Ventilation Information Paper
n° 24
May 2008

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International Energy Agency
Energy Conservation in Buildings
and Community Systems Programme

Air Infiltration and Ventilation Centre

Trends in the Polish building ventilation market and drivers for change

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1 System of Polish regulation related to buildings

1.1 Introduction

The constitutional responsibility of the state for the living conditions of its citizens and its obligations stemming from international conventions, EU directives, and other binding decisions of international organisations, are reflected in the hierarchically ranked Polish legal acts, such as [1]:

- the Constitution (health protection, civil rights, sustainable development) which is the grounds for drafting Parliament bills,
- Parliament bills, defining the rights (the environmental protection law, the construction law, the energy law, the health protection law, the compliance evaluation system, the inspection services' obligations and scope of competence) etc.
- Government and ministerial ordinances, supporting the implementation of legal acts (technical conditions to be met by buildings and their localisation, the technical conditions of the use of residential buildings, safety certification and safety mark, conditions of connecting the users to the heating network, energy efficiency requirements for heating systems, power labels and profiles, scope and form of the construction design),
- ministerial instructions, setting forth detailed requirements.

The structure of legal acts and ministerial ordinances envisages the formulation of requirements and it defines the formal grounds for the functioning of control institutions (e.g., construction inspection, sanitary inspection, labour safety inspection).

1.2 Technical criteria to be met by built structures and their localisation

Efforts were made twice in the recent decade to adjust the legal regulations to the new requirements supplement and enrich the contents of the ordinance without changing its structure, traditionally accepted by the technical world.

Ordinance on the technical criteria to be met by built structures and their localisation [3] - contents:

Chapter I.	General provisions
Chapter II.	Building plot's development and management
Chapter III.	Buildings and rooms
Chapter IV.	Technical outfit of buildings
Chapter V.	Structure safety
Chapter VI.	Fire safety
Chapter VII.	Safety of use
Chapter VIII.	Hygiene, health, and environmental protection
Chapter IX.	Noise and vibration protection
Chapter X.	Energy saving and thermal insulation
Chapter XI.	Transition and final provisions

The above list of contents, in which the technical solutions are determined first and then recommendations on meeting the basic requirements are defined, does not help to successfully fulfil the user's needs.

1.3 Control activities

The execution of the implementation of statutory tasks was delegated in Polish legislation to respective inspection services: *the State Sanitary Inspection, the State Environmental Protection Inspection, and the Main Construction Supervision Office*. However, poor consistency of the provisions leads to a poor enforcement of these regulations and is a reason why "the protection of the natural environment and the building" in practical life remains beyond the reach of all these inspections.

1.4 Polish Standards

Standards should be an inseparable supplement for legal documents to define the methods for requirement definition, performance criteria, calculation methods, measurements strategy and methodology, research procedures, etc. With the relatively small set of national standards in Poland, the ISO and CEN standards are being consequently introduced. It should be pointed out that due to the large number of standards that have to be implemented many of them are only approved in English. Until they are published in Polish they cannot be used in the process of legislation (citizens speaking only Polish should be able to read any document of the biding legal system). The delay in both translations and development of Polish appendixes to CEN standards (when necessary) is not decreasing.

2 Requirements for new buildings and retrofitted buildings

2.1 Indoor air quality

Permissible values of concentration and intensity of factors hazardous to health, emitted in all living areas by building materials, equipment and furnishing, are set out in a Regulation of the Minister of Health and Social Care of 12 March 1996 [4]. This regulation, rather unique in Europe and in the World, sets two categories of rooms, i.e. A and B. Category A covers rooms designated for living, rooms designated for permanent occupation by patients in health care buildings, rooms designated for permanent occupation of children in educational buildings and rooms designated for food products storage. Rooms designated for occupation in public utility buildings, other than included to category A, as well as auxiliary spaces in dwellings should meet criteria for category B spaces.

The regulation specifies permissible concentration values (average 24 hrs) for 35 chemicals. Moreover, in the case of 17 substances and their mixtures this Regulation sets restrictions (in many cases their application is generally forbidden) as for their content in building materials. The Regulation is used basically during the process of building materials' certification and is not familiar to HVAC designers.

According to the regulation, construction materials are also checked against the amount of natural radioactive isotopes. Tested materials should meet two criteria f_1 and f_2.

$$f_1 = 0.00027 \cdot S_K + 0.0027 \cdot S_{Ra} + 0.0043 \cdot S_{Th} \leq 1$$
$$f_2 = S_{Ra} \leq 185 \ Bq/kg$$

where:

S_K - concentration of the potassium - 40 isotope in building material, Bq/kg

S_{Ra}- concentration of the radium - 226 isotope in building material, Bq/kg

S_{Th}- concentration of the thorium - 228 isotope in building material, Bq/kg

2.2 Ventilation

In Poland the minimum flow of outdoor air in apartment houses, residential buildings and public buildings is specified in the Polish Standard PN-83 B-03430/Az3:2000 [7]. Ventilation system in residential buildings should at least ensure:

- outdoor air supply to rooms and kitchen with external window,
- exhaust of used air from kitchen, bathrooms, separate toilets, auxiliary rooms without windows (cloak room, storeroom), rooms divided from any of these places by more than 2 doors or for rooms located on the upper levels in multi-storey single family

housesor multi-storey apartments in multifamily houses.

Ventilation rates for the apartment are characterised by the sum of the air rates extracted from the rooms mentioned above. These volumes, regardless of the ventilation type, should be at least:

- for kitchens with external windows, using gas or coal cookers - 70 m^3/h
- for kitchens with external windows, using electric cookers:
  - in apartments for up to 3 people - 30 m^3/h
  - in apartments for more than 3 people - 50 m^3/h
- for kitchens without external windows, or for kitchen with electric cookers - 50 m^3/h
- for bathrooms (with or without toilet) - 50 m^3/h
- for separate toilets - 30 m^3/h
- for an auxiliary room, without windows - 15 m^3/h
- for rooms divided from the other rooms with air exhaust by more than 2 doors or for rooms located on upper levels in multi-storey single family houses or multi-storey apartments in multifamily houses - 30 m^3/h

Kitchens without external windows, fitted with gas cookers, should have mechanical exhaust ventilation: the extracted airflow should be at lest 70 m^3/h.

Buildings of up to 9 stories may use passive stack ventilation or mechanical ventilation. Higher buildings should have mechanical exhaust or mechanical supply-exhaust ventilation. Mechanical ventilation should operate 24 hours a day. During the night (e.g. between 10.00 p.m. and 6.00 a.m.) the ventilation airflows given above may be reduced to values ensuring 20 m^3/h per person.

In public utility buildings ventilation requirements are defined by the minimum ventilation rates (outdoor air) per person:

- for rooms permanently or temporarily occupied by people - 20 m^3/h per person.
- for public buildings where smoking is allowed - 30 m^3/h per person
- for kindergartens, infants day nursery - 15 m^3/h per child
- for air conditioned rooms or rooms with not openable windows - 30 m^3/h per person
- for air conditioned rooms or rooms with not openable windows where smoking is allowed - 50 m^3/h per person

If in a ventilated room other sources of pollution than human beings are present, the ventilation rate should be evaluated on the basis of mass balance of pollutants. It should be noted that in Poland smoking outside clearly marked smoking areas in all public places is forbidden.

As ventilation system parameters other than ventilation intensity also influence the indoor environment "Technical criteria to be met by built structures and their localisation" [3] specifies a lot of additional requirements for ventilation installation. Only the most important are described below.

Air re-circulation can be used when the designation of ventilated spaces is not associated with the presence of bacteria causing illnesses, with emission of substances harmful to humans' health or with unpleasant odours and requirements for minimum outdoor air are met. In health care building re-circulation requires the special permission of the local sanitary inspector.

In case of mechanical ventilation supply-exhaust or air conditioning systems with air rate at least 10000 m^3/h heat recovery from the exhaust is obligatory. Devices used for this purpose should have solutions minimising air leakage between air streams to:

- 0.25% of exhaust air in case of plate heat exchanger or heat pipes exchanger,
- 5% of exhaust air in case of rotary wheel exchangers, all of the above with respect to pressure difference of 400 Pa.

Devices used in mechanical ventilation systems and air-conditioning systems should be protected against the pollutants in outdoor air and in special cases in re-circulated air by effective air filtration:

- heat exchangers, cooling coils, and heat recovery devices: filters at least class G4,
- humidifiers: filters at least class F6.

Typical ducts in mechanical ventilation systems and air conditioning systems should fulfil criteria for the class A of airtightness (table 1). In case of ventilation ducts in high pressure installations as well as in case of overpressured parts of the exhaust installations that remove polluted air containing substances harmful to humans health or flammable substances and if there is a possibility of its leakage into the spaces designated for permanent occupation, the ducts should fulfil criteria for the class B of airtightness (table 1).

Table 1. Permissible values of the duct leakage coefficient [3]

Test overpressure in the duct, Pa	Dust leakage coefficient	
	class A, $m^3/(m^2 \cdot h)$	class B, $m^3/(m^2 \cdot h)$
400	≤ 4.78	≤ 1.59
1000	-	≤ 2.89

Set of 14 conditions describes the location of air intake and exhaust from mechanical systems. Group of other requirements state that duct systems as well as all devices should have easy access necessary for proper maintenance including cleaning.

2.3 Thermal comfort

In many countries requirements for thermal comfort are based on the PMV - PPD model. Although in Poland such standards also exists, thermal comfort in mechanically ventilated or air-conditioned spaces is the subject of the Polish Standard PN-78/B-03421 [6]. The Standard introduces the concept of "optimal" and "permissible" conditions for both winter and summer. Physical activity plays the role of basic criterion for parameters selection. It is estimated by summing the total heat loss depending on the body position and additional heat loss depending on the type of physical activity (table 2). Physical activity is categorised in three groups:

- low < 200 W,
- medium - 200÷300 W,
- high > 300 W.

Table 2. Estimation of mans physical activity [6].

Total heat loss depending on the body position		Additional heat loss depending on the type of physical activity			
Body position	Total energy lose W	Type of work	using hand	1 arm	2 arms
Sitting	120	Light work	30	60	120
Standing	140	Medium work	50	90	150
Moving	240	Heavy work	60	120	180

Table 3. Calculation indoor air parameters for the winter period [6].

Physical activity	Air temperature	Relative humidity		Maximum air speed
		Optimal	Permissible	
	°C	%	%	m/s
Low	20÷22			0.2
Medium	18÷20	40÷60	30	0.2
High	15÷18			0.3

Table 4. Calculation indoor air parameters for the summer period [6].

Physical activity	Optimal conditions		Permissible conditions			Maximum air speed
	Air temperature	Relative humidity	Temperature in case when heat gains for 1 m² of the floor of room or working zone are		Relative humidity	
			below 50 W/m^2	above 50 W/m^2		
	°C	%	°C	°C	%	m/s
Low	23÷26	40÷55				0.3
Medium	20÷23	40÷60	t_z+3	t_z+5	70	0.4
High	18÷21	40÷60				0.6

Designing conditions for indoor air according to PN-78/B-03421 [5] are presented in tables 3 (winter) and 4 (summer). Important remarks for tables 20 and 21:

- In the case where there is no possibility of humidification in winter it is allowed not to meet the permissible minimum value and to add into the calculation values resulting from outdoor conditions and room moisture balance
- Permissible values of temperature in summer may be taken into account only when there is no possibility to cool the air. One should select the values between optimal and permissible. Symbol t_z denotes outdoor air temperature according to Polish Standard PN-76/B-03420 [5].
- It is allowable when selecting indoor air temperature from the "optimal" range permissible values of relative humidity should be selected respectively: for the temperature 26 °C – not above 55%, and for 23 °C not above 65% relative humidity (not according to the permissible values).
- Because of the necessity of taking into account the heat radiation, indoor temperature for winter may be selected only when the mean temperature of inner surfaces of envelope components $\tau_{p\,śr}$, is not less than 2 °C from minimum indoor temperature associated with specific physical activity. If this condition is not fulfilled, the case require individual evaluation of the f indoor temperature. Mean temperature of inner surfaces of envelope components $\tau_{p\,śr}$ is calculated using equation.

$$\tau_{p\,śr} = \frac{\sum(F_i \cdot \tau_{p\,i})}{\sum F_i}, \text{°C}$$

where:

$\tau_{p\,i}$ temperature of inner surfaces of envelope component, °C

F_i surface area, m^2

2.4 Energy standards

Currently the thermal insulation requirements for buildings are regulated by the ordinance of the Minister of Infrastructure on technical criteria to be met by built structures and their localisation [3].

Concerning a multi-family building or a collective residential building, the energy conservation requirements are fulfilled, if the value of the E factor, representing the computational demand for heat consumed by the building during the heating season is smaller than the upper limit value E_0.

For a residential single-family house the energy conservation requirements are fulfilled, if:

- the E factor value is smaller than the upper limit value E_0, or
- the external walls meet the requirements of thermal insulation and other energy-saving requirements, specified in the annex to the resolution .

For a public utility building the energy conservation requirements are fulfilled, if the external walls meet the requirements of thermal insulation and other energy-saving requirements, specified in the annex to the resolution

The required values E_0 of the building seasonal heat demand factor depend on the building shape ratio A/V, and for residential and collective residence buildings amount to:

for $A/V \leq 0.20$, $E_0 = 29$ kW·h/(m^3·a)

for $0.20 < A/V < 0.90$,

$$E_0 = 26.6 + 12\,A/V \text{ kW·h/(m}^3\text{·a)},$$

for $A/V \geq 0.90$, $E_0 = 37.4$ kW·h/(m^3·a),

where:

A is the total surface area of all outer walls (including windows and balcony doors), roofs and floor-roofs, floors on ground, floors above unheated basements, floors above passages, which separate the building's heated section from ambient air, as measured along outer boundaries;

V is the cubic capacity of the building's heated section, computed according to the relevant Polish Standard, which sets out the procedures to compute the building's cubic capacity.

Poland still has not completed implementation of the EPB Directive. In October 2007 the Parliament approved changes to Building Code. The Minister responsible for construction and housing has been authorised to issue the set of ordinances related to EPBD implementation.

First ministerial ordinances were published but substantial parts of secondary legislation are still missing (e.g. calculation procedure for certification of buildings, requirements for air conditioning inspections). Few concepts of calculation procedures for certification of buildings were published for discussion. The ordinance is expected in June 2008.

3 Ventilation systems in typical Polish buildings

3.1 Residential buildings

Almost all residential buildings in Poland (single and multifamily) are equipped with passive stack ventilation. It is forbidden to use this system in buildings higher than 9 storeys (earlier 11 storeys). As investment costs are very low it was usually chosen by investors even though from exploitation point it create a lot of problems. Unfortunately, this type of ventilation is not a subject of any calculations during the design process. Cross sections of stacks, the type of ventilation grilles, air tightness of envelope components are selected by a rule of thumb or are not taken into consideration at all. Energy conservation action, supported by the Government, advises air sealing of the building envelopes. However, very often it results in very negative consequences related to the decrease of ventilation intensity (mould growth or CO poisoning incidents).

Possible introduction of obligations to prove (by calculation during the design stage) proper operation of the system in reference weather conditions could be a great driving force for the introduction of a better controllable mechanical or hybrid system to residential buildings.

Buildings higher than 9 (earlier 11) storeys are typically equipped with mechanical exhaust systems (without heat recovery). These buildings are characterised by the highest exploitation costs (air change rate close to required, no heat recovery, additional energy consumption for air transport).

In the biggest Polish towns (e.g. Warsaw , Cracow, Poznan, Gdynia) the first apartment buildings equipped with air conditioning appeared. Usually the simple split or multisplit systems are used.

New single family buildings are more and more often equipped with air handling units with heat recovery. At the beginning cross flow heat exchangers (thermal efficiency 60%) were popular while currently counter flow heat exchangers or rotary wheels (with efficiency ~90%) are attracting the attention of investors. Additional ground air heat exchangers (energy saving and defrost solution) are very interesting options [10].

3.2 Public utility buildings

For a number of years, air conditioning systems were regarded as a luxury, not a technical system for many types of buildings. Air conditioning was installed in high class hotels, theatres, operating theatres in hospitals. Most popular was full air system with constant air volume. After 1990, a rapid increase of water–air systems was observed (usually fan coil systems). In modernised buildings very often direct expansion split and multisplit systems were used.

There is no institution responsible for analysis of the ventilation market. Data on the number of systems, preferred types, installed power or annual energy consumption do not exist. Information presented below are based on:

- increase in the volume of public utility buildings (hotels, banks, hospitals, supermarkets)
- data on the use and production of substances harmful to ozone layer,
- data on sales of air conditioning units provided by key companies on Polish market

Data do not cover air conditioning systems installed in industry (technology air conditioning).

Based on the assumptions presented above numbers and the electrical power of installed engines can be:

- Autonomic air conditioners (monoblock, split, multisplit, roof-top etc.):
  - Total number of units - 120000
  - Mean electrical power ~ 3 kW
  - Total demanded power 3 x 120000 = 360 000 kW = 360 MW
- Chillers for centralized air conditioning systems:

- Total number of units - 2000
- Mean electrical power ~ 60 kW
- Total demanded power 60 x 2000 = 120 000 kW = 120 MW

Thses calculations lead to the conclusion that peak demand for electrical power is 360 + 120 = 480 MW.

Additionally in the Polish market in 2007 1000-1100 heat pumps were sold (40 % of them are heat pumps with ground heat exchangers). Annually the market is growing by 25% [8].

4 Preferences and opinions of Polish HVAC designers

There is no available data on Polish HVAC designers preferences except the survey carried out by Warsaw University of Technology in 2000 [9]. Due to the method of collecting information, the survey was applied to the HVAC designers working in design offices within Warsaw limits. In order to achieve the highest response rate and to avoid discrepancies in the interpretation of questions, individual interviews with designers were preferred.

One of the aims of the survey was to establish the percentage of each type of HVAC systems designed by the investigated engineers in the past 15 years (1985-2000):

- Air- water systems (with fan coils) (30%),
- Constant Air Volume – CAV (single zone) (18%),
- Variable Air Volume – VAV (with return fan) (13%),
- Variable Air Volume – VAV (single fan) (9%),
- Constant Air Volume – CAV (multi zone) (12%),
- Dual duct (10%),
- Displacement systems (4%)
- Air- water systems (with chilled beams) (4%).

On the basis of the replies obtained in the survey one can create a totally fictitious figure of a „typical Polish designer" giving the most frequent answers. Naturally, many designers who took part in the survey would not agree with the opinions expressed by the „typical" representative of the investigated group [9].

The „typical designer" believes that IAQ problems are most of all due to the incorrect operation of HVAC system. Although the typical designer has no problems with the design of correctly operating systems (correct airflow, good thermal comfort, adequate filtering/cleaning), he thinks that problems are often caused by incorrect design, incorrect automatics, low quality of manufacture, inadequate maintenance and incorrect use of rooms or buildings.

The Polish designer is aware of low standard requirements on the part of the investor who wishes to become - at the lowest cost possible – the owner of a building which can be classified as air conditioned. As a result, the „typical designer" mainly has to design systems fitted with fan coils. Their capacity to ensure adequate IAQ and good thermal quality is rated between „satisfactory" and „good". Due to such a choice of the system, the main design problem is to obtain systems able to guarantee good humidity control.

It should be noted that, according to the survey, the Polish designers neglect factors related to pollutant generation from building material, furnishings and pollutant generation due to occupant activities. The replies never mention microbiological pollution or cigarette smoke. Strangely enough, the designers seem to be convinced that they can ensure adequate airflow and obtain an adequate degree of air cleaning.

Opinions presented above were collected in 2000. At the moment knowledge about IAQ problems seems to be wider. Designers usually suggest higher than minimum ventilation rates (eg. 50 m^3/h person instead minimum permissible 30 m^3/h in air conditioned rooms). Additionally one can observe increasing number of air conditioning systems with chilled beams while the number of systems with fan-coils is decreasing.

5 Characteristics of the market

From many years a trend of an annual increase in the volume of the market by 10-20% has been observed (with fluctuations reflecting general condition of Polish economy). The Association of Polish Ventilation periodically carries out the survey of the ventilation and air conditioning market. The newest report (with data from 2006) was prepared on a survey of 40 companies [2]. The Survey had a mixed qualitative-quantitative character.

The survey confirmed the general positive trends. The turnover of only 2 companies (from 40) dropped in 2006 compared to 2005. The vast majority of the companies declared a substantial increase (two categories were marked) <0%-29%> and <30%-59%>.

Plans for the year 2007 were also optimistic. 90% of companies expected an increase in company turnover. More than 40 % agreed that year 2006 indicated that there is a need for investment in quality. Rising expectations of clients require more advanced technologies and higher quality products.

The Polish ventilation market is dominated by importers (65.1 % of total turnover), Polish producers have only 32.4% share in the turnover (companies that both produce and import units has a 2.6% share). The market is also strongly concentrated (20 % of companies has a 76.7 % of turnover).

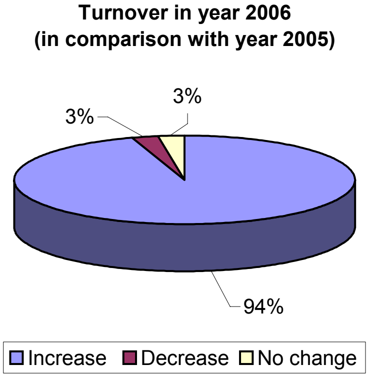

Figure 1. The comparison of turnover of ventilation companies in 2005 and 2006 [2].

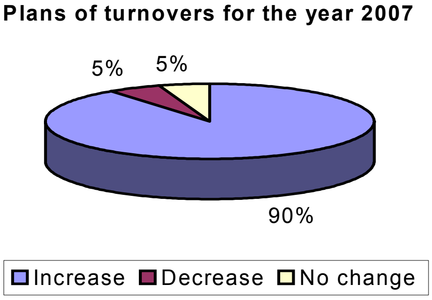

Figure 2. The plans for the year 2007 (in comparison with 2006) [2].

6 Key forces driving changes in Polish ventilation market

The Polish ventilation market is changing rapidly. Key forces driving changes in Polish ventilation market are:

- rising expectations of users (investors on the construction market are interested in better controllable ventilation systems and in air conditioning),
- rising costs of energy that draw attention of investors towards energy efficient systems able to utilise renewable energy
- incorporation of a great number of CEN standards into the set of Polish Standards; (in the coming few years this process will force dramatic changes in Polish secondary legislation)
- The implementation of the EPB Directive (the influence on ventilation market seems to be obvious but as substantial parts of secondary legislation are still missing it is impossible to estimate how strong this process could be).

7 References

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8 Acknowledgments

The paper uses part of outcomes from the project SURE-BUILD „Sustainable rehabilitation of buildings" financed by the Royal Norwegian Ministry of Foreign Affairs through The Cooperation Programme with the EU Candidate Countries within Higher Education and Research 2002-2005.
The author would like to cordially thank Dr Marian Rubik from Warsaw University of Technology for providing unpublished estimations of air conditioning market in Poland and fruitful discussions.

This information paper is one of the outcomes of the workshop 'Trends in national building ventilation markets and drivers for change', held in Ghent (Belgium) on March 18 and 19 2008. This workshop was an initiative of AIVC, organized by INIVE EEIG, in collaboration with REHVA and with the European SAVE-ASIEPI and SAVE Building Advent Projects. The workshop was supported by the EPBD Buildings Platform.