ANNEX 5

EBC

Energy in Building and
Communities Programme

AIVC Technical Note 72
Ventilation Requirements and Rationale behind. Standards and Regulations of dwellings, office rooms and classrooms

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Participating countries in the EBC: Australia, Austria, Belgium, Brazil, Canada, P.R. China, Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Republic of Korea, the Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Turkey, United Kingdom and the United States of America.

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Preface

The International Energy Agency

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

The IEA Energy in Buildings and Communities Programme

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

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

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

Objectives: The strategic objectives of the EBC TCP are as follows:

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

Means: The strategic objectives of the EBC TCP will be achieved by the means listed below:

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

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

The Executive Committee

Overall control of the IEA EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA EBC Implementing Agreement. At the present time, the following projects have been initiated by the IEA EBC Executive Committee, with completed projects identified by (*) and joint projects with the IEA Solar Heating and Cooling Technology Collaboration Programme by (☼):

Annex 1: Load Energy Determination of Buildings (*)
Annex 2: Ekistics and Advanced Community Energy Systems (*)
Annex 3: Energy Conservation in Residential Buildings (*)
Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)
Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)
Annex 20: Air Flow Patterns within Buildings (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: ☼ Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: ☼ Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: ☼ Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
Annex 52: ☼ Towards Net Zero Energy Solar Buildings (*)
Annex 53: Total Energy Use in Buildings: Analysis and Evaluation Methods (*)
Annex 54: Integration of Micro-Generation and Related Energy Technologies in Buildings (*)

Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost (RAP-RETRO) (*)
Annex 56: Cost Effective Energy and CO_2 Emissions Optimization in Building Renovation (*)
Annex 57: Evaluation of Embodied Energy and CO_2 Equivalent Emissions for Building Construction (*)
Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements (*)
Annex 59: High Temperature Cooling and Low Temperature Heating in Buildings (*)
Annex 60: New Generation Computational Tools for Building and Community Energy Systems (*)
Annex 61: Business and Technical Concepts for Deep Energy Retrofit of Public Buildings (*)
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Annex 70: Energy Epidemiology: Analysis of Real Building Energy Use at Scale
Annex 71: Building Energy Performance Assessment Based on In-situ Measurements (*)
Annex 72: Assessing Life Cycle Related Environmental Impacts Caused by Buildings
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Annex 88: Evaluation and Demonstration of Actual Energy Efficiency of Heat Pump Systems in Buildings

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Working Group - Indicators of Energy Efficiency in Cold Climate Buildings (*)
Working Group - Annex 36 Extension: The Energy Concept Adviser (*)
Working Group - HVAC Energy Calculation Methodologies for Non-residential Buildings (*)
Working Group - Cities and Communities
Working Group – Building Energy Codes

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Summary

Many differences exist between countries in the requirements and regulations for ventilation of dwellings, offices, classrooms and other spaces. Sometimes the variation of the ventilation requirements for the same building type between countries is more than a factor of five. There are strong drivers, e.g., climate change, to reduce energy consumption for HVAC and therefore these variations are worth examining. Before reducing ventilation rates, it is critical to understand the reasons behind them. Demand control to adjust the ventilation flows is becoming more common in many countries, but the control approaches are quite different, for instance humidity versus CO_2 control. This document provides insight into the reasons for ventilation requirements across different countries to provide policy makers and standardization committees information for the discussions about ventilation. Although this document doesn't discuss the relation between pandemic management and required ventilation levels, it can help the discussion to know which drivers are behind current regulation.

An overview of results of this survey from 29 countries show large differences in ventilation requirements for dwellings, as well for living rooms and so-called “wet rooms” (kitchen, toilet, and bathroom) In this report we have defined a methodology to compare the requirements from country to country, which are expressed in different ways. The requirements can depend on dimensions of rooms, number of persons per room, number of rooms, and ventilation system type. For example, sometimes the requirements are expressed per person, sometimes per m^2 floor area, mostly in volumetric flow rates but also in air change rates. In this study, assumptions were made for room size and occupancy to compare the ventilation rates. The data gathered for AIVC countries are based on an input from individuals; the data for non AIVC countries are taken from literature. Not all country information came from experts in the ventilation field. To understand ventilation requirements in most cases also requires knowledge of the building regulations and laws.

The rationale behind the ventilation requirements includes the following elements:

- Human odour: Human bioeffluents, often with CO_2 as marker criteria
- Moisture: Human activities (e.g., washing, showering, washing dishes, cooking)
- Health impact
- Dilution of other internally generated pollutants
- Formaldehyde emissions
- Cooking fumes and combustion products
- Bacteria, viruses
- Sick building syndrome symptoms
- Radon

For habitable rooms, apart from the so-called wet rooms, almost all countries mention CO_2 as indicator for bioeffluents as a rationale. For bathrooms, human activities and moisture production are the most important drivers. For toilet rooms, rationales are related to the spreading of odour to other rooms. For kitchens, diluting products from cooking processes are, as can be expected, the most important rationale.

The ratio between the highest and the lowest value between countries in terms of ventilation is larger in dwellings (3 to 10) compared to offices and classrooms (2 to 3). An explanation for this difference might be the more consistent activity in offices and schools. Many of these ventilation regulations were written in the same period (early 1990’s) and are generally based on the same available literature.

1. Introduction

1.1. Goal

The goal of this AIVC project “Rationale behind ventilation requirements and regulations,” which started in 2017, was to collect information about the requirements and rationale behind requirements and regulations in different countries, to analyse these data, to categorize them and to produce recommendations based on the latest research findings.

1.2. Organization of the project

Questionnaires were sent out to members of the AIVC Board for the 16 AIVC countries (See Appendix 1: Results from Questionnaires12). Furthermore, a literature review was conducted that identified other important data. In some cases, national standards and regulation were used directly. In total, information from 29 countries is considered in this report.

Because of the different way the requirements and/or guidelines are formulated or expressed, for instance differences in format and units, a methodology is made with some assumptions and calculations for comparing the results between the different countries. Most building regulations have a philosophy that impacts how the requirements are interpreted, such as whether the regulation is targeting minimum or high performance.

1.3. Reasons behind this report

Internationally there are many different requirements and regulations for ventilation. Sometimes the variation is greater than a factor of five. There are strong drivers to reduce energy consumption for HVAC due to climate change. Therefore, the variation in requirements and regulation is worthwhile to study. The main purpose of ventilation is to secure an indoor environment where health, comfort, productivity and sometimes integrity of the building construction will not be negatively influenced by a constituent in the air. Since we do not have enough knowledge about the relation of many contaminants and ventilation, it is difficult to set a hard minimum for ventilation in all environments and situations. To change ventilation requirements, it is necessary to better understand the reasons behind the current values.

2. Data gathering

2.1. General information

A detailed and accurate collection of the various requirements in countries with respect to ventilation is hard to define for various reasons, e.g. multitude of legislations, change over time of legislation, and various types of specifications ranging from guidelines to legislation with enforcement.

Therefore, we have opted not to focus this report on a detailed reporting of the various specifications by country but to collect such information (which in most cases is quite reliable but often not complete) and to use this information as a basis for analyzing global tendencies and to draw conclusions.

In the annexes, specific information by country is given but with the important remark that this information might be not complete and/or out of date.

2.2. Information collected from various AIVC countries

A questionnaire (See Appendix 1: Results from Questionnaires) was developed and filled in by a number of AIVC member countries and Portugal.

Information on the rationale behind the requirements is not always clear (See Chapter 3). After receiving the national data, the authors of this Technical Note analyzed the information and developed a national summary for each submission. This national summary was sent back to each national representative for review.

The initial data was produced in 2017, and this report was published in 2023. While some countries might have changed their requirements in the meantime, the findings of this report can be updated at a later stage.

2.3. Data from literature

Based on a literature review in the AIVC database AIRBASE, we found several reports with overviews of national requirements (See: Appendix 2: Data from Literature). As can be seen in those data, there is a lot of information on flow rates but also on contaminants and contaminant concentration limits. However, a logical rationale for the requirement is not given in most of this literature. One may expect that minimizing exposure based on health reasons is in most cases the driver. Comfort in terms of hindrance of odours caused by bioeffluents is often used as a basis for the requirements. [1][2][3][4][5][6][7]

2.4. Data from European standards

European standards are the result of consultation and consensus between representatives from the various national standardisation organizations. These standards can therefore be regarded as a synthesis of consensus views by these experts.

The following observations are important:

- There are two different types of EN standards for ventilation:
    - Product standards, with the goal to minimise the trade barriers between countries, mainly consisting of test methods
    - Standards with ventilation classes for buildings
- These EN standards don’t contain specific requirements, but include informative annexes with possible values that could be used. This approach reflects that there is no broad consensus about the requirements.
- These EN standards allow various approaches for expressing ventilation, e.g.:
    - Per person
    - Per person and per m² of floor area
    - A maximum CO_2 increase above the outdoor level

3. Methodology for comparison of requirements and regulations

3.1. Introduction

Although we have surveys from several AIVC countries, not all AIVC countries provided information. (See: Appendix 1: Results from Questionnaires) Spain is the only AIVC country that has a cumulative CO_2 criterion for ventilation in their requirements. The yearly average CO_2 concentration must be smaller than 900 ppm, and the yearly CO_2 concentration accumulated over 1600 ppm must be smaller than 500.000 ppmhour. Ppmhour describes the accumulation of the average CO_2 concentration above 1600 ppm per hour during a year. A lot of other countries have also used CO_2 as the basis for their requirements in habitable rooms, but CO_2 is not used as their legal requirement. Some countries have CO_2 control in their energy standards to reduce ventilation rates under low occupancy, i.e., demand control ventilation.

Carbon dioxide (CO_2) is from a historic view a reference point for ventilation levels. It is a marker for bioeffluents (see §4.3).[8]. The role of CO_2 to control indoor air quality in buildings is based on the fact that CO_2 generated by people breathing may be used as a marker for the bioeffluents produced by people. CO_2 is harmless at normal indoor levels for pollutants generated by the occupants. Based on international accepted literature concerning CO_2 as a marker for bioeffluents, 7 to 10 dm^3/s per person outdoor air is in this report taken as a reasonable level for habitable spaces. CO_2 as indicator or marker for IAQ in rooms is only effective when:

- The ventilation level required by the inhabitants is dominant to all other sources such as emissions for building materials and furniture.
- Other sources, for instance combustion products, moisture and indoor temperature do not require higher ventilation rates.

Another aspect which plays a role in comparing data from different countries is whether or not the required flow must always be achieved or only when the space is occupied. In case of demand-controlled ventilation, the requirement might be relevant when the control parameter is above a certain target. Some countries have forbidden or at least don't activate demand control based on occupation. In some countries the required ventilation flows don't have to occur at the same time in each room. In a dwelling all people cannot be at the same time in the living room and in the bedrooms, hence ventilating both bedrooms and living room at the required level at the same time is not required. This is the reason why comparing requirements from countries is not always straightforward and may sometimes result in misleading conclusions.

An example of the data collected is shown in Figure 1. This example is only to show that the requirements are different in different countries.

As can be seen the units of the requirements vary, often making it difficult to compare the requirements without knowing room dimensions and/or number of persons in the room.

AIVC Countries	Living room							
	Per m²		Per person					
	$dm^3/s\ m^2$	$m^3/h\ m^2$	m^3/h pp	dm^3/s pp	h^{-1}	ppm CO_2	floor area	supply
BE	1							
CH			12 15					
CN			30	8.3				
CZ					0,3-0,6			
DE					1-1,5			
DK	0.3	1.08						
ES					y<900	5000000ppmh>1600		
FI	0.5	1.8						
FR								x
GR			8,5 - 17					
JP					0.5			
KR					0.5			
NL	0.9	3.24						
NO		1.2						
NZ					0.35		1/20	
PT					1			
SE	0.35	1.26						
UK							1/20	

Figure 1: An example of the data collected on dwellings (see appendix 1 for more details)

3.2. Data of the rooms used for comparison

As can be seen from figure 1, ventilation requirements are expressed in many different ways; flow rates in dm^3/s or m^3/h, air change rates in h^{-1}, and flowrates per m^2 floor area. In some cases, the requirements depend on the number of persons in a room or the number of rooms in a dwelling. This means that some comparisons can't be made without room dimensions and sometimes the number of occupants. Given these complexities, the following table contains the assumptions for room dimensions used to compare ventilation requirements in this report. For some countries, these dimensions may not be representative, as each of the 29 countries concerned have their own specific characteristics.

Table 1: Dimensions of rooms used for comparing ventilation requirements

	Width (m)	Depth (m)	Height (m)	Volume (m^3)	Floor Area (m^2)
Living A	3,5	5,75	3	60	20
Living B	4	7	3	84	28
Living C	5	8	3	120	40
Kitchen	4	3	3	36	12
Bathroom	3	2	3	18	6
Toilet	1,25	1,35	3	5	1,7
Office room	3,2	3,13	3	30	10
Classroom	6	8	3.5	168	48

3.3. Residential ventilation requirements

3.3.1. Living rooms

Six countries expressed their requirements in flowrate per m^2 floor area, two countries in flowrate per person and six countries in air change rate. To compare the requirements, assumptions have to be made for the size for the living room. See Table 1 the dimensions used in this analysis. For 4 persons in living rooms A, B and C, the reported data for the living room are given in Figure 2, Figure 3 & Figure 4. In case a country did not specify a flow for the living room in the questionnaire, they are not presented in the following figures. However, that does not mean they have no requirements. For example, ASHRAE 62.2 [9] only specifies the total ventilation rate for the dwelling, hence comparisons with other countries for the living room cannot be made.

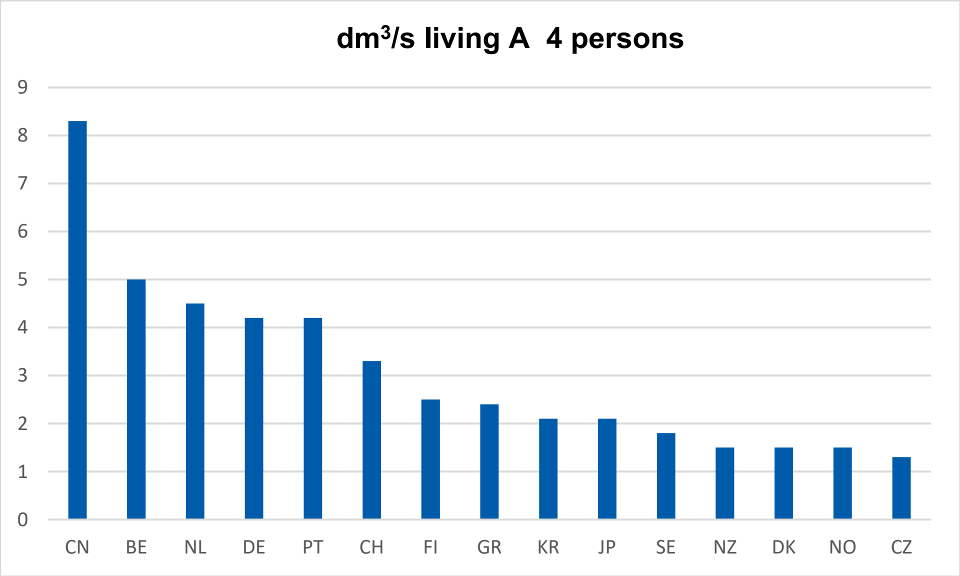

Figure 2: The minimum flow rate per person for 15 countries living A (20m²) with 4 persons

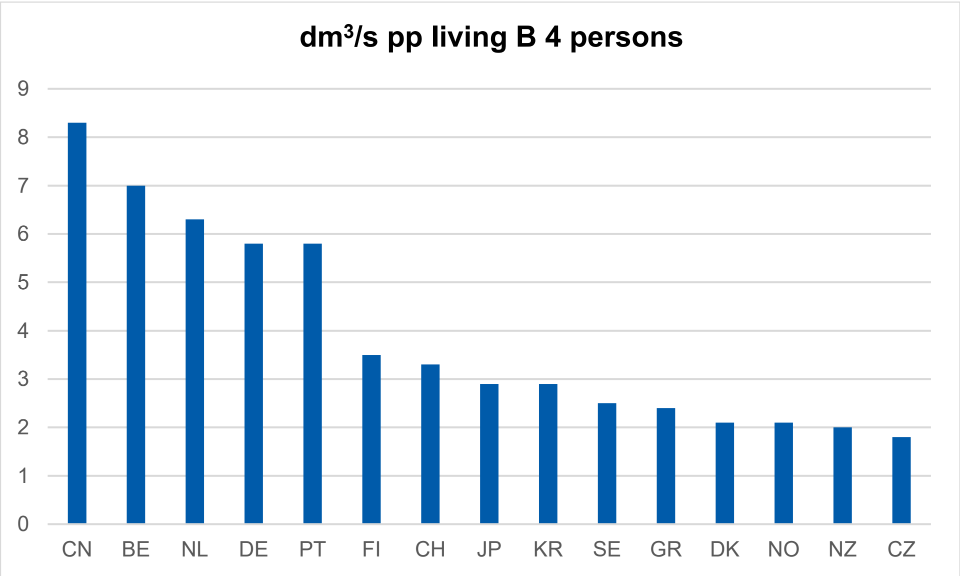

Figure 3: The minimum flow rate per person for 15 countries living B (28 m²) with 4 persons

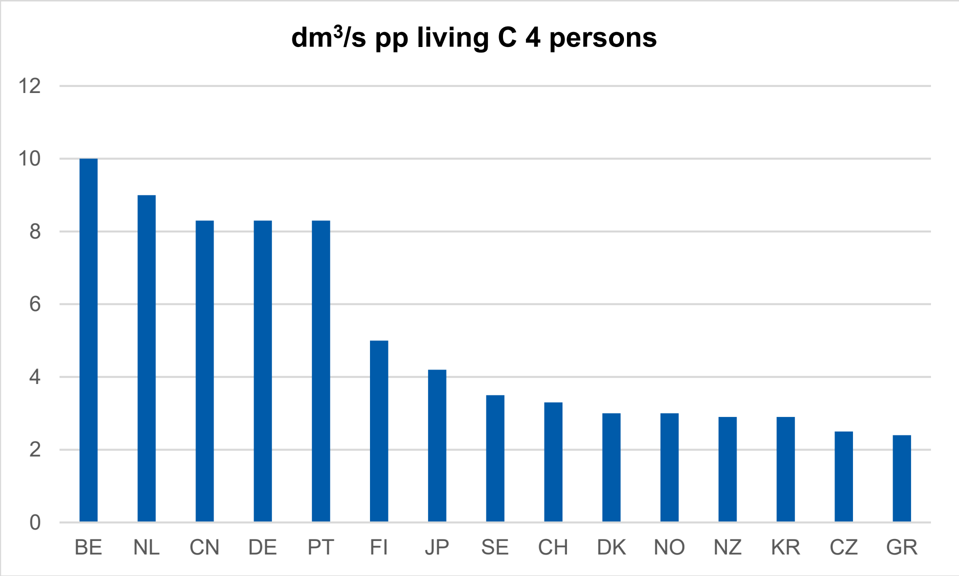

Figure 4: The minimum flow rate per person for 15 countries living C (40 m²) with 4 persons

As can be seen from Figure 2, Figure 3 & Figure 4, depending on the type of expression of the requirements, the sequence is changing. The bigger the living room, a fixed flow rate per m^2 leads to higher flowrates per person as can be expected. In particular, the countries at the right-hand side of Figure 2, Figure 3 & Figure 4 become a little bit bigger. The ratio between the highest and the lowest value in Figure 4 is around 4.

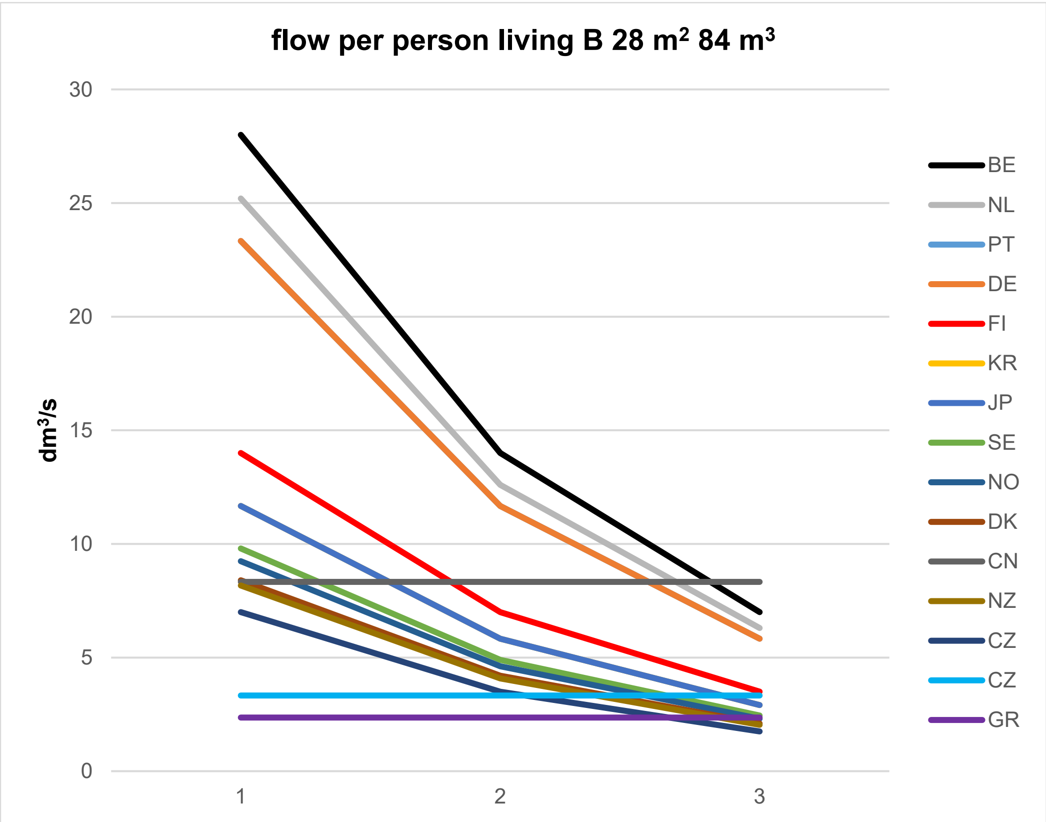

Figure 5: Relation between flowrate per person and the number of persons in the living room (B) (28 m²)

China, Greece and Switzerland have a constant flowrate per person regardless the floor area. All of the other twelve countries have requirements that depend on floor area, with a higher the number of persons leading to a lower flowrate per person. For reference, an adult person with medium activity and 7 dm^3/s results in an equilibrium CO_2 concentration of about 1200 ppm.

The requirements used in this study are taken from the answers in the questionnaire or from literature. The minimum values found have been analysed. These values may have no relation with what occupant experience in their buildings.

3.3.2. Kitchens

For kitchens, the requirements are more straightforward to interpret, with the results given in Table 2 and Figure 6.

The ratio between the lowest and highest value in Figure 6 is 5. The average value is about 19 dm^3/s.

Table 2: Minimum requirements for kitchens

Country	dm^3/s	Country	dm^3/s	Country	dm^3/s
IT	42	FI	20	NZ	12
PT	40	DK	20	KR	11.7
CZ	28	HU	20	DE	11.1
BE	21	LT	20	NO	10
NL	21	RO	20	SE	10
FR	21	SI	16.7	GR	9.4
USA	21	UK	13	PL	8.3

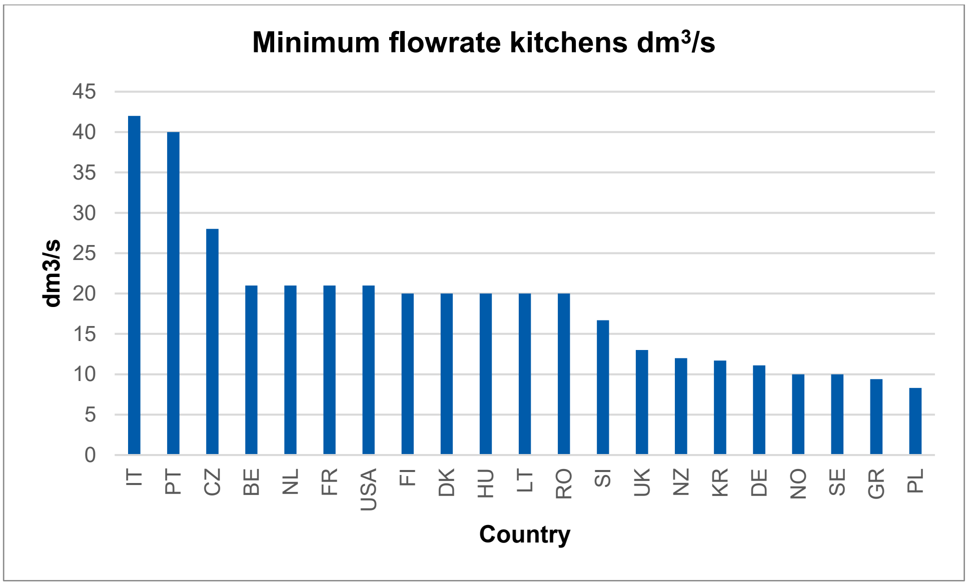

Figure 6: The minimum required flowrate for kitchens

3.3.3. Bathrooms

Table 3: Minimum requirements for bathrooms

Country	dm^3/s	Country	dm^3/s	Country	dm^3/s

IT	22	FI	15	NZ	10
CZ	21	HU	15	SE	10
USA	20	LT	15	GR	10
PT	20	BE	14	FR	8.5
SI	17	NL	14	UK	8
DK	15	PL	14	RO	7
NO	15	DE	11		

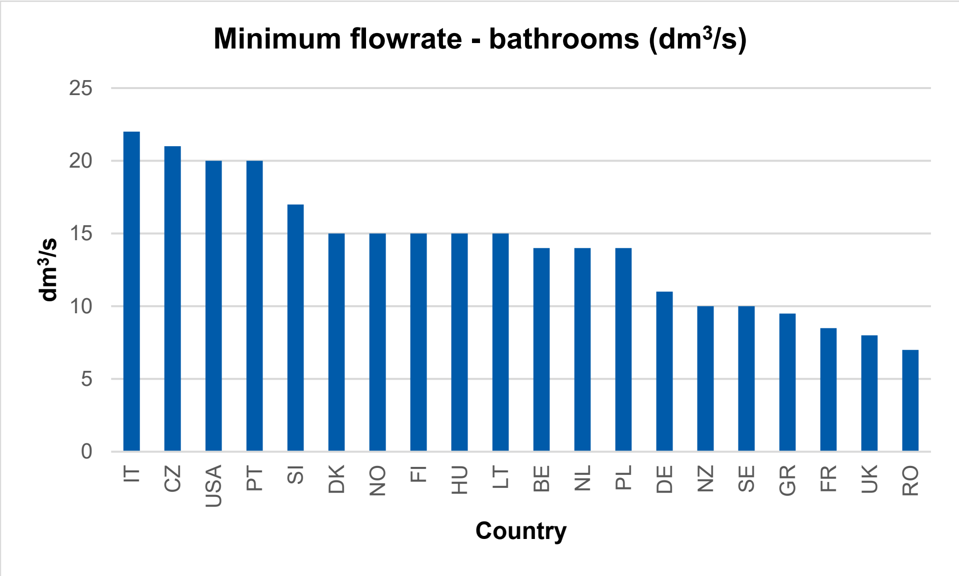

Figure 7: The minimum required flowrate for bathrooms

The ratio between the lowest and highest value in Figure 7 is about 3. The average value is about 14 dm^3/s.

3.3.4. Toilets

Table 4: Minimum requirements for toilets

Country	dm^3/s	Country	dm^3/s	Country	dm^3/s
PL	13.9	HU	9	NL	7
NO	10	FR	8.33	PT	6.9
BG	10	IT	8.3	RO	6.7
LT	10	SI	8.3	UK	6
DK	9	CZ	7	DE	6
SE	9	BE	7		

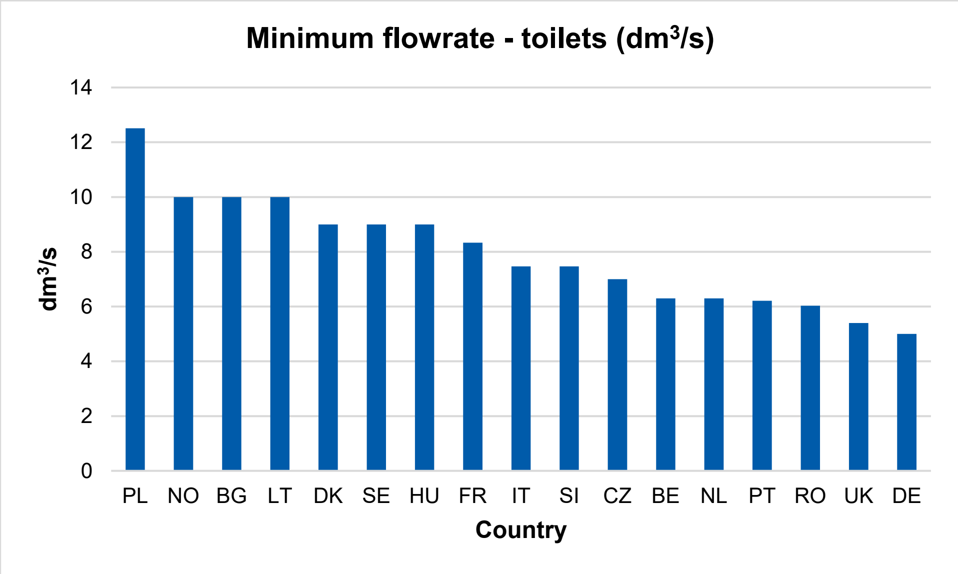

Figure 8: The minimum required flow rate for toilets

The ratio between the lowest and the highest ventilation requirement for toilet rooms is about 2,5. Most values are between 5 and 10 dm^3/s. which may be expected for a room where normally only one person is inside during a relatively short time.

Most of the requirements for the so-called wet rooms are exhaust requirements. Some countries do not explicitly say exhaust, but simply state that the capacity must be at the required level.

3.3.5. Whole house

Finally, based on all the data found, the whole house air change rate is calculated (or derived from literature) for dwelling A and shown in Figure 9. Due to big differences in the regulations, it is difficult to compare the requirements for the whole house without detailed knowledge of the background of these regulations. Nevertheless, in Figure 9 an attempt is given.

Table 5: Minimum air change rate for the whole dwelling

Country	ACH(h^{-1})	Country	ACH(h^{-1})	Country	ACH(h^{-1})
CZ	1	JP	0.5	FR	0.4
GR	0.7	KR	0.5	USA	0.4
HU	0.6	CZ	0.5	NZ	0.35
PT	0.6	FI	0.5	SE	0.35
BE	0.55	LT	0.5	IT	0.30
RO	0.54	SI	0.5	BG	0.26
NL	0.52	NO	0.48	AT	0.15
DK	0.51	PL	0.44		
DE	0.51	UK	0.43		

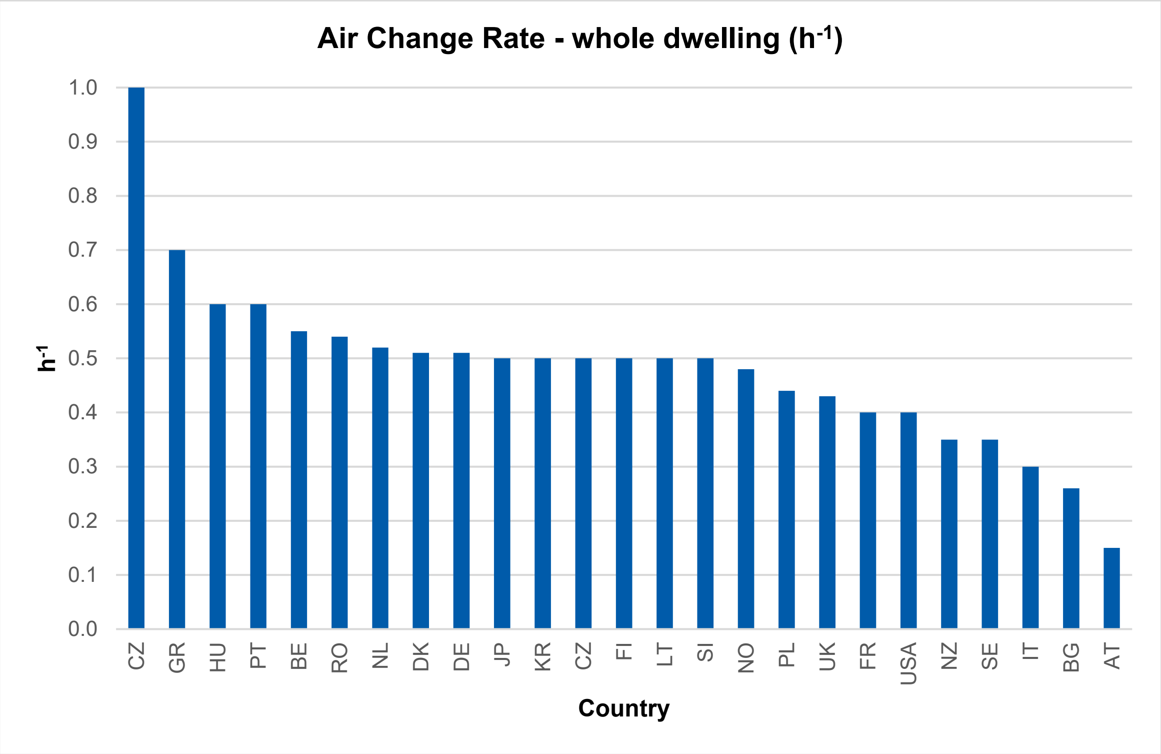

Figure 9: Air Change Rate for the whole dwelling

The ratio between the lowest and the highest value is about 6. Most values are between 0,4 h^{-1} to 0,6 h^{-1}, and the average is 0,48 h^{-1}. Austria and China are typically outliers because they differ so much from the other countries. The total volume of the dwelling has a direct effect on the air change rate, and they will differ from country to country. Nevertheless Figure 9 gives a reasonable impression of the dispersion between countries.

The values used are either the explicit required value for the whole dwelling or in case of requirements per room the lowest value of:

- the sum of the requirements for each room
- the required total mechanical extraction

3.4. Ventilation requirements for Offices

The ratio between the lowest and the highest ventilation requirements for offices is about 2, which is lower that for the other spaces considered. The reason might be that in an office room the activity is rather constant in terms of producing bioeffluents, but this can’t be verified. Most values are between 5 and 10 dm^3/s. The average is 8,4 dm^3/s. In some countries the requirements are specified in labour or worker protection legislation.

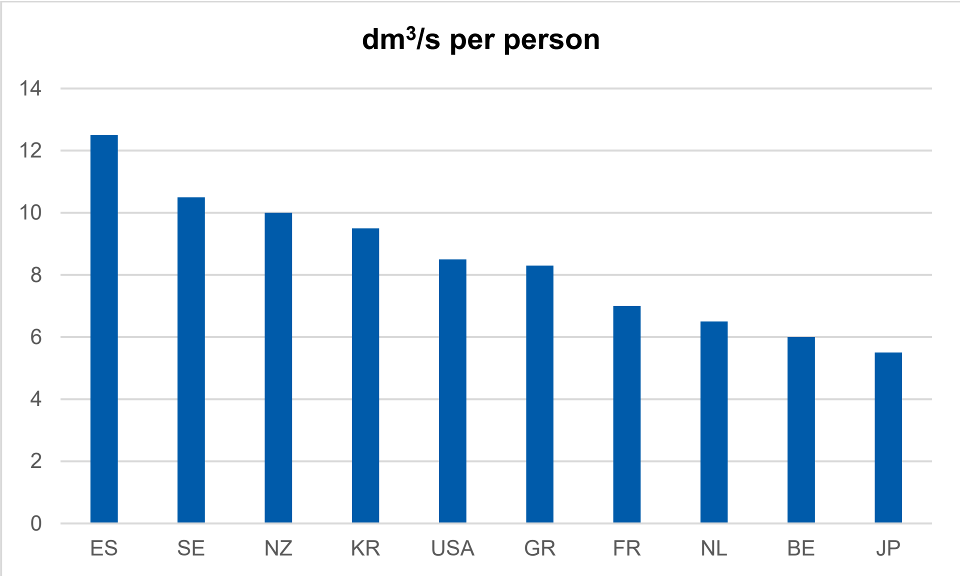

Figure 10: Flowrates per person for office rooms

3.5. Ventilation requirements in Classrooms

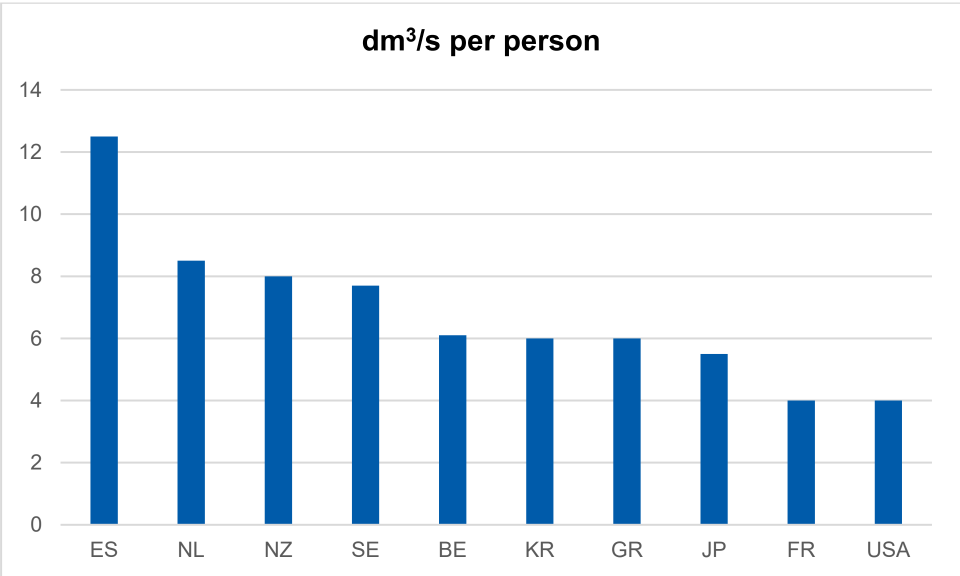

Figure 11: Flowrates per person for classroom

The ratio between the lowest and highest ventilation requirements in classrooms is about 3, which is lower than dwellings but higher than offices. The reason might be that in a classroom the difference of activity as well as age of persons may play a role. Most values are between 4 and 8 dm^3/s. The average is 6,8 dm^3/s.

4. Analysis

4.1. From prescriptive to performance-based requirements

Ventilation requirements exist in different ways, including both prescriptive and performance based.

Prescriptive requirements are mostly expressed under the form of constructive specifications. An example is the requirement of openable windows. Openable windows were required in several countries around 1900. Daylight and allowing outside air entering rooms were the drivers.

Performance based requirements are sometimes based on health risk. There are a few countries that use this as starting point for their requirements, e.g., the UK, but they have translated these requirements into flowrates. Spain has an approach based on the integral exposure over a year based on indoor CO_2 levels. Most countries simply specify prescriptive ventilation flows in their requirements. The spectrum of prescriptive to performance based requirements ranges from;

- openable areas such as windows with a minimum area of opening,
- flowrates
- CO_2 limits
- maximum concentrations for certain pollutants
- inhaled dose of a certain pollutant

There is no country where the health risk is defined in relation to the ventilation requirements.

4.2. Legal status

Legal requirements are the strictest legal status given that building regulations are binding. A lot of countries have only a voluntary ventilation standard, while many developing countries do not have any requirement for ventilation. Some countries have standards that are coupled to a code of practice. A code of practice is a prescriptive way of how to meet the ventilation requirements in practice. In fact, the requirements vary from guidelines to legal requirements.

In countries with requirements, there is a wide variation in compliance checks and enforcement of the requirements. It varies from no control or a check of the building plan, to onsite measurements with a required commissioning report.

By analyzing the questionnaires from AIVC countries, the following observations can be made:

- Because of the legal requirements on energy use in buildings, in European countries for example, the ventilation specifications have in most countries moved from voluntary standards to building regulations.
- Several European countries (e.g., Belgium, France, Greece, Netherlands, Spain, Sweden and UK) have ventilation requirements in their building codes.
- New Zealand and South Korea have ventilation requirements in their building code.
- Japan has ventilation requirements in their Building Law.
- The USA have detailed standards for ventilation from ASHRAE. In some states they, or portions of the standards, have been adopted as legal requirements.
- Australia has plans to set the ventilation requirements in the building code.

The status of a building code might also differ per country. In most countries the building code is somehow related to a law.

4.3. Historical development

There are overviews regarding the historical development of ventilation guidelines and regulations. See Figure 12. These data are mainly taken from M. Sherman [10] along with some other specific data.

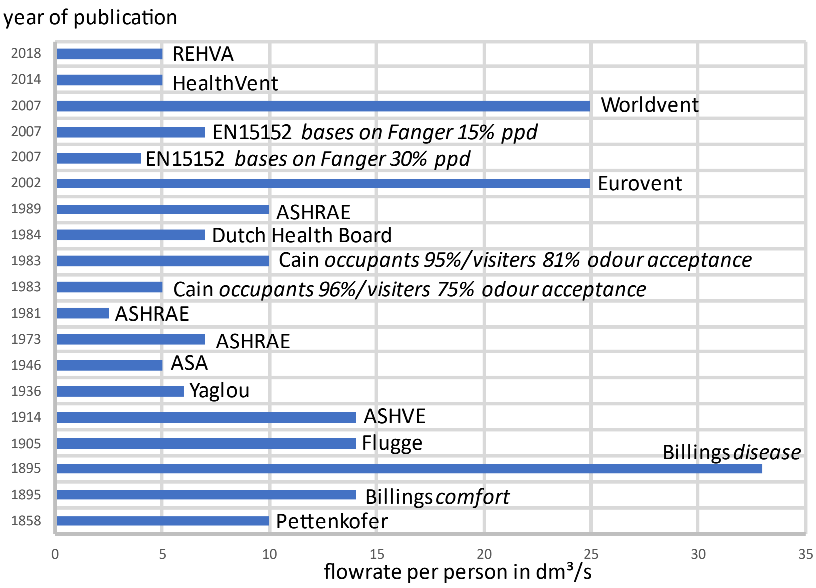

Figure 12: Overview of ventilation guidelines and regulations over the last 160 years

Regarding the development of ventilation guidelines and regulations over time, three different drivers can be distinguished:

- Health as a driver
  - Ventilation levels around or above 25 dm^3/s seems to be driven by health reasons. Billings [11] refers to diseases. Nevertheless, most countries have not chosen health and disease as rational for their requirements, although they assume that ventilation has a positive effect on health.
- Energy use as a driver
  - The energy penalty can act as a major driver for limiting the air flow rates. An illustration can be found in Figure 12: ASHRAE specified in 1973 7 dm^3/s per person. Due to the oil crisisses of 1973 and 1979, this value was reduced to 2,5 dm^3/s per person
- Comfort as a driver
  - The most common driver for ventilation requirements seems to be comfort and odour perception. Pettenkofer 1858 [8] was the first one who stated that CO_2 was a good driver for ventilation requirements as a surrogate for other bioeffluents. His recommendation of 10 dm^3/s per person is still consistent with the requirements in several countries.
  - Based on human bioeffluents and the acceptability of odour nuisance, almost all ventilation requirements between around 5 dm^3/s per person and 10 dm^3/s per person have odour perception from human bioeffluents as a basis. The differences are based on the percentage of dissatisfied people which per country is judged as acceptable. See for instance the studies of Cain [12] and Fanger [13]. Odour nuisance is in fact a comfort criterion, and comfort is of course part of health.

Most requirements based on odour nuisance assume that the required ventilation rates also impact many other pollutants at the same time, in some cases diluting them to acceptable indoor levels. Over the last years more and more people have realized that this may betrue for many indoor pollutants but certainly not for all.

Radon, formaldehyde, and fine particles indoors are examples for which the indoor levels might be above acceptable levels. In building practice there are enough examples where these contaminants have required modifications of either the maximum allowance of a certain product or additional requirements for minimum ventilation when these products are applied in buildings.

5. Rational behind the requirements

5.1. Rational mentioned by countries

Based on this survey, the different rationales employed are rather variable, and in some countries multiple rationales are mentioned in this survey. Typical rationales for certain rooms are presented in Table 6. For some countries, a more detailed description why they have chosen a rational or a combination of rationales is given. No detailed scientific reports are provided to support these choices.

Explanation for Table 6 (for a total of xxx countries):

Color Black	Black	*1 to 3 countries*
Color Grey	Grey	*4 to 7 countries*
Color Yellow	Yellow	*8 to 10 countries*
Color Blue	Blue	*more than 10 countries*
White		*not mentioned or specified*

Table 6: Reported rationales for several types of rooms

Rationales reported	**Room type**					
	Living Bedroom	**Kitchen**	**Bath room**	**Toilet room**	**Office room**	**Class room**
Odour, Bioeffluents	Blue	Black	Black		Blue	Blue
Odour/smells cooking products		Blue				
Moisture/Dampness	Blue	Blue	Blue	Blue	Blue	Blue
Moisture/ Cooking	Blue	Blue				
Moisture/Washing/showering/laundry		Blue	Blue	Blue		
Preventing spreading of contaminants		Yellow	Yellow	Yellow		
Emissions from building materials and furniture	Grey	Grey			Grey	Grey
Formaldehyde	Black				Black	Black
Other VOC's	Grey	Grey	Grey	Grey	Grey	Grey
Airborne particles	Black	Black			Black	Black
CO	Black	Black			Black	Black
Viruses	Black	Black	Black	Black	Black	Black
Sick Building Syndrome	Black	Black	Black	Black	Black	Black

The most used leading rationales for ventilation requirements are:

- bioeffluents
- Moisture
- VOC's

5.2. Philosophies

When studying the national requirements and their differences, one gets the impression that for each country experts who were involved with national ventilation requirements studied the available literature and made engineering judgements for the required ventilation levels in their country. Although sometimes substantial variations, there probably is in each case a philosophy behind the identified requirements.

For instance, giving inhabitants of buildings the control of their ventilation systems to ensure that the required flowrates can be realized is one such principle. Whether or not the inhabitants do that is their decision. In parallel, switching on the heating system is not required, but people must have the option to do so when they desire.

There are also countries that give specific information on natural ventilation and the time these natural systems need to perform in accordance with the requirements, i.e., in relation to weather conditions. The Netherlands for instance claims that during at least 83% of the time, inhabitants must have the possibility to reach the flow rates required. [14] For natural ventilation this is based on climate conditions, specifically wind speed and outside/inside temperature difference.

In the ASHRAE ventilation requirements for non-residential buildings, the requirements consist of 2 parts: ventilation related to the presence of occupants (flow rate per person) added with a ventilation related to the emission of other sources (flowrate per square meter floor area). The idea behind this is consistent with the idea that in a space with a a large floor area, the emission from building materials and furniture plays a more significant role in the cleanliness of the indoor air. There are also European standards with the same approach.

Analysis of the data delivered for this study does not give any information on a possible relation with the outside temperature or windspeed for the ventilation requirements. The only country in this study where ventilation may be reduced due to outside temperature is Finland.

6. Design, Handing over, Commissioning, Use and Maintenance

To be able to judge differences between ventilation requirements, it is not only important to look at the quantitative requirements but also to consider other effects such as the design and choice of the ventilation system, installation and construction quality, procedures for handing over and commissioning, the use of the ventilation provisions by the inhabitants and finally the way the ventilation systems will be maintained. See also EPBD 19a.[15]

A good design starts with an inventory of the possibilities and limitations. A new prEN standard is under development “EN 15665: Ventilation systems in residential buildings” [16]. Two approaches are elaborated in this draft, namely prescriptive- based and performance- based approaches. What is new in this standard is that natural as well as mechanical and hybrid systems are included. A complete design method is also given.

Some countries are working on mandatory handing over and commissioning rules. In most countries there is no obligation for handing over and commissioning. It looks like there is a growing interest for mandatory regulations at this point. Also, the proposal for revision of the EPBD foresees the mandatory inspection of larger ventilation installations.

EU standards for handing over ventilation systems exist, see EN 12599 (2012) [17]. In this study no country was identified with a mandatory legal requirement. The QualiCheck EU project [18] has produced a framework for material and workmanship also for ventilation systems.

In IEA Annex 27 “Evaluation of domestic ventilation systems” [19], the reliability of ventilation systems was studied for mechanical exhaust and balanced ventilation systems, including the dependence on the maintenance frequency.

See Figure 13 where the reliability is given for mechanical ventilation systems over time.

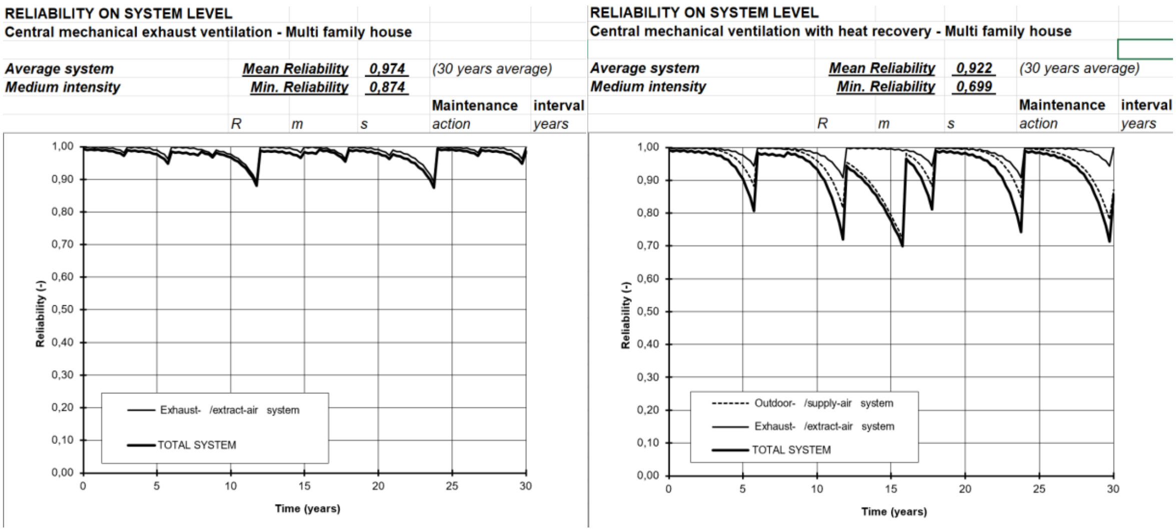

Figure 13: Reliability of mechanical ventilation systems

Mechanical ventilation, even with regular maintenance does not always deliver the design flows. The reliability is never 100%. With medium intensity maintenance for exhaust systems, the reliability was estimated to be 97,4 % for balanced systems and 92.2% for systems with heat recovery. Compared with natural systems which are depending on the weather, the reliability is definitely higher. For the Netherlands the reliability of natural ventilation was estimated at 83 %.

7. Recent developments

7.1. IAQ metrics

IAQ metrics is an area of ongoing research and discussion. A number of indoor air pollutants associated with chronic health effects have been identified, for instance fine particles and products from cooking processes. However, progress is limited due to lack of information on the contribution of different indoor sources, exposure, health effects and the role of occupant behaviour.

A good understanding of pollutants sources in the indoor environment, exposure time and health-based limits is necessary to develop a ventilation strategy based on health. Any ventilation strategy should be capable of addressing both health and comfort. To prevent or reduce risks to health, exposure limit values (ELV) are a necessity. Since most dose-effect relations are not clear or simply not known, the ventilation level required in relation to health will only be based on experts best judgement.

The DALYs, Disability Adjusted Life Years approach is a possible metric which also takes into account long and short-term exposure. Studies for new IAQ metrics are ongoing and progressing (IEA Annexes 68 and 86).[19][20]

AIVC has organised several webinars related to these issues. Related information can be found here: https://www.aivc.org/events/webinars.

7.2. Airborne infectious virus transmission and the role of ventilation

Ventilation dilutes constituents generated indoors as well as exhausts local contaminant sources to the outside. In 2020, an AIVC working group was created to study ventilation and COVID-19. See also the specific newsletters of AIVC on COVID 19. (see AIVC website). Ventilation by dilution also has in most cases a limited effect on reducing the risk of exposure at close distance to an exhaust plume from an infected person.

Ventilation is only one means to reduce indoor exposure to airborne viruses and other pathogens. Gravitational settling, deposition onto surfaces, filtration, and deactivation are other important mechanisms. It is important to understand the difference between ventilation rates, air movement within a room and air transport from one room to another. For example, there can be air movement in a room without outdoor air ventilation, and viruses can be affected by air movement only. The higher the ventilation rate in a room, the lower the viral concentration in that room. But increasing the ventilation rate also causes more air movement in a room and may affect the transport of air from one room to another adjacent room, or from an infected person to an uninfected person in the same room.

The quantity of ventilation needed depends on the amount and nature of the virus aerosols. If the emission characteristics of COVID and the dose-response curve of the aerosols was known, then it would be more straightforward to calculate the ventilation rate needed to control occupants' exposure.

In some European countries CO_2 sensors are now obligatory for certain rooms in specified buildings such as offices and schools. Non compliancy with the national ventilation regulations became apparent during the COVID 19 crisis. To increase awareness of ventilation, the occupants of a room can get a CO2 reading, which might stimulate them to act to improve ventilation, for instance switching the mechanical ventilation to a higher level, opening a window, or reducing occupancy.

8. Conclusions

For various reasons (evolution in requirements, various types of specifications, etc.), it is not straightforward to generate a precise overview of the various specifications in countries regarding ventilation. Therefore, the information collected about countries for this study allows the development of an overall impression of the status.

Comparing ventilation requirements requires more than just comparing values from standards and building regulations. The most important difficulty for comparison is the way requirements are expressed. The units are quite different, for example flowrate per person, flowrate per square meter floor area or air change rate.

The effect of the level of ventilation requirements/guidelines on the energy use of buildings between countries is noticeable in the answers from the experts.

Large variations in ventilation requirements are found. There is no evidence to assume that the health effect is in a linear way related to the change in ventilation requirements.

No profound scientific and clearly explained reports were found as background and rationale for the requirements. In most cases the requirements are based on a philosophy followed by best guesses made by experts and/or information or specifications available in other standards and regulations.

Some historical differences can be explained by energy efficiency motivations and health concerns around the world over decades. For instance, concerns about formaldehyde concentrations in buildings have affected ventilation requirements.,

Although almost all countries indicate bioeffluents and moisture as the major reasons for ventilation, the maximum ratio between the highest and lowest value in ventilation requirements/guidelines for kitchens is still about 10.

There are strong drivers for designing and operating buildings, i.e., climate change to reduce energy consumption for HVAC, and therefore these variations in ventilation requirements and regulations are worth studying.

Almost all experts have indicated that removing cooking products is the rationale behind the kitchen ventilation requirements.

For bathrooms, the rationale behind ventilation rates is moisture control. For toilet rooms, spreading of contaminants and smells to other parts of the building is mostly the rationale behind the requirements.

Human bioeffluents are mostly mentioned as rationale behind the requirements for habitable rooms apart from kitchens, bathrooms and toilet rooms.

The ratio between highest and lowest ventilation requirements is much smaller for office rooms and classrooms. This is consistent with more homogeneous occupancy and activities in these rooms.

Most of the differences in the requirements can be explained by the acceptance of differences in odour hindrance or nuisance.

9. Recommendations

The differences in ventilation requirements are large and not clearly explained by scientific studies. The dominant role thhat ventilation is going to play for heating and cooling in the near future requires the following actions:

1. Any group or committee in charge of making proposals for ventilation requirements should formulate the goal and background for these goals.
2. Any group or committee in charge of making proposals for ventilation requirements should compose a scientific background report, with at least the following chapters:
   - Bases for their choices
   - The philosophy
   - The rationale
   - Used and applied background material
   - The field of application
   - The role of inhabitants with regard to the use of ventilation provisions
   - Specific sensitive groups
   - Exceptions
   - Climate zone
   - Energy consequences

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- Dimitris A. Charalambopoulos, Greece
- Takao Sawachi, Japan
- Yun Gyu Lee, Republic of Korea

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12. Appendix 1: Results from Questionnaires

1. Australia (Table 7)
2. Belgium (Table 8)
3. France (Table 9)
4. Greece (Table 10)
5. Japan (Table 11)
6. Netherlands (Table 12)
7. New Zealand (Table 13)
8. South Korea (Table 14)
9. Spain (Table 15)
10. Sweden (Table 16)
11. United States of America (Table 17)

Table 7: Results from Questionnaires - Australia

Country 1	Australia
General	
Do you have requirements on ventilation for dwellings, offices and schools?	Yes
Does these requirements take into account sensitive or other specific groups (children)?	Not specifically
Is infiltration (unintended airflow through cracks) considered as a part of the ventilation flow in your calculation methods to fulfil the requirements?	Yes
Is window airing assumed as ventilation flow?	yes (in res); no in non-res
Are the requirements for ventilation legislative?	For residential: Not at the moment (2018) but expected in 2019 (for res). Prior to the expected new code, ventilation requirements were generic, not specific (e.g., no minimum rate). For non-res, some minimum flow rates required now, but in 2019 code the emphasis will be on verification of the air quality (refer to table V2.4.5. Both 2019 codes (res and non-res) will include for the first time a maximum air leakage rate.
Are there other means to ensure minimum ventilation levels for instance guidelines, standards or labelling schemes etc?	Guidelines and Handbooks; non-mandatory
Are there regulations for commissioning and or quality assurance (legislative or voluntary) and how is it arranged?	Very haphazard: a very big problem in residential; somewhat controlled in high-end non-res buildings by clients/project managers (especially if they want buildings certified for LEED / GreenStar / NABERS etc
Dwellings	
What are the requirements for ventilation in case of new dwellings for:	In general: P2.4.5 (a) A space within a building used by occupants must be provided with means of ventilation with outdoor air which will maintain adequate air quality. The ABCB Handbook on IAQ refers to ISO 16814 for a definition of acceptable IAQ.
living room	5 - 10% ventilation opening: floor area
bedroom	5 - 10% ventilation opening: floor area
bathroom	25 l/s
toilet	25 l/s
kitchen	25 l/s
other rooms	
What is the rationale (reasons behind and motives) behind these requirements specified per room, see below:	No specific requirements for living and bedrooms.
living room	
bedroom	
bathroom	25 l/s
toilet	25 l/s
kitchen	25 l/s
other rooms	
Laundry	40 l/s
Sub-floors	1000 - 6000mm^2/m of wall
Roof space	0.2% - 1% of ceiling area
Schools	

What are the requirements for ventilation in case of new schools specified per room:	No regulatory requirements for schools that I know of
classroom	
toilet	
kitchen	
other rooms	
What is the rationale behind these requirements in case of schools specified per room:	
classroom	
toilet	
kitchen	
other rooms	
Offices	
What are the requirements for ventilation in case of new offices for:	In general: "a space in a building used by occupants must be provided with means of ventilation with outdoor air which will maintain adequate air quality" FP4.3
offices	
meeting room	
toilet	
kitchen	
other rooms	
What is the rationale behind these requirements in case of offices specified per room	
offices	
meeting room	
toilet	
kitchen	
other rooms	

Table 8: Results from Questionnaires - Belgium

Country 2	Belgium
General	
Do you have requirements on ventilation for dwellings, offices and schools?	Yes – for all new buildings and for all workplaces
Does these requirements take into account sensitive or other specific groups (children)?	No
Is infiltration (unintended airflow through cracks) considered as a part of the ventilation flow in your calculation methods to fulfil the requirements?	No
Is window airing assumed as ventilation flow?	No
Are the requirements for ventilation legislative?	Yes
Are there other means to ensure minimum ventilation levels for instance guidelines, standards or labeling schemes etc?	In office buildings CO_2 limit as alternative for air flow rates per person
Are there regulations for commissioning and or quality assurance (legislative or voluntary) and how is it arranged?	Yes – for new dwellings in Flemish region
Dwellings	
What are the requirements for ventilation in case of new dwellings for:	
living room	3,6 m³/h.m²; min 75 m³/h; can be limited to 150 m³/h
bedroom	3,6 m³/h.m²; min 25 m³/h; can be limited to 72 m³/h
bathroom	3,6 m³/h.m²; min 50 m³/h; can be limited to 75 m³/h
toilet	25 m³/h
kitchen	Close kitchen: 3,6 m³/h.m²; min 50 m³/h; can be limited to 75 m³/h; Open kitchen: 75 m³/h
other rooms	hallways: 3,6 m³/h.m² (transfer is authorized)
What is the rationale (reasons behind and motives) behind these requirements specified per room, see below:	
living room	
bedroom	
bathroom	
toilet	
kitchen	
other rooms	
Schools	
What are the requirements for ventilation in case of new schools specified per room:	
classroom	22 m³/h.pers; max 4 m²/pers[1].
toilet	25 m³/h per toilet or 15 m³/h.m²
kitchen	22 m³/h.pers; max 10 m²/pers.
other rooms	Rooms not for human occupation: 1,3 m³/h.m²
What is the rationale behind these requirements in case of schools specified per room:	

[1] The number of persons to be used is the highest value of the number of persons as identified by the user and the floor area divided by 4

classroom

toilet

kitchen

other rooms

Offices

What are the requirements for ventilation in case of new offices for:	
offices	22 m^3/h.pers; max 15 m^2/pers.
meeting room	22 m^3/h.pers; max 3,5 m^2/pers.
toilet	25 m^3/h per toilet or 15 m^3/h.m^2
kitchen	22 m^3/h.pers; max 10 m^2/pers.
other rooms	Rooms not for human occupation: 1,3 m^3/h.m^2
What is the rationale behind these requirements in case of offices specified per room.	
offices	
meeting room	
toilet	
kitchen	
other rooms	

Recommendations

What are new insights that would change current ventilation standards, and how would this effect current standards

Table 9: Results from Questionnaires - France

Country 3	**France**
Do you have requirements on ventilation for dwellings, offices and schools?	Yes. Regulation for dwellings (Arrêté du 24 mars 1982) requires minimum extract flows in humid rooms with possibility of demand control ventilation (verified by "Avis technique" ie technical agreement), Design of ventilation for workers is based on "code du travail" (minimum supply air /pers or possibility to use openable windows), Design of ventilation for other peoples (pupils for example) is based on "Reglement sanitaire départemental" which specify minimum airflows depending on the use of the room and/or number of people in the room.
Does these requirements take into account sensitive or other specific groups (children)?	No
Is infiltration (unintended airflow through cracks) considered as a part of the ventilation flow in your calculation methods to fulfil the requirements?	Infiltration is taken into account for the design of air inlet sections in case of single flow (extract) mechanical systems. Air renewal due to infiltration is not taken into account to fulfill airflows requirements
Is window airing assumed as ventilation flow?	No for residential buildings build after 1983. Yes for non-residential buildings, if the volume/worker is > 15 m^3 and the level of physical activity is low, >24 m^3 else
Are the requirements for ventilation legislative?	Yes. Regulation for dwellings (Arrêté du 24 mars 1982) requires minimum extract flows in humid rooms with possibility of demand control ventilation (verified by "Avis technique" ie technical agreement), Design of ventilation for workers is based on "code du travail" (minimum supply air /pers or possibility to use openable windows), Design of ventilation for other peoples (pupils for example) is based on "Reglement sanitaire départemental" which specify minimum airflows depending on the use of the room and/or number of people in the room.
Are there other means to ensure minimum ventilation levels for instance guidelines, standards or labeling schemes etc?	Yes. The NF DTU 68.3, french voluntary standard, defines the rules of installation, design and sizing for mechanical ventilation system installations. For all public constructions, the installation and design according to this DTU 68.3 are required and the DTU 68.3 is stated as a reference in case of judicial procedure. French labeling NF VMC and CSTBat for residential applications ensures that ventilation systems and/or components are able to provide required minimum airflows with also other minimum performance level (low electrical power consumption for fans, sufficient pressure drop, minimum efficiecy or heat recovery, ...)
Are there regulations for commissioning and or quality assurance (legislative or voluntary) and how is it arranged?	No regulation. Some labeling scheme on buildings ensure commissioning of ventilation systems: - Effinergie labels - NF Habitat
What are the requirements for ventilation in case of new dwellings for:	Ventilation has to be global for the dwelling and permanent. For demand control ventilation, minimum airflows can be lower for the dwelling, and the system has to be validated by a ministry agreement to ensure that IAQ is reasssured: is this made via the GS14 procedure for "Avis techniques" i.e french technical agrement
living room	air supply terminal (mechanical or passive air inlet)
bedroom	air supply terminal (mechanical or passive air inlet)

bathroom	minimum achievable extract airflow: 30 m^3/h for the first bathroom of dwellings with more than 2 rooms; 15 m^3/h for small dwellings (2 or less rooms) or other bathromms in bigger dwellings;
toilet	minimum achievable extract airflow: 30 m3/h if single toilet in dwellings with more than 4 rooms; 15 m^3/h else (smaller dwellings or multiple toilets)
kitchen	achievable extract airflow between 75 and 135 m^3/h, depending on the size of the dwelling; + cannot be lower than 20 to 45 m^3/h, depending on the size of the dwelling (if no demand controll system)
other rooms	minimum achievable extract airflow of 15 m^3/h for "humid" rooms air supply terminal for living spaces
What is the rationale (reasons behind and motives) behind these requirements specified per room, see below:	The global ventilation rate has been designed on typical dwellings in order to ensure air quality. It has been translated in fixed extract flows for each humid rooms (where humidity is producted) in order to facilitate design and installation of ventilation systems; The principle of air circulation, from living spaces to humid/technical rooms where air is extracted, has been stated in order to save energy (heating of outdoor air)
living room	principle of dilution of pollutant: "new" air shall be supplied directly in living rooms without recicurlating from other rooms - principle of dilution
bedroom	principle of dilution of pollutant: "new" air shall be supplied directly in living rooms without recicurlating form other rooms - principle of dilution
bathroom	Humidity (main source of building desease) has to be extract directly close to the main sources -
toilet	Humidity (main source of building desease) has to be extract directly close to the main sources -
kitchen	Humidity (main source of building desease) has to be extract directly close to the main sources -
other rooms	Humidity (main source of building desease) has to be extract directly close to the main sources -
What are the requirements for ventilation in case of new schools specified per room:	
classroom	supply air flows (outdoor air) 15m^3/h / pers for school from primary and secundary school (<16 ans) 18 m^3/h for high school demand control ventilation is authorized CO2 level shall be <1000 ppm
toilet	extract flows 30 m^3/h if single (30 + 15*N) m^3/h if N toilets
kitchen	25 m^3/h/meal if <150 meals 20 m^3/h/meal if >150 and <500 meal 22 m^3/h /pers. In the dining room
other rooms	offices or teachers' room: see offices regulation laboratory with specific pollution shall have its own specific ventilation
What is the rationale behind these requirements in case of schools specified per room:	
classroom	Specified per person - to ensure good IAQ (CO_2 level < 1000 ppm)
toilet	Humidity (main source of building desease) has to be extract directly close to the main sources
kitchen	Extract pollutant close to the source

other rooms	
What are the requirements for ventilation in case of new offices for:	
offices	offices, local without physical work: 25 m^3/h/pers. In case of ligth physical work: 45 m^3/h/pers
meeting room	30m^3/h/pers.
toilet	extract flows 30 m^3/h if single (30 + 15*N) m^3/h if N toilets
kitchen	25 m^3/h/meal if <150 meals 20 m^3/h/meal if >150 and <500 meal 22 m^3/h /pers. In the dining room
other rooms	restauration rooms, selling rooms: 30 m^3/h/pers. Local with high physical activity: 60 m^3/h/pers.
offices	In closed rooms where workers are staying, air has to be renewed in order to: - maintain atmosphere in a state of property to preserv health - avoid too high rise of temeprature, bad odoors and cpondensation
meeting room	
toilet	
kitchen	
other rooms	

Recommendations

What are new insights that would change current ventilation standards, and how would this effect current standards	Research works have been done in order to ensure comissing protocoles. This will be included in the revision of EN 14134 for residential ventilation. New tendancy in order to improve good ventialtion instalaltion would be to generalise autocontrol of installation + comissioning by third party (not regulatory for the moment).

Table 10: Results from Questionnaires - Greece

Country 4	**Greece**
General	
Do you have requirements on ventilation for dwellings, offices and schools?	Yes
Does these requirements take into account sensitive or other specific groups (children)?	No other than the air volume in relevance with the use of building.
Is infiltration (unintended airflow through cracks) considered as a part of the ventilation flow in your calculation methods to fulfil the requirements?	No. It only counts in heating/cooling load calculations.
Is window airing assumed as ventilation flow?	yes - only in residential dwellings /no - generally
Are the requirements for ventilation legislative?	yes - mainly it is mandated by relevant regulations and standards
Are there other means to ensure minimum ventilation levels for instance guidelines, standards or labeling schemes etc?	Other - for all types of buildings except residences, irrelevant to natural ventilation design, it is mandatory by law to provide mechanical ventilation (in most cases with heat recovery included).
Are there regulations for commissioning and or quality assurance (legislative or voluntary) and how is it arranged?	No, not directly mandated by law
Dwellings	
What are the requirements for ventilation in case of new dwellings for:	Regulation for Energy Performance of Buildings, T.O.T.E.E. 20701 -1/2017, Table 2.3
living room	There is only a requirement for housing as a unit: $15 m^3/h$/person (5 persons per 100 m^2)
bedroom	
bathroom	
toilet	
kitchen	
other rooms	
What is the rationale (reasons behind and motives) behind these requirements specified per room, see below:	Hygienic and IAQ
living room	
bedroom	
bathroom	
toilet	
kitchen	
other rooms	
Schools	
What are the requirements for ventilation in case of new schools specified per room:	Regulation for Energy Performance of Buildings, T.O.T.E.E. 20701 -1/2017, Table 2.3
classroom	$22 m^3/h$/person (50 persons/100 m^2)
toilet	
kitchen	
other rooms	
What is the rationale behind these requirements in case of schools specified per room:	Hygienic and IAQ

classroom	
toilet	
kitchen	
other rooms	
Offices	
What are the requirements for ventilation in case of new offices for:	KENAK Π.2.3
offices	There is only requirement for offices: 30 m^3/h/person (10 persons/100 m^2)
meeting room	
toilet	
kitchen	
other rooms	
What is the rationale behind these requirements in case of offices specified per room.	Hygienic and IAQ
offices	
meeting room	
toilet	
kitchen	
other rooms	
Recommendations	
What are new insights that would change current ventilation standards, and how would this effect current standards	It is suggested that dependency on sole natural ventilation schemes, apart from the residential sector, could also be allowed to other light ventilation requirements building uses.

Table 11: Results from Questionnaires - Japan

Country 5	**Japan**
General	
Do you have requirements on ventilation for dwellings, offices and schools?	Yes
Does these requirements take into account sensitive or other specific groups (children)?	No
Is infiltration (unintended airflow through cracks) considered as a part of the ventilation flow in your calculation methods to fulfil the requirements?	Yes, but partly.
Is window airing assumed as ventilation flow?	No
Are the requirements for ventilation legislative?	Yes
Are there other means to ensure minimum ventilation levels for instance guidelines, standards or labelling schemes etc?	Yes. There is another building code for centrally air-conditioned non-residential buildings, which requires 20 m^3/h per occupant.
Are there regulations for commissioning and or quality assurance (legislative or voluntary) and how is it arranged?	Yes. There is another regulation for hygiene of building indoor environment, which requires regular measurement of pollutant concentration including CO2, CO, particles.
Dwellings	
What are the requirements for ventilation in case of new dwellings for:	installation of mechanical ventilation for habitable rooms, having capacity of 0.5 ACH.
living room	0.5 ACH
bedroom	0.5 ACH
bathroom	no regulation, but there are guidelines recommending some amount of local exhaust ventilation
toilet	the same as above
kitchen	there is a building code, which requires local exhaust ventilation in parallel with combustion speed.
other rooms	0.5 ACH for habitable rooms
What is the rationale (reasons behind and motives) behind these requirements specified per room, see below:	
living room	formaldehyde of 0.08 ppm as acceptable concentration for any 30 min.
bedroom	the same as above
bathroom	humidity
toilet	smell
kitchen	concentration of CO
other rooms	formaldehyde of 0.08 ppm as acceptable concentration for any 30 min.
Schools	
What are the requirements for ventilation in case of new schools specified per room:	

classroom	formaldehyde of 0.08 ppm as acceptable concentration for any 30 min. plus CO_2 concentration of 1500 ppm as acceptable concentration at the end of classes (this CO2 requirement is made by the guidelines by the Ministry of Education).
toilet	smell
kitchen	concentration of CO
other rooms	formaldehyde of 0.08 ppm as acceptable concentration for any 30 min.
What is the rationale behind these requirements in case of schools specified per room:	formaldehyde of 0.08 ppm as acceptable concentration for any 30 min. plus CO_2 concentration of 1500 ppm as acceptable concentration at the end of classes (this CO2 requirement is made by the guidelines by the Ministry of Education).
classroom	
toilet	smell
kitchen	concentration of CO
other rooms	formaldehyde of 0.08 ppm as acceptable concentration for any 30 min.

Offices

What are the requirements for ventilation in case of new offices for:	
offices	20 m^3/h per occupant plus formaldehyde 0.08 ppm, but the latter requirenent is not so critical as the former requirement.
meeting room	the same as the above
toilet	15 ACH
kitchen	concentration of CO
other rooms	formaldehyde of 0.08 ppm as acceptable concentration for any 30 min.
What is the rationale behind these requirements in case of offices specified per room.	
offices	unidentified pollutants, just represented by CO2 concentration
meeting room	the same as the above
toilet	15 ACH
kitchen	concentration of CO
other rooms	formaldehyde of 0.08 ppm as acceptable concentration for any 30 min.

Recommendations

What are new insights that would change current ventilation standards, and how would this effect current standards	any addition of pollutants' list by WHO. When newly added, the government tends to check if there is possibilities of the violation of the acceptable concentration.

Table 12: Results from Questionnaires - Netherlands

Country 6	**Netherlands**
General	
Do you have requirements on ventilation for dwellings, offices and schools?	Yes. The requirements for living areas in dwellings are flow rate per in m^2 floor area For the kitchen, toilet and bathroom it is a fixed air flow rate For schools and offices flowrate per person
Does these requirements take into account sensitive or other specific groups (children)?	No
Is infiltration (unintended airflow through cracks) considered as a part of the ventilation flow in your calculation methods to fulfil the requirements?	• No, for newly constructed buildings • No, for buildings with major renovations • Yes, for the existing building stock
Is window airing assumed as ventilation flow?	Only top hung windows 1,8 m above floor level are assumed as ventilation provisions but also for airing. All other large openings are assumed to be only for airing
Are the requirements for ventilation legislative?	Yes
Are there other means to ensure minimum ventilation levels for instance guidelines, standards or labeling schemes etc?	Yes, there are standards with test methods to check whether or not de ventilation provisions are fulfilling the legislative requirements, there are also several codes of practice including practical examples for schools and dwellings There is a rule by law that the principle of equivalence can be used to show the performance criteria
Are there regulations for commissioning and or quality assurance (legislative or voluntary) and how is it arranged?	There is a voluntary system for quality insurance organized by the ventilation manufacturers to check the performance of the ventilation system for dwellings, but it is rarely used
Dwellings	
What are the requirements for ventilation in case of new dwellings for:	
living room	0,9 dm^3/s per m^2 floor area
bedroom	0,9 dm^3/s per m^2 floor area
bathroom	14 dm^3/s
toilet	7 dm^3/s
kitchen	21 dm^3/s
other rooms	
What is the rationale (reasons behind and motives) behind these requirements specified per room, see below:	Ventilation requirements in the Netherlands are based on humans and their unavoidable activities in a building such as washing, bathing, showering and cooking. The ventilation requirements don’t take into account other pollutants for instance emissions from furniture, building materials etc. They are assumed to be not harmful at the level of ventilation required. Product requirements on emissions from all kind of materials should be such that no health problems may occur. Although this was the philosophy, in real practice is has only be done for formaldehyde.

living room	Odour; based on CO^2 level of max 800 ppm above outside, the flow per person of 7 dm^3/s
bedroom	Odour; based on CO2 level
bathroom	Moisture production during bathing and showering, based on the assumption that over 24 h daily cycle the humidity of the construction is the same as the day before
toilet	preventing the spread of contaminants produced and a minimum for one person so 7 dm^3/s
kitchen	Moisture and odour and other contaminants produced during cooking
other rooms	There are also requirements for specific rooms such as: boiler rooms with open gas boilers

Schools

What are the requirements for ventilation in case of new schools specified per room:

classroom	flowrate 8.5 dm^3/s
toilet	7 dm^3/s
kitchen	21 dm^3/s
other rooms	

What is the rationale behind these requirements in case of schools specified per room:

classroom	Odour; based on CO_2 level
toilet	preventing the spread of contaminants produced and a minimum for one person so 7 dm^3/s
kitchen	Moisture and other contaminants produced during cooking
other rooms	There are also requirements for specific rooms such as: boiler rooms with open gas boilers

Offices

What are the requirements for ventilation in case of new offices for:

offices	flowrate 6,5 dm^3/s per person
meeting room	flowrate 4,0 dm^3/s per person
toilet	7 dm^3/s
kitchen	21 dm^3/s
other rooms	

What is the rationale behind these requirements in case of offices specified per room.

offices	Odour; based on CO_2 level
meeting room	Odour; based on CO_2 level
toilet	preventing the spread of contaminants produced and a minimum for one person 7 dm^3/s

kitchen	Moisture and other contaminants produced during cooking,
other rooms	There are also requirements for specific rooms such as: boiler rooms with open gas boilers
Recommendations	

What are new insights that would change current ventilation standards, and how would this effect current standards	For new and future requirements more emphasis should be given to:
	• particle matter from
	  ○ cooking
	  ○ candle burning
	  ○ woodstoves
	• increase of absolute humidity in dwellings
	• air cleaning.

Table 13: Results from Questionnaires - New Zealand

Country 7	New Zealand
General	
Do you have requirements on ventilation for dwellings, offices and schools?	Yes. We have standards that are not enforced if an acceptable solution is implemented. One acceptable solution is the requirement of a window (that is openable) with a window size of 5% of the floor area. This is enforced or in lieu of a window mech. vent needs to be provided. Mechanical ventilation and a specific airflow is only required if the room has no wall bordering the outdoor.
Does these requirements take into account sensitive or other specific groups (children)?	No
Is infiltration (unintended airflow through cracks) considered as a part of the ventilation flow in your calculation methods to fulfil the requirements?	No. However, the passive ventilation requirements originally conceived assumed a degree of infiltration but does not specify the assumed amount.
Is window airing assumed as ventilation flow?	Yes. This is the simplest acceptable solution to provide an openable window with a window area of 5% of the floor area.
Are the requirements for ventilation legislative?	Yes.
Are there other means to ensure minimum ventilation levels for instance guidelines, standards or labeling schemes etc?	Yes. There are standards NZS 4303, AS1668.2 but they are not enforced.
Are there regulations for commissioning and or quality assurance (legislative or voluntary) and how is it arranged?	No.
Dwellings	
What are the requirements for ventilation in case of new dwellings for:	There is a requirement of a window (that is openable) with a window size of 5% of the floor area. This is enforced but the numbers below are recommendations and are only required if the room has no wall bordering the outdoor.
living room	0.35 ACH but no less than 7.5 l/s person
bedroom	0.35 ACH but no less than 7.5 l/s person
bathroom	25 L/s intermittent or 10 L/s continuous or openable window
toilet	Flow rates in AS1668.2 if no external wall is available
kitchen	50 L/s intermittent or 12 L/s continuous or openable window
other rooms	
What is the rationale (reasons behind and motives) behind these requirements specified per room, see below:	Not Room specific just general: a) Cooking fumes and odours b) Moisture from laundering, utensil washing, bathing and showering c) Odours from sanitary and waste storage spaces d) Gaseous by-products and excessive moisture from commercial or industrial processes e) Poisonous fumes and gases f) Flammable fumes and gases g) Airborne particles h) Bacteria, viruses or other pathogens, or i) Products of combustion.
living room	
bedroom	

bathroom	
toilet	
kitchen	
other rooms	
Schools	
What are the requirements for ventilation in case of new schools specified per room:	Openable window area 5% of floor area (enforced)
classroom	8 L/ s person
toilet	
kitchen	
other rooms	10 L/ s person
What is the rationale behind these requirements in case of schools specified per room:	
classroom	
toilet	
kitchen	
other rooms	
Offices	
What are the requirements for ventilation in case of new offices for:	AS1668.2 and NZS 4303.
offices	10 L/s person
meeting room	10 L/s person
toilet	25 L/s person
kitchen	
other rooms	
What is the rationale behind these requirements in case of offices specified per room.	Not Room specific just general: a) Cooking fumes and odours b) Moisture from laundering, utensil washing, bathing and showering c) Odours from sanitary and waste storage spaces d) Gaseous by-products and excessive moisture from commercial or industrial processes e) Poisonous fumes and gases f) Flammable fumes and gases g) Airborne particles h) Bacteria, viruses or other pathogens, or i) Products of combustion.
offices	
meeting room	
toilet	
kitchen	
other rooms	
Recommendations	
What are new insights that would change current ventilation standards, and how would this effect current standards	Implement mech. or natural ventilation systems/designs. Have quality control of mech. Ventilation system, airtighter building envelopes, airtightness requirements

Table 14: Results from Questionnaires - South Korea

Country 8	South Korea
General	
Do you have requirements on ventilation for dwellings, offices and schools?	Yes
Does these requirements take into account sensitive or other specific groups (children)?	Yes
Is infiltration (unintended airflow through cracks) considered as a part of the ventilation flow in your calculation methods to fulfil the requirements?	No
Is window airing assumed as ventilation flow?	No. However, in the certification system for eco-friendly buildings such as G-SEED, there is a requirement to install more than a certain percentage of windows that can be opened and closed.
Are the requirements for ventilation legislative?	Yes
Are there other means to ensure minimum ventilation levels for instance guidelines, standards or labeling schemes etc?	Yes
Are there regulations for commissioning and or quality assurance (legislative or voluntary) and how is it arranged?	Yes
Dwellings	
What are the requirements for ventilation in case of new dwellings for:	More than 0.5 times per hour Applied to newly built apartment complexes over 100 households
living room	0.5±25%
bedroom	0.5±25%
bathroom	Separate exhaust system installation
toilet	Separate exhaust system installation
kitchen	0.5±25%
other rooms	0.5±25%
What is the rationale (reasons behind and motives) behind these requirements specified per room, see below:	Ventilate to solve sick house syndrome problem
living room	-
bedroom	-
bathroom	-
toilet	-
kitchen	-
other rooms	-
Schools	
What are the requirements for ventilation in case of new schools specified per room:	
classroom	21.6m^3/person hour
toilet	-
kitchen	-

other rooms	-
What is the rationale behind these requirements in case of schools specified per room:	Minimum required ventilation per person
classroom	Calculated based on 30 students per class
toilet	-
kitchen	-
other rooms	-
Offices	
What are the requirements for ventilation in case of new offices for:	
offices	34.2 m^3/person hour or ventilation rate should be more than 4 times per hour
meeting room	-
toilet	-
kitchen	-
other rooms	-
What is the rationale behind these requirements in case of offices specified per room.	Minimum required ventilation per person
offices	
meeting room	-
toilet	-
kitchen	-
other rooms	-
Recommendations	
What are new insights that would change current ventilation standards, and how would this effect current standards	Currently, the indicators of ventilation standards are formaldehyde and carbon dioxide, but contaminants such as fine dust are likely to be added as indicators.

Table 15: Results from Questionnaires - Spain

Country 9	**Spain**
General	
Do you have requirements on ventilation for dwellings, offices and schools?	Yes
Does these requirements take into account sensitive or other specific groups (children)?	No
Is infiltration (unintended airflow through cracks) considered as a part of the ventilation flow in your calculation methods to fulfil the requirements?	Yes
Is window airing assumed as ventilation flow?	Other. Window micro ventilation, infiltration and vents are assumed as ventilation flow.
Are the requirements for ventilation legislative?	Yes. The Building Code includes IAQ regulations since 2006, which were updated last June. The Building Code applies to dwellings and garages. The Thermal Facilities Code applies to the rest of buildings. Both codes are legislative.
Are there other means to ensure minimum ventilation levels for instance guidelines, standards or labeling schemes etc?	No
Are there regulations for commissioning and or quality assurance (legislative or voluntary) and how is it arranged?	Yes. Each autonomous community can regulate this aspect.
Dwellings	
What are the requirements for ventilation in case of new dwellings for:	Performance requirement:
living room	Yearly average CO_2 concentration < 900 ppm & yearly CO_2 concentration accumulated over 1600 ppm < 500000 ppm·hour
bedroom	
bathroom	
toilet	
kitchen	
other rooms	Removal of usual contaminants (the limit is not specified)
What is the rationale (reasons behind and motives) behind these requirements specified per room, see below:	
living room	Dilution of contaminants from human activity
bedroom	
bathroom	
toilet	
kitchen	

other rooms	Dilution of contaminants such as humidity, odour and VOC in the case of storage rooms and waste bin rooms; and carbon monoxide and nitrogen oxides in the case of garages.

Schools

What are the requirements for ventilation in case of new schools specified per room:	There are 5 methods to achive the set IAQ (EN 13779): Method 1 (ventilation flow per person)
classroom	12.5 l/s/ 1.2 decipols
toilet	
kitchen	
other rooms	
What is the rationale behind these requirements in case of schools specified per room:	
classroom	IAQ 2 or IAQ 1 (kindergardens)
toilet	
kitchen	
other rooms	

Offices

What are the requirements for ventilation in case of new offices for:	There are 5 methods to achive the set IAQ (EN 13779): Method 1 (ventilation flow per person)
offices	12.5 l/s/ 1.2 decipols
meeting room	
toilet	
kitchen	
other rooms	
What is the rationale behind these requirements in case of offices specified per room.	
offices	IAQ 2
meeting room	
toilet	
kitchen	
other rooms	

Recommendations

What are new insights that would change current ventilation standards, and how would this effect current standards	This new IAQ regulation was enforced in June 2017. It was updated to become further performance-based in order to allow innovation and the use of energy efficient ventilation systems. The future of the Spanish IAQ regulation will be influenced by the implementation of the current regulation, the definition of air permeability limits to the building envelope in the energy saving regulations

Table 16: Results from Questionnaires - Sweden

Country 10 **Sweden**	
General	
Do you have requirements on ventilation for dwellings, offices and schools?	Yes
Does these requirements take into account sensitive or other specific groups (children)?	No, no specific requirements
Is infiltration (unintended airflow through cracks) considered as a part of the ventilation flow in your calculation methods to fulfil the requirements?	No
Is window airing assumed as ventilation flow?	No, not as ventilation flow. However, the possibility for airing is a requirement.
Are the requirements for ventilation legislative?	Yes
Are there other means to ensure minimum ventilation levels for instance guidelines, standards or labeling schemes etc?	Yes, there are guidelines.
Are there regulations for commissioning and or quality assurance (legislative or voluntary) and how is it arranged?	Yes, legislative, ovk (mandatory ventilation control) and ventilation control when ventilation system is completed (plan och bygglagen).
Dwellings	
What are the requirements for ventilation in case of new dwellings for:	
living room	the legistlation is based on function, for the whole residential building the legislative requirement is 0.35 l/m^2 floor area and second
bedroom	4 l/s and bed (from Byggvägledning, BBR)
bathroom	10 l/s (from Byggvägledning, BBR)
toilet	10 l/s (from Byggvägledning, BBR)
kitchen	10 l/s with the possibility to boost the flow (from Byggvägledning, BBR)
other rooms	
What is the rationale (reasons behind and motives) behind these requirements specified per room, see below:	Probably an approximate value that 0.5 changes per hour is adequate (and in line with Fanger).
living room	
bedroom	
bathroom	
toilet	
kitchen	
other rooms	
Schools	
What are the requirements for ventilation in case of new schools specified per room:	For shools and office (working premises) s the only requirements is that CO2 is under 1000ppm, and according to general advice, this means that outdoor air flow is 7 l/s per person+ 0,35 l/sm2 floor area. The advice is also that the ventilation shall be designed so that the spreading of pollutants shall be limited.
classroom	

toilet	Only advice: exhaust 3 l/sm^2 floor area, but minimum 15 l/s
kitchen	
other rooms	Only advice: cleaning area minimum 15 l/s, shower minimum 15 l/s
What is the rationale behind these requirements in case of schools specified per room:	The requirements were based on CO2 (max 1000) from 1993. In the analysis of the new requirements, the level of ventilation was said to be in the same order as previously and also that it was in agreement with the Japanese, Norwegian, USA requirements, and in accordance with EU directive. They also refer to mould in buildings/sick building syndrome and allergy (in particular children in schools).
classroom	
toilet	
kitchen	
other rooms	
Offices	
What are the requirements for ventilation in case of new offices for:	For offices the only requirements is that CO2 is under 1000ppm, and according to general advice, this means that outdoor air flow is 7 l/s per person+ 0,35 l/sm^2 floor area. The advice is also that the ventilation shall be designed so that the spreading of pollutants shall be limited.
offices	
meeting room	
toilet	Only advice: exhaust 3 l/sm^2 floor area, but minimum 15 l/s
kitchen	
other rooms	Only advice: cleaning area minimum 15 l/s, shower minimum 15 l/s
What is the rationale behind these requirements in case of offices specified per room.	The requirements were based on CO2 (max 1000) from 1993. In the analysis of the new requirements, the level of ventilation was said to be in the same order as previously and also that it was in agreement with the Japanese, Norwegian, USA requirements, and in accordance with EU directive. They also refer to mould in buildings/sick building syndrome and allergy (in particular children in schools).
offices	
meeting room	
toilet	
kitchen	
other rooms	
Recommendations	
What are new insights that would change current ventilation standards, and how would this effect current standards	There is a strive to simplify the rules and the construction cost.

Table 17: Results from Questionnaires - USA

Country 11	**USA**
General	
Do you have requirements on ventilation for dwellings, offices and schools?	Yes. ASHRAE 62.1-2022 does not cover dwellings; that is covered by ASHRAE 62.2
Does these requirements take into account sensitive or other specific groups (children)?	To some degree
Is infiltration (unintended airflow through cracks) considered as a part of the ventilation flow in your calculation methods to fulfil the requirements?	No
Is window airing assumed as ventilation flow?	No, but there is path for natural ventilation
Are the requirements for ventilation legislative?	Not unless they are adopted by a local government or other agency
Are there other means to ensure minimum ventilation levels for instance guidelines, standards or labeling schemes etc?	Not in this standard
Are there regulations for commissioning and or quality assurance (legislative or voluntary) and how is it arranged?	Yes. ASHRAE 62.1-2022 does not cover dwellings; that is covered by ASHRAE 62.2
Dwellings	
What are the requirements for ventilation in case of new dwellings for:	**ASHRAE 62.1-2022 does not cover dwellings**
living room	
bedroom	
bathroom	
toilet	
kitchen	
other rooms	
What is the rationale (reasons behind and motives) behind these requirements specified per room, see below:	
living room	
bedroom	
bathroom	
toilet	
kitchen	
other rooms	
Schools	
What are the requirements for ventilation in case of new schools specified per room:	The requirements depend on occupant density, i.e.,, number of occupants per 100 m^2 of floor area. The values below are based on the default occupancy density listed in the standard.
classroom	Abour 4 L/s per person in lecture classrooms; about 7 to 9 L/s per person in classrooms with younger children
toilet	25 L/s continuous for public toilet, 35 L/s if not continuous

kitchen	3.5 L/s per m^2 of floor area
other rooms	
What is the rationale behind these requirements in case of schools specified per room:	Control of contaminants that are linked to the number of occupants (primarily but not exclusively bioeffluents) plus control of contaminants linked to the floor area (but not specific contaminants). Assume higher sources in younger age classrooms.
classroom	
toilet	Removal of odors and moisture
kitchen	Removal of odors, moisture and other contaminants
other rooms	
Offices	
What are the requirements for ventilation in case of new offices for:	The requirements depend on occupant density, number of occupants per 100 m^2 of floor area. The values below are based on the default occupancy density listed in the standard.
offices	8.5 L/s per person
meeting room	3.1 L/s per person
toilet	25 L/s continuous for public toilet, 35 L/s if not continuous
kitchen	3.5 L/s per m^2 of floor area
other rooms	
What is the rationale behind these requirements in case of offices specified per room.	Control of contaminants that are linked to the number of occupants (primarily but not exclusively bioeffluents) plus control of contaminants linked to the floor area (but not specific contaminants)
offices	
meeting room	
toilet	Removal of odors and moisture
kitchen	Removal of odors, moisture and other contaminants
other rooms	
Recommendations	
What are new insights that would change current ventilation standards, and how would this effect current standards	

13. Appendix 2: Data from Literature

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ANNEX 5

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