

# Special HVAC solutions for the refurbishment of historic buildings



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## Introduction

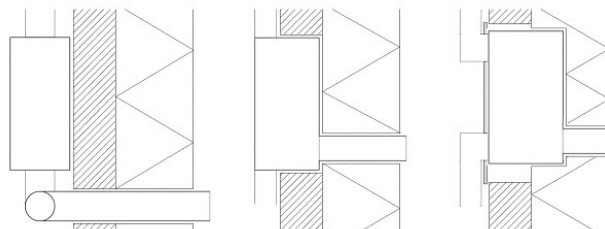
Where space is limited and invasive interventions have to be avoided – be it historic buildings in particular or refurbishment projects in general – particular awareness and special solutions for HVAC systems are needed. Within FP7 project 3ENCULT a number of such solutions have been developed and tested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

## Values and potential in historic buildings

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<sub>2</sub> emissions to climate change. And they do not always offer "comfort" – to people as well as to artworks contained in them. The research project 3ENCULT (Efficient energy for EU cultural heritage, cofunded by the European Union Seventh Framework Programme FP7/2007-2013, see <http://www.3encult.eu/en/project/welcome/default.html>) aims at demonstrating that a considerable reduction in energy demand – by factor 4 to 10 – is achievable, also in historic buildings, respecting their heritage value. Besides solutions for the building envelope, such as internal insulation, special HVAC solutions (ventilation with heat recovery in particular) where developed. To demonstrate the application in real buildings, one of the solutions was realized in a case study (CS5, Innsbruck, Austria).

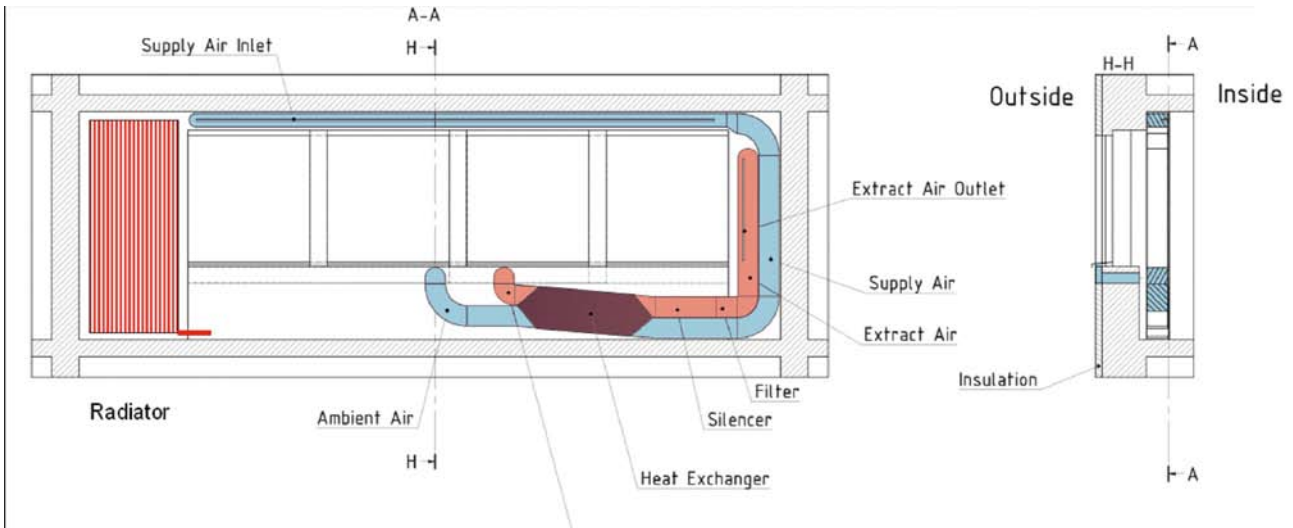
## How HVAC can improve building existing buildings

The following examples show, how HVAC can improve building existing buildings. These solutions are useful not only for historic listed buildings but also for refurbishing of other existing buildings. New products, such as flat heat recovery systems are available, which can be integrated in a space saving way at the wall (see **Figure 1**) or ceiling.

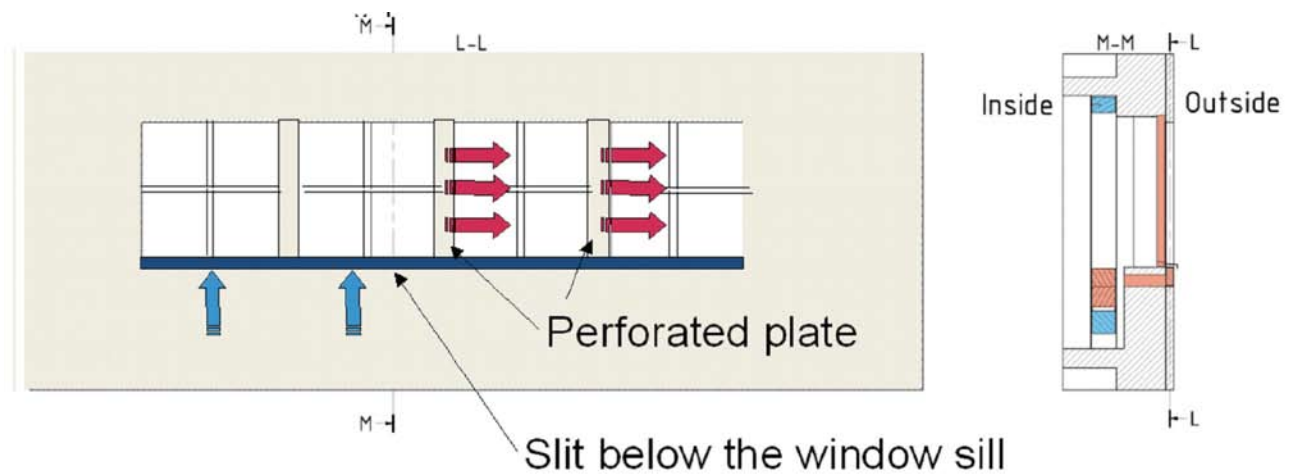


**Figure 1.** The heat recovery system can be placed at the wall (wall mounted (left)) or in the wall (wall integrated (middle and right)). This way, the outdoor air and the exhaust air duct are as short as possible (cost, energy and space saving).

The advantage of the application of mechanical ventilation systems in historic buildings is not only the high indoor air quality and saving of ventilation losses by heat recovery, but also the low indoor air humidity to be guaranteed during the heating season. This is an important boundary condition, especially if internal insulation is applied. Damages by humidity and mold growth can largely be avoided.



**Figure 2.** Wall integrated decentral ventilation system for school buildings (supply air inlet at the window lintel, extract air outlet besides the window).



**Figure 3.** Wall integrated decentral ventilation system (view from outside). Exhaust air outlet via perforated plate, outdoor air inlet via slit below the window sill.

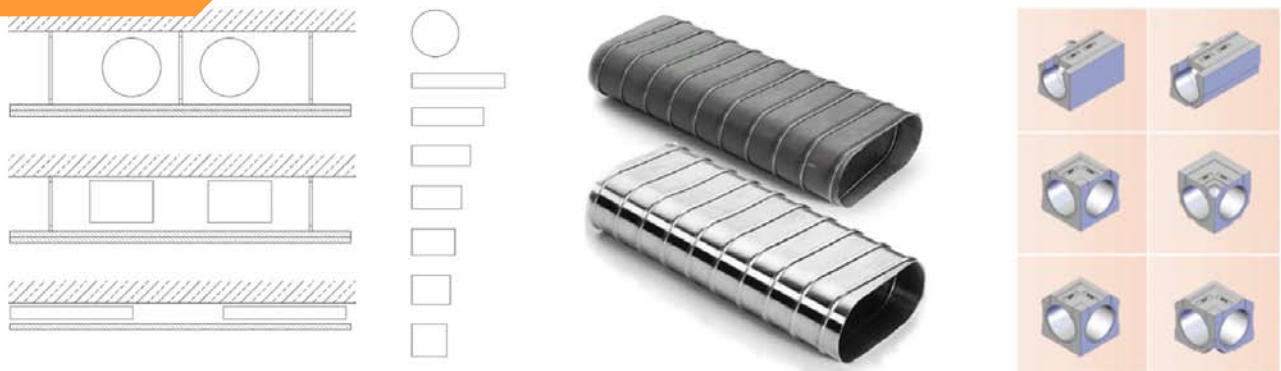
### Decentral versus central mechanical ventilation

Decentral 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 2**).

A flat counter flow heat exchanger can be mounted at the parapet, whereas the supply air inlet and the exhaust air outlet are placed above and besides the window respectively. In order to avoid any grill at the façade for ambient air intake, a slit below the

window sill can be applied. For exhaust air outlet, this possibility is not valid, because condensation and freezing problems at the wall surface would occur. Therefore a perforated plate or a cover plate in front of the window post is suggested as exhaust air outlet (see **Figure 3**).

The suggested design can be realized for buildings where an external insulation is applicable. In this case, the flat air ducts for ambient and exhaust air can be integrated in the insulation layer. After finishing the plaster (outside) and dry walling (inside), no ductwork is visible



**Figure 4.** Reduced clear height of suspended ceiling by application of rectangular silencers (left). Pressure drop equivalent cross sections of round and flat ducts (second left); Special ductwork for integration in existing buildings (right).

from both sides. For most of the listed buildings however, no external insulation is appropriate. In those cases a central heat recovery should be preferred.

Vertical ducts with a horizontal distribution at the attic might be a good compromise for historic buildings. Suspended ceilings have to be avoided, if the original height of the room and/or the original state of the original ceiling itself is to be preserved.

**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 refurbishing market are available (see **Figure 4**).

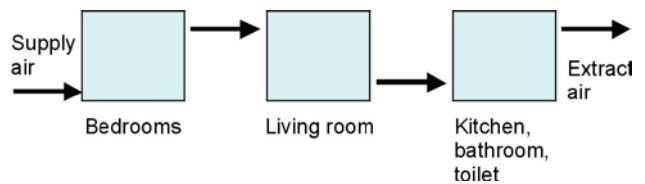
As shown in **Figure 4** (left), the cross section of a flat duct can be chosen in such a way, that the pressure drop per meter is equivalent to that of a circular shaped ducts. With this space saving design, the ducts can be placed behind a suspended ceiling without changing the clear height of the room significantly.

**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 toilet, bathroom and kitchen). This principle helps to avoid ductwork and to build energy and cost efficient ventilation systems (see **Figure 5**).

**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 (see [Pfluger 2013a]). A fan is used to duct the air from the corridor to the class rooms and back



**Figure 5.** Principle of cascade ventilation (supply air only in bedrooms, living rooms are regarded as overflow zones).

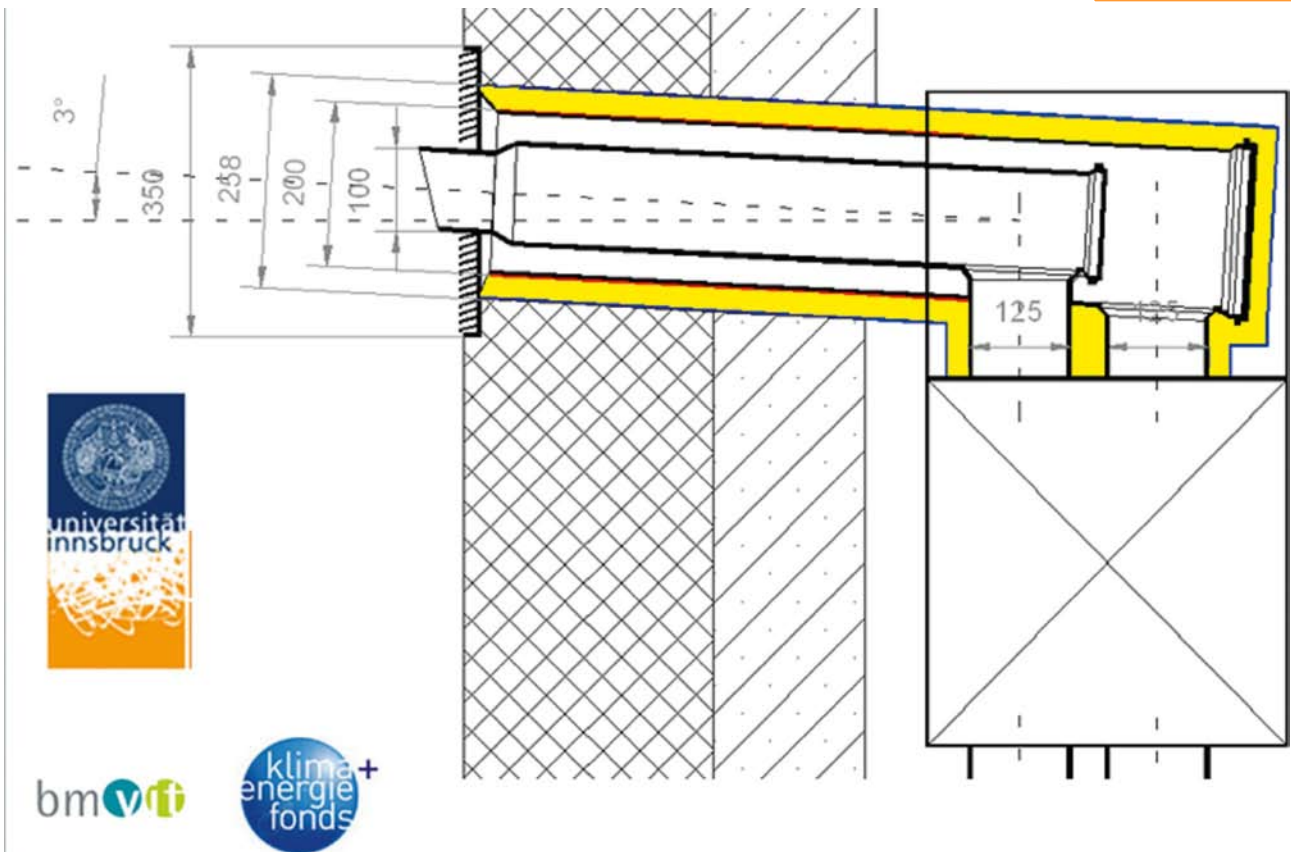


**Figure 6.** Active overflow ventilation in prototype classroom in Innsbruck, air inlet via textile diffuser and fan from corridor (preheated supply air from central heat recovery unit at the attic without duct via staircase and corridor).

again (see **Figure 6**). A central heat recovery unit, placed at the attic, takes the air from the toilets and wardrobes 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.

**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. The outdoor air is ducted through the annular gap whereas the exhaust air flows through the central duct (see **Figure 7**). As shown by ▶



**Figure 7.** 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 company POLOPLAST.

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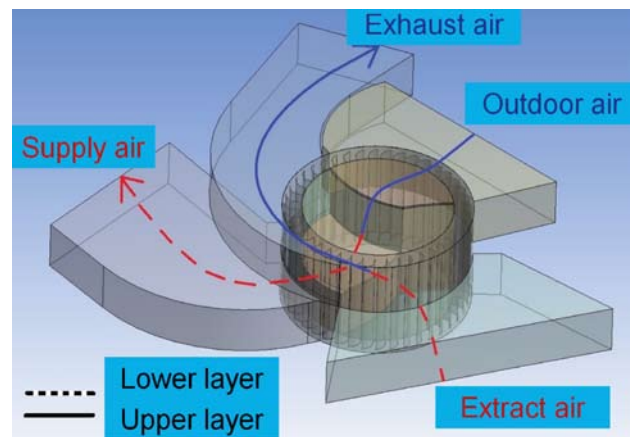
- ▶ tracer gas measurement, there is no danger of short circuit flow from exhaust air outlet to outdoor air inlet.

The use of coaxial ducts in ventilation systems was published in [Pfluger 2013b].

### 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 8**) 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.

A detailed description of the system as well as the calculations and results are given in [Pfluger 2013c]. ■



**Figure 8.** Heat recovery fan developed by University of Innsbruck within the research project Vent4Reno (INTERREG)

### References

[Pfluger 2013a] Pfluger, R., Längle, K.: Minimal Invasive Ventilation Systems with Heat Recovery for Historic Buildings, Conference proceedings 11<sup>th</sup> REHVA World Congress, CLIMA 2013

[Pfluger 2013b] Pfluger, R., Feist, W., Hasper, W.: The use of coaxial ducts in ventilation systems, Pollack Periodica, Vol. 8. No. 1, 2013, S. 89-96

[Pfluger 2013c] Pfluger, R., Speer C., Feist W., Weger J., Zgaga J.: Entwicklung eines hocheffizienten Ventilators mit integrierter Gegenstromwärmerückgewinnung für den Einsatz in der Gebäudemodernisierung, Bauphysik 4/2013

[www.3encult.eu](http://www.3encult.eu)

[www.buildup.eu/communities/culturalheritage](http://www.buildup.eu/communities/culturalheritage)

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## News flash: Windsor Conference 2014

10<sup>th</sup>- 13<sup>th</sup> April 2014,  
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The 8<sup>th</sup> Windsor Conference will focus on bringing the academic comfort research into the real world context.

### Themes for 2014 include

- 1) *Comfort and productivity*
- 2) *Occupant behaviour*
- 3) *Modelling*
- 4) *Simulation and monitoring*
- 5) *The future of comfort research*

**ABSTRACTS:** Contributing authors should submit an abstract of no more than one page to the organising committee **30<sup>th</sup> October 2013**.



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