WS 6 Special HVAC Solutions for the Refurbishment of Historic Buildings

WS organizer: 3ENCULT project consortium

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Presentations at the workshop:

1. *Introduction – values and potential in historic buildings*
   (Alexandra Troi, EURAC research, alexandra.troi@eurac.edu)
2. *A variety of solutions to choose from – how HVAC can improve building existing buildings*
   (Rainer Pfluger, University of Innsbruck, rainer.pfluger@uibk.ac.at)
3. *Multidisciplinary design for integrated solution in historic buildings*
   (Enrico Zara, ARUP, enrico.zara@arup.com)

Introduction & background

Where space is limited and invasive interventions have to be avoided – be it historic buildings in particular or refurbishment projects in general – particular awareness and special solutions for HVAC systems are needed. Within FP7 project 3ENCULT a number of such solutions have been developed and tested at case studies. These and the design approach were presented for discussion at the workshop.

Both HVAC industry and building companies as well as professionals working in the refurbishment sector were invited to join the discussion, feed it with their experience and so contribute to the guideline being developed. The outcome of the workshop should be used to improve the impact of the 3ENCULT project and to be implemented in continuous professional development.

Summary of the presentations

Values and potential in historic buildings – introduction to 3ENCULT project

Historic buildings are the trademark of numerous European cities, they are a living symbol of Europe's rich cultural heritage & diversity and reflect the society's identity and need to be protected. They do, however, also show a high level of energy inefficiency and thus contribute with considerable CO_2 emissions to climate change. And they do not always offer "comfort" – to people as well as to artworks contained in them. 3ENCULT aims at demonstrating that a considerable reduction in energy demand – by a factor of 4 to 10 – is achievable in historic buildings, whilst respecting their heritage value.

Taking as an indicator for the number of historic buildings – which are not necessarily listed but anyway "worthy of preservation" – the number of dwellings built before 1919 or 1945, it can be estimated that 14% resp. 26% is the share of European building stock targeted by 3ENCULT – with 180 Mt of CO_2 possibly being saved every year if this is retrofitted with factor 4.

Preservation in these buildings has many drivers and constraints ranging from historical aesthetics and urban planning to provide scientific archaeological sources. Depending on the kind of value and the specific building it might be more important to keep the substance (in terms of original material) or the appearance and limit a visual impact. The fundamental principle in conservation however being the reversibility of any intervention.

To include all stakeholders in the energy retrofit of a historic building is therefore a base principle postulated by 3ENCULT – and that this multidisciplinary exchange, starting with a comprehensive diagnosis, supports the design and includes monitoring and control. There is no "one-fits-all"-solution – each historic building is unique. This project will rather propose a "pool" of solutions and guidance how to find the right one for the specific building.

A variety of solutions to choose from – how HVAC can improve building existing buildings

In his presentation "**A variety of solutions to choose from**", Rainer Pfluger showed examples, how HVAC can improve existing buildings. The following main topics were taken into account, with special focus not only on historic listed buildings but also refurbishment of other existing buildings.

- **Decentral/central mechanical ventilation**
  Decentralised systems can help to avoid ductwork (horizontal and vertical distribution ducts). The drawback is the number of holes to be drilled for outdoor and exhaust air ducts (see **Figure 11**). Vertical ducts with horizontal distribution in the attic might be a good compromise for historic buildings. Suspended ceilings should be avoided as far as possible.
- **Special ductwork for renovation**
  Flat ducts and prefabricated ductwork helps to integrate ventilation systems in existing buildings where space for installations is limited. It was shown, that the pressure drop of flat ducts can be equivalent to round ducts with slightly higher cross section area. New products especially for the refurbishment market are available (see **Figure 12**).
- Principle of **cascade ventilation**
  The principle of cascade ventilation is to guide the air from the sleeping room via 'overflow' openings to the living rooms and the corridor to the extract air rooms (such as the toilet, bathroom and kitchen). This principle helps to avoid ductwork and to build energy and cost efficient ventilation systems.

- Principle of **active overflow ventilation – adapted to school buildings**
  This principle is frequently used for residential buildings, within the 3ENCULT project; it was transferred to the use in school buildings. A fan is used to duct the air from the corridor to the class rooms and back again (see **Figure 13**). A central heat recovery unit takes the air from the toilets and cloakrooms for preheating the outdoor air, which is ducted to the staircase. This way, vertical and horizontal ducts can be avoided, because the staircase and corridors are used as a duct.

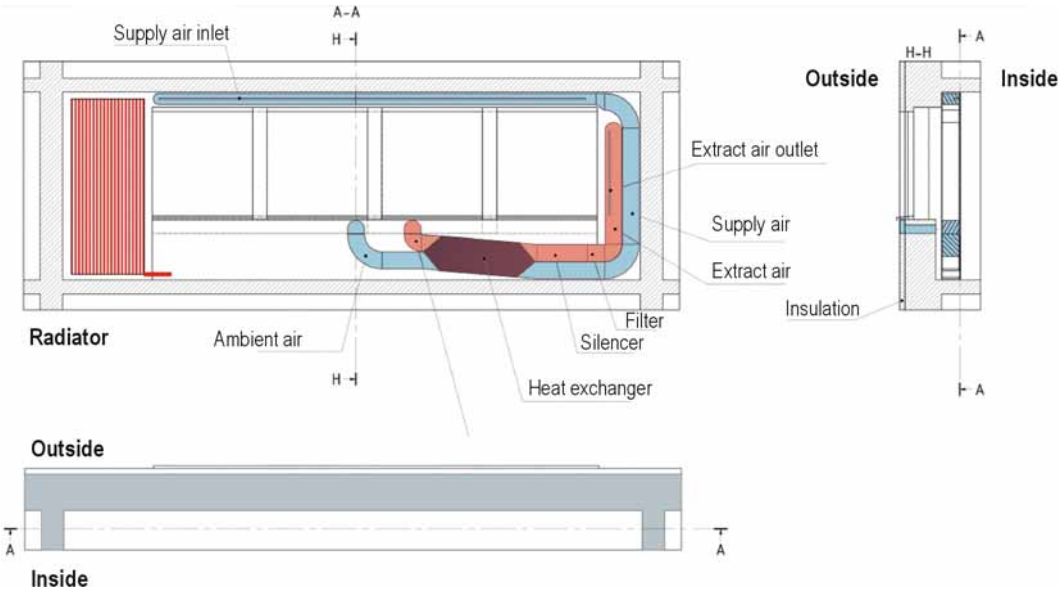

Figure 11. *Decentralised Ventilation system for school buildings.*

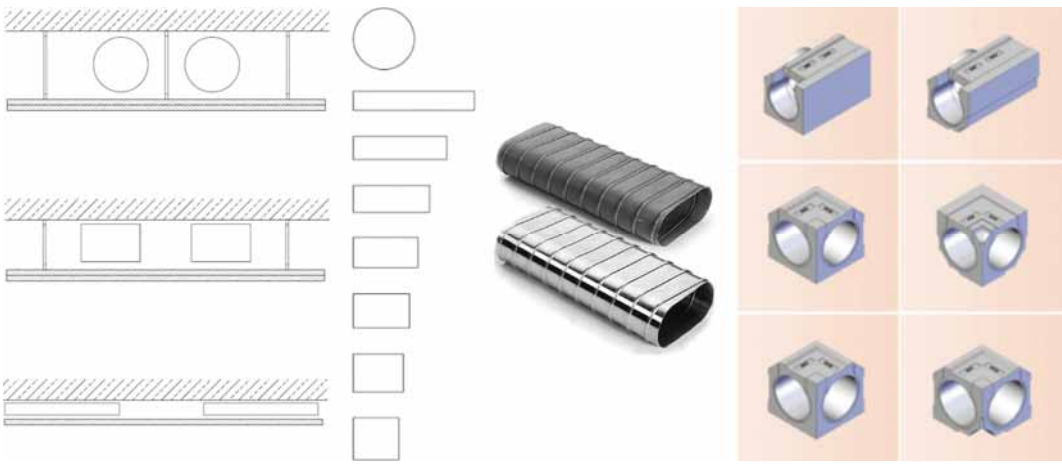

Figure 12. *Special ductwork for integration in existing buildings.*

- **Coaxial duct system** for ambient/exhaust air
  Coaxial duct systems, developed by University of Innsbruck can help to minimize the number of holes through the external walls (see **Figure 14**). The outdoor air is ducted through the annular gap whereas the exhaust air flows through the central duct. As shown by tracer gas measurement, there is no danger of short circuit flow from exhaust air outlet to outdoor air inlet.
- Combined **fan and heat recovery**
  New types of space saving heat recovery systems will help to integrate high efficient ventilation systems in existing buildings. The innovative development of a combination of fan and heat exchanger (see **Figure 15**) by University of Innsbruck is an example of that type of unit which can be integrated in the external wall. This will help to save space, energy and money.

Figure 13. *Active overflow ventilation in prototype class room in Innsbruck (A), textile diffuser and fan.*

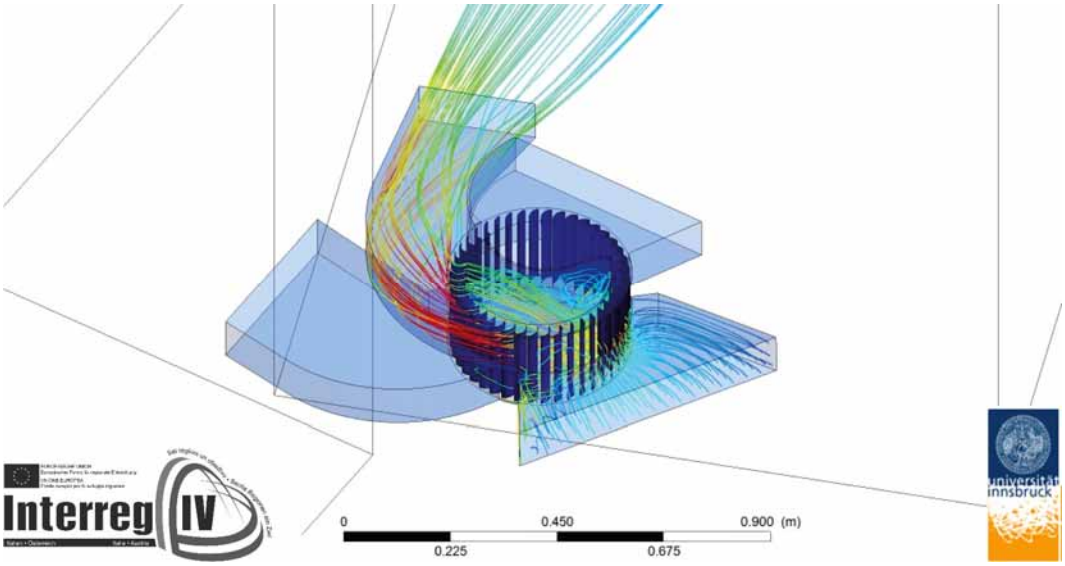

Figure 14. *Coaxial duct for outdoor air intake and exhaust air outlet developed by University of Innsbruck within the research project 'low_vent.com' - prototype built by POLOPLAST*

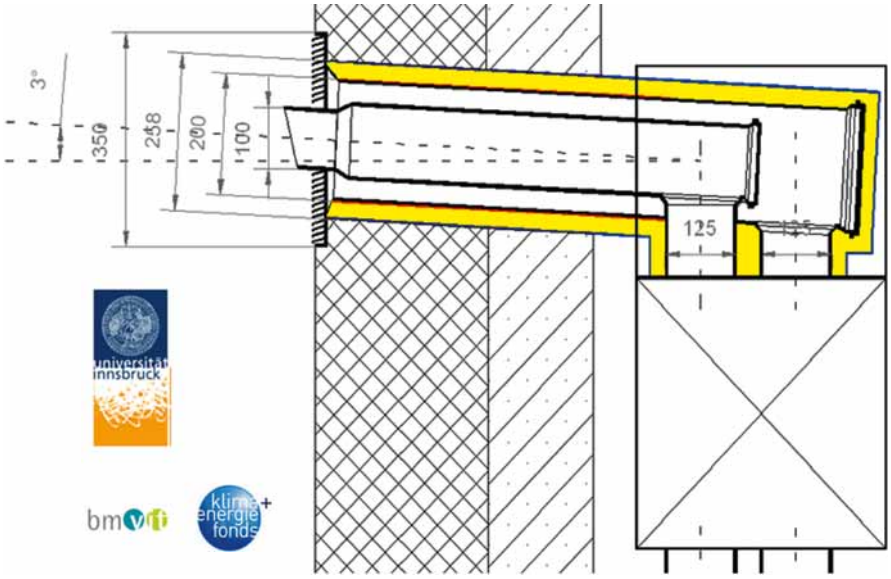

Figure 15. *Heat recovery fan developed by University of Innsbruck within the research project Vent4Reno (INTERREG).*

Multidisciplinary design for integrated solution in historic buildings

Existing buildings are part of a city's or town's heritage, skyline and distinct character. Although seen by many as a valuable asset and fundamental to successful operation, they also consume significant energy, resources and investment. Maintenance, new technologies and occupancy changes also need to be considered.

A multidisciplinary approach provides the best result in terms of performance improvement.

In this process a key element is to predict the building behaviour under different design scenarios.

An energy model is a calculation tool that is usually applied in order to assess: relative performance of options, energy measurement prioritization, existing building modelling for improvement, fault detection, operations optimization and compliance with standards.

Depending on the design stage, the accuracy of the model can change drastically. For a concept design it could be possible to estimate the loads, when the design is advanced it could be used to have a better idea of the final energy consumption of the building.

An energy model is based on assumptions; in fact to calculate the annual energy use it is necessary to considers typical schedules for all the parameters like:

- Lighting;
- Plugs loads;
- Internal loads;
- Infiltration
- Etc...

When all this information is provided the software is able to estimate the performance of the modelled building (heating, cooling and electrical loads etc..). However it is important to bear in mind that an energy model cannot predict human behaviour, that of course af radically affects the final consumption of the building.

Common issues related to an energy model can be: data organization, phasing/timing, excess of detail and false expectation.

An energy model is a very effective tool for multidisciplinary design. Moreover many engineering disciplines are involved: building physics, facades, HVAC system and architecture. It is becoming an essential tool for modern design, and since the final result is usually very simple and straightforward, it is also very important for communication purposes.

Discussion and main results

The discussion was initiated and guided by the following questions:

1. Experiences & opinions from participants with regard to their practical experience with HVAC in historic buildings and refurbishment projects:

- What is different in HVAC for new buildings / refurbishing?
- Is there any further demand for research and products for integration of ventilation in historic buildings / refurbishing?

2. Experiences & opinions from participants with regard the following 3ENCULT hypotheses:

- Different building types require different approaches (thermal mass, natural ventilation and HVAC solutions)
- It is possible to achieve better results by working together across disciplines (e.g. windows, envelope, HVAC systems)
- Energy models are a suitable tool to forecast which is the best the strategy

Acknowledgement

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References

www.3encult.eu
www.buildup.eu/communities/culturalheritage