelines? (E.g. orientation and height difference between windows in building?)

- Only the width and height of the window.

State the name of relevant national standards/guidelines for your country and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 12 - Ventilative cooling parameters relevant to national standards/guidelines for residential buildings in Switzerland

Parameters	**National standard SIA 180**			
Single-sided ventilation	Yes			
Cross ventilation	No (as single sided)			
Stack ventilation	Yes			
Night cooling	Yes			
Free cooling	Yes			
Hybrid systems	Yes			
Position of windows in building	No (single zone)			
Is wind included in your calculation?	No			
Effect of having manual or automatic window operation	No			
Steady-state or dynamic calculation?	No			
Time-step (monthly or hourly)?	Hourly			
Indicate important issues not included in this table	One set of boundary conditions for thermal protection and one for comfort.			

Table 13 - Ventilative cooling parameters relevant to national standards/guidelines for non-residential buildings in Switzerland

Parameters	**National standard SIA 180**			
Single-sided ventilation	Yes			
Cross ventilation	No (as single sided)			
Stack ventilation	Yes			
Night cooling	Yes			
Free cooling	Yes			
Hybrid systems	Yes			
Position of windows in building	No (single zone)			
Is wind included in your calculation?	No			
Effect of having manual or automatic window operation	No			
Steady-state or dynamic calculation?	No			
Time-step (monthly or hourly)?	Hourly			
Indicate important issues not included in this table				

7.1.3.4. A3.4: Australia (standards)

Which voluntary national standards/guidelines are relevant to ventilative cooling incl. short scope and type of document (system design/performance)? * *see introduction for system design/performance*

- Voluntary (only for commercial, mandatory over 1000 m^2):
    - Nabers (Rating scheme)
- Mandatory:

- AS 1668.2 - The use of ventilation and air conditioning in buildings -Mechanical ventilation in buildings
- AS 1668.4 - The use of ventilation and air conditioning in buildings - Natural ventilation of buildings

How is the air flow rate determined for ventilative cooling in your national standards/guidelines?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
  - For mechanical ventilation is either a function of the ventilated area or of the number of people occupying the space; for natural ventilation, the size of the opening is a fraction of the ventilated area)
- More detailed calculation e.g. incl. window position and size in building (building design)

Are the effects of actual window position and geometry of the building included in your national standards/guideline? (E.g. orientation and height difference between windows in building?)

- No

State the name of relevant national standards/guidelines for your country and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 14 - Ventilative cooling parameters relevant to national standards/guidelines for residential buildings in Australia

Parameters	**AS 1668.4**	**AS 1668.2**		
Single-sided ventilation	Yes	Not applicable		
Cross ventilation	Only window sizing for borrowed ventilation	Not applicable		
Stack ventilation	No	Not applicable		
Night cooling	No	Not applicable		
Free cooling	No	Only states that mechanical systems should have an economy mode		
Hybrid systems	No	Not applicable		
Position of windows in building	Yes	Not applicable		

Is wind included in your calculation?	No	Not applicable		
Effect of having manual or automatic window operation	No	Not applicable		
Steady-state or dynamic calculation?	Percentage of floor area	Not applicable		
Time-step (monthly or hourly)?	Not applicable	Not applicable		
Indicate important issues not included in this table		Only indicates a minimum fresh air flowrate		

Table 15 - Ventilative cooling parameters relevant to national standards/guidelines for non-residential buildings in Australia

Parameters	**AS 1668.4**	**AS 1668.2**	**Nabers (Rating scheme)**	
Single-sided ventilation	Yes	Not applicable	Not applicable	
Cross ventilation	Only window sizing for borrowed ventilation	Not applicable	Not applicable	
Stack ventilation	No	Not applicable	Not applicable	
Night cooling	No	Not applicable	Not applicable	
Free cooling	No	Only states that mechanical systems should have an economy mode	Not applicable	
Hybrid systems	No	Not applicable	Not applicable	
Position of windows in building	Yes	Not applicable	Not applicable	

Is wind included in your calculation?	No	Not applicable	Not applicable	
Effect of having manual or automatic window operation	No	Not applicable	Not applicable	
Steady-state or dynamic calculation?	Percentage of floor area	Not applicable	Not applicable	
Time-step (monthly or hourly)?	Not applicable	Not applicable	Not applicable	
Indicate important issues not included in this table		Only indicates a minimum fresh air flowrate	Rating tool (after building completion) that does not consider ventilative cooling	

7.1.3.5. A3.5: United Kingdom (standards)

Which voluntary national standards/guidelines are relevant to ventilative cooling incl. short scope and type of document (system design/performance)?

- *Guideline:* CIBSE TM59, Design methodology for the assessment of overheating risk in homes
- *Guideline:* CIBSE AM10, Natural Ventilation for non-domestic buildings (currently under revision)

How is the air flow rate determined for ventilative cooling in your national standards/guidelines?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
- More detailed calculation e.g. incl. window position and size in building (building design)
  - Yes, to this option

Are the effects of actual window position and geometry of the building included in your national standards/guidelines? (E.g. orientation and height difference between windows in building?)

- Yes, it is specified for domestic dynamic simulations, for non-domestic the driving forces for natural ventilation are calculated - this requires position, orientation (relative to wind) and area of openings.

State the name of relevant national standards/guidelines for your country and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 16 - Ventilative cooling parameters relevant to national standards/guidelines for residential buildings in United Kingdom

Parameters	**Guideline - CIBSE** (TM59 Design methodology for the assessment of overheating risk in homes)			
Single-sided ventilation	Yes			
Cross ventilation	Yes			
Stack ventilation	Yes			
Night cooling	Yes			
Free cooling	Yes			
Hybrid systems	Yes			
Position of windows in building	Yes			
Is wind included in your calculation?	Yes			
Effect of having manual or automatic window operation	Yes			
Steady-state or dynamic calculation?	Dynamic			
Time-step (monthly or hourly)?	Hourly			
Indicate important issues not included in this table				

Table 17 - Ventilative cooling parameters relevant to national standards/guidelines for non-residential buildings in United Kingdom

Parameters	**Guideline - BB101** (Guidelines on ventilation, thermal comfort and indoor air quality in schools)	**Guideline - CIBSE AM10:2005** (Natural Ventilation for non-domestic buildings) - currently under revision		
Single-sided ventilation	Yes	Yes		
Cross ventilation	Yes	Yes		
Stack ventilation	Yes	Yes		
Night cooling	Yes	Yes		
Free cooling	Yes	Yes		
Hybrid systems	Yes	Yes		
Position of windows in building	Yes	Yes		
Is wind included in your calculation?	Yes	Yes		
Effect of having manual or automatic window operation	Yes			
Steady-state or dynamic calculation?	Dynamic as it refers to National Calculation Methods.	Steady state		
Time-step (monthly or hourly)?	Hourly			
Indicate important issues not included in this table		The guideline is mainly concerned with ventilation for IAQ. Thermal mass is not considered in the calculation.		

7.1.3.6. A3.6: Norway (standards)

Which voluntary national standards/guidelines are relevant to ventilative cooling incl. short scope and type of document (system design/performance)?

- NS 3031 Calculation of energy performance of buildings. Method and data:
    - The standard includes three calculation options:
        - Monthly calculation (stationary method) according to NS-EN ISO 13790
        - Simplified time calculation (dynamic method) according to NS-EN ISO 13790
        - Detailed calculation programmes (dynamic method) validated according to NS-EN 15265
    - Only monthly calculation is described in detail in this standard. For dynamic calculation methods refer to NS-EN ISO 13790 or validated calculation programmes.
    - The standard includes inputs that will be used for calculation against public requirements. The values have been prepared for documentation of regulations and do not represent real conditions.
    - The standard contains common determinations and inputs to be used for all three of the above calculation methods.
    - NS 3031 can be used to:
        - Evaluate whether the building meets the energy requirements given in the Regulations
        - Document theoretical energy requirements for energy certificates for buildings
        - Show a typical level of existing buildings' energy needs and document the theoretical energy performance of a building in connection with energy certification
        - Optimize the energy performance of a new building using the method of alternative solutions or specified conditions of use
        - Assess the impact of possible energy measures on existing buildings by calculating energy demand with and without energy measures, both with regard to reduced energy consumption, CO_2 emissions and reduced energy costs
    - The standard complements and complies with the rules and methods contained in the European Building Energy Directive (European Parliament and Council Directive 2002/91/EC on energy performance of buildings), giving the user, the necessary choices and calculation data as provided for in the European standards.
    - There is also a supplement to NS3031 for more comprehensive energy calculations for buildings and energy supply systems: SN/TS 3031:2016.
- NS-EN 15251:2007+NA: 2014 as described in Chapter 2.1.3 but for Norway applies: Incorporated in this standard is National Annex NS-EN 15251:2007/NA: 2014.

How is the air flow rate determined for ventilative cooling in your national standards/guidelines?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
- More detailed calculation e.g. incl. window position and size in building (building design)

- Cooling demand for space cooling and cooling by ventilation air could be calculated by a dynamic method with time steps of one hour or shorter, according to NS 3031. The method will take advantage of ventilative cooling, either mechanical by fans or natural. NS 3031 is mandatory for calculation of buildings' energy performance.

Are the effects of actual window position and geometry of the building included in your national standards/guidelines? (E.g. orientation and height difference between windows in building?)

- It is not specifically mentioned, but a correct calculation according to NS 3031 is for certain conditions necessary to divide the building into two or more zones. This will indirectly take window position into consideration.

State the name of relevant national standards/guidelines for your country and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 18 - Ventilative cooling parameters relevant to national standards/guidelines for residential buildings in Norway

Parameters	**NS-EN 3031:2014**	**SN/TS 3031:2016**		
Single-sided ventilation	Yes [13]	Yes [13]		
Cross ventilation				
Stack ventilation				
Night cooling	Yes	Yes		
Free cooling	Yes	Yes		
Hybrid systems	Yes	Yes		
Position of windows in building	(Yes) [14]	(Yes) [14]		
Is wind included in your calculation?				
Effect of having manual or automatic window operation				
Steady-state or dynamic calculation?	Both is possible	Dynamic		
Time-step (monthly or hourly)?	Both is possible	Hourly		

Indicate important issues not included in this table				

[13] Not explicitly described as single sided, only as part of ventilation

[14] Only for heat gain, not for ventilation

Table 19 - Ventilative cooling parameters relevant to national standards/guidelines for non-residential buildings in Norway

Parameters	**NS-EN 3031:2014**	**SN/TS 3031:2016**		
Single-sided ventilation	Yes [15]	Yes [15]		
Cross ventilation				
Stack ventilation				
Night cooling	Yes	Yes		
Free cooling	Yes	Yes		
Hybrid systems	Yes	Yes		
Position of windows in building	(Yes) [16]	(Yes) [16]		
Is wind included in your calculation?				
Effect of having manual or automatic window operation				
Steady-state or dynamic calculation?	Both is possible	Dynamic		
Time-step (monthly or hourly)?	Both is possible	Hourly		

Indicate important issues not included in this table				

[15] Not explicitly described as single sided, only as part of ventilation

[16] Only for heat gain, not for ventilation

7.1.3.7. A3.7: Austria (standards)

Which voluntary national standards/guidelines are relevant to ventilative cooling incl. short scope and type of document (system design/performance)?

- For calculating thermal summer comfort and/or overheating risk of rooms without technical cooling, there's ÖNORM B 8110-3. Its algorithms are closely linked to ISO 13791 and ISO 13792.
- For ventilation in non-residential buildings there is ÖNORM EN 13779.

How is the air flow rate determined for ventilative cooling in your national standards/guidelines?

- In ÖNORM 8110-3, valid for thermal summer comfort analysis in non-cooled-homes, ACH is calculated hourly from opening area, temperature difference and stack effect. No wind effect may be taken into account.
- In ÖNORM B 8110-6, valid for energy demand calculations according to the EPBD, night ventilation may only be taken into account at a fixed ACH of 1,5 h^{-1}.

Are the effects of actual window position and geometry of the building included in your national standards/guideline? (E.g. orientation and height difference between windows in building?)

- See above: Regarding thermal summer comfort in free running rooms: No, to orientation, since wind effects are excluded. Yes, to height differences between windows in buildings. Regarding energy demand reduction from Night Ventilation: No

State the name of relevant national standards/guideline for your country and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 20 - Ventilative cooling parameters relevant in national standards/guidelines in Austria

Parameters	**ÖNORM B 8110-3 summer overheating prevention in free running rooms**	**ÖNORM B 8110-6 annual cooling demand**	
Single-sided ventilation	Yes	No, but fixed ACH 1,5 h^{-1}	
Cross ventilation	No	No, but fixed ACH 1,5 h^{-1}	
Stack ventilation	Yes	No, but fixed ACH 1,5 h^{-1}	

Night cooling	Yes	Yes, at fixed ACH 1,5 h^{-1}	
Free cooling	No	No	
Hybrid systems	No	No	
Position of windows in building	Yes, as regards to height	No, but fixed ACH 1,5 h^{-1}	
Is wind included in your calculation?	No	No	
Effect of having manual or automatic window operation	No	No	
Steady-state or dynamic calculation?	Dynamic, limited to one design day	Steady-state	
Time-step (monthly or hourly)?	Hourly	Monthly	
Indicate important issues not included in this table			

7.1.3.8. A3.8: Belgium (standards)

Which voluntary national standards/guidelines are relevant for ventilative cooling incl. short scope and type of document (system design/performance)?

- NBN D50-001: national standard with requirements for ventilation in residential buildings
  - There is one paragraph about intensive ventilation which is not required in the legislation. Opening area for windows is advised as function of the floor area of the dwelling.
  - No differentiation is made between single-sided and cross ventilation.
- NBN EN 13779: standard about ventilation in non-residential buildings

How is the air flow rate determined for ventilative cooling in your national standards/guideline?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
  - In Belgium, it is not the air flow rate that is defined, but the minimum openable area (windows, doors). This minimum openable area is determined by a simple Calculation
- More detailed calculation e.g. incl. window position and size in building (building design)

Are the effects of actual window position and geometry of the building included in your national standards/guidelines? (E.g. orientation and height difference between windows in building?)

- No

State the name of relevant national standards/guidelines for your country and furthermore, indicate which parameters regarding ventilative cooling are included, below:

- See above.
- The filled in tables correspond to
- the Belgian national legislation, see Table 37 and Table 38

7.1.3.9. A3.9: Ireland (standards)

State the name of relevant national standards/guidelines for your country and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 21 - Ventilative cooling parameters relevant to national standards/guidelines for residential buildings in Ireland

Parameters	**Guideline - CIBSE** (TM59 Design methodology for the assessment of overheating risk in homes)			
Single-sided ventilation	Yes			
Cross ventilation	Yes			
Stack ventilation	Yes			
Night cooling	Yes			
Free cooling	Yes			
Hybrid systems	Yes			
Position of windows in building	Yes			
Is wind included in your calculation?	Yes			
Effect of having manual or automatic window operation	Yes			
Steady-state or dynamic calculation?	Dynamic			

Time-step (monthly or hourly)?	Hourly			
Indicate important issues not included in this table				

Table 22 - Ventilative cooling parameters relevant to national standards/guidelines for non-residential buildings in Ireland

Parameters	**Guideline - CIBSE AM10** (Natural Ventilation for non-domestic buildings (currently under revision))			
Single-sided ventilation	Yes			
Cross ventilation	Yes			
Stack ventilation	Yes			
Night cooling	Yes			
Free cooling	Yes			
Hybrid systems	Yes			
Position of windows in building	Yes			
Is wind included in your calculation?	Yes			
Effect of having manual or automatic window operation				
Steady-state or dynamic calculation?	Steady state			
Time-step (monthly or hourly)?				

Indicate important issues not included in this table	The guideline is mainly concerned with ventilation for IAQ. Thermal mass is not considered in the calculation.			

7.2. Annex B (missing ventilative cooling aspects in legislation)

This section compiles the replies from the countries regarding the missing aspects found in National or regional legislation concerning ventilative cooling e.g. by looking into which ventilative cooling aspects or parameters are included in national or regional legislation.

7.2.1. B1: Italy (legislation)

Since when is the current national building legislation enforced?

- 1991: implementation of National Energy Plan on energy saving and renewable in buildings
- 2005: EPBD implementation (D.Lgs. n. 192, 2005 modified and integrated by D.Lgs. n. 311/2006)
- 2008: implementation of directive 2006/32/EC (D.Lgs. n. 115/2008)
- 2009: national guidelines on energy performance certificates (D.P.R. n. 59/2009 and D.M. 26 June 2009)
- 2011: Renewable Energy Directive implementation (D.Lgs. n. 28/2011) including mandatory integration of renewable energy in Buildings
- 2013: EPBD2 implementation by D.L. n. 63/2013 and L. n. 90/2013, (fully integrated into Italian legislation in 2015): introduction of energy efficiency checks, verifications and inspections on heating/cooling systems, of a 'Net-Zero Building' concept, stricter requirement for minimum energy performance; new definition of EPC (layout, indicators, harmonization of regional EPC and establishment of a national information system)
- 2014: 2012/27/EC directive implementation (D.Lgs. n. 102/2014), including a national strategy for energy renovation of the building stock and policies for public buildings
- 2015: published three decrees to update the energy performance calculation method, the national guidelines for the energy performance certificates and for project technical reports

When is the next revision of your national building legislation?

- Don't know

Which changes has there been (if any) in your national building legislation since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))

- Nothing changed

How is the air flow rate determined for ventilative cooling in your national building legislation/guidelines?

- Fixed ACH [*]? (if, yes - what is it?)
  - Energy performance of buildings is calculated assuming fixed ACH, which is 0.5 ACH in case of natural ventilation (in former UNI TS 11300-1 version it was 0.3 ACH)
- Simple calculation e.g. excl. building design
- More detailed calculation e.g. incl. window position and size in building (building design)

Which standards/guidelines are referred to in your national building legislation/guidelines (if relevant incl. short scope)?

- Energy Performance calculation methodologies refer to the National Standard UNI TS 11300, which is a national implementation of the European Standard EN ISO 13790:2008.
- Regional calculation methodologies refer almost entirely to the National Standard, while only Lombardy and the Autonomous Province of Bolzano adopted standards derived directly from the EN ISO 13790:2008.

Are the effects of actual window position and geometry of the building included in your national building legislation/guideline? (E.g. orientation and height difference between windows in building?)

- No

State the name of your national legislation/guideline and furthermore, indicate which parameters regarding ventilative cooling are included, below:

- In Italy, no legislation explicitly tackles ventilation requirements.

7.2.2. B2: Denmark (legislation)

Since when is the current national building legislation enforced?

- The recent Building Regulation (BR15) was published 01.07.2017.

When is the next revision of your national building legislation?

- It is expected certainly in 2020 however earlier updates are possible.

Which changes has there been (if any) in your national building legislation since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- Several changes have been incorporated between 2015 and recent version from July 2017, however none of them influence Ventilative Cooling
- Changes can be found at:
    - https://www.trafikstyrelsen.dk/DA/Presse/Nyhedsarkiv/Byggeri/2017/04/Horing-over-udkast-til-aendring-af-bygningsreglement-2015.aspx

How is the air flow rate determined for ventilative cooling in your national building legislation/guideline?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
- More detailed calculation e.g. incl. window position and size in building (building design)

<u>Residential buildings</u>

- In residential buildings air flow rate is determined as minimum air flow pr. heated floor area. The fresh air flow rate must not be lower than 0.3 l/sm^2 heated floor area and can be provided by natural, mechanical or hybrid system.
- Demand controlled ventilation may be used provided that the fresh air supply by this means will not be lower than 0.3 l/s per m².
- Kitchens, bathrooms, toilets/sanitary rooms, must be provided with extraction capacity, correspondingly at: 20, 15 and 10 l/s, which are irrespective to their floor area.

Day-care institutions

- Must be ventilated with systems that have inlet out exhaust and are equipped heat recovery with preheat possibility.
- Minimum air flow is given as sum of air flow per child/adult and square meter of heated floor area.
- Minimum supply is at 3 l/s per child, 5 l/s per adult and 0.35 l/s per heated floor area.
- If a ventilation system with demand-controlled ventilation is used, the specified air volumes may be deviated from when demand is reduced. The ventilation during the hours of use may, however, not be less than 0.35 l/s per m² floor area.

Schools and rooms for teaching

- Must be ventilated with systems that have inlet out exhaust and are equipped heat recovery with preheat possibility.
- Minimum air flow is given as sum of air flow per child/adult and m^2 of heated floor area.
- Minimum supply is at 3 l/s per child, 5 l/s per adult and 0.35 l/s per heated floor area.
- If a ventilation system with demand-controlled ventilation is used, the specified air volumes may be deviated from when demand is reduced. The ventilation during the hours of use may, however, not be less than 0.35 l/s per m² floor area.

Which standards/guidelines are referred to in your national building legislation/guideline (if relevant incl. short scope)?

- DS 447- Ventilation in buildings – mechanical, natural and hybrid ventilation systems.
- DS/EN ISO 7730 – Ergonomics of the thermal environment -- Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria
- DS 428 Code of practice for technical measures for fire protection in ventilation systems
- Ventilation systems with forced air supply and extraction must comply with the requirements for heat recovery set out in EU Regulation No 1253/201

Are the effects of actual window position and geometry of the building included in your national building legislation/guideline? (E.g. orientation and height difference between windows in building?)

- No, it is not reflected in the Building Regulations directly but in the guideline for Building Regulations for single family houses that may be only natural ventilated following can be found:

- "Single-family houses which include holiday homes, semi-detached, terraced, cluster, linked houses etc., are buildings comprising one dwelling, where separation is not achieved by horizontal party walls.
- Natural ventilation functions by air being supplied via valves in external walls and removed via natural stack effect through exhaust ducts from kitchens and bathrooms/WC above the roof. Supply of fresh air in habitable rooms: Opening window, hatch or external door and one or more fresh air vents with a total unobstructed opening of no less than 60 cm^2 per 25 m^2 room floor area. The opening area to the external air may be determined on the basis of ventilation engineering calculations. Supply of fresh air in kitchens: Opening of no less than 100 cm^2 onto an access space and an opening window, hatch or external door. Supply of fresh air in bathrooms and sanitary accommodations: Opening of no less than 100 cm^2 onto an access space. In addition, if the room comprises an external wall, it must have an opening window, hatch or external door. Removal of indoor air in bathrooms and sanitary accommodations: Exhaust duct with a cross section of no less than 200 cm^2
- Supply of fresh air in basements: Supply of fresh air through one or more fresh air vents. Removal of indoor air in basements: Removal of indoor air from at least one basement room via an exhaust duct with a cross section of no less than 200 cm^2."

State the name of your national legislation/guideline and furthermore, indicate which parameters regarding ventilative cooling are included, below:

- Legislative document is Building Regulation from 01.07.2017
- In Denmark, regional legislation does not exist. It is only legislation at national level that applies
- Guideline of Building Regulation document is SBi Anvisning 258. This document explains "how to read" the Building Regulations

Table 23 – Ventilative cooling parameters in legislation and or/guidelines for residential buildings in Denmark

Parameters	**Danish legislation, BR15**	**SBi 213 guideline** (to compliance calculation)	
Single-sided ventilation	No	Yes. Opening area to floor area ratio is taken into account when determining airflow.	
Cross ventilation	No	Yes. Opening area to floor area ratio is taken into account when determining airflow.	
Stack ventilation	No	No	
Night cooling	No	Yes	

Free cooling	No	Yes	
Hybrid systems	No	Yes - simplified	
Position of windows in building	No	No	
Is wind included in your calculation?	No	No	
Effect of having manual or automatic window operation	No	Yes - simplified	
Steady-state or dynamic calculation?	Thermal comfort may be documented by simplified dynamic calculation [17]	Steady state calculation for energy compliance [18]. Simplified hourly calculation for thermal comfort.	
Time-step (monthly or hourly)?	Comfort: hourly calculation Energy performance: monthly calculation	Monthly for energy calculation. Hourly for simplified thermal comfort.	
Indicate important issues not included in this table	Question if legislation directly address Ventilative Cooling or cooling by means of air. For Danish case the answer would be No		

[17] For buildings where windows can be opened to create ventilation, the provision is usually observed when, by calculation, it can be documented that the indoor temperature exceeds 27°C for no more than 100 hours per year and for no more than 25 hours per year, the temperature exceeds 28°C.Documentation of the thermal indoor climate must be based on a simulation of conditions in the critical room based on Design Reference Year, DRY 2013. For dwellings, documentation may be made based on simplified calculations.

[18] Compliance tool Be18 calculation

Table 24 – Ventilative cooling parameters in legislation and or/guideline for non-residential buildings in Denmark

Parameters	**Danish legislation, BR15**	**SBi 213 guideline** (to compliance calculation)	
Single-sided ventilation	No	Yes. Opening area to floor area ratio is taken into account when determining airflow	
Cross ventilation	No	Yes. Opening area to floor area ratio is taken into account when determining airflow	
Stack ventilation	No	No	
Night cooling	No	Yes	
Free cooling	No	Yes	
Hybrid systems	No	Yes - simplified	
Position of windows in building	No	No	
Is wind included in your calculation?	No	No	
Effect of having manual or automatic window operation	No	Yes - simplified	
Steady-state or dynamic calculation?	Thermal comfort to be documented by dynamic calculation [19] Energy performance is documented through steady-state calculation [20]	Steady state calculation for energy compliance. Simplified hourly calculation for thermal comfort **must not be used for non-residential buildings**	
Time-step (monthly or hourly)?	Comfort: hourly calculation	Monthly for energy calculation.	

	Energy performance: monthly	Hourly for simplified thermal comfort	
Indicate important issues not included in this table	Question if legislation directly address Ventilative Cooling or cooling by means of air. For Danish case the answer would be No		

[19] For buildings other than dwellings, the client determines the maximum number of hours per year during which an indoor temperature of 26°C and 27°C, respectively, may be exceeded. Documentation of the thermal indoor climate must be based on a simulation of conditions in the critical room based on Design Reference Year, DRY 2013

[20] Compliance tool Be18 calculation

7.2.3. B3: United Kingdom (legislation)

Since when is the current national building legislation enforced?

- Latest revision of Part L (conservation of fuel and power) was in 2013 (with some amendments in 2016) and of Part F (ventilation) was in 2013

When is the next revision of your national building legislation?

- In a cycle of 5 years

Which changes has there been (if any) in your national building legislation since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- No technical changes, some explanatory amendments in 2016 because of the withdrawal of some paragraphs

How is the air flow rate determined for ventilative cooling in your national building legislation/guideline?

- Fixed ACH [*]? (if, yes - what is it?)
    - Purge ventilation is specified for IAQ – no ventilative cooling guideline is included in the regulations
- Simple calculation e.g. excl. building design
- More detailed calculation e.g. incl. window position and size in building (building design)
    - It is considered in the design to achieve the Target CO_2 Emission Rate (TER) and is included in the National Calculation Method (NCM) for buildings other than dwelling and Standard Assessment Procedure (SAP) for dwellings

Which standards/guidelines are referred to in your national building legislation/guideline (if relevant incl. short scope)?

- Find attached at the end of this section. Apart from reference to relevant BS, reference to CIBSE AM10 and AM13, CIBSE Guide A and Building Bulletin 101 is particularly relevant to ventilative cooling

Are the effects of actual window position and geometry of the building included in your national building legislation/guideline? (E.g. orientation and height difference between windows in building?)

- Yes, in particular for dwellings

State the name of your national legislation/guideline and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 25 – Ventilative cooling parameters in legislation and or/guideline for residential buildings in United Kingdom

Parameters	**National legislation: Part F (England and Wales)**		
Single-sided ventilation	Yes		
Cross ventilation	Yes		
Stack ventilation	Yes		
Night cooling			
Free cooling	Yes (purge ventilation)		
Hybrid systems	Yes		
Position of windows in building	Yes		
Is wind included in your calculation?			
Effect of having manual or automatic window operation			
Steady-state or dynamic calculation?	Steady state		
Time-step (monthly or hourly)?	Monthly		

Indicate important issues not included in this table	Ventilative cooling, the regulation is mainly concerned with IAQ. SAP (CO_2 emissions regulation) does not treat ventilative cooling		

Table 26 – Ventilative cooling parameters in legislation and or/guideline for non-residential buildings in United Kingdom

Parameters	**National legislation Part F and L (England and Wales), National Calculation Method**		
Single-sided ventilation	Yes		
Cross ventilation	Yes		
Stack ventilation	Yes		
Night cooling	Yes		
Free cooling	Yes (purge ventilation)		
Hybrid systems	Yes		
Position of windows in building	Yes		
Is wind included in your calculation?	Yes		
Effect of having manual or automatic window operation	Yes		
Steady-state or dynamic calculation?	Steady state in NCM, Dynamic in approved tools		
Time-step (monthly or hourly)?	Monthly, Hourly		
Indicate important issues not included in this table			

Please see below in Figure 5 for references on standards referred to in Approved document part F (Building Regulation for England and Wales).

F1

Section 8: Standards and other publications

Standards

BS EN 378-3:2008 *Refrigerating systems and heat pumps. Safety and environmental requirements. Installation site and personal protection.*

BSI PD CR 1752:1999 *Ventilation for buildings – design criteria for the indoor environment.*

BS 5502:2003 *Buildings and structures for agriculture. Various relevant parts including: Part 33:1991 Guide to the control of odour pollution,* AMD 10014 1998. *Part 52:1991 Code of practice for design of alarm systems, emergency ventilation and smoke ventilation for livestock housing*, AMD 10014 1998.

BS 5454:2000 *Recommendations for the storage and exhibition of archival documents.*

BS 5925:1991 *Code of practice for ventilation principles and designing for natural ventilation.* AMD 8930 1995.

BS 7913:1998 *Principles of the conservation of historic buildings.*

BS EN 13141-1:2004 *Ventilation for buildings. Performance testing of components/products for residential ventilation. Externally and internally mounted air transfer devices.*

BS EN 13141-3:2004 *Ventilation for buildings. Performance testing of components/products for residential ventilation. Range hoods for residential use.*

BS EN 13141-4:2004 *Ventilation for buildings. Performance testing of components/products for residential ventilation. Fans used in residential ventilation systems.*

BS EN 13141-6:2004 *Ventilation for buildings. Performance testing of components/products for residential ventilation. Exhaust ventilation system packages used in a single dwelling.*

BS EN 13141-7:2004 *Ventilation for buildings. Performance testing of components/products for residential ventilation. Performance testing of a mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwellings.*

BS EN 13141-8:2006 *Ventilation for buildings. Performance testing of components/products for residential ventilation. Performance testing of unducted mechanical supply and exhaust ventilation units [including heat recovery] for mechanical ventilation systems intended for a single room.*

BS EN 13986:2004 *Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking.*

Other publications

American Conference of Government Industrial Hygienists (ACGIH)
Industrial ventilation 26th Edition, *Manual of recommended practice.*
Available from: www.acgih.org/store

BRE

BRE Digest 464, Part 1: *VOC emissions from building products. Sources, testing and emission data*, 2002. ISBN 978 1 86081 546 1.

BRE Digest 464, Part 2: *VOC emissions from building products. Control, evaluation and labelling schemes*, 2002. ISBN 978 1 86081 547 8.

BSRIA

Ventilation hygiene toolkit:
BSRIA Facilities Management Specification
1 *Guidance to the standard specification for ventilation hygiene*, 2002. ISBN 978 0 86022 454 9.

Chartered Institution of Building Services Engineers (CIBSE)

Applications Manual AM10: *Natural ventilation in non-domestic buildings*, 2005.
ISBN 978 1 80328 756 0.

Applications Manual AM13: *Mixed mode ventilation*, 2000. ISBN 978 1 90328 701 4.

CIBSE Guide A: *Environmental design*, 2006.
ISBN 978 1 90328 766 8.

CIBSE Guide B: *Heating, ventilating, air conditioning and refrigeration*, 2005.
ISBN 978 1 90328 758 3.

TM13: *Minimising the risk of Legionnaires' disease*, 2002. ISBN 978 1 90328 723 1.

CIBSE Commissioning Codes, available from: www.cibse.org/index.cfm?go=publications.view&item=266.

CIBSE TM26 *Hygienic maintenance of office ventilation ductwork*, 2000.
ISBN 978 1 90328 711 8.

Defence Estates

Defence Works Functional Standard, Design and Maintenance Guide 08: *Space requirements for plant access operation and maintenance*, 1996.
ISBN 978 1 11772 785 4. Available from: www.defence-estates.mod.uk/publications/dmg/dmg_08.pdf

Department for Children, Schools and Families (DCSF);

Building Bulletin 101, *Ventilation of school buildings*, 2006. ISBN 978 0 11271 164 3.
See: www.teachernet.gov.uk/iaq

F1 STANDARDS AND OTHER PUBLICATIONS

Department of Health Estates and Facilities Division

HTM 03; Part A – *Ventilation in healthcare premises: Design and validation*, 2007.

HTM 03; Part B – *Ventilation in healthcare premises: Verification and operational Management*, 2007.

HBN (various).

Energy Saving Trust

Good Practice Guide 192. *Designing energy efficient multi-residential buildings*, 1997.
Available from: www.est.org.uk/bestpractice/index.cfm (archived).

Health and Safety Executive (HSE)

HSE Catering Information Sheet No 10, *Ventilation of kitchens in catering establishments*, 2007. Available from: www.hsebooks.com.

HSE Catering Information Sheet No 11, *The main health and safety law applicable to catering*, 2000. Available from: www.hsebooks.com.

HSG 258 *Controlling airborne contaminants at work. A guide to local exhaust ventilation* (LEV), 2008. ISBN 978 0 71766 298 2.

HSG 193. *COSHH Essentials*. Accessed on: www.coshh-essentials.org.uk

HSG 202 *General ventilation in the workplace – Guidance for employers*, 2000.
ISBN 978 0 71761 793 7.

L8 *Legionnaires Disease: The control of legionella bacteria in water systems.* Approved code of practice and guidance, 2000.
ISBN 978 0 71761 772 2.

L24 Workplace (Health, Safety and Welfare) Regulations 1992. *Approved Code of Practice and guidance*, 2001. ISBN 978 0 71760 413 5.

HVCA

HVCA DW/144 *Specification for sheet metal ductwork – low, medium and high pressure/air systems*, 1998. ISBN 978 0 90378 327 9.

HVCA DW/154 *Specification of plastics ductwork*, 2000. ISBN: 0 90378 331 2.

HVCA DW/143 *A practical guide to ductwork leakage testing*, 2000. ISBN: 978 0 90378 330 9.

HVCA DW/172 *Specification for kitchen ventilation systems*, 2005
ISBN 978 0 90378 329 3.

HVCA TR/19 *Guide to good practice. Internal cleanliness of ventilation systems*, 2005.
ISBN 978 0 90378 335 4.

Legislation

Factories Act 1961, Chapter 34.

Welfare of Farm Animals (England) Regulations 2000, SI 2000/1870.

Welfare of Farm Animals (England) (Amendment) Regulations 2002, SI 2002/1646.

Welfare of Farm Animals (England) (Amendment) Regulations 2003, SI 2003/299.

Department for Communities and Local Government

Planning Policy Statement (PPS) 15: *Planning and the historic environment*; DoE, 1994. Paragraphs 6.1 to 6.40 have been superseded by Circular 01/2007, *Revisions to principles of selection for listing buildings*. Both available at: www.communities.gov.uk/planningandbuilding/planning/planningpolicyguidance/historicenvironment/ppg15.

Review of health and safety risk drivers (BD 2518). Available at: www.communities.gov.uk/documents/planningandbuilding/pdf/reviewhealthsafety.pdf.

Figure 5 - LIST of REFERENCES in PART F (Ventilation) in the Building Regulation for England and Wales

7.2.4. B4: Austria (legislation)

Since when is the current national building legislation enforced?

- March 2015

When is the next revision of your national building legislation?

- Presumably 2019

Which changes has there been (if any) in your national building legislation since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- There have been no changes

How is the air flow rate determined for ventilative cooling in your national building legislation/guideline?

- Fixed ACH without any sensitivity to building design in case of cooling demand compliance tool

- More detailed calculation incl. window position, size and temperature in case of IEQ compliance tool for free running rooms

Which standards/guidelines are referred to in your national building legislation/guideline (if relevant incl. short scope)?

- For energy demand compliance, the calculation method is defined within ÖNORM B 8110-5, -6, ÖNORM H 5055, 5056, 5057, 5058 and 5059. All together they are Austria's answer to the EPBD requirements and Austria's Interpretation of EN ISO 13790. Within these standards, it is ÖNORM B 8110-5 which defines the outdoor climate and the usage input parameters.
- For thermal summer comfort of rooms without cooling demand (obligatory for residential) buildings, compliance calculation is defined in ÖNORM B 8110-3. Its algorithms are closely linked to ISO 13791 and ISO 13792.

Are the effects of actual window position and geometry of the building included in your national building legislation/guideline? (E.g. orientation and height difference between windows in building?)

- Within the compliance tool for thermal summer comfort, the ACH is calculated with a simplified formula from window area, window height and temperature difference. Windows in two different levels are accounted for. No option is given to take into account cross ventilation. No wind effect may be taken into account.
- The formula is:

$\dot{V} = 0{,}7 \cdot C_{ref} \cdot A \cdot \sqrt{H} \cdot \sqrt{\Delta T}$ with C_{ref} Austauschkoeffizient; C_{ref} = 100 $m^{0,5}/(h \cdot K^{0,5})$

If windows in two heights are applied, the surface calculation is altered to $A_{eff} = \sqrt{\dfrac{1}{\dfrac{1}{A^2_{oben}} + \dfrac{1}{A^2_{unten}}}}$

State the name of your national legislation/guideline and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 27 – Ventilative cooling parameters in legislation and or/guideline for residential buildings in Austria

Parameters	**National standard ON B 8110-3 being obligatory referred to in national building code OIB RL 6 forming the compliance for summer comfort in buildings without cooling demand**	**National standard family ON B 8110-3, -6 and ON H 5055, 5056, 5057, 5058, 5059 being obligatory referred to in national building code OIB RL 6 forming the compliance for energy demand for heating, cooling and lighting in buildings**	
Single-sided ventilation	Yes	No, fixed ACH	

Cross ventilation	No	No, fixed ACH	
Stack ventilation	Yes	No, fixed ACH	
Night cooling	Yes	Yes, at fixed ACH of 1,5 h^{-1}	
Free cooling	Not applicable, since only meant for buildings without cooling demand	Now cooling demand in residential buildings is allowed. Result of cooling demand calculation has to be zero	
Hybrid systems	Not applicable, see above	See above	
Position of windows in building	Yes, partly: Only regarding relative vertical distance of windows, not orientation	Not applicable, since ACH is fixed	
Is wind included in your calculation?	No	Only by influencing the infiltration rate	
Effect of having manual or automatic window operation	No	No	
Steady-state or dynamic calculation?	Dynamic, on basis of a repeated design-day	Steady state, with some performance indicators having been derived from preliminary dynamic simulation	
Time-step (monthly or hourly)?	Hourly	Monthly	
Indicate important issues not included in this table			

Table 28 – Ventilative cooling parameters in legislation and or/guideline for non-residential buildings in Austria

Parameters	**National standard ON B 8110-3 being obligatory referred to**	**National standard family ON B 8110-3, -6 and ON H 5055, 5056,**	**Österreichische Arbeitsstättenverordnung**

	in national building code OIB RL 6 forming the compliance for summer comfort in buildings without cooling demand	**5057, 5058, 5059 being obligatory referred to in national building code OIB RL 6 forming the compliance for energy demand for heating, cooling and lighting in buildings**	
Single-sided ventilation	Yes	No, fixed ACH	No, n.a.
Cross ventilation	No	No, fixed ACH	No, n.a.
Stack ventilation	Yes	No, fixed ACH	No, n.a.
Night cooling	Yes	Yes, at fixed ACH of $1{,}5h^{-1}$	No, n.a.
Free cooling	Not applicable, since only meant for buildings without cooling demand	Yes, partly, within manual alteration of SEER	No, n.a.
Hybrid systems	Not applicable, see above	Yes, partly. Night ventilation does lower the technical cooling demand	No, n.a.
Position of windows in building	Yes, partly: Only regarding relative vertical distance of windows, not orientation	Not applicable, since ACH is fixed	No, n.a.
Is wind included in your calculation?	No	Only by influencing the infiltration rate	No, n.a.
Effect of having manual or automatic window operation	No	No	No, n.a.
Steady-state or dynamic calculation?	Dynamic, on basis of a repeated design-day	Steady state, with some performance indicators having been derived from preliminary dynamic simulation	n.a.

Time-step (monthly or hourly)?	Hourly	Monthly	n.a.
Indicate important issues not included in this table			See below [21]

[21] In the "Österr. Arbeitsstättenrichtlinie" thresholds for IEQ parameters are defined. They are defined in quite narrow bands, closely following ISO 7730 or even worse. Only by courageous interpretation designers can push the limits.

7.2.5. B5: Switzerland (legislation)

Since when is the current national building legislation enforced?

- 2014

When is the next revision of your national building legislation?

- 2018 - Continuous process

Which changes has there been (if any) in your national building legislation since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- No change

Which standards/guidelines are referred to in your national building legislation/guideline (if relevant incl. short scope)?

- SIA 180 for thermal protection
- SIA 382 for air conditioning performance

Are the effects of actual window position and geometry of the building included in your national building legislation/guideline? (E.g. orientation and height difference between windows in building?)

- Yes

State the name of your national legislation/guideline and furthermore, indicate which parameters regarding ventilative cooling are included, below:

- SIA 180 for thermal protection
- SIA 382/2 for air conditioning and mechanical installations and air conditioning system required performance

Table 29 – Ventilative cooling parameters in legislation and or/guideline for residential buildings in Switzerland

Parameters	**National legislation SIA180**		
Single-sided ventilation	Yes		
Cross ventilation	No (as single sided)		
Stack ventilation	Yes		
Night cooling	Yes		
Free cooling	Yes		
Hybrid systems	Yes		
Position of windows in building	No (single zone)		
Is wind included in your calculation?	No		
Effect of having manual or automatic window operation	No		
Steady-state or dynamic calculation?	No		
Time-step (monthly or hourly)?	Hourly		
Indicate important issues not included in this table	One set of boundary conditions for thermal protection and one for comfort		

Table 30 – Ventilative cooling parameters in legislation and or/guideline for non-residential buildings in Switzerland

Parameters	**National legislation SIA 180**		
Single-sided ventilation	Yes		
Cross ventilation	No (as single sided)		
Stack ventilation	Yes		

Night cooling	Yes		
Free cooling	Yes		
Hybrid systems	Yes		
Position of windows in building	No (single zone)		
Is wind included in your calculation?	No		
Effect of having manual or automatic window operation	No		
Steady-state or dynamic calculation?	No		
Time-step (monthly or hourly)?	Hourly		
Indicate important issues not included in this table	One set of boundary conditions for thermal protection and one for comfort		

7.2.6. B6: Australia (legislation)

Name of your national legislation/guideline:

- National Construction Code (National)
- Basix (Regional, NSW)
- Apartment Design Guide (Regional, NSW)

Since when is the current national building legislation enforced?

- 2016

When is the next revision of your national building legislation?

- 2019

Which changes has there been (if any) in your national building legislation since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- N/A

How is the air flow rate determined for ventilative cooling in your national building legislation/guideline?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
    - Window area is a percentage of floor area, depending on the room location in the building
- More detailed calculation e.g. incl. window position and size in building (building design)
    - Yes, to this option

Which standards/guidelines are referred to in your national building legislation/guideline (if relevant incl. short scope)?

- AS 1668.2 - The use of ventilation and air conditioning in buildings -Mechanical ventilation in buildings
- AS 1668.4 - The use of ventilation and air conditioning in buildings - Natural ventilation of buildings

Are the effects of actual window position and geometry of the building included in your national building legislation/guideline? (E.g. orientation and height difference between windows in building?)

- Not generally. These effects are taken into account only when the national/regional full building thermal simulation is to demonstrate the building energy performance.

State the name of your national legislation/guideline and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 31 – Ventilative cooling parameters in legislation and or/guideline for residential buildings in Australia

Parameters	**National legislation (National Construction Code – Part 2)**	**Regional legislation (NSW BASIX Certification)**	**Apartment Design Guide**
Single-sided ventilation	Yes	Yes	Yes
Cross ventilation	No [22]	No [22]	(only distance between windows)
Stack ventilation	No [22]	No [22]	No
Night cooling	No [23]	No [23]	No
Free cooling	No	No	No
Hybrid systems	No [22]	No [22]	No
Position of windows in building	No [22]	Yes	No

Is wind included in your calculation?	No [22]	No [22]	No
Effect of having manual or automatic window operation	No	No	No
Steady-state or dynamic calculation?	Not applicable [22]	Not applicable [22]	Not applicable
Time-step (monthly or hourly)?	Not applicable [22]	Not applicable [22]	Not applicable
Indicate important issues not included in this table			Windows opening is a simple percentage of floor area calculation

[22] It is "Yes" if the designer chooses to satisfy the energy efficiency requirements using a building simulation software (Dynamic, hourly simulation).

[23] Natural Ventilation by opening windows in favourable conditions is considered active 24/7

Table 32 – Ventilative cooling parameters in legislation and or/guideline for non-residential buildings in Australia

Parameters	**National legislation (National Construction Code – Part 1)**		
Single-sided ventilation	Yes		
Cross ventilation	No [22]		
Stack ventilation	No [22]		
Night cooling	No [22]		
Free cooling	No [22]		
Hybrid systems	No [22]		
Position of windows in building	No [22]		
Is wind included in your calculation?	No [22]		

Effect of having manual or automatic window operation	No [22]		
Steady-state or dynamic calculation?	Not applicable [22]		
Time-step (monthly or hourly)?	Not applicable [22]		
Indicate important issues not included in this table			

7.2.7. B7: Norway (legislation)

Since when is the current national building legislation enforced?

- The current Building Regulations came into force 01.01.2017.

When is the next revision of your national building legislation?

- It is expected in 2020

Which changes has there been (if any) in your national building legislation since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- Several changes have been incorporated between 2015 and recent version from January 2017, however none of them influence Ventilative Cooling
- Changes can be found here:
  - https://dibk.no/byggereglene/endringshistorikk-tek17/endringshistorikk

How is the air flow rate determined for ventilative cooling in your national building legislation/guideline?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
- More detailed calculation e.g. incl. window position and size in building (building design)

Residential buildings:

- In residential buildings air flow rate is determined as the maximum of three different calculations:
  - Residential units shall have ventilation that ensures an average fresh air supply of at least 1.2 m^3 per hour per m^2 floor area when the housing unit is inhabited. Demand controlled ventilation may be used provided that the fresh air supply by this means will not be lower than 0.3 l/s per m^2.

In addition, the guideline adds: The provisions on air volumes can best be met with mechanical ventilation. Balanced ventilation with heat recovery will often be most suitable to meet energy requirements (Chapter 14) and thermal insulation requirements (§ 13-4). Natural driving forces can be used to ensure ventilation according to this section, but window airing is usually considered as an additional ventilation. Therefore, ventilation should be possible with closed windows.

- Bedrooms shall be supplied with a minimum of 26 m^3 of fresh air per hour per bed when the room is in use. Guideline adds that demand controlled ventilation is possible
- Rooms not intended for permanent residence shall have ventilation that ensures a minimum of 0.7 m^3 of fresh air per hour per m^2 of floor space.
- Kitchen, toilet and wet room will have an extraction of air with satisfactory efficiency.
  The guideline adds: The purpose of the extract is to remove contamination and moisture from the indoor air.
  Continuous extracts from the kitchen can be solved with extracts that are designed and placed so that pollution from the stove and the like is effectively absorbed and prevents food from spreading in the building. Unfavourable design or placement of stove or extract will result in increased exhaust volume required.
  Pre-accepted performance.
  The requirement for exhaust is taken care of when the exhaust volume is minimum as indicated in Table 33, Also in case of forced ventilation, the amount of air supplied must be equal to the extract volume given in Table 33.

Table 33 - Table Air extraction volume in housing (named §13-2 in actual document):

Room	**Normal ventilation**	**Forced ventilation**
Kitchen	36 m^3/h	108 m^3/h
Bath	54 m^3/h	108 m^3/h
Toilet	36 m^3/h	36 m^3/h
Laundry room	36 m^3/h	72 m^3/h

<u>Ventilasjon i byggverk for publikum og arbeidsbygning</u>

1. Fresh air supply due to contaminants from persons with light activity must be at least 26 m^3 per hour per person. At a level of activity other than light activity, the fresh air supply should be adjusted to ensure that the air quality is satisfactory
   - Guidance to above; To calculate the fresh air volume in a room designed for other than light physical activity, one can use table for metabolic activity in NS-EN ISO 7730: 2005, Appendix B
2. Fresh air supply due to contamination from materials, products and installations shall be minimum
   - 2.5 m^3 per hour per m^2 floor area when the utility unit or rooms are in use
   - 0.7 m^3 per hour per m^2 floor area when the utility unit or rooms are not in use

Pre-accepted performance

- The values in Table 34 must be used when dimensioning if there is no information about the required person load. In general, the net area must be used to calculate the number of people who can stay in the room. For sales premises, the net area is open to the public. For offices, gross area, including warehouse, communication area and the like, is used.

Table 34 - Dimensioning person load for selected types of areas (named § 13-3 in actual document)

Type of area	**m^2 pr. person**
Office building	15
Sales premises	2,0
Educational rooms and living rooms in schools and day care centres	2,0
Assembly rooms without fixed seating	0,6
Room with standing place	0,3
Dining places with chairs and tables	1,4

Which standards/guidelines are referred to in your national building legislation/guideline (if relevant incl. short scope)?

- The calculations of buildings' energy requirements and heat loss figures must be carried out in accordance with Norwegian Standard, NS 3031: 2014 Energy performance of buildings. Calculation of energy needs and energy supply.

Are the effects of actual window position and geometry of the building included in your national building legislation/guideline? (E.g. orientation and height difference between windows in building?)

- No

State the name of your national legislation/guideline and furthermore, indicate which parameters regarding ventilative cooling are included, below:

- Legislative document is “Forskrift om tekniske krav til byggverk (Byggteknisk forskrift) TEK17” (Regulations on technical requirements for construction work (Building Technology Regulations) TEK17)

Table 35 – Ventilative cooling parameters in legislation and or/guideline for residential buildings in Norway

Parameters	**TEK 17**		
Single-sided ventilation	No		

Cross ventilation	No		
Stack ventilation	No		
Night cooling	No		
Free cooling	No		
Hybrid systems	No		
Position of windows in building	No		
Is wind included in your calculation?	No		
Effect of having manual or automatic window operation	Yes		
Steady-state or dynamic calculation?	Both is possible		
Time-step (monthly or hourly)?	Both is possible		
Indicate important issues not included in this table	Thermal mass		

Table 36 – Ventilative cooling parameters in legislation and or/guideline for non-residential buildings in Norway

Parameters	**TEK 17**		
Single-sided ventilation	No		
Cross ventilation	No		
Stack ventilation	No		
Night cooling	No		
Free cooling	No		
Hybrid systems	No		
Position of windows in building	No		

Is wind included in your calculation?	No		
Effect of having manual or automatic window operation	Yes		
Steady-state or dynamic calculation?	Both is possible		
Time-step (monthly or hourly)?	Both is possible		
Indicate important issues not included in this table	Thermal mass		

7.2.8. B8: Belgium, Flanders region (legislation)

Since when is the current national building legislation enforced?

- The current regional (Flanders) building legislation is the Energy Order of the Government of Flanders of 19.11.2010. The current version of the appendices of this order (with the calculation method) were enforced on 01.03.2017

When is the next revision of your national building legislation?

- The next revision of the appendices is on 01.01.2018

Which changes has there been (if any) in your national building legislation since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- Non-residential buildings:
- Ventilative cooling is now included in the calculation of the net energy demand of cooling (as an additional term in H_V) in office and school buildings. Four types are distinguished:
  - Natural ventilation by day
  - Natural ventilation by night
  - Mechanical ventilation by day
  - Mechanical ventilation by night
  - For natural ventilation: the airflow is calculated in a simplified way as a function of the area of the windows and the way they open. There are also correction factors for thermal mass and operation time.
- Residential buildings:
- No changes in the current version, but there are changes planned in the version from 01.01.2018.

- The flowrate for manual openings of the windows is the volume of the dwelling multiplied by a factor between 0 and 1.1. This factor depends on the “potential for intensive ventilation”. This potential is determined by:
    - Availability of openings for intensive ventilation
    - Safety (burglar proof)
    - Ventilation capacity: cross/stack or single-sided
    - Control: automatic or manual

How is the air flow rate determined for ventilative cooling in your national building legislation/guideline?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
    - <u>Residential buildings:</u>
    - New: see above
    - Current: Airflow for manual openings of the windows = 45.3 x net openable area of all windows x reduction factor (depending on the burglary risk and type of window)
    - <u>Non-residential buildings:</u>
    - See above
- More detailed calculation e.g. incl. window position and size in building (building design)

Which standards/guidelines are referred to in your national building legislation/guideline (if relevant incl. short scope)?

- For ventilation in appendices IX and X:
    - NBN D50-001: national standard about ventilation in residential buildings
- European standards about ventilation: NBN EN 12792:2003: ventilation of buildings – symbols and terminology, NBN EN 12599:2000, NBN EN 13779:2004: ventilation of non-residential buildings – performance requirements, NBN EN 13141-1 and 2:2004, NBN EN 1027:2000, NBN EN 13829:2001
- Appendix V and VI have a whole section of referred standards (EN and ISO), as seen below in Figure 6:

ARI Standard 560:2000	Absorption water chilling and water heating packages (ARI: Air-Conditioning and Refrigeration Institute)
ISO 15099:2003	Thermal performance of windows, doors and shading devices - Detailed calculations
NBN D 50-001:1991	Ventilatievoorzieningen in woongebouwen
NBN EN 308:1997	Heat exchangers - Test procedures for establishing performance of air to air and flue gases heat recovery devices
NBN EN 410:2011	Glass in building - Determination of luminous and solar characteristics of glazing
NBN EN 1027:2000	Windows and doors - Watertightness - Test method
NBN EN 12309-2:2000	Gas-fired absorption and adsorption air-conditioning and/or heat pump appliances with a net heat input not exceeding 70 kW - Part 2: Rational use of energy
NBN EN 13141-1:2004	Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 1: Externally and internally mounted air transfer devices.
NBN EN 13363-1:2007	Solar protection devices combined with glazing. Calculation of solar and light transmittance - Part 1: Simplified method
NBN EN 13363-2:2005	Solar protection devices combined with glazing - Calculation of solar and light transmittance - Part 2: Detailed calculation method

NBN EN 13829:2001	Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method
NBN EN 14134:2004	Ventilation for buildings - Performance testing and installation checks of residential ventilation systems
NBN EN 14511:2011	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling
NBN EN 14825:2013	Air conditioners, liquid chilling packages and heat pumps, with electrically driven compressors, for space heating and cooling - Testing and rating at part load conditions and calculation of seasonal performance
NBN 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
NBN EN 60034-1:2010	Rotating electrical machines - Part 1: Rating and performance
NBN EN 60904-1:2007	Photovoltaic devices - Part 1: measurement of photovoltaic current-voltage characteristics.
NBN EN ISO 10211:2008	Thermal bridges in building construction - Heat flows and surface temperatures - Detailed calculations
NBN EN ISO 12241:1998	Thermal insulation for building equipment and industrial installations - Calculation rules
NBN EN ISO 13789:2008	Thermal performance of buildings - Transmission and ventilation heat transfer coefficients - Calculation method
NBN EN ISO 13790:2004	Thermal performance of buildings - Calculation of energy use for heating (supersedes EN 832)
NBN EN ISO 14683:2008	Thermal bridges in building construction - Linear thermal transmittance - Simplified methods and default values

Figure 6 - Section of referred standards (EN and ISO)

Are the effects of actual window position and geometry of the building included in your national building legislation/guideline? (E.g. orientation and height difference between windows in building?)

- No

State the name of your national legislation/guideline and furthermore, indicate which parameters regarding ventilative cooling are included, below:

- Legislative document is "Energiebesluit van de Vlaamse Regering van 19 November 2010" (Energy Order of the Government of Flanders of 19.11.2010) with following appendices related to ventilative cooling:
    - Bijlage V: Bepalingsmethode van het peil van primair energieverbruik van woongebouwen. (Appendix V: calculation method of primary energy use in residential buildings).
    - Bijlage VI: Bepalingsmethode van het peil van primair energieverbruik van kantoren, scholen en andere niet-residentiële gebouwen (Appendix VI: calculation method of primary energy use in non-residential buildings).
    - Bijlage IX: Ventilatievoorzieningen in woongebouwen (Appendix IX: ventilation in residential buildings)
    - Bijlage X: Ventilatievoorzieningen in niet-residentiële gebouwen (Appendix X: ventilation in non- residential buildings)

Table 37 - Ventilative cooling parameters in legislation and or/guideline for residential buildings in Belgium (Flanders)

Parameters	**Regional legislation - Bijlage V and Bijlage IX**		
Single-sided ventilation	No difference between single-sided, cross or stack ventilation		
Cross ventilation	No		
Stack ventilation	No		
Night cooling	No		
Free cooling	Yes		
Hybrid systems	No		
Position of windows in building	No		
Is wind included in your calculation?	No		

Effect of having manual or automatic window operation	No		
Steady-state or dynamic calculation?	Steady-state		
Time-step (monthly or hourly)?	Monthly		
Indicate important issues not included in this table	Opening of windows only included in the calculation of overheating, not in the calculation of primary energy use		

Table 38 – Ventilative cooling parameters in legislation and or/guideline for non-residential buildings in Belgium (Flanders)

Parameters	**Regional legislation Bijlage VI and Bijlage X**		
Single-sided ventilation	No difference between single-sided, cross or stack ventilation		
Cross ventilation	No		
Stack ventilation	No		
Night cooling	Yes		
Free cooling	Yes		
Hybrid systems	No		
Position of windows in building	No		
Is wind included in your calculation?	No		
Effect of having manual or automatic window operation	No		

Steady-state or dynamic calculation?	Steady-state		
Time-step (monthly or hourly)?	Monthly		
Indicate important issues not included in this table	Mechanical additional ventilation is included in the legislation		

7.2.9. B9: Ireland (legislation)

Since when is the current national building legislation enforced?

- Its inception was 1997 with the current revision of the residential building regulations active since 2017 and the non-residential since 2008. A new revision of the non-residential building regulations is due in 2018.

When is the next revision of your national building legislation?

- 2018 for non-residential, 2019 for residential?

Which changes has there been (if any) in your national building legislation since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- There have been a number of changes to the regulations following the adoption of the EPBD recast in Irish law. These are largely related to new fabric and airtightness requirements, new energy performance targets and integration of renewable energy technologies for both new and existing buildings. There has been a new section added dealing specifically with overheating, though this refers to the use of CIBSE TM52 to estimate the risk of overheating and use guidance from this document to avoid same. Overheating is not mentioned in the residential buildings regulations. Cooling is also not mentioned in the residential building regulations

How is the air flow rate determined for ventilative cooling in your national building legislation/guideline?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
- More detailed calculation e.g. incl. window position and size in building (building design)

The ACH is not determined for the purposes of cooling. There is a ventilation rate calculated when the building is in cooling mode. However, this estimates the losses/gains due to ventilation and does not necessarily allow for ventilative cooling. This is calculated using a cooling set point and includes for ventilation losses associated with infiltration and mechanical ventilation, defined according to a national database of activities and their demand profiles.

$$u_{v-cool} = u_{v-\inf} / 3.6 + u_{v,m}$$

Which standards/guidelines are referred to in your national building legislation/guideline (if relevant incl. short scope)?

- EN 13790 / EN 15242 / CIBSE TM52 / CIBSE TM37

Are the effects of actual window position and geometry of the building included in your national building legislation/guideline? (E.g. orientation and height difference between windows in building?)

- Not for the calculation of energy implications. It does state that a dynamic simulation should be completed to assess the overheating risk for naturally ventilated spaces. For mechanically ventilated spaces it assumes the set point is maintained and calculates and airflow rate to achieve this

State the name of your national legislation/guideline and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 39 – Ventilative cooling parameters in legislation and or/guideline for residential buildings in Ireland

Parameters	**TGD Part F - Ventilation**		
Single-sided ventilation	Yes		
Cross ventilation	Yes		
Stack ventilation	Yes		
Night cooling			
Free cooling			
Hybrid systems			
Position of windows in building	Yes		
Is wind included in your calculation?	No		
Effect of having manual or automatic window operation	No		
Steady-state or dynamic calculation?	Steady state		

Time-step (monthly or hourly)?	Monthly		
Indicate important issues not included in this table	No Ventilative cooling in legislation		

Table 40 – Ventilative cooling parameters in legislation and or/guideline for non-residential buildings in Ireland

Parameters	**TGD Part F - Ventilation**		
Single-sided ventilation	Yes		
Cross ventilation	Yes		
Stack ventilation	Yes		
Night cooling			
Free cooling			
Hybrid systems			
Position of windows in building	Yes		
Is wind included in your calculation?	No		
Effect of having manual or automatic window operation	No		
Steady-state or dynamic calculation?	Steady state		
Time-step (monthly or hourly)?	Monthly		
Indicate important issues not included in this table	No Ventilative Cooling in legislation		

7.3. Annex C (missing ventilative cooling aspects in compliance tools)

This section compiles the replies from the countries regarding the missing aspects found in national compliance tools concerning ventilative cooling e.g. by looking into which ventilative cooling aspects or parameters are included in national compliance tools.

7.3.1. C1: Denmark (compliance tool)

Which changes has there been (if any) in your national compliance tools since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- Significant changes to Be15 compliance tool has been introduced in year 2015 when new Building Regulation was published. The most significant changes are:
  - New energy frames were included in the tool
  - New method to calculate energy from renewable sources, such as, photovoltaic cells and house windmills
  - New reference year weather data
  - New reference at 300 lux for supplement for energy frame in buildings requiring above average lighting level

How is the air flow rate determined for ventilative cooling in your national compliance tool?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
- More detailed calculation e.g. incl. window position and size in building (building design)

It is provided as fixed air flow in l/sm^2 of heated floor area. Different air flows may be specified for mechanical and natural systems and for both systems there is possibility to differentiate air flow from day to night

Are the effects of actual window position and geometry of the building included in your national compliance tool? (E.g. orientation and height difference between windows in building?)

- Neither actual window position nor its geometry is directly specified in the compliance tool. However, air flow typed in the compliance tool should indicate actual airflows in the room therefore also indirectly refer to real openings situation

State the name of your national compliance tool and furthermore, indicate which parameters regarding ventilative cooling are included, below:

- Be18

Table 41 - Ventilative cooling parameters in national compliance tools in residential buildings in Denmark

Parameters	**Be18**			

Single-sided ventilation	Not specific but there is link between anticipated air flow and effective window area			
Cross ventilation	Not specific but there is link between anticipated air flow and effective window area			
Stack ventilation	No			
Night cooling	Yes, separate air flow can be specified			
Free cooling	Yes, by natural ventilation, then no fan energy consumption			
Hybrid systems	Yes, natural and mechanical system can be specified in one building			
Position of windows in building	No			
Is wind included in your calculation?	No			
Effect of having manual or automatic window operation	Yes, automatic control would increase anticipated air flow			
	Simplified hourly calculation			

Steady-state or dynamic calculation?	Energy: Steady-state			
Time-step (monthly or hourly)?	Comfort: Hourly			
	Energy performance monthly calculation			
Indicate important issues not included in this table				

Table 42 - Ventilative cooling parameters in national compliance tools in non-residential buildings in Denmark

Parameters	**Be18**			
Single-sided ventilation	Not specific but there is link between anticipated air flow and effective window area			
Cross ventilation	Not specific but there is link between anticipated air flow and effective window area			
Stack ventilation	No			
Night cooling	Yes, separate air flow can be specified			
Free cooling	Yes, by natural ventilation, then no			

	fan energy consumption			
Hybrid systems	Yes, natural and mechanical system can be specified in one building			
Position of windows in building	No			
Is wind included in your calculation?	No			
Effect of having manual or automatic window operation	Yes, automatic control would increase anticipated air flow			
Steady-state or dynamic calculation?	Thermal comfort: Not included in compliance tool			
	Energy: Steady-state monthly			
Time-step (monthly or hourly)?	Monthly			
Indicate important issues not included in this table	Thermal comfort: Not included in compliance tool. Overheating hours are recalculated to Watts and add as punishement for energy performance			

7.3.2. C2: United Kingdom (compliance tool)

Which changes has there been (if any) in your national compliance tools since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- No changes

How is the air flow rate determined for ventilative cooling in your national compliance tool?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
    - For dwellings based on compliance tool SAP
- More detailed calculation e.g. incl. window position and size in building (building design)
    - For non-residential buildings based on dynamic simulation.

Are the effects of actual window position and geometry of the building included in your national compliance tool? (E.g. orientation and height difference between windows in building?)

- Yes, for non-residential buildings.

State the name of your national compliance tool and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 43 - Ventilative cooling parameters in national compliance tools in residential buildings in United Kingdom

Parameters	**SAP**			
Single-sided ventilation				
Cross ventilation				
Stack ventilation				
Night cooling				
Free cooling				
Hybrid systems				
Position of windows in building	Partly			
Is wind included in your calculation?	Yes, monthly adjustment for infiltration			
Effect of having manual or automatic window operation	Partly			

Steady-state or dynamic calculation?	Steady state			
Time-step (monthly or hourly)?				
Indicate important issues not included in this table	Ability to calculate natural ventilation, although Appendix Q databases can be used for input values			

Table 44 - Ventilative cooling parameters in national compliance tools in non-residential buildings in United Kingdom

Parameters	**NCM**			
Single-sided ventilation	Yes			
Cross ventilation	Yes			
Stack ventilation	Yes			
Night cooling	Yes			
Free cooling	Yes			
Hybrid systems	Yes			
Position of windows in building	Yes			
Is wind included in your calculation?	Yes			
Effect of having manual or automatic window operation	Yes			
Steady-state or dynamic calculation?	Dynamic			

Time-step (monthly or hourly)?	Hourly			
Indicate important issues not included in this table				

7.3.3. C3: Switzerland (compliance tool)

Which changes has there been (if any) in your national compliance tools since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- No change

Are the effects of actual window position and geometry of the building included in your national compliance tool? (E.g. orientation and height difference between windows in building?)

- We have 3 compliance tools (Techtool, LesoSai and DIAL+)
- The first two ask the window size only. DIAL+ consider multiple windows with different shapes and types where the position is also important to calculate stack effect. No wind is considered in the tools

State the name of your national compliance tool and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 45 - Ventilative cooling parameters in national compliance tools in residential buildings in Switzerland

Parameters	**CH DIAL+**	**CH Techtool**	**CH LesoSai**	
Single-sided ventilation	Yes	Yes	Yes	
Cross ventilation	Yes (vertical)	No	No	
Stack ventilation	Yes	Yes	Yes	
Night cooling	Yes	Yes	Yes	
Free cooling	Yes	Yes	Yes	
Hybrid systems	Yes	Yes	Yes	
Position of windows in building	Yes	Yes	Yes	
Is wind included in your calculation?	No	No	No	

Effect of having manual or automatic window operation	Yes	No	No	
Steady-state or dynamic calculation?	Dynamic	Dynamic	Dynamic	
Time-step (monthly or hourly)?	Hourly	Hourly	Hourly	
Indicate important issues not included in this table				

Table 46 - Ventilative cooling parameters in national compliance tools in non-residential buildings in Switzerland

Parameters	**CH DIAL+**	**CH Techtool**	**CH LesoSai**	
Single-sided ventilation	Yes	Yes	Yes	
Cross ventilation	Yes (vertical)	No	No	
Stack ventilation	Yes	Yes	Yes	
Night cooling	Yes	Yes	Yes	
Free cooling	Yes	Yes	Yes	
Hybrid systems	Yes	Yes	Yes	
Position of windows in building	Yes	Yes	Yes	
Is wind included in your calculation?	No	No	No	
Effect of having manual or automatic window operation	Yes	No	No	
Steady-state or dynamic calculation?	Dynamic	Dynamic	Dynamic	

Time-step (monthly or hourly)?	Hourly	Hourly	Hourly	
Indicate important issues not included in this table				

7.3.4. C4: Australia (compliance tool)

State the name of your national compliance tool and furthermore, indicate which parameters regarding ventilative cooling are included, below:

Table 47 - Ventilative cooling parameters in national compliance tools in residential buildings in Australia

Parameters	**AccuRate**	**BERS Pro**		
Single-sided ventilation	Yes	Yes		
Cross ventilation	Yes	Yes		
Stack ventilation	Yes	Yes		
Night cooling				
Free cooling	Yes	Yes		
Hybrid systems	Yes	Yes		
Position of windows in building	Yes	Yes		
Is wind included in your calculation?	Yes	Yes		
Effect of having manual or automatic window operation	No	No		
Steady-state or dynamic calculation?	Dynamic	Dynamic		
Time-step (monthly or hourly)?	Hourly	Hourly		

Indicate important issues not included in this table				

Table 48 - Ventilative cooling parameters in national compliance tools in non-residential buildings in Australia

Parameters	**Any building simulation software**			
Single-sided ventilation	Yes			
Cross ventilation	Yes			
Stack ventilation	Yes			
Night cooling	Yes			
Free cooling	Yes			
Hybrid systems	Yes			
Position of windows in building	Yes			
Is wind included in your calculation?	Yes			
Effect of having manual or automatic window operation	Yes			
Steady-state or dynamic calculation?	Dynamic			
Time-step (monthly or hourly)?	Hourly			
Indicate important issues not included in this table	Any building simulation software can be utilized to compare the performance of a			

	specific building with a reference "compliance" building. The proposed design has to be better or at least equal to the reference in terms of energy efficiency			

7.3.5. C5: Belgium (compliance tool)

Table 49 - Ventilative cooling parameters in national compliance tools in residential buildings in Belgium

Parameters	**EPB**			
Single-sided ventilation	Natural ventilation strategy cannot be selected			
Cross ventilation	Natural ventilation strategy cannot be selected			
Stack ventilation	Natural ventilation strategy cannot be selected			
Night cooling	No differentiation between day and night			
Free cooling	Yes			
Hybrid systems	No			
Position of windows in building	No			
Is wind included in your calculation?	No			
Effect of having manual or automatic window operation	No			

Steady-state or dynamic calculation?	Steady-state			
Time-step (monthly or hourly)?	Monthly			
Indicate important issues not included in this table	Opening of windows only included in the calculation of overheating, not in the calculation of primary energy use			

Table 50 - Ventilative cooling parameters in national compliance tools in non-residential buildings in Belgium

Parameters	**EPB**			
Single-sided ventilation	Natural ventilation strategy cannot be selected			
Cross ventilation	Natural ventilation strategy cannot be selected			
Stack ventilation	Natural ventilation strategy cannot be selected			
Night cooling	No differentiation between day and night			
Free cooling	Yes			
Hybrid systems	No			
Position of windows in building	No			
Is wind included in your calculation?	No			

Effect of having manual or automatic window operation	No			
Steady-state or dynamic calculation?	Steady-state			
Time-step (monthly or hourly)?	Monthly			
Indicate important issues not included in this table				

7.3.6. C6: Italy (compliance tool)

Table 51 - Ventilative cooling parameters in national compliance tools in residential buildings in Italy

Parameters	**(South Tyrol), ProCasaClima 3.0**	**Docet V3.4 (residential only <200 m^2)**		
Single-sided ventilation	Predefined by tool	Natural ventilation strategy cannot be selected		
Cross ventilation	Predefined by tool	Natural ventilation strategy cannot be selected		
Stack ventilation	Predefined by tool	Natural ventilation strategy cannot be selected		
Night cooling	Yes	No differentiation between day and night		
Free cooling	No	Fixed ACH		
Hybrid systems	No	Fixed ACH		

Position of windows in building	No	Yes (but it does not influence ventilation issues)		
Is wind included in your calculation?		No		
Effect of having manual or automatic window operation	No	No		
Steady-state or dynamic calculation?	Steady-State	Steady-State		
Time-step (monthly or hourly)?	Monthly	Monthly		
Indicate important issues not included in this table				

Table 52 - Ventilative cooling parameters in national compliance tools in non-residential buildings in Italy

Parameters	**(South Tyrol), ProCasaClima 3.0**			
Single-sided ventilation	Predefined by tool			
Cross ventilation	Predefined by tool			
Stack ventilation	Predefined by tool			
Night cooling	Yes			
Free cooling	No			
Hybrid systems	No			
Position of windows in building	No			

Is wind included in your calculation?				
Effect of having manual or automatic window operation	No			
Steady-state or dynamic calculation?	Steady-State			
Time-step (monthly or hourly)?	Monthly			
Indicate important issues not included in this table				

7.3.7. C7: Austria (compliance tool)

There are a number of commercial software tools available, which fully rely on the national standards, which are ÖNORM B 8110-3, -5 and 6, as well as ÖNORM H 5055 to 5059. The manufacturers undergo a voluntary validation procedure to ensure compliance with the standardized algorithms.

7.3.8. C8: Norway (compliance tool)

Which changes has there been (if any) in your national compliance tools since the questions answered in the State-Of-The-Art Review from 2015? (see Annex D (State-of-the-art-review questionnaire))?

- No relevant changes

How is the air flow rate determined for ventilative cooling in your national compliance tool?

- Fixed ACH [*]? (if, yes - what is it?)
- Simple calculation e.g. excl. building design
- More detailed calculation e.g. incl. window position and size in building (building design)
    - Yes, if zoning is chosen for the Calculation

Are the effects of actual window position and geometry of the building included in your national compliance tool? (e.g. orientation and height difference between windows in building?)

- Yes, if zoning is chosen for the calculation

State the name of your national compliance tool and furthermore, indicate which parameters regarding ventilative cooling are included, below:

- Two tools are used for compliance check in Norway: SIMIEN and TEK-sjekk Energi. SIMIEN is the most widespread of these two.

Table 53 - Ventilative cooling parameters in national compliance tools in residential buildings in Norway

Parameters	**SIMIEN**			
Single-sided ventilation	Single-sided ventilation cannot specifically be chosen. Natural ventilation strategy can be chosen, with fixed airflow rates that has to be separately calculated and for compliance check to be in accordance with NS 3031. Airing through window according to NS-EN 15242 or a chosen schedule can also be selected.			
Cross ventilation	Cross ventilation cannot specifically be chosen. See above			
Stack ventilation	Natural ventilation strategy cannot be selected. See above			
Night cooling	Yes, with a fixed airflow rate			
Free cooling	By natural ventilation, see above			

Hybrid systems	By choosing two separate ventilation, one mechanical and one natural			
Position of windows in building	Only if zoning is used			
Is wind included in your calculation?	Only by manual schedule			
Effect of having manual or automatic window operation	No			
Steady-state or dynamic calculation?	Dynamic			
Time-step (monthly or hourly)?	Hourly			
Indicate important issues not included in this table				

Table 54 - Ventilative cooling parameters in national compliance tools in non-residential buildings in Norway

Parameters	**SIMIEN**			
Single-sided ventilation	Single-sided ventilation cannot specifically be chosen. Natural ventilation strategy can be chosen, with fixed airflow rates that has to be separately calculated and for compliance check			

	to be in accordance with NS 3031. Airing through window according to EN 15242 or a chosen schedule can also be selected.			
Cross ventilation	Cross ventilation cannot specifically be chosen. See above			
Stack ventilation	Natural ventilation strategy cannot be selected. See above			
Night cooling	Yes, with a fixed airflow rate			
Free cooling	By natural ventilation, see above			
Hybrid systems	By choosing two separate ventilation, one mechanical and one natural			
Position of windows in building	Only if zoning is used			
Is wind included in your calculation?	Only by manual schedule			
Effect of having manual or automatic window operation	No			
Steady-state or dynamic calculation?	Dynamic			

Time-step (monthly or hourly)?	Hourly			
Indicate important issues not included in this table				

7.4. Annex D (State-of-the-art-review questionnaire)

7.4.1. D1: Replies from IEA Annex 62 deliverable, State-of-the-art-review from 2015 in the section: "Ventilative cooling in energy performance calculations"

Building Code (**Legislation**)

Residential

Energy consumption for cooling

	Italy	NL	UK	DK	Ireland	China	Norway	Japan	CH	Belgium	USA Cal.
Is energy consumption for cooling considered?	No	Yes	Yes	Yes	No	No	No[1]	Yes	Yes	Yes	Yes
Is energy consumption for cooling considered separately?	No	No	Yes	No	No	No	No	Yes	Yes[2]	No	No
Is auxiliary and parasitic consumption from mechanical ventilation considered separately?	No	No	Yes	No (1)	Yes	No	No	Yes	--	No	No[3]

[1] Although energy demand for cooling is not explicitly mentioned in the Building Code, it is included in the total energy budget or energy measures required in the Building code.

[2] Electricity is separated from heat and hot water consumption. Cooling is part of electricity (1. lighting, 2. ventilation, 3. cooling, 4. auxiliary installations)

[3] But taken into account in the entire calculation

Is the energy consumption for (de-) humidifying considered separately?	No	No	Yes	No	No	No	No	No	Yes	No	?

Building parameters influencing ventilative cooling

Requirements on	Italy	NL	UK	DK	Ireland	China	Norway	Japan	CH	Belgium	USA Cal.
window size	No	No[4]	Yes	Yes	No	Yes	indirect	Yes	Yes[5]	No	Yes
window size per orientation	No	No	No	No	No	Yes	indirect	Yes	No[6]	No	Yes
solar shading	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes[7]	No	Yes
solar shading per orientation	Yes	No	No	No	No	Yes	Yes	Yes	Yes	No	Yes
thermal mass	Yes	No	No	No	No	No	No	No	Yes[8]	No	[9]
thermal mass per orientation	No	No	No	No	No	No	No	No	No	No	

Ventilation

	Italy	NL	UK	DK	Ireland	China	Norway	Japan	CH	Belgium	USA

4 only for daylight access

5 5% of floor area

6 This is not in the Energy code but in the norm for protection from overheating

7 0.1 or see graph in appendix.

8 45 Wh/m2K according to EN 13786

9 Not found by Regina Bokel

											Cal.
Does the hygienic ventilation system require minimum air flow rates?	Yes [10]	Yes	Yes [11]	Yes	Yes [12]	Yes	Yes	Yes	Yes [13]	Yes[14]	Yes [15]
Does the hygienic ventilation system require maximum air flow rates?	No	Yes	No	No	No	No	No	No	Indirect[16]	No	No
Does the hygienic ventilation system require different air flow rates in summer and winter?	No	No	No	No	No	No	No	No	Yes [17]	No	No
Does the intensive ventilation system require minimum air flow rates?	No[18]	Yes	Yes [19]	Yes	~~No~~ Yes [20]	Yes	[21]	Yes	Yes [22]	No	No
Does the intensive ventilation system require maximum air flow rates?	No	No	No	No	No	No		No	Yes [23]	No	No
Does the intensive ventilation system include night-time ventilation?	No	No [24]	No	No	No	No		Yes	Yes	No	No

10 depends on person/m^2

11 The requirement is in l/s, varies according to the room use e.g. 8l/s for bathroom, 13l/s for kitchen and for the whole house depends on number of bedrooms e.g. 21l/s for a house with three bedrooms or minimum of 0.3l/s per floor area

12 Airflow requirements are based on opening area and subject to use.

13 25-30 m^3/h per person

14 3.6 m^3/h.m^2 supply

15 See section 120 of California Code of Regulations, Title 24, part 6

16 through thermal balance equation

17 3 m^3/m^{2}h, 10 m^3/m^{2}h

18 A heat recovery ventilation is required if total airflow and number of operation hours is above the value in the table in DPR 412/93 Art.5, comma 13 e Allegato C

19 It is called 'purge' ventilation and is required in every habitable room, minimum 4 air changes per hour

20 Answer changed by editor based on the response on the question “Are there requirements for indoor air quality”

21 Not filled out

22 3 m^3/m^{2}h

23 10 m^3/m^{2}h

24 Night time ventilation is not mentioned in the building code.

Ventilation openings and position

	Italy	NL	UK	DK	Ireland	China	Norway	Japan	CH	Belgium	USA Cal.
Does the position of inflow air relative to the outflow air influence ventilative cooling?	No	?[25]	Yes	[26]	No	No	[27]	Yes	No	No	No
Is a minimum inflow opening area required for outside walls?	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes [28]	No	Yes
Is a minimum inflow opening area for outside walls required per orientation?	No	No	No	No	No	No	No	No	No	No	No
Is a minimum inflow opening area required for inside walls?	No	No	No	Yes	Yes	No	No	No	No	No	No

25 Possible
26 no answer
27 no answer
28 5% of the floor area

Is a minimum outflow opening area required for outside walls?	No	No	Yes	No	Yes	No	No	Yes	No	No	No[29]
Is a minimum outflow opening area for outside walls required per orientation?	No	No	No	No	No	No	No	No	No	No	No
Is a minimum outflow opening area required for inside walls?	No	No	No	Yes	Yes	No	No	No	No	No	No
Are there requirements for grid flow characteristics?	No	Yes	Yes[30]	Yes[31]	No	No	No	[32]	Yes	No	Yes[33]
Other aspects?	No	No	No	No	No	No	No	No	No	No	No

Safety

	Italy	NL	UK	DK	Ireland	China	Norway	Japan	CH	Belgium	USA

29 No difference between inflow and outflow

30 These are described in the compliance software (SAP) and is known as annex Q

31 Transfer of air from more to less polluted rooms is not allowed

32 no answer

33 Naturally ventilated spaces shall be permanently open to and within 20 feet of operable wall or roof openings to the outdoors. Operable openings shall be readily accessible to building occupants whenever the space is occupied.

											Cal.
Do the fire regulations influence ventilative cooling?	No[34]	?	[35]	Yes[36]	No	Yes	No	Yes	Yes	[37]	No
Do the burglary regulations influence ventilative cooling at night-time operation?	No	Yes		Yes[38]	No	No	No	No	Yes	Yes	?
Do the burglary regulations influence ventilative cooling at daytime during absence?	No	Yes		Yes[39]	No	No	No	No	Yes		?
Does the rain tightness regulation influence ventilative cooling?	No	No		No	No	Yes	No	No	Yes		No
Do the controllability regulations influence	No	Yes		No	No	No	No	No	No	Yes	?

[34] Fire protection may actually pose limits to the use of ventilative cooling solutions, in particular for buildings exceeding 500m^2. The legislation is rather complex and addresses specific building types (e.g. residential, hotels, schools, hospitals...). For example, the DM 246/1987 reports the requirements that residential buildings must respect in terms of internal, smoke-proof subdivisions (see aside)

[35] All these aspects are considered in 'purge' ventilation calculations and included in the min recommendation of 4 air changes per hours

[36] Yes, fire sections have to be intact, but natural ventilation in a way is promoted since it is highlighted that it could serve as smoke venting in case of fire.

[37] the empty grids in this table had no answer from Belgium

[38] For automatically operated windows for venting

[39] For automatically operated windows for venting

ventilative cooling?											
Do the cleaning regulations influence ventilative cooling?	No	No		No	No	Yes	No	No	No		No
Do the acoustical regulations influence ventilative cooling?	No[40]	Yes		Yes[41]	No	Yes	No	No	No		No
Do the insect-proof regulations influence ventilative cooling?	No	Yes		Yes[42]	No	No	No	No[43]	Yes		Yes
Other aspects	No	No		No	No	No	No	No	No		flood

Temperature, Air velocity and Humidity

	Italy	NL	UK	DK	Ireland	China	Norway	Japan	CH	Belgium	USA Cal.

[40] The Decree DPCM 5/12/97 "Determinazione dei requisiti acustici passivi degli edifici" gives indications on the "potere fonoisolante apparente" (sound reduction index) , and other 4 acoustic performance indices. However, these indices do not take into account the specific location of the buildings (urban/rural...). This may actually pose severe limitations to ventilative cooling at a design stage

[41] Noise limits indoors are 58DB for traffic noise and 64DB for Railroad

[42] It is stated that openings directly to outside should not allow access of microorganisms

[43] inlet/outlet opening of outdoor air and the top of the exhaust opening needs insect-proof installation in sanitary meaning

Are maximum summer temperatures included in the building code?	No[44]	No	No	Yes	No	Yes	Yes	No	Yes	Yes[45]	Yes[46]
Is the maximum summer temperature determined by the adaptive comfort theory?	No	No	No	No	No	No	No	No	Yes	No	Yes[47]
Other aspects	No	No	No	No	No	No	Yes[48]	No	No	No	No
Is there a maximum air velocity required in a room?	No[49]	Yes	No	Yes	No	Yes	No	No	Yes	No	Yes[50]
Is this maximum air velocity related to the room air temperature?	No	No	No	Yes	No	No	No	No	Yes	No	No[51]

44 The recent Presidential Decree 74/2013 sets lower air temperature threshold for the cooling period, calculated as the average of the monitored temperatures: 26°C with a 2 degrees tolerance, except for some particular cases (e.g. buildings with swimming pools, buildings housing diplomatic offices or international organization) for whom local authorities can decide that limits may not be respected.

45 overheating indicator

46 85 °F, section 6, 120 2 c

47 at least for the calculation, and from ASHRAE 55 or ASHRAE handbook, fundaments volume, Chapter 8 (except for winter humidification and summer dehumidification)

48 Windows should be openable

49 No national requirements, UNI EN 7730 reports maximum air velocities as a function of the air temperature, but to our best knowledge local legislation does not refer explicitly to this standard. The Presidential Decree 74/2013 sets the lower air temperature threshold for the cooling period but does not address adaptive-model logics, nor the exploitation of devices to increase the indoor air velocity during the cooling season.

50 discharge velocity at 15 feet of the unit

51 Although implicit in ASHRAE 55

Other aspects	No	No	No	No	No	No	No	No	No	No	No
Is there a maximum RH required?	No[52]	No	No	Yes	No	Yes	No	No	Yes	No	No?
Is there a minimum relative humidity required?	No	No	Yes[53]	Yes	No	Yes	No	No	Yes	No	No?
Do the maximum and minimum RH depend on the inside air temperature?	No	No	No	No	No	No	No	No	Yes	No	
Do the maximum and minimum relative humidity depend on the outside air temperature?	No	No	No	No	No	No	No	No	Yes	No	
Other aspect	No	No	No	No	No	No	No	No	No	No	No

Energy Performance (compliance tools)

52 Usually regional legislations state in general terms that internal spaces must present minimum quality of healthiness/salubrity, but without specifying requirements. The standard "UNI EN 13779: Ventilazione degli edifici non residenziali-Requisiti di prestazione per i sistemi di ventilazione e di climatizzazione" provides some indicative parameters, such as a RH range between 40 and 60%

53 A very complex method of calculating humidity activity in residential rooms to prevent mould growth is included in the Building Regulations.

Residential Buildings

General Questions

	Italy	NL	UK	DK	Ireland	China	Norway	Japan	CH	Belgium	USA Cal.
Is an Energy Performance (calculation) required for a building?	Yes	Yes	Yes [54]	Yes	Yes	No	Yes [55]	Yes	Yes	Yes	Yes
To which version of the EP-regulation do the answers of this questionnaire refer to?	[56]	[57]	[58]	[59]	[60]	No	[61]	[62]	[63]	2013	2013 [64]
In the determination/ calculation of the overall EP, is the consumption for cooling considered?	[65]	Yes		Yes	No	No	Yes	Yes	No[66]	Yes	Yes
If no (active or passive) cooling system is installed in the building, is there a	No	Yes [67]		Yes	No	No	No	?	No	Yes [68]	No

[54] All systems are considered because buildings are modelled as whole system using SAP for domestic and NCM for non-residential.

[55] In the calculation of the energy need for cooling the ventilative cooling can be included as a heat loss.

[56] The main Decree on energy performance of buildings are: Legge 373/1976, Legge 10/1991, DPR 412/1993, D.Lgs. 192/2005, D.Lgs. 311/2006, D.P.R. 2 aprile 2009 n. 59, D.M. 26 giugno 2009, DM 11 Marzo 2010, DM 26 Gennaio 2010. The standards are into force from 1976. They have been updated regularly.

[57] The standards are into force from 1995. They have been updated regularly. The method concerning cooling has been changed in the past. When what changes were made is beyond the scope of this questionnaire (will take a lot of time to find these details)

[58] Building Regulations Part L or F, 2014

[59] BR2010

[60] Residential - 2011

[61] Directive 2002/91/EC

[62] 2013.10, Act on the Rational Use of Energy (Energy conservation Law)

[63] no information

[64] California Energy Code, 2013, Title 24, part 6

[65] The Legislative Decree 63/2013, which implements at national level the European Directive 2010/31, states that the Energy Performance Certificate will include the energy consumption for (heating and) cooling. However, at present the comprehensive EP Certificate has not been finalized.

[66] Calculation necessary for heating demand. Cooling demand is supposed to be implicitly considered not necessary.

[67] if no cooling system is present, fictitious cooling is taken into account (Residential buildings only)

[68] value depends on overheating indicator

cooling penalisation in the EP?											
Is the EP-requirement (Epr) different if a cooling system is installed or not?	No	No		Yes [69]	No	No	No	No	No	No	No
In which classification category falls the calculation method?	BmSm	BmSm		BmSm	BmSm	-	BhSh or BmSm	[70]	BmSm	?	BhSh[71]

Non-Residential Buildings

For Non-Residential buildings the same questions are asked as for Residential Buildings. There are differences between Residential and non-residential buildings, but the differences between the countries are as large as the differences between residential and non-residential buildings are therefore the results of the questions for non-residential buildings which is not discussed in detail.

	Italy	NL	UK	DK	Ireland	China	Norway	Japan	CH	Belgium	USA Cal.
Is an Energy Performance (calculation) required? If not, do not answer the other questions!	Yes	Yes	Yes [72]	Yes	Yes	No	Yes [73]	Yes	Yes	Yes	Yes

[69] If a cooling system is installed you are allowed to use the actual COP else needed cooling is calculated with a COP of 2
[70] no answer
[71] http://bees.archenergy.com/referencemethod.html
[72] All systems are considered because buildings are modelled as whole system using SAP for domestic and NCM for non-residential.
[73] In the calculation of the energy need for cooling the ventilative cooling can be included as a heat loss.

To which version of the EP-regulation do the answers of this questionnaire refer to?	[74]	[75]	[76]	[77]	[78]	No	[79]	[80]	[81]	2013	2013[82]
In the determination/ calculation of the overall EP, is the consumption for cooling considered?	[83]	Yes		Yes	No	No	Yes	Yes	Yes[84]	Yes	Yes
If no (active or passive) cooling system is installed, is there a cooling penalisation in the EP?	No	Yes[85]		Yes	No	No	No[86]	?	No	No	No
Is the EP-requirement (Epr) different if a cooling system is installed or not?	No	No		Yes[87]	No	No	No[88]	No	No[89]	No	No

[74] The main Decree on energy performance of buildings are: Legge 373/1976, Legge 10/1991, DPR 412/1993, D.Lgs. 192/2005, D.Lgs. 311/2006, D.P.R. 2 aprile 2009 n. 59, D.M. 26 giugno 2009, DM 11 Marzo 2010, DM 26 Gennaio 2010. The standards are into force from 1976. They have been updated regularly.

[75] The standards are into force from 1995. They have been updated regularly. The method concerning cooling has been changed in the past. When what changes were made is beyond the scope of this questionnaire (will take a lot of time to find these details)

[76] Building Regulations Part L or F, 2014

[77] BR2010

[78] Non Residential - 2008

[79] Directive 2002/91/EC

[80] 2013.10, Act on the Rational Use of Energy (Energy conservation Law)

[81] no answer

[82] California Energy Code, 2013, Title 24, part 6

[83] The Legislative Decree 63/2013, which implements at national level the European Directive 2010/31, states that the Energy Performance Certificate will include the energy consumption for (heating and) cooling. However, at present the comprehensive EP Certificate has not been finalized.

[84] Calculation of heating demand. Cooling demand is necessary if air conditioning is present.

[85] if no cooling system is present, fictitious cooling is taken into account (Residential buildings only)

[86] Actually there is a small potential energy "credit" when cooling is not provided as the baseline building used for assessment will have mechanical cooling operated to a set point of 27C

[87] If a cooling system is installed you are allowed to use the actual COP else needed cooling is calculated with a COP of 2

[88] No the baseline building used for assessment comparison purposes does not change whether or not cooling is installed in the actual building being assessed

[89] Cooling energy consumption is considered in electricity consumption. Heat and hot water is treated separately. Cooling needs are calculated with a dynamic separate calculation and translated to energy consumption with machine COP and added to the electricity consumption

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Annex 62: Ventilative Cooling

The Executive Committee of the IEA Energy in Buildings and Communities programme (IEA EBC) approved the IEA EBC Annex 62 on Ventilative Cooling in November 2013 with a four year working and reporting phase from 2014 – 2017. In order to address the cooling challenges of buildings the research focus of the annex has been the development of design methods and compliance tools related to predicting, evaluating and eliminating the cooling need and the risk of overheating in buildings, and new attractive energy efficient ventilative cooling solutions. The Participants in this task are Austria, Belgium, P.R. China, Czech Republic, Denmark, Finland, Germany, Greece, Italy, Ireland, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States of America.