# Finnish design ventilation rates for residential buildings

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**Abstract.** Implementation of EU directives has forced EU member countries to revise the building regulations related energy efficiency. The 2017 revision of the building codes is due to the requirement set in the EPBD 2010 for all new buildings to be nearly zero buildings by 2020.The Finnish Ministry of the Environment (in charge of building regulations) invited FINVAC Federation of Finnish HVAC Associations to revise the guidelines values of ventilation rates as part of the nearly zero energy building regulations. At the same time, the Finnish Society of Indoor Air Quality and Climate updated its voluntary Classification of Indoor Environment. Several methods were used in the study to collect information and develop the new guideline values. European studies, such as HEALTHVENT, and relevant CEN standards were taken into consideration in drafting the design ventilation rates. Existing legislation on housing conditions gave the minimum levels and, finally, the recommended values were defined using expert interviews, workshops and public review process. Earlier studies had indicated that earlier design ventilation rates were too high for small apartments. Ventilation rates were considered too low for homes of elderly people and residential kitchen hoods, and some larger apartments. Furthermore, the balance of outdoor and exhaust air flows needed revision due to the improved tightness of the building envelope. Energy efficiency and avoidance of draught and noise were also taken into account. This paper presents the numeric values of the ventilation rates in the new building regulations and the design guidelines supporting them.

## 1 Background

Implementation of EU directives [10,11] has forced EU member countries to revise the building regulations related energy efficiency. In Finland the process started in 2013, as a part to revise the whole National Building Code of Finland within 5 years. The regulations in the revision process include also those dealing with indoor environment and ventilation. The Finnish Building code Part D2 [1] was first given in 1976 and revised frequently based on the collected experience, and to follow the changes in construction practice and demands for better energy efficiency and indoor environment. The Building code Part D2 was revised and published in 2012 to fulfil the requirements in the Energy Performance of Buildings Directive 2002.

The National Building Codes included both mandatory requirements and non-mandatory guidelines. In 2017, the Codes were rewritten as decrees and significant part of the former non-mandatory texts were omitted from them. At the same time, the nearly zero buildings requirements set in the EPBD 2010 were implemented. The new Decree for indoor air quality and ventilation [2] specifies the minimum design ventilation rate to be 6 $dm^3/s$, person (outdoor air), and 0,35 $dm^3/s$, $m^2$ floor area for residential buildings. The code also specifies that the ventilation shall be controlled by demand when feasible.

The mandatory requirements in the Decree were considered to be too plain and inadequate for practical design. As a response to this, the Finnish Ministry of the Environment (in charge of building regulations) invited FINVAC, Federation of Finnish HVAC Associations, to write design guidelines for residential and non-residential buildings.

## 2 Methods

The revision of the guidelines was based mainly on the existing National decrees and experience from practice. Several methods were used in the study to collect information: an expert panel, questionnaires to experts in two stages, interviews of selected experts, open workshops, and analysis of results in the light of the existing building code, and also acknowledging the work done in the working groups of CEN TC 156. The participants of the study were selected from the members of FINVAC, representing various professions in the construction process.

An expert panel was established for the study, a questionnaire was sent to selected ventilation experts of

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FINVAC in two stages. Two open seminars were organized for professionals. Seminars were monitored and results analysed. Interviews of selected experts were focusing on specific technical questions. European studies, such as HEALTHVENT and BPIE were taken into consideration in drafting the design ventilation rates. The revised ventilation guidelines for residential buildings presented in this paper are the outcome of this process. The values are optimized for energy efficiency and indoor air quality. The guidelines for non-residential buildings are presented in another paper [3].

The current and recommended ventilation rates in Europe were studies during the revision process. Table 1 shows the results of the BPIE study [4]. Significant variation between countries can be seen, but the Finnish minimum whole building ventilation rate 0,35 $dm^3/s, m^2$ is in line with several EU MS.

The CEN standard EN 16798-1 [5] suggests 10, 7, or 4 $dm^3/s$,person for design ventilation rate in categories I, II and III. The Finnish minimum is between cat II and III. The CEN EN 16798-1 also suggests to add ventilation due to emissions from building materials. Finland has had an emission control system of building material since 1995 [6]. This procedure has significantly reduced the emissions and the need for ventilation. Currently more than 4500 building materials, furnishings and ventilation components have been tested and labelled for low emission. It was considered more feasible to specify the ventilation rates by building and room type which is always know at design stage.

The HealthVent project compared guideline values for ventilation rates, too. The results showed that the previous Finnish guideline values [1] for exhaust from bathrooms and toilets were very close to the European averages. The guideline value for kitchen for continuous operation, 8 $dm^3/s$, was smaller than in most other countries in the comparison, but the required boost of the kitchen exhaust to min 20 $dm^3/s$ bring the rate close to the European average. [6]

The previous Finnish guideline values were also in line with categories II and III of the EN 16798-1, with the exception of the kitchen described above.

Based on the above comparisons, no major changes to the previously used levels of room ventilation rates were made. The main focus was in the clarification of the requirements of the decree to harmonise the design practises.

**Table 1.** Ventilation standards for new dwellings in eight EU MS (Source: BPIE 2015 report based on feedback from country experts) [4].

| Country and Standard Reference | Whole Building Ventilation Rates | Living Room | Bedroom |
|---|---|---|---|
| **Brussels**[1)] (NBN D 50-001) | 3,6 $m^3/h, m^2$ | Min. 75 $m^3/h$ (limited to 150 $m^3/h$) | Min. 25 $m^3/h$ (limited to 72 $m^3/h$) |
| **Denmark**[1)] (BR10) | Min. 0,3 $dm^3/s, m^2$ | Min. 0,3 $dm^3/s, m^2$ | |
| **France**[1)] (Arrêté 24.03.82) | 10-135 $m^3/h$ (depending on room number and ventilation system | | |
| **Sweden**[1)] (BFS2014:13 – BBR21) | Supply: min 0,35 $dm^3/s$, $m^2$ floor area | | |
| **Germany**[2)] (DIN 1946-6) | 15-285 $m^3/h$ | | |
| **Italy**[2)] (Legislative Decree 192/2005 UNI EN 15251 | Naturally ventilated 0,3-0,6 vol/h | 0,011 $m^3/s$ per person for an occupancy level of 0,04 persons/$m^2$ | |
| **Poland**[2)] (Art 149 (1) – Journal of Laws 2002 no. 75 item 690, as amended and PN-B-03430:1983/ Az3:2000 | 20 $m^3/h$ for each permanent occupant should be calculated according to the Polish standard but not less than 20 $m^3/h$ | 20-30 $m^3/h$ for each permanent occupant (for public buildings) For flats, it is a summary of flow from all rooms | |
| **UK**[2)] (Approved Document F) | 13-29 l/s (depending on bedrooms | | |
| EN 15251 | 0,35-0,49 $dm^3/s, m^2$ | 0,6-1,4 $dm^3/s, m^2$ | |

| Country and Standard Reference | Kitchen | Bathroom + WC | WC Only |
|---|---|---|---|
| **Brussels**[1)] | Open kitchen Minimum 75 $m^3/h$ | Minimum 50 $m^3/h$ (limited to 75 $m^3/h$ | Minimum 25 $m^3/h$ |
| **Denmark**[1)] | 20 $dm^3/s$ | 15 $dm^3/s$ | 10 $dm^3/s$ |
| **France**[1)] | Continuous: 20-45 $m^3/h$ | | Minimum 15 $m^3/h$ |
| **Sweden**[1)] | | | |
| **Germany**[2)] | 45 $m^3/h$ | 45 $m^3/h$ | 25 $m^3/h$ |
| **Italy**[2)] | | 4 vol/h | |
| **Poland**[2)] | 30-70 $m^3/h$ | 50 $m^3/h$ | 30 $m^3/h$ |
| **UK**[2)] | 13-60 $dm^3/s$ | 8-15 $dm^3/s$ | 6 $dm^3/s$ |
| EN 15251 | 14-28 $dm^3/s$ | 10-20 $dm^3/s$ | 7-14 $dm^3/s$ |

*1) Requirement*
*2) Recommendation*

# 3 Results

## 3.1 Design principles

In the design guideline, the requirements of the Decree were formulated as follows:

Outdoor airflow rates for the whole building should be designed to meet following minimum requirements:

1) The outdoor airflow rate calculated over the whole floor surface area must be at least 0,35 $dm^3/s, m^2$ **and**
2) the outdoor airflow rate for the whole apartment must be at least 18 $dm^3/s$ **and**
3) each room must have an outdoor airflow rate at least 0,35 $dm^3/s, m^2$ **and**
4) each residential room must have an outdoor airflow rate of at least 8 $dm^3/s$. Bedrooms over 11 $m^2$ floor area must have outdoor airflow rate at least 12 $dm^3/s$.
5) If there is a sauna in the apartment, the total outdoor airflow rate must be increased by 6 $dm^3/s$.

The first three requirements come directly from the Decree. The fourth requirement is based one the minimum ventilation rate of 4 $dm^3/s$, person, and the possibility of two children sharing the bedroom. For the 'master' bedroom, probably shared by two adults, 12 $dm^3/s$ for two people was considered appropriate.

## 3.2 Minimum outdoor airflow rates of the whole apartment

The minimum outdoor airflow rates of apartments according to these requirements is shown in Table 2. The first (or only) residential room must have an outdoor airflow rate of at least 12 $dm^3/s$. The following residential rooms must have an outdoor airflow rate of at least 8 $dm^3/s$. Outdoor airflow rate must be raised if there is more than one bedroom with floor area over 11 $m^2$.

**Table 2.** Minimum outdoor airflow rate of apartments during normal usage.

| Floor area of the apartment ($m^2$) | Outdoor airflow rate ($dm^3/s$) based on number of residential rooms (rr) | | | | | |
|---|---|---|---|---|---|---|
| | 1 rr | 2 rr | 3 rr | 4 rr | 5 rr | 6 rr |
| 20 | **18** | | | | | |
| 30 | **18** | | | | | |
| 40 | **18** | **20** | | | | |
| 50 | **18** | **20** | | | | |
| 60 | | **21** | **28** | | | |
| 70 | | **25** | **28** | | | |
| 80 | | **28** | **28** | **36** | | |
| 100 | | | **35** | **36** | **44** | |
| 120 | | | **42** | **42** | **44** | **52** |
| 150 | | | | **53** | **53** | **53** |

The residential rooms include living rooms, bedrooms and other similar rooms. If there is a sauna in the apartment the total outdoor airflow rate must be increased accordingly. Other combinations of floor area and room numbers must comply with requirements 1-5 above.

The outdoor and exhaust airflow rates are normally designed to be equal. The airflow rates of the whole building should be designed so that the building would not be continuously over or under pressured and that pressure difference between indoors and outdoors would not exceed 5 Pa.

The ventilation system of the apartment must have a boost option allowing 30 % increase in the whole building ventilation rate. The ventilation system can be run at 60 % of the designed normal airflow rates when the apartment is empty.

The measured airflow rates of the whole apartment can differ 10 % from the designed airflow values. Methods for measuring airflow rates measurements are illustrated in standard EN 12599 [7].

## 3.2 Minimum outdoor airflow rates for individual rooms

The total airflow rate of the whole apartment is shared to individual rooms according to Table 3. If necessary, specific room airflow rates should be increased to achieve balance between outdoor and exhaust airflow rates. The measured airflow rates of individual rooms can differ 20 % from the designed airflow values. Outdoor air supply for fire place, central vacuum cleaner, kitchen hood or other separate exhaust device must be ensured.

**Table 3.** Outdoor and exhaust airflow rates for individual rooms during normal usage.

| Room | Outdoor airflow rate ($dm^3/s$) | Outdoor airflow rate ($dm^3/s$) |
|---|---|---|
| Largest or only bedroom / other bedroom over 11 $m^2$ floor area | **12** | |
| Other bedroom | **8**[1)] | |
| Other residential rooms like living room under 22 $m^2$ (not a kitchen) | **0,35**[1)] /$m^2$ | |
| Kitchen, cooking area, kitchenette | | **8 (25)**[2,3)] |
| Bathroom | | **10**[3)] |
| Separate toilet | | **7**[3)] |
| Walk-in closet | | **6**[3)] |
| Storage | | **6**[3)] |
| Sauna in the apartment | **6** | **6** |
| Utility room | | **8**[3)] |
| Mechanical room | | **3**[3)] |

1) Outdoor air flow rate can be partly compensated with air transferred from a bedroom

2) Exhaust air flow rate of the kitchen hood or kitchen must be at least 25 $dm^3/s$ during cooking. Outdoor air supply during the boost must be ensured.
3) Outdoor air flow rate can be entirely compensated with air transferred from a residential room

**Table 4.** Airflow rates for apartment house communal spaces

| Room | Outdoor airflow rate ($dm^3/s,m^2$) | Outdoor airflow rate ($dm^3/s,m^2$) |
|---|---|---|
| Stairway[1)] | **0,5** 1/h | **0,5** 1/h |
| Storages | **0,35** | **0,35** |
| Steam room of the communal sauna | **2** | **2** |
| Bathroom of the communal sauna | **equal to exhaust /** transfer air | **16** $dm^3/s$ /shower |
| Chancing room of the communal sauna | **2** | **2** |
| Communal laundry room[2)] | **1** | **1** |
| Drying room for laundry[3)] | **2** | **2** |
| Club or other communal room[4)] | **1** | **1** |
| Lobby and corridors | **0,35** | **0,35** |

1) Airflows rates can be reduced during winter
2) Airflow rates can also be designed based on heat gains
3) Air flow rates can be reduced if a dehumidifier is used
4) At least 12 $dm^3/s$

The guideline contains practical examples on the design of ventilation flow rates for different sizes of apartments and houses.

## Discussion

In the design stage the number of occupants for a specific apartment is not known. Thus the design has to be based on some other criteria. New guidelines give are based on number and size of the rooms in the apartment. The ventilation rate 6 $dm^3/s$, person has been used as the basic ventilation rate since 2012 in Finland. The experience from practice shows that it is an appropriate value as a minimum ventilation rate.

## References

1. National Building Code of Finland. Part D2. Indoor Climate and Ventilation of Buildings Regulations and Guidelines 2012. Ministry of the Environment, Finland.
2. Decree of the Ministry of the Environment on the Indoor Climate and Ventilation of New Buildings 1009/2017.
3. Seppänen O, Ahola M, Säteri J Finnish Guidelines of Ventilation Rates for Non-residential Buildings. Clima 2019 Conference (submitted)
4. Analysis of residential building regulations in eight EU member states. Buildings Performance Institute Europe (BPIE), 2015. ISBN: 9789491143106
5. EN 16798-1:2018 Energy performance of buildings. Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.
6. Brelih, Nejc, Seppänen Olli. “Ventilation rates and IAQ in European standards and national regulations” presented at the AIVC conference Oct 12-13, 2011, Brussels, Belgium.
7. EN 12599:2012 Ventilation for buildings - Test procedures and measurement methods to hand over air conditioning and ventilation systems.
8. Opas ilmavaihdon mitoitukseen muissa kuin asuinrakennuksissa. FINVAC 2018. (Guidelines for ventilation design in non-residential buildings.
9. Classification of Indoor Environment 2018, Target Values, Design Guidance, and Product Requirements, Finnish Society of Indoor Air Quality and Climate. 2018.
10. Directive 2002/91/EC of the European Parliament and of the Council on the energy performance of buildings
11. Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings