



International Energy Agency

**Energy Conservation in
Buildings and Community
Systems Programme**

17.1.2006

Annex 50

Prefabricated Systems for Low Energy / High Comfort Building Renewal

1. Background

Energy conservation is largely dominated by existing buildings. In most industrialized countries new buildings will only contribute 10 % -20 % additional energy consumption by 2050 whereas more than 80% will be influenced by the existing building stock. If building renovation continues at the current rate and with the present common policy, between one to over four centuries will be necessary to improve the building stock to the energy level of current new construction. Accordingly, building renovation has a high priority in many IEA countries and it plays an important role in the building related IEA R&D programmes.

Currently, most present building renovations address isolated building components, such as roofs, façades or heating systems. This often results in inefficient and in the end expensive solutions, without an appropriate long term energy reduction. Optimal results can not be achieved by single renovation measures and new problems could arise, including local condensation or overheating.

On the other hand the comfort gap between new and existing buildings is growing continuously leading to a decreasing attractiveness of the existing building stock.

IEA research has contributed substantially to concepts and technologies suitable for new buildings. But, many of these concepts and technologies have not yet been adapted or optimised for retrofitting of existing buildings.

Standard concepts for energy efficient buildings and an increasing level of prefabrication have substantially enhanced the quality and comfort of new buildings, e.g. low energy and passive houses. Advanced measurement technologies allow new quality standards in prefabrication. These successful concepts and methods should now be translated to new standard solutions for building renewal.

2. Scope

The project focuses on typical apartment blocks representing approximately 40 % of the European dwelling stock. However, appropriate single family homes are not excluded.

The project concentrates on:

- Minimising the primary energy consumption (in the range of 30-50 kWh/(m²·year) for heating, cooling and hot water, per gross floor area),
- Optimising the integration of solar energy use,
- Increasing living comfort by better space use,
- Assuring good thermal and acoustical comfort, good indoor air quality and daylighting conditions,
- Assuring a fast, high quality and cost-effective construction process.

3. Objectives

The objectives are the development and demonstration of an innovative whole building renovation concept for typical apartment buildings based on:

- Prototype, prefabricated roof systems with integrated HVAC, hot water and solar systems,
- Highly insulated envelopes with integrated new distribution systems for heating, cooling and ventilation.

The advantages of these prototypes include:

- Achieving energy efficiency and comfort for existing apartment buildings comparable to new advanced low energy buildings,
- Optimised constructions and quality and cost efficiency due to prefabrication,
- Opportunity to create attractive new living space in the prefabricated attic space and by incorporating existing balconies into the living space,
- A quick renewal process with minimised disturbances for the inhabitants.

4. Means

Preparation-Phase

During an initial period of twelve months the group of project partners will be assembled to represent building stock owners, industry partners, building designers and research institutions and the final project plan will be developed.

The preparation phase serves to organize the collaboration between the partners, to involve the additional partners where needed (a special effort will be made to have a good representation of all stakeholders dealing with the renovation process), to define the national contributions and to secure national funding.

During the whole Annex, subtasks A and E are performed by the same group of participants in order to assure the coherence and continuity of the concept.

The outcome of the preparation phase will be the final Annex plan.

Subtasks

A: Concept definition and specification		
B: Integrated roof systems	C: HVAC and solar systems	D: Façade elements
E: Monitoring and dissemination		

Subtask A: Concept definition and specification

The first subtask focuses on the development of the whole building renovation concept and on its implementation and overall consequences. During this phase variations of prototypes will be simulated, optimised, designed and specified. This will result on the one hand in addressing the require-

ments of the planned demonstration projects and on the other hand in more general guidelines for efficient retrofitting concepts of apartment buildings.

Subtask A will develop the overall concept for the low energy renovation and provide the general specifications for subtasks B, C and D and will ensure the coordination of this work. To do this job, the Subtask A team will:

- Study the renovation market and needs in each participating country.
- Define insulation levels, heating and cooling demands.
- Develop the overall design of the renovation concept.
- Solve the important issues of the design of the new heating system, the ventilation system, the hot water supply and probably other new systems to be installed, all taking into account constraints of the existing structure. It must be decided to what extent the existing systems will be reused or replaced and how system integration is possible.
- Perform the building simulations, considering energy, comfort, daylight and environmental impact. The role of solar energy – solar thermal and PV.
- Define the insulation and airtightness levels, heating and cooling demands.
- Define the ventilation system, air change rate, principal positioning of air in- and outlets, internal air flows, and heat recovery.
- Define the specification of interfaces between building components.
- Study and evaluate the economical aspects of the concept, including amongst other things the reduction of energy bills, retrofitting cost, increased living space, time, etc.
- Determine the barriers to implementation and study the feasibility.

Subtask B: Integrated roof systems

The new prefabricated roof construction is the central element of the renewal concept, providing new roof space and hosting the new HVAC and solar systems.

The design process will focus on prefabrication, quality assurance, cost optimisation, and rapid construction as well as architectural aspects/features for the retrofit concept and the integration of this into the existing environment. The design teams (architects and engineers) and industry partners would be in close cooperation with the research institutes.

The subtask includes design optimisation, prefabrication, quality assurance and final on site construction.

The work to be done in Subtask B includes:

- The evaluation of new roof concepts. Each participating country will study the most common roof types in their country in order to make a further selection and choice of the construction type to be included in the retrofit catalogue in order to obtain a better focus. A catalogue of new roof systems will be provided. Each proposed concept has to be checked against the existing regulations/building standards in each country. The focus will be on different types of steep roofs but flat roof constructions are not excluded. The catalogue will describe the proposed new roof concepts, their construction, building physics, summer and winter comfort, dimensioning, interfaces to the other building parts, quality and cost aspects.
- The evaluation and provision of advanced measurement technologies that allow precise data measurement for prefabrication. The specific task is that reliable data have to be available long before the existing roof structure has to be removed.
- The development of improved design concepts for solar integration and prefabrication, including concepts for easy transportation and assembling of the roof parts on site.

- The final design and production of roof constructions for the demonstration buildings, including coordination with HVAC and solar systems, quality assurance and installation on site. Design should include the reduction of cooling loads and possibilities to solve problems with summer over-heating.
- The evaluation of the roof performance (tolerances, thermal quality, moisture and air tightness, potential for improvements).

Subtask C: HVAC and solar systems

In building retrofit the existing heating and hot water system has to be considered when designing the new HVAC system. To achieve a cost effective building renovation the possible interaction between existing and new components have to be studied.

Two main strategies will be investigated:

- The existing heating and hot water system has to a large extent to be replaced. Concepts for a new, optimised heating and a ventilation system will be developed, splitting heating and ventilation (for district, wood or oil heating) or combining them (for gas, solar or heat pumps).
- The existing heating and hot water system is partially reused (and improved) and only the ventilation system is newly installed. In this case the heating will remain in the basement, whereas the ventilation system will be installed in the attic.

The goal of the design process will be highly compact roof integrated and modular systems that can include the use of solar energy (thermal and/or PV), ventilation, heat recovery and in specific cases also heating, cooling and domestic hot water. The industry partners will be supported by the research teams and the design teams of Subtask C.

The work includes system and component optimisation (new and where appropriate existing), production and installation during the prefabrication of the roof and façade elements and performance testing.

The work to be done in Subtask C includes:

- The evaluation of heating, ventilation, hot water and solar concepts including PV, taking into account the existing system. A catalogue of typical modular solutions sets will be produced. This will describe the proposed modular concepts, the partial integration of the existing systems, the energy demand and solar fraction, dimensioning, interfaces to the other building and installation parts, quality and cost aspects.
- The development of improved design concepts for solar integration and pre-installation in the roof construction.
- The final design and production of modular HVAC components to be used for the demonstration buildings, including coordination with roof builders, coordination of interfaces to new and existing distribution systems, quality assurance and roof factory installation.
- The evaluation of the HVAC/solar performance (energy performance, performance adjustments (commissioning), potential for improvements).

Subtask D: Façade elements

Façade elements include windows and other openings, opaque wall insulation and integrated service distribution for heating, cooling and ventilation. This concept allows rapid construction from the outside with minimal disturbance for the inhabitants.

The challenge of this subtask will be the optimisation of duct work integration and new window design, which reduces thermal bridges and optimises daylighting and shading. An added value is

achieved when old balconies which cause thermal bridges can be converted to or replaced by sun-spaces or living room extensions.

The design team (architects and engineers) and industry partners will combine form and function and coordinate their work with the requirements of Subtask B and C. This includes the design, prefabrication as far as possible, construction and quality assurance on site as well as architectural aspects/features for the retrofit concept and the integration of this into the existing environment.

The work to be done in Subtask D includes:

- A survey of common façade types. Each participating country will study the most common façade types in their country in order to make a further selection and choice of the construction types to be included in the retrofit catalogue in order to obtain a better focus. Each proposed concept has to be checked against the existing regulations/building standards in each country.
- The evaluation and provision of advanced measurement technologies that allow precise data measurement for prefabrication.
- The evaluation of new façade concepts. A catalogue of new façade systems - including cladding systems and compact façades - will be provided. The outcome of the above study will provide the focus on the choice of façade concepts to be included in the catalogue. It will describe the proposed concepts, their construction, dimensioning, interfaces to other building components, quality and cost aspects.
- The development of improved designs with special focus on smart window integration, prevention of thermal bridges, HVAC and electrical integration. Other issues are prefabrication, concepts for easy transportation and mounting of the façades on site.
- The final design and production of façade elements for the demonstration buildings, including coordination with HVAC and roof systems, quality assurance and installation on site.
- The evaluation of the façade performance (tolerances, thermal quality, moisture and air tightness, potential for improvements).

Subtask E: Monitoring and dissemination

The demonstration projects will be measured and analysed by the research partners before (as far as possible) and after renovation. This will include energy performance, air tightness, comfort, cost analysis and acceptance by inhabitants and building owners. The renovation process of the case study buildings will be documented (e.g. video, photo, ...)

The dissemination will mainly address designers, building stock owners and decision makers.

The work to be done in Subtask E includes:

- The definition of a monitoring concept for the overall performance of the renovated buildings (thermal, ventilation, solar, comfort).
- The specification of instrumentation for monitoring and commissioning.
- Performance monitoring, evaluation of acceptance by inhabitants and building owners, system optimisation (commissioning) and reporting.
- The evaluation of cost structure and saving potentials.
- The documentation and dissemination of case study buildings.
- The documentation and dissemination of the global concept for correct retrofitting of apartment buildings, including elements for all target groups.

5. Results

The deliverables from the project will be a set of condensed documentation covering:

- The whole building concept documenting typical solutions for prefabricated roofs with integrated HVAC components and for façades (D2)
- Guidelines for system evaluation, design, the construction process and quality assurance (D3)
- Documentation of case studies. This should include at least one demonstration building per participating country (D4)
- A synthesis report for a broad audience, demonstrating the potential of prefabricated retrofit (D5)

The products of the work performed in the Annex will be written for use by:

1. Building designers who focus on advanced building retrofit, energy, HVAC and sustainable construction
2. Building industry with an interest in prefabrication of high performance energy building retrofit
3. Apartment building owners with an interest in advanced renovation concepts

Results will include:

D1	An 'Internet and intranet' site. The intranet site will contain all meeting proceedings, the Annex papers and drafts of the final reports. The Internet site will contain general information about the project, an annual newsletter that informs about developments, linked activities and practical applications.
D2 Subtask A	A first report on prefabricated building retrofit concepts, typical retrofit solutions, performance requirements and general specifications.
D3 Subtask B,C,D	A second report documenting typical solutions for roof, façade prefabrication and HVAC/solar integration, including detailed specifications and interface definitions.
D4 Subtask E	A third report documenting the demonstration buildings before and after renovation, the benefits achieved, a cost analysis and the results of the monitoring task.
D5 Subtask E	A fourth and final report will summarize the concept of prefabricated retrofit and the solutions available for all target groups.
D6 Subtask E	The Internet site will be updated with all final Annex reports and available popularisation tools, focusing on the broad public.

All reports will be published in printed form and on CD-ROM. The reports D2, D3 and D4 target the building designers and the building industry, while report D5, the newsletter and the Internet site are intended for a broader audience.

6. Time Schedule

The Annex is divided into a preparation phase and a working phase.

The preparation phase starts on January 1, 2006 with duration of 1 year.

The working phase starts on January 1, 2007 and remains in force until June 30, 2010. An extra six months will be used by the Operating Agent and the subtask leaders to finalise the reports.

The concept definition will be initiated during the preparation phase and will be completed by end 2007 (D2). The coordination and support of Subtasks B, C and D will continue until the end of 2008.

Subtasks B, C, and D will work in parallel. The demonstration work will be carried out between mid 2008 and mid 2009, with reporting to be completed by the end of 2009.

Experts involved in subtask A will continue their work in Subtask E. Subtask E will undertake the monitoring in winter 2008/2009 (i.e. before renovation) and in winter 2009/2010 (i.e. after renovation) and provide a draft report by mid 2010. All reports will be reviewed and published by the end of 2010.

Subtask	Prep. Phase	Working phase			
	2006	2007	2008	2009	2010
Subtask A: Concepts					
Subtask B: Roofs					
Subtask C: HVAC					
Subtask D: Façades					
Subtask E: Monitoring, dissemination					
Meetings	● ●	● ●	● ●	● ●	● ●

- Kick off meeting
- Working meeting

7. Specific obligations and responsibilities of the participants

1. Each participant shall work in at least one of the subtasks of the Annex. Subtask A participants should also work in Subtask E.
2. Each participant shall provide the Operating Agent with information and written material on the work carried out in the subtask she or he is working on.
3. Each participant shall participate in reviewing the final report of the subtask she or he is working on.
4. Each participant shall attend the semi-annual Annex working meetings. If several people from the same country participate, that country should designate at least one expert per subtask in which it participates to attend the meetings and to act as a technical contact regarding the national subtask contribution.

8. Specific obligations and responsibilities of the subtask leaders

The subtask leaders are required to:

- Coordinate the work performed under the subtask
- Assist the Operating Agent in preparing the detailed work plans
- Chair the subtask part of the semi-annual Annex meetings and provide the OA with the results
- Secure coordination of Subtasks and demonstration projects
- Coordinate the final reporting resulting from the Subtask

- Assist the Operating Agent in editing the final reports of the Annex

They are participants who provide a high level of expertise to the subtask they manage and undertake substantial research and development in the field of the subtask. They are confirmed by the Annex participants.

Subtask leaders will be proposed and confirmed during the preparation phase.

9. Specific obligations and responsibilities of the Operating Agent

The additional duties of the Operating Agent are:

1. Preparation of a detailed working program for the Annex in consultation with the Annex participants and submit the program for approval to the Executive Committee
2. Providing the participants with the necessary guidelines for the work they have to carry out
3. Coordination of the efforts of the participants and subtask leaders and ensure the flow of information
4. Preparation and chairing of the Annex working meetings, together with the subtask leaders
5. Reporting the results of the Annex meetings to participants and the Executive Committee
6. Preparation of the reports, mentioned under section (5), together with the participants and the subtask leaders
7. Publication of the reports, mentioned under section (5), after approval by the Executive Committee. That approval should be gained at the latest six months after completion of the Annex
8. Providing semi-annual reports to the Executive Committee on the progress and the results of the work performed under the Annex
9. Performing such additional services and actions as may be decided by the Executive Committee, acting by unanimity

10. Funding

1. *Semi-annual meetings.* The working meetings, mentioned in section 9, item 4, shall be hosted in turn by one of the several participants. The costs of organizing the meeting shall be borne by the host participant.
2. *Publications.* The costs of publishing the final reports described in section 9, item 7 shall be met by the Operating Agent.
3. *Task sharing activities.* Each participating country shall commit a minimum of six person-months of labour for each year of the Annex term. In addition, the subtask leaders shall commit a further two person-months per year, while the Operating Agent shall commit a further four person-months per year.
4. *Demonstration projects.* The participating countries shall contribute to the demonstration projects. At least 3 apartment buildings renovations shall be demonstrated. The costs of such renovation and legal liabilities related to the renovation works to be performed are part of a separate agreement between the investors, the local design teams and eventual funding bodies.
5. *Individual financial obligations.* Each participating country or, in case the country is not a member of the Executive Committee the participant, shall bear all costs it incurs in carrying out the Annex activities. Funding is expected to cover labour costs, consumables, investments, reporting (included eventual overhead costs) and travelling for participation in two

expert meetings per year during the four years working phase of the Annex. For the subtask leaders funding shall allow for an extra two person-months per year. For the Operating Agent funding shall allow for an extra four person-months per year and the attendance at the semi-annual Executive Committee meetings.

6. *Obligations during preparation phase.* Each participating country or, in case the country is not a member of the Executive Committee the participant, shall bear all costs it incurs to prepare the Annex activities. Funding is expected to cover labour costs, reporting (included eventual overhead costs) and travelling for participation in two preparation meetings in 2006. For the Operating Agent funding shall allow for an extra four person-months and the attendance at the semi-annual Executive Committee meetings

11. Information and intellectual property

1. All Annex related information will be stored in a password protected Annex website. Each participating country and each participant has access to that website through a password, they receive. The site will be managed by the Operating Agent. For the duration of the Annex, all specific Annex information, except the published reports, is considered not to be public domain.
2. All Annex participants have the right to publish congress and journal papers that report on Annex related work. When doing so, the Annex shall be acknowledged as one of the vehicles that assisted in carrying out the work.
3. All final reports will be public domain.

12. Operating agent

The designated Operating Agent is: **Mark Zimmermann, Architect, Swiss Federal Laboratories for Materials Testing and Research, 8600 Duebendorf, Switzerland.**

13. List of participants

The proposed organisations that are possible participants in the Annex are listed below. The experts listed are the names of those who attended the kick-off meeting in Lucerne/Buergenstock, Switzerland, October 3-5, 2005.

Country	Institution	Expert names	ExCo representative	Signature
Austria	AEE INTEC, Feldgasse 19, 8200 Gleisdorf	Blümel Ernst		
Belgium	Laboratory of building physics, KULeuven, Kasteelpark Arenberg 40, 3001 Heverlee	Houvenaghel Geert, Engineer	Lebrun Jean	

Denmark	Velux A/S, Ådalsvej 99, 2970 Hørsholm	Dvårsäter Anna, Project Engineer	Kristensen Poul Erik	
France	Lafarge, 61 rue des Belles Feuilles, 75116 Paris	Birault Alain, Market Development Manager	Hérant Pierre	
	Saint-Gobain Isover, Les Miroirs 92096 La Défense Cedex	Andersson Patrik, Prod- uct and solutions devel- opment manager		
	Saint-Gobain Isover, Les Miroirs 92096 La Défense Cedex	Cousin Stéphane, Int. Marketing Manager		
	EDF R&D, Les Renardières, Avenue des Renardières, Ecuelles, 77 818 – Moret-sur-Loing Cedex	Duforestel Thierry, Dr. Engineer		
Germany	Fraunhofer-Institut für Bauphysik, Gottschalkstrasse 28a, 34127 Kassel	Kempkes Christoph, Dipl.-Eng.	Gehrman Jürgen	
Sweden	Lund University, PO Box 118, 221 00 Lund, Sweden	Karlsson Bjorn, Prof.	Rolén Conny	
Switzerland	Renggli AG, Gleng, 6247 Schoetz	Jordi Martin, Carpenter / Engineer	Eckmanns Andreas	
	HTA Lucerne, Technikumstrasse, 6048 Horw	Schwehr Peter, Dr., Architect		
	Empa, Ueberlandstrasse 129, 8600 Duebendorf	Zimmermann Mark, Architect		

The grey cells are countries that are not Contracting Parties in the Implementing Agreement on Energy Conservation in Buildings and Community Systems. In such cases, the expert should sign and Executive Committee Approval is required.