International Energy Agency

# Energy Conservation in Buildings & Community Systems

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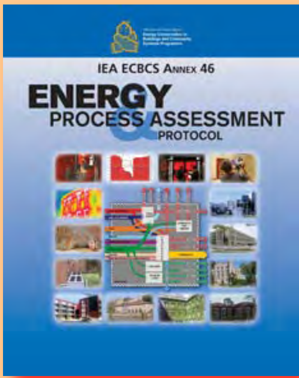
ECBCS News June 2010 - Issue 51

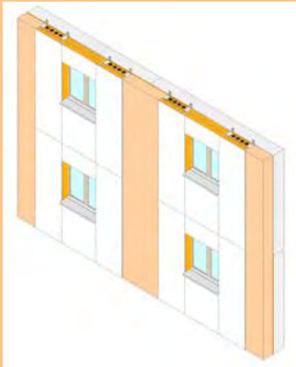
# Energy in the UK

## An Ambition for Zero Carbon Buildings

## Spain Joins ECBCS




## Informed Decision-Making for Retrofit



## A New Approach to Sustainable Renovation

## How Occupants Affect Energy Use

# Energy & Low Carbon Buildings in the United Kingdom

**Clare Hanmer, ECBCS Executive Committee Member for the United Kingdom**

This article gives an overview of energy supply and demand for the United Kingdom, and the role of energy policy and regulations and research and development on buildings. Economic, environmental and social factors are all pushing for a reassessment of the sources from which energy can be supplied and constraints are being placed on how much should be used by the various end-use sectors. These concerns have led to a policy ambition that all new buildings should become ‘zero carbon’ by 2019, with renewable energy supplies being carefully matched to reduced demands. To support this ambition, major UK research and demonstration efforts are currently being directed towards how to robustly and cost-effectively construct low and zero carbon buildings on a large scale, and how to refurbish the existing building stock to high standards.

Increased emphasis is being placed on demand reduction and securing energy supplies which do not rely on fossil fuels, particularly a higher proportion of renewables in the energy supply mix. There are significant drivers for reducing dependence on fossil fuels that include:

- mitigating climate change from combustion of fossil fuels and other environmental concerns
- economic competitiveness - improved energy efficiency and conservation can reduce operational costs for users
- security of supply - the UK is increasingly reliant on fuel and electricity imports
- anticipating significant future price increases for fossil fuels
- improving housing quality and alleviating ‘fuel poverty’

## National Energy Supply & Demand

*Energy Supply*

From the mid-16th Century until the mid-20th Century, the countries now forming the United Kingdom used coal as the principal heating fuel. From the mid-20th century until the present day, a mix of oil, natural gas and to a lesser extent nuclear power have formed the dominant sources supplying UK energy demands. The major changes taking place are illustrated by the fuel mix used to generate electricity (Figure 1). In 1990 this was dominated by coal, while by 2007 a large proportion of this had been replaced by gas, as had most of the fuel oil-based generation. In the same time period, wind-generated electricity has gained in importance, along with other renewable energy sources (Figure 2). Oversight of national energy supplies is provided by the Department for Energy and Climate Change (DECC).

*Energy Demand*

Standards relating to building energy demand - in the form of $CO_2$ reduction requirements - are set individually by the following governmental bodies in the countries forming the United Kingdom:

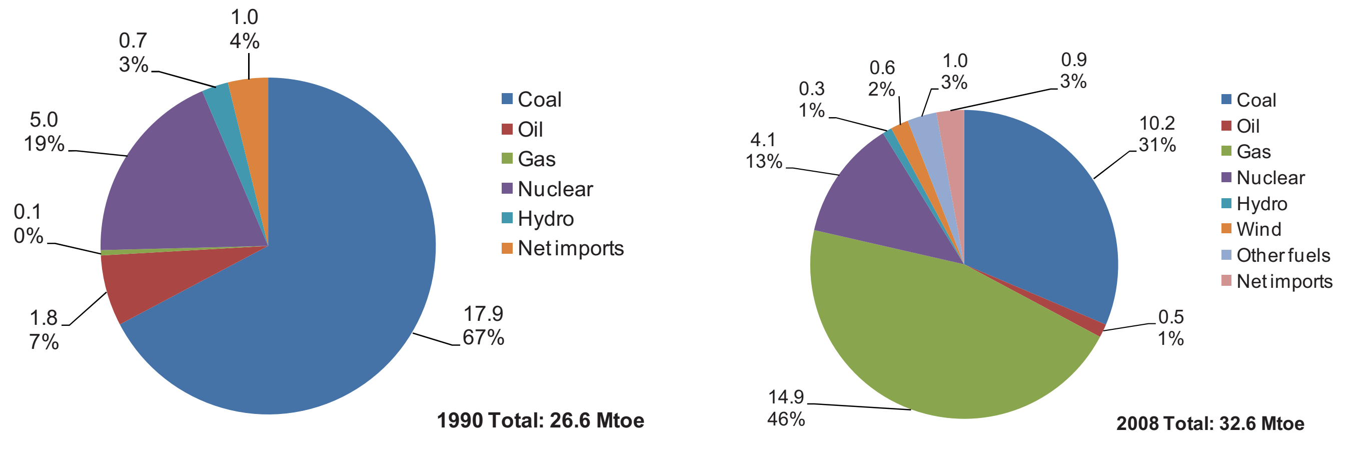



*Figure 1. Total electricity supplied by fuel type in the UK in (a) 1990 and (b) 2008. (Data source: DECC, Mtoe = million tonnes of oil equivalent)*

Published by AECOM Ltd on behalf of the IEA ECBCS Programme

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Print version (ISSN 1023-5795): 9Lives 80 paper with 80% recycled content
Online version (ISSN 1754-0585): available from *www.ecbcs.org*

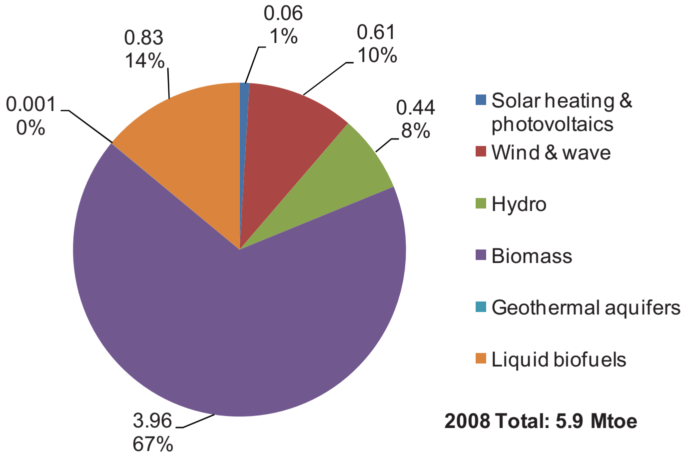



*Figure 2. Total use of renewables for heat and electricity in the UK in 2008. (Data source: DECC)*

**Cover Picture: The 'One Brighton' Development**

This is a new sustainable residential development by Crest Nicholson BioRegional Quintain that uses a dedicated energy services company to operate and maintain the on-site infrastructure, from whom the occupants directly purchase their energy. It relies on biomass district heating with a 500 kW boiler serving two 10 $m^3$ thermal storage tanks. Each dwelling has a heat exchanger link with the district system for both domestic hot water and space heating. Space heating is delivered within each dwelling using individual balanced mechanical ventilation units with heat recovery. A roof-top 9.5 $kW_{peak}$ photovoltaic power array directly serves the common parts of the building (e.g. lifts, CCTV and corridor lighting). Other power requirements are purchased in bulk from renewable off-site sources.

- Northern Ireland: Department of Finance and Personnel N.I.
- Wales: National Assembly for Wales (from 2012)
- Scotland: Scottish Building Standards Agency
- England (and Wales until 2011): Department for Communities and Local Government

Figure 3 shows the recent demand for energy by end use from dwellings and service sector buildings. Space and water heating are the dominant energy uses.

*Distributed Generation*

Distributed energy generation from micro-generation, at a building level to large scale combined heat and power is increasing in significance. In the past, with the exceptions of areas such as Woking and Southampton, there were few large scale community heating schemes in the UK. This situation has changed in recent years, for example with a new community heating network now in operation in central Birmingham. Now planning requirements are making it more common that community energy schemes (district heating or combined heat and power) are being considered for large scale developments. 'Feed-in tariffs' in place from April 2010 will allow owners of micro-generation systems to receive financial benefits for displacing electricity generation from the national grid. It is planned to introduce financial incentives for renewable heat generation in 2011.

*Decarbonising the Energy System*

The 2008 UK Climate Change Act is the world's first long-term legally binding framework to address climate change. The UK Low Carbon Transition Plan sets out how the UK will by 2020 meet the required 34% cut in emissions on 1990 levels, towards which a reduction of 21% has already been attained.

## An Ambition for Zero Carbon

An overview of the current and anticipated future UK housing stock is presented in Figure 4. There are a number of drivers requiring and encouraging more energy efficient buildings with less energy-related $CO_2$ emissions. Minimum standards set by legal requirements include:

- Planning approval, sometimes including minimum requirements for use of renewable energy, and
- Building Regulations that set minimum requirements.

Moreover, the implementations of the EU Energy Performance of Buildings Directive by the countries forming the United Kingdom require energy certification to be carried out and reported.

Existing Government policy is to require all new buildings in England to be 'zero carbon', although a final decision on the definition(s) of 'zero carbon' has not yet been made. But, it is likely to be based on a hierarchical approach, in which first of all minimum energy efficiency measures should be adopted, then on-site low and zero carbon energy supply technologies and finally off-site 'allowable solutions'.

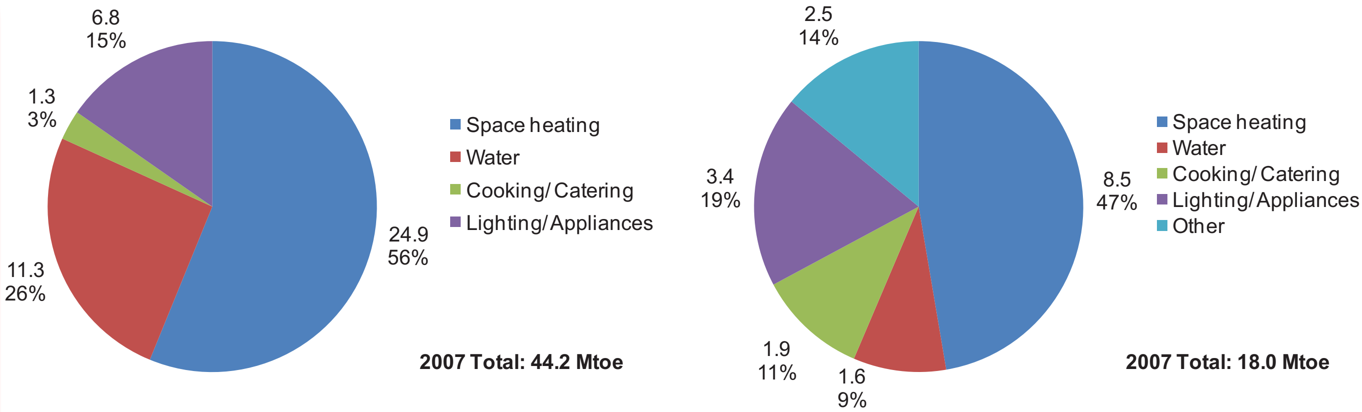



*Figure 3. Energy end use in the UK in 2007 for (a) domestic sector and (b) service sector. (Data source: DECC)*

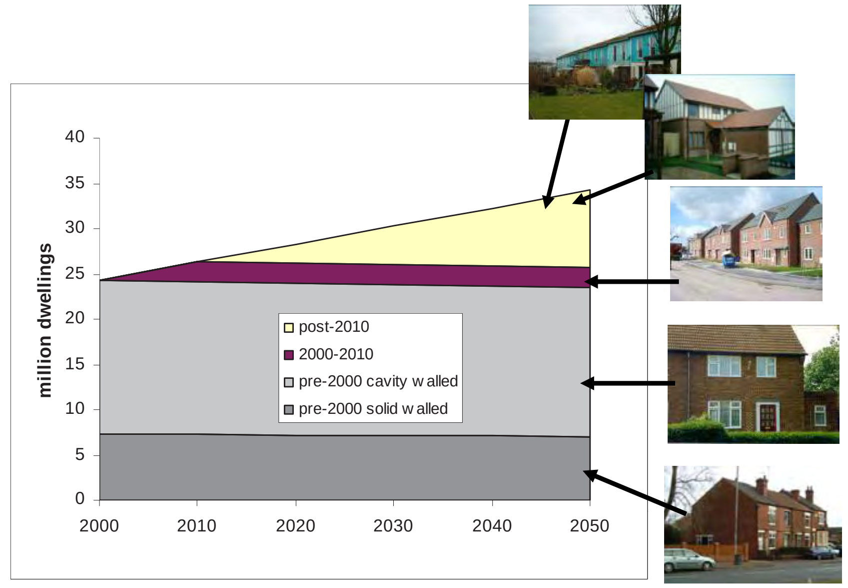



*Figure 4. Overview of current and anticipated future UK dwelling stock. (Source: Robert Lowe and Paul Ruyssevelt)*

Zero carbon new buildings are planned according to the following timetable:

- dwellings and schools from 2016
- public sector buildings from 2018
- commercial buildings from 2019

The Building Regulations for England and Wales have recently revised to require a 25% reduction in $CO_2$ emissions for new buildings compared with previous levels. For existing buildings, there are minimum requirements for making energy efficiency improvements for the building fabric and services whenever work is carried out.

The 'Code for Sustainable Homes' provides an indication to industry and occupants about what measures are considered to be best practice, and which may eventually become minimum standards for all new construction. In general, state funded new housing construction is required to achieve minimum standards under the CSH. For buildings other than dwellings, certain BREEAM ratings are generally required for state funded projects such as schools and other public buildings. Both the Code for Sustainable Homes and BREEAM cover a range of assessment criteria, including energy-related carbon dioxide emissions, water use, ecology, health and wellbeing, management and construction materials. High standards achieved under the Code for Sustainable Homes and BREEAM are considered to have marketing potential for commercial developments.

The 'Zero Carbon Hub' has been established to take responsibility for co-ordinating delivery of low and zero carbon new houses. It will provide information on best practice to help builders.

## Towards Low & Zero Carbon Buildings

*Research & Development*

Funding for buildings-related energy research in the UK is the responsibility of a number of organisations. Figure 5 summarises sources of energy innovation funding. The Low Carbon Innovation Group (LCIG) brings together the UK's three main independent, publicly-backed energy innovation organisations, the Carbon Trust, the Energy Technologies Institute (ETI) and the Technology Strategy Board (TSB). These organisations are working together to accelerate the development and deployment of new low carbon technologies. Each member has a different strength, and activities are led by whoever is best placed to deliver results. The Research Councils' Energy Programme provides the framework and funding for basic R&D. This is supported by the UK Energy Research Centre in

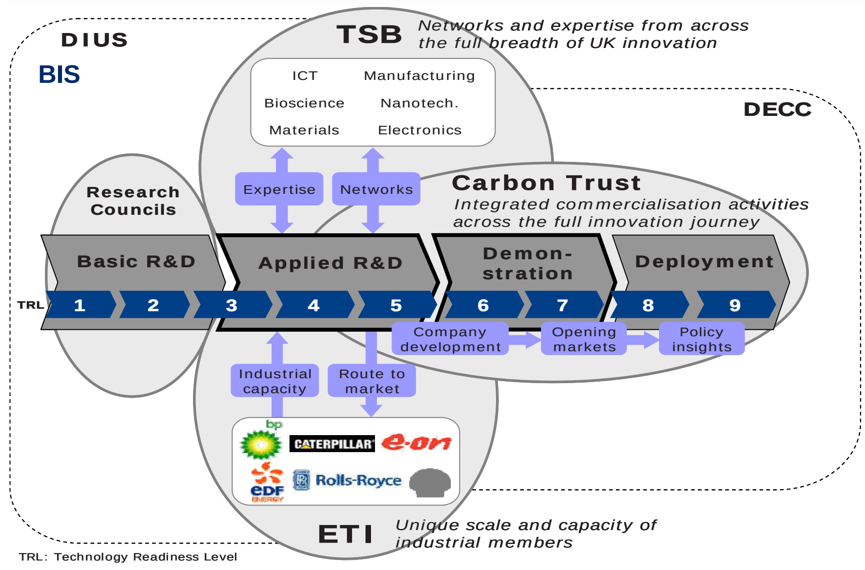



*Figure 5. UK energy innovation funding. (www.lowcarboninnovation.co.uk)*

### The Existing UK Housing Stock

The historical context for the existing UK housing stock is significant. About half of the dwellings (from a total stock of about 24 million) were constructed when coal fires were used for room heating. About a quarter of all dwellings have 'solid masonry' walls and were built before about 1920. More recent low rise dwellings have 'cavity masonry' walls, built after 1920. About half of the existing cavity-walled dwellings have had their cavity walls insulated since the 1970s. Very few of the solid walls in dwellings have been insulated. Central heating systems have been fitted to the majority of existing dwellings, with about 70% of the total stock now using natural gas as the primary heating fuel. Successive tightening of the Building Regulations for new housing over the previous 15 years has led to higher minimum levels of insulation standards, air tightness, heating system efficiency and lighting efficacy.

To support a **full spectrum of Energy research** to help the UK meet the objectives and targets set out in the 2007 Energy White Paper

To **work in partnership** to contribute to the research and postgraduate training needs of energy-related business and other key stakeholders

To increase the **international visibility** and level of international collaboration within the UK energy research Portfolio.

To expand the **UK research capacity** in energy-related areas.

***2008 - 2011 = £319M planned investment***

*Figure 6. The objectives of the UK Research Councils' Energy Programme. (www.rcukenergy.org.uk)*

which 18 universities participate to carry out whole systems energy research. The objectives are summarised in Figure 6.

*UK Energy Research Centre (www.ukerc.ac.uk)*
The UK Energy Research Centre is a national co-ordination network for interdisciplinary whole systems energy research involving more than 70 researchers. It performs a range of activities, including:

- forming a bridge between the UK energy research community and the wider world of business, policy and international energy research,
- publishing a Research Atlas (landscape, roadmaps, research register),
- hosting the Energy Data Centre,
- convening the National Energy Research Network (with 500 members),
- hosting the Meeting Place (with 15 to 20 events each year), and
- carrying out technology and policy assessments.

*Demonstration Projects*
Large scale deployment of low and zero carbon new buildings is expected to take place in the UK within the next 10 years. To date there have been a number of either one-off or small scale developments. Many of these have been initiated by the private sector, including highly motivated individuals, and some public and private sector developers have already constructed low and zero carbon buildings. Several large scale demonstration projects for new dwellings are now under development. The 'Carbon Challenge' programme has provided funding towards several such projects.

Carbon Challenge sites must reach the highest level of the Code for Sustainable Homes. Specifically, the highest energy standard under the CSH requires 'net zero carbon emissions' for each new home, with energy taken from the national electricity grid being balanced by renewable energy supplied. Carbon Challenge sites currently under construction are:

- Hanham Hall, Bristol (180 homes)
- South Bank Phase One, Peterborough (400 homes)
- Brodsworth, Doncaster (450 homes)
- Bickershaw, Wigan (650 homes)

Refurbishing existing buildings, 50% of which will still be here in 2050 is an important area for the UK. In the £17M 'Retrofit for the Future' programme, the Technology Strategy Board is supporting innovative proposals for retrofit of social housing to low carbon standards. Funding for 87 projects has been announced.

The 'Threadneedle Low-Carbon Work-place Trust' is a commercial initiative in which the Carbon Trust, fund manager Threadneedle and developer Stanhope are partners in a new fund that aims to significantly increase the availability of high specification low carbon commercial property in the UK. It will refurbish up to 50 properties over the next five years to best practice low carbon standards. Occupiers will be offered space at market rates and will benefit from significant reductions in carbon emissions and energy consumption. They will also receive ongoing assistance to help them occupy the buildings to their full low carbon potential.

**Further Information**
For additional information, please see:
*www.carbontrust.co.uk*
*www.decc.gov.uk*

## New Member Country: Spain Joins the ECBCS Programme

On behalf of the ECBCS Executive Committee, I am pleased to announce the recent decision of the Ministry of Industry, Tourism and Trade of the Government of Spain to accept an invitation to join the ECBCS Programme. The Government of Spain has designated Tecnalia to represent them. The Executive Committee welcomes Jose Maria Campos, currently Head of Energy in Buildings & Urban Areas at Tecnalia as the first Executive Committee member for Spain and we look forward to co-operating with their research community to pursue the ECBCS Strategic Plan. More information about energy in buildings and communities in Spain will be provided in a future edition of ECBCS News.

*Dr Morad R. Atif*

*ECBCS Executive Committee Chair*

# How Occupant Behaviour Influences Real Building Energy Use

## ECBCS Project Update

Hiroshi Yoshino, Tohoku University, Japan & Shuqin Chen, Lawrence Berkeley National Laboratory, USA

One of the most significant barriers for achieving substantial improvement of building energy efficiency is a lack of knowledge about the factors determining the energy use. To better understand this issue, an ECBCS project is in progress - 'Annex 53: Total Energy Use in Buildings - Analysis and Evaluation Methods'.

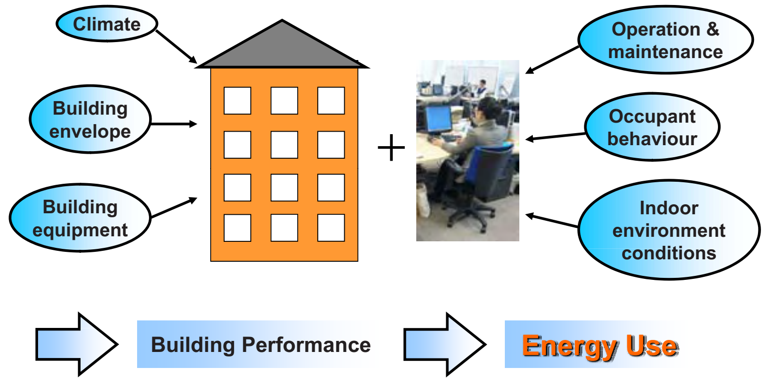



*Figure 1. The six factors directly influencing building energy use.*

Well known factors of direct influence are climatic conditions, the building envelope, and building services performance, but energy use also depends on operation and maintenance, occupant behaviour and indoor environmental conditions. Figure 1 schematically indicates the relationship between these factors and energy use. Most importantly, a scientific methodology does not yet exist to clearly and thoroughly account for:

- interactions between the six influencing factors, especially those involving occupants' activities and behaviour, or
- energy use predictions when all of the influencing factors have been taken into account.

Figure 2 provides an illustrative example of measured energy use of air-conditioners in apartments in a multi-family building in China. It can be seen that even for the same kind of end use in similar dwellings, there is a large variation in electricity consumption. The reason for this is that actual building energy use is arises from the combined effect of the various influencing factors.

Inconsistencies in terminology relating to building energy use is also a surprisingly serious problem. This hinders both attempts to understand the influencing factors and the analysis of real energy use.

The project is working to improve understanding of how the six factors combine to influence building energy use, with particular emphasis placed on occupant behaviour. It also aims to improve the treatment of these factors within the building energy field, and to more closely relate this to the real world. Hence, the intention is to have a better understanding of how to robustly predict total energy use in buildings, so enabling the improved assessment of energy–saving measures, policies and techniques.

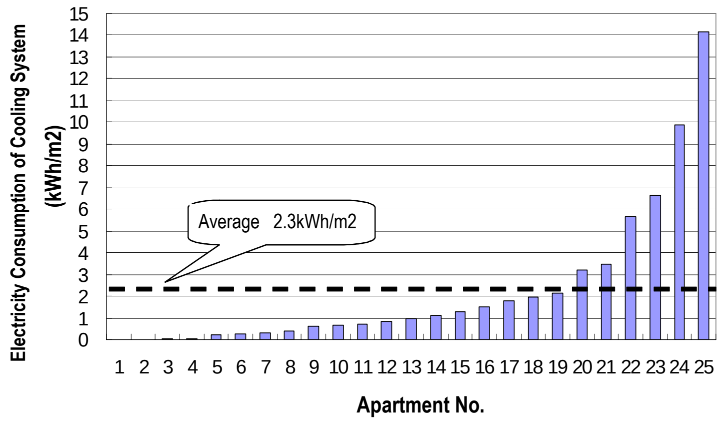



*Figure 2. Household electricity use for split-unit air-conditioners in Beijing, China, measured in 2006.*

### Research Objectives

The main project objectives are to develop and demonstrate with respect to energy use:

- The approach to describe occupant behaviour quantitatively
- New methodologies to analyze total building energy use and to then investigate the factors that influence total energy use
- Methodologies and techniques for monitoring total building energy use
- How monitored data can be used to provide indicators of building energy performance
- Methodologies to predict total energy use in buildings and to assess the impacts of energy saving policies and techniques including the influence of occupant behaviour

Four distinct areas of research have been established:

- Definitions and reporting
- Case studies and data collection
- Statistical analysis
- Energy performance evaluation

*Definitions & Reporting*

It is usually very difficult to compare the same type of energy use data from different case studies and to then correctly draw conclusions from such comparisons. This is due to poorly defined building energy use concepts, as well as inconsistencies between classifications and definitions for energy end uses presented in many existing case studies. Therefore, making consistent definitions relating to terminology for building energy use, influencing factors, and other related items is the main goal of the 'definitions and reporting' research topic. This is the fundamental basis by which we achieve a thorough understanding of energy use in buildings. Therefore, a three stage approach has been adopted:

1. A 'state-of-the-art' review is to be conducted for terminology relating to building energy use, building energy performance, influencing factors, system boundaries and conversion factors.
2. A comprehensive set of definitions is to be agreed, to create a consistent language for building energy research. This will cover terminology for energy use, energy boundaries, conversion factors for different energy sources, the six factors of direct influence, economic and social effects (indirect), as well as energy performance indicators.
3. A reporting format is to be developed for the scientific expression of the above items using consistent definitions and correct application in other parts of the project.

*Case Studies & Data Collection*

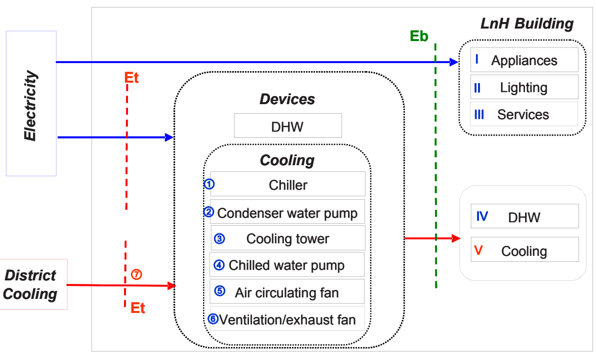
Collection, review and selection of case studies, with documentation and analysis of their energy use data are critical aspects of the research. The key point is to define the cases to be examined under a variety of occupant behaviour patterns. The intention is to collect about 30 case studies from different countries, according to the following four building categories:

- Office buildings - large-scale, high-rise offices; small-scale offices;
- Residential buildings - single family houses; multi-family apartments.

**Lincoln House**

- Construction dates
  - Began:1996
  - Finished:1998
- Floor count:23
- Height: 106 m
- Owner: Swire properties, Hong Kong
- Building uses
  - Office
- Structural types
  - Highrise
- Architectural style
  - Modern
- Materials
  - Glass
  - Concrete
  - reinforced

(a)




- Step 1: Sketch map of energy flow & boundary
- Step 2: Delivered to the building-Eb
- Step 3: Delivered to the building-Et
- Step 4: Calculation of energy index

(b)

*Figure 3. Selection of a case study for analysis.*

Figure 3 is an example of how a case study will be analyzed: Lincoln House is selected for the research. Its basic information, such as the building function, floor area and construction materials are collected and are listed in Figure 3(a), while Figure 3(b) shows the general approach to the energy analysis, in which different end uses and boundaries are clearly identified in Step 1. In Step 2 and Step 3, energy flows across different boundaries are illustrated and then finally in Step 4, energy indices are calculated. The development of a 'real-time measurement techniques' database is the other target for data collection. Figure 4 shows such a data collection network. Separate meters, such as for electricity meters or meters for district heating are installed on site to measure the energy consumption of different end uses in buildings. These data are collected from terminals and passed to to concentrators. Data is then sent to databases using various communication technologies. Building and use (meter value) databases are the two dominant types. Web-based analysis and reporting

**Planned Project Deliverables**

The deliverables are planned to be:

- Definitions of terminology, indicators and influencing factors for building energy use
- Case studies of energy end use in buildings
- Demonstration of measurement and data acquisition technologies for long term monitoring - planned to be an on-line database
- Illustration of the relationship between the characteristics of the database and the statistical / prediction methods that are best suited to the aims of the analysis
- Methodologies with presentation of case studies
- A methodology for analysis of the effect of the six directly influencing factors on building energy use, by end use
- Demonstrations of the effect of energy saving technologies and occupants' behaviour and lifestyle changes on energy use

are used to display the monitoring results.

*Statistical Analysis*

Prediction methods and identification of the main factors relevant to total energy use are focal points for this research. So, in parallel with the case studies, statistical analysis forms another important part of this project. This needs to be undertaken not only for global, national and regional total energy use in buildings, but also for total energy use in individual buildings.

Deciding on sample size and information is the most important issue in statistical analysis. Without doubt an ideal database for statistical studies is to have the sample sizes as large as possible and sample information as in depth as possible. But, this would cause significant difficulties in data collection. Hence a compromise must be reach to balance between the sample size and the sample information for statistical analysis. When statistical analyses for global, national and regional total energy use in buildings are developed it is a reasonable solution to obtain information relating to building energy use to a medium extent, along with medium sample sizes. However, detailed building information should be obtained at a fine temporal resolution and for multiple years if individual buildings are to be analysed.

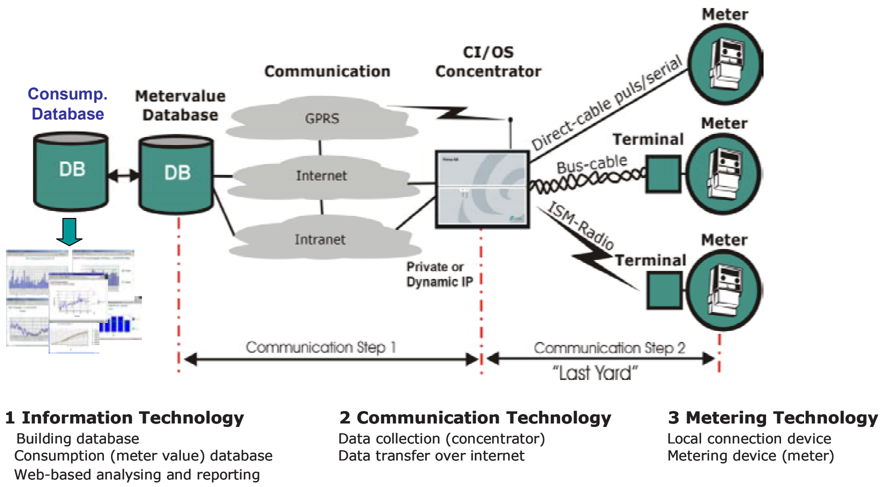



*Figure 4. Development of a real-time measurement techniques database.*

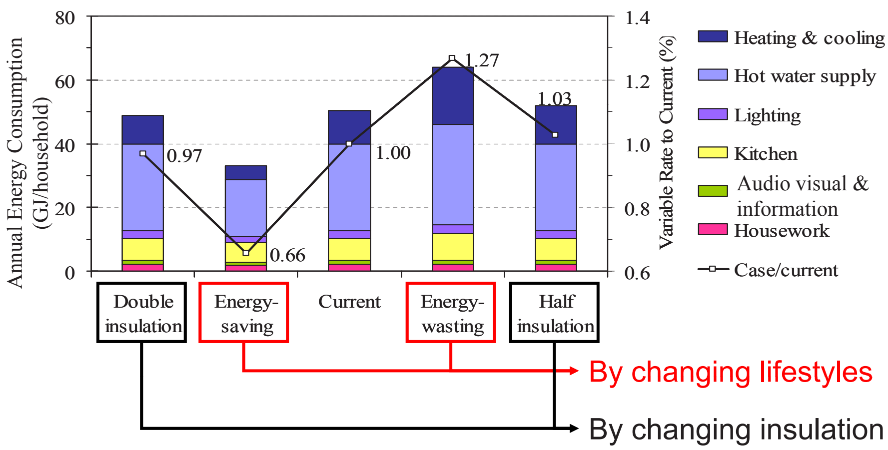



*Figure 5. Analysis of the effect of lifestyle changes and insulation levels on residential energy use.*

*Energy Performance Evaluation*

The final important aspect to the project is analysis by specific methods of the relationships between influencing factors for building energy use, especially of occupant behaviour and lifestyle. Apart from this, other items of work include:

- evaluation of existing and new performance indicators for total energy use taking into account the influencing factors;
- exploring knowledge about and demonstration of methods to predict the effect of energy saving technologies and changes to occupant behaviour and lifestyle on building energy use.

Figure 5 shows an example of a simul-ation study of the influence of envelope insulation and occupants' energy saving actions on resid-ential energy use: A two-storey 153 m$^2$ detached house with four occupants in Sendai, Japan, was selected as the simulation subject. The simulation results show that lifestyle greatly influences energy use. Changes in lifestyle are then seen to have a large energy saving potential, while the energy saving effect of envelope insulation is not so distinct.

**Further Information**

For further information, please see:
*www.ecbcs.org/annexes/annex53.htm*

For the latest announcements about ECBCS-related meetings and conferences, please see:

***www.ecbcs.org/meetings***

# Sustainable Building Stock Renovation: A Novel Approach

## ECBCS Project Outcome

**Mark Zimmermann, EMPA, Switzerland**

New energy-efficient buildings are important, and so is the energy use of the existing building stock. The importance of building renewal for sustainable development is unquestionable. By 2050, about 90% of building energy use will be caused by those built before 2000. At the same time existing buildings often offer poor comfort and flexibility and can no longer compete with new buildings. Repair and 'soft' renovations cannot solve the problem and partial renovations are often expensive and ineffective.

The focus of the ECBCS project 'Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings' is on apartment buildings with a general renovation need. This should not only offer significantly improved energy efficiency, but also occupant comfort. The concept is based on highly standardized and prefabricated renovation modules for façades and roofs.

Universities, industry, architects and building owners are partners in this international project, which focuses on the following topics:

- minimising primary energy use in the range of 30 - 50 kWh/(m²·year) for heating, cooling and hot water, per unit gross floor area,
- improving comfort, space use and quality of living in old buildings,
- ensuring quality of the indoor environment with respect to thermal comfort, noise reduction, indoor air quality and daylight, and
- ensuring the construction process is integrated and cost-effective.

*Holistic Building Renewal*

The project offers new solutions for the holistic renewal of apartment buildings. Energy-related measures are often not economic in themselves. They have to be combined with measures that create additional added value. A comprehensive renewal is an opportunity for measures that not only repair a building but improve it for future generations of occupants.

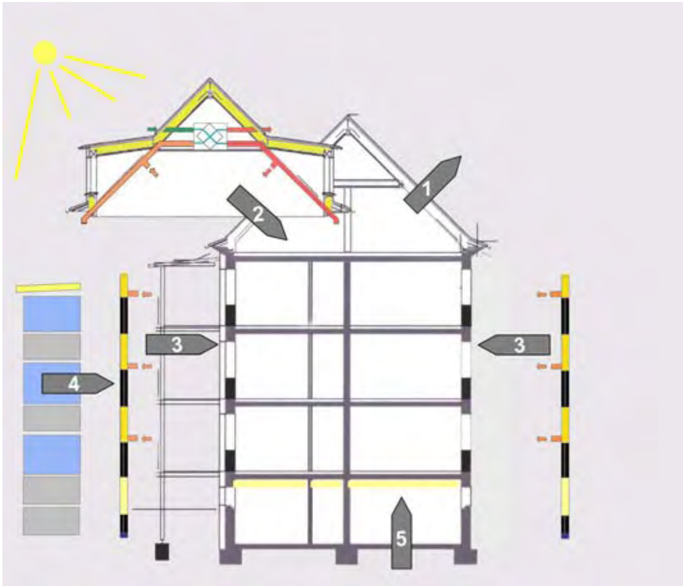



*Figure 1. Renovation concept: removal of old roof (1+2), mounting of façade elements with integrated ventilation ducts (3), closing of balconies (4, optional), insulation of basement (5).*

The proposed concept includes construction of new thermal envelope is constructed enclosing the existing building. This also allows improvement of the façades, room extensions and new attic accommodation. The new building envelope has the quality of new construction. It is well insulated, physically sound and delivers excellent comfort. A new mechanical ventilation system with heat recovery - a pre-requisite for low energy buildings such as those built to the Passivhaus standard - is integrated in the façade and roof modules. Optimised constructions, an efficient construction process, high quality standards and reliable financial control are important features of this concept.

### High Quality Renovation Modules for Façades & Roofs

Well-integrated façade and roof modules have been developed in collaboration with major European construction companies. The highly standardised modules are light weight constructions which can be prefabricated to any size by leading timber construction companies and mounted in collaboration with local contractors.

These highly standardized modules still allow much flexibility: The construction technique for the modules is standardised. This allows dimensionally correct application, excellent thermal insulation and fire protection according to national standards. The size of the modules can be easily adapted to the existing building and the final cladding is an architectural decision. This allows the architect to concentrate on the façade appearance without concern about the technical construction behind it. Ventilated cladding systems and traditional rendering are both possible with this approach.

The façade modules are designed to fit with the existing window openings. All major integration issues to be solved are concentrated close to such areas: window integration, solar shading, ventilation ducts, and additional services such as IT or electrical wiring.

The spaces between window openings are normally very simple to insulate. They do not need extensive planning and design and can be constructed in a traditional way by local craftsmen. Mineral wool, foam insulation or blown-in fibres may be used. Finally, the façade cladding - ventilated or rendered - has to be completed. In summary, there are three parts to the new façade construction:

- prefabricated façade modules with integrated windows and building services,
- simple insulation of the spaces between the modules, and
- façade cladding.

With this approach there is a high level of standardisation as well as system flexibility giving the potential for large scale application. The roof modules follow the same principle, permitting the layers of the façade construction to continue into the roof. This guarantees all services within the façade and the roof can be easily connected.

*3-D Measurement of Existing Buildings*
To guarantee the renovation modules will fit on the existing building envelope, special 3-D laser scanning technologies or photogrammetry have to be used to take measurements. These technologies have been further developed for the purpose of building renovation.

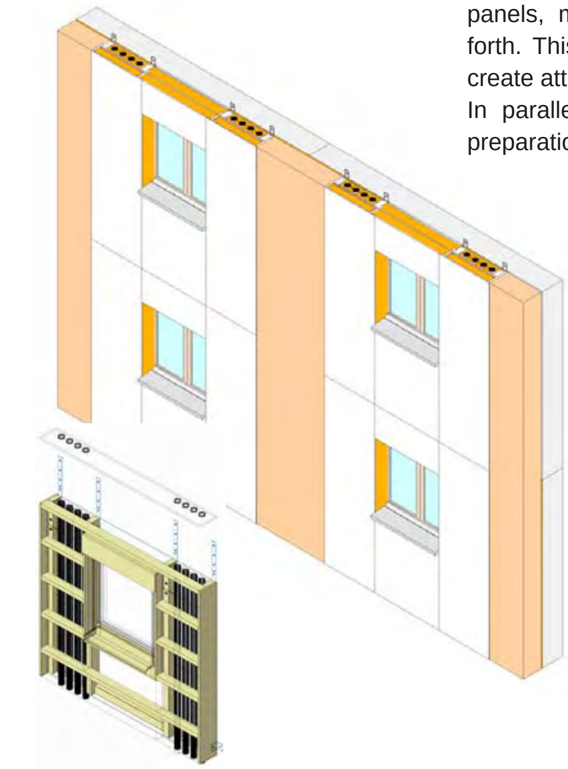


*Figure 2. Façade modules produced precisely to size and mounted onto the façade with the spaces between the modules traditionally insulated. (Inset: façade module showing integrated ventilation ducts.)*

*Laser Scanning*
The building is needs to be laser scanned from all sides. This allows accurate isometric mapping of the building. Millions of recorded points allow an accurate representation of the building shape. Detailed 3-D measurements, irregularities and distortions of the building façades can be extracted by computer analysis. The detailed data sets are available for planning, accurate production of the prefabricated elements and for mounting of the modules.

*Photogrammetry*
Photogrammetry can be used for buildings with true planar façades. It is much simpler to apply than laser scanning. The building can be photographed with a good digital camera and the pictures completed with reference measurements. Special computer programs allow normalisation of the pictures, from which 3-D measurements can then be taken.

*Renovation Process*
Existing roofs may be completely removed and replaced by prefabricated roof modules, which allows an optimised use of roof space and the integration of modern technologies such as solar panels, mechanical ventilation and so forth. This opportunity is often used to create attractive new attic apartments.
In parallel with the roof replacement, preparations are required for mounting the façade elements. If needed, existing balconies - usually with thermal bridges - are removed and the size of window openings adjusted. The building owners decide to what extent they wish to change and improve the existing building structure. Often, the opportunity is used for optimising floor plans: For example, existing balconies can be used to enlarge living rooms or kitchens. This can be done easily because a new external building envelope is constructed around the existing building.

Next, the prefabricated façade modules need to be fixed to the existing façade. Windows and solar shading are normally integrated in these modules, as are the ducts for the ventilation system or new electrical wiring. If not already done so, old windows are removed and the air in- and outlets drilled. Finally, the inside soffits are being completed and decorated. If no other internal refurbishment is planned, the retrofit is already completed. In fact, during the renovation the occupants may stay in their apartments: The disturbance is minimal and lasts only a few days.

If needed, room enlargements, roof extensions and new elevators can be realised at the same time. In addition, the elements for roof extensions can be combined with those for the façades.

Finally, the gaps between the façade elements are insulated and closed and

*Figure 3. Refurbished row house at Dieselweg in Graz (left) and original situation (right).*

the finish is applied according to the architect's design. Ventilated façades as well as rendered finishes are both possible.

## Outcomes

The ECBCS project, 'Prefabricated Systems for Low Energy Renovation of Residential Buildings' has significantly advanced the possibilities for low energy renovation. Specific outcomes from the project are:

- market analysis and concept development,
- technology development,
- demonstration projects, and
- planning tools.

*Market Analysis & Concept Development*
The existing building stock was analysed and the requirements and possibilities for advanced low energy retrofit were evaluated. The study has produced building typologies that provide basic data for the evaluation of the renovation potential of the existing stock, for the definition of retrofit strategies and the envelope characteristics of specific building types.

*Technological Development*
The establishment of a building typology was important for the development of standardised façade- and roof modules with a large potential for application. To date, the prefabrication technology for façade and roof modules has been developed and tested. Close attention has been paid not only to building physics, but also to fire protection and logistics. This has resulted in highly standardised renovation modules that concentrate on the window areas requiring high levels of detailing.

Special attention was given to laser scanning methods for building measurements. The scanning process and the post treatment of data have been researched and further developed. Due to precise and efficient measurement technologies, good progress in planning, production and mounting is expected.

*Figure 4. Existing buildings can be laser scanned. The result is a photorealistic 3-D-picture allowing the required measurements to be extracted.*

*Demonstration Projects*
Demonstration projects are important to prove the practical feasibility of the concept. Five demonstration sites with more than 200 renovated apartments have been successfully completed in Austria and Switzerland. The energy use of all renovated buildings has been reduced by 80% - 90%. Solar installations on most of the buildings are expected to reduce the imported energy use to close to zero. Further demonstration buildings are likely to be completed only following the conclusion of the project, although it is intended to document them as additional case studies.

*Planning Tools*
Successful building renovation does not only depend on technical issues. The development of an optimal renovation strategy is as important. For this purpose, an electronic 'retrofit advisor' tool has been developed. It allows the evaluation and comparison of the economic, environmental and social impact of different renovation strategies. The tool includes a straightforward interface to assist non-professional users.

### Further Information

Results and publications from the project are expected by early 2011. Additional Information is available from:
*www.ecbcs.org/annexes/annex50.htm*

## The Future for Sustainable Built Environments with High Performance Energy Systems

### Conference Announcement

*19th October - 21st October, 2010, Munich, Germany*

Integrating maximum renewable energy supplies creates opportunities for leading-edge technologies and new solutions for buildings, communities and energy supply systems. In addition to the presentation of new results and technologies, conference participants are expected from government, research and industry. The event therefore creates the chance for an open interdisciplinary discussion on how to address the upcoming challenges of energy transition.

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# Energy Efficient Retrofit Measures for Government Buildings: New Help for Decision Makers

## ECBCS Project Outcome

Alexander Zhivov, USACE Engineer Research and Development Center, USA

The energy efficiency of government and public buildings must be improved to successfully cope with increasing energy costs and mitigate climate change. However, in the existing building stock concerns about energy use generally take second place to and can be perceived to be incompatible with goals of maintaining occupant comfort or building functionality.

Before decision makers will consider energy conservation in buildings as a primary goal, they must overcome their reservations about the compatibility of energy conservation with occupants' comfort and productivity, and building functionality. They need to see convincing, real-world examples of how measures that reduce energy use can also improve comfort and functionality.

Good technologies and a wide range of options for retrofit measures that meet these requirements are already available. ('Retrofit measure' means here the full range of possibilities for energy-related refurbishment, renovation or retrofit.) The main obstacle to their implementation is simple lack of knowledge of their intelligent application. Adoption of energy efficiency measures needs to be integrated into facilities management with long-term planning for common retrofit measures when updating the building fabric, services and processes. This needs to become part of normal operations, maintenance and building use.

### A New Decision Making Toolkit

To provide decision makers with comprehensive information in an accessible form, the 'EnERGo' IT-Toolkit has been produced by the ECBCS project "Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings". This provides guidelines for the whole decision making process involved in identifying energy conservation opportunities and improving building indoor environments through retrofitting projects to improve energy-efficiency.

For every possible retrofit measure, there is an installation cost and a payback time that can vary greatly depending on the building and the climatic zone in which the building is located. Additionally, the combined effect of different retrofit measures can be lower or greater than each applied in isolation. A decision to implement a retrofit measure often implies a long term commitment as part of facilities maintenance and management. It is very important to select optimal retrofits for each application. It is intended that the EnERGo IT-Toolkit will help to analyze the energy saving potentials of existing public and government buildings during the development of retrofit projects.


*Figure 1. The 'EnERGo' IT-Toolkit.*

A **Performance Rating** tool allows the comparison of a given building's consumption to a national average. Consumption data for heat, electricity and water are provided for different types of buildings. Performance data are available for a total of 12 countries.

While the complete dataset required to analyze older building retrofit concepts may sometimes be available, a detailed building inspection (following the **Electronic Building Inspection Protocol** provided in EnERGo) is often the only way to assemble all the data required for a calculation or simulation of the building.

An **Operation and Maintenance Checklist** is a guide to provide users with key information about operation and maintenance (O&M) management, technologies, and energy efficiency and cost-reduction approaches. It contains information on why O&M is important and the potential for savings when it is properly applied. Furthermore, it defines the major types of O&M programme and provides guidance on best practice about how they should be structured. It also provides information on state-of-the-art maintenance technologies and procedures for key equipment, and identifies information sources and points of contacts to assist with carrying out the work.

An **Energy and Process Assessment Protocol** (Figure 2) provides an energy assessment methodology and procedure suitable for different types of sites, including:

- a variety of different non-industrial buildings with energy requirements dominated by climate, and
- industrial buildings which have high energy loads dominated by internal processes and have high

ventilation requirements per unit floor area.

The Energy Concept Adviser (produced by the ECBCS project 'Annex 36: Retrofitting in Educational Buildings - Energy Concept Adviser for Technical Retrofit Measures') already includes more than 50 **Retrofit Case Studies** describing application of different energy conservation technologies in retrofit projects. The EnERGo IT-Toolkit also includes more than 45 additional case studies developed under the European project, 'BRITA in PuBs' . The case studies contain information on the site of the building, the retrofit concept, the retrofit cost, energy savings, lessons learned, and general information on retrofitted buildings. Case studies (Figure 3) can be selected from a selection matrix, which shows the types of retrofit measures used in each.

A Database of more than 400 promising **Energy Conservation Measures** and energy saving technologies (current, proven, well known or under-used) has been developed. The database summarizes international experience of building retrofit. It includes the technologies or measures that can be categorized as: building envelope, internal load reduction, lighting, HVAC systems, energy consuming processes in the building, and supplemental energy systems (e.g., compressed air, steam system, etc.)

For each energy conservation measure there is either a short description or a more detailed screening analysis. The detailed screening report includes a technology description, qualitative and quantitative (simulation based) analysis of energy savings and simple payback by climate and building / system type.

The **Energy Efficiency Calculator for Building Retrofit** provides a holistic interdisciplinary methodology for the assessment of energy efficiency of non-residential buildings. The basis of the calculations is the classification into a representative zone or area of similar utilization and conditioning (heating, cooling, ventilation, and lighting). For each zone, the energy demand for heating, domestic hot water, air conditioning, and lighting is calculated under the assumption of either user-defined or default utilization profiles. Thermal properties of the building envelope play a significant role in the calculation. The total energy to be provided for the whole building is calculated, considering mutual interactions between the zone and the installed building services systems. The assessment of the energy sources used, which considers the fuel value and its environmental compatibility, weights the amount of energy with its primary energy factors to yield the primary energy demand. The primary energy demand gives information on the total energy efficiency of a given building.

If limited funding is a problem, an Energy Performance Contract (EPC) might present a possible solution. An EPC is a financing mechanism used to install energy conservation measures at a site. These conservation measures generate energy-related cost savings, which are then used to pay financing costs on the loan and to fund services such as operations and maintenance (O&M) and measurement and verification (M&V).

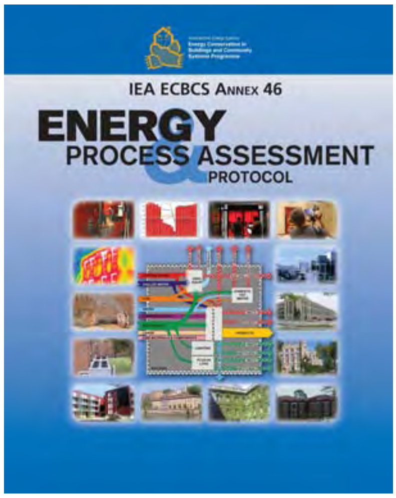


*Figure 2. The 'Energy and Process Assessment Protocol' report.*

EnERGo includes a **Best Practice Guide for using EPCs**. The Best Practice Guide describes the most common energy efficiency measures installed under EPCs, and the typical implementation process. The basic steps in this process are very similar across all of the governments that participated in the project. Fifteen detailed case studies of EPCs included in the tool can be used for familiarization with the concept of using private capital to improve the energy efficiency of government buildings. In addition to the Best Practice Guide, EnERGo includes a **Calculation Tool for Energy Performance Contracts** that allows detailed cost calculations of planned retrofit measures. Based on cost, interest rate and savings, the calculator determines the length of time required to pay off an EPC.

**Retrofitting of dormitories**
**City Vert-Bois, Montpellier, France**

**1. Photo**

Figure 1 : South view of the building after retrofitting

**2. Project summary**

The University City Vert-Bois was built in 1968 in Montpellier. It is constituted by 6 buildings in a green parc, close to the university Paul Valery.
The 6 buildings have the same structure. Directed north-south, they were constituted of 166 rooms and collective toilets before retrofitting.
Since 2003, all operations of retrofitting systematically bring elements of sanitary comfort in rooms (washbasin, toilet, and shower). From this date, all the technical installations were also renovated, the swallowed facades, the waterproof nesses of roofs. These facades don't require heavy maintenance for several years, except the paintings.
This case study concerns the building D of the University City, where rooms were transformed into studios in 2003.

*Figure 3. Example of a retrofit case study.*

**Further Information**

The EnERGo IT-Toolkit is available later this year via the project website, with a single-zone model version available as shareware. For the participating countries in the project, a special licensed multi-zone model version will be available via national representatives. For further information, please see: *www.ecbcs.org/annexes/annex46.htm*

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