Refurbishment of old buildings for sustainable use

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ABSTRACT

REVIVAL is an energy demonstration project supported by the European Commission under the THERMIE programme. There are six demonstration sites in five EU countries. Ventilation and cooling of non-domestic buildings, even in northern Europe, is one of the main issues and REVIVAL contains both naturally and mechanically ventilated and cooled buildings. It also has a strong emphasis on architecturally important buildings and how changes can be made without damaging the appearance.

The project lasts for five years from 2003 to 2008 and covers design, refurbishment, monitoring and dissemination. Common Tasks bring all the sites together and include Design Forums, common monitoring protocols, CO_2 and environmental assessments, design monographs and finally a new Refurbishment Design Handbook.

REVIVAL will demonstrate how existing buildings can be refurbished to give good internal comfort conditions, especially in summer, with low energy consumption using a mixture of best practice and innovative measures.

1. BACKGROUND

REVIVAL is a demonstration project on refurbishment of non-domestic buildings to improve their energy performance and internal comfort conditions. Ventilation and cooling of non-domestic buildings, even in northern Europe, is one of the main issues and REVIVAL contains both naturally and mechanically ventilated and cooled buildings. It has a strong emphasis on architecturally important buildings and how changes can be made without damaging the appearance. It is supported by a THERMIE grant from the European Commission and runs from 2003 to 2008.

Refurbishment of existing buildings is a neglected area; in as much as most attention is focussed on new buildings where there is much work on low and even zero energy buildings and many high profile demonstrations. But in most European cities there is a vast stock of existing buildings, many of which are getting to the end of their useful life. Demolition is an option but the alternative of refurbishment is starting to be seen as a more environmentally friendly and sustainable option, for reasons of architectural value, materials use, neighbourhood disruption, waste disposal, etc. However old buildings can use large amounts of energy and provide poor internal conditions for occupants and generally not meet current requirements or expectations. Common environmental problems are high heating demand, poor lighting, poor ventilation, solar penetration and glare, poor control of heating and cooling, etc.

Refurbishment to upgrade a building, improve comfort or reduce energy consumption, can be an ongoing process whilst occupation continues, or at the other extreme, stripping the old building back to its essential structure and rebuilding. The renovation of the REVIVAL building sites covers the whole range, from year on year improvements without moving the occupants, through decanting the occupants to other parts or adjacent buildings during refurbishment, to complete renovation of derelict buildings.

In 2006 a new factor comes into play with the Energy Performance in Buildings Directive.

With display of energy consumption figures in public, and maybe some private, buildings, the pressure to improve the energy performance of buildings before their normal refurbishment date may increase. In addition, disclosure of energy consumption data is likely to be required when a building is sold or re-let and this will highlight any bad energy consuming building which may lead to lower rents or sale prices. REVIVAL offers much needed help in this area about how to reduce energy consumption of existing buildings.

REVIVAL has its roots in another project. "OFFICE" was an R&D project run by the University of Athens, which investigated the energy refurbishment options for ten office buildings in nine European Countries and compared the effects of similar strategies to dissimilar buildings. A Handbook for "Energy Efficient Office Refurbishment" was one of the deliverables, which was published, by James and James in 2001.

2. THE ISSUES OF REFURBISHMENT

There are numerous questions to be asked about refurbishment from an energy perspective:

- Can we reduce energy consumption to current standards?
- How can we improve cooling, ventilation and comfort, without increasing energy consumption?
- How can we make best use of the existing structure, e.g. the thermal mass?
- How can we use the higher ceiling heights?
- How do we retain the existing appearance of architecturally important buildings whilst improving energy and comfort?
- Can we make changes with occupants in place?
- Is the life cycle CO_2 assessment positive compared with demolition and rebuilding?
- For multiple building owners, how do changes change the overall CO_2 emissions of their buildings stock?

Answers to these and other questions are being sought in this project and will be brought together in a new version of the Refurbishment Design Handbook at the end of the project in 2008.

3. THE PROCESS OF REVIVAL

REVIVAL started officially in April 2003. Each site has survey, design, construction and monitoring stages, with separate design teams answering to different clients. The "Common Tasks" of REVIVAL aim to bring the different buildings and their teams together so that cross fertilisation can take place and so that useful conclusions can be brought out at the end for wider use and dissemination.

"Design Forums" are taking place on each site, bringing together the project designers with experts from the REVIVAL team to share experiences, investigate differences and hopefully improve designs. Specific issues, such as the use of phase change materials for night cooling, are being drawn out of the Forums for further investigation and the results will be published as a set of "Design Monographs".

Monitoring of energy consumption before and after the refurbishments is required, though due to changes in use or derelict buildings, modelled pre-refurbishment energy demand will also be used where appropriate. A common monitoring protocol is being developed and all results will be compared at the end of the project to generalise the conclusions.

Meetings of all the partners are held every six months with visits to the pre- and post- refurbishment sites organised at the same time so that all participants can get a real understanding of the issues and solutions being used on all the sites.

A life-cycle CO_2 assessment procedure will be used which is sensitive to the emissions associated with the manufacture of materials, transportation to site, construction, energy in use and maintenance, final demolition and disposal of wastes. This will be applied to the refurbishment of the existing building and comparisons made with the reference case of demolition and new-build. A general environmental assessment of the results of refurbishment of the buildings will also be made.

A CO_2 stock analysis model will also be developed, starting with the construction of a dynamic population model for a group of buildings or building stock, taking into account existing buildings, refurbishment, demolitions and new build. This will be tested out with the demonstration site owners. To provide part of the data-

base, a detailed analysis of the energy use and consequent CO_2 emissions of all activities associated with the refurbishment on one of the large sites (in France) will be undertaken.

Monitoring of the energy use and internal conditions of the refurbished buildings will be carried out for at least a year following refurbishment.

One of the important final outputs of the Common Tasks will be the Design Handbook for energy efficient refurbishment of non-domestic buildings. This will distil out the technical issues and solutions to problems and will cover all energy using aspects of non-domestic buildings.

4. SIX DEMONSTRATION SITES

Six demonstration sites are currently included in REVIVAL from five European Countries. Starting with those which are being refurbished with occupants in place, Stevenage Borough Council in UK are making several improvements to their existing offices to reduce summer overheating and to reduce energy consumption generally. In the original areas of the building, the thermal mass of the building hidden behind the false ceiling, enhanced by phase change material, is being used as a night cooling system with local fans and openings in the windows. Improved control in the air-conditioned part of the building together with low energy lighting and controls is also being installed.

In Greece the Ministry of Finance offices in Athens were refurbished some 10 years ago but energy usage is high and internal conditions poor for much of the year. A carefully designed package of improvements is now proposed to improve working conditions and greatly reduce energy consumption. These include external solar shading, some improved glazing, improved artificial lighting with photo control, demand controlled ventilation, ceiling fans, a new radio controlled comfort control system, night ventilation, heat recovery and an economiser on the cooling system. The building will be maintained in use as these changes take place.

The second project in Greece is the refurbishment of a historic hospital building, the KAT hospital in Athens. This hospital was partly refurbished for the Olympic Games but now a further, comprehensive refurbishment package of wall and window insulation, reducing very high ceiling heights, solar shading, lighting improvements, and heating and cooling improvements, will add to on-going upgrading of the whole hospital complex, which has to be kept in operation throughout the renovation.

At Nantes in western France refurbishment of a large secondary school complex is taking place. Walls will be insulated some internally and some externally, windows replaced and provided with horizontal shading devices, new ventilation and lighting systems with improved controls, night ventilation and a new air control system on the boilers to cope with reduced heat demand. The work takes place in several buildings at different times, so that school can continue during the changes with decanting from one part to another. It is on this site that the comprehensive energy use and CO_2 audit of the refurbishment process is taking place.

In the north of the Netherlands, the Dutch Royal Navy is refurbishing an eight-storey block previously used for housing, for offices. The block called the Albatross, which is in a very exposed location, will be provided with a new second skin containing shading, controlled passive ventilation with variable opening vents, low energy lighting and equipment and the block will be connected to the on-site CHP system for heating. It is hoped to provide some PV panels in the roof area. This is a comprehensive refurbishment of a very visible block and the over cladding with the second skin will change the appearance of the block and solve many of the current problems of air infiltration, poor insulation and cold bridging. The consultants carried out a comprehensive life cycle environmental analysis of the various options for the block–from demolition to refurbishment–before the final solution was chosen.

The last building is in Florence and is the complete refurbishment of a historic hospital office block. A comprehensive package of low energy measures will be installed including double glazed windows with integral shading devices and a magnetic sealed operating system. This system is very applicable where solar shading of a historic façade is necessary, but the appearance cannot be changed. Other measures include night ventilation, ceiling fans, high efficiency lighting with occupancy and daylight control systems to minimise energy use, and op-

timised HVAC systems with radiant heating and cooling and sophisticated controls.

5. RESULTS ANTICIPATED

The calculated savings in energy use of the refurbished buildings varies from 40 to 60% with CO_2 reductions estimated at between 40 and 75%. These comparisons are against current or estimated energy consumption figures, not current building standards but projects aim in all cases to minimise energy use by innovative means and thus it is expected that the final buildings will have lower energy use than an equivalent new buildings built to current regulation standards.

Paybacks on the packages of measures are estimated at between six and 22 years but these figures are notoriously variable. In some of the buildings the measures taken are to reduce overheating and improve comfort in other ways and thus to avoid the installation of more energy intensive equipment. Stevenage is a good example where use of passive and night cooling measures are being used instead of installing an air-conditioning system to combat an existing overheating problem.

The other results coming out of the project will be to provide low energy solutions to some of the major issues or problems in refurbishment. How to activate the thermal mass of an old building whilst not exposing it, - using false ceilings and phase change material. How to provide solar shading without changing the appearance of buildings – internal blinds or blinds enclosed in glazing or carefully integrated external shading. How to install new control systems without internal disruption–use radio systems. How to improve daylighting and reduce artificial lighting–control systems. How to insulate walls without changing appearances–a mixture of internal and external insulation.

In addition the buildings will demonstrate a range of measures equally applicable to new buildings, but retrofitted, including adding a second skin, using condensing boilers, sophisticated controls on ventilation, heating and cooling, treating thermal bridging, and renewable sources-photovoltaics and solar water heating.

6. CONCLUSIONS

Many buildings cannot be demolished due to their historic and architectural value. Many existing buildings waste vast amounts of energy in use. Many existing buildings give poor comfort to occupants. Many existing buildings have alterations during their active lifetime. Renovation to improve comfort and energy consumption is possible in all these situations. Decisions as to what to do need careful consideration, and if occupants are to stay in place during refurbishment, careful implementation.

Energy consumption per square metre of a refurbished building may well remain above an equivalent new building, designed from the start for low energy use, but can easily be 50% less than previously. Energy efficient renovation may not be cheap and simple paybacks may be long. However decisions as to whether to demolish or refurbish can be taken on a life cycle basis and take into account embodied energy and construction energy and can consider the effects of waste materials generated and the demand for new material.

Energy use of existing buildings is a topic becoming of greater importance as the Energy Performance of Buildings Directive comes into force. Renovation simply to reduce energy consumption before a building is sold or re-let may become necessary and the display of energy use data may stimulate more energy awareness leading to more action. REVIVAL will offer much useful experience in this area.

Much refurbishment of existing buildings treats them as second grade buildings and thus little effort is made to bring them fully up to modern standards of internal comfort and efficient use of energy. REVIVAL will demonstrate that properly refurbished office and other non-domestic buildings can be just as good as new buildings.