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VENT DIS.COURSE
(EIE/04/022/S07.38630)

Development of Distance Learning Vocational Training Material for the Promotion of Best Practice Ventilation Energy Performance in Buildings

Prepared by
Maria Kolokotroni

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Brunel University
Mechanical Engineering
School of Engineering and Design
Uxbridge, UB8 3PH, UK.
Tel: +44 1895 266688 Fax: +44 1895 2

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1. Introduction

This is the final report for the Vent DisCourse project entitled Development of Distance Learning Vocational Training Material for the Promotion of Best Practice Ventilation Energy Performance in Buildings (EIE/04/022/S07.38630) which is partly funded by the European Commission, Intelligent Energy Europe Programme. The overall duration of the project was 24 months, starting on the 1st January 2005 to the 31st December 2006.

The project Vent DisCourse had the main aim to develop and promote training material in a multi-lingual distance-learning format for building professionals to facilitate the implementation of best practice ventilation energy performance (both for indoor environmental quality and thermal comfort) in large new and retrofitted buildings of various types.

This publishable final report describes work carried out on the different tasks and the achievements of the project.

1.1. Project objectives

The main objectives of the project were the following:

- Accelerate the implementation of a core area (ventilation) within the Energy Performance of Buildings Directive (EPBD) at European and national levels.
- Improve energy efficiency in buildings by directly transferring existing knowledge to appropriate actors in a suitable format.
- Develop and promote vocational training material in a distance-learning format for building professionals.
- Facilitate the implementation of best practice ventilation energy performance (both for indoor environmental quality and thermal comfort) in large new and retrofitted buildings of various types. This will be achieved by designers having the know-how (together with calculation methods) on minimising the need for mechanical ventilation (by applying passive ventilation techniques) and specify energy efficient plant where this is necessary.

All of the above objectives are directly related to one area of the EPBD and therefore are directly relevant to all current European and national actions for the implementation of the Directive.

Development objectives included:

(a) evaluation of distance learning training methods for effective market penetration and

(b) collection/evaluation/classification of existing and recently developed knowledge of energy efficient ventilation technologies into distance learning training formats.

Promotion objectives include pilot seminars, Continuing Professional Development (CPD) material in professional journals and targeted initiatives (flyers, advertisements) in addition to the available training material in three distance-learning formats.

1.2. The consortium

Vent DisCourse is coordinated by:

- Brunel University (Brunel)
  Kingston Lane, UB8 3PH, Uxbridge, UK
The project partners are:

- **National and Kapodestrian University of Athens (NKUA)**
  6 Chr. Lada str, 10561, Athens, Greece

- **Federation of European Heating and Air conditioning Associations (REHVA)**
  De Mulderij 12, 3831 AJ Leusden, The Netherlands

- **BSRIA Ltd (BSRIA)**
  Old Bracknell Lane West, RG12 7AH, Bracknell, UK

- **Ecole Nationale TPE, Laboratoire Sciences de L’ Habitat – CNRS-DGCB (ENTPE)**
  Maurice Audin, 69518 Vaulx en Velin, France

In addition a number of major subcontractors were involved as follows:

- **Veetech Ltd** as a subcontractor to Brunel

- **University of Thessaloniki** as a subcontractor to NKUA

- **FINVAC** as a subcontractor to REHVA

- **AIVCF** as a subcontractor to ENTPE
2. Description of work

This section outlines work carried out in each technical work package and briefly describes the management of the project.

2.1. Summary of work packages and partners involved

Figure 1 presents the time span and relationship of work packages and partners involved.

Section 2.2 presents a summary of the activities in each Work Packages and Section 2.3 summarises the management of the project. The main results of the project are presented in Sections 3-9 outlining the main results and achievements of each work package.

2.2. Summary of work packages

Work Package 1: Project Management – Leader: Brunel

This work package involved all management activities associated with running the project smoothly and effectively. A brief outline of the achievements of this WP is included in section 2.3.
Work Package 2: Review and Evaluation of educational distance learning methods for target audience and their application to building ventilation vocational training material. – Leader: NKUA

The aim of this work package was to evaluate how the objectives of European and national energy related ventilation policies and programmes can be embodied within distance learning training. In general, learning requires a variety of learning activities to develop understanding of knowledge and mastery of the skills in a subject. Different activities are optimally supported by different learning media. In distance learning self study will play a large part, but support is needed from tutors/experts, from other students, and from learning materials. In designing distance learning materials in the different media we have to consider how each type can support active learning. This work package investigated appropriate technology so that an appropriate blend of learning activities is made available to the target audience. Therefore WP2 investigated the following:

1. Target audience/trainees. This activity included identification and assessment of the market needs and developed a classification scheme in order to structure available material.

2. Evaluation of applicable distance learning methods. This activity investigated appropriate methods for target audiences.

The work carried out in WP2 is described in a report ‘Review and evaluation of educational distance learning methods for target audience and their application to building ventilation vocational training material’. The main results including market needs within the participating countries are summarised in section 3.

Work Package 3: Collection, evaluation and classification of the necessary information and material to develop the distance learning training material… – Leader: ENTPE

This WP was carried out partly in parallel with WP2. The main effort was focused on collection, review and classification of recently emerging but existing knowledge in the field of ventilation for buildings, (in terms of indoor environmental quality, thermal comfort and energy consumption). There categories were investigated for their relevance to the project and usefulness in developing training material:

- Recently completed RTD and dissemination projects funded by the Commission (eg SOLVENT, URBVENT, NATVENT, RESHYVENT, TIPVENT, SAVEDUCT) which contain in-depth described new technological and legislative developments.
- Industrial information, testing methods, predictive software and existing applications in buildings mainly available within participating countries.
- Conclusions from international collaborative projects (eg HybVent) and also recent development in countries outside the EU.
- AIVC publications which proved the most relevant source of information for the development of the educational material.

The work carried out in WP3 is described in a report ‘Collection, evaluation and classification of the necessary information and material to develop the distance learning educational material: Review of existing material’. The main results are summarised in section 4.

Work Package 4: Development of the distance learning training material – Leader: Brunel

WP4 developed the modules of the distance learning educational material. This consisted of six modules which were anticipated in the beginning of the project and were extensively discussed and redefined during the project review meetings. The material also contains
appropriate assessment in the form of assignments; these will include a combination of
numerical exercises and essay/reports. These assignments will be forwarded to the
instructors for reviewing, so that the course is judged as successful for the participants and
lead to the award of certification. The material was developed so that printed versions are
possible so that trainees are able to have access to them at any time. The material was also
developed so that it could be used on electronic media; WebCT was used as an example on
how this can be done. An educational electronic site was created specifically for the use of
registered trainees and was used for the pilot training during this project.

Therefore, the training material (modules) is available in the following three formats:

1. Printed material in the form of traditional distance learning education delivery format
which is favoured by trainees who are restricted in internet access and time –
perhaps undertaken this training to further their knowledge and career prospects.
This category of trainees is a very important target audience because they are
usually building professional already in employment and by undertaking this training
will contribute directly and immediately to the implementation of energy related
building ventilation measures for the implementation of the EPBD. Some
supplementary material which is difficult to produce in a print form (eg case-studies
and computerised tools) was included in a CD-ROM which can be used free-standing
or in an internet connected computer for further access to materials. This material
was translated to Finnish as an example on how training material can be translated in
another language. This material has also been translated into French ready to be
used by educational establishment in France.

2. Electronic version of modules based on WebCT educational software. This version of
the material is suited to trainees that are directly sponsored by employers to
undertake this training and have continuous and fast access to internet facilities. It
could be used by companies within their CPD programme and because of its
distance learning format and its established certification scheme (by University
participants) can be favoured by employees (trainees) as they can carry it out within
their employment environment. Using WebCT group projects can be carried out by
trainees from different locations and chat areas would further encourage discussions
between trainees. It also provides the facility to create bulletin boards in which new
information on the modules can be accessed very quickly and where new initiatives
and legislative announcements can be reach current and past trainees.

3. A condensed version of the full printed material was also developed suitable for
publication in appropriate professional journal and were published in the REHVA
journal during the project. This material was translated in two national languages
(Greek and French) and it is now ready to be published in suitable professional
journal in the corresponding countries.

The titles of the developed material in print and WebCT format are the following:

- Foundation module: Principles of energy efficient building (Brunel)
- Module 1: Natural and hybrid ventilation (Veetech Ltd)
- Module 2: Ventilation for urban buildings (NKUA)
- Module 3: Energy efficient mechanical ventilation (REHVA)
- Module 4: Assessment of building ventilation (BSRIA)
• Common Resource Module: Computerised Tools and Case-studies (Brunel)

The titles of the CPD articles as published in the REHVA journal are:

- CPD1: Displacement Ventilation in non-industrial premises (REHVA)
- CPD2: Performance of natural ventilation in the urban environment (NKUA)
- CPD3: The energy impact of ventilation (VeeTech Ltd)
- CPD4: Assessment of ventilation and comfort (BSRIA)

A more detailed description of the developed material is included in section 5.

Work Package 5: Establishment of the training methodology and description of the organisation of the material – Leader: BSRIA

WP5 developed and documented the training methodology. This is aimed for training organisation that would use the developed training material so that trainers become acquainted with the aims of the material. In this way, they will be able to develop (or even adapt) lessons and training (for example in a block delivery teaching method lasting a few hours, a few days or one week suitable for short CPD training activities). This methodology is based on the developed distance learning material and has drawn its content from WP4 and WP6. The aim is to be used after the conclusion of the project either by the participants of the consortium or by other educational interested bodies.

WP5 also developed the operational schedule of the on going course. Conditions concerning the strategy which has to be followed in order to achieve self-sustainability of the structure was formulated as well as certification award scheme (mainly through the activities of the participating universities).

The work carried out in WP5 is described in the reports ‘Establishment of the training methodology’ and ‘Operational Schedule and Certification’. The main results are summarised in section 6.

Work Package 6: Testing of the vocational training package by selected European experts and through pilot distance learning activities – Leader: REHVA

This WP6 is concerned with the testing of the training material. This has been achieved by:

- four pilot seminars with the objective of examining the effectiveness of the developed material, by presenting it to interested building professionals and educators active in the field, inform the concerned building professionals on the availability of the training material and to increase their awareness on the energy efficient use of ventilation technologies.
- the developed training material was distributed to individual experts for comments and evaluation.
- distance learning courses were organised (co-ordinated by REHVA and Brunel) in order to test the integrity of the developed training package and the efficiency of the training module. Students from six European universities participated in these courses.
The results of this WP6 are described in section 7.

**Work Package 7: Preparation of Final distance learning modules and delivery to Commission**  
– Leader: Brunel

This WP7 is concerned with the revision of the training material and methodology by incorporating all received comments and results of the evaluation process (pilot seminars, pilot courses, evaluation by experts).

Some comments about the results of this WP7 are presented in section 8. However, the main results have been already presented in section 5 (describing WP4).

**Work Package 8: Common Dissemination Activities – Leader: REHVA**

This WP8 is dedicated to dissemination activities additional to those incorporated in the previous WPs (eg pilot seminars, publication of CPD articles). These activities include the project’s website, newsletter, publication of CPD articles, announcement in European conferences, and a plan for the future use of the created educational material. These activities are described in section 9.

2.3. Management of project (work package 1)

This WP1 is concerned with the smooth running of the project and communication between partners involved. As anticipated in the beginning of the project five project meetings were held;

(a) kick-off meeting at Brunel (1-2 March 2005) during which the work programme was discussed in detail and targets set,

(b) 1st review meeting (22 May) in Santorini Greece following the PALENC international conference,

(c) 2nd review meeting was held at Brunel University on 14-15 November 2005. During this meeting work on the educational package contents was discussed in detail and a schedule for finalising the task was agreed on,

(d) 3rd review meeting was held at the Energy Institute, London on 23-24 February 2006. During this meeting work on the educational package contents was finalised and further dissemination activities were planned in detail and

(e) Final review meeting was held at Lyon on 22nd November 2006, during the EPIC/AIVC conference. During this meeting pilot courses results were discussed and a timetable for finishing the project successfully was drawn.

A project website is established (dea.brunel.ac.uk/ventdiscourse) and updated regularly with information and results on the project. This website also includes a member’s area which further facilitates communications between the partners.

Most of the partners had the opportunity to discuss issues during the following three events:

(a) AIVC/EPBD conference held in Brussels (21-23 September 2005)

(b) CLIMA2005 Conference in Lausanne where the project held a workshop on 12th October.

(c) EPIC/AIVC conference in Lyon where a presentation about the project was made.
3. **Main results of WP2: Review and Evaluation of educational distance learning methods for target audience and their application to building ventilation vocational training material**

The ‘Review and Evaluation of educational distance learning methods for target audience and their application to building ventilation vocational training material’ report is the deliverable in the WP2 of the ‘Vent Dis.Course project’. The scope of this work was to evaluate how the objectives of European and national energy related ventilation policies and programmes can be embodied within distance learning vocational training. The objective is to identify the market needs and two categories of potential trainees for which to develop vocational training material for the participating countries: France, Greece, Finland and the UK. This report will serve for generating solutions in the further WP-s. This report was prepared on the bases of the national reports of the participating countries and completed by the task leader by integrating with summaries and conclusions.

The report shows that:

1. Currently the UK market is characterised by a number of courses on ventilation and building services addressed at engineers who are already in the industry. Additionally the UK market is well prepared for the EPBD implementation. Engineers are aware of the coming regulations and seminars addressed at architects, building services engineers, contractors and developers are already taking place in order to meet the new legislation and the role of ventilation and its energy impact on buildings.

   In the other participant countries, courses on ventilation are generic and very limited and the EU Building Directive has not been efficiently introduced in their markets. Additionally, there is a lack of knowledge on the relation between ventilation systems and energy performance of buildings although the coming legislation of the building energy performance.

   Distance learning vocational training on building ventilation is well developed in the UK. In the other participant countries, engineers are provided with vocational training on building services but this is not in distance learning mode of study. In Greece and Finland distance education is encouraged and under development while in France is not yet existent.

   Currently, paper based material; web-based material and CPD articles are the three applicable distance learning vocational training methods for engineers. Specifically, building designers (architects) and building services engineers form the two categories of potential trainees for which vocational training material will be developed further in this project.

2. The three distance learning methodologies, paper based material, web-based material and CPD short articles, described in this report, could form appropriate vocational training and provide engineers with courses on ventilation and its energy impact within the frames of the new legislation of the energy performance of buildings.

   It seems that the paper-based material is the preferred distant learning method among students and engineers already occupied in the industry who wish to continue with further training. Internet based material is also desirable but this should be complementary to the paper based material. CPD short articles form also an appropriate way of education as they analyse contemporary issues, i.e. new legislations, in short and comprehensive way.

   In all the EU member countries, the EU Building Directive should be implemented from January 2006. This will have an impact on the market and industry of the countries; legislation should be updated in order to meet the new building regulations. Engineers could be provided with information and further training on the new legislation, appropriate design and training on ventilation technologies via distance learning vocational training material in order to meet the new requirements.
The report is structured along three sections:
The first section analyses the professional activity of the participating countries including statistical data on the professions in the engineering area. We can conclude that in all countries professional institutions for the heating, ventilation and air-conditioning of buildings provide engineers with technical manuals, guides and information on current legislation. The professional bodies for engineers to address at are: FINVAC in Finland, Technical Chamber of Greece in Greece and CIBSE, ASHRAE and HVCA in the UK.

Based on statistics, in Greece, out of 87,400 professional engineers subscribed in the Technical Chamber of Greece 13.6% are subscribed as mechanical engineers and 3.3% as mechanical & electrical engineers.

In the UK 5,780 companies are operating as heating and ventilation engineers that occupy 10,757 engineers from whom 82.5% are architects and 17.5% building services engineers. Additionally, based on data derived from the ETB, dated 2003-2004, in the engineering area, out of 312,916 engineers, 19.5% are employed as mechanical engineers and 50.7% as plumbers, heating & ventilation engineers.

It should be noted that in the UK a wide range of professions work on ventilation issues compared to Greece where only mechanical engineers are specialised on building services.

The second section of the report focuses on the existing ventilation related material in the participating countries and the applicable distance learning methodology. The training material on ventilation is distinguished in non-distant and distant learning courses.

Non-distant ventilation training material:
In Finland, ventilation-training material is provided in three Universities and in four Technical Colleges. In all Universities apart from one, the ventilation courses are limited and consist part of the applied thermodynamics and energy technology section. The courses aim at building services engineers, whereas some introductory courses aim at architects. Additionally, FINVAC provide engineers with vocational training material. All modules require full attendance.

In France, architects, mechanical and civil engineers are provided with courses on ventilation in the frames of their first-degree studies. However, there are no specific courses on ventilation, but ventilation material is covered in the frames of heat and mass transfer or HVAC system courses.

In Greece, ventilation-training material is provided in the majority of the Hellenic Universities at first degree and postgraduate degree courses. The courses aim mainly at mechanical engineers while introductory modules on the principles of ventilation aim at architects. All modules require full attendance. Additionally, the Center of Professional Training for the Professional Mechanical-Electrical Engineers supported by the Technical Chamber of Greece provides vocational training on ventilation and building services.

In the UK, the majority of training material on ventilation can be provided through distance learning. Only one college provides 1 or 2 day courses on ventilation that require full attendance from the students.

Distant learning ventilation material:
The Government of Finland encourages the distant learning methodology, but it is still under development. Although some distance-learning courses are available at primary and secondary schools none is applied at university and professional level.

In France, distance learning is not developed.

In Greece, only one institutional body provides distance-learning material. Unfortunately the structure of the scheme is not very flexible and the training material on ventilation is not very detailed. The training program of the institution leads to a Bachelor (undergraduate studies), a Master’s (postgraduate studies) and a PHD.

It should be noted that the training material on ventilation is provided in a series of modules part of the Bachelor or the Master’s courses. Based on information derived from the institution, there is a great demand for attendance in the scheme and a limited number of offered places. Additionally only 13% of the students are graduating. Therefore, questions could be raised for the efficiency and the structure of the institution.

On the other hand, distance-learning material is widely used in the UK: A number of Universities provide distant learning material on ventilation in the frames of postgraduate
studies. The courses can be covered in 3 to 5 years. Additionally, three main web based schemes provide independent modules on heating, refrigeration and air conditioning of buildings.

**Applicable distance learning methodology:**
Three applicable distance-learning methodologies for vocational training have been identified in the report:

Paper based material, web based material and Continuing Professional Development (CPD) short articles.

The paper-based material is the preferred distant learning method among students and engineers already occupied in the industry who wish to continue with further training. Internet based material is also desirable but preferably this should be additional to the paper based material.

CPD short articles are usually published in professional journals and explain a specific issue, i.e. new legislation, in 2-3 pages.

The third section of the report refers to the market needs of the participating countries regarding the distance learning material on ventilation issues and its energy impact within the EU Building Directive.

In France, the new thermal regulation for summer comfort and the application of the European directive will have an impact on the market. Additionally, the French ministry of the Housing is working on a new ventilation regulation applied to indoor air quality and health.

It is possible to say that there is a lack of knowledge on the relation between ventilation systems and energy performance of buildings although the French thermal regulation “RT2000”.

In Greece, currently the main characteristics of the market (architects, engineers, building operators and contractors) could be described as follows:

**Building ventilation:**
In Greece, the use of air conditioning is being increased significantly. Extended monitoring has shown that naturally ventilated buildings typically use less than 50% of the corresponding energy consumption of air conditioned buildings, (NatVent-natural non-domestic ventilation). Apart from natural ventilation, various ventilation solutions could be applied in the Greek building stock and lead to great energy savings. However, these techniques are still foreign in the Greek market. The main training needs on building ventilation could be summarised as follows:

- Lack of knowledge on the relation between the ventilation and the energy performance of buildings.
- Unavailability of legislation on ventilation issues to a large target group (architects and building services engineers) and unavailability of best practice guidelines-benchmark for the design of different types of buildings.
- Isolation of the Greek market from the European industries. New innovative ventilation systems that are already applied abroad should be introduced in the Greek market. New solutions will promote education and knowledge and new jobs in the industry.
- Demonstration of best practice examples of abroad with energy efficient ventilation systems will increase the public awareness and the confidence of architects, building services engineers and contractors.

**EU Building Directive:**
- Need to introduce the EU Building Directive in the Greek Market and its effect on the building design and Greek legislation

The implementation of the EU Building Directive in Greece will begin in January 2006. However, the majority of the building designers and building services engineers are unaware of the coming legislation and its effect on the building design and operation.

The national legislation concerning the minimum required thermal insulation, the HVAC and the heating system should be updated in order to meet the EU Building Directive
requirements. Also new legislation should be enacted concerning natural and artificial lighting. Finally new calculation methodology for the energy consumption of buildings should be developed taking into account all the above parameters. Currently, the methodology and the format of the EU Building Directive scheme are being developed by the Hellenic Ministry of Development and the Ministry of Environment and Public Works.

**Distance learning material on ventilation:**
The applicable distance learning material on building ventilation is very generic and provides education on the principles of energy efficient ventilation techniques (i.e. natural ventilation, passive cooling). Additionally, it is not addressed at professionals and does not include the implementation of the EPBD and the role of ventilation on the building energy consumption.

In the UK, ventilation related courses cover a very broad spectrum of areas and knowledge is disseminated through a developed distance learning methodology. Universities and independent web based schemes offer a large variety of distance learning courses at beginners and professional engineers already involved in the market. The current legislation on ventilation is easily accessible to the architects and building services engineers through technical manuals. CIBSE and BSRIA publications provide the required ventilation rates for different type of buildings and guidelines for the design of naturally or mechanically ventilated buildings. The EU Building Directive has been introduced in the UK market. A series of seminars on the EU Building Directive addressed at architects, building services engineers, contractors and developers are taking place and:

- Inform the building services engineers and designers on the EPBD articles and the new events on the EU building Directive
- Analyse the impact of the Directive that will have on the building design
- Analyse the requirements to meet with the Government legislation

Moreover, innovative ventilation solutions are applied in the UK industry aiming at low energy buildings. During the last decade an increase number of buildings have been built. However, it is noted that many engineers and architects require additional training to understand the role of energy efficient ventilation and, in particular, how it can be applied. Specific training needs are required in the area of the building design. Suggested areas of training include the follows:

- Health and Comfort
- Cooling
- Pre Conditioning (Heating and Cooling) of Supply Air
- Urban areas
- Demand control
- Integrating ventilation system with fire and smoke control measures
- Sustainability and life cycle issues
- Ventilation in urban buildings

Additionally, it is noted that specific training needs in the area of design is required on the technical aspects of ventilation (i.e. sizing a system, determining natural driving forces), safety issues (prevent spread of fire, smoke and legionella), understanding of the occupancy needs and loads, and ways of compliance with the Building Regulations.

In conclusion, there will always be need to improve the skills, competence and knowledge of professional engineers. Time pressure and professional responsibilities comprise a barrier to the continuing training of professionals. Distant learning vocational material provides flexibility, independent studies, individualization, globalisation of the market, easy exchange of experience and adaptation to the new technology and legislation. The potential trainees for which the proposed vocational training material is proposed are building designers (architects) and building services engineers. The training material will focus on the ventilation and its energy impact to meet the building regulations and the EU Building Directive. All applicable distance learning methodologies already mentioned, are appropriate for the dissemination of the knowledge on ventilation and its relevance to EPBD.
Therefore, the training material will be disseminated through:

- Printed material in the form of distance learning education delivery format or CD-ROM
- Web-based modules
- A condensed version of the full printed material will be published in professional journals
4. **Main results of WP3: Collection, evaluation and classification of the necessary information and material to develop the distance learning training material.**

Existing education material provides the background knowledge required for building ventilation. In this WP3, suitable textbooks and other training material were identified and the main effort was focussed on collection, review and classification of recently emerging but existing knowledge in the field of ventilation for buildings, in terms of indoor environmental quality, thermal comfort and energy consumption. There exist a number of recently completed RTD and dissemination projects funded by the Commission, which contain in depth, described new technological and legislative developments. They also include industrial information, testing methods, predictive software and existing applications in buildings. WP3 also investigated conclusions from international collaborative projects and recent development in countries outside the EU. These developments were evaluated and classified so that they can be translated to educational format suitable to target trainees.

Therefore, WP3 identified material in relation to building ventilation that has been produced recently by research and dissemination projects at National, European and International level, evaluate their applicability to the aims of the EPBD, and classify them in preparation for the development of distance learning training material.

This information is given about following items in the frame of (a) recent European projects, (b) IEA annex, (c) other supports and (d) CEB standards. The publications were studied and their content was classified according to the following:

1. Technological developments
2. Industrial information
3. Testing methods
4. Predictive software
5. Existing applications in buildings
6. Case studies
7. Developments linked to ventilation requirements:
   - 7.1 protection of buildings (fire security, terrorism attacks),
   - 7.2 air quality and health,
   - 7.3 materials.
8. Critical barriers vs. ventilation systems.
9. Impact of double skin façade on ventilation system design.

Some materials in relation to building ventilation have been presented in the report ‘Collection, evaluation and classification of the necessary information and material to develop the distance learning educational material: Review of existing material’. As mentioned before, these materials have been produced recently by research projects at National, European or International level. General and technical information concerning 9 items has been implemented and products interesting in the frame of Vent Dis. Course project underlined.

Most of these materials can be used and integrated in the project. However it’s necessary to verify some copyright for handbooks published by private publisher.

According to the classification of the technical items proposed in the project for the development of distance learning training material most of these items are treated by the materials mentioned in the report, tables 1 and 2.
Table 1: Background knowledge from recent European projects according to items proposed

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Table 2: Background knowledge form other projects and publications according to items proposed

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Software and case studies included in deliverables of European projects could be integrated in the educational material to complete handbook and exercises for example. It should be noted that the use and the integration of related materials are depending on the conclusion of WP2 concerning the typology of the users in the frame of ventilation energy performance of buildings.
5. Main results of WP4: Development of the educational material

As mentioned before, WP4 developed the modules of the distance learning educational material. This consisted of six modules which were anticipated in the beginning of the project and were extensively discussed and redefined during the project review meetings. The material also contains appropriate assessment in the form of assignments. The material was developed so that printed versions are possible so that trainees are able to have access to them at any time. The material was also developed so that it could be used on electronic media; WebCT was used as an example on how this can be done. An educational electronic site was created specifically for the use of registered trainees and was used for the pilot training during this project. Finally, a condensed version of the full printed material was also developed suitable for publication in appropriate professional journal and were published in the REHVA journal during the project. This material was translated in two national languages (Greek and French) and it is now ready to be published in suitable professional journal in the corresponding countries. Therefore, this section discusses the results in three parts

(a) Structure of the developed educational material (print format)
(b) Description on how it was implemented in an education electronic platform, and
(c) Description of the condensed articles (CPD articles) suitable for publication in professional journals

5.1. Structure of the Developed Educational Material (print format)

Based on the results of WP2 and WP3 and discussions during the project review meetings, the educational material was developed in six modules, the following:

- Foundation module: Principles of energy efficient building ventilation
- Module 1: Natural and hybrid ventilation
- Module 2: Ventilation for Urban Buildings
- Module 3: Energy Efficient Mechanical ventilation
- Module 4: Assessment of Building Ventilation
- Common Resource Module

In order to address the needs of distance learning students the following principles were followed in developing each module.

Each module is divided into sections that the students can absorb in one session (for example 2-3 hours of study). Therefore each chapter is approximately 10-12 pages long to include the following elements:

1. Chapter objectives – so those students are aware of the goals to be achieved by studying this specific section.
2. Introduction to the section.
3. 4-5 sub-sections each with some illustrations in the form of pictures or graphs and with a number self assessment questions.
4. The self assessment questions are designed to revise the material learnt in the sub-section and the students should attempt themselves. Solutions to the personal feedback questions is provided separately so that the students can instantly check their workings.
5. More complicated sub-sections which contain key or difficult to understand principles include worked examples so that the students have a similar solutions before they attempt the corresponding personal feedback question.
6. Each section includes a summary at the end to highlight the key elements learnt while studying it.
Two assessment exercises were developed. The first tests knowledge of modules 1 and 2 and comprises of a design exercise for a notional building to follow natural and hybrid ventilation strategies. The notional building could be placed in a rural or urban site and trainees are asked to recommend suitable solutions. Material from the common resource module can be used to carry out this assignment. The second assignment tests knowledge of modules 3 and 4 and takes the form of an open book examination where trainees are asked to solve problems similar to the ones contained in the material. They are also asked to write a report for a building owner who would like to investigate some ventilation problems in his building.

As mentioned before, the contents were first developed by the participating organisations based on published material on ventilation. AIVC resources were heavily used. It should be noted that this WP4 developed the first version and then a number of European Experts on ventilation commented on the first draft of the material and their comments were incorporated in a second version (this is described in Section 7, WP6). The first draft version is has also been tested by students in six universities (Brunel, Helsinki, Athens, LaRochelle, ENTPE, Prague) using distance learning principles and utilising the WebCT platform to facilitate delivery. Comments from students were implemented in the final version of the material. The material was translated in Finnish for further opportunities of training. This is discussed in section 8 (WP7). It is the intention that translation in other languages will follow, for the whole material or parts of it.

5.1.1. CONTENTS OF EDUCATIONAL MATERIAL

A listing of the contents of each module is included in the following pages:
Foundation module: This consists of 55 pages covering the following:

Chapter 1 Ventilation Requirements
  1.1 Air Quality .......................................................... ...............................
  1.1.1 Classification of Indoor Air Quality ..............................................................
  1.1.2 Ducts and air filter efficiency ..................................................................
  1.1.3 Sick Building Syndrome ........................................................................
  1.1.4 Outdoor Air Quality .............................................................................
  1.2 Thermal Comfort .................................................................................
  1.2.1 Personal Factors .............................................................................
  1.2.2 Environmental Factors ........................................................................
  1.2.3 Perception of Thermal Comfort ...........................................................
  1.3 Climate .........................................................................................
  1.3.1 Global Climate .............................................................................
  1.3.2 European Climates ........................................................................
  1.3.3 Local Climates ...................................................................................

Chapter 2 Criteria for Ventilation Rates
  2.1 Airflow Control Parameters ........................................................................
  2.2 Human Occupancy ................................................................................
  2.3 Indoor air Pollutants .............................................................................
  2.4 Heating and cooling load .................................................................
    2.4.1 Thermal Load $\Phi$ ........................................................................
    2.4.2 Space heat gain components ..........................................................
    2.4.3 Calculating heat gains ....................................................................

Chapter 3 Energy use of ventilation
  3.1 Psychrometry ................................................................................
    3.1.1 Humid Air ................................................................................
    3.1.2 Psychometric Chart ........................................................................
  3.2 Psychrometric processes associated with ventilation ....................
    3.2.1 Sensible heating and cooling ........................................................
    3.2.2 Humidification and Dehumidification ............................................
  3.3 Heating/cooling demand and energy consumption of ventilation ........
  3.4 Fans .................................................................................................
    3.4.1 Power Demand of fans .....................................................................
    3.4.2 Specific Power of Fans ....................................................................
    3.4.3 Installation losses of fans .................................................................
  3.5 Ducts .................................................................................................
    3.5.1 Pressure drop in duct system ...........................................................
  3.6 Ventilation efficiency ............................................................................
    3.6.1 Contaminant Removal Effectiveness (CRE) ....................................
    3.6.2 Air Change Efficiency ....................................................................

Module 1: Natural and hybrid ventilation: This consists of 80 pages covering the following:
  Chapter 1 Natural Ventilation Concepts ..............................................
  1.1 Basic Definitions ..............................................................................
  1.2 Natural and Hybrid Ventilation - Range of Applicable Building Types and Locations
  1.3 Advantages and Disadvantages ......................................................
  1.4 Self Assessment Questions .............................................................
  Chapter 2 Natural Ventilation Techniques ............................................
  2.1 Natural Ventilation Approaches ....................................................
  2.2 Hybrid Ventilation Techniques .....................................................
  2.3. Self Assessment Questions ............................................................
  Chapter 3 Natural Ventilation Components ............................................

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February 2007
3.1 Hybrid Components - Fans

3.2 Self Assessment Questions

Chapter 4 Air Flow through Openings

4.1 Introduction

4.2 Questions

Chapter 5 Wind Driven Ventilation

5.1 Wind Induced Pressure Distribution

5.2 Estimating Wind Induced Pressure

Chapter 6 Stack Driven Ventilation

6.1 Stack Effect: Single Zone - Uniform Internal Temperature Distribution

6.2 Stack Effect Advanced

6.2 Questions

Chapter 7 Combining Wind and Stack Driven Ventilation Adding Hybrid Fans

7.1 Combining Wind with Stack Pressure

7.2 Pressure Effects due to Hybrid Ventilation

Chapter 8 Calculating Natural Ventilation Rate Using the Flow Equations, Wind Pressure and Stack Pressure Equations

8.1 Single Zone Network Models

8.2 Calculating the Natural Ventilation Rate

8.3 Multi-Zone Network Models

Chapter 9 Controlling Natural and Hybrid Ventilation

9.1 Reasons for Control

9.2 Natural and Hybrid Control Systems

9.3 Control Sensors

9.4 Passive Cooling Control Rules

9.5 Sensor Location

Chapter 10 Other Issues: Variability of Natural Ventilation and Resultant Energy Impact

10.1 Variability of Ventilation Rate

10.2 Variability of Flow Pattern

10.3 Resultant Energy Impact

Chapter 11 Designing for Natural and Hybrid Ventilation

11.2 Advanced Project
Module 2: Natural and hybrid ventilation in the urban environment: This consists of 62 pages covering the following:

CHAPTER 1 Natural and Hybrid Ventilation in Urban Buildings

1.1 Natural Ventilation
1.2 Hybrid Ventilation

1.2.1 Hybrid ventilation – Advantages
1.2.2 Hybrid ventilation - Disadvantages
1.2.3 Control Parameters for Hybrid Ventilation
1.2.4 Control Strategies for Hybrid Ventilation

1.3 Questions for self assessment

CHAPTER 2 Impact of the Urban Environment on Natural and Hybrid Ventilation

2.1 Wind speed
2.1.2 Direction of airflows with respect to canyon axis
2.1.3 Model to predict wind speed
2.1.4 Description of the proposed model
2.1.5 Sequence of calculations

2.2 Temperature distribution
2.2.1 Analysis of the air and surface temperature in urban canyons

2.3 Outdoor pollution
2.3.2 Ventilation strategies and guidelines to reduce exposure to outdoor pollutants

2.4 Noise levels ventilation potential in urban areas
2.4.1 Noise levels in street canyons and potential of natural ventilation
2.4.2 Noise Control Strategies for Natural Ventilation

CHAPTER 3 Natural Ventilation Strategies to Enhance Airflows in Urban Environments

3.1 Balanced stack ventilation
3.2 Passive downdraught evaporative cooling
3.2.1 Example

3.3 Solar-assisted ventilation
3.4 Fan assisted ventilation

3.5 Fan assisted ventilation
3.6 Self assessment Questions

CHAPTER 4 Evaluation of the natural & hybrid ventilation potential in urban environments

4.1 Natural ventilation and IAQ
4.1.1 Evaluation of natural ventilation and night cooling in urban areas

4.2 Evaluation of hybrid ventilation
4.2.1 Performance of hybrid ventilation systems

4.3 Self Assessment Questions

CHAPTER 5 A methodology to calculate the optimum openings for naturally ventilated buildings located in urban canyons

5.1 Description of the methodology

5.2 Architecture Scenario and Databases
5.3 Tool for calculations of ach or openings
5.3.1 Single-sided scenario

Calculation of the optimal opening
5.3.2 Stack-induced scenario

5.4 Self assessment Questions
CHAPTER 6 Performance of hybrid ventilation in urban environments through experimental data

6.1 Comparison of hybrid ventilation, natural ventilation and mechanical ventilation

6.2 Performance of two different hybrid ventilation systems

6.2.1 Pilot ventilation system

6.2.3 Results & Conclusions

6.3 Self Assessment Questions

CHAPTER 7 Recommendations for the Use of Natural and Hybrid Ventilation Systems in Urban Buildings

7.1 Maximization of the natural driving forces

7.2 Consideration of thermal comfort

7.3 Improvement of IAQ

7.4 Energy considerations

7.5 Self Assessment Questions
Module 3: Energy Efficient Mechanical Ventilation: This consists of 95 pages covering the following:

CHAPTER 1 Principles of mechanical ventilation
1.1 Properties of mechanical ventilation .................................................................
1.2 Definition of air flows in the mechanical ventilation system ................................
1.3 Supply air flow rates ..............................................................................................
   1.3.1 General principle to define supply air flow rate .................................................
   1.3.2 Human occupancy ............................................................................................
   1.3.3 Known emissions ............................................................................................
   1.3.4 Heating and cooling load .................................................................................
   1.3.5 Extract air flow rates ......................................................................................
1.4 Air balance, direction of the air flows and air quality .............................................
1.5 Heating demand and energy consumption of ventilation ........................................
1.6 Ventilation and pressure differences in the building ..............................................
1.7 Questions for self assessment .................................................................................

CHAPTER 2 Ventilation of residential buildings
2.1 Why mechanical ventilation ..................................................................................
2.2 Mechanical exhaust ventilation ............................................................................
2.3 Ventilation with air heating ...................................................................................
2.4 Design ventilation rates .......................................................................................  
2.5 Questions for self assessment .................................................................................

CHAPTER 3 Ventilation of non-residential buildings
3.1 Ventilation systems for non-residential buildings ...................................................
   3.1.1 Constant air flow system for ventilation ............................................................
   3.1.2 Ventilation in chilled beam system .................................................................
   3.1.3 Fan coil system ................................................................................................
   3.1.4 Variable air volume system (VAV) .................................................................
3.2 Removal of Extract Air .........................................................................................
   3.2.1 Extract Air and Exhaust Air ...........................................................................
3.3 Air recirculation .....................................................................................................
3.4 Heating demand of air flow ..................................................................................
3.5 Cooling demand of the air flow ............................................................................
3.6 Questions for self assessment .................................................................................

CHAPTER 4 Ducts
4.1 Duct system .........................................................................................................
4.2 Pressure drop in duct system ................................................................................
4.3 Balancing of air flows ............................................................................................
4.4 Tightness of the duct system ..................................................................................
   4.4.1 General ............................................................................................................
4.4.2 Selection of air tightness class .........................................................................
4.4.3 Air tightness test .............................................................................................
4.5 Thermal insulation ...............................................................................................  
4.6 Cleanliness of the duct system .............................................................................
4.7 Questions for self assessment .................................................................................

CHAPTER 5 Air handling units
5.1 Air handling units ................................................................................................
5.2 Location of the air handling unit, outdoor air intakes and exhaust openings ..........
   5.2.1 General ...........................................................................................................
   5.2.2 Recommendations for Intake Openings ..........................................................
   5.2.3 Recommendations for Exhaust Openings .......................................................
5.3 Questions for self assessment

CHAPTER 6 Filters
6.1 General principles
6.2 Use of Air Filters
6.3 Questions for self-assessment

CHAPTER 7 Heat recovery
7.1 General
7.2 Heat recovery without condensation or moisture transfer
7.3 Heat recovery with condensation or moisture transfer
7.4 Heat recovery with run-around coils
7.5 Pressure conditions and recirculation
7.6 Questions for self-assessment

CHAPTER 8 Room air distribution
8.1 Basic air distribution patterns
8.2 Mixing ventilation pattern
8.2.1 General principles
8.2.2 Installation of air terminal devices in the duct system
8.3 Displacement Ventilation
8.3.1 Principle
8.3.2 Air flow pattern
8.3.3 Temperature distribution
8.3.4 Effect on energy consumption
8.4 Questions for self-assessment

CHAPTER 9 Control of ventilation and air conditioning
9.1 Basic control systems
9.2 Control of Ventilation
9.2.1 Air quality controlled ventilation
9.2.2 Displacement ventilation
9.3 Questions for self-assessment

CHAPTER 10 References and additional reading

CHAPTER 11 Appendix 1 European standards related to mechanical ventilation
Module 4: Assessment of Building Ventilation: This consists of 80 pages covering the following:

CHAPTER 1 Measuring Ventilation Parameters

1.1 Air temperature

1.2 Humidity

1.3 Air Pressure

1.3.1 Absolute pressure

1.3.2 Differential pressure

1.3.3 Units of pressure

1.3.4 Errors in pressure measurement

1.4 Air Velocity

1.4.1 Pitot-static tube

1.4.2 Errors in air velocity measurement

1.5 Air Flow

1.5.1 Flow measurement in ducts using pressure differential devices

1.5.2 Flow measurement in ducts by Pitot traverse

1.5.3 The Wilson Grid

1.5.4 Terminal hoods

1.5.5 Errors in flow rate measurement

1.5.6 Selection of airflow measurement techniques

CHAPTER 2 Assessment of ventilation and comfort

2.1 Air Tightness

2.1.1 Reasons for Airtight Buildings

2.1.2 Measurement of Building Air Tightness

2.1.3 Leakage Testing of Ductwork

2.2 Air Change Rate and Ventilation Effectiveness

2.2.1 Tracer gas methods

2.3 Air Pollutants

2.4 Thermal Comfort

CHAPTER 3 Commissioning and Balancing Ventilation Systems

3.1 Commissioning Principles

3.1.1 Tolerances

3.2 Commissionable Systems

3.3 Commissioning Techniques

3.3.1 Commissioning mechanically ventilated buildings

3.3.2 Commissioning naturally ventilated buildings

3.4 Commissioning Checklist

CHAPTER 4 Commissioning Controls and Sensors

4.1 Location of Sensors

4.1.1 Temperature sensors

4.1.2 Humidity sensors

4.1.3 Ventilation rate sensors

4.2 Calibrating Sensors

4.3 Commissioning Controls

4.3.1 Pre-commissioning

4.3.2 Commissioning

4.4 Controls Commissioning Checklist

4.4.1 Information

4.4.2 Requirements for specific systems
CHAPTER 5 Operation and Maintenance

5.1 Scope of operation and maintenance

5.2 Filtration

5.2.1 Media filters

5.2.2 Non-media filters

5.3 Ventilation hygiene

5.4 Duct Cleaning

5.4.1 Manual vacuuming

5.4.2 Hand wash/wipe

5.4.3 Hand wipe in clean room environment

5.4.4 Steam washing

5.4.5 Chemical spray

5.4.6 Mechanical brushing

5.4.7 Air jetting

5.4.8 High volume air blast

5.4.9 Sectional extraction

5.4.10 Sectional blocking

5.4.11 Sealing or encapsulation

5.4.12 Hand scrape

5.5 Kitchen extracts

CHAPTER 6 Design and Construction Issues

6.1 Fire Safety

6.1.1 Fire Protection Concepts

6.1.2 Fire Dampers

6.1.3 Fire Barrier Penetrations

6.1.4 Smoke Extract Control

6.2 Suspension systems

6.2.1 Load estimates

6.2.2 Key design factors

6.3 Noise Attenuation

6.3.1 Simple ventilators

6.3.2 Ducted ventilation

6.4 Weather Rejection

6.5 Load Limits for Fixings

6.6 Corrosion

6.6.1 Avoidance of corrosion

6.6.2 Corrosion in ventilation systems
Common Resource Module: This consists of 15 pages and a CD-ROM covering the following:

Chapter 1  Computerised Tools

1.1 Types of Ventilation Models
1.1.1 Network (Zonal) Models
1.1.2 Integration of Models with Thermal Models
1.1.3 Computational Fluid Dynamics
1.2 Comparison of Simulation Models
1.3 Contact Information for Ventilation Models

Chapter 2  Examples of Computerised tools

2.1 EXAMPLE 1: STACK SIM Version 1
2.1.1 INPUT PARAMETERS
2.1.2 RESULTS

In addition a computerised tool which is available in the public domain (developed by Brunel) is provided in the CD-ROM

Finally, case-studies material is included in the CD-ROM in the form of information generated in two projects NATVENT and HYBVENT.
5.2. STRUCTURE OF THE DEVELOPED EDUCATIONAL MATERIAL (electronic format)

This section describes the function of the web based version of the training material and a description of the WebCT platform used as an example case-study. It then describes the Vent DisCourse training material as this has been implemented in the WebCT platform and how these can be used by the trainees including communication with the trainers and assessment.

5.2.1. Web Based Training Material

The web based version of distance learning training material has the function of enabling trainees to access the developed material from different locations through a high speed internet connection. It could be used by companies within their CPD program and because of its distance learning format and its established certification scheme (by University participants) can be favoured by employees (trainees) as they can carry it out within their employment environment. The Web based version of the educational material will be made available using the WebCT educational software package, currently in use by Brunel University.

The Web based version of the material will also facilitate interactions between trainees and tutors by means of a discussion forum (bulletin board) established on the server of Brunel University, which will also assist the exchange of information, knowledge and experiences among the trainees. An electronic version of the printed educational material will also be made available on the Web Based version as well as other computerised materials such as calculation tools and engineering reference materials such as pressure drop charts. Case-studies of buildings with energy efficient ventilation design will also be made available for download using the WebCT educational software. The case-studies will contain a range of buildings from European countries showcasing monitored ventilation results of the ventilation systems applied to the buildings.

5.2.2. Description of WebCT

The WebCT educational software is an e-learning tool aimed at providing institutions with online course management, teaching, communication and learning tools to enable the development of internet based learning. Using WebCT the tutor will have the flexibility to deliver their course in the best way that fits their teaching style and their students’ needs using a range of developed tools that can assist both the tutor and student.

Figure 1 shows the logon screen of the WebCT educational software, accessed through the Brunel University website.
Figure 1: WebCT logon screen through the Brunel University website

Functions of WebCT

The WebCT educational software has a number of functions that will be used for delivering the distance learning training material developed in WP4 (a print version of the six modules of the distance learning training material, each to include educational content in self-learning sections, self-learning exercises and model assignments for assessing the learning of the trainees) to the trainees via the internet.

The functions of WebCT that will be used for the purposes of the Vent Dis.Course project are:

Remote logon facility providing access to the educational package through a high speed internet connection.

Description of the whole course for a specific group of students providing objectives, duration, tutors, assessments.

Secure download location for the six modules of the distance learning training material.

Secure download of the self assessment answers.

Appointment of specific release date and duration of self assessment answers.
On-line discussion forums allowing interaction between trainees and tutors and the exchange of information, knowledge and experiences among trainees.

**Example of WebCT Functionality**

WebCT can be accessed through the Brunel University website from the Web-based learning link as shown in Figure 2.

![Figure 2: Brunel University WebCT access](image-url)
A user name and password supplied by Brunel University to the trainee must be entered to gain access to the WebCT learning base developed specifically for the Vent Dis.course project, as shown in Figure 3.

Figure 3: WebCT logon screen through the Brunel University website
Figure 4 shows the first screen after access has been granted to WebCT. From this stage the interface has been specifically designed to meet the needs of the trainee and the tutor using the distance learning training material.
Description of Vent Dis.Course training material as implemented on WebCT

The WebCT educational package for Vent Dis.Course is split up into four sections with a representative icon on the menu page for each as shown in figure 4.

Module Notes
Module Question Answers
Collaboration
Assessment

Module Notes

The module notes section of the WebCT platform contains the paper based material developed in WP4 in an electronic format for download by the user. The distance learning training material is split up into 6 modules:

Foundation Module
Module 1: Natural and Hybrid Ventilation
Module 2: Natural and Hybrid Ventilation in the Urban Environment
Module 3: Energy Efficient Mechanical Ventilation
Module 4: Assessment of Building Ventilation
Common Resource Module

As shown in Figure 5.
Figure 5: WebCT menu screen for Module Notes section
The six modules are then split up further into sub-categories, which can be considered as study units for the trainee making the material easier to study with self-assessment questions and answers available at the end of each study unit. Module 1 is shown as an example in Figure 6.

![Figure 6: Sub-category selection screen of Module 1: Natural and Hybrid Ventilation](image-url)

**Module 1 - Natural and Hybrid Ventilation**

Each section below counts for 1 study unit of the whole course, please complete the questions after each unit. Answers will be made available by administrator.

1. Natural Ventilation Concepts
2. Natural Ventilation Techniques
3. Natural Ventilation Components
4. Air Flow Through Openings
5. Wind Driven Ventilation
6. Stack Driven Ventilation
7. Combining Wind and Stack Driven Ventilation with Mixed Mode Fans
8. Calculating Natural Ventilation Rate Using the Flow Equations, Wind Pressure and Stack Pressure Equations
9. Controlling Natural and Mixed Mode Ventilation
11. Designing for Natural and Mixed Mode Ventilation

Answers
The study unit that has been selected to study by the trainee is viewed on the screen inside WebCT via an external viewer, depending on the format of the material e.g. .pdf or .doc. The functions of that viewing program can then be used, for example to print the material.

**CHAPTER 1 Natural Ventilation Concepts**

**Learning Objectives**

This chapter outlines the development of natural and mixed mode ventilation systems for buildings and introduces basic definitions. After you have studied this chapter and completed the personal feedback form you should be able to:

1. Understand the concepts of natural and mixed mode ventilation;
2. Understand the conditions under which natural and mixed mode ventilation is applicable.

**Figure 7:** Selected sub category output screen showing chapter 1 of Module 1.
The selective release of self assessment question answers can also be set by the tutor using the WebCT interface as shown in figure 8. The tutor can select the dates of release or specify the time period that the self assessment question answers will be made available to the trainee for.

**Figure 8: Selective release function for release of self assessment question answers**
**Collaboration**

The collaboration icon leads the user to the collaboration menu which enables the Web CT functions of discussions, e-mail and chat to be used by the user or set up for use by the tutor. The Collaboration menu is shown in figure 9.
Discussions

The discussions function enables the trainee to communicate with other trainees studying distance learning training material developed by the Vent Dis.Course project or communicate with the tutor. This will facilitate interactions with the tutors and most importantly the exchange of information, knowledge and experiences among the trainees.

The user of the material may leave a message to be read by other users or reply to a message already posted in a particular discussions topic. New topics for discussion may be set by the tutors. Figure 10 shows the discussions screen where topics can be set and messages can be sent a read.
Figure 10: Discussion forum

E-mail

An internal e-mail system is available enabling the trainee to contact the tutor directly without making the message available in the discussions forum. This function ensures the tutor has always got a functioning email address for the trainee for the purpose of notifying the trainee of important information needed during the duration of the course.
Chat

The chat function makes the communication between tutor and the trainees more interactive. A chat room may be created by a user with other users then joining that chat room for interactive conversation. All users must be online at the same time. Figure 12 shows the chat selection screen where chat room can be accessed.
Figure 12: Chat function of WebCT
Assessment

The assessment menu page has two functions which may be used for the purposes of the Vent Dis.Course project.

Quizzes/Surveys
Assignments

The Quizzes/Surveys function will enable the student (trainee) to leave feedback on the course. This will be a useful function when the distance learning training material developed by the Vent Dis.Course project will be tested by means of a pilot course, which will take place during WP6: Testing of the vocational training package by selected European experts and through pilot distance learning activities.

Feedback questionnaires may be specifically designed and posted on the internet using this function for the purposes of collecting comments of the participants for possible improvement during the finalization of the educational material and the training methodology.

The assignments function will enable the tutors to upload assignment to a secure location on WebCT, specifying the selective release dates and notifying the student (trainee) of specific instructions related to the assignments.

Figure 13: The Assessment function menu screen
5.3. CONTENTS OF SHORT EDUCATIONAL ARTICLES FOR CPD

In addition to the material developed for master level professionals, four short articles were developed on specific topics for wider dissemination. The topics were chosen because they were indications that they would be of interest to engineers or because they cover results of recent research activities. The articles were firstly written in English and published in the REHVA journal and there are also being translated into another three languages for further opportunities for dissemination in national professional journals. The articles cover the following topics:

1. DISPLACEMENT VENTILATION IN NON-INDUSTRIAL PREMISES

This article (Skistad 2006) gives a brief description of displacement ventilation as used in non-industrial premises. The main advantage of displacement ventilation is that it can provide better air quality in the occupied zones than mixing ventilation. The system is best suited for meeting rooms and other premises where air quality is the main objective. When the main objective is cooling and temperature control, as in most office spaces, other systems may be more advantageous. The article is based on Rehva Guidebook no.1: “Displacement Ventilation in Non-industrial Premises” (Skistad et al, 2002).

2. PERFORMANCE OF NATURAL VENTILATION IN THE URBAN ENVIRONMENT

This article (Farrou and Santamouris, 2006) focuses on the performance of natural ventilation in the urban environment as this can be seriously reduced by the specific urban characteristics. The main constraints to natural ventilation in the urban context are reduced wind speeds, high ambient temperatures due to the heat loads from the buildings and traffic (island effect), increased external pollutants and increased noise levels. This article evaluates the potential application of natural ventilation in urban buildings based on the results of theoretical and experimental research that was carried out in real urban environments. Additionally, alternative ventilation strategies are described that can be used to enhance airflow in naturally ventilated buildings in urban areas.

3. ENERGY IMPACT OF VENTILATION:

This article (Liddament, 2006) focuses on the energy impact of ventilation. In energy efficient buildings the energy impact of ventilation can account for 50% of total energy dissipation. Therefore understanding this energy impact is vital for proper resource management. This course provides simple guidance on calculating ventilation related energy losses for both heating and cooling conditions. (Colliver, 1995)

4. ASSESSMENT OF VENTILATION AND COMFORT

This article (Brown, 2006) briefly discusses the relationship between design, commissioning and control of building ventilation systems to achieve an optimal balance of comfort and energy performance. It then describes the practical measurement of ventilation and comfort parameters that will assist in “tuning” the building systems to meet the needs and expectations of the occupants.

The articles are published in the REHVA journal are available from www.rehva.com
6. Main results of WP5: Establishment of the training methodology and description of the organisation of the material

This section mainly concerns the description of the training methodology. The training methodology is aimed at training organisations intending to use the training material developed in the project so that trainers become acquainted with the aims of the material and the appropriate means of delivery. Trainers can then develop (or even adapt) lessons and training schedules to meet local needs e.g. in a block delivery teaching method lasting a few hours, a few days or one week suitable for short CPD training activities. By following the guidelines of the training methodology, the content of the assessment material is compatible with the aims of the developed training material and their relevance to the EPBD. This methodology is therefore based on the developed distance learning material and will be used after the conclusion of the project either by the participants of the consortium or by other educational interested bodies.

In parallel with the training methodology, the operational schedule of the on-going course has been created. The longer term maintenance and sustainability of the course has also been discussed.

The course material is aimed at postgraduate students with either an engineering or architectural background. It is envisaged that the full course could be offered as either part of a Masters degree course or as a stand-alone continuing professional development (CPD) course. Therefore, any potential student should have completed a first degree (i.e. a bachelors degree) in a relevant subject. Selected parts of the course can also be offered as short courses, seminars and CPD articles.

It is envisaged that full course will be offered in a distance-learning format, methods of which are discussed in this report. This does not preclude parts of the material being delivered by other methods such CPD articles and conventional lectures.

6.1. Operational schedule

It is important that a course for ventilation system designers fits both the educational context and the professional context in the countries where it is made available. This is so that successful students are properly recognised and rewarded for their efforts. The suggested routes to achieving these rewards are:

The complete course can form part of a master’s degree in building engineering or related subject.

All or part of the course can be recognised (accredited) as continuing professional development by professional institutions (e.g. the constituent professional bodies of REHVA).

In order to be consistent with (a) the overall length of the course including personal study, tutorials (if provided) and assessment exercises should be at least 150 hours. This is typically equivalent to 15 university credits. This is based on the UK practice of awarding credits for modules based on 10 hours work per credit. UK Masters level modules are typically 15 credits each, with 180 credits needed for the award of a Masters degree. Similar criteria apply in most European countries. Transferability of courses throughout Europe has been helped with the introduction of the European Credit Transfer System (ECTS), which specifies credits for student workload and a system for grade equivalence.

The structure of the course is based on existing distance learning courses provided by Brunel University. The material is structured in 5 modules that are intended to be studied in sequence.

“Module 0” is the foundation module. This provides basic information on issues in ventilation system to provide a common basis for students from a variety of backgrounds to study the technical modules. The other modules are:
Module 1 Natural and hybrid ventilation
Module 2 Ventilation in urban buildings
Module 3 Energy efficient mechanical ventilation
Module 4 Assessment of building ventilation

Each of these modules is broken down into discrete chapters. Each chapter is intended to be absorbed at a single learning session and is provided with personal feedback questions that the student can use to evaluate their understanding of the material. The structure is shown graphically in Figure 1.

Modules 1 to 4 are available as paper versions or for electronic distance learning and full draft versions have already been produced.

In addition, there is a common resource “module” containing supporting material in only electronic formats. This can be provided through web access or on CD and includes extended cases studies, software models, background information for assignments and other multimedia material considered potentially useful to students. The material supplied by the project group is mainly in English but equivalent or additional material in local languages can easily be added for other countries.

Each country and educational institution has their own criteria/curricula for educational programmes leading to recognised qualifications. Integration of the material developed as part of this project into an educational programme is at the discretion of the institution concerned to meet its own objectives. The material can be used in the format supplied or adapted to suit local needs. For example, natural ventilation is not so relevant in Nordic counties and so may be deemphasised from any programmes offered in these countries. However, architects, construction consultants and ventilation designers operate in an international market so they should be familiar with concepts even if these are not widely used locally.

Figure 1 Graphical representation of course structure
The estimated study time to be applied to each module is shown Table 1. This includes personal feedback and assessment exercises.

Table 1 Study times

<table>
<thead>
<tr>
<th>Module</th>
<th>Study time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module 0 Foundation module</td>
<td>30</td>
</tr>
<tr>
<td>Module 1 Natural and hybrid ventilation</td>
<td>30</td>
</tr>
<tr>
<td>Module 2 Ventilation in urban buildings</td>
<td>20</td>
</tr>
<tr>
<td>Module 3 Energy efficient mechanical ventilation</td>
<td>40</td>
</tr>
<tr>
<td>Module 4 Assessment of building ventilation</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>150</strong></td>
</tr>
</tbody>
</table>

The authors will provide a selection of draft assessment question for each module. These are based on the contents of the module and supporting material from the common resource module. However, the way in which assessments are used will vary depending on the specific requirements of the training institution and qualification body. For example, some institutions may offer qualifications purely on the basis of assessment while others may require a combination of assessments and formal examination. In all cases the institution will need to adhere to its own system for ratification of courses and awards, whether this is
though an internal mechanism (universities) or third party accreditation (other training centres) or both. It is mainly for this reason that the project partners have decided not to impose rigid certification process for institutions and awards.

Continuing professional development (CPD) articles represent an alternative form of learning resource where specific elements of the course are distilled into short presentations that can be published in conventional media such as professional and trade journals. These articles include technical information, illustrative case studies and questions. Readers of the journal can submit their answers to the publisher for evaluation, correct answers being rewarded with CPD points that are recognised by professional institutions. Four of these CPD articles have been produced so far on the basis of the draft modules.

6.2. Certification and long term maintenance

The issue of certification (accreditation) of training institutions, courses and awards was mentioned in the original project proposal. The advantage of certification is that it is can provide consistency of training and qualifications throughout the participating countries. The disadvantages are the potential inconsistencies of Vent DisCourse requirements with local rules for academic and professional qualifications and the long-term administrative overhead (with associated costs) of operating a Europe wide scheme.

Proposals for a certification scheme were presented at the second project meeting (November 2005). As a result of discussions between partners concerning the needs of the training institutions and professional bodies in the countries that they represent it was decided not to impose specific certification requirements for institutions or awards within the scope of the project. This means that training institutions will be able to make best use of the material within the context of their established qualification frameworks at both institutional and national level. The quality of training and awards will be assured through the normal quality control mechanisms operating in the universities and other institutions delivering the training. The project partners will concentrate on developing the material and the delivery mechanism.

This decision does not preclude the possibility of mutual recognition of awards and qualifications or the future establishment a certification scheme if supported by stakeholders.

It is important that the material developed in the project continues to be developed after completion of the project, in line with technical progress in ventilation technology and feedback from the training institutions that use the material. One way of achieving this would be by a continuing collaborative effort between the original project partners and the institutions that take up the material, possibly with an annual conference to discuss feedback and disseminate proposed changes and additions. Such a conference could be coordinated through REHVA.

In conclusion, the course material has been designed around a modular concept for distance learning and is suitable for both electronic and traditional means of dissemination.

Where the course leads to a recognised qualification, the material would need to be assessed by the relevant national qualifications assessment body. As a quantified contribution to continuing professional development, the course would need to be approved by a relevant professional institute such as CIBSE (Chartered Institute of Building Services Engineers) in the UK.

As the course is aimed at the postgraduate market, possibly as part of a master’s programme, it should be easily transferable across Europe after the Bologna Declaration.
7. **Main results of WP6: Testing of the vocational training package by selected European experts and through pilot distance learning activities**

The Distant Learning Material was tested by using three methods.

1) Evaluation the material by experts in ventilation technology representing ventilation industry, consulting, teaching and research. Experts were selected to that they represented also the geographic and climatic distribution in Europe.

2) Evaluation workshops were organized in four locations in Europe. Experts of ventilation were invited into those courses to evaluate the material and to give feedback for improvements. The seminars were organized by REHVA in Prague, by ETPE in Lyon, France, by University of Athens in Greece, and BRIA in UK.

3) Pilot training with university students in seven universities representing different geographical and climatic regions in Europe. The feedback was collected from both students and teachers.

### 7.1. Review of the material by the experts

The draft material was reviewed by following 10 European experts of ventilation. The comments were dealing general presentation, layout, typos and language. All comments were distribute to authors, and integrated in the final text.

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>Background</th>
<th>Reviewed modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jorma Railio</td>
<td>Finland</td>
<td>Manufacturer</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Peter Warren</td>
<td>UK</td>
<td>Research</td>
<td>Natural and hybrid</td>
</tr>
<tr>
<td>Peter Novak</td>
<td>Slavenia</td>
<td>Consult</td>
<td>All</td>
</tr>
<tr>
<td>Johnny Andersson</td>
<td>Sweden</td>
<td>Consult</td>
<td>All</td>
</tr>
<tr>
<td>Karel Kabele</td>
<td>Czeck R</td>
<td>Instructor</td>
<td>All</td>
</tr>
<tr>
<td>Cesare Joppolo</td>
<td>Italy</td>
<td>Professor</td>
<td>All</td>
</tr>
<tr>
<td>Michael Schmidt</td>
<td>Germany</td>
<td>Professor</td>
<td>All</td>
</tr>
<tr>
<td>Nejat Demircioglu</td>
<td>Turkey</td>
<td>Mech eng + instructor</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Derrick Braham</td>
<td>UK</td>
<td>Consult</td>
<td>All</td>
</tr>
<tr>
<td>Nick Cullen</td>
<td>UK</td>
<td>Consult</td>
<td>Natural and hybrid</td>
</tr>
</tbody>
</table>

### 7.2. Evaluation workshops

Four evaluation workshops were organized in May-December, 2006, in Prague (REHVA), Greece (NKUA), France (ENTPE), and UK (BSRIA). In addition, a workshop was organized at Lausanne, Switzerland, within the programme of CLIMA 2005 conference. In general the Course material was well received and appreciated. The comments form the seminars were collected and distributed to authors. With their participation, the attendants received the seminar proceedings that included the programme of the seminar, a copy of all presentations in English and a sampler of the Vent Discourse training material. Presentations from the seminars are available from the project’s website.

**Seminar in Prague:**

This was the first evaluation workshop held on 16 May 2005 in Prague. This was organised by REHVA under the auspices of the 17th international conference of air-conditioning and
ventilation. It was attended by representatives of professional bodies from Europe and the US, academics and students who made specific comments and promised valuable contributions. There were presentation by M Kolokotroni, O Seppannen, M Liddament, R Brown, I Farrou and J Shilliday.

Seminar at DeMontfort University, UK

The Vent Dis.Course project had its second seminar/evaluation workshop for the distance learning training material it is developing, on 12 July 2006 at the Queens Building, DeMontfort University, hosted by Dr M Cook of the Institute of Energy and Sustainable Development. The seminar was organised by BSRIA under the auspices of the CIBSE Natural Ventilation Group Seminar Programme and included presentations by Dr Maria Kolokotroni, Martin Liddament, Reginald Brown. It was advertised through CIBSE and by direct mail to BSRIA members. It was attended by representatives of industry and CPD providers in the UK, together with academics and students from DeMontfort University.

The speakers outlined the background to the project, development of the training materials and arrangements for dissemination in the UK including how the material would be made available to universities and other training providers to incorporate in their own training schemes. Much of the discussion concerned arrangements for the pilot courses and recruitment of experts to review of the material. Several members of the audience offered their assistance for this task and materials were emailed to them after the workshop.

The seminar concluded with a guided tour of the Queens Building which was one of the first purpose-designed naturally ventilated educational buildings in the UK.

Seminar at NKUA University, Greece

The Vent Dis.Course material was presented during the national seminar entitled: ‘Building Energy Consumption – Evolution in the Area of Building Ventilation and Insulation Materials’ The seminar was held in Athens (at the University Campus in Zografou) on 3rd October 2006. The seminar was organized by the National and Kapodestrian University of Athens (Greece) and the Aristotle University of Thessaloniki (Greece) within the frames of the European research programme ‘Vent Discourse’ ‘Development of Distance Learning Vocational Training Material for the Promotion of Best Practice Ventilation Energy Performance in Buildings’ and the National research programme ‘SAPPEK’ ‘Design and Development of Innovative Stonewool Products for the Energy Upgrading Of Existing and New Buildings’.

The aim of the seminar was to disseminate the training material that was developed within the Vent Dis.Course project and to present the outcome and progress of the national programme SAPPEK. The lectures that were carried out were split into two sessions: the morning session concerning the Vent Dis.Course project and the evening session including the presentations of the SAPPEK project.

Within the frames of the morning session on the Vent Dis.Course project, an introductory presentation was carried out regarding the objective of the Vent discourse material and a description of the current status of the energy consumption of buildings in Greece focusing on the area of ventilation. Four presentations followed on the individual modules that were developed within the project. Although the seminar was national and it was addressed at a Greek audience the official language of the presentations was Greek or English.

The lecturers were: Jason Shilliday representing Brunel University and responsible for the presentation of the Foundation and Resource Module, Martin Liddament representing VeeTech Ltd and responsible for the presentation of Module 1, Mat Santamouris and Ilgenia Farrou representing NKUA and responsible for the introductory presentation and presentation of Module 2 respectively. Modules 3 and 4 were presented by Agis Papadopoulos representative of the Aristotle University of Thessaloniki. As it was decided among the Vent Discourse partners, all presentations followed the same layout and context with the presentations of the seminar that was held in Prague on 16th May 2006.
The seminar was advertised by NKUA (through emails and posters) and the Technical Chamber of Engineers (TEE) (a summary of the programme was advertised in one of the weekly issues of TEE three weeks before the seminar date). The seminar was of great interest and well received. The attendants were post-graduate students and professionals with a background on engineering or physics, the majority of them were architects and civil engineers.

Seminar at ENTPE, Lyon, France
Following the lectures held in November, a seminar held on 20th of December 2006 in ENTPE, to receive formalized comments by the students (master students in Building Sciences) in the presence of their tutor and invited expert.

Workshop at CLIMA 2005, Lausanne, Switzerland
A workshop was organized for CLIMA 2005 Conference, 8-10 October 2005, Lausanne, Switzerland. This workshop was very useful in order to announce the project and also get feedback from experts on the structure of the material. A paper was written on the workshop and this was distributed by post after the conference to all participants of the conference.

7.3. Testing at universities
The Distant Learning Course was tested in Finland, France, Czech Republic, Denmark, Greece and UK. The countries were selected so that they represent different climates and building traditions of Europe. Eighteen students used the material in their studies either for Master’s or PhD level. These students returned individual comments through an ‘end-of-course’ questionnaire. In addition 40 students (La Rochelle and ENTPE) used the material through their teachers; they returned collective comments through their teachers.

The following is a description on how testing was carried out with students at Brunel University. As mentioned before students from other universities also used the WebCT internet platform established at Brunel University. All students were given username and passwords to assess the material which is password protected.

How pilot training was carried out at Brunel University
The Pilot Training at Brunel started on the 2nd October 2006 and was completed on 12th January 2007 with the submission of the second assignment. It included seven students at masters and doctoral levels. All students studied the material and six (of the seven) submitted two assignments so that they are assessed for the module. They have all submitted very good assignments and were marked by M Kolokotroni; (course lecturer at Brunel).

The students were given access to the WebCT material in the beginning of October and were told to study the Foundation module.

A week later, they were given their first assignment (mainly concerned with Natural and Hybrid Ventilation Design) based on Modules 1 and 2. Submission of the assignment was set for 10 November 2006 in consultation with the students. Most students were MSc students in the beginning of their studies (so relatively free of other homework) so one month was a reasonable period. They were weekly meetings with the students to answer possible questions and also email was used in between. The ‘common resource’ module was also useful for this phase of training, in particular the section about computerised tools.

After finishing the first assignment, students were told to study modules 3 and 4. The second assignment was given to the student in the middle of November with a deadline for submission 12 January 2007 (just after the Christmas break). Weekly meeting continued with the students and queries were answered via email. As mentioned before six students...
have successfully completed the training with very good results. They have returned the ‘end-of-course’ questionnaire with very useful, mostly contents related comments.

**Student feedback and summary of comments**

The results of the ‘end-of-course’ comments by the students, collected with a detailed questionnaire are summarized in the following. More detailed information is given in the report ‘WP6 Final Report: Testing of the vocational training package by selected European experts and through pilot distance learning activities’.

**General impression**

The general impression on the content of the education material is very positive and promising. It was believed that material is a very concise, pragmatic and comprehensive report on methodologies to assess measure and qualify the building ventilation parameters and the commissioning process that takes a building from “practical completion” to a functioning environment.

In general, the material was well received and understood; the students admitted that it covers a great range of issues on ventilation that were not taught as a whole in their first degree. Also, the testing of the Vent Discourse material formed a good example of using the distance learning methodology as this process is not widely used.

The general impression of the training material is that it is concise and very detailed on every chapter.

**Over all evaluation of the Course**

The difficulty level of each module varied according to the background (first degree) of each student; however the difficulty level would range at the scale of ‘3’ or ‘4’ with 5 representing ‘very difficult’. In general, students have more difficulty to understand chapters with equations i.e. Module 2 – Chapter 2, Module 3 – Chapter 4. The average evaluation of the material was 3 – just on the right level. Evaluation of course depended on the background and the level of studies – however, the not so much as could have been assumed.

Module 4 ‘Assessment of Building Ventilation’ was of particular interest as none of the issues that are presented are taught in some universities. Usually, post graduate and PhD students deal with monitoring and commissioning issues via practice when participating in experiments, however the theoretical background is often missing.

The questions, exercises and assignments form excellent tools to enable the student to better comprehend the material. The content and level of this tools is of adequate quality, however the way of presenting them to the student could be more user friendly in specific cases (specific comments below)

The material is provided in such a way that it is easy to study through a distance. It is adequate for people desiring more specific knowledge on the subject but having other responsibilities or being unable to be in a classroom. The student can adjust his/her own learning process to his/her ability and time availability, without being affected by the different backgrounds and entry levels of other students. The tools available to support the process are of high quality and can easy the learning process for the student by providing good coaching and communication tools.

The structure and content of the course is useful and appropriate to master degree students.

The material is presented in a clear manner, without difficulty to understand. The questions, exercises and assignments are adapted to the different modules. The common resource module is adequate. Students suggest to supplement by a technical glossary about ventilation systems, mainly for master students.
The students have been happy to study the material in distance learning mode for the interaction and the self-evaluation. But this tool cannot be used in place of classroom. Some information of foundation module, modules 3 and 4 need some requisite for master students. The material is very helpful, and the students and teachers in general thank to the team behind the publication.

Some improvements are still suggested:

It would be better if the course book (all modules) has even more consistent format of presentation: heading, table and figure in titling and numbering method as a unity book. One table or a figure only has a specific number throughout the book. It will make easy to refer to and minimise confusion. Consistency of symbol and notation will help much to avoid misinterpretation. List of symbols is necessary.

Self assessment questions were consider adequate for all modules, however it might be better if some examples of problem solving are described as well in the text.

Does the course fit in the degree studies?

The initial level of the training material is quite appropriate for anyone having a slightly technical background and at least a BSc degree. It might be too basic for experts on building ventilation, but this is not the target group.

7.4. Future development of material and training

Suggestions for further development and improvement of the structure include a general online introduction providing information on the structure of the material, the modules to follow, reference to the tutors and giving a timetable of the material with hours to spend on each module and deadlines for the questions.

Also, it would be desirable to give the possibility to the students to have access to different modules at the same time in the case that issues mentioned in a specific module are explained in other modules (for example module 2 relies on the foundation module and refers to it. It would be user-friendly and time consuming if the students could have access on-line from module 2 to the foundation module.)

Some students expressed the need for more pictures and illustrations and examples of applications (i.e. Module 2, case studies, Module 4 pictures of sensors, examples of IAQ monitoring in buildings)

The students got easily familiar with the distant learning methodology. However, some of them expressed their preference to the traditional way of learning with the physical attendance in the classroom and the interaction between the students and tutor; in this way questions can be answered immediately. Also, the students are closer to a timetable and can profit from the others’ questions. However, these issues can be solved in the distance learning methodology by using deadlines, and also the further development of the chat room in the WebCT platform with common hours when all users, students and tutors would be on line.
8. **Main results of WP7: Preparation of Final distance learning modules and delivery to Commission**

8.1. **Final preparation of the educational material**

As mentioned before all comments from testing the material was distributed to authors and relevant comments were incorporated in the material. There was no need to change the structure of the material but numerous comments were received on the detailed points. This was very welcomed by the partners and it indicated that initial time dedicated to formulate the structure was well spent. I also indicated that it is very important to have specialised technical person to prepare the material.

8.2. **Translation of all educational material to Finnish**

A large amount of effort was dedicated to the translation of the material into Finnish. This is because there are plans to make the material available through REHVA to be translated in the national languages of their members. Therefore, the method had to be demonstrated.

The translation process have been developed and tested in the project during 2006 through a subcontractor (FINVAC). Files are organised so that the original layout can be used and the only the text translated. This applies also to figures, captions and tables (an example of translated pages is shown in the following pages).

As mentioned before, the final text will be offered for translation and use in training to all 30 REHVA member associations so that it can be used both in professional training and in academic institutions.
| **•** the processes causing pollution shall be equipped with local exhaust systems | - epäpuhtauksia aiheuttavat prosessit varustetaan paikallisilla poistoilmalaitteilla |
| **•** pollution generating processes should be located in separate rooms whenever possible to minimise the spread of pollutants to other rooms | - epäpuhtauksia aiheuttavat prosessit eristetään omiin tiloihinsa aina kuin mahdollista epäpuhtauksien leviämisen ehkäisemiseksi |
| **•** the air balance (difference between supply and exhaust air flows) of the rooms should be so that air flows from less polluted rooms to more polluted rooms | - virtaustaseen (ero tulo- ja poistoilmavirtauksien välillä) huoneissa tulee olla sellainen, että puhdas ilma virtaa epäpuhtaampiin vyöhykkeisiin eikä päinvastoin. |
| **•** supply air jets should be directed so that they do not increase the spread of pollutants but decrease it. | - tuloilmasuihkut tulee suunnata siten, että ne vähentävät epäpuhtaampia leviämistä, eikä päinvastoin. |

The air balance principle of the ventilation means that air always flows from room with higher air quality to the rooms with lower air quality and higher pollution generation. This means that clean air is supplied in the cleaner rooms and exhausted from the polluted rooms, and air is transferred from “clean” to “dirty” rooms.

In residential building this means that outdoor air is supplied to bedrooms and living rooms and exhausted from kitchens, bathrooms and toilets, etc.

In commercial buildings air is supplied to the occupied zones and exhausted from rooms with pollution generation so that air balance is positive in the occupied rooms and negative in rooms with higher pollution generation. The following principles should be applied. They are illustrated in Figure 2.
1) pollution generation processes are equipped with local exhaust; 2) exhaust air grilles and openings are located above the warm pollution generation sources; 3) air is supplied in the occupied zone in the rooms with high pollution generation to reduce exposure of the occupants to pollutants; 4) clean air is supplied to rooms with no specific pollution generation; 5) total exhaust air flow is larger than the supply air in the rooms with high pollution generation; 6) air is transferred from cleaner areas to more polluted areas through the openings in walls or doors.

Figure 2 Principles to control air quality in mechanical ventilation system.

1) Epäpuhtauslähteet varustetaan paikallisella poistojärjestelmällä; 2) Poistoilmaventtiilit ja aukot sijoitetaan lämpimän epäpuhtauslähteen yläpuolelle; 3) Ilma tuodaan likaiselle oleskeluvyöhykkeelle vähentämään oleskelijoiden altistumista epäpuhtauksille; 4) Puhdasta ilmaa tuodaan myös huoneisiin, joissa ei ole epäpuhtauslähteitä; 5) Kokonaispoistoilmavirta on suurempi kuin likaisen huoneiden tuloilmavirta; 6) Ilma siirretään puhtaimmilta vuohakaiveltä likaisemmille väliseinien tai ovien aukoista.

Kuva 2. Periaatekuva koneellisen ilmanvaihdon ilmankausta, joka mahdollistaa hyvän ilmanlaadun

1.5 Heating demand and energy use for ventilation

Heating demand of outdoor air supplied to the rooms can be calculated from the

Huoneisiin toimitettavan ulkoilman lämmitystarve voidaan laskea seuraavasti

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The following equation (assumes 100% outdoor air):

\[
\Phi_{\text{vent}} = c_{pa} q_{m} (t_{\text{sup}} - t_{\text{out}})
\]

Where

- \( \Phi_{\text{vent}} \) is the heating demand, kW
- \( c_{pa} \) is the specific heat capacity of air = 1 kJ/kgK
- \( q_{m} \) is the mass flow to the air, kg/s
- \( t_{\text{sup}} \) is the supply air temperature, °C
- \( t_{\text{out}} \) is the outdoor temperature, °C

Energy use for heating the air flow is calculated from the equation:

\[
Q_{\text{vent}} = c_{pa} \sum q_{m} (t_{s} - t_{u}) \Delta \tau
\]

Where

- \( c_{pa} \) is the specific heat capacity of air, \( c_{pa} = 1 \) J/kgK
- \( Q_{\text{vent}} \) is the heating energy for the air flow during time \( \Delta \tau \), kWh
- \( q_{m} \) is the mass flow to the air during time period \( \Delta \tau \), kg/s
- \( t_{s} \) is the supply air temperature, °C
- \( t_{u} \) is the outdoor temperature, °C
- \( \Delta \tau \) is the time period during which the air flow and temperatures occur, h

In practice the density of the air is assumed usually constant and the relation is used in the following format:
When the air flow is constant, the formula gets the form:

\[ Q_{vent} = c_{pa} \rho \sum q_v (t_{sup} - t_{out}) \Delta \tau \]  

\[ Q_{vent} = c_{pa} \rho \sum q_v (t_{sup} - t_{out}) \Delta \tau \]

In equation (7) the term \( \sum (t_{sup} - t_{out}) \Delta \tau \) is the sum of temperature differences over the selected time period. This is graphically illustrated in Figure 3.

Yhtälössä (7) termi \( \sum (t_{sup} - t_{out}) \Delta \tau \) on aikavälillä \( \Delta \tau \) esiintyvien lämpötilaerojen summa (astetuntiluku), mikä esitetään kuvassa 3.

Shaded area in this temperature graph is proportional to the energy use for ventilation during selected period of time.

Kuvassa varjostettu lämpötila-alue on verrannollinen ilmanvaihdon energiankulutukseen valittuilla aikavälillä.

Figure 3 Energy use for ventilation, principle.

Kuva 3 Periaatekuva ilmanvaihdon energiankulutuksesta.

1.6 Ventilation and pressure differences in the building

Ventilation affects also the pressure differences over the building structures. This can be beneficial or harmful. In situations with no special requirements or emissions, ventilation systems should be designed for neutral pressure conditions.
One of the most important issues in respect of healthy buildings is to keep building structures dry and prevent the condensation in and on structures. In cold climates the water content of the air is usually higher indoors than outdoors. If the pressure is higher indoors the air with high moisture content may flow into the cold structure and water vapour may condense and cause mould growth, reduce the thermal insulation properties and lead to other harmful effects. To decrease the risk of condensation these buildings should have higher exhaust flow rates than supply flow rates.

<table>
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<th>in the building.</th>
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<td>One of the most important issues in respect of healthy buildings is to keep building structures dry and prevent the condensation in and on structures. In cold climates the water content of the air is usually higher indoors than outdoors. If the pressure is higher indoors the air with high moisture content may flow into the cold structure and water vapour may condense and cause mould growth, reduce the thermal insulation properties and lead to other harmful effects. To decrease the risk of condensation these buildings should have higher exhaust flow rates than supply flow rates.</td>
<td>Yksi tärkeimmistä toimenpiteistä terveellisen sisäympäristön varmistamisessa on pitää talon rakenteet kuivina ja estää kondensointuminen rakenteiden sisällä sekä päällä. Kylmissä ilmastonalaisissa ilman vesisisältö on yleensä suurempi sisällä kuin ulkona. Jos paine on suurempi sisätiloissa, lämmin ja kostea sisälma virtaa ulos rakennuksesta törmäten matkalla kylmiin rakenteisiin. Tällöin rakenteiden pinnoille voi kondensoida vettä, josta taas voi seurata homeen kasvua, lämpöeristyksen huononemista ja muuta haitallista. Kondensaatiotiskin vähentämiseksi kylmissä ilmastonaloissa rakennusten poistoilmavirran tulee olla tuloilmavirtausta suurempi.</td>
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9. Main results of WP8: Common Dissemination activities

This section describes and lists the dissemination activities during the project. It concludes with plans for future use of the educational material.

9.1. Description of activities

Website

A website dedicated to the project was created where all information about the objectives, development and results of the project will be published (www.brunel.ac.uk/ventdiscourse). Information is updated regularly and will be available to interested bodies for a number of years.

Presentation to conference, articles published and papers

Three planned presentations were made to three European conferences.

AIVC/EPBD Conference: 21-23 September 2005, Brussels

A presentation about the project was made within the EPBD strand of the conference, session 8 (Dissemination, training and non-technical issues), Friday 23 September.

CLIMA2005 Conference: 8-10 October 2005

A workshop was organized for CLIMA 2005 Conference, 8-10 October 2005, Lausanne, Switzerland. A paper was written on the results of the workshop. This was included in a hard volume with all papers of the workshops and was distributed by post after the conference to all participants of the conference.

EPIC/AIVC Conference, 20-22 November 2006

A paper of the developed educational material was presented to the EPIC/AIVC conference on 22nd November 2006. The paper is included in the proceeding of the conference.

International Journal of Ventilation paper, summer 2007

A paper based on the results of the project has been submitted for publication to the international journal of ventilation. If accepted the paper will be published in summer 2007 and will reach audiences beyond Europe.

REHVA Journal article

An article about the project was published in the REHVA journal.

First CA-Webzine article

An article about the project was published in Webzine, the regular electronic newsletter of the European Building Performance Directive Concerted Action in August 2005.

Second CA-Webzine article

An article with the results of the evaluation workshop in Prague was published in Webzine, in June 2006.

IEEA newsletter:

A short paragraph about the evaluation workshop in Prague was included in this newsletter.

CIBSE Natural Ventilation Group Newsletter

An article about the project was to be included in the Natural Ventilation Group Newsletter of CIBSE in September 2006.

CIBSE Journal:
An article with the results of the evaluation workshop in DeMontfort University was published in the CIBSE journal, in September 2006. This generated some interest from professional to participate in future training.

REHVA General Assembly

Two presentations about the project were made to REHVA’s general assemblies in Moscow, May 2006 and Lausanne October 2005.

Newsletter

The first newsletter of the project was distributed through REHVA journal, AIVC/INIVE AIR magazine and was made available to conferences (CLIMA 2005 and PANLEC 2005).

The second and final newsletter with the results of the project will also be distributed through REHVA journal and AIR magazine and will be available to relevant conferences (eg CLIMA 2007, June 2007 and AIVC/PANLEC, September 2007).
9.2. Future use of the Vent Discourse material and plans for translation

REHVA

The material will be made available to REHVA national members in 30 European countries. These REHVA organisations represent more than 100,000 experts in the area of building services engineering. The material will be also made available through AIVC/INIVE to all members of the organization. Specific plans are already made for some countries.

Greece

The aim is to implement the Vent Discourse material as a part of the post graduate course ‘Energy Design and Environmental Quality of Buildings’ that is being carried out by the group of building Environmental studies of the National and Kapodestrian University of Athens, in collaboration with the European Organisation of Research on Renewable energy, and the Centre of Vocational Training. The seminar is addressed at professionals with a degree on building studies i.e. architects, mechanical engineers, physicists, etc. The seminar is established the last 2 years and currently runs for 3 months.

Moreover, the Vent Dis.Course material will be provided by the National and Kapodistrian University of Athens’ Vocational Training Centre as a distance learning programme. Aim of the National and Kapodistrian University of Athens’ Vocational Training Centre is the provision of adult education services, Ultimate aim of the programme is the meeting of the detected educational needs and the provision of complementary necessary qualifications in people that wish to amplify their knowledge and gain new professional skills in building ventilation, thus improving their cognitive level and reinforcing their competitiveness within the market.

Additionally, it is considered to promote the Vent Dis.Course material through the Technical Chamber of Greece (TEE). The Technical Chamber of Greece was established in 1923 and is a public legal entity. Among its duties, it participates in international organisations, in unions and federations of engineers, develops relations with similar organisations of other countries and organises conferences, exhibitions and seminars of relevant interest in the field of engineers.

France

The course will be implemented by credits by the institution for all the master students at ENTPE. In the other hand, all the modules have been translated in French to order to prepare the dissemination of this tool in France, professional users and students.

UK

Brunel University has already integrated the material in the MSc Building Services Engineering with Sustainable Energy. This MSc will be available in Distance Learning mode of study from September 2007.

BSRIA is examining the possibility of publishing part of the material in a condensed form as a stand alone reference book for existing building services engineers.
10. Summary of main results and conclusions

This report describes the EIE project entitled ‘Development of Distance Learning Vocational Training Material for the Promotion of Best Practice Ventilation Energy Performance in Buildings’ (Contract no EIE/04/022/S07.38630) which is partly funded by the European Commission, Intelligent Energy Europe Programme. The overall duration of the project was 24 months, starting on the 1st January 2005 to the 31st December 2006.

The project is coordinated by Brunel University (Mechanical Engineering Department), with the participation of University of Athens (Department of Applied Physics), REHVA (Federation of European Heating and Air conditioning), BSRIA Ltd (Building Services Research Industrial Association), ENTPE (Ecole Nationale TPE, Laboratoire Sciences de L’Habitat – CNRS-DGCB) and four major subcontractors; Veetech Ltd, Université of Thessaloniki, FINVAC and AIVCF.

The main final achievements of the project are:

1. Development of educational material on energy efficient ventilation suitable for distance learning and testing through pilot distance learning activities in six European Universities.
2. Description of its training methodology and operational schedule for implementation into masters level training and translation to other languages.
3. Dissemination by organising workshops, publication of Continuing Professional Education (CPD) articles in professional journal (REHVA journal) and announcements in relevant European conferences and events.
4. Development of plans for the future use of the distance learning educational material by participating universities, REHVA through its members and INIVE.

THE DISTANCE LEARNING EDUCATIONAL MATERIAL

Requirements, market and availability of source material

A review and evaluation of educational distance learning methods for target audience and their application to building ventilation vocational training material was carried out as part of the project. It concluded that there is need to improve the skills, competence and knowledge of professional engineers but time pressure and professional responsibilities comprise a barrier to the continuing training. Distant learning vocational material provides flexibility, independent studies, individualization, globalisation of the market, easy exchange of experience and adaptation to the new technology and legislation. The training material of this project focuses on the ventilation and its energy impact to meet the building regulations and the EU Building Directive. A market study carried out indicated that the potential trainees for which the vocational training material would be developed are building designers (architects) and building services engineers. A study of all applicable distance learning methodologies was carried out and concluded that the following products are appropriate for the dissemination of the knowledge on ventilation and its relevance to EPBD. Therefore, the training material will be disseminated through:

- Printed material in the form of distance learning education delivery format or CD-ROM
- Web-based modules
- Continuing Professional Education articles (CPD) suitable for publication in professional journals
- Active plans for the translation of the material into other languages and demonstration of its implementation through example translations.

It followed a study concerning the collection, evaluation and classification of the necessary information and material to develop the distance learning training material. Available sources were identified and classified according to their usefulness for the education material.
Contents of the distance learning training material

The results of the above studies were used and the educational material was developed in six modules. These are listed below indicating their contents:

- **Foundation module**: Principles of energy efficient building ventilation: Ventilation Requirements, Criteria for Ventilation Rates, Criteria for Ventilation Rates
- **Module 1: Natural and hybrid ventilation**: Natural Ventilation concepts, Natural Ventilation concepts, Natural ventilation components, Airflow through openings, Wind driven ventilation, Stack driven ventilation, Combining wind and stack driven ventilation, adding hybrid fans, Calculating natural ventilation rate using the flow equations, wind pressure and stack pressure equations, Controlling natural and hybrid ventilation, Other issues, Designing for natural and hybrid ventilation
- **Module 2: Ventilation for Urban Buildings**: Natural and hybrid ventilation in urban buildings, Impact of the urban environment on natural and hybrid ventilation, Natural ventilation strategies to enhance airflows in urban environments, Evaluation of the natural and hybrid ventilation potential in urban environments, A methodology to calculate the optimum openings for naturally ventilated buildings located in urban canyons, Performance of hybrid ventilation I urban environments through experimental data, Recommendations for the use of natural and hybrid ventilation systems in urban buildings
- **Module 3: Energy Efficient Mechanical ventilation**: Principles of mechanical ventilation, Ventilation of residential buildings, Ventilation of non-residential buildings, Ducts, Air handling units, Filters, Heat recovery, Room air distribution, Control of ventilation and air conditioning, European standard related to ventilation.
- **Module 4: Assessment of Building Ventilation**: Measuring ventilation parameters, Assessment of ventilation and comfort, Commissioning and balancing ventilation systems, Commissioning controls and sensors, Operation and maintenance, Design and construction issues
- **Common Resource Module**: Computerised Tools, Case-studies (available in a CD-ROM)

Training methods

In order to address the needs of distance learning students the following principles were followed in developing each module. Each module is divided into sections that the students can absorb in one session (for example 2-3 hours of study). Therefore each chapter is approximately 10-12 pages long to include the following elements:

1. Chapter objectives – so those students are aware of the goals to be achieved by studying this specific section.
2. Introduction to the section.
3. 4-5 sub-sections each with some illustrations in the form of pictures or graphs and with a number of self assessment questions.
4. The self assessment questions are designed to revise the material learnt in the sub-section and the students should attempt themselves. Solutions to the personal feedback questions should be provided separately so that the students can instantly check their workings.
5. More complicated sub-section which contain key or difficult to understand principles should included worked examples so that the students have a similar solutions before they attempt the corresponding personal feedback question.
6. Each section includes a summary at the end to highlight the key elements learnt while studying it.

Two assessment exercises were developed. The first tests knowledge of modules 1 and 2 and comprises of a design exercise for a notional building to follow natural and hybrid ventilation strategies. The notional building could be placed in a rural or urban site and trainees are asked to recommend suitable solutions. Material from the common resource module can be used to carry out this assignment. The second assignment tests knowledge of modules 3 and 4 and takes the form of an open book examination where trainees are asked to solve problems similar to the ones contained in the material.
All material has been translated in Finnish to be used by universities in the country and to serve as an illustrative example on how translation can be achieved in other languages.

**Implementation to an educational internet platform, pilot training and evaluation.**

The developed modules have been implemented into a web based version of the training material. The WebCT platform was used as an example case-study. The Vent Dis.Course WebCT material is split up into four sections with a representative icon on the menu page; (a) Module Notes (b) Module Question Answers (c) Collaboration and (d) Assessment.

This internet platform has been used for the pilot distance learning training. Pilot training was carried out by master and doctoral students in six universities: representing different geographical and climatic regions in Europe; Helsinki University of Technology, Danish Technical University, Brunel University, University of Athens, University of La Rochelle, Technical University of Prague, ENTPE). Feedback was collected from both students and teachers and will be used for future updates of the material.

Five workshops were organized in which the educational material was presented to interested experts (building professionals and educators). These were held in Lausanne Switzerland (CLIMA 2005 conference), Prague Czech Republic (17th international conference of air-conditioning and ventilation Conference), DeMontfort University, UK, Athens University, Greece, ENTPE, Lyon France. Comments on the structure and content of material were collected and used in the revisions.

The material was also scrutinized by 10 European experts who offered valuable detailed comments on the content and presentation.

**Short educational articles**

In addition to the material developed for postgraduate professionals, four short articles were developed on specific topics for wider dissemination. The topics were chosen because they were indications that they would be of interest to engineers or because they cover results of recent research activities. The articles were firstly written in English and published in the REHVA journal (available from www.rehva.com). The titles are:

- Displacement Ventilation in non-industrial Premises
- Performance of Natural Ventilation in the Urban Environment
- Assessment of Ventilation and Comfort
- Energy Impact of Ventilation
- Performance of Natural Ventilation in the Urban Environment

These have also been translated in Greek and French for further opportunities for dissemination in national professional journals.

**SUMMARY OF CONCLUSIONS**

The project has produced distance learning education material dedicated to energy efficient ventilation. The material has been produced in formats suitable for masters level training (distance learning textbook and implementation to an education internet platform) and distance learning continuing professional education (CPD articles in professional journals).

The educational material was tested by European experts, evaluation workshops and pilot distance learning courses. The feasibility of translating this material in other languages was demonstrated by translating both the distance learning textbook and the CPD articles.

It was found that there is a great demand for distance learning training material suitable for industrial and educational training in relation to emerging issues in energy and buildings.

Future plans include confirmed use of the education material by participating university in their master level courses and further use by other organizations through REHVA’s membership and INIVE’s educational activities.

More information about the project and results can be found in http://dea.brunel.ac.uk/ventdiscourse.