V entilation
I nformation
P aper
n° 21
May 2008

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Energy Conservation in Buildings
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Trends in the Norwegian building ventilation market and drivers for change

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1 Introduction

The Norwegian building ventilation market is strongly influenced by official regulations. Norwegian authorities decided in 2004 to implement EPBD as relevant to the EEA Agreement (European Economic Area). The responsibility for the implementation was given to two different ministries:

- Ministry of Local Government and Regional Development - calculation methods and minimum requirements
- Ministry of Petroleum and Energy - energy performance certificate and inspections

Energy use in buildings and ventilation is mainly regulated in Technical Regulations under the Planning and Building Act and The Work Environment Act.
The responsible bodies are:

- The National Office of Building Technology and Administration. Responsible for administering and interpreting national building regulations, and with the authority to administer a centralized system for the authorization of designers, constructors or controllers in the building industry.
- The Norwegian Labour Inspection Authority is a government agency under the Ministry of
- Labour and Social Inclusion, focused on occupational safety and health.

This is the current status for the implementation of EPBD:

- A method for calculation of the energy performance of buildings (EPBD Article 3) is implemented:
- *NS 3031:2007 - Calculation of energy performance of buildings - Method and data*
- Minimum energy performance requirements (EPBD Article 4-6) are implemented.
- *New energy requirements in Technical Regulations under the Planning and Building Act* (TEK). Principally, these requirements apply to all new buildings and to all existing buildings undergoing major renovation.
- No implementation is yet introduced regarding the energy performance certification of buildings or the regular inspection of boilers and air-conditioning system with accompanying requirements for experts and inspectors. In the autumn of 2007 The Ministry of Petroleum and Energy proposed some necessary changes to The Energy Act. A Report to the Storting (St.meld.) from the Government is expected in 2008, which is to be followed by a more detailed Technical Regulations. This certification and inspection system is expected to be implemented early next year

2 National trends in IAQ requirements and market characteristics

Minimum requirements for ventilation of buildings are given in TEK with guidelines and in The Working Environment Act with guidelines (no 444).

Requirements are given for residential and for none-residential buildings in the TEK.

The Work Environment Act only gives requirements for none-residential buildings.

2.1 Ventilation requirements for none-residential buildings

The basic principles for design of minimum ventilation requirements in noneresidential buildings (Commercial and public buildings) are the same in TEK and in 444. This method was introduced more than 10 years ago and is still fully accepted. There is one important difference, 444 recommends that a safety factor of 1,3 shall be used. The ventilation system shall be dimensioned with a minimum of the required flow rate multiplied byh 1,3. This will ensure the need for increased ventilation in new building and flexibility regarding future change in the use of the premises.
The necessary minimum air supply is to be determined by the number of occupants, the use of materials and the activities:

A) Due to number of occupants (normal 7-10 l/s, person).
B) Due to use of materials (normal 0,7-2 l /s pr. m² floor area)
C) Due to activities

The necessary air supply is to be determined by adding the values for A and B, and comparing it to the value of C. The largest value is to be chosen and used for the design of the ventilation plant.

2.2 Requirements on ventilation of residential buildings

The basic principle for calculation of minimum ventilation requirements in residential buildings was introduced more than 10 years ago and is still in force.

Residential buildings/dwellings shall have ventilation which ensures a proper indoor

climate for the occupants. The ventilation shall be adapted to the function of each room

To ensure acceptable indoor air quality, the rooms should have at least 0,5 air changes per hour even when the room or the dwelling is not in use.
The air flow shall be from rooms with higher requirements for air quality to those with lower requirements. Kitchens and sanitary rooms shall have minimum exhaust air flow as:

Room	Exhaust airflow (l/s)
Kitchen	10/30[1)]
Bath	15/30[2)]
WC	10
Washing/Drying[4)]	10/20[3)]

- Forced exhaust from cooker hood
- Forced exhaust from rooms without windows to open
- Forced exhaust from rooms without windows to open
- Drying tumbler without condenser must have separate exhaust. With several washing machines in one room, the given values are valid for each machine.

2.3 Observations

The minimum requirements on ventilation of buildings as mentioned above have not been changed due to the implementation of EPBD.

In practice most new buildings, residential as well as non-residential fulfill the minimum ventilation requirements. A big problem today is the malfunction of cooker-hoods, due to airflows being too small (30 l/s), “modern” hood design and “free” location.

In most new office buildings IAQ and thermal comfort requirements are quite high.

Due to high cooling loads , especially during the last ten years, local cooling systems with chilled beams or chilled ceilings are often installed.

It has been proven that these installations use a lot of energy, also to distribute the cold water. The revised TEK proposes to construct the building in order to avoid unnecessary cooling. Central cooling by the ventilation air is assumed to be enough, which means that ventilation systems might have to provide airflows higher than minimum ventilation requirements. In existing non-residential buildings built during the last ten years the minimum requirements for ventilation are normally fulfilled.

In existing residential buildings built during the last ten years, single family houses often fulfill the minimum requirements on ventilation demands. However a majority of flats are built with simple ventilation installations that do not fulfill the minimum ventilation requirements.

In older buildings it is quite common that minimum ventilation requirements are not fulfilled

2.4 Compliance system

The National Office of Building Technology and Administration administers a centralized system for the authorization of designers, constructors or controllers in the building industry.

According to the Planning and Building Act the municipality shall ensure that the necessary control is exercised.

The control may be exercised by means of documented self-inspections or by an independent enterprise.

The developer, the responsible applicant, the responsible designer, and the responsible contractor are obliged to provide information necessary for exercising control.

The responsible applicant shall ensure that a plan of control is made. There must be documentation to show that the control has been carried out as planned.

The municipality may in special cases engage professional assistance in order to have the necessary inspection carried out. Upon discovery of significant lack of control, the municipality may stop the project and insert another form of control. It is also possible to withdraw the approval for the body.

A revision of the Planning and Building Act in 2008 will include an even more stringent control system with an extensive use of independent control.

The revision has been deemed necessary due to the large extent of building faults. It is estimated that the costs due to faults are higher than the total profit in the sector, i.e. 5-10%.

The authorities have clearly stated that the fulfillment of energy demands will be given high control priority; thus, extensive use of independent control regarding energy matters is expected.

2.5 Industrialization

In Norway there is a steady but slow development towards a more industrialized building process including ventilation installments. There is less handicraft and more erection on a typical Norwegian building site.

The most common type of contracts for non-residential buildings and apartment buildings are “General contract” with one contract covering the whole building process including design and construction works. One-family-houses are mostly built as standard houses, with all basic information in a design catalogue.

Ventilation installations are to a steady growing degree based on intelligent products, “plug and play”. There is also a clear trend that traditional ventilation contractors expand their business to become mechanical contractors and offers design, installation and maintenance services for technical installations and building automation.

2.6 Market

The total market for new non-residential buildings in Norway has grown during the last 10 years from 2.500.000 m^2 up to 3.500.000 m^2. During this period there has also been a remarkable increase in standards with regard to energy efficiency of the installed ventilation systems. Market value for ventilation installations (end value) are now estimated to approx. 350.000.000 €.

The total market for new residential buildings in Norway has grown from 20-25.000 units up to 30-35.000 units during the last 10 years. To day approx. 50% of the built units are flats. During this time there has also been a remarkable increase in the standard of the installed ventilation systems, though flats often have a low standard on installation.

Professional mechanical contractors are now showing a growing interest in the residential building market. Market value for ventilation installations (end value) is now estimated to approx. 120.000.000 €.

In addition, the market for service activities are now estimated to approx. 120.000.000 €.

A general problem in Norway (as in most other countries?) is that the market for renovation and maintenance (smaller activities that do not need permission) has increasingly become a market for "black" craftsmanship.

3 National trends in energy requirements and markets

3.1 Climate change

In 2007 there was a dramatic change in public acceptance of changes in climate and their effects. The Norwegian Nobel Committee decided that the Nobel Peace Prize for 2007 was to be shared between the Intergovernmental Panel on Climate Change (IPCC) and Al Gore Jr. for their work regarding manmade climate change. IPPC states that:

- Energy efficiency options for new and existing buildings could considerably reduce CO_2 emissions with net economic benefit. Many barriers exist against tapping this potential, but there are also large co-benefits (high agreement, much evidence).
- By 2030, about 30% of the projected GHG emissions in the building sector can be avoided with net economic benefit
- Energy efficient buildings, while limiting the growth of CO2 emissions, can also **improve indoor** and outdoor **air quality**, improve social welfare and enhance energy security
- Opportunities for realising GHG reductions in the building sector exist worldwide. However, multiple barriers make it difficult to realise this potential. These barriers include availability of technology, financing, poverty, higher costs of reliable information, limitations inherent in building designs and an appropriate portfolio of policies and programs
- The magnitude of the above barriers is higher in the developing countries and this makes it more difficult for them to achieve the GHG reduction potential of the building sector.

The new energy requirements under implementation (basically the implementation of the EPBD) are in accordance with the statements of the ICCP. It is expected that the political interest and pressure for GHG reductions will be large and lasting. As a consequence there is also expected to be a growing political interest on increasing energy efficiency in buildings

This is expected to cause major changes in the building sector, and to create large market opportunities for Mechanical Contractors and Technical Installations in buildings (including ventilation installations).

3.2 Energy requirements

The minimum Energy Performance of a building is fulfilled by

- Satisfying demands to specific solutions under letter a)
- Satisfying demands to total net energy demand under letter b)
- Satisfying absolute minimum demands under letter c)

a) Specific energy measures
Specific energy measures must fulfill the following demands:

- Total glaze, window, and door area less than 20% of heated area (BRA)
- U-value exterior walls: 0,18 W/m^2 K.
- U-value roof: 0,13 W/m^2 K
- U-value floor on ground or against outdoor air: 0,15 W/m^2 K.
- U-value glaze/ windows/doors: 1,2 W/m^2 K average incl. frame

- Normalized thermal bridges, less than 0,03 W/m^2 K for small houses and 0,06 W/m^2 K for other buildings.
- Building air tightness: 1,5 air changes pr. hour at 50 Pa pressure difference.
- For small houses: 2,5
- Heat recovery in ventilation plants, average temperature efficiency over a year: 70%.
- Specific Fan Power in ventilation plants (SFP)
- None residential buildings: 2/1 kW/m^3 s (occupied/not occupied)
- Residential buildings 2,5 kW/m^3 s (day and night)
- Automatic outdoor sun shading equipment or other solutions to fulfil demands for thermal comfort without use of local cooling.
- Automatic reduced room temperature during nights and weekends
- It is allowable to make technical changes regarding one or several of the above listed specific energy measures, if compensated with other measures on the list in such a way that the total energy demand for the building is not increased.

b) Total net energy demand
Total net energy demand for buildings should not exceed:
Calculation of Total net energy demand should be based on given and standardized values for user dependent data, and average metrological data for Norway.

Building categories	Net energy demand kWh/m^2 heated area and year
Single-family houses of different types	125 + 1600/heated area
Apartment blocks	120
Day-care centre	150
Office buildings	165
Schools	135
Universities/Colleges	180
Hospitals	325
Nursing homes	235
Hotels	240
Sport facilities	185
Shopping centers	235
Art/science buildings	180
Light industry, workshops	185

Calculation of Total net energy demand should be based on given and standardized values for user dependent data, and average metrological data for Norway.	Single family houses	Apartment blocks	Day-care centre	Office buildings	Schools	Universities /colleges	Hospitals	Nursing homes	Hotels	Sport facilities	Shopping senters	Cultural buildings	Light industry/ workshop
Room heating	51	30	67	33	39	33	57	49	61	48	45	65	67
Heating ventilation air	6	7	26	21	27	24	42	38	29	40	34	26	25
Water heating	30	30	10	5	10	5	30	30	30	50	10	10	10
Fans and pumps	8	10	23	22	25	27	54	48	35	23	42	24	21
Lighting	17	17	21	25	22	25	47	47	47	21	56	23	19
Tech. equipment	23	23	5	34	13	34	47	23	6	3	4	3	23
Local cooling	0	0	0	0	0	0	0	0	0	0	0	0	0
Cooling battery	0	0	0	24	0	30	50	0	31	0	47	26	21
Total net energy demand	136	118	152	165	137	179	327	234	239	185	237	178	186
Rounded energy scope	125+	120	150	165	135	180	325	235	240	185	235	180	185

3.3 Energy for ventilation

According to TEK guidelines (table 3), ventilation (incl. optional cooling) represents 10-15% of the energy budget for residential buildings, and 30-50% for none-residential buildings. Specific energy measures regarding ventilation as given in TEK are foreseen.

Energy demand for water heating, lighting and technical equipment is considered as user dependent data and should be calculated with given standardised values.

A stated political intention regarding the new energy requirements is to have buildings with less uncontrolled air leakages, but with a good indoor climate. This means that ventilation with heat recovery will be mandatory.

3.4 Innovation

Norwegian authorities have decided to increase the demands for energy efficiency of buildings at least every 5 years. To be able to reduce the energy demand of the different building categories, requirements for even more energy efficient ventilation plants must be expected.

The innovative development in the Norwegian ventilation industry is now focused on delivering good IAQ with a low energy demand and small emissions of GHG. In practice this means:

- Low SFP-values by efficient products, proper duct design and construction as well as good balancing and commissioning
- High efficient heat recovery including defrosting
- Airflow design based on scientific IAQ criteria, controlled by actual demand

The present requirements and guidelines regarding IAQ and ventilation airflows seems to be based on "good engineering practice" more than scientific documentation. Consequently, it is important that HVAC designers make a more qualified evaluation than only using the minimum outdoor air flow rates in the building codes or working

environment legislation. Reviews of regulations and standards indicate that these conclusions may be valid worldwide.
A harmonisation of the methods in regulations and standards seems to be needed.

3.5 Challenges and knowledge

The new energy demands already in place in Norway has resulted in a reduction in total energy demand for buildings by approx. 30%. Since user dependent energy demand should be calculated with given standardised values, the actual reduction is estimated to be 50-60%.

This is a tremendous challenge for the building sector as "everything" must be improved. Design, standard details and products, documentation, production methods, quality control etc…

To meet the future challenges and improve the competence level in the sector, the building industry has established an innovative program, the "Low-energy program", in cooperation with architects and authorities. The program's strategy is to reduce the total energy consumption and increase the share of renewable energy in the building sector.
The strategy includes:

- Development of knowledge and competence for everyone employed in the sector, in total approx. 300.000 persons.
- Systematic implementation of knowledge in industry and education institutions
- Development and implementation of new technology
- Development of improved products

During the next ten years the Norwegian building industry should develop the most energy efficient buildings with the best IAQ in Europe.

3.6 Financial stimuli

Enova is a public enterprise owned by the Royal Norwegian Ministry of Petroleum and Energy. Its main mission is to contribute to environmentally sound energy, along with the rational use and production of energy. Improved energy efficiency, more flexible energy supply and decreased dependence on direct electricity for heating, and an increased share of renewable energy sources, other than large hydropower, in the energy supply mix are key features of Norwegian energy policy.

Enova focuses its efforts on both the energy supply and energy requirements.

Enova has recently entered into two contracts with large Mechanical Contractors regarding implementation of energy efficient applications in new and existing buildings

4 National trends in air tightness requirements and markets

Requirements of building air tightness are given in TEK *Specific energy measures*. This is one of several tremendous challenges for the building sector.

It has been proven that it is possible to fulfill the requirements for air tightness, however, this requires attention to details and also practice on the building site.

The Norwegian Ventilation industry has already developed simplified methods and equipment to measure and document building air tightness. The price for this equipment is approx. 1000 €, allowing everyone to perform control measurements at the most convenient time in the building process.

Duct air tightness has for many years been required in Norway, according to Norwegian Standards. A low SFP-factor can only be achieved with a low duct leakage.

5 Conclusions

IAQ and ventilation is given rather high attention in the Norwegian building industry.
The new energy demands, basically an implementation of the EPBD, are a major driver for change. In practice it makes modern energy efficient ventilation compulsory in all types of buildings, which was not the case up to now.

6 References

1. Technical Regulations under the Planning and Building Act 1997
2. New energy demands in Technical Regulations from 2007
3. The working environment act of 2007
4. Guideline 444 Indoor climate and air quality on working places NS 3031 Calculation of energy performance of buildings - Method and data
5. Rationale for IAQ regulations in Scandinavia, similarities and differences;J Halvarsson, SO Hanssen and HM Mathisen.

7 Acknowledgments

This Information Paper has been written in the framework of the Norwegian participation to the AIVC. It was been presented during the international workshop "Trends in national building ventilation markets and drivers for change" held in Ghent (Belgium) on 18-19/03/2008.

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.


The Air Infiltration and Ventilation Centre was inaugurated through the International Energy Agency and is funded by the following countries: Belgium, Czech Republic, Denmark, France, Greece, Japan, Republic of Korea, Netherlands, Norway and United States of America.

The Air Infiltration and Ventilation Centre provides technical support in air infiltration and ventilation research and application. The aim is to promote the understanding of the complex behaviour of the air flow in buildings and to advance the effective application of associated energy saving measures in the design of new buildings and the improvement of the existing building stock