Nordic approaches to improve and validate indoor air systems

Even more focus must be put on well functioning and low energy consumption of Indoor Climate installations, if we are to meet the existing and coming demands for ensuring both control of healthy indoor climates and low energy consumption.

Ventilation Technology for such demands to Indoor air quality is already on the market.

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Installations of indoor air systems – or indoor air installations – have severe cost impact in buildings, and have in most cases been thoroughly designed before any installation works are initiated at the building site.

Everything should be easy to accomplish: Buy the specified components and units, ensure that everything is CE marked as demanded, put the stuff together according to the design engineer's specification. Then, plug in, push the green button and enjoy an excellent indoor air climate. PERFECT.

WHY is this logic not the normal outcome?

Those who are involved in building processes have the knowledge of constraints and bottlenecks which must be solved during the construction. Cost implications are usually the battlefield for construction and civil engineering companies. Hence, successful companies are those that have learned how to better cut costs during the construction phase.

BUT is this a law of nature? Must it stay this way?

We don't accept it to continue in this manner!!!

The above mentioned nature of construction companies, subcontractors and sub-subcontractors, has improved significantly over the last decades, and the cost structure has dramatically changed. The economic power, that used to be placed at the construction companies' internal "civil engineering processes", are now distributed into several building blocks – for the complete construction program.

The major change has been the cost of the technical package installed in new buildings or during general renovation.

Indoor air systems play a significant role in this change of allocated building costs, and furthermore it has become the major portion in the running costs of the building during use.

Changing of paradigm

Indoor air systems have their natural structure, and one of the rules is that final adjustments and inspection of functionalities cannot be made before the building is nearly finished. The difficulties of running the indoor air installations in conjunction with heating, lighting and office equipment limit the possibilities for functional tests during construction. And partial approvals of installed systems are not an option.

Indoor air systems must be proven functional and operational when the systems and the building are in the stage of nearly being handed over to the owner or the tenants. This challenge has been addressed in many manners throughout the different building traditions in the various nations.

In the Nordic countries, we began using the quality control way, as it seems logically easy to ensure that the new European quality control systems would be functional enough to guarantee the aimed assurance of well installed and well functional indoor air systems, which would meet the aimed energy consumption, in general.

It works well in some building programs, but unfortunately not in several others. That's not good enough!!

New Methodologies are needed

The traditional systems using partial approvals and sectional acceptance are not suited for indoor air systems installed during the construction process.

It is also unlikely that several other technical systems shall always achieve their targeted functions by using this traditional methodology, that has its historical background in economic reasons that require partial payments. Such partial payments are due to be paid at specifically agreed milestones in the building program. The mechanism is ok for that purpose, of making partial payments, and it must be kept, as it works well for that purpose.

However, and as mentioned earlier, is it necessary to introduce tests that ensure that technical installations work properly in such a manner that they simulate the complete building.

Over the recent years, the term "Commissioning" has been used for such inspections and tests of technical installations. It is especially clear to everyone that indoor air systems can only be properly inspected and tested when the building construction is completed, and other installations are installed and working as well. Secondly, the influences from other installations must be carefully specified, as to ensure correct stipulation of effects, for the on-site measurements or the theoretical technical calculations.

The clever methodology of Commissioning is, in other words, inspection of installed systems, and spot checks of randomly sampled rooms and sections throughout the building - in other words, measuring the indoor air systems production of airflow, directions and energies in the air and for the transportation of that energy. The impact of the indoor air systems and the other heating and or cooling installations and the impact from windows, as to facilitate correct energy calculations - which can be scaled up for the entire building.

Using such a methodology proves to tenants and building owners that installed systems are working properly, and it verifies that energy calculations are met at satisfactory levels. Running costs has been part of the financial motivation for investing in the specific building, and they will be an everlasting bill to carry as long as the building is used. Additionally, such a methodology will clearly ensure the contractor that his component deliveries and installation work is correct. This is a new behavior, but it is at the same time also a win-win situation.

Figure 1 shows how much the energy use to run indoor climate systems varies in the European cities.

It is logic that control of indoor air flow and energy put into the air for heating and comfort is a valuable factor to be in control of, from the first day such systems are put into operation. That is a major responsibility we have at our desks.

How is it possible???

SWEDEN has been the first national market to implement a legal requirement on functional checks of the ventilation systems. Since 1991, the so called OVK (compulsory ventilation check) regulation forces the owner of a building to ensure that the ventilation system works as intended. These OVK checks must be made before the buildings are taken in daily use, and thereafter at repeated fixed intervals. The regulation states that the OVK checks must be undertaken by an officially authorized inspector – an "*OVK-besiktningsman*".

The "*Besiktningsmannen*" inspects the installations and approve it, ensuring that the legal demands are fulfilled and that the mechanical system functions are as intended. Such inspections must be undertaken when a tenant is replaced or the ownership of buildings is changed.

DENMARK is well on its way of implementing a new standard for Commissioning. It is as well an extension

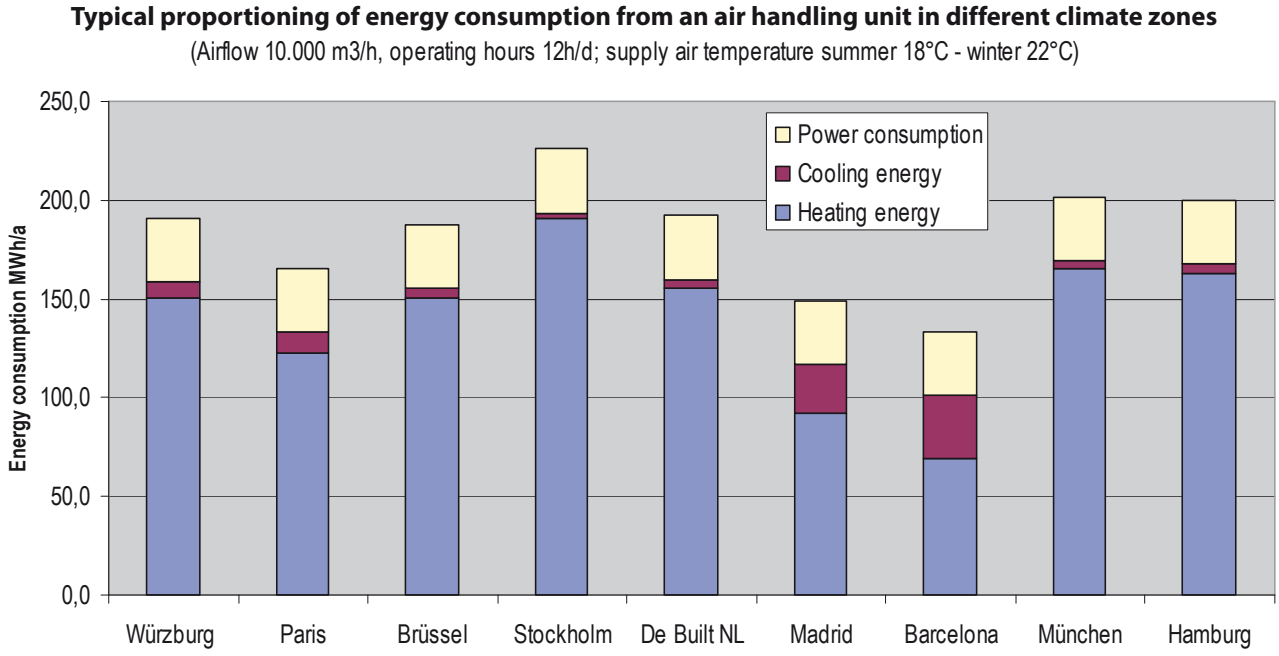

Figure 1. Example of typical energy transported through air handling units in different climates in Europe.

to the revision of the **DS447 Standard for Building Ventilation.** That revision highlighted the necessity to establish a new methodology, to ensure that the higher demands for indoor air installations are obeyed, so that heating and lighting energy improvements can be shown to be working at the end of a building process. The necessity to prove **the energy frame** is met – it is the way to ensure the demanded low energy consumption onwards, and to hold energy expenses at budgeted levels. DS447 Specifies demands for mechanical, natural and hybrid ventilation systems.

DS447 is an integrated part in the building Code.

The Energy Frame is the legal demanded level which must be met in a planned building program, and is specified by law. It is clearly expressed in the Building Regulations. The Energy Frame sets limits for energy supplied for heating, ventilation, cooling, hot water supplies and lighting. That gives for instance 52.5 kWh per m² per annum plus 1 650 kWh as a unified addition per flat.

It seems logic that such low energy levels per m² need detailed inspections of the Climate shell and the technical installations independent of each other. The inspections are only possible and/or natural in different time capsules in the building program, and demand further developments, as to be detailed enough in how new materials, building processes and completion works coincide.

It will be an issue in that process of making the new Danish Commissioning Standard to specify that, and how user behavior must be handled, and how user behavior must be linked to the commissioning report.

NORWAY has minimum requirements for **environment and health**, including indoor environment and ventilation of buildings, given in following codes:

- Technical Regulations under the Planning and Building Act added with guidelines
- The Working Environment Act with guidelines.

Demands concerning material emissions are included.

Minimum **energy performance** requirements are given in separate codes, as TEK § 14.

The minimum Energy Performance of a building is fulfilled by:

- Satisfying demands to specific solutions or
- Satisfying demands to total net energy demand (Energy frame)

A method for calculation of the energy performance of buildings is an integrated part in TEK: recommendation, NS 3031:2007+A1:2011 – Calculation of energy performance of buildings –Method and Data [1]

According to this method (with the given normative input), ventilation (incl. optional cooling) stands for 10-15% of the energy budget (net energy demand) for residential buildings, and 30–50% for non-residential

buildings. Specific energy measures regarding ventilation as given in TEK are foreseen, i.e.:

- Heat recovery in ventilation plants, average temperature efficiency over a year: 80%/70%.
- Specific Fan Power in ventilation plants (SFP) :
  - □ None residential buildings: 2/1 kW/m³ s (occupied/not occupied)
  - □ Residential buildings 2,5 kW/m³ s (day and night)

It is practically mandatory to install balanced ventilation with high efficiency heat recovery.

Air tightness in new buildings of 1,5 air changes per hour at 50 Pa pressure difference (small houses 2,5).

NS 3700:2010 Criteria for passive houses and low energy houses - Residential buildings [2] and

prNS3701 Criteria for passive houses and low energy houses – Non Residential buildings [3] (in force spring 2012) indicates the level of future minimum demands in building codes.

The Norwegian Energy Certification System (ECS) [4] demands an energy certificate to be acquired for all new buildings and all buildings being sold or rented. Energy inspection of technical installations including ventilation is (with limitations in accordance with the EPBD) is required to be carried out every 4th year, with the first time within two years after handing over. The Energy inspection is a first step to minimum requirements for commissioning of technical installations.

The Norwegian Building Authority has developed a guideline [5] to perform an independent building control. New regulations regarding independent building control will enter in to force 1.7.2012.

Some examples of control items:

- Airtightness
- Energy performance
- Ventilation

In preparation for entering the new regulation regarding independent building control, prNS 8450 – Control of design and building of construction works, was launched. The document was however not accepted.

There is now a discussion on the need for development of supplementary information to the Norwegian Building Authority guidelines.

FINLAND has since 1995 an Indoor Air Classification into three classes, S1, S2 and S3, as target levels for the various uses of indoor spaces. This classification gives a possibility to define and specify higher target values than just the minimum level regulated since 1987 in part D2 of the National Building Code of Finland, which also sets some minimum requirements for ventilation system commissioning, such as an obligation to check the air tightness of ductwork and to measure supply and extract air flows, both for the whole building and for individual rooms. Revision of the Classification as well as revisions of the Finnish Building Code in 2008 and 2012 strengthened the demands of air tightness as to limit the energy used for indoor climates.

It is practically mandatory to install heat recovery in ventilation, and demands concerning material emissions are included in good indoor air design practice.

It is also to a wider extent demanded to prove air tightness in new buildings and to prove functionality of indoor air installations also in real practice.

Inspections aren't yet on the level as a commissioning will be, but improvements are been made via training of supervisors and inspectors.

The aim is to close the gaps mentioned in this article.

The gains

The aim is to establish a workable win – win environment for everyone in building programs, in a controlled way, and transparent in the working process in erecting buildings as this is works now. The new method should include the technical systems because they are, in most cases, responsible for the major share of the building initial budget, and they will cost even more during the use of the buildings during their lifetime.

Energy losses are significant in too many indoor air systems, and the ECO design initiative has only impact on the components used in the Indoor climate systems. This statement simply means that ECOdesign establishes rules for products which a manufacturer can be taken to court for if it doesn't perform as demanded in the ECO design regulative.

The EPBD sets, from the building point of view, rules for how the components in the market must be built into systems that will ensure the low energy consumption target specified for the individual building and in accordance to national and European legal demands.

We have the possibility to be frontrunners in well doing. When the good practice is one step ahead of the legal system, then this good practice can become the legal minimum, and make it possible for the legal system to understand the complexity in indoor climate systems combinations through proven experiences, meeting BAT (Best Available Technology) theories without being able to have all details controlled and steered every second. We, who have dealt with these issues in this area for a lifetime, have realized that.

In addition, numerous institutes and scientists have analyzed and evaluated which parameters need to be governed and controlled thoroughly. Both are dedicated to achieve good Indoor Air Quality, and to do it at the lowest energy use as possible.

Example: Duct air leakages

It is a common knowledge that air leakages in ducts and ductworks, in too many ventilation systems, cause severe loss of energy. It is not only loss of air, planned to be inflated in specific building sections or rooms, it is as well the energy put into that air – as for instance heating or cooling energies. The EU made an analysis, and the Fraunhofer Institute in Frankfurt took the complete analyzes to a higher level with a detailed analytic calculation. That calculation defines the loss, or waste of energy, due to simple leakage, if the average simple ductworks, which is the normality in the most systems installed during the latest 30 years, is installed. If such systems were only one class higher in tightness as to the Class B level, the savings potential are at least 15%.

- Using the energy consumption for air transport in Europe, which is statistically defined to be around 197 000 GWh/a
- 15% of that – equates to 29 550 GWh/a
- The equivalent amount of CO_2 gives (660 grams/kWh) a total of 17 730 000 ton per annum.

That analysis gives a scale of the importance of why it is necessary to use new methods in inspections and control of such systems during their lifetime, but the EC, in the recast of the EPBD, didn't introduce a requirement for the outcome of such findings to be implemented, i.e., that severe malfunctions or energy losses should they be corrected properly, within a limited period of time. It seems that the politicians didn't have the courage to demand that energy savings that have been detected throughout Europe should always be implemented.

It is sad that the indoor climate industry has been so neglected in the overall political arena, when it is a statistical evidence, from all formal statistical annual analyses, that energy used in buildings is approximately 40% of all energy used, compared to transport, that counts for 28% of the energy used. The society and politicians pay attention to the 28% and don't find means or aims in how the larger portion, the 40% consumed in buildings, can be reduced. The components are on the market and in the warehouses, but legal actions – similar to what is normal for transport – cannot be highlighted in the political agenda.

Tight buildings reduce energy losses, but require controlled ventilation and heating installations as to secure proper indoor air quality for users. We need to adjust accordingly to reach that, via intelligent new methods in the manner and systems we will be using in the future.

And the indoor climate industry must join forces in the marketplace and the political arena to convey the knowledge we have to the decision makers.

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