INTERNATIONAL ENERGY AGENCY
Energy conservation in buildings and community systems programme

26th AIVC Conference

Ventilation in Relation to the Energy Performance of Buildings

Conference Report

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1 Introduction

The 26th AIVC Annual Conference took place in Belgium at the Hotel Husa President Park, located in Brussels. Some 250 participants from 27 different countries attended the conference, which spanned three days and consisted of more than 100 paper and poster presentations. It focused on ventilation in relation to the energy performance of buildings.

With the exception of the opening and closing session, there were the whole time 2 parallel tracks. The first track of the conference dealt with typical ventilation topics whereby 2 sessions focused on whole heat, air and moisture transfer in buildings. The second track focused on the topic of energy performance regulations in buildings and in particular the implementation of the European Energy Performance of Buildings Directive (EPBD).

Summaries of the different sessions of the conference may be found below.

2 R&D on Ventilation

W. de Gids

The conference offered a lot of interesting papers and posters varying from airtightness of building to development of innovative ventilation systems. Energy was in almost all papers and posters the leading item.

The sessions were devoted to the following topics:

- Airtightness
- Energy performance
- Measurements / Diagnostic
- Modeling
- Strategies
- Ventilation systems

On the topic airtightness and energy performance there were papers and posters from the USA, Germany and France. One of the results of the USA study on commercial buildings showed clearly the impact of infiltration due to air leakage of buildings of about 20% of the energy use by buildings. A study from France showed that airtightness of dwellings counts for about 25% of the energy use. So after two decades of research, airtightness is still an important phenomenon. A number of measurements of airtightness on French dwellings were presented, showing a relation between the airtightness level itself and the flow exponent (Figure 1).

The paper on air tightness of ductwork form the USA made it quite clear that on this aspect a lot of progress can be made in the USA compared to Europe (Figure 2).

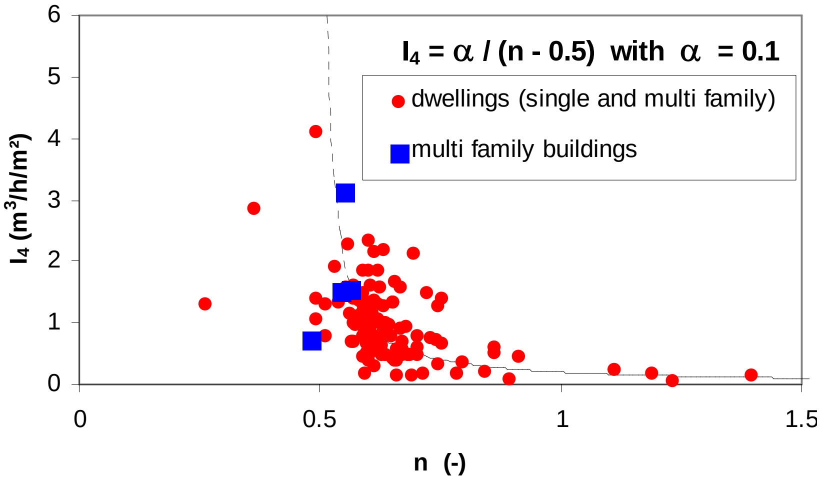

Figure 1: Relation between the flow exponent value and the infiltration rate. The dotted line represents the hyperbolic fit (Litvak et al., 2005)

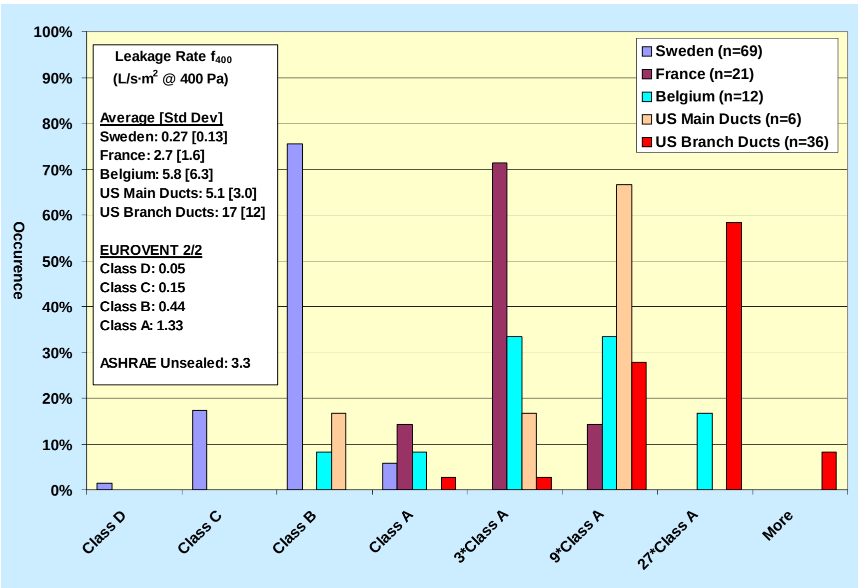

Figure 2: Duct pressurization results (Wray et al., 2005)

Measurement techniques on air tightness had also some attention by Germany and France. Advanced and simpler techniques were demonstrated. The simple technique used the existing exhaust system to quantify in a rough way the air tightness of dwellings. A number of diagnostic methods were presented.

Studies on schools were related to energy performance and indoor air quality and comfort. Overheating and bad IAQ was reported from schools in Greece.

Modeling is a topic that is presented in almost all AIVC conferences. There was less attention to CFD modeling during this conference compared to earlier conferences. Some examples of full scale physical modeling were presented. The focus in modeling was on combined heat and airflow modeling. Papers presented from studies in USA and Belgium showed the combines application of these models.

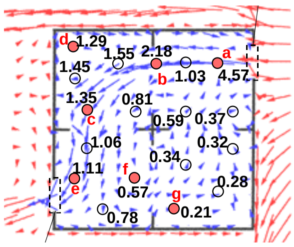

Figure 3: Illustration of modelling results (Nishizawa et al., 2005)

Most of the modeling studies paid attention on probabilistic approach in modeling in relation to comfort (Belgium) for the prediction of windspeed in canyons (Greece) and for the evaluation of the performance of ventilation systems. (Sweden) An old discussion came along about the relation between windspeed and terrain roughness. The application field of the power law of logarithmic law was discussed because of the use of it in a Portuguese study.

A number studies on innovative ventilation systems were presented. From hybrid systems in livestock buildings (Denmark) and in dwellings (Japan and Greece) to humidity controlled ventilation of dwellings. (France). Night cooling strategies (Belgium) and pre-cooling and pre-heating through ground coupled heat exchangers also got some attention. Even the results of the application of full natural ventilation systems in dwellings in China were presented.

The trends observed during the conference are the following:

- More natural/passive and hybrid ventilation systems including
  - pre heating / night ventilation / demand control
  - mostly for research purposes
- More emphasis on IAQ and health than on energy
- Infiltration still needs attention in relation to energy
- Special attention on IAQ and comfort in schools
- Ventilation IAQ/comfort studies carried with combined modelling
- Probabilistic modelling is popular under researchers (but when and how to use it for industry to assess correctly innovative ventilation systems?)

2.1 Whole building heat, air and moisture transfer (Annex 41)

H. Hens

Divided over two sessions, eight papers were presented. In a first paper the annex history, topic, objectives, subtasks and intended products were presented. A second paper highlighted subtask 1 on the basics and modeling principles in more detail, with a summary of the common exercise 0 and 1 results gained so far. These exercises learned that modeling moisture buffering is not as easy as could be assumed, the main reason being the large inertia linked to moisture movement and storage. As a consequence, only thin surface layer participate actively in the moisture exchange with the interior environment. The third paper focused on measuring the moisture buffering capacity of different materials. Main questions to be answered are how and what combined property can be seen as a usable material characterization. Paper four discussed a typical whole building application: what effects has attic ventilation in a cool climate when the ceiling below is extremely well insulated but not necessarily air-tight. The conclusions underline that in terms of moisture tolerance, air-tightness of the ceiling is more important than ventilating the attic.

The fifth paper documented experimental work on moisture buffering in a small test room under well controlled conditions. Paper six discussed modeling results, looking to the effect of simplified buffering models on predicted relative humidity indoors. Quite important in thermally transient conditions was the fact if the simplified model accounted for the thermal effect on buffering or not. The calculations also showed that buffering helps in diminishing energy consumption for latent heat effects, but has no impact on the power needed to handle latent heat effects. Finally, paper seven and eight again looked to application. Questions tackled were the energy performance of a ventilation system controlled by the relative humidity in the rooms and the indoor climate design for a monumental building with a new function and periodically high moisture loads. The conclusions were quite interesting. A relative humidity controlled ventilation system has hardly any impact on energy consumption but performs quite well in reducing the relative humidity peaks indoors. In the monumental building, however, buffering only, without a correctly designed HVAC-system, could not guarantee a good indoor climate.

Main conclusion was that, although we just started with the annex 18 months ago, some interesting results already came out, proving the just in time necessity of expanding the heat, air moisture approach to the whole building level.

3 Energy Performance of Buildings

3.1 EP standards and calculation procedures

J.-R. Millet

Jaap Hogeling gave an overview of implementation of the CEN mandate. He pointed out the reasons and interest of them. Standards will increase the accessibility, transparency and objectivity of the energy performance assessment. The use of CEN standards for calculating energy performance, including energy performance certification and the inspection of boilers and air-conditioning systems will also reduce costs compared to developing and maintaining separate standards at national level. Nevertheless, Standards should be flexible enough to allow for necessary national and regional differentiation.

The final results will be:

1. a clear method for determining the overall energy performance of new and existing buildings, using standard performance calculation methods for building products, buildings, installations and systems, including heating, cooling, ventilation, infiltration and lighting.
2. Methods of assessment suitable to certify buildings including their installations.
3. General guidelines for the inspection of boilers, heating systems and air-conditioning systems required by Article 8 and 9.

Hans Erhorn made a point on Status of work in EPBD CA (Concerted Action) regarding procedures. Intended use of CEN differs quite a lot between the Member States: some countries will use at least some parts of the standards, but not the whole standard. A comment arises that detail of input is too high for practical use, especially in existing buildings.

One important question is how much simplifications are acceptable/needed? Some requests have to be taken into account as simplifications for building geometry, default values for constructions and service systems, comparable procedures for residential and non-residential buildings

Dick Van Dijk presented the calculation procedures, focus of standards prEN15203 and prEN-ISO13790 “Calculation of energy use for space heating and cooling “ He distinguished different levels in the calculation : energy performance certificate and ways to express the energy performance , calculation of overall energy use in buildings, calculation of delivered energy, calculation of net energy for heating and cooling

The important requirements to calculation methods, in the context of building regulations are: transparency (in particular in case of minimum energy requirements), robustness, reproducibility, affordability, and efficiency. Fully described simple methods appear to be a good answer to these points in this context.

Jean-Robert Millet presented the Ventilation related aspects in the CEN calculation procedures with focus on prEN 15241 & 15242. The first one "Calculation methods for the determination of air flow rates in buildings including infiltration (prEN 15242)" is devoted to the calculation on the ventilation flows in a building (e.g.) between rooms and with the outside. The second one "Calculation methods for energy losses due to ventilation and infiltration in commercial buildings" (prEN 15241) is devoted to the energy impact of the ventilation system. The relationship with the other standards depends on the applications: design and dimensioning standard, airflow and energy due to ventilation standards, overall energy and summer comfort standards.

Jaap Hogeling made the **Johan Zirngibl** presentation on the treatment of heating systems in the CEN/EPBD standards worked out by CEN TC 228/WG4. He distinguished between overall energy use, primary energy and CO_2 emissions, annual performance of the different heating technologies, economic calculations for RES, inspection/maintenance of heating systems and boilers. One particular point was on the final expression of results either on primary energy (using primary energy factor or primary resource energy factor) and CO_2 emission factors: marginal CO_2 emission factor (takes into account the reduction of energy consumption) and end use CO_2 emission factor (average emission factor for a complete year by specifying the uses).

3.2 *Inspection and commissioning of technical installations*

Not yet available

3.3 Existing buildings: Calculation procedures - certification, labeling

Aleksander Panek

The session “**Calculation procedures - certification, labeling”** coordinated with the help of the EIE-SAVE project ENPER-EXIST (Applying the EPBD to improve the Energy Performance Requirements to Existing Buildings) attracted 85 people from various European countries.

The analysis provided in the original proposal of Directive on energy performance of buildings [COM (2001) 226 final, 11.5.2001] prepared by the EC indicated the global potential of about 22 per cent reduction of present consumption that can be realised by 2010 by economically feasible investment. The consumption was estimated for heating, hot water, air conditioning and lighting and it should be remembered that it accounted only EU-15 and not EU-25. Different researches and studies prepared nationally are reporting at least similar potential at New Member States. Moreover, the achievement of energy standard same as for the newly constructed building by existing one after modernisation is considered to be difficult. Some other issues as e.g. data collection, accuracy of assessment, adaptation of calculation methodologies, data bases and verification protocols have been discussed.
The saving potential and mentioned difficulties are showing importance of existing building stock in EPBD implementation. The objective of the session was to present areas of interest of ENPER project itself, and the interaction with other ongoing SAVE supported projects, to finally confront their scope with a scope of one of the main topics of Concerted Action the Certification of Buildings where the official statements of 21 Member States are discussed.
The table below shows the coverage of the issues of concern by the fore mentioned SAVE project that have been presented on a session.

Additionally to these, the RESNET assessment network operating in US for many years has been presented by the US Raters and collaboration on future development offered.

The general conclusion of the session could be expressed as follows:
Existing buildings did not attract adequate recognition within the national and CEN procedures as their potential impact on energy conservation. Therefore there is a need for intensive co-operation in the subject.

Issues of Concern	Con Action	Enper exist	EPA NR	EP Label	Best cert	Resnett	Budi	Stable	Impact
Certification acceptance									
Information campaigns									
Certifiers selection and training									
Certifiers accreditation									
Pilot tests on real buildings									
Building assessment method			AR*	OR*	AR*	AR*			
Software tools			D**	D**	Use	Use			
Certification organisation and impact									
Knowledge of building stock									

*AR – asset rating, OP- operational rating; **D- under development (light color indicates indirect address of the issue).

3.4 Indoor climate considerations and the EPBD

Olli Seppänen

Easy way to reduce energy consumption is to reduce indoor environmental quality. This is what happened after the first energy crisis in 70´s and sick building syndrome and other indoor problems were created. This is what has to be avoided by integrating IAQ in the implementation of energy performance directive.

Indoor environment is not only the comfort issue as it also affects performance and health (Seppänen 2005)

1. High and low indoor temperature reduces performance
2. Low ventilation rates increase short term sick leave caused
3. Good ventilation improves the productivity or low ventilation rates decrease performance
4. Poor air quality in general reduces performance

Alternate approaches how to handle the overheating risk in energy performance calculations
(Dick van Dijk 2005)

1. Ignore comfort level,
2. Fixed comfort level,
3. Allow higher kWh/m^2 if with better IAQ (neutralise comfort level)
4. Require for lower kWh/m^2 with bad IAQ (penalty for bad comfort)
5. Prescriptive requirement

A NEW EUROPEAN STANDARD draft standard prEN 15251 (Olesen 2005)

Standard sets the requirement which parameters have to be specified and gives examples of numeric values in three categories for:
- sizing the equipment (fixed value)
- energy calculations (range of temperature)
- evaluation of indoor environment and long term indicators
- inspections and measurements in existing buildings
- classification and certification criteria of indoor environment

Indoor environmental factors in the standard
- Thermal environment – temperature (air and operative temperature)
- Ventilation rates
- Air quality (only CO_2)
- Draft (air velocity for winter and summer)
- Noise level
- Humidity (only for specific cases, do not humidify or dehumidify too much)
- Lighting

Indoor temperature should depend on the running outdoor temperature (Nicol 2005)

Conclusions:

- Indoor climate affects, not only comfort but also, performance, health and productivity
- Energy performance is not improved if indoor air climate is getting worse due to energy saving measures
- It does not make any sense to declare energy consumption if indoor environment is not specified at the same time
- Information on indoor air quality has to be included in energy certificates and other performance criteria of buildings
- Fortunately, technologies exist for simultaneous improvement of energy efficiency and indoor environment (Keep cool Leutgöb 2005 and many others)

3.5 Very low energy new and existing buildings

Viktor Dorer

The demand of new and existing very low energy buildings is much lower than the required demands for ordinary new buildings based on the EPBD procedure. However these buildings represent the technology which is expected to become a commonly required standard under future revisions of the EPBD energy codes. The presentations summarized below are to be seen in this context with the EPBD.

H. Erhorn presented the successful introduction of low energy houses in Germany, starting with the solar architecture buildings, designed for maximum solar gain or for minimized losses. He highlighted the long introduction periods and emphasised the need for close collaboration with industry. Demonstration buildings are necessary to promote the technology and to learn from it. Small loads require very low power system. Small wood stove would lead to overheating of the room, if not attached to the hot water storage.

K. Engelund Thomson reported about the promotion of low energy buildings in Denmark. The low energy building class 2 is at 75 %, class 1 at 50 % of the present energy code level. These levels are envisaged to become the required levels in the revision of the energy regulation in the years 2010/ 2015. For extension and renovations still three approaches are accepted: U-value, heat loss or energy frame approach.

S. Dyrbøl presented three low energy inspiration projects in perspective to EPBD: A class 1 low energy building, a renovation project and an optimized renovation project. She concluded that class 1 low energy building are feasible with existing technology, that renovation has be approached by an integral planning process, and proposed for costs to change from pay-back time to net present values.

H. Erhorn-Kluttig presented projects in the EU FP6 Eco-buildings part, namely DEMOHOUSE, ECO-Culture, SARA, and in more detail the project BRITA in PuBs, where 9 public buildings, representing 18‘000 comparable buildings in Europe, are retrofitted to an energy standard significantly lower than the present EPBD standard. A list of retrofit measure was presented both for envelope and fenestration, and for the integration of renewable energy and local energy conversion systems.

A. Pindar outlined the Passive-On project where two possible approaches to bring Passive Houses to the Mediterranean are evaluated: to adapt the present PH standard (example requirement 15 kWh/m^2 for heating to be split into 10 for heating, 5 for cooling), or to develop an independent standard considering passive cooling.

H. Kaan reported about a similar project to promote the Passive House standard in western and northern European countries by identifying the energy saving potential in Europe, by specifying climate and country related constructions, by preparing national info packages and a web site, and by harmonizing PH certification with EPBD procedures.

Conclusions
Already today very low energy buildings comply with future EPBD energy requirements, and have to pass a certification procedure. The Passive House technology is established for new buildings, the present focus of technology development is on retrofit. The technology has to be pushed in an ongoing effort, promoting new technologies and gaining experience. For this, demonstration projects and collaboration with key industry are crucial. A holistic approach in planning has to be promoted. Cooling aspects and perhaps also embedded energies have increasingly to be considered.

Calculation procedures must be detailed but remain applicable. They should credit the use of innovative low energy technologies.

3.6 Airtightness and the energy for transport

Not yet available

3.7 Innovative systems and the EPBD

François Durier

In the framework of this session, innovative systems were defined by Peter Wouters and Nicolas Heijmans (BBRI - Belgium) as building systems which give better energy performance and whose performance cannot be assessed by standard methods. This lack of testing or calculation method for performance assessment of innovative systems could create barriers to their market introduction.

According this session speakers, examples of innovative systems can be found in building envelope (insulation, windows, double skin facade, use of thermal mass,…), heating (solar, condensing boilers, CHP, heat pumps, biomass, geothermal,…), cooling (passive cooling, absorption chiller,…), ventilation (hybrid, natural, ground heat exchangers, humidity or CO_2 controlled,…), lighting (daylighting, high efficiency artificial), controls and monitoring.

Hans Erhorn (Fraunhofer Institut für Bauphysik - Germany) mentioned that using innovative systems is investigated in several European Eco-buildings research projects ; potential of innovative systems requires to integrate them in energy performance procedures and EPBD Concerted Action identified several systems for which members states do not know yet how to take them into account in national regulations.

Peter Wouters noticed that performance assessment procedure for innovative systems could rely on the equivalence principle (can the performance be compared to the one of classical systems ?), event if this approach may sometimes be difficult to apply.

Nicolas Heijmans described the probabilistic approach used in Rhesyvent project about hybrid ventilation: several (100) calculations from a set of input data, each of them being associated to a probabilistic distribution, were perfomred in order to compare innovative and conventional systems. Hans Erhorn also mentioned the possible use of a simple calculation method from existing standards and litterature, as in BestFacade project about double skin facades.

According to Peter Wouters, the assessment procedure of innovative systems, wathever its type, should be transparent and reliable, offer help for optimisation, rely on available input data, be opened to new developments, software independent, available now... Nicolas Heijmans pointed out the need of consistency between countries, but also the need to authorise national approaches (national concepts, national boundary conditions, national calculation procedures,…).

Suzanne Dyrbøl (Rockwool International) proposed that innovative systems focus where the largest saving potentials exist, unlike for e.g. efficient insulation which mainly goes to the new buildings market while saving potentials are bigger in the existing buildings, and recommended to set up regulations with mandatory requirements and to use money available in the most efficient way (incentives, subsidiaries) to develop the market of innovative systems.

Finally, Alice Andersen (WindowMaster - Denmark) pointed out that barriers exist for natural ventilation systems, due to limited requirements in standards; in such a case, requirements should avoid fixed limit values (e g. room temperatures, air flow rates, CO_2 concentrations) never to be exceeded but should prefer mean values, with autorisations to go beyond limits for small periods of time.

3.8 Dissemination, training and non-technical issues

M Kolokotroni

The session addressed non-technical implementation and formal training issues in the context of EPBD.

Implementing the EPBD requires raising awareness and training of hundred thousand of people in Europe. Some countries have practical experiences and specific projects are running for facilitating the introduction of EPBD. Formal aspects of training should also be addressed in particular in the areas of certification of buildings and installations.

The session contained four presentations, a summary of which in given below:

Training of inspectors in the context of EPBD by H Van Eck, NOVEM, The Netherlands
H Van Eck gave a summary of the needs for training and presented a graph indicating the certification chain. Certification needs can be summarised as follows:

- An Industry Advisory report on number of certificates is expected soon – the first indication are that many experts are needed (eg 2.5 million of dwellings in the UK, more than 2.5 million non-domestic in Germany in 2006)
- Responsibilities for service quality –what people? Start point could be the EN/National standards to the service delivery
- Energy use, reality versus calculation (Quality of methods and Quality of experts) for advice and inspection
- EPBD article 10 stipulated that work should be carried out in an independent manner by qualified persons
- Quality of supervision of experts – authorised agencies, professional bodies, accreditation bodies, scheme administrator (national and regional authorities).

Vent DisCourse by M Kolokotroni, Brunel University, UK
M Kolokotroni presented a project currently funded by EIE which addresses the issue of training material development within the chain of certification. The project aims to develop distance learning training material for the promotion of best practice ventilation energy performance in buildings. Within the project, it is proposed that distance learning might be a suitable format for training large number of professionals. For this the training methodology, operational schedule and requirements for certification must be addressed in detail.

Implementation of EPBD in the real world by A Papadopoulos, Aristotle University Thessaloniki, GR
A. Papadopoulos highlighted that apart from technical issues, other factors that influence the implementation of the EPBD should be addressed such as social, economic and cultural aspects. Also hidden factors such as financial and availability of human resources. Such issues can be summarised as follows in the form of questions:

- Hard question-why do things develop so slowly?
  - –Example: Densely built urban environment – complex legislative framework and financial incentives, lack of proven expertise, unwillingness to abandon the 'business as usual' approach, low energy prices.
- Can the EPBD enforce the accelerated propagation of energy efficient technologies?
  - One barrier was outlined: Tariff structure of utilities does not benefit the penetration
  - Soft barriers (eg human resources and local acceptance): Design Advice & Support Units are required.

In conclusion, EPBD is a useful background for enforcing development – the key issue for its effective penetration is to engage local people according to the local needs and the local potential. In addition, pricing of energy should be based on its costing for market penetration of EPBD.

Towards Class A : Municipal Buildings as shining examples by P Schilken, Energie-Cites, France

P Schilken described a project currently funded by EIE. This project is a continuation of the Display Label project for municipal buildings and addresses a similar problem with the same solution. The scheme is voluntarily at present.

- **The label includes –**
  - primary energy, GHG emissions and water consumption, distribution of energy sources.,

    - communication with the public
    - display classification could be replaced with national classifications
- Display also includes practical advice and description of technical issues in simple words
- Facilitates communications with councillors, managers of municipal buildings, general public and building users and therefore bridging the gap between Europe and its citizens

In conclusion, session 8 addressed different aspects of non-technical issues

- Description of the whole chain of certification and requirements
- Methods for developing training material
- Pricing, cultural and methods of penetration, involvement of local community
- Methods of adaptation of existing successful certification schemes

The Air Infiltration and Ventilation Centre was inaugurated through the International Energy Agency and is funded by the following seven countries:

Belgium, Czech Republic, France, Greece, The Netherlands, Norway and United States of America.

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

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