Solar Renovation Demonstration Projects

A Technical Report of IEA Solar Heating and Cooling
Task 20 Subtask C
Design of Solar Renovation Projects
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Solar Renovation Demonstration Projects

IEA Solar Heating and Cooling Programme Task 20

"Solar Energy in Building Renovation"

Subtask C: "Design of Solar Renovation Projects"

Technical Report No Task 20 STC N20

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ABSTRACT

In the framework of the IEA SHC Programme, a Task on building renovation was initiated, "Task 20, Solar Energy in Building Renovation." In a part of the Task, Subtask C "Design of Solar Renovation Projects," different solar renovation demonstration projects were developed.

The objective of Subtask C was to demonstrate the application of advanced solar renovation concepts on real buildings.

This report documents 16 different solar renovation demonstration projects including the design processes of the projects. The projects include the renovation of houses, schools, laboratories, and factories. Several solar techniques were used: building integrated solar collectors, glazed balconies, ventilated solar walls, transparent insulation, second skin facades, daylight elements and photovoltaic systems. These techniques are used in several simple as well as more complex system designs.

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TASK 20 - SOLAR ENERGY IN BUILDING RENOVATION

Task 20, Solar Energy in Building Renovation, is the first Task within the Solar Heating and Cooling SHC Programme of the International Energy Agency to focus specifically on increasing the use of solar energy in existing buildings. The objective of the Task is to increase solar energy applications in existing buildings by developing strategies to effectively and economically integrate solar designs and concepts into the renovation process. The Task includes compiling guidelines for designers and remodellers, obtaining their support for the concept of solar renovation, and providing them with the necessary information on solar opportunities.

Renovating or remodelling can be motivated by a variety of needs. These include a desire to repair or replace a leaking roof, deteriorated concrete balcony, or poorly insulated windows; increase living or work space area; upgrade a building's appearance; improve indoor comfort levels; improve daylight usage; reduce utility expenses; or accommodate changes in building use. Regardless of the reason, renovation presents special challenges and opportunities to apply different solar energy strategies.

Task 20 is divided into seven Subtasks, each coordinated by a lead country:

Subtask A: Evaluation of Existing Building Applications (Sweden)
This Subtask focussed on obtaining information from existing solar renovation projects. Information was collected on the reasons for the renovation, the various features employed, the renovation process, and the occupants' reactions.

Subtask B: Development of Improved/Advanced Renovation Concepts (Belgium)
The main focus of Subtask B was to develop improved and advanced renovation concepts. A wide variety of possible systems, components, and strategies were identified and analysed in specific renovation situations to assess their feasibility and performance.

Subtask C: Design of Solar Renovation Projects (Denmark)
Subtask activities were divided into two areas: participation in the design of solar renovation projects and evaluation of solar renovation projects. Subtask participants reported on designs in ongoing and planned solar renovation projects and developed monitoring procedures and reporting formats.

Subtask D: Documentation and Dissemination (Netherlands)
Under this Subtask, the results of the Task were summarized and documented. Various information dissemination methods were used.

Task 20 was extended for two years, until December 1998, and three new Subtasks have been initiated:

Subtask E: Evaluation of Demonstration Projects (Germany)

Subtask F: Improvement of Solar Renovation Concepts and Systems (Switzerland)

Subtask G: Dissemination of Results (Netherlands)

The results of these Subtasks will available when Task 20 is completed.

EXECUTIVE SUMMARY

Objective

As the amount of existing buildings is much higher than the number of buildings being built, and as many of the existing buildings need improvements, a large renovation potential exists. This need for renovation provides an opportunity to use solar energy strategies. Thus, the IEA SHC Task 20 was initiated to increase solar energy applications in existing buildings by developing strategies to effectively and economically integrate solar designs and concepts into the renovation process. To accomplish this objective, Subtask C was established to demonstrate advanced solar renovation concepts. This has led to the improved design and construction of several innovative demonstration projects. These demonstration projects will be evaluated in Subtask E: "Evaluation of Demonstration Projects."

Demonstration projects

This report documents 16 different solar renovation projects including their design processes. The projects include the renovation of houses, schools, laboratories, and factories. Several solar techniques were used: building integrated solar collectors, glazed balconies, ventilated solar walls, transparent insulation, second skin facades, daylight elements and photovoltaic systems. These techniques were used in several simple as well as more complex system designs.

The solar renovation projects are intended to serve as inspiration and examples for people responsible for building renovation such as architects, engineers, building owners and investors. The following examples show how solar energy in building renovation can be integrated in an architecturally, technically, and economically attractive way. The projects reported are not to be seen as the only possible solutions for specific problems, but more as good examples of solving different renovation needs by using solar energy.

Design process

Several designs were discussed and recommendations were made. Also, new designs were developed and proposed to the design teams of the demonstration projects. For each project, the IEA SHC Task 20 experts served in an advisory capacity only. However, a number of suggestions by the group were investigated and some found their way into the projects.

The design and evaluation methodology used consisted of the following steps: 1) Initial Project Screening, 2) Review and Critique, 3) Documentation of the Design Process, and 4) Development of Monitoring Formats and Questionnaires.

Based on these solar renovation demonstration projects, Task experts were able to derive a number of conclusions on the reasons for renovation, energy use, thermal and visual comfort, and economic aspects.

Reasons for renovation

The most important reasons for renovation were to end ongoing degradation of building construction (e.g., as an effect from thermal bridges and moisture damages); to reduce maintenance costs for technical installations; to reduce the energy demands; to avoid thermal discomfort from cold interior surface temperatures of external walls; to improve indoor visual comfort while maintaining or improving thermal comfort; to obtain noise protection; to extend living space during the heating season; to give an added value to apartments, making them more attractive to the renting market, and to improve architecturally unappealing facades.

Energy savings

Significant reductions of the energy use for space heating, ventilation, and domestic hot water are expected or have been achieved in most of the demonstration projects. In addition, reductions of electricity use for lighting via daylighting are estimated in some of the projects.

For glazed balconies, the net energy demand for space heating is expected to be reduced by 25 - 40 kWh/m^2 of occupied floor area per year. In the case of solar preheating of ventilation air from different ventilated solar wall systems, the net energy demand for space heating is expected to be reduced by 15 - 45 kWh/m^2 of occupied floor area per year. The use of transparent insulation on the facades is expected to reduce the net energy demand for space heating by approximately 50 kWh/m^2 of occupied floor area per year.

The use of roof integrated solar collectors is expected to reduce the net energy demand for domestic hot water to 10 - 32 kWh/m^2 of occupied floor area per year.

Regarding the energy demand for lighting, the use of different daylighting systems is expected to give energy savings of 50% corresponding to net energy demands of 6 - 15 kWh/m^2 of occupied floor area per year.

Thermal and visual comfort

In most of the demonstration projects, large improvements in thermal and visual comfort are expected.

The improved thermal comfort was achieved by avoiding draught from cold by using TI walls and glazed balconies, and by preheating ventilation air via solar based elements such as glazed balconies, ventilated solar mass walls and unglazed transpired collectors.

The visual comfort was improved by increasing the light level, avoiding glare, and providing a more uniform light distribution to the indoor areas. This was achieved by using TI glazings and increasing the glazing areas using well insulated, low-e, gas filled double or triple glazings.

Economics

Most of the solar renovations were more expensive to build than conventional renovations. However, the solar renovation projects served multiple purposes besides saving energy, for example, technical problems such as building degradation, noise problems and moisture damages were solved, thermal and visual comfort was improved and in several cases, the living space was expanded using glazed balconies.

Furthermore, the successful solar renovation projects made use of the following non-technical benefits: better aesthetic value, noise protection, more attractive apartments, competitive edge in the rental market, and projects that visualised a concern for sustainability of the building owner.

Lessons learned

The most important lessons learned when implementing solar energy features into building renovation were:

- Some of the solar technologies investigated have made steps toward becoming cost-effective. However, because of high initial investment costs other technologies were preferred mainly from other kinds of added valve. Steps toward reduction of costs for these solar components and systems are necessary.

- Solar concepts should be considered as an integrated component of every building renovation energy analysis and as part of the whole building's design. An energy study should be the main element of the integrated energy design process.

- It is important that the solar concepts applied in building renovation serve other purposes besides energy savings.

- Designers and constructors doing solar renovations need input from educated planners.

- Architects and engineers should be taught about the functional aspects of building-integrated solar energy design if solar energy systems are to be widely used in building renovation.

- Building-integrated solar designs often include new and special (sometimes complex) systems. Therefore, education and training about construction methods of building-integrated solar measures are required for the craftsmen involved in building renovation.

- More exemplary building-integrated solar energy systems need to be designed, constructed and reported. The case studies will help to build confidence in the use of solar energy technologies in building renovation.

A goal for the future should be to develop efficient, inexpensive, intelligent building-integrated solar systems that are cost effective on a short time basis (3 - 15 years), as the extended lifetime of a building is typically 30 years or more.

INTRODUCTION

In the framework of the IEA Solar Heating and Cooling (SHC) Programme, a Task on building renovation was initiated (Task 20, Solar Energy in Building Renovation) to increase solar energy applications in existing buildings by developing strategies to effectively and economically integrate solar designs and concepts into the renovation process. To accomplish this objective, Subtask C "Design of Solar Renovation Projects" was established to demonstrate advanced solar renovation concepts. In Subtask C, different solar renovation projects were evaluated, designs were improved and several innovative demonstration projects were constructed.

This report documents 16 solar renovation projects, including the design processes of the projects. The projects include the renovation of houses, schools, laboratories, and factories. Several solar techniques were used: building integrated solar collectors, glazed balconies, ventilated solar walls, transparent insulation, second skin facades, daylight elements and photovoltaic systems. These techniques were used in several simple as well as more complex system designs.

Subtask results show that significant and effective building renovation using solar features can reduce building energy consumption and improve the indoor environment (thermal and visual comfort).

Under this Subtask, collaborative research on the demonstration projects was carried out. Participating experts were responsible for reviewing proposals for each of the evaluated project designs and thus influenced the final design of most of the solar renovation projects.

This report first describe the methodology used for designing, selecting, and evaluating the project proposals. Then a short description and detailed design reports for each solar renovation demonstration project is provided. Finally, overall conclusions and lessons learned for integrating solar energy into building renovation are given. Supplementary background material is provided in the Annex.

The solar renovation projects are intended to serve as inspiration and examples for people responsible for building renovation (architects, engineers and consultants, building owners, investors, etc.). The examples show how solar energy in building renovation can be integrated in an architecturally, technically, and economically attractive way. The projects reported are not to be seen as the only possible solutions for specific problems, but more as good examples of solving different renovation needs by using solar energy.

The demonstration projects show that it is possible to make use of the expertise of the IEA SHC Task 20 participants and that by using solar energy in building renovation large energy savings can be obtained. The project also shows the importance of an integrated design strategy combining conventional and solar techniques for building renovation.

DESIGN AND EVALUATION METHODOLOGY

The design and evaluation methodology used consisted of the following steps: Initial Project Screening, Review and Critique, Documentation of the Design Process, and Development of Monitoring Formats and Questionnaires. Highlights of the methodology are as follows:

Initial Project Screening

Demonstration projects proposed for inclusion in IEA SHC Task 20 were subject to an initial screening by the participants based on:

- *Interest in the concepts.* Whether the central concepts in the design were consistent with the concepts that had been evaluated in Subtask B, and whether the particular applications were considered representative.

- *Stage of development.* The degree to which the project could be influenced by IEA SHC Task 20 work. While the ideal project was one that was still in the conceptual design stage, it was recognized that projects that were further along and incorporated features of interest should still be considered.

While it was considered desirable that the proposed projects had a high degree of likelihood of being built, this was not used to rule out particular projects. This was done as means for acknowledging the uncertainty of the project development process and the changes that can occur over time as design/building decisions are made. Task participants agreed that the documentation on the design process would in itself be a very valuable output.

Review and Critique

Each participant prepared a summary information on their proposed projects based on a framework developed in the Subtask (see Annex A.1). The summary information focussed on the solar design features and their rationale. Review comments were prepared and returned to the proposer in advance of the semi-annual IEA SHC Task 20 Experts' Meetings. At these meetings, the proposals were reviewed, and each proposer responded to the critiques, based on the requirements of their clients, and revised the proposal as appropriate. This process continued throughout the design development phase.

Net energy demand

In this Subtask, the effectiveness of the 16 solar renovation projects are compared using the net energy demand for three types of energy use: 1) energy demand for space heating and ventilation, 2) energy demand for domestic hot water, and 3) energy demand for artificial lighting. The net energy demand is defined as the simulated annual energy demand per square metre occupied floor area. It does not take into account the efficiency of the heating, ventilation, domestic hot water or electricity systems nor does it consider the type of fuel used in these systems.

Documentation of Design Process

The objective of documenting the design process was to gain a better understanding of how the design process could be influenced to increase the likelihood of incorporating solar features in existing buildings.

Reports documenting the results of the design process were developed for each project. Key features of these design reports, which were essentially expansions of the framework developed for the review and critique process, were:

- An explanation of the steps followed in the design process which focus on the most significant aspects of the design decision making process. Associated drawings/schematics were included as necessary.
- A comparison of the solar renovation strategies to conventional renovation strategies in terms of selected attributes (energy performance, economics, environmental benefits, etc.).
- A list of recommended changes in the design based on the review comments to help identify the impacts of the Task 20 review and critique stage in the final design, as well as that of other reviewers.

The design reports are the heart of this Subtask C report.

Monitoring Formats and Questionnaires

A format for collecting performance information from monitored projects was developed (see Annex A.2). The purpose of these formats was to provide a common framework for evaluating the results of the demonstration project. In addition to the monitoring formats, each participant was to develop a methodology to report on the nontechnical factors, such as building occupant attitudes. A representative questionnaire was developed to aid participants in this effort (see Annex A.3). The details of the monitoring protocols, were the responsibility of each participant based on the requirements of the particular project.

SOLAR RENOVATION DEMONSTRATION PROJECTS

Short description of proposals

The following section presents short descriptions of the 16 demonstration projects. Table 1 is a list of the demonstration projects and contains projects that were or will be built. It is important to note that a few of these projects are concepts only and will not be built.

Table 1. Solar renovation demonstration projects of IEA SH&C Programme Task 20.

Project Title	Building Type	Solar Technologies
Belgium, Rue Jacobs 70, 4.	Residential	Light cores for daylight, attached sun space.
Belgium, Rue Sedent, 4.	Residential	Glazed balconies and galleries, light cores for daylight.
Switzerland, Affolternstrasse 38, 1 ★.	Residential	Transparently insulated (TI) walls, roof integrated solar collector (DHW).
Switzerland, Brugghof 11, 1 ★.	Residential	TI walls, PV-system.
Switzerland, Valency building, 1.	Residential	TI walls.
Switzerland, Wollerau, 1.	Residential	TI walls.
Switzerland, Technical School Lucerne, 4.	School	Glazed second skin facade, daylighting.
Germany, "Villa Tannheim", 1★.	Office	TI walls, advanced glazings, roof integrated solar collector (DHW).
Germany, Salzgitter, 1 ★.	Factory	TI for thermal insulation and improved daylighting.
Denmark, The Yellow House, 2 ★.	Residential	Roof integrated solar collector (DHW), Glazed balconies, ventilated solar walls for preheating ventilation air, PV-system.
The Netherland, Brandaris, 2 ★.	Residential	Roof mounted solar collector (DHW), glazed balconies.
The Netherlands, Hoog Zandveld, 3.	Residential	Roof mounted solar collector (DHW), glazed balconies.
Sweden, Onsala, 1 ★.	Residential	Roof integrated solar collector (DHW).
Sweden, Rannebergen, 3.	Residential	Roof integrated solar air collector, ventilated/unventilated solar mass walls.
Sweden, Västra Gårdstensbergen, 3.	Residential	Roof integrated solar collector (DHW).
USA, Thomas Stone High School, 4.	School	Air collectors for preheating ventilation air, daylight, solar pool heating.

1: Built, 2: Will be built, 3: Might be built, 4: Concepts only
*: Projects that will be monitored: CH, D, DK, NL, S

A brief description of the final design of the selected solar renovation demonstration projects is given below. The selected projects represent a range from single solar measures to more advanced and complex renovations which include several solar measures.

Rue Jacobs 70, Belgium

This typical Belgian row house became too small for a growing family, therefore, renovation was necessary. Expansion and remodelling of the living space provided an opportunity to incorporate unique daylighting features and other energy saving measures. This project involved a redistribution of the inner rooms which reduced the size of the north-west facing rooms (acting as buffer spaces) and enlarged the south-east living areas. An innovative lightcore was created by adding roof windows, redesigning the staircases and insulating the attic. In addition, the garden was lowered to allow daylight to enter the lowest floor which also provided space for a two-level greenhouse on the south-east facade. The results of the renovation will be an improved living space and energy savings of about 40% (from 86 kWh/m^2 occupied floor area to 53 kWh/m^2 occupied floor area per year). This project was a conceptual study and will not be built within the time frame of Task 20.

Rue Sedent, Belgium

This eight storey, 66 unit apartment building is 30 years old and the building's east facade lack daylight. Each apartment was redesigned to have an east and west facing facade and duplexes would occupy two floors. The renovation is to incorporate glazed galleries along the eastern facade, glazed balconies on the western facade and light cores for the garages and the staircases. The net energy demand for space heating is expected to be reduced by 25% (from 64 kWh/m^2 occupied floor area to 47 kWh/m^2 occupied floor area per year) and more sunny and daylit living spaces are expected.

Affolternstrasse 38, Switzerland

This small three storey building with 11 apartments (700 m^2 heated floor area) was built in 1969 and is situated at the edge of a village in the Swiss midland. High energy demand and problems with draught and deteriorating facades were the reasons for the renovation. New windows, improved insulation from the ground to the roof, solar collectors for domestic hot water and a new efficient oil boiler were installed. The north, west and east facades were insulated with 10 cm mineral wool and covered with concrete fibreboard. The south facade was completely covered with transparent insulation (TI) facade elements and Venetian blinds for solar gain control were installed.

It is expected that the net energy demand for space heating would be reduced from 158 kWh/m^2 occupied floor area to around 50 kWh/m^2 occupied floor area per year. The expected savings from the solar collector system is expected to be 18 kWh/m^2 occupied floor area per year.

The renovation was completed in March 1996. The monitoring plan includes information on occupant reactions and evaluation on the use of the solar gain control.

Brugghof 11, Switzerland

This four-level apartment building with 12 apartments was built in 1971 and is an early example of the use of external insulation (5 cm) covered with vented rain cladding on a massive brick wall. Due to the unappealing facade, mould and moisture damage in the area of cold bridges, and insufficient comfort, a renovation was planned in 1994. At the same time, the building owner was planning to introduce new products for solar energy usage and decided to use this renovation for demonstration of new products (photovoltaic (PV) roof shingles, transparent insulation (TI) facade elements for wall heating).

In the framework of a study about structural and architectural integration of TI facade elements for building renovation, several solutions for the design of the south-west oriented TI facade and its shading were proposed. Together with the conventional renovation measures (insulation of roof, cellar, and facades, new windows, elimination of cold bridges at the balconies) the net energy demand for space heating was expected to be reduced from 101 kWh/m^2 occupied floor area to 46 kWh/m^2 occupied floor area per year. The installation of mechanical ventilation was discussed but was not incorporated.

Construction took place during summer 1996, monitoring started in October 1996 and will last for one year.

Valency building, Switzerland

The first renovation project in Switzerland using transparent insulation for wall heating was a small single family home located above a drinking water supply station of the city of Lausanne.

The project was included in this Subtask, because the results from the monitoring phase could be evaluated by the Task 20 participants. The renovation was completed in 1992 and included transparently insulated facades on all sides. A traditional metal facade technique with integrated movable Venetian blinds for solar gain control was used. Due to the special building situation, the heated space was not able to be insulated from the cool tank of the public drinking water supply. Therefore, even though there have been energy savings, these have been much lower than would otherwise have occurred. The net energy demand for spacing heating has been reduced from 211 kWh/m^2 occupied floor area to 105 kWh/m^2 occupied floor area per year.

Wollerau, Switzerland

Two identical apartment buildings closely situated with south oriented main facades were due for renovation to improve the overall appearance and to reduce the energy demand. Complete repair of the roof, new windows and facade insulation with a finishing system were planned. The south oriented balconies were not suited for glazing and so, to increase the use of solar energy, it was decided to use transparent insulation (TI) in the parapets of the south facade. To keep the investment within the given limits, the TI facade elements contain fixed louvers for solar gain control instead of using adjustable roller blinds.

The net energy demand for space heating is expected to decrease from 185 kWh/m^2 occupied floor area to around 50 kWh/m^2 occupied floor area per year. Designers anticipate that the 40 m^2 TI facade would reduce the net energy demand by approximately 2,400 kWh/year.

Technical School Lucerne, Switzerland

The buildings of the Technical School of Lucerne are built in the typical construction practices of the sixties and early seventies. The main structural features are a modular steel skeleton with concrete floors and a light curtain wall facade. The interior climate is uncomfortable: hot during the summer and cold in the vicinity of the facade during the winter due to insufficient insulation.

A project team of teachers and students was set up in 1993 to evaluate a renovation with a second skin facade and compare it with a traditional renovation approach. The project served as a teaching tool for heating, ventilating and air conditioning (HVAC) and architectural students at the school.

For different renovation concepts, the net energy demand for space heating and comfort (overheating) were evaluated using the DOE-2 building energy analysis software and the TRNSYS-COMERL thermal analysis tool. The findings from this study are valid and applicable to all buildings of this type. And, the architectural conversion of the theoretical concepts were elaborated on by a group of architectural students from the school.

The extensive simulations conducted, showed a 55% reduction in the net energy demand for space heating using conventional renovation techniques compared to the current situation. However, if a second skin facade was used the net energy demand would be reduced by 74% (from 115 kWh/m^2 occupied floor area to 35 kWh/m^2 occupied floor area per year) compared to the current situation. Also, the conventional renovation would increase the number of hours exceeding the maximum acceptable indoor temperature in the top level rooms, while the second skin solution would reduce the number of hours exceeding the maximum acceptable indoor temperature significantly compared to the actual situation.

Unfortunately, this renovation project will not be realised in the near future because of financial limitations. However, the construction and monitoring of a prototype second skin facade element is being discussed.

Villa Tannheim, Germany

Before this old historic building could be used as the new international headquarters for the International Solar Energy Society (ISES), a thorough and specific energy saving renovation was required. The aim of the renovation was to reconstruct the outer appearance of the patrician building with integration of solar energy techniques.

Walls were insulated with an 8 to 10 cm thick exterior insulation and finishing system, and the stone ornaments around the windows and other distinctive details of the facade were re-modelled. For ecological and technical reasons, the roof of the building was insulated with recycled paper insulation. 53 m^2 of the building's western facade was covered with a transparent exterior insulation and finishing system. Instead of the existing double-pane windows, new super glazing with a center U-value of about 0.4 W/m^2K was installed. The glazing system in these windows uses triple glazing and a new low-e coating and xenon-gas fill. The new heating system was supplemented by a 7.5 m^2 solar collector system that was integrated into the south roof of the building.

The net energy demand for space heating is expected to be reduced by more than 70% compared to before the renovation when the net energy demand was 250 kWh/m^2 occupied floor area per year. Additionally, the net energy demand for domestic hot water will be reduced by 84%. However, it is important to emphasize, that just by changing the use of the building from a residential building into an office building the energy demand for space heating and domestic hot water would be reduced significantly.

Monitoring of the building began in 1995.

Salzgitter, Germany

Hall 1 of the Linke-Hofmann-Busch company in Salzgitter is representative of post World War II factory halls. These buildings are characterised by their large single-glazed facades (more than 60% of the outer facade), with the remaining part of the facade made of uninsulated brick walls with a U-value of 1.3 W/m^2K. Using computer programs for daylighting and dynamic thermal simulations, various renovation concepts were prepared for this 40,000 m^2 building. A promising concept from an energy and economical point of view was the use of transparent insulation (TI) between 2 single panes of glass in place of the existing windows. This renovation increased the use of solar energy by providing excellent daylighting conditions and improved the thermal insulation, thus reducing cold drafts from the facade. Construction has been completed and early results from the daylighting strategies appear to be very successful.

The net energy demand for space heating is expected to be reduced from 300 kWh/m^2 occupied floor area to 200 kWh/m^2 occupied floor area per year.

Monitoring of the building began in January 1997.

The Yellow House, Denmark

This four storey building contains eight apartments with a total gross floor area per apartment of 59 m^2. Before the renovation the average total net energy demand for space heating, domestic hot water, and electricity for one apartment was approximately 190 kWh/year per m^2 occupied floor area. This high energy demand and the building's degradation due to moisture in the walls made this building a good candidate for renovation.

The goal of the renovation was to reduce the total energy demand to a level significantly lower than that of a house designed in accordance with the Danish Building Regulations of 1995. This was achieved by using some of the most promising solar energy technologies known today, realizing that these technologies might not be economically attractive until further technological developments and economies of scale have taken effect.

This solar energy renovation was achieved by a adding south facing glazed balcony to the building, preheating air in ventilated solar walls with integrated photo voltaic modules and preheating air in the glazed balconies. All windows had highly insulating glazing with low-e coating. All south facing windows also had integrated Venetian blinds for solar gain control. The ventilation system was a simple and effective demand controlled exhaust system. Use of daylight was increased by installing larger windows in the new glazed facade. Domestic hot water was heated by roof integrated solar collectors. Parts of the existing exterior walls was insulated with opaque insulation.

Designers expect a 68% reduction in the total net building energy demand for space heating, domestic hot water and electricity for lighting. This corresponds to a total net energy demand of 60 kWh/m^2 occupied floor area per year.

The renovation was completed in November 1996. Monitoring and a study on user behaviour started in the spring of 1997 and will continue for a two year period.

Brandaris, The Netherlands

Renovation of the "Brandaris" in Zaandam near Amsterdam, a high-rise multifamily building with 384 apartments began in 1997. This building is being renovated because the central heating system and individual domestic hot water systems needed to be replaced. A feasibility study on solar renovation focussed on the use of solar collectors for domestic hot water, glazed balconies for preheating of ventilation air and transparent insulation for daylighting has been performed within the framework of IEA SHC Programme Task 20. It is expected that the renovation will reduce the net energy demand for space heating and domestic hot water by up to 50% (from 160 kWh/m^2 occupied floor area to 80 kWh/m^2 occupied floor area per year) due to the solar and energy conservation features.

Hoog Zandveld, The Netherlands

Hoog Zandveld in Nieuwegein, near Utrecht consists of three blocks and was built in 1975. Each block consists of a wing with a west-facing 6 storey apartment building, and a wing of two layers of single family houses (total 4 storeys) facing south and west. There are 6 types of apartments having an average net floor area of 57 m^2.

Hoog Zandveld was developed as a potential case study for solar renovation. The project started from the need to replace the existing domestic hot water system and the building owner's desire to enhance the attractiveness of the building. The proposed solar solutions were:

- Change the DHW system into a collective system and combine it with the space heating system.
- Add glazed balconies for preheating ventilation air and thermal comfort.

The solar and energy conservation features are expected to decrease the net energy demand for space heating and domestic hot water by 30% (from 259 kWh/m ^{2} occupied floor area to 183 kWh/m^2 occupied floor area per year).

Both of the above approaches require an integral approach, which should include a vision for future buildings. So far, the housing association has decided to maintain the buildings in their current state.

Onsala, Sweden
To improve the potential savings from installing solar collectors on existing multifamily buildings with flat roofs, a new prefabricated roof module with an integrated solar collector was developed. The roof module is to be mounted directly on traditional roof trusses and so is also suitable for new buildings. The first roof modules were applied in a new building project in Onsala, Sweden. About 200 m^2 of roof module collectors were mounted on the heating plant and the carport of a new residential building area with 36 apartments. The net energy demand for domestic hot water was reduced by 40% (from 50 kWh/m^2 occupied floor area to 30 kWh/m^2 occupied floor area per year). The roof modules were mounted in August 1995 and the project was completed in May 1996.

Monitoring and evaluation was completed at the end of 1996.

Rannebergen, Sweden
This project involves the application of solar measures to a typical concrete multifamily building from the 1970's. The proposed solar renovation affects 188 apartments. The renovated heated floor area is 11,000 m^2. The solar measures are: 1) roof mounted solar air collectors for heating air to be circulated in prefabricated insulated facade elements to reduce heat losses through the facades. 2) simple solar mass walls on parts of the south facade in order to avoid rain water penetration and reduce cold bridges. 3) solar heated air from unglazed transpired collectors mounted on the south wall of the staircases for preheating of ventilation air. The net energy demand for space heating and domestic hot water was expected is to be reduced by 50% (from 250 kWh/m^2 occupied floor area to 125 kWh/m^2 occupied floor area per year).

Västra Gårdstensbergen, Sweden
This project involves the application of solar measures to a typical concrete multifamily building built in the 1970's. The proposed solar renovation involves two buildings with 60 apartments corresponding to approximately 5,000 m^2 heated floor area with a common heat supply. There are about 1,000 apartments in the complex and all apartments have flat roofs. The two buildings that are to be renovated will be equipped with new inclined roofs using 200 m^2 of roof module collectors on the south facing roof of the high rise building to preheat domestic hot water. The roof module collectors were previously developed in the Onsala project. The net energy demand for domestic hot water is expected to be reduced by 40% (from 50 kWh/m^2 occupied floor area to 30 kWh/m^2 occupied floor area per year).

Thomas Stone High School, USA

This project involves the renovation of an existing 15,000 m^2 high school and the addition of 5,576 m^2 to increase total student capacity from 1,250 to 1,600. The school is located in Waldorf, Maryland. The main purpose of the renovation is to upgrade the school facilities to meet modem instructional purposes. In developing the design a broad range of energy features were considered. The key solar features evaluated included daylighting with roof apertures (skylights and roof monitors), preheating of ventilation air using unglazed transpired collectors, solar water heating, and solar pool heating. In combination with upgrades to the lighting and mechanical systems, it was estimated that energy savings up to 74% (from 144 kWh/m^2 occupied floor area to 38 kWh/m^2 occupied floor area per year), relative to a conventional renovation/addition, were possible. However, as a result of funding limitations (both design and construction), most of the solar features, and a number of the energy conservation features were not included in the final specifications. Renovation of the school began in the fall of 1996 and will be completed in early 1999.

Detailed Design Reports

Detailed design reports for the solar renovation demonstration projects are presented on the following pages. The projects are presented in accordance with the framework for final project summaries that was developed by IEA SHC Task 20 participants. The design reports include comments and reactions taken from the review and critique phase in the Subtask. These comments include those of the IEA SHC Task 20 participants as well as those of the national design teams.

Rue Jacobs 70

Theoretical Project

Initiators Mr & Mrs Sellier, owners

Project manager None

Participants None

Financing
- Financing is mostly provided by the owners
- The "Fonds des Logements" ("Funds for Lodgings") contributes partially to this financing

Contact person Arnaud Nihoul & Bénédicte Collard
"Architecture & Climat"
Place du Levant, 1, B-1348 Louvain-la-Neuve
Phone: + 32/10/472160, Fax: + 32/10/474544

Building type Single family row house

Location Perwez, small town in the Brabant wallon

Climatic data
Latitude: 50°37' Longitude: - 4°48' Elevation: 150 m
Heating degree days: 2,080 (on a 15°C base) / 3,004 (on a 18°C base)
Length of heating season: 269 days (on a 15 °C base) / 365 days (on a 18°C base)
Mean outdoor temperatures, °C:

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
3.17	3.91	5.88	9.22	13.25	16.25	17.55	17.57	15.18	11.17	6.34	3.50

Number of sunshine hours, all year: 1,540 hours

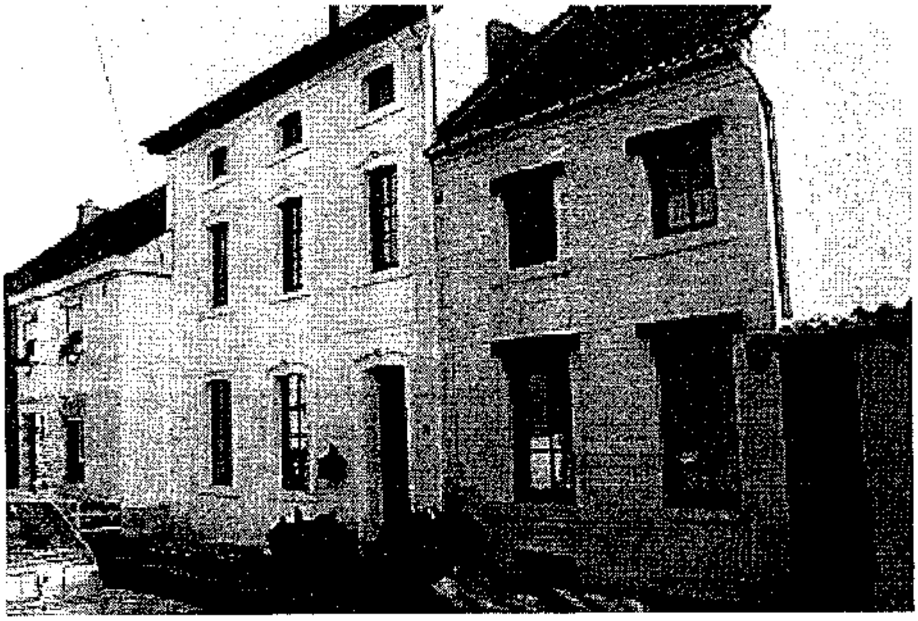
For detailed climate description see Annex A.4

Basic data
- Two living floors + a cellar + an unoccupied attic
- Existing floor area: 256 m^2
- Existing volume: 705 m^3
- The front facade (along the street) faces northwest, while the rear facade, facing southeast, leads to a 40 m^2 garden.
- The building is more than one hundred years old, and is constructed of massive bricks walls (40 cm for the external walls, 35 cm for the inner load bearing walls)
- Heating devices: Oil-fired central heating

Renovation reasons Lack of space for a growing family which has 6 children. What's more, the age of this house implied a necessary renovation.

Why solar To improve daylighting and to obtain a more pleasant indoor environment.

Major goals
- Increase living space
- Maximise the natural daylight contribution
- Reduce the annual energy demand

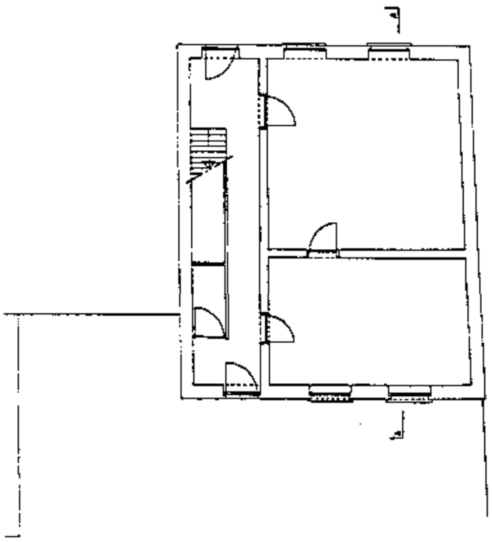


View of the northwest facade

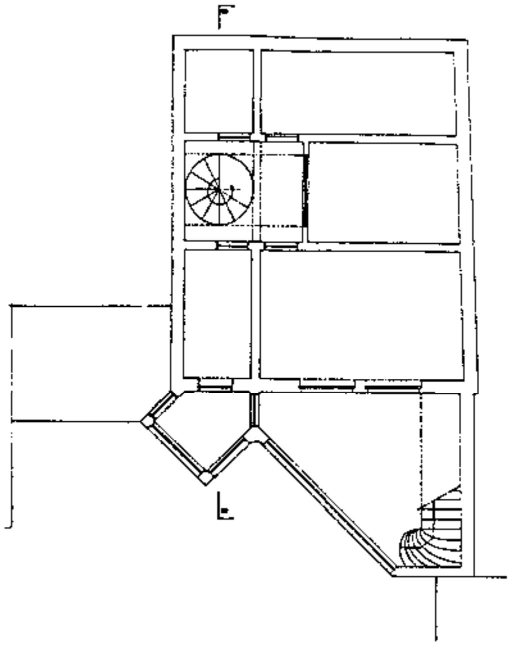
View of the southeast facade

Proposed design Inner renovation:

- Redistribution of the inner rooms, reducing the northwest rooms areas while extending the southeast living areas.
- New design for the staircases, to be coupled with a light core.



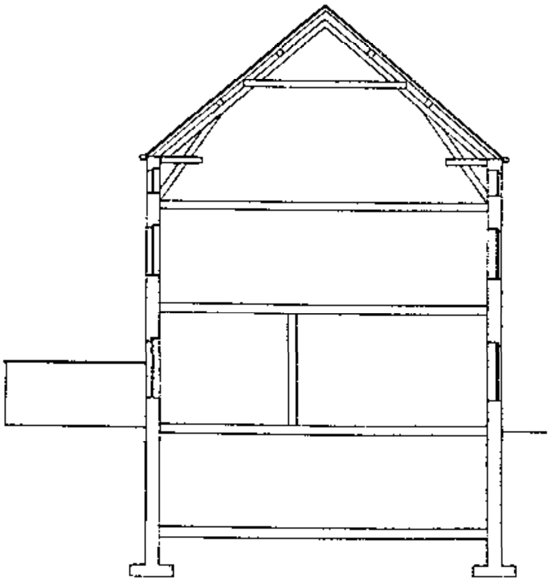
Ground floor before renovation



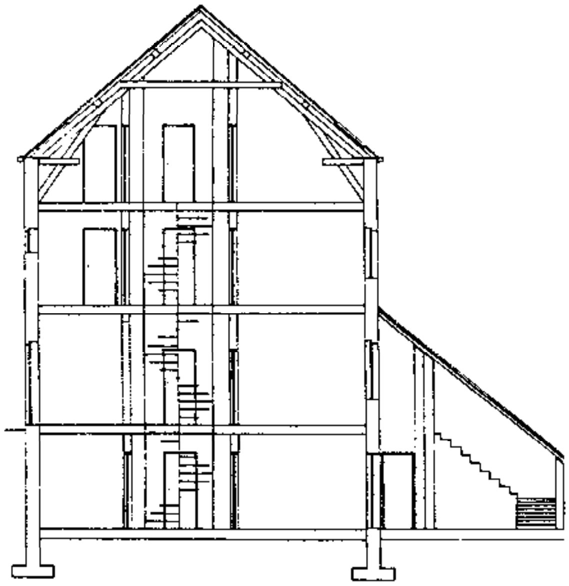
Ground floor after renovation

External renovation:

- Insulation of the attic and addition of roof windows.
- Lowering of the garden level so that natural daylight can enter the lowest floor.
- Incorporation of a two level greenhouse on the south-east facade.



Section AA before renovation



Section BB after renovation

Energy demand The net energy demand for space heating before the renovation is 86 occupied floor area per year and the net energy demand for DHW is 15 kWh/m^2 occupied floor area per year. After the solar renovation, the net energy demand for space heating is expected to be 53 kWh/m^2 occupied floor area per year.

The level of insulation is:
- uninsulated attic
- massive bricks walls of 40 cm
- double glazing

Costs Unknown

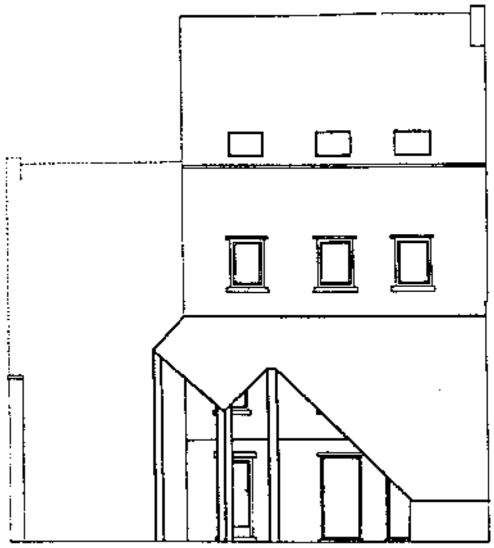
Time schedule This project will not be built.

Conclusions The net energy demand for space heating is reduced by 40 % (53 kWh/m^2 occupied floor area per year instead of 86 kWh/m^2 occupied floor area per year). However, the results are obtained with the simulation tool LPB4 and do not include the possible effects of occupant behaviour. Therefore, these estimates could be somewhat optimistic.
- Temperatures in the different rooms with no heating devices (daily average):

	1	2	3	4	5	6	7	8	9	10	11	12
Jan	4.94	5.44	5.49	5.67	6.55	6.80	7.10	7.24	6.02	4.93	5.21	7.62
Feb	6.31	3.87	7.02	7.45	8.63	8.95	9.28	8.99	7.74	6.68	6.93	10.89
Mar	9.16	9.76	10.06	10.86	12.09	12.43	12.98	12.61	11.14	10.15	10.45	15.28
Apr	13.48	14.24	14.48	15.91	16.58	16.96	17.88	18.01	16.01	15.47	15.76	20.03
May	17.12	17.90	17.97	20.06	20.33	20.53	21.53	22.55	19.70	20.25	20.38	24.42
June	20.46	21.31	21.32	23.68	23.61	23.81	24.86	26.38	23.17	24.02	24.20	27.45
July	22.46	22.30	22.38	25.54	24.69	24.89	25.81	27.15	24.12	24.78	24.98	28.38
Aug	21.11	21.82	22.00	23.74	24.46	24.73	25.37	25.98	23.48	23.68	23.88	28.56
Sep	18.07	18.67	18.96	20.07	21.46	21.76	22.12	21.86	20.00	19.57	19.80	25.94
Oct	13.24	14.54	14.83	15.37	16.80	17.16	17.52	16.95	15.69	14.54	14.80	19.97
Nov	8.20	8.75	8.75	9.03	9.92	10.20	10.45	10.60	9.32	8.27	8.56	11.16
Dec	5.11	5.60	5.53	5.71	6.37	6.62	6.97	7.30	6.02	4.99	5.41	6.96

1: Toilet basement floor
2: Wash-room
3: Boiler
4: Staircases & entrance hall
5: Library & office
6: Dining and living rooms
7: Bedrooms
8: Kitchen
9: Small central living rooms
10: Toilets (first floor and attic)
11: Bathrooms
12: Greenhouse

All the temperatures that are underlined are symptomatic of general overheating. However, the house is not equipped with an air conditioning system, so this is not considered in the simulation. What's more, the simulation has been done considering the apertures are always closed (e.g. the windows between the greenhouse and the house itself).



Backwards facade after renovation

Similar projects -

Design process

This was only a theoretical project based on a standard typology for the Brabant wallon. On this basis, a renovation which could occur in three different levels was elaborated on:

1. Conversion of the unoccupied attic into a supplementary living space. This meant insulation of the attic and roof windows. It was possible to take advantage of this situation to rework the staircases in connection with a light core in the heart of the house. This light core could diffuse daylight to the adjacent rooms.

2. Extension of the southeast facade and of all the southern rooms through a two level greenhouse, so that preheating and circulation of the air was possible.

3. Modification of the roof tilt.

Following an lEA SHC Task Expert meeting, it was decided that it would be better to start with an actual situation so that plausible figures could be obtained before the renovation.

A single family-house which was nearly a perfect copy of the theoretical one was used as a model. What's more, this house was occupied by a family of eight persons that intended to renovate the attic. Therefore levels 1 and 2 of the previous project were adapted.

Rue Sedent

Theoretical Project

Initiators -

Project manager Vincent Musiek

Participants -

Financing Possible premium for rehabilitation (financial support which can be obtained in the region Walloon for undertaking works to repair sick buildings.

Contact persons
Arnaud Nihoul & Bénédicte Collard
"Architecture & Climat
Place du Levant, 1, B-1348 Louvain-la-Neuve
Phone: 32/10/472160, fax : 32/10/474544

Building type Residential building, multifamily occupation, frame structure, built in 1976

Location Rue Sedent - 5100 Jambes (built-up area of Namur)

Climatic data
Latitude: 50°27' Longitude : - 4°52' Elevation : 80 m
Heating degree days : 2,310 (on a 15°C base) / 3,339 (on a 18°C base)
Length of heating season: 263 days (on a 15°C base / 365 days (on a 18°C base)
Mean outdoor temperatures, °C :

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
3.17	3.91	5.88	9.22	13.25	16.25	17.55	17.57	15.18	11.17	6.34	3.50

Number of sunshine hours per year : 1,550 hours

For detailed climate description see Annex A.4

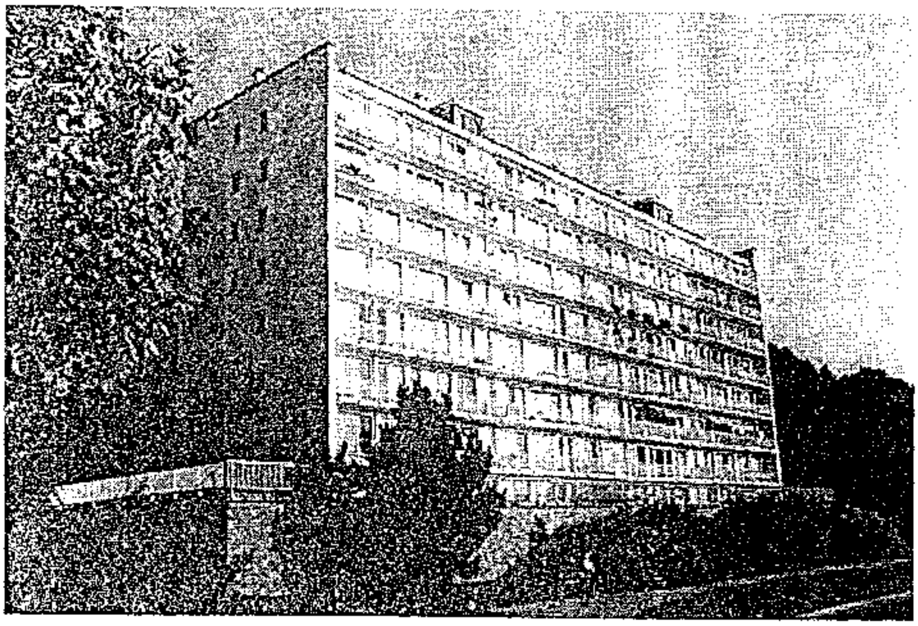
Basic data –

- 8 storey, 66 east or west facing apartments, 51 garages
- Two major facades, one facing east and protected by the hill, the other facing west to the valley
- Frame concrete structure filled in by concrete blocks
- Double external walls
- Two wells of stairs
- Flat roof
- Floor areas : Apartment with one bedroom : 45 m^2
  apartment with two bedrooms : 63 m^2
  apartment with three bedrooms : 71 m^2
- Almost symmetrical distribution (except in front of the staircases) of the rooms along a North - South medium axis

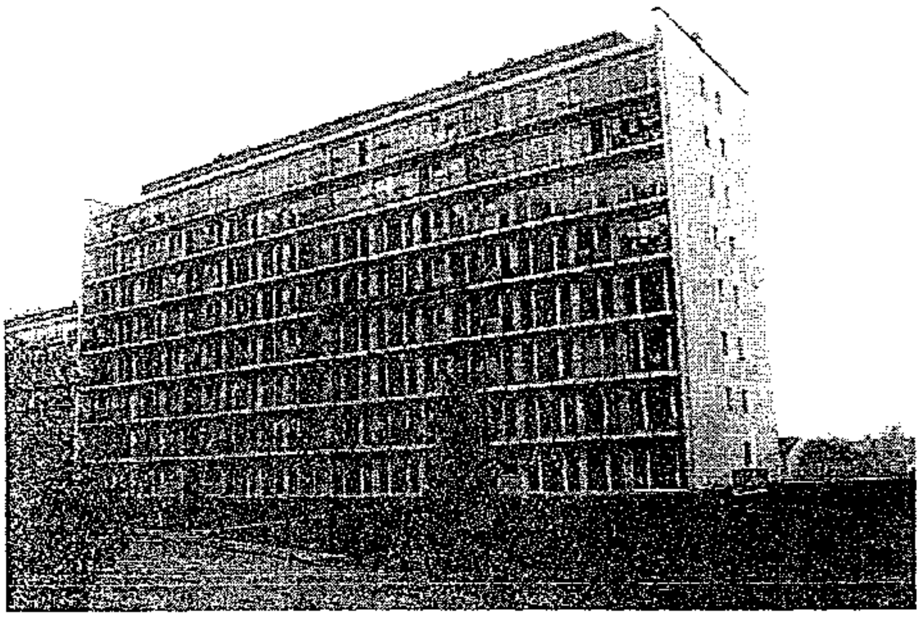
The level of insulation is: Complete insulation (walls, ground slab, roof)
Double glazing

Renovation reasons Deterioration of concrete construction, lack of sun on the eastern facade and noise problems in ground apartments make it necessary to renovate this building.

It should be noted that this kind of building is usually demolished rather than renovated. This project could be considered as an example of an alternative to demolition.



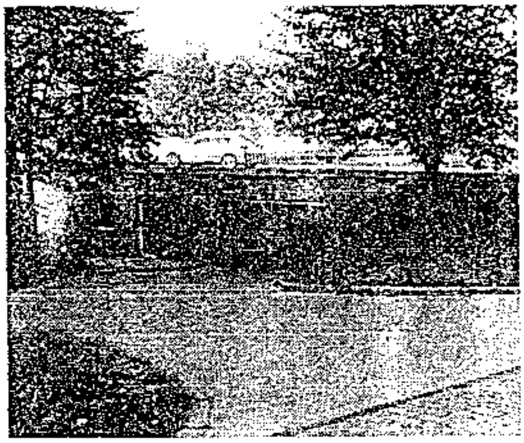
Western facade



Eastern facade

Why solar

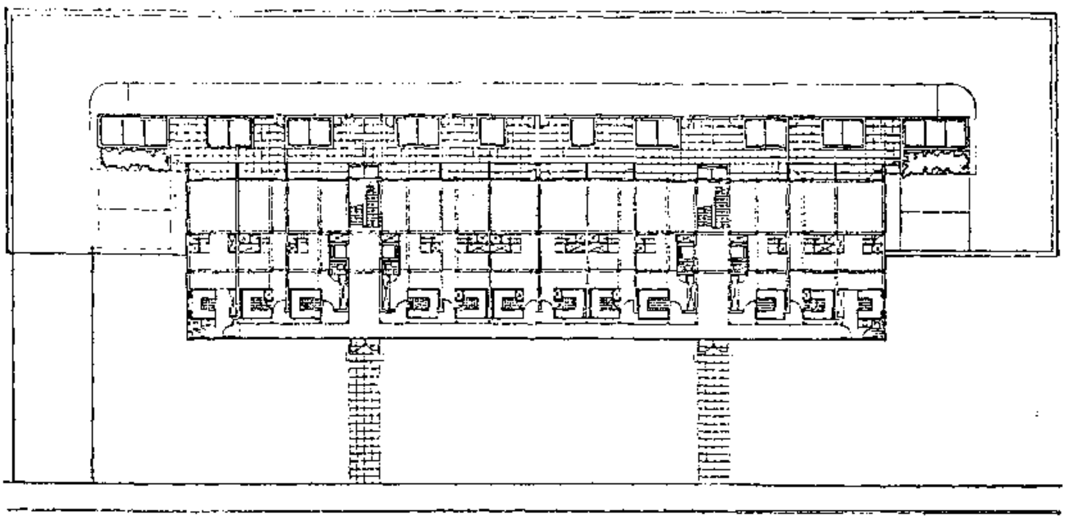
It would be interesting to take advantage of the renovation to solve the following daylighting problems. Since the building has an east-west orientation and the apartments are facing either east or west, sunlight reaches the apartments for only a few hours of the day. Also, the eastern facade faces a wooded hill, so these apartments are rather dark and the staircases and garages lack daylight.



Garages *Staircases*

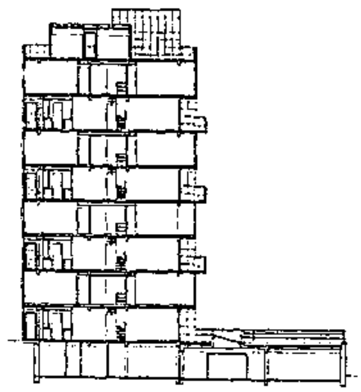
Major goals –
- To redistribute the living functions to increase the amount of daylight received by each apartment
- To increase the amount of daylight in the garages and staircases
- To solve the problem of noise from cars reaching apartments on the ground floor

Proposed design – Two floor apartments (duplex) facing east and west

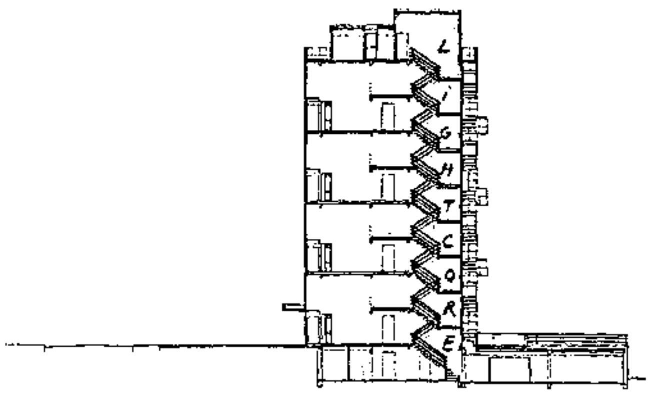


Ground floor

- Glazed galleries along the eastern facade



Balconies on the west facade (and small private gardens on the ground floors)
Parking would be eliminated from here
Light cores for the garages and the staircases



Energy demand The annual net energy consumption (kWh/year) for heating and domestic hot water before renovation was:

	1 bedroom	2 bedrooms	3 bedrooms
day	4,890	5,250	6,490
night	1,950	2,300	2,800

Assuming that the domestic energy demand for a family of three or four persons in a comparable public housing unit is about 3,500 kWh/year, the net energy demands (kWh/year) for space heating for this building are expected to be:

	1 bedroom	2 bedrooms	3 bedrooms
24 hour	3,340	4,050	5,790

Dividing these results by the floor area, the net energy demands for space heating (kWh/m^2 occupied floor area) are expected to be:

	1 bedroom	2 bedrooms	3 bedrooms
24 hours	74.22	64.29	81.55

The energy demand after renovation is based on simulations of apartments with two bedrooms occupied by a family with young children. According to the location in the building, nine different types of apartments can be identified:

South

6	3	*	*	3	3	3	3	*	*	3	7
4	1	*	*	1	1	1	1	*	*	1	5
4	1	*	*	1	1	1	1	*	*	1	5
4	1	*	*	1	1	1	1	*	*	1	5
4	1	*	*	1	1	1	1	*	*	1	5
4	1	*	*	1	1	1	1	*	*	1	5
4	1	*	*	1	1	1	1	*	*	1	5
8	2	*	*	2	2	2	2	*	*	2	9

North

East facade

** apartments with three bedrooms*

Staircases and garages were not modelled and the thermal impact of light cores would be insignificant. The major goal of the light cores is to increase natural lighting and thus thermal comfort.

For the individual apartment the energy demand for space heating is expected to be:

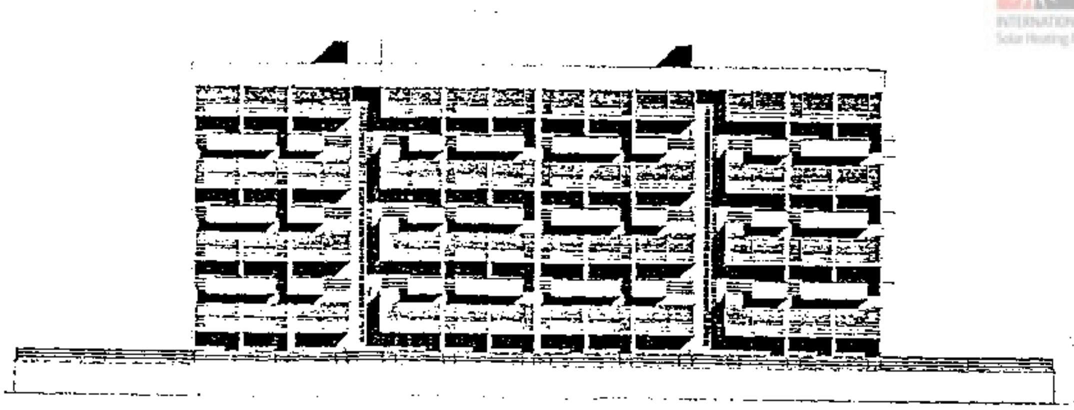
Type	Number	Floor Area (m^2)	Energy demand (kWh/year)
1	36	98	3,917
2	6	98	4,923
3	6	98	5,203
4	6	105	5,415
5	6	105	5,919
6	1	105	7,028
7	1	105	7,600
8	1	105	6,608
9	1	105	7,196

If the above values are multiplied by the number of each type of apartment and then divided by the total building floor area, an annual net energy demand per m^2 occupied floor area of about 46.7 kWh, as compared to 64 kWh before renovation.

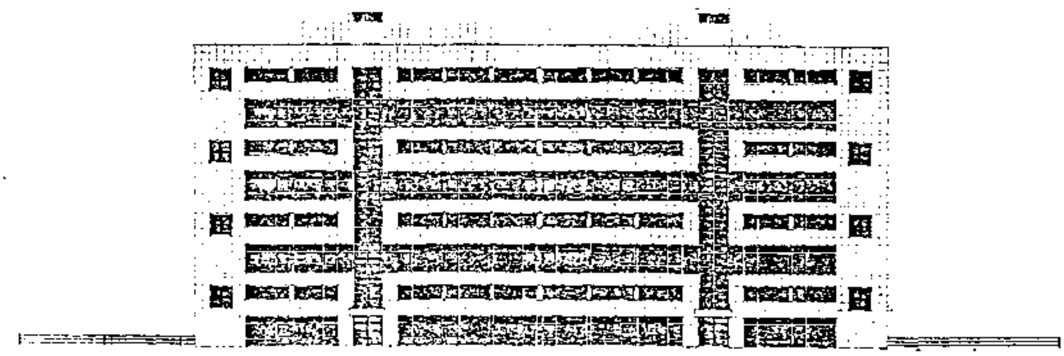
Costs Unknown.

Time schedule This project will not be realised.

Similar projects No other projects because the current attitude is to demolish these kinds of buildings rather than to renovate them.



Western facade



Eastern facade

Conclusions

Only the primary frame structure is to be maintained, and the whole building layout should be organized. This would result in energy savings of about 25%, and make the living spaces sunnier and more comfortable. The cost of such a renovation would be quite high, and so it might be simpler to rebuild the entire building. However, this project proposal can be considered as a good alternative to demolition and waste.

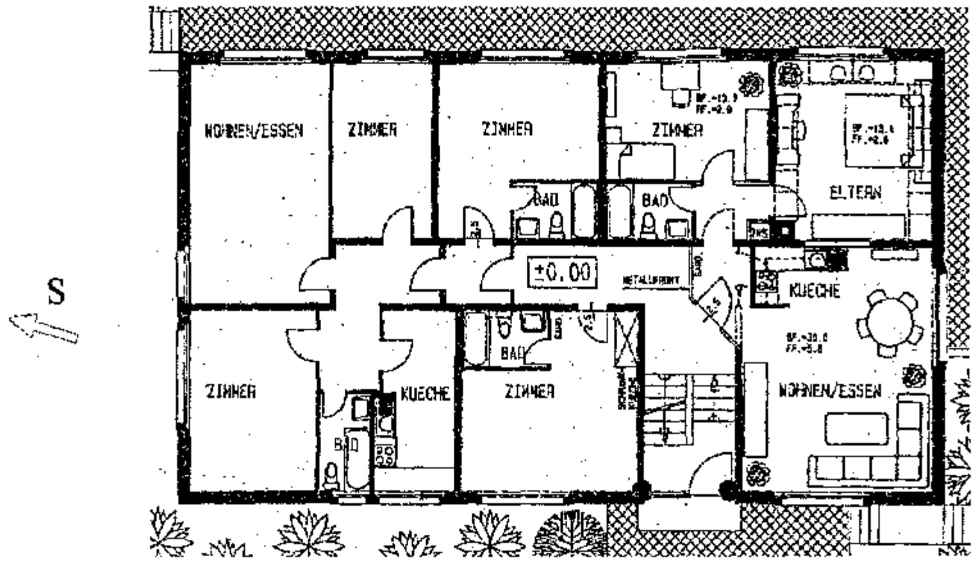
Affolternstrasse 38

Initiator	Pension fund of Ernst Schweizer AG
Project manager	Andreas Haller, Ernst Schweizer AG, CH-8908 Hedingen, Phone: +41 1 763 63 80; e-mail: ahaller@access.ch
Participants	- Pension fund of Ernst Schweizer AG - Ernst Schweizer AG, Hedingen - Beat Züsli, Architect, Lucerne - Eternit AG, Niederurnen - Schenker Storen AG, Schönenwerd - S.R.Hastings/W.Frei, on behalf of Swiss Federal Office of Energy (monitoring)
Financing	Pension fund of Ernst Schweizer AG (92%); Swiss Federal Office of Energy (4%); Canton of Zurich (4%). Special interest rates for environmentally advanced housing projects.
Building owner	Pension fund of Ernst Schweizer AG
Contact person	Andreas Haller, Ernst Schweizer AG, CH-8908 Hedingen
Building type	Residential
Location	Switzerland; village, small community
Climatic data	Latitude: 47°23' Longitude: -8°45' Elevation: 507 m

Heating degree days, year/heating season: 3,379/3,043 DD (18/18°C)
Average ambient temperature, year/heating season: 8.7/4.9 °C
Length of heating season: October 1st to May 31st (229 days)
Number of sunshine hours per year/heating season: 2,022/939 h
For detailed climate description see Annex A.4

Basic data

Size:	1556.8 m^3
Height:	3 stories
Heated floor space:	701.7 m^2
Number of apartments:	11 (size: 1 to 3 bedrooms)
Construction year:	1969



Floor plan of ground floor

Energy demand

Space heating:	158 kWh/m^2 occupied floor area per year (calculated)
Lighting:	28 kWh/m^2 occupied floor area per year (estimation)
DHW:	28 kWh/m^2 occupied floor area per year (estimation)

Level of insulation:

U-value of opaque walls:	1.18 W/m^2K
U-value of glazing:	2.8 W/m^2K
U-value of ceiling to roof:	1.50 W/m^2K
U-value floor to cellar:	1.92 W/m^2K

Opaque wall area:	423 m^2
Glazing area:	106 m^2
Ceiling to roof area:	234 m^2
Floor to cellar area:	234 m^2

Heating system: Oil fired central heating and DHW system using an average of 17,300 litres of oil per year (170 MWh).

Occupancy: 30 persons, average of 12 hours per day.

Renovation reasons

Moisture and mold problems during the winter, especially in building corners. Very high energy consumption, which is not in accordance to the environmental aims of the owner. Improved heating system is to comply with clean air regulations.

Major goals

Expected energy savings: 110 kWh/m^2 occupied floor area per year (reduction to 30% of present level), eliminate moisture and mold, improve indoor comfort during the heating season, reduce net energy demand for domestic hot water to 10 kWh/m^2 occupied floor area per year.

Why solar

The metal construction company Ernst Schweizer AG is engaged in R&D of transparent insulation (TI) systems. After prototype development of a new TI facade system, the company was seeking an opportunity to demonstrate the feasibility of the system in building renovation projects. The residential building "Affolternstrasse 38" in Hedingen, one of the buildings owned by the pension fund, was the most promising candidate for a facade renovation using TI. This building had a high energy bill, moisture problems in most of the rooms and the facades showed first signs of deterioration. The first step in the renovation was a detailed analysis of the actual state of the building and a renovation project proposal which emphasised energy conservation. The second step was to investigate the application of TI and solar collectors for DHW and propose variations.

Proposed design

– Basic short term energy measures:
- Thermostatic controlled radiator valves
- Insulation of heat pipes
- Insulation 14 cm of attic floor (attic not inhabited)
- Insulation 8 cm of cellar ceiling

Improved energy measures:
- New heating system and separation of DHW from space heating system
- Solar preheating of DHW
- New windows (U-value 1.3 W/m^2K)
- Facade insulation 10 - 14 cm

Advanced solar renovation:
- TI facade elements on south and west facades

Costs

	Conservation l oil per year	Investment CHF	Investment ECU
Basic short term energy measures			
Thermostat controlled radiator valves	500	4,200	2,600
Insulation of heat pipes	400	3,500	2,200
Insulation of roof floor (14 cm)	3,100	28,000	17,000
Insulation of cellar ceiling (6-8 cm)	2,100	21,000	12,800
Improved energy measures			
New heating system	1,700	35,000	21,200
Facade insulation 14 cm (0.22 W/m^2K)	4,700	148,000	89,700
Solar collectors for preheating DHW	1,100	29,000	17,600
New windows (glazing 1.3 W/m^2K)	1,200	65,000	40,000
Sun protection for windows		26,000	15,800
Advanced solar renovation			
TI elements south facade	950	20,000	12,200
TI elements west facade	530	32,000	19,400

Similar projects

See German example "Sonnenäckerweg" in Subtask A.

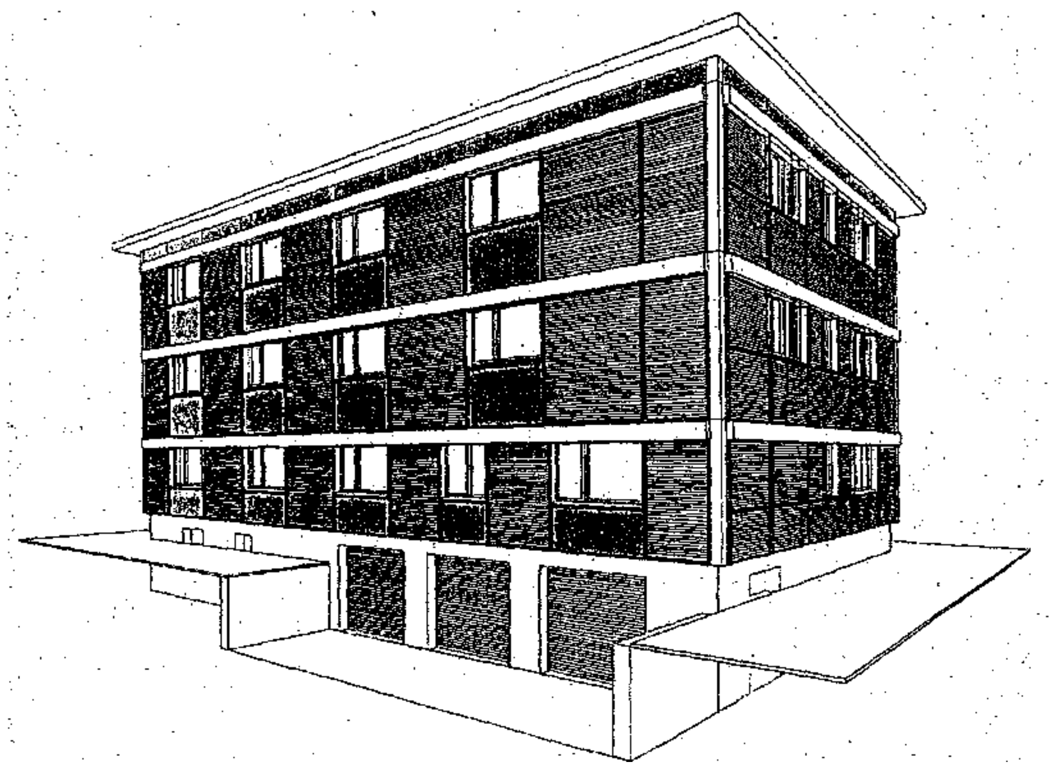
Design process

It was agreed that the basic and improved energy measures were the prerequisite to implementing the advanced solar renovation systems. The main concern of the owner was how this building would look after renovation. By the end of August 1994, the first detailed proposals for the facade designs were available from the architect. External shading devices for the TI parts of the facade were the only viable solution for solar gain control, therefore, the shading systems had to be taken into account as a major design element.

The primary attempt was to minimise the number of elements in the facades and use them for all four orientations, in order to maintain a consistent view for all facades:
- Use the same external Venetian lamella blind system for window and TI element shading.
- The Venetian lamella blind cages, imitated by respective cladding elements where shading is not required, to provide the same horizontal accentuation around the whole building.
- The planes of the TI facade elements are perpetuated around the building by respective cladding elements.

For shading the parapet underneath the windows several solutions were studied:
- Special Venetian lamella blinds with Venetian lamella angle variations only in the upper part to allow a certain amount of daylight and transparency (south and west facade).
- Fixed Louvers for parapets on the south facade (not suitable for west orientation).
- Standard insulation and cladding underneath the windows of the west facade.

The presented proposal eliminated the TI elements in the window parapet on the west facade and used a special Venetian lamella blind for this part of the south facade.



First design proposal with TI wall on west and south facades

Project review during 3rd Expert meeting, September 1994
A suggestion was made to review the shading devices for the windows from an architectural point of view because of the use of another type of window shading device other than the one for the TI-modules would open up the large facade to the west during the summer.

Project review by the building owner, October 1994
It became clear that the first cost estimate was too high, mostly due to the cost of the shading system and its installation. This updated budget proposal was not accepted by the building owner, and so two cheaper options were evaluated and the equivalent energy price for the different variants was calculated. The recommended insulation measures were not questioned and were part of all the variants.

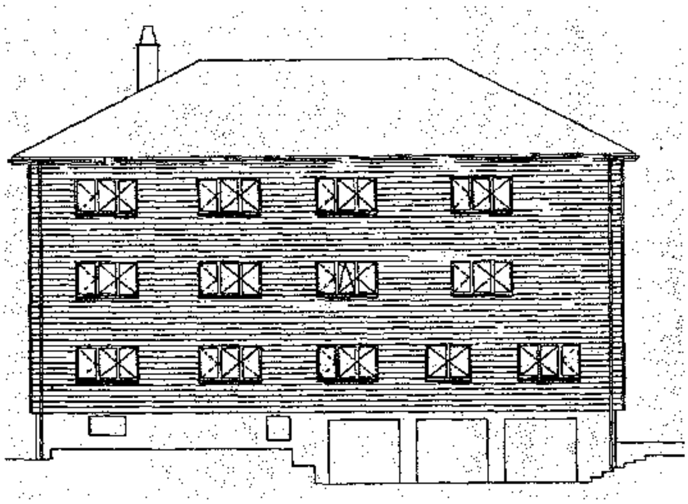
The different variants were:
Variant A) Facade insulation with fibre cement cladding, TI facade west and south.
Variant B) Facade insulation with fibre cement cladding, TI facade south only.
Variant C) Facade insulation covered with plaster, TI facade south only.

Equivalent energy prices:

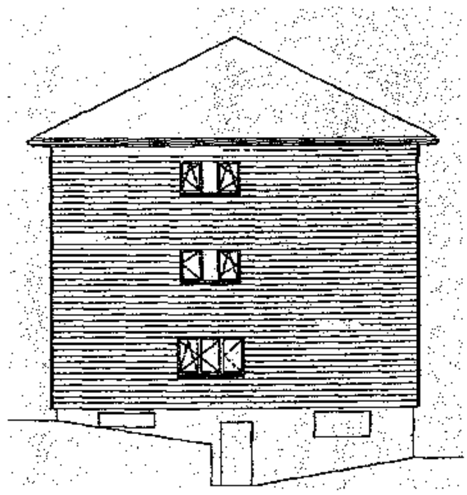
	South facade	West facade	Total
Variant A	0.62 CHF/kWh	1.96 CHF/kWh	1.00 CHF/kWh
Variant B	0.62 CHF/kWh	-	0.62 CHF/kWh
Variant C	0.78 CHF/kWh	-	0.78 CHF/kWh

The calculation is based on an interest rate of 6% and a life time of 30 years for fibre cement cladding and TI, and 20 years for plaster covered insulation facade.

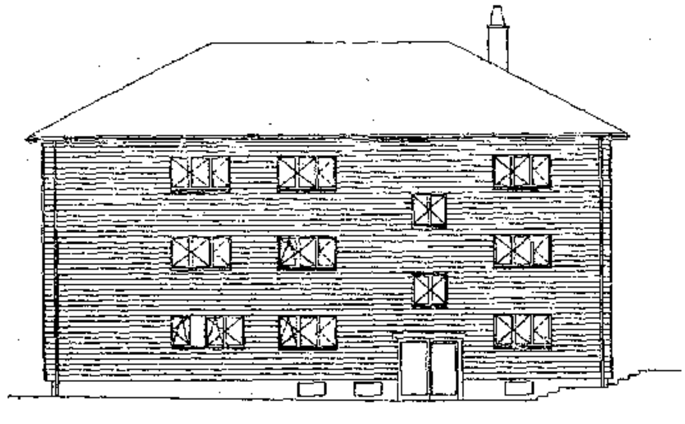
First project redesign
In January 1995 the building owner decided to follow variant B, and the architect got the mandate to proceed with the project work. The architect reviewed the new design concept for the facades and came up with a new solution using a modern and elegant facade design - a lap jointed sheeting from fibre cement -
for the orientations without TI. The south facade would then have its own style derived from the elements of the solar energy system.



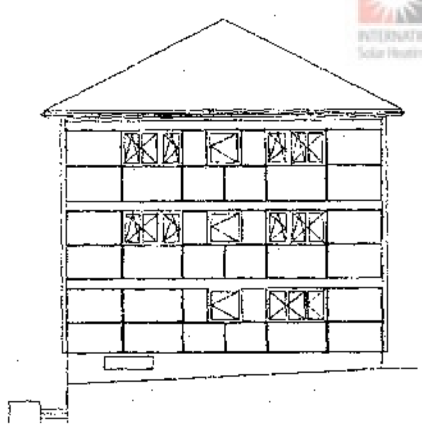
Renovated west facade



Renovated north facade



Renovated east facade



South facade with TI wall

Intermediate steps and decisions between January 1995 and June 1995

- Redesign of regular facades for variant B was accepted in February 1995
- Construction permit was granted in May 1995.
- The building owner decided to include, a solar domestic water system and a new boiler in the tender.
- Financial support from the canton of Zurich and the Swiss Federal Office of Energy was granted in June 1995 (total 50% of non recovered additional costs for TI facade; subsidies of ECU 200 per m^2 solar collectors).

Project review by the building owner

- The building owner decided in June 1995 to proceed with the renovation project with a upper cost limit of CHF 500,000, equivalent to ECU 312,000.

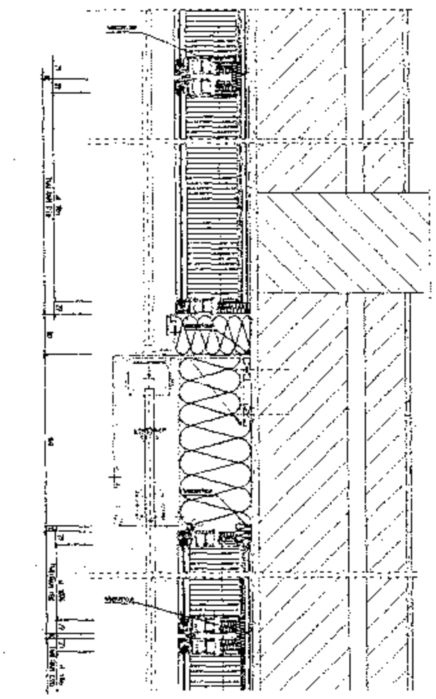
Key figures of project budget:

Project costs based on first contractor offer (June 1995)	CHF	CHF
Regular renovation package, (i.e. facade, windows, insulation)	383,370	
Additional costs for TI facade south	63,736	
Renovation package with TI facade south	447,106	447,106
Solar domestic hot water system		33,372
New boiler and retrofit of heating system		40,500
Unexpected items		22,222
Contribution from Canton of Zurich and the Swiss Federal Office of Energy		-43,200
Total costs		500,000

Construction details

For the construction, a detailed work plan and design of the technical details were required. Key questions were:

- The positions of the window plane
- The joining of the various elements in the window area
- Corner joints with the TI elements



Vertical section of TI facade (without window joints)

Experiences

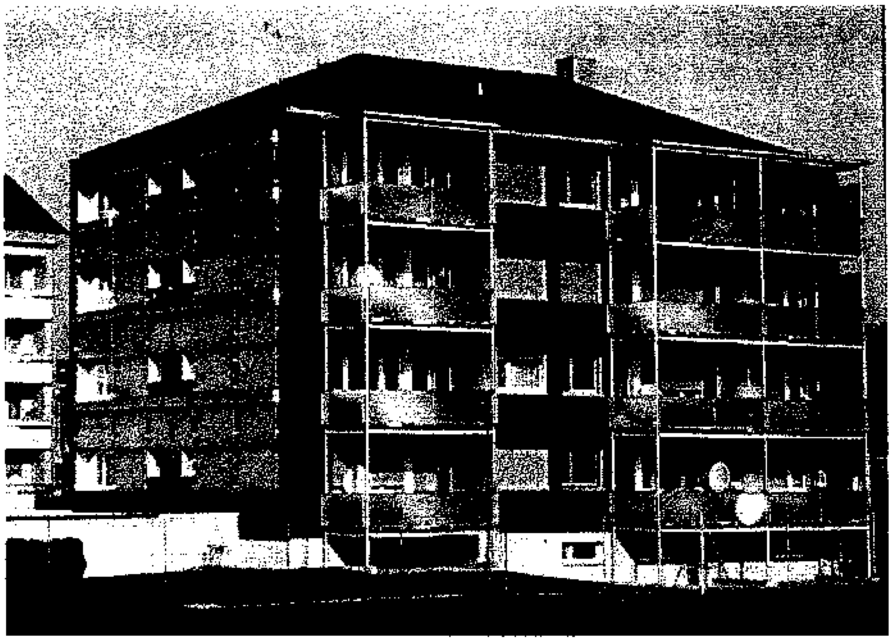
During planning, production and construction of the TI facade it became clear that there were several new aspects to be taken into account for this type of facade renovation. The most important were:

- Detailed planning of the whole facade was required, including the determination of the dimensions of all windows and deviations from the vertical.
- Construction workers needed to be carefully instructed. Good co-ordination between the involved companies (windows, window frame, shading system including electrician, TI elements) was very important.
- Mounting of the facade element needed to be very accurate in order to meet tolerance requirements to joining elements.
- Scaffolding needed to allow for the additional layers in front of the existing facade since the fully covered TI facades might not anchor to the existing facade.

Final conclusions for the advanced TI wall system

- No handling of fragile TI material was required on the construction site.
- Mounting of the prefabricated facade elements was very efficient.
- Errors in planning, production and mounting were very difficult to correct on site as the system did not allow for any additional or unexpected tolerances.
- The planning effort is much greater than for normal facade renovation.
- The TI wall element system should be modified to allow for construction tolerances.

Brugghof



Brugghof 11 southwest facade before renovation with TI

Initiator Eternit AG, Niederurnen

Project manager Markus Haab, Eternit AG, CH-8867 Niederurnen, phone: +41 55 617 13 97
fax: +41 55 617 12 71

Participants
- Eternit AG, Niederurnen
- Architekturbüro Züsli und Lüsch, Lucerne
- Architekturbüro F.Noser AG, Oberurnen
- S.R. Hastings/W. Frei, ETH-Hönggerberg, Zurich; on behalf of Swiss Federal Office of Energy (research study)

Financing Pension fund of Eternit AG

Building owner Stiftung Wohnkolonie Eternit, Niederurnen

Contact person Andreas Haller, Ernst Schweizer AG, CH-8908 Hedingen

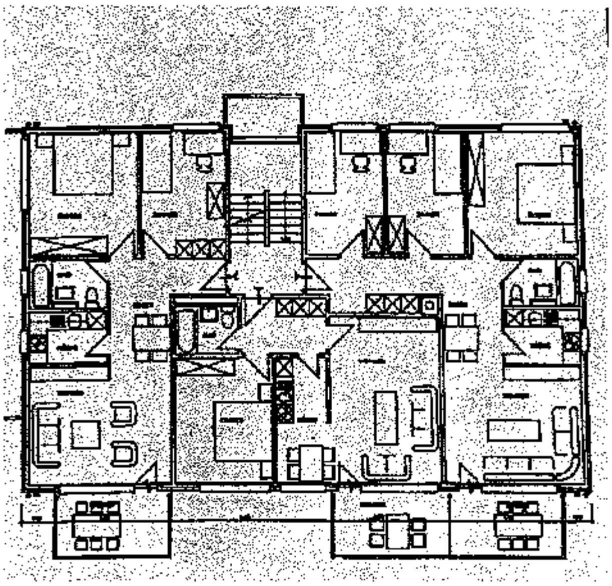
Building type Residential

Location Switzerland; pre-alpine village

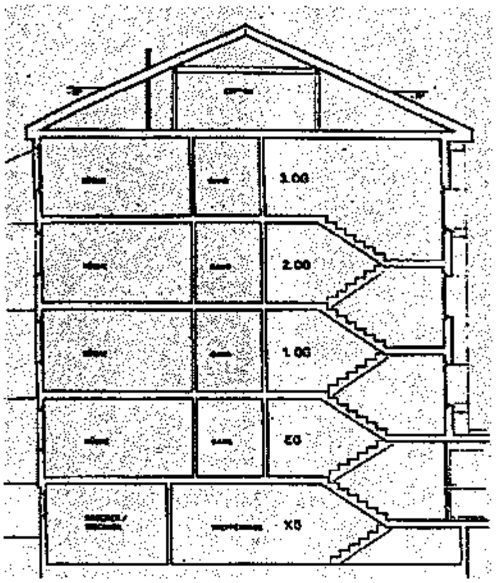
Climatic data Latitude: 47°13' Longitude: -9.06
Elevation: 434 m
Heating degree days, year/heating season: 3,223/2,988 DD (18/18°C)
Average ambient temperature, year/heating season: 9.4/5.8 °C
Length of heating season: October 1st to May 31st (233 days)
Number of sunshine hours, year/heating season: 2,084/1,017 h
For detailed climate description see Annex A.4

Basic data

Size: 2,010 m^3
Height: 4 stories
Heated floor space: 966 m^2
Number of apartments: 12 (size: 2 to 4 bedrooms)
Construction year: 1971



Typical floor plan



Section of the building

Energy demand

Space heating: 101 kWh/m^2 occupied floor area per year (measurement)
Lighting: 28 kWh/m^2 occupied floor area per year (estimation)
DHW: 28 kWh/m^2 occupied floor area per year (estimation)

Level of insulation
U-value of opaque walls: 0.49 W/m^{2}K
U-value of glazing: 2.80 W/m^{2}K
U-value of ceiling to roof: 2.32 W/m^{2}K
U-value floor to cellar: 1.89 W/m^{2}K

Areas
Opaque wall area: 523 m^2

Heating system: Oil fired central heating and DHW system using an average of 15,700 litres of oil per year (156.6 MWh)

Occupancy: 32 persons, average of 12 hours per day

Renovation reasons

Moisture and mould problems during the winter, especially in the building corners and where the balconies were attached and thermally connected to the building. Unappealing facade. Energy demand was 25% above regulations for new buildings.

Why solar

For marketing and educational reasons Eternit AG was seeking a building close to its headquarters to demonstrate the application of their solar energy systems. Eternit AG is a manufacturer of facade and roof cladding materials and systems and the company is a market leader for non-metallic ventilated curtain wall systems, mainly for apartment buildings, in Switzerland. Also, their roofing systems are very popular and the second most used systems after roof tiles. Eternit took a strategic decision to start to provide solar energy systems in combination with its traditional facade and roofing products and started several co-operative efforts for marketing, e.g. for TI wall heating elements and PV roof tiles.

With the need for a demonstration building for the new products, it was decided to conduct a feasibility study for a building renovation including the solar energy systems.

At that time (1994) an architectural study for a conventional renovation of the building "Brugghof 11" was being conducted by a local architect. Although this building had been renovated some years ago and had a rather low energy demand it had served as a demonstration building for a new cladding material that had some long-term aesthetical problems. The aim of the project was to improve the attractiveness of the building facades and of the interior.

The new energy concept [1] and the proposals for the TI facade were worked out to some extent under a project "Architectural and constructive integration of TI facades in building renovation" funded by the Swiss Federal Office of Energy [2].

Major goals

The net energy demand for space heating was expected to be reduced to 46% of the present level corresponding to an energy saving of 55 kWh/m^2 occupied floor area per year. Other expectations were improved attractiveness of the building, moisture and mould problems eliminated, and improvement of comfort during the heating season. No changes in energy demand were expected for domestic hot water and electricity.

Proposed design

Conventional conservation measures:
- Insulation of roof: 10 cm mineral wool
- Insulation of cellar ceiling: 5 cm mineral wool
- New windows (U-value 1.3 W/m^{2}K)
- Facade insulation 10 cm (instead of today's 6 cm)
- Elimination of cold bridges of balconies

Improved energy conservation measures:
- Insulation of roof: 18 cm
- Insulation of cellar ceiling: 8 cm
- New windows (U-value 1.3 W/m^{2}K)
- Facade insulation 16 cm

Optimized renovation
- Mechanical ventilation system with heat recovery

Advanced solar systems
- TI facade elements on south-west facade
- 3 kW roof installation with PV tile system

The net energy demand for space heating per m^2 occupied floor area for the proposed design is shown in the diagram below:

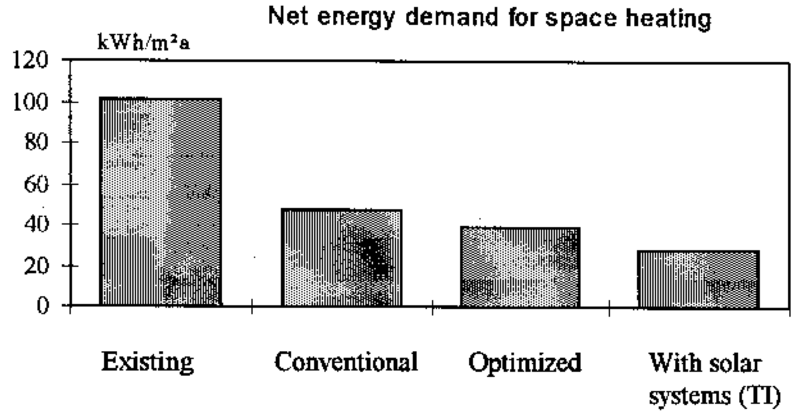


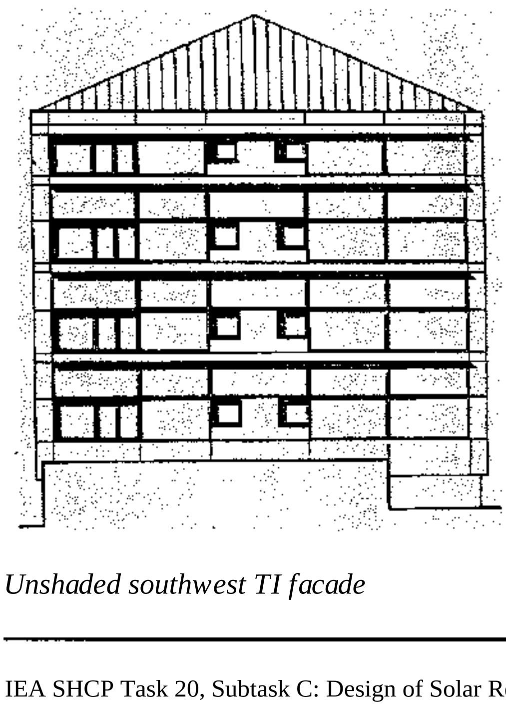
Table 1. Comparison of net energy demand for different renovation concepts for the Brugghof project

Design variants For the application of the TI wall a design study was conducted. The following aspects were addressed:

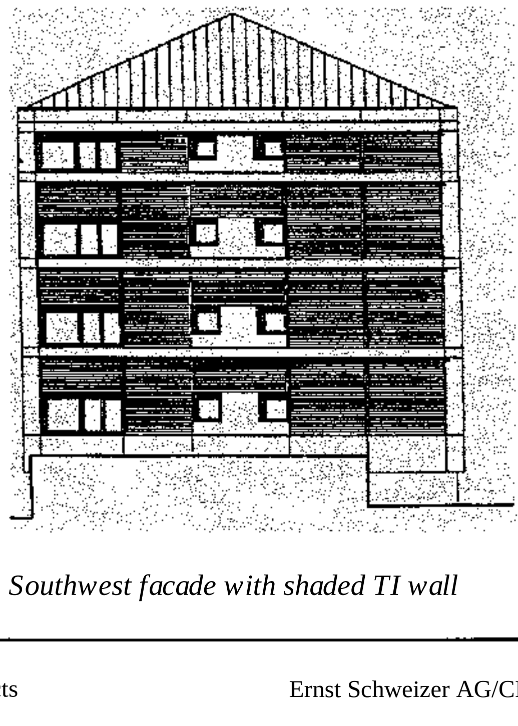
- the arrangement of the facade elements
- variation of the different possibilities for solar gain control
- construction details for TI elements and solar gain control
- construction details for joints
  combination with the opaque insulated facades

Final design For the final renovation project, the following measures were based on the detailed calculation :

facade insulation with 12 cm mineral wool
insulation of cellar ceiling with 5 cm mineral wool
insulation of attic / roof with 10 cm mineral wool
new windows (U-value 1.3 W/m^2K)
69 m^2 TI wall elements on south-west facade with external Venetian lamella blinds as solar gain control
1 kW_{peak} integrated PV roof tile systems
new balconies without cold bridges
new kitchen and bath installations



Unshaded southwest TI facade



Southwest facade with shaded TI wall

Costs	Standard/improved insulation of envelope	810,000 CHF
	New balconies	100,000 CHF
	Solar systems	122,000 CHF
	New kitchen/bathroom	336,000 CHF
	Overall renovation budget	1,368,000 CHF

Time schedule	Call for tender	January 1996
	Award of workmanship	End of February 1996
	Start renovation	1.5.1996
	TI facade	July 1996
	End of renovation	15.8.96
	Start of monitoring	1.9.96

Similar projects See German example "Sonnenäckerweg" in Subtask A.
See Swiss example "Affolternstrasse" in Subtask C.

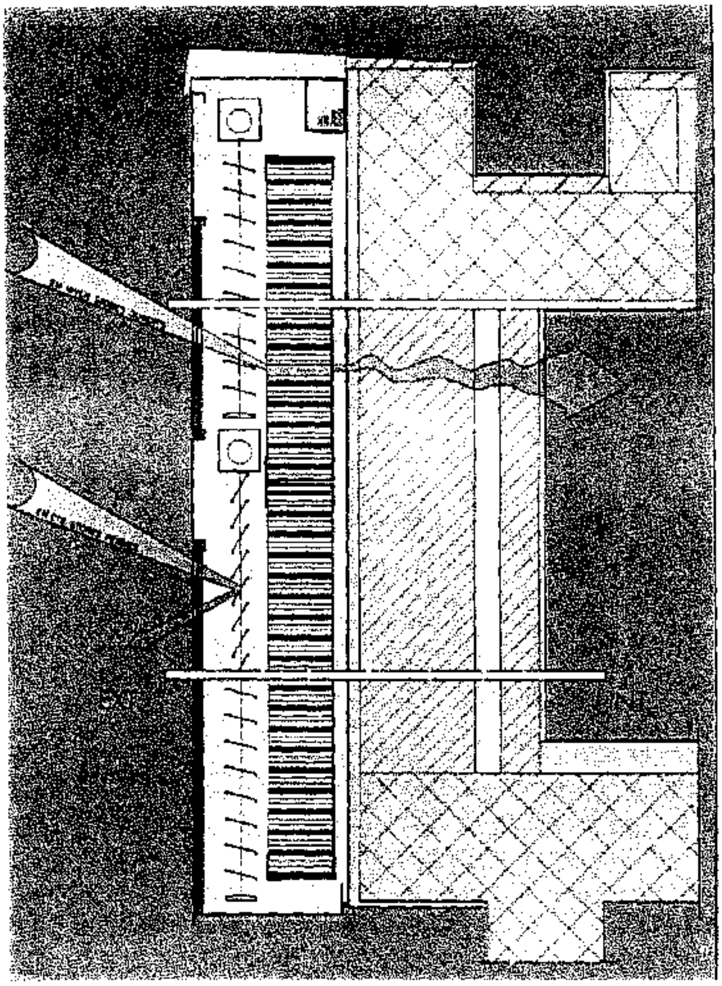
References

[1] B.Züsli "Energiestudie Brughof 11"; Metron Architekturbüro AG, CH-5200 Brugg, 1995.

[2] B. Züsli "Bauliche und architektonische Integration von transparenter Wärmedämmung (TWD) an bestehenden Gebäuden"; Metron Architekturbüro AG, CH-5200 Brugg / Forschungsstelle Solararchitektur ETH-Hönggerberg, 1996.

[3] Metron Architekturbüro AG: "Structural and Architectural Integration of Transparent Insulation (TI) in Building Renovation"; Paper to the 4th European Conference on Solar Energy and Architecture and Urban Planning; Berlin, March 1996.

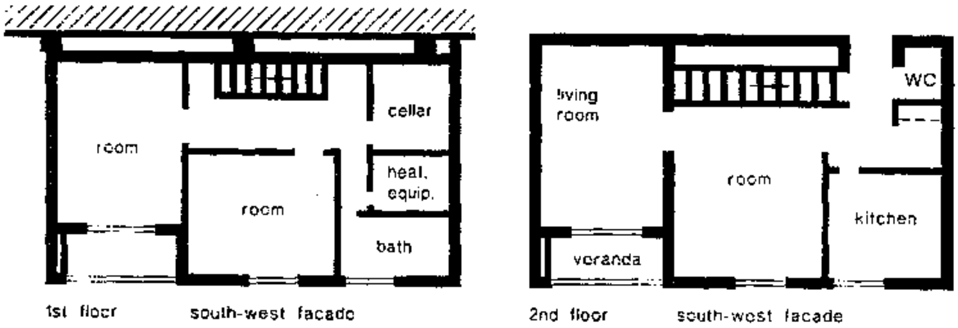
Valency building



Initiator	Lausanne Public Utilities (Services Industriels de la Ville de Lausanne)
Project manager	Lausanne Public Utilities (Services Industriels de la Ville de Lausanne)
Participants	- Félix Construction SA in collaboration with Lamelcolor and Multiverres SA - Okalux Kapillarglas GmbH (Germany)
Financing	Lausanne Public Utilities
Building owner	Lausanne Public Utilities
Contact person	P. Favre, SI Service Energie, rue de Genève 52, CH-1004 Lausanne Phone: +41 21 315 83 53, fax: +41 21 315 83 58
Building type	Residential, one family
Location	Switzerland; city, near lake
Climatic data	Latitude: 46.53 °N Longitude: 6.65 °E Elevation: 400 m Heating degree days, year/heating season: 2914/2676DD (18/18°C) Average ambient temperature, year/heating season: 10.5/6.7°C Length of heating season: October 1st to May 31st (214 days)

Number of sunshine hours per year/heating season: 2,299/1,043 h
For detailed climate description see Annex A.4

Basic data The building to be renovated is a small one-family residential house built in 1957. It is owned by the Lausanne public utility, and adjacent to a large water tank (6300 m^3). The inhabited space spreads over two levels, 81 m^2 each, and the basement level is used for parking and a technical room for electrical equipment used for the water tank.



Plan of both floors of the Valency building

The facade walls are uninsulated cavity walls (from inside to outside: 1 cm inside coating, 6 cm brick wall, 4 cm air cavity, 17.5 cm brick wall, 2 cm outside coating), the roof is flat with 4 cm insulation (from inside to outside: 1 cm inside coating, 20 cm reinforced concrete slab, 4 cm cork insulation, 2 cm outside tightness coating). The slab between the basement and the lower inhabited floor is an uninsulated slab (from top to bottom: 2 cm wooden floor, 4 cm screed, 20 cm reinforced concrete slab). The windows are normal double glazing (U-value 3.0 W/m^2K) and are primarily on the southwest facade (orientation: 222° from North). Parts of the exterior walls on the first floor are adjacent to the ground.

Energy demand The building is heated with an oil-fired central heating system. The consumption is 2,800 kg of fuel per year for a heated area of 153 m^2. The net heating energy demand for space heating and domestic hot water is 183 kWh/m^2 occupied floor area per year, which is produced by the same burner. A simple check with a heat balance calculation method [5] shows that this number is realistic, the simple calculation gives 211 kWh/m^2 per year. The difference is acceptable, considering that there are very large uncertainties on the boundary conditions towards the bottom of the building. The temperature of the technical room for electrical equipment, which is 2/3 of the ground area, is not accurately known, but has a significant impact on the energy used for space heating because of the uninsulated slab.

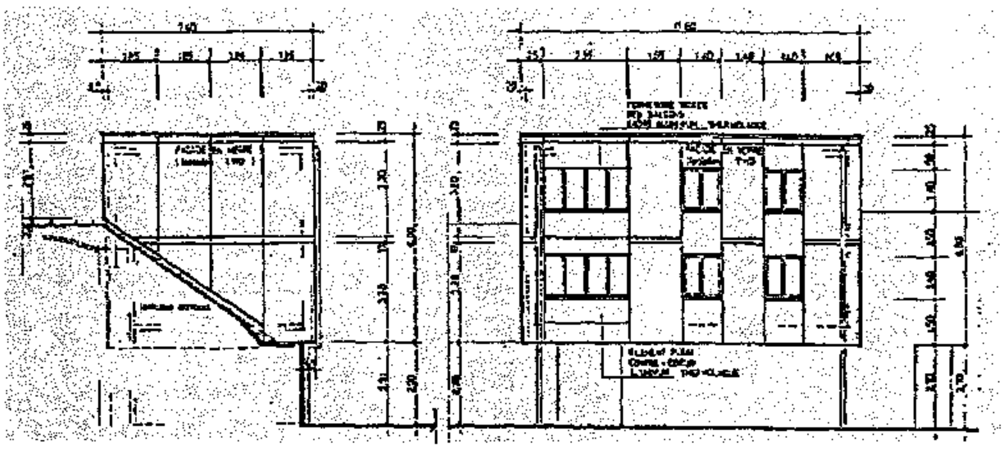
Renovation reasons In Switzerland more than one third of the total energy demand is used for space heating and so there is general agreement that the quantity of fossil fuels used for space heating should be drastically reduced. Well established technologies, such as direct gain passive solar systems or atria, are already financially profitable, but new techniques such as Transparent Insulation (TI) are not. For this reason, the promotion of these techniques is mainly done by non-profit organisations such as public authorities, for example as pilot projects.

Why solar The building of Valency had to be renovated, and offered a good opportunity to try a new solar technology. Moreover, its small size (only 153 m^2 of heated floor) could allow a relatively inexpensive trial. The renovation project will show the feasibility of the TI use in both renovated and new buildings. Figures show the plan of the building, the facades and pictures taken from the same point, one before and one after renovation.

Major goals Based on a simple calculation with a heat balance method, the anticipated reduction of the net demand for heating energy is about 60 % compared to the basic building [3]. This number is very high, but it should be noted that, because the building is poorly insulated, it is rather easy to get a significant improvement, even with simple measures.

Proposed design The main part of the renovation is the use of TI on all external facades which are not adjacent to the ground (130 m^2). The renovation was essentially considered a demonstration project for this new insulation technique, but secondary improvements were also made, such as using glazed balconies to act as an atrium instead of normal open balconies (more details can be found in [1] or [2]).

The TI material was manufactured by Okalux GmbH. The insulation layer was made of stacked 10 cm long capillary tubes perpendicular to the wall surface, closed at their end towards the inside of the building by a layer of single glazing to prevent convection through the capillary tubes. On the opposite side of the TI material, a venetian blind provided solar gain control to avoid summer overheating and radiative losses during the nights of the heating season. Finally, an outside layer of single glazing protected the system from the outdoor climate (rain, wind, etc .).



Facades of the Valency building

Costs The total renovation cost was CHF 330,000. Not all of this amount was directly connected to the Transparent Insulation itself. The table below gives an overview of the cost distribution.

Metallic construction (an unknown part of the bill corresponds to the transparent insulation, the rest to the glazed balconies)	60.4 %
Data acquisition, regulation	10.1 %
Insulation of walls adjacent to ground	8.3 %
Transparent insulation material	6.5 %
Scaffolding, wall preparation	5.4 %
Tin-plate ware	5.4 %
Electrical installations	3.8 %

The part of the cost directly connected to the TI renovation is estimated to be around 75 % of the total, i.e. CHF 1900/m^2 for the 130 m^2 of TI wall.

View of the building after and before renovation

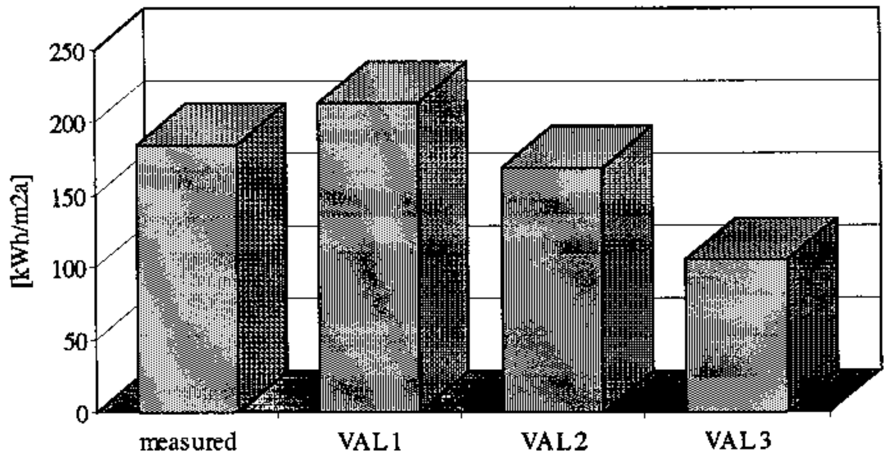
Monitoring The building has been monitored but the results regarding energy demand are not very detailed. User behaviour and the tight coupling to the domestic hot water tank have a strong influence on the energy demand, but it was not possible to quantify these parameters from the monitoring data. In order to get more detailed information and to generalise the experiences from this project, a parametric study with a simulation model was made [6].

Parameter study The simulation study was designed to give more precise energy saving numbers, and help to evaluate the thermal comfort. It compared the original building, a building with similar characteristics but with standard insulation (walls and roof with U-value of 0.3 W/m^{2}K) with the same building using TI. From this comparison, experts could evaluate the benefits of TI compared to standard thermal insulation. The simulation code used was a dynamic nodal network model, which allowed for the inclusion of all the transient effects and the modelling of the global characteristics of the TI layer [4].

Results The following variants were modelled and simulated using weather data from the local design reference year. Internal gains were not taken into account:

- VAL 1: Original, not renovated building
- VAL 2: Renovation with standard insulation measures (10 cm glass wool in facades)
- VAL 3: Renovated with TI walls as in real renovation

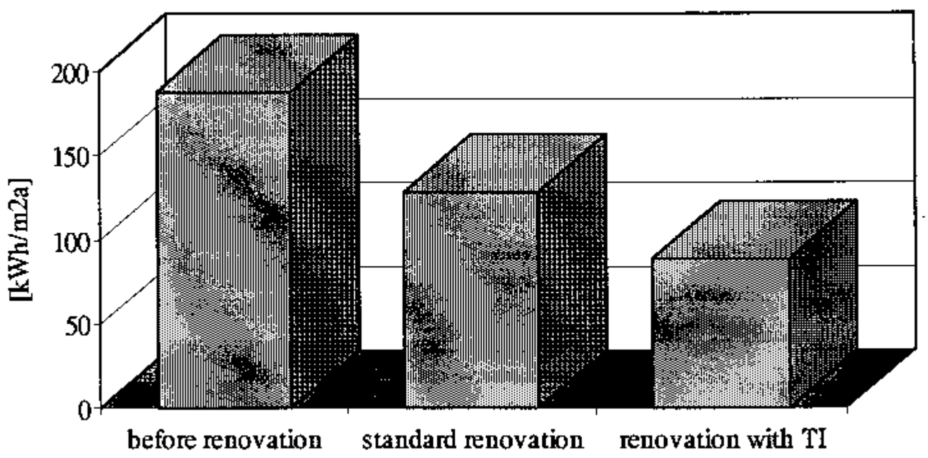
For comparison: The measured annual auxiliary space heating demand of the original building was 183 kWh per m^2 occupied floor area.



Simulated net energy demand for space heating for the different renovation variants

The auxiliary heating demand for the original building compared well with the "measured" data from the energy bills. The results showed that a simple insulation did not give a large improvement, but that the Transparent Insulation allowed for much larger reductions. This was mostly due to the high transmission losses to the water tank that could not be reduced by simple insulation of the envelope.

For more typical buildings, the results are quite different. The simulation model was modified with a more typical distribution of windows and window areas, orientation of the main facade towards the south and only one floor in contact with the ground. The water tank was eliminated. The modelled standard renovation includes insulating the facades with 10 cm of opaque insulation.



Simulated net energy demand for space heating in a typical building

Conclusions The simulation study showed that TI as a renovation system also for more typical buildings has a large potential for saving heating energy.

Similar projects See German example "Sonnenäckerweg" in Subtask A.
See Swiss example "Affolternstrasse" in Subtask C.

References

[1] G.Furneaux: "Application de l'isolation transparente à un immeuble d'habitation", in Journal de la construction de la Suisse romande, Vol.66 no 10, May 1992

[2] P.Favre & M.Bonvin: "Rénovation TWD de Montétan, aspects constructifs et éléments d'évaluation ", in Transparente Wärmedämmerung, Erfahrungsberichte aus der Praxis, meeting organised at ETH-Zürich, June 1994

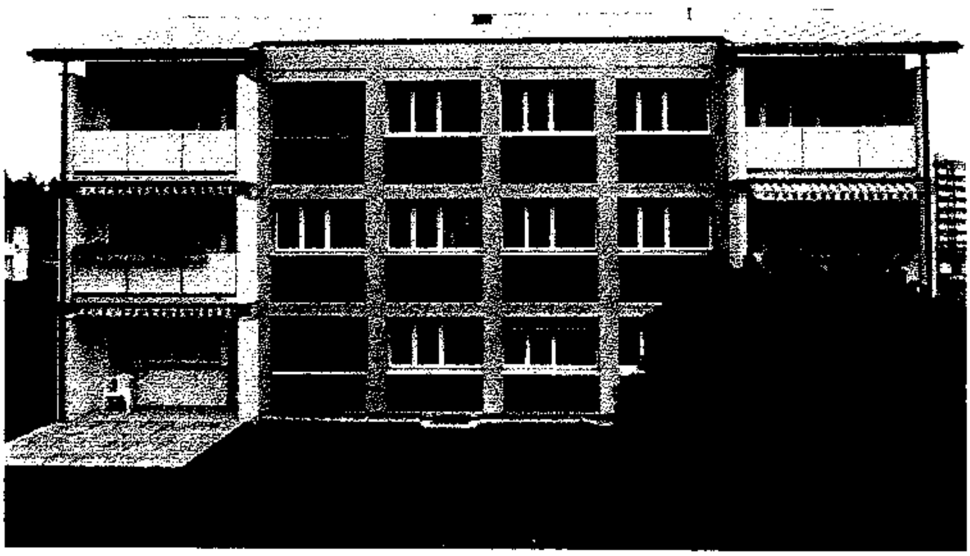
[3] Granit SA (F.Doppenberg & A.Abächerli): "Etude 1, bilan thermique Montetan Sud", Lausanne, August 1991

[4] N.Morel: "PASSIM User's Manual", LESO-PB/EPFL, May 1984

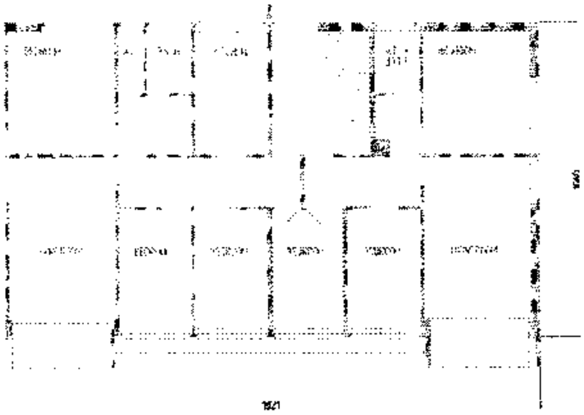
[5] LESO-PB: "LESOSAI-X User's Manual", LESO-PB/EPFL, January 1991

[6] N.Morel: "Transparent Insulation - A Simulation Study", Building Rehabilitation Using Transparent Insulation, Final Report, LESO-PB/EPFL, November 1995.

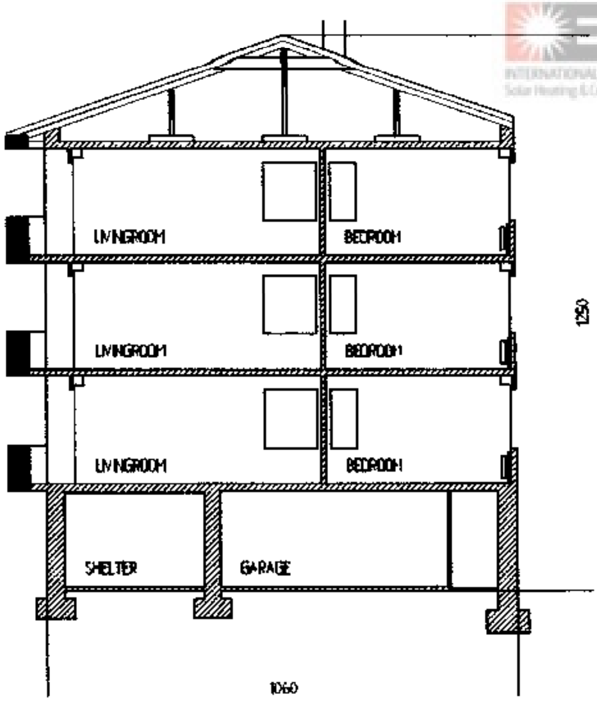
Wollerau



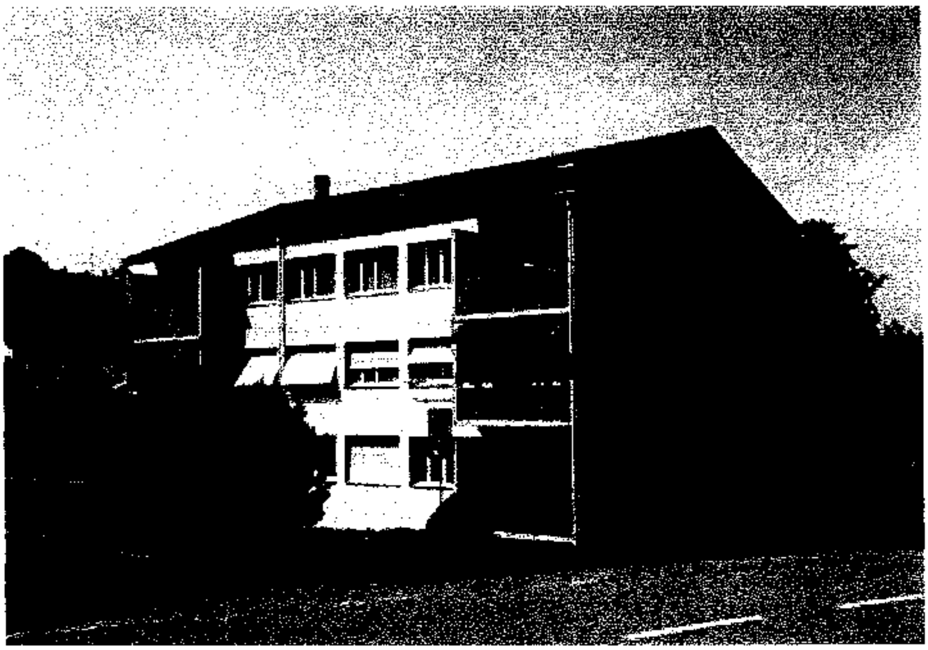
Initiator	Gebrüder Frey AG, CH-8832 Wollerau
Project manager	A.Müller AG, Generalunternehmungen, CH-Baar
Participants	Alfred Müller Generalunternehmungen AG Ernst Schweizer AG, Metallbau, CH-8908 Hedingen
Financing	Private
Building owner	Gebrüder Frey AG, CH-8832 Wollerau
Contact person	Dr. P. Schneiter, c/o Ernst Schweizer AG, CH-8908 Hedingen Phone: +41 1 763 62 31, fax: +41 1 76 88 51
Building type	Apartment building
Location	Village, Swiss midland
Climatic data	Latitude: 47.20°N Longitude: -8.73 °E Elevation: 512 m Heating degree days, year/heating season: DD (18/18°C): 3,329/3,038 Average ambient temperature, year/heating season: 9.5°C/5.65°C Length of heating season: October 1st to May 31st (208 days) Number of sunshine hours per year/heating season: 2,027/1,085 h For detailed climate description see Annex A.4
Basic data	Construction year: - 1965 Size: 1,481 m^3 (overall volume) Height: 3 stories Heated floor space (one building): 593 m^2



Floor plan ground floor



Section of the building



Building before renovation

Energy demand	Space heating:	185 kWh/m^2 occupied floor area per year (calculation)
	Electricity:	30 kWh/m^2 occupied floor area per year (estimate)
	DHW:	30 kWh/m^2 occupied floor area per year (estimate)

Construction details	Level of insulation	U-value of walls:	1.0 W/m^{2}K
		U-value of windows:	2.7 W/m^{2}K
		U-value of ceiling to roof:	1.2 W/m^{2}K
		U-value floor to ground:	0.5 W/m^{2}K

Renovation reasons

The roof, plaster wall covering, windows and roller blinds of these twin apartment buildings had reached the end of their lifetime and showed signs of deterioration. In addition, the original construction insulation levels and construction details (cold bridges) did not comply with current standards, and the heating energy demand was above average and the current building codes for new buildings.

Why solar

On the initiative of the building owner, solar renovation measures were requested to be evaluated within the renovation project:

- Solar thermal collectors for DHW: This would have required many changes in water piping inside the apartments and disturbed the tenants too much.
- Glazed balconies: The existing balconies were made from projecting concrete plates on the bottom and sides. These cold bridges could not be eliminated by a glazing construction.
- Transparent Insulation: The central part of the south facade consisted of horizontal rows of windows and parapets. These parapet areas were well suited for the application of TI facade elements.

After the basic evaluation of the different concepts, it was decided to follow up the TI wall heating systems in more detail. Because of the regularity of the facade, it was proposed to use newly developed prefabricated TI facade elements. A system for solar gain control was proposed and the energy gains from the TI wall were estimated using a simplified one-zone model for the simulation code HELIOS.

These simplified calculations showed that a reduction of the net energy demand of about 70 kWh/a per m^2 TI facade area could be expected, so it was recommended to equip all radiators with thermostatic control valves, limited to 22°C.

Major goals

Major goals of the renovation were to replace the degraded components at the end of their lifetime in order to protect the structure of the buildings. The renovation was also to include practicable improvements to reduce heating energy demand to a reasonable level, keeping in mind a 30 year life span. Furthermore, within a reasonable budget, some improved measures to reduce the heat energy demand using solar energy were to be implemented.

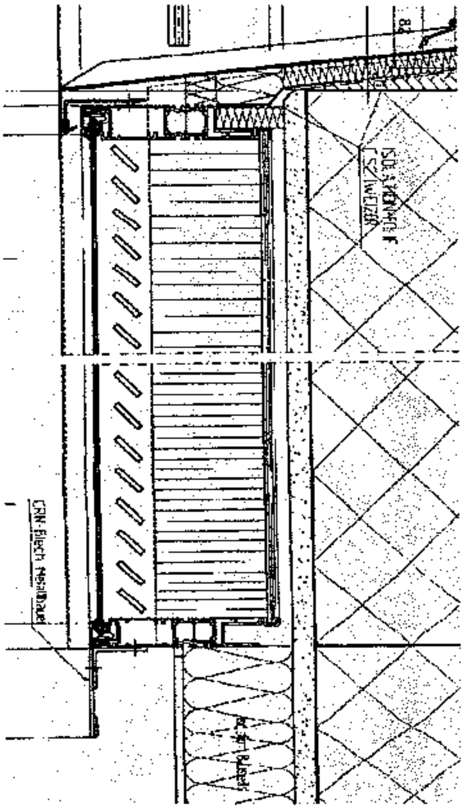
Proposed design

Except for the TI facade this project included the conventional measures of an energy conscious, high quality building renovation. The shingle roof was completely refurbished and insulated. Windows were replaced using low-e glazing and new shading systems (Venetian blinds instead of roller blinds). All facades, except for the central part of the south facade, were insulated with 10 cm mineral wool covered with plaster. Additional measures were the insulation of the cellar ceiling and the heat pipes and the installation of thermostatic control valves at the radiators.

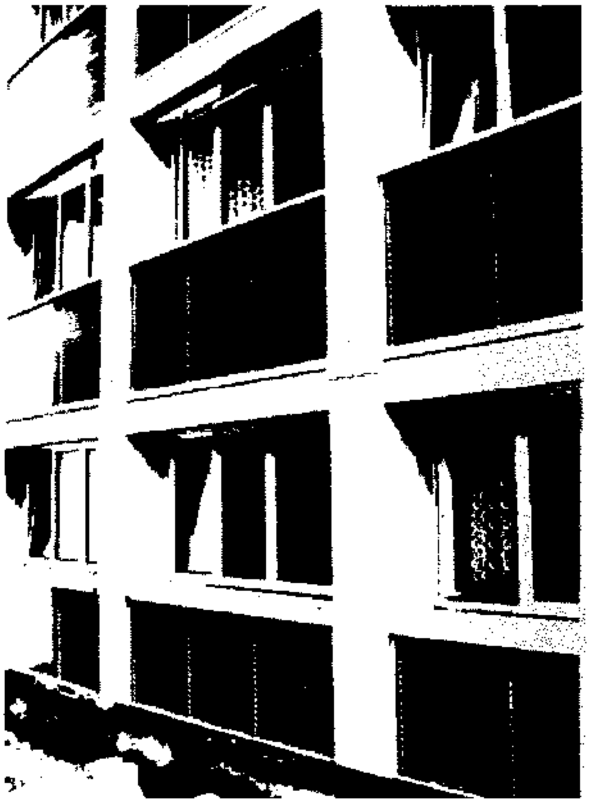
For the central part of the south facade the installation of TI facade elements in the parapets of the windows was proposed. TI wall heating elements usually need solar gain control for summer months. Because of construction difficulties and high costs, movable external shading devices, e.g. Venetian blinds, were not appropriate.

As an alternative, the results from a research project about fixed shading concepts [1], [2] were adapted to this application. The final shading construction for solar gain control of the TI-facade elements consisted of fixed element integrated lamellas, as sketched below.

The expected net energy demand for space heating in the renovated buildings was 56 kWh/m^2 occupied floor area per year without TI facade elements, and 50 kWh/m^2 occupied floor area per year with TI element.



Section of TI-facade elements with integrated lamellas for shading in summer



South facade with TI facade element in the parapets

Costs The costs for the TI facade elements was approximately 610 ECU per m^2 including the metal facade elements. The installed cost of the central part of the south facade was 40,000 ECU per building.

Monitoring No monitoring was planned because the installed TI area was small relative to the size of the apartments and its expected impact on users behaviour.

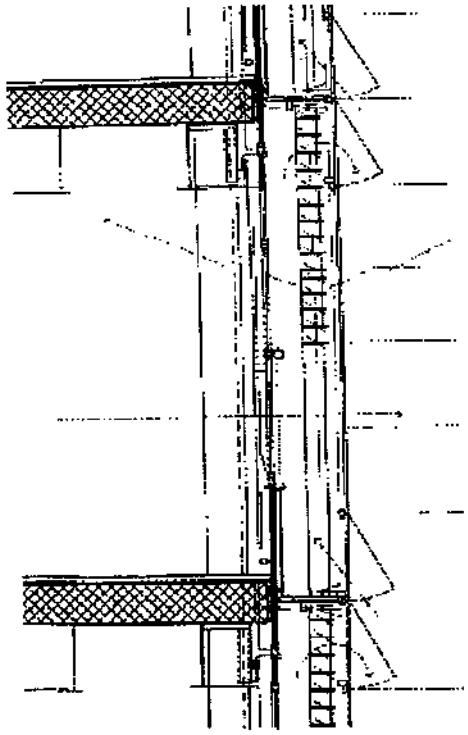
Similar projects See German example "Sonnenäckerweg" in Subtask A.
See Swiss example "Affolternstrasse" in Subtask C.

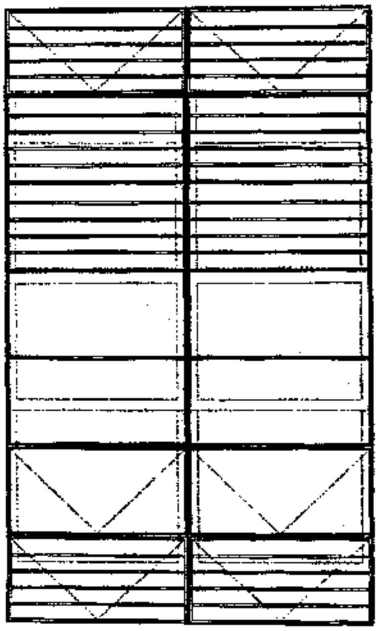
References

[1] Gebäude mit transparenter Isolation - Optirnierung des Überhitzungsschutzes ; Final Report; Ernst Schweizer AG on behalf of the Swiss Federal Office of Energy - HBT Solararchirtektur, ETH-Hönggerberg, CH-8093 Zürich, February 1995.

[2] Einfluss der Beschattungstechnik von transparent wärmegedämmten Massivwänden auf den Raumkomfort; Final Report, Ernst Schweizer AG on behalf of the Swiss Federal Office of Energy - HBT Solararchirtektur, ETH-Hönggerberg, CH8093 Zürich, September 1995.

Technical University Lucerne



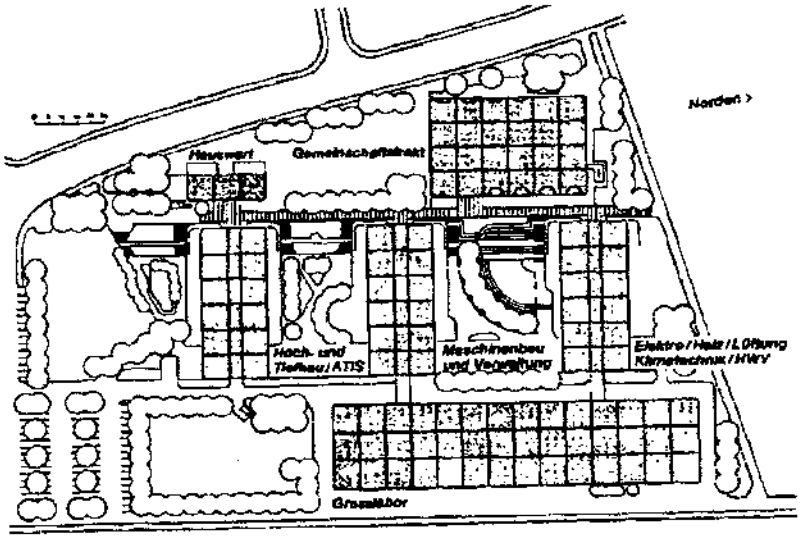


Initiator	Technical University of Lucerne
Project manager	M.G. Trawnika, dipl. Ing. ETH, HVAC Department of ZTL A. Meletta, dipl. Architect ETH, Architecture Department of ZTL Phone: +41-41-410.22.31
Participants	A. Bucher, W. Ernst, Ch. Fierz, B. Gut, U. Pfammatter, M. Rinderknecht, A. Wirz S.R.Hastings/W.Frei, on behalf of the Swiss federal office of energy (project support).
Financing	Swiss federal office of energy, Technical School Lucerne
Building owner	Canton of Lucerne
Contact person	M.G. Trawnika, dips. Ing. ETH, HVAC Department of ZTL Phone: +41-41-349.33.06
Building type	School
Location	Switzerland; central midland
Climatic data	Latitude: 47°02' Longitude: -8.31 Elevation: 445 m Heating degree days, year/heating season: 3,243/2,978 Kd (18/18°C) Average ambient temperature, year/heating season: 8.7/4.0 °C Length of heating season: October 1st to May 31st (228 days) Mean daily number of sunshine year / heating: 2,025/1,050 h For detailed climate description see Annex A.4

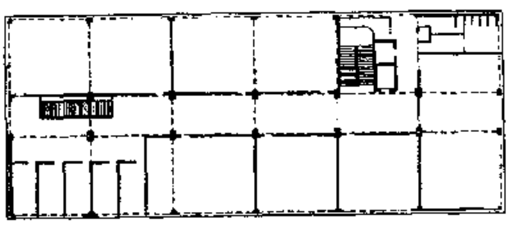
Basic data Construction period: 1972 - 1977 in two phases

Size:	Large complex of different buildings
Height:	2 to 5 stories
Total heated floor space:	27,500 m^2
Floor space of evaluated building:	5,390 m^2

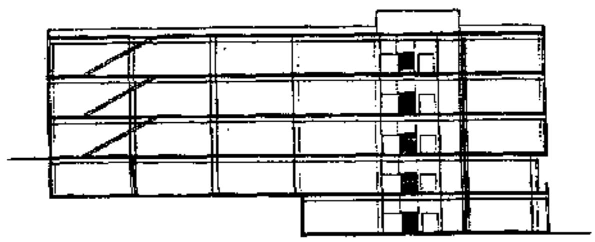
Plan of the Technical School Lucern



Floor plan of the evaluated building



Section of the evaluated building



Construction Modular steel skeleton construction with concrete floors and light metal curtain wall facade.

Energy demand

Space heating:	115 kWh/m^2 occupied floor area per year (measured)	
Electricity:	50 kWh/m^2 occupied floor area per year (measured)	
Level of insulation:	U-value of curtain walls:	0.85 W/m^{2}K
	U-value of massive walls:	0.52 to 0.56 W/m^{2}K
	U-value of glazing:	3.10 W/m^{2}K
	U-value of window frames:	5.70 W/m^{2}K
	U-value of ceilings:	0.45 to 0.59 W/m^{2}K
	U-value floor to ground:	0.75 W/m^{2}K
Curtain wall module:	Dimensions:	1.50 x 4.59 m
	Aluminium area:	2.54 m^2 / 37%
	Frame area:	1.09 m^2 / 16%
	Window area:	3.26 m^2 / 47%
Heating system:	Since 1994 gas (80%) and oil (20%) fired co-generation plant.	

Occupancy:	Max. 25 persons per class room, usually from 8:00 - 12:00 and 13:00 - 17:00
Infiltration rate:	0.8 air change per hour
Ventilation:	Exhaust ventilation with 4,470 m^3/h air exchange volume
Shading:	Electrically driven external venetian blinds

Renovation reasons

A 1992 study stated that the building facades were in good shape, but the building construction and energy features did not comply with current know-how or energy standards. The poor insulated building elements resulted in high heating energy demand and reduced comfort due to low surface temperatures of the facade. The damping of the solar gain from the light metal curtain wall was responsible for massive overheating inside the buildings during the summer. The shading system was not sufficiently sturdy to withstand the weather conditions and maintenance costs for the Venetian blinds was approximately - 45,000 ECU per year.

Major goals

The initial goals were to improve the thermal comfort, reduce the heat energy demand and to find a more cost effective solution for shading in the buildings. Ecological aspects like disposal of old and new materials and the use of passive solar concepts were to be included, as well. A further goal was to develop a renovation concept which minimised additional HVAC installations.

Why solar

As The Swiss Federal Office of Energy became the sponsor of this work the project scope was broadened to the whole class of these buildings types. And the project focussed on a comparison of second skin facade as a solar renovation concept with conventional renovation techniques.

Proposed design

- Glazed second skin facade of a 60 cm distance from the existing facade, separated at each floor level. Ventilation flaps at the bottom and top of every facade module
- Sun tracking Venetian blinds in the upper part of the facade element for improved daylighting
- Glare protection by fabric blinds in front of the existing windows
- Exposed existing concrete ceiling as heat storage

Glazing versions:

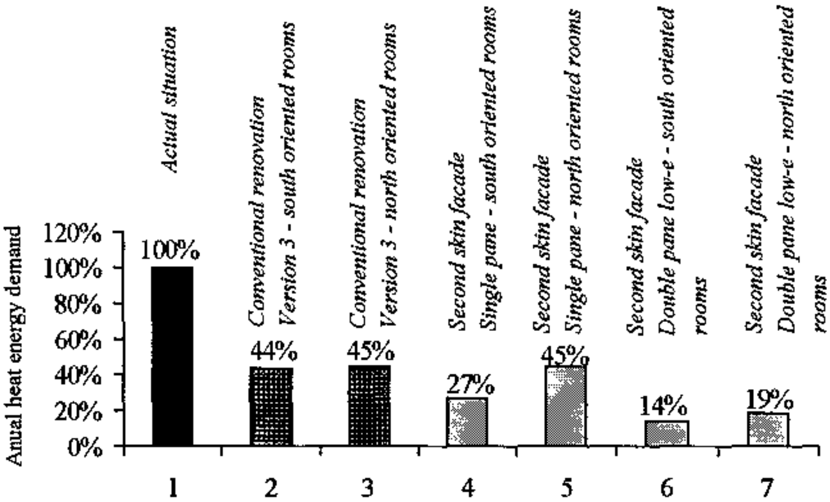
1: Second skin with single pane/inner glazing with existing double pane
2: Second skin with double low-e pane/inner glazing with existing double pane

Reference

Version 1:
- Additional insulation of the existing element frames (60 mm)
- Replace existing glazings with 2-pane low-e glazings
- Expose concrete ceiling for heat storage
- Replace the existing lighting equipment to reduce heat load

Version 2:
- All measures of version 1, and
- Additional insulation of parapets

Version 3 (for comparison with second skin versions, only):
- Additional insulation of the existing element frames (60 mm)
- Replace existing glazings with 2-pane low-e glazings
- Replace the existing lighting equipment to reduce the heat load



Actual heat energy demand for different renovation designs

Costs

The savings in energy costs were relatively low compared to the investment costs. However, the existing facade had almost reached half of its expected lifetime of 30 years and so the investment cost for its replacement had to be taken into illustrate this, the original costs were extrapolated to today's price level for comparison, though the replacement of the original facade would not comply to the building code.

Renovation version	Investment [CHF]	Energy demand [MWh/a]	Energy price [CHF/kWh]
Actual state (replacement)	2,600,000	470	-
Conventional renovation version 2	2,761,000	300	0.546
Conventional renovation version 3	1,983,000	343	0.523
Second skin version 1	3,910,000	274	0.442
Second skin version 2	4,607,000	129	0.300

Life cycle analysis of the different versions show that any second skin solution are superior to the conventional facade renovation.

Conclusions

It would be technically attractive to implement any of the evaluated renovation variants. Also, the architectural requirements could be met. The conventional renovation concepts only reduced the heat energy demand, but the comfort situation could not be improved, the overheating problems increased and the maintenance costs would not be reduced.

The second skin approach reduced heat energy demand, improved thermal comfort, allowed for night cooling and improved the use of daylight. The maintenance costs were reduced due to the protection of the shading devices.

These results represented an intermediate state of the project because of the various assumptions and simplifications in the simulation models. For the verification and optimization of the second skin approach, it was proposed that a modular prototype is constructed for evaluation and measurements.

Similar projects None

Design process

The project was set up as an interdisciplinary study between the departments of architecture and HVAC at the university. Experts from the school and outside experts evaluated special aspects of the project.

The Architecture Department followed through the project in three steps:

1) The 5th term of the architecture course of 1993/94 was set up to familiarize students with the possibilities of a renovation using the existing building structure and facade, and to discuss concepts for a second skin facade.

2) A study group of four architecture students worked during the 6th term in the spring of 1994 on different second skin solutions and a conventional renovation for comparison, based on the results from the 5th term. This study group was supported by two students and an assistant teacher of the HVAC department. The plan was to complete the first results from detailed energy simulations, unfortunately, this was not possible in the expected time frame because the results were not ready within the class term.

3) After the completion of the simulation study of the HVAC study group, a small team supported by outside simulation experts refined the architectural concept according to the simulation results.

In parallel, the HVAC department conducted several steps of the energy and comfort studies:

1) Diploma work in 1993 evaluated the existing situation regarding heat energy demand. Conventional renovation strategies were studied by modelling the building with DOE-2.

2) A pilot group of two students and an assistant worked on simulation models for second skin facades during the spring term of 1994. It became clear that the models and tools were too complex to deliver results within the expected time frame.

3) Hereafter, support was given by outside simulation experts using modified tools for air movement calculations (TRNSYS-COMERL) to construct the appropriate models. The parameter study was conducted by the HVAC department.

Villa Tannheim

Initiator International Solar Energy Society (ISES), Fraunhofer-Institut für Solare Energiesysteme (ISE), Deutsche Bundesstiftung Umwelt

Project manager Peter O. Braun, Fraunhofer ISE

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Financing Subsidies by Deutsche Bundesstiftung Umwelt, Fraunhofer ISE and Freiburger Wirtschaftsförderung

Building owner Municipality of Freiburg

Contact person ISES - Burghard Holder; Fraunhofer ISE - Karsten Voss

Building type Multi-family building, now mainly used as an office building

Location Germany; outside centre of Freiburg

Climatic data The climate is continental with relatively mild temperatures. About 7 months are above 10°C. The annual mean outdoor air temperature is 10.4°C. The latitude is 48.0°. The elevation is 269 m. The mean daily total radiation on horizontal surface is 3,038 Wh/m^2. The heating season lasts from September to May. The number of heating degree days is 3,334 DD (15°/20°C). For detailed climate description see Annex A.4.

Basic data The building size is approximately 13 m x 14 m with three storeys resulting in approximately 540 m^2 of heated living area.

Energy demand The net energy demand for space heating was approximately 200 kWh/m^2 occupied floor area per year, but could not be measured before renovation due to the fact that it was not inhabited for several years before the renovation. Single pane windows and uninsulated massive brick walls of 40 cm thickness were found. The building had not been renovated for more than 40 years. Ventilation was achieved by opening windows and the heating energy was supplied by an oil burner from around 1950.

Renovation reasons The entire building need renovation. Due to the fact that the International Solar Energy Society was to be the new inhabitant of the building, the renovation was done more accurate in details than it is standard in Germany.

Why solar The new building occupant, International Solar Energy Society, wanted to demonstrate solar technologies.

Major goals Due to the fact that the building had not been used for a long time, the exterior and interior of the envelope had to be renovated. The thermal comfort was to be improved by insulating the building envelope. The use of a composite TI system was the first test of new prefabricated TI modules, and the market introduction of the system. The expected net energy saving was about 70% for space heating and 50% for domestic hot water compared to the demands before the renovation.

Proposed design

- New glazings and frames (overall U-value of 1.0 W/m^2K)
- Facade insulation (8 - 10 cm)
  Transparent Insulation, 53 m^2 gross area plastered-compound-system on the west facade
- Solar collector for domestic hot water (7.5 m^2 flat plate solar collector)
- New heating device (high efficient gas burner instead of oil)

Costs The total costs for the project investments linked to energy, including facade (53 m^2 of TI), roof and cellar insulation, window and frame exchange as well as the technical renovation of the heating system were approximately 150,000 ECU.

energy measures	DM	ECU
new windows (70 m^2)	75,000	41,000
cony. insulation facade (450 m^2)	116,000	64,000
TI-facade (53 m^2)	20,000	11,000
roof insulation	20,000	11,000
insulation cellar	7,500	4,200
new heating system	43,000	23,900
collector-system	16,000	8,900

Time schedule

Concept development	9/94
Financial negotiations	10/94
Construction Phase	10/94 - 12/94
Monitoring phase and documentation	1/95 - 6/96

Similar projects None.

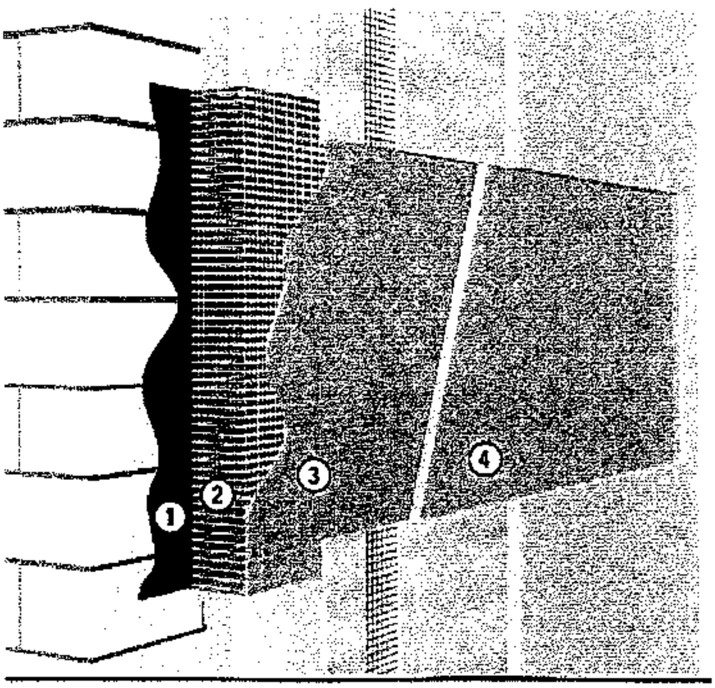
Design Process

There was no design process due to a time limitation as the project had to be finished 3 months after the decision of ISES to accept the move to Freiburg. Nevertheless, there was much discussion during the construction phase.

Transparent Insulation: From the beginning, it was planned to install the TI compound system (see figure below). The maximum size of elements was 1.2 m in width and 2.5 m in length. The resulting design solution significantly changed the design of the facade. On the other hand, the installation was now much easier than it was before. The elements were prefabricated and installed quite quickly. The installation on the west facade, which is of course performing less than on south facade, was a decision of retaining the character of the beautiful old building, which is mainly expressed by the north and south facades.

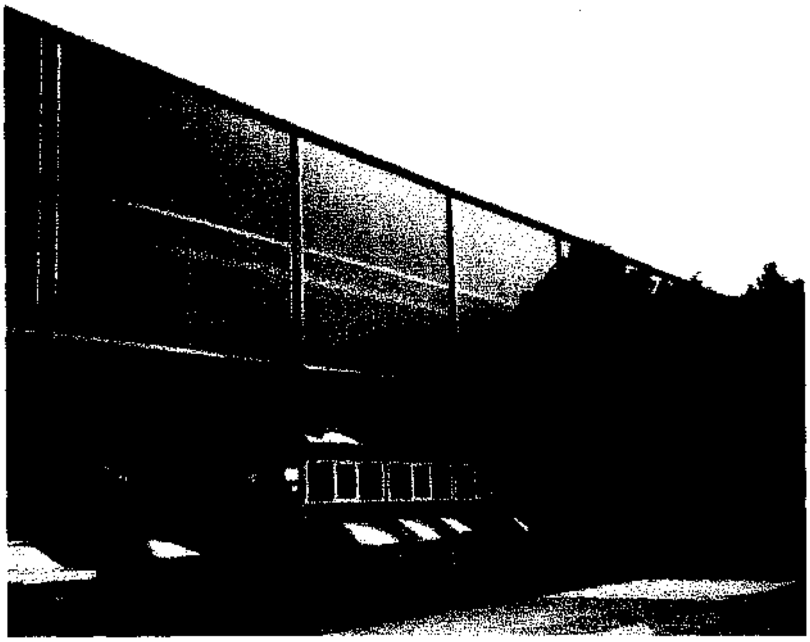
Windows: The decision to use super-glazing with a U-value of 0.4 W/m^2K (triple glazed), which were just ready for the market in autumn 1995, was based on the interest of how these new type of windows would perform. The disadvantage of using these is that they have very small scales. Therefore, edge losses in frames and connectors inside the panes which has a great impact on the overall performance of the windows, result in an overall U-value of approximately 1.0 W/m^2K.

Opaque insulation: The decision to install 8 cm of polystyrene on all other facades was made after confirming that the building ornaments could be reconstructed, which gave the building a beautiful design. This was quite costly, but the character of the building was retained as much as possible. On the other hand, there was no chance to install more than these 8 cm because the crossing points of the facade and the roof and the ornamental construction of the balconies would interfere. The side walls of the cellar also were completely insulated because a new drainage system had to be installed to avoid moisture inside the cellar walls.



Schematic drawing of the TI compound-system.
The TI structure is stuck to the wall and transparently plastered.

Industrial hall LHB



Initiator PREUSSAG AG, Fraunhofer Institut für Solare Energiesysteme (ISE), The German Ministry of Education and Research (BMBF)

Project manager Peter O. Braun, Fraunhofer ISE

Participants
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Financing Private: 66%, governmental (BMBF): 34%

Building owner Linke-Hofmann-Busch (LHB)

Contact person Adrian Galetzky, LHB; Karsten Voss, Fraunhofer ISE

Building type Industrial assembly hall

Location Germany; countryside

Climatic data The climate is continental with relatively mild temperatures
About 5 months are above 10°C
The annual mean outdoor air temperature is 8.4°C
The latitude is approximately 52°. The elevation is appr. 100 m
The mean daily total radiation on horizontal surface is 2.495 Wh/m^2
The heating season lasts from September to May

The number of heating degree days is 3,933 DD (15°/20°C)
For more or less similar climate description see Annex A.4

Basic data

The building size is approximately 200 m x 200 m^2 = 40,000 m^2, divided into 7 "ships". The mean height is 15 to 18 m. The facades are mostly based on a 5 m high brick-wall on which a 10 m high one-pane-glass construction is held in place by a steel sub-construction. The roof monitors are oriented north and south. There is no shading on the north side but some shading on the south facade by trees and shading of the east and west facades by similar buildings 20 m away.

Energy demand

The net energy demand for space heating was approximately 300 kWh/m^2 occupied floor area per year, but could not be measured exactly due to the fact that the district heating system supplies heat for all the halls combined. Artificial lighting was used excessively due to the aging and pollution of the glazings. The building did not have a cooling system or a mechanical ventilation system. However, a high air change was needed due to the significant pollution inside the hall. The hall only used natural ventilation by opening the large doors on the north and south side of the hall. This system provided good ventilation in the summer, but in winter it resulted in high ventilation heat losses.

Renovation reasons

The brick part of the facade was degraded due to moisture. The glazing part of the facade was built as a single-pane construction in a steel grid, which caused severe comfort problems due to cold air draughts inside the building. The glazings were irreversible polluted, which hampered daylight from entering the building. Even though the heating energy demand was very high, the inside temperature would not reach a level of 13°C during severe winter periods.

Why solar

A basic study prepared by the Fraunhofer-ISE showed that using Transparent Insulation (TI) inside the glazing area of the building would help to reduce the cold draughts (due to the insulating effect of the TI-material) and improve the lighting (due to the light diffusing effect of the TI-material).

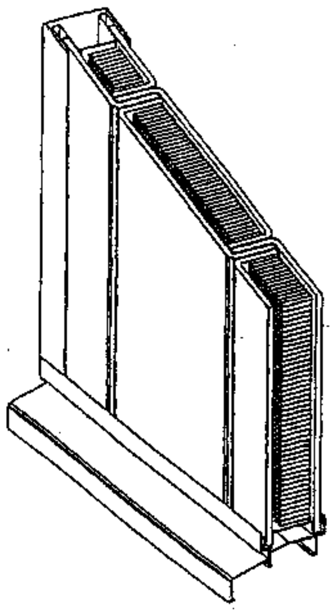
Major goals

The major goals of the project were to improve the thermal and day-lighting situation and in turn reduce the fluctuation of workers due to illness etc. Besides this, the reduction of the heating and lighting energy demand was important, but not the main aspect. The reconstruction of the facades was the first step in a bundle of measures to improve the whole energy supply of the hall.

Proposed design

In the first layout, the construction was based on a mullion-transom system with glazing filled with 60 mm of TI-capillary material. Several improvements were made in terms of costs, but the minimum cost for this construction was 330 DM/m^2 (e.g. 180 ECU/m^2) which was too high for the investor. To lower the costs, it was decided to use glass elements filled with 40 mm of TI for a price of about 260 DM/m^2 (e.g. 145 ECU/m^2). This would result in a U-value of the facade in the range of 1.9 W/m^2K.

The whole glazed facade of the building was reconstructed in four steps and started with the west facade in 1995, the east facade and roof monitors in 1996, the north and south facades in 1997. Each facade has an area of about 2,000 m^2, which resulted in investment costs of about 400,000 ECU per facade. The proposed design was a very simple glazing construction formed by industrial glazing with a filling of 40 mm of TI inside the U-shape of two of these glazings.



Sketch of the daylighting elements using TI

Costs The proposed total costs for the project including the design, demolition of the old facade and construction of the new facade was approximately 2 MECU for a facade area of 7,440 m^2.

Time schedule

Concept development	4/93-8/93
Financial negotiations	1/94-10/94
Expected final confirmation for support	11/94
Final design of project	12/94-3/95
1. Construction Phase	5/95-9/95
2. Construction Phase	5/96-9/96
3. Construction Phase	5/97-9/97
Monitoring phase and documentation	6/95-6/98

Similar projects There is a similar project in Switzerland, but it is not part of Task 20.

Design Process

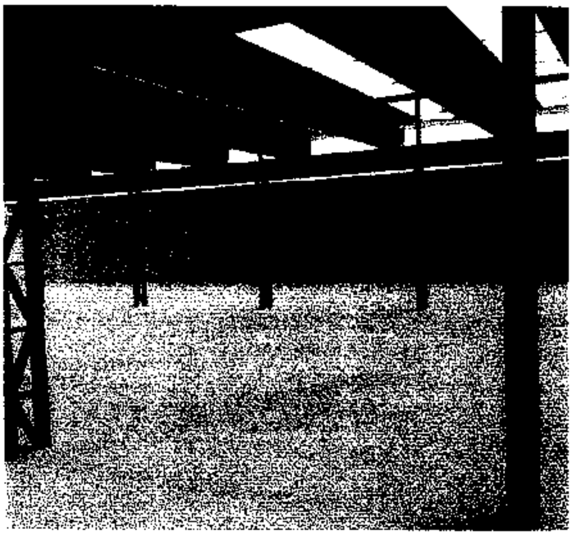
At the 3rd Expert meeting in September 1994, it was stated that the U-value of such a construction may not be sufficient due to the thermal bridges of the glass. Calculations using WINDOW 4.0 however showed a U-value of at least 1.9 W/m^2K. Still, a compromise between the financial and energy reduction possibilities was necessary. Simulations showed, that it did not make much sense to have much lower U-values because at this level of insulation the ventilation losses started to be the dominant energy loss factor. This was due to an air change rate of 2 to 3 volumes per hour.

Another comment from that meeting was that the large area of glazing might cause higher lighting levels than needed. Therefore, it was discussed to close parts of the glazing area using opaque materials, e.g. insulation material. Simulations with the Radiance-programme of Lawrence Berkeley Laboratories (LBL) showed quite an improvement in the lighting situation inside the hall throughout most of the year (see Figures below). Only in periods where the sun had a very low angle of incidence was there a problem. The renovation started with the west facade in order to have a first impression of the daylighting effects. Workers' comments after the installation of the west facade in summer 1995 were that glare was not a problem because of the large distance between the glazed facade and the work places.

From other projects we know that TI as a daylighting element may cause glare if the viewer is looking perpendicular into the structure of the capillary or honeycomb material. Therefore, it was agreed that the TI should only be placed in the top or bottom area of the facade.

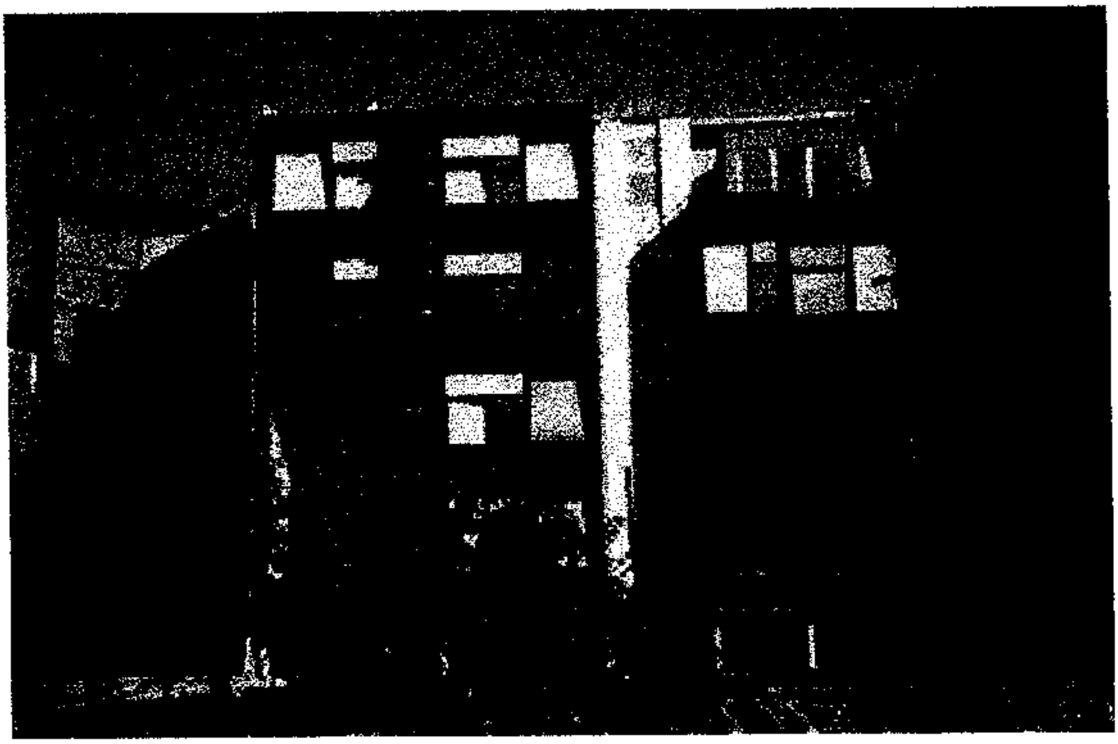
Other comments from the Expert meeting were that an unshaded south-facade could cause overheating and glare problems in the spring or autumn. For this project however, overheating did not seem to be a problem due to the high air change rates and the possibility for natural ventilation using the doors on the north and south facades. Also, the installation of a controllable ventilation system and a heat recovery system were recommended but, since the building facades needed to be reconstructed as soon as possible because of the degradation, the highest priority with respect for investments was given to the reconstruction of the facade.

Daylighting situation after renovation with Transparent Insulation (computer image)



Daylighting situation after renovation with clear glass (computer image)

The Yellow House



Initiator SBS Byfornyelse s.m.b.a. (urban renewal company), the Danish Ministry of Housing and the Municipality of Aalborg, Denmark.

Project manager Olaf Bruun Jørgensen, Esbensen Consulting Engineers FIDIC

Participants

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- Jens Gilling A/S, contractor (energy elements)

Financing The Danish Ministry of Housing and the Municipality of Aalborg

Building owner The Municipality of Aalborg

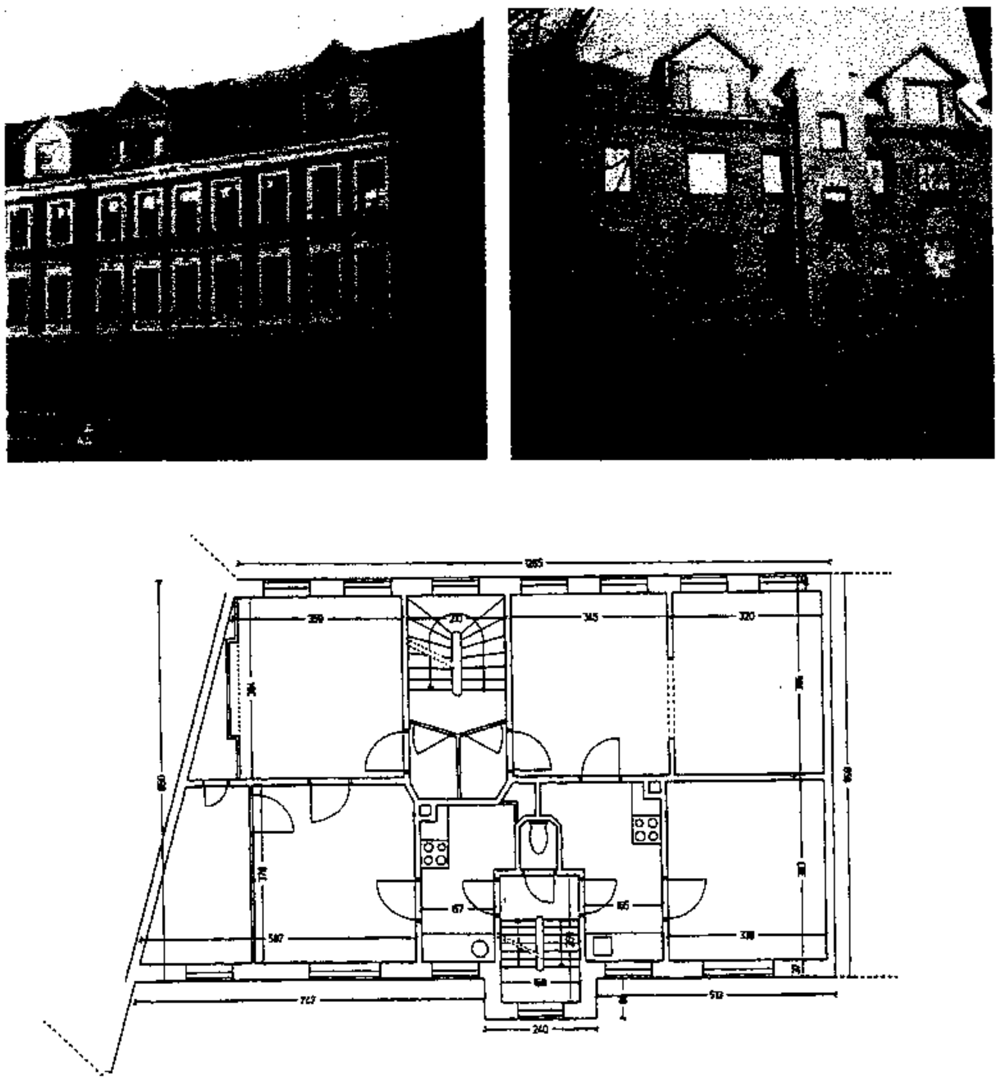
Contact person Olaf Bruun Jorgensen, Esbensen

Building type Residential - HR (four storey)

Location Denmark - city centre

Climatic data The climate is Atlantic with relatively mild temperatures. About 5 months are above 10 °C. The annual mean outdoor air temperature is 7.6 °C. The latitude is 55.6°. The mean daily total radiation on a horizontal surface is 2,782 Wh/m^2. The daily mean number of sunshine hours is 4.3. The heating season lasts from mid September to mid May. The number of heating degree days is 3102 (18 °C). For detailed climate description see Annex A.4.

Basic data The existing building is a four storey building with 8 apartments and a floor area of 450 m^2. One facade faces north to the street and one faces south to the backyard. The facades and a horizontal section of the apartments are shown below. The skyline profile varies between 5 ° and 45 °, depending on the floor level.



Floor plan and facades before renovation

Energy demand The annual net energy demands for space heating and ventilation, domestic hot water and lighting for one apartment was respectively approximately 132, 27 and 31 kWh/m^2 occupied floor area (monitored in a similar single glazed apartment before the renovation). The exterior walls were massive brick walls. The glazing percentage of the facades was approximately 15%. The apartments were ventilated by natural ventilation and the building had a central heating plant connected to a district heating system. All radiators were placed along the facades.

Renovation reasons

The basic reason for the renovation was the high energy demand for space heating. In addition, some degradation due to moisture damage had occurred. Finally, the Danish Ministry of Housing wanted to demonstrate that an efficient building renovation, regarding energy demand, indoor climate and environmental relations, can be carried out.

Why solar

The above mentioned intentions from the Danish Ministry of Housing relate to several different urban renewal projects: traditional renovation, renovation concentrating on the use of water ("The Blue House"); renovation concentrating on the protection of the environment ("The Green Quarter"); new apartment building based on ecological design strategies ("The Ecological New Building"); and finally this project, which was to concentrate on using solar energy to reduce the energy demand for space heating, domestic hot water and electricity ("The Yellow House").

Major goals

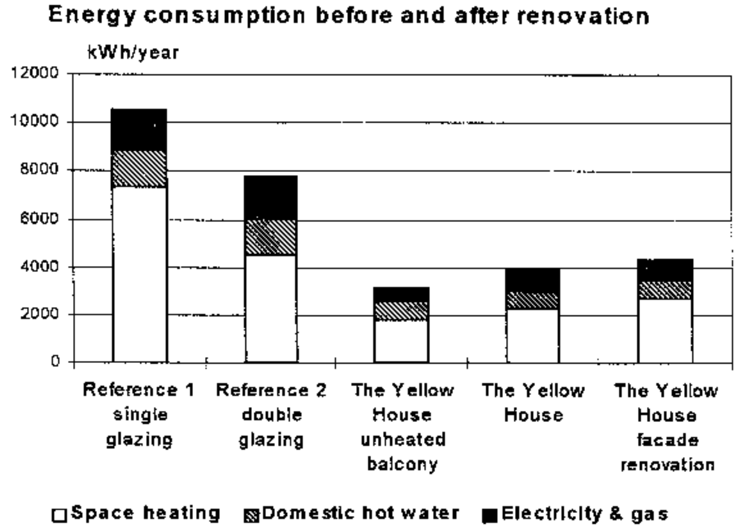
The major goals of the project were to reduce the net energy demand for space heating, ventilation and domestic hot water to a level lower than that of a new house designed in accordance with the Danish Building Regulations, BR-95: maximum 70 kWh/m^2 occupied floor area per year (only space heating and ventilation). The use of electricity for equipment and lighting was to be reduced to 30% of the typical present level. In addition, the renovation was to increase the thermal and visual comfort (no draught from cold surfaces plus more daylight in the old and dark apartments). It also was intended to end the ongoing degradation of the facade due to moisture. No considerations for the economics were made since the goal was to show that it is technically possible to reduce the energy use in residential buildings to a level as described above using solar energy.

Proposed design

The shaded part of the south facing facades would be insulated. Passive solar gains would be achieved by adding a south facing, highly insulated and heated glazed balcony and preheating ventilation air in ventilated solar walls with integrated PV-modules. All he windows would be highly insulating low-e glazings. The south facing windows would also have integrated Venetian blinds to provide solar shading and to reduce the U-value. The ventilation system would be demand controlled (moisture or CO_2 content). Furthermore, the increase of the floor area would allow a higher use of passive solar during most of the year. The utilization of daylight would be increased by installing larger windows in the new facade. Domestic hot water would be supplied from roof integrated solar collectors. The energy demand for electricity would be reduced using energy efficient appliances: refrigerator, oven, automatic dishwasher, laundry machinery, lighting, etc. For architectural reasons, only small changes would occur in the north facade.

The use of advanced glazed balconies, extra insulation, high performance windows, etc. was estimated to reduce the energy demand for space heating and ventilation by 74% (to 34 kWh/m^2). Using solar collectors for domestic hot water, the net energy demand was expected to be reduced by 56% (to 12 kWh/m^2). Thus, the net energy demand for space heating, ventilation and domestic hot water was expected to be reduced to 3,019 kWh/year or 46 kWh/m^2 occupied floor area per year corresponding to 30% of the present level in poorly insulated old buildings. The use of electricity for equipment and indoor lighting was expected to be reduced respectively 8 and 6 kWh/m^2 occupied floor area per year corresponding to 55% of the present level.

A stacked bar chart of the total net energy demand for the final design of "The Yellow House" compared to other advanced solar energy renovation concepts for the building is presented below;

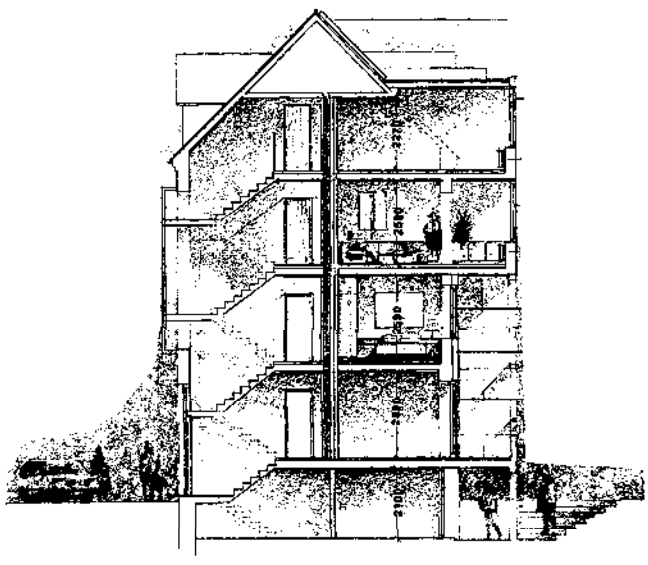


Reference 1, Single glazing: Unrenovated building, all windows are single glazed.
Reference 2, Double glazing: Unrenovated building, all windows are double glazed.
The Yellow House, Unheated balcony: Solar heated balcony.
The Yellow House: The actual project.
The Yellow House, Facade renovation: Existing facade replaced by glazed facade.

Net energy demand [kWh/year], for different solar energy renovation concepts for "The Yellow House"

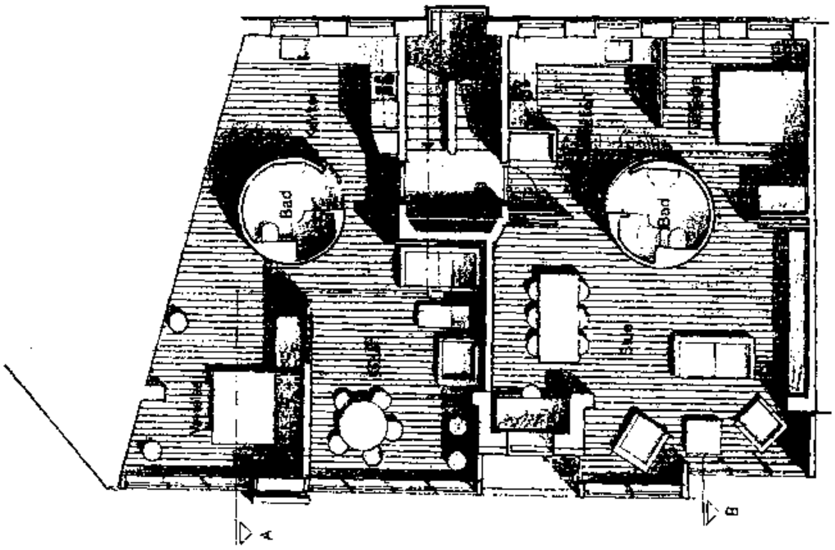
From the Figure above it is seen that improving the quality of the apartments by changing the floor plan to an open floor plan design and increasing the living area by adding a heated and highly insulated glazed space only causes a modest increase in the total energy demand (bar 3 and 4) compared to the solution that gives the maximum energy savings. It is also seen that large savings can be obtained by only renovating the south facade using similar techniques as in the renovation of the entire apartment (bar 5).

A vertical cross section of The Yellow House is shown below.



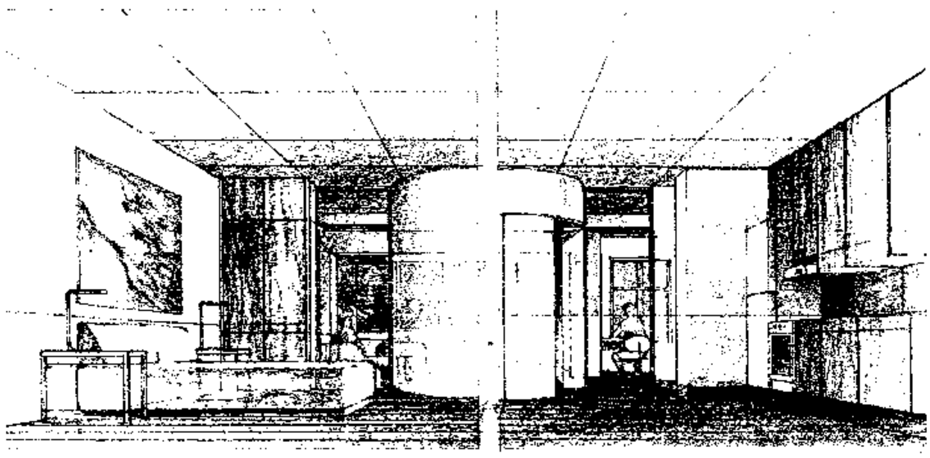
Vertical cross section

By using the added glazed space in combination with a new floor plan (the open floor plan design illustrated below), a well balanced overall solution for the complete apartment is achieved.



Floor plan of "The Yellow House"

The use of a new glazed facade will change the daylight conditions in the apartments dramatically by improving the level of illumination and the quality of light, as well as the visual comfort.



Isometric view illustrating the effect of the open-floorplan design

Costs

The total cost for the project was 2.26 MECU. The additional costs for the research part and the feasibility study was 0.9 MECU. The costs for developing and implementing the different innovative parts of the project was 1.36 MECU.

Time schedule	Concept development	06/94 - 09/94
	Development and test of special components	08/94 - 11/94
	Mounting and test of prototype	09/94 - 12/94
	Project delayed (finding new building)	
	Design of final project	05/95 - 12/95
	Construction of project	01/96 - 11/96
	Commissioning	11/96 - 01/97
	Monitoring period	05/97 - 07/98
	Documentation, progress reports, etc. 10/94, 03/95, 10/95, 02/96, 10/96, 06/98.	

Parts of this renovation project can be compared to the case study on "Advanced glazed balconies for solar based preheating of ventilation air" which was reported on in Subtask A.

Design Process

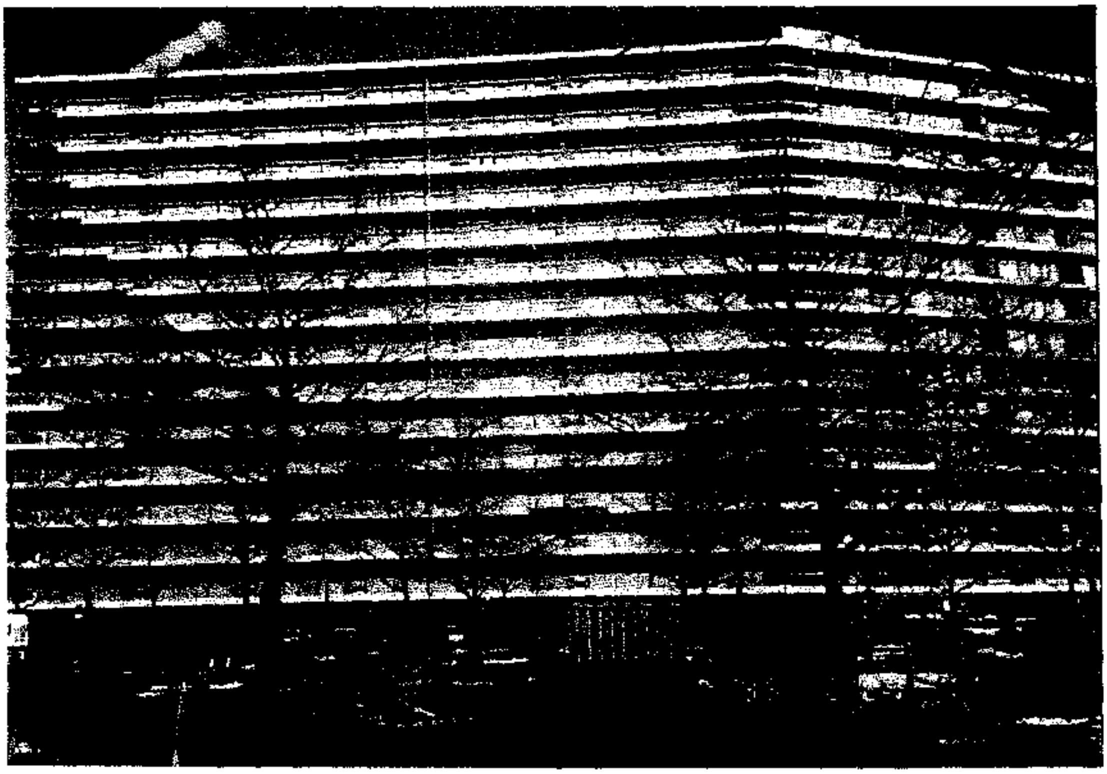
Originally, the proposal included daylight windows/clerestories with integrated Venetian blinds in each apartment. At the 3rd Expert Meeting in September 1994, it was noted that such advanced daylight windows for redirecting daylight deeper into the apartments might cause serious structural problems. For that reason and also because the energy saving potential was too small, the advanced daylight windows were cancelled. Furthermore, not using the advanced daylight windows with integrated fixed lamellas would also provide a better visual contact with the outdoor environment. Thus, the design was changed and new, larger windows were installed into a new facade, which improved the level of daylight in the apartment significantly.

For architectural reasons a vertical surface was originally preferred which meant that the PV-panels needed to be vertical. However, the design strategy was later changed to allow larger variations in the facade. This meant that both vertical and tilted PV-panels could be used in the project.

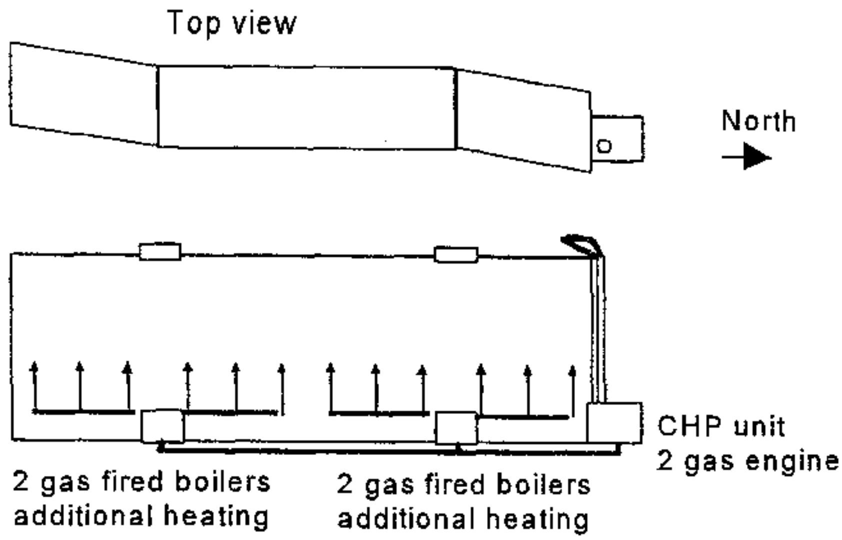
At the technical tour at the 4th Expert Meeting, March 1995, a new window from Interpane (used in the German demonstration project "Villa Tannheim") was studied. The visual performance of this window was very pleasing, but it was decided to use these windows only on the north facade because the integrated Venetian blinds, which were an important element of the design strategy, would damage the soft low-e window coating.

Unfortunately, the client was not able to buy the building originally selected and so, another building was selected for demonstrating the design. The solar incidence on this building however, was very different on the floor levels because of the shading effects from other buildings. Therefore, the design was changed, illustrating the possibility of making use of the different solar energy features on the different floor levels. Major changes were that the glazed facades on the ground floor were less sophisticated, that is, unventilated solar mass walls was no longer used, and the number of apartments were reduced from 14 to 8.

Brandaris



Participants	- Woningstichting Patrimonium - W/E consultants
Financer	Building owner, EC Thermie 1996 (requested)
Building owner	The building is owned by a housing company
Contact person	Chiel Boonstra, W/E Consultants
Building type	Multifamily - Residential - High-rise 14 storeys
Location	Zaandam, near Amsterdam, in The Netherlands
Basic data	The project consists of one building, built in 1968. It contains 384 similar apartments in 14 layers. The building facades are facing east and west. All apartments have a floor area of 80 m^2.



Building, orientation and installations

Climatic data

The standard number of degree days in the heating season is 2,804, base 18°C/15.5°C.

month	average temperature °C	average global radiation kWh/m^2/day, horizontal
October	7.9	1.72
November	6.3	0.79
December	2.4	0.5
January	2.7	0.60
February	2.1	1.27
March	4.3	2.25
April	7.7	3.57
Heating season	4.8	1.53

For detailed climate description see Annex A.4.

Energy demand

Space heating is supplied by a collective system with a Combined Heat and Power plant and assisting burners. The net energy demand for space heating is 145 kWh/m^2 occupied floor area per year (1,700 m3 natural gas per apartment per year). Domestic hot water was produced by a kitchen gas burner, demanding 15 kWh/m^2 occupied floor area per year (239 m^3 natural gas per apartment per year).

Renovation reasons

Necessary technical maintenance: collective heating system in need of replacement, kitchen gas burners cause indoor air quality problems.

Future possibilities for renting the building had to be ensured. This was expected to be achieved by improving the building image and diversifying the dwelling types.

Why solar

A collective solar system was proposed because of the opportunity to save primary energy in an economically efficient way. A "face lift" approach might by a good solution for this project. Glazing of a number of balconies and the application of TI could contribute to an improved building image, diversity, indoor comfort, etc.

Energy demand

The net energy saving (for space heating and domestic hot water) was estimated to be about 50%, the breakdown is as follows:

Net energy demand in kWh/m^2 occupied floor area (80 m^2 per apartment)

	present	proposed
space heating	145	47.5
domestic hot water	15	31.9
hotfill/coldfill equipment	0	32.8
cooking	7.3	7.3

Space heating savings were due to: improved insulation and airtightness, low-e glazing, glazed balconies (90 dwellings) and TI (10 dwellings). Increased domestic hot water energy demand because of improved comfort. Hotfill equipment: washing machines in 100% of the households, dishwashers in 10% and dryers in 20%. Present energy use is electricity (not shown) and cooking would remain constant.

Proposed design

A pre-study was made, in which several options were investigated. A collective solar system, contributing to space heating, domestic hot water and hotfill equipment has been developed in detail. Glazed balconies system have been studied and optimised in detail:

The collective solar system would have a total of 750 m^2 collector area, unshaded on the flat roof. The solar storage would be 15 m^3. The solar boiler would contribute to the collective heating system (one system for space heating and DHW) that would be heated by the existing plant (CHP and assisting burners). To maximise the solar contribution, the return temperature of the collective circuit would be kept as low as possible, using low temperature heating, improved domestic hot water heat exchangers and low flow rate pumps.

Glazed balconies would be optimised with respect to energy savings, thermal comfort, and other user aspects. Measurement would include: improved airtightness of non-balcony facade, low-e glazing, provisions to connect solar shading, insulation of balcony side wall, floor and ceiling.

Additional measurements to include:

- Cavity wall insulation, U = 0.46 W/m^{2}K
- Floor insulation above boxes, U = 0.37 W/m^{2}K
- Replacement of all single glazing by low E glazing
- Improved airtightness
- Three speed individual mechanical exhaust ventilation
- Individual heat metering
- Connections for hotfill equipment

Costs

The proposed costs per apartment was estimated to be 17,500 ECU (entire renovation, excluding design costs, subsidies and VAT), or is 6,720,000 ECU for the entire building (384 apartments). The costs, related to solar measures, was 4,700 ECU per apartment (1,800,000 ECU entire building).

Time schedule The preliminary time schedule was:

Design	September *1996* - April 1997
Construction	May *1997* - May *1998*
Monitoring	April 1997 - July 1999
Dissemination	May *1997* - December 1999

Design Process

The feasibility study was made in close cooperation with the building owner and his various responsibilities: technical, financial, maintenance, occupants' contact. The content of the project can be judged as realistic.

Integrated innovative approaches needed an initiating and supporting body, as the scope of the project exceeded the normal responsibilities. For instance the collective solar system could be run by the utility company, while the current heating system was run by the building owner. External driving forces as Thermie or Novem funding were needed to change the current practice.

Hoog Zandveld

Participants
- Woningbouwvereniging Onze Woning
- Adviesbureau Nieman (project coordination)
- Ecofys (advice regarding the solar DHW system)
- W/E Consultants (advice regarding the glazed balconies/ventilation)

Financing Building owner, state subsidies for energy efficiency, additional support

Building owner The building is owned by a social housing company

Contact person Chiel Boonstra, W/E Consultants

Building type Residential, Multifamily, 6 storeys

Location Nieuwegein, a new suburb of Utrecht, in the centre of The Netherlands.

Basic data The projects consists of three blocks, built in 1975. Each block consists of a wing of a 6 storey apartment building that faces west. A wing of two layers of single family houses (total 4 storeys) faces south and west. There are 6 types of apartments which have an average net floor area of 57 m^2.

Climatic data The standard number of degree days in the heating season is 2,804, base 18°C/15.5°C.

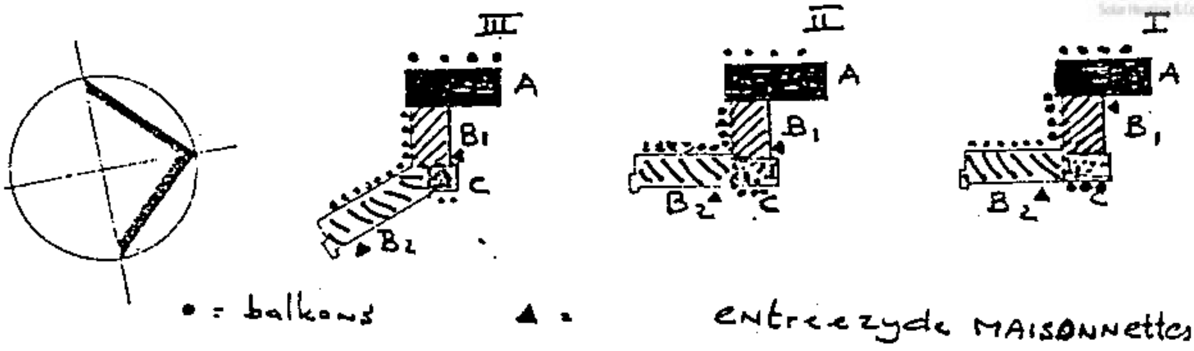
month	average temperature °C	ave. global radiation **kWh/m**^{2}/day, horizontal
October	7.9	1.72
November	6.3	0.79
December	2.4	0.5
January	2.7	0.60
February	2.1	1.27
March	4.3	2.25
April	7.7	3.57
Heating season	4.8	1.53

For detailed climate description see Annex A.4.

Energy demand Hot water for space heating was supplied by a central boiler. Its efficiency was estimated to be 80%. The energy demand for space heating, corrected for degree-days, was 1,520 m^3 natural gas on average per apartment. This related to a net energy demand of 208 kWh/m^2 occupied floor area per year.

For domestic hot water, 70% use an open geyser (210 m^3 natural gas, cooking included) and 30% an electric water heater (1,730 kWh on average per year). The annual average net energy demand was 36 kWh/m^2 occupied floor area per year for the open geysers and 87 kWh/m^2 occupied floor area for the electric water heating.

Renovation reasons The initial reason to renovate was the need for replacement of the open geysers, which were near the end of their useful service lives. There were also problems with thermal bridges and humidity. The building had already been partially insulated.



Orientation of building blocks

Why solar

A solar system could improve the comfort level and indoor climate (no NOx) without increasing the energy demand. Energy would be saved by abandoning the electrical boiler system.

A "face lift" approach might by a good solution for this project. Glazing of the balconies could save the problem with thermal bridges and reduce energy use.

Major goals

The expected reduction of the total net energy demand was *75* kWh/m² occupied floor area corresponding to 443 m³ natural gas per apartment. The savings were divided as follows:

solar system	*26* kWh/m² occupied floor area per year	156 *m*³ natural gas
glazed balconies	39 kWh/m² occupied floor area per year	*225* m³ natural gas
additional insulation	11 kWh/m² occupied floor area per year	*62 m*³ natural gas

The expected savings are in comparison to a conventional system, that provides a comfort similar to the solar system. Compared to the current energy demand, which is achieved with low comfort, hardly any savings would be realized.

Proposed design

A pre-study was been made, in which options for solar domestic hot water, glazed balconies, and additional insulation measures were investigated.

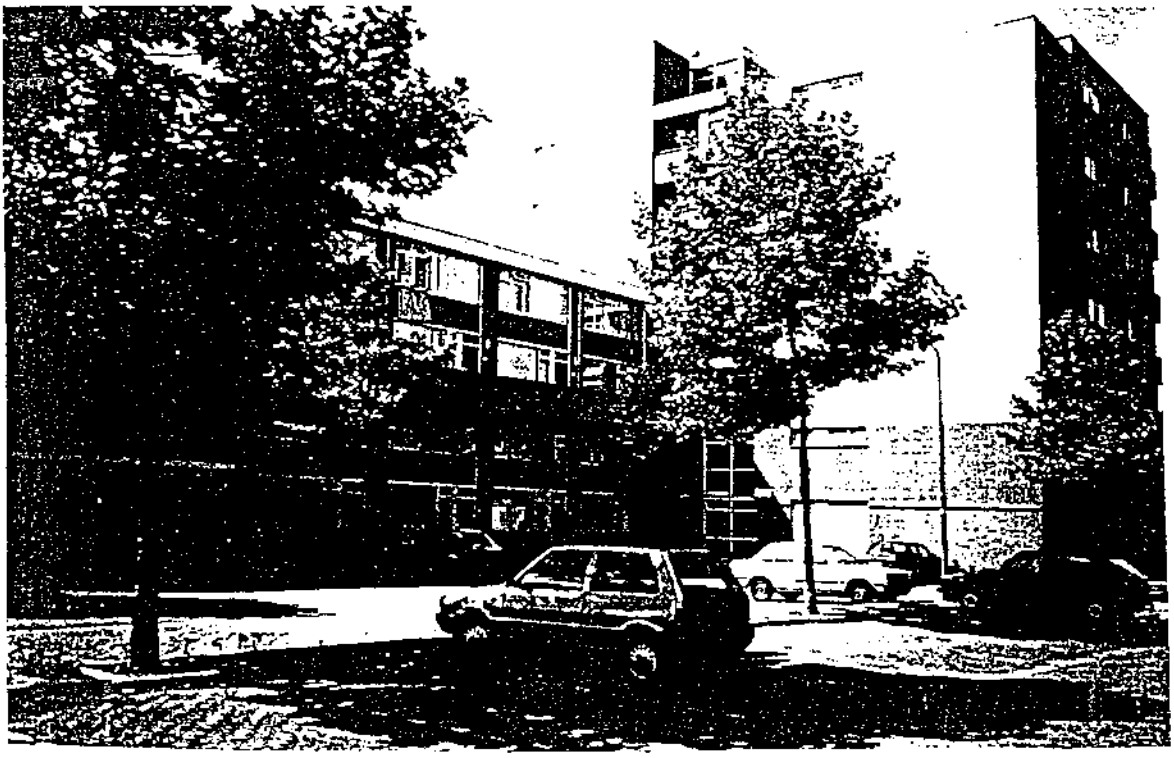
Each building would have a central solar system to preheat domestic hot water. A new burner in the wing apartments would heat the water to the final temperature. An insulated domestic hot water circuit would be installed in the building. The solar collector area would be *20* m² and the water heater volume would be 600 litres.

The dwellings in the low wing would have individual solar water heaters with supplementary heating provided by the central space heating circuit. To limit heat losses of the central circuit in the summer, the solar water heaters would be "loaded" for a few hours at night. Each apartment would have a solar collector area of *2.8 m*² and a water heater volume of *200* litres. The savings are compared to a central system without a solar water heater.

The balconies of the west-oriented apartments in the high-rise wing would be glazed (single glazing). The low wing would have maisonette flats that were well suited for glazed balconies adjacent to the living rooms. The galleries at the opposite side of the building would remain unglazed because of ventilation requirements.

Additional insulation measurements included:

- Extra insulation of roof (U-value reduced from 1.25 W/m^2K to 0.4 W/m^2K)
- Extra insulation of ground floor (U-value reduced from 0.63 W/m^2K to 0.36 W/m^2K)
- Replacement of all single glazing by double glazing (applicable only for bedrooms in 70 apartments)



Apartment building with low and high wing

Costs The proposed costs per apartment was estimated to be 7,300 ECU (excluding design cost subsidies and excluding VAT), which was 175 MECU for one block of 24 apartments.

Time schedule The preliminary time schedule was:

Actual

Concept development	11/93 - 1/94
Financial negotiations (capitalized maintenance costs, subsidies, extra investments, extra support)	2/94 - 10/94

Proposed

Integration in IEA Task 20-work	
Design of final project	3 months
Construction of the project	6 months
Monitoring period	15 months

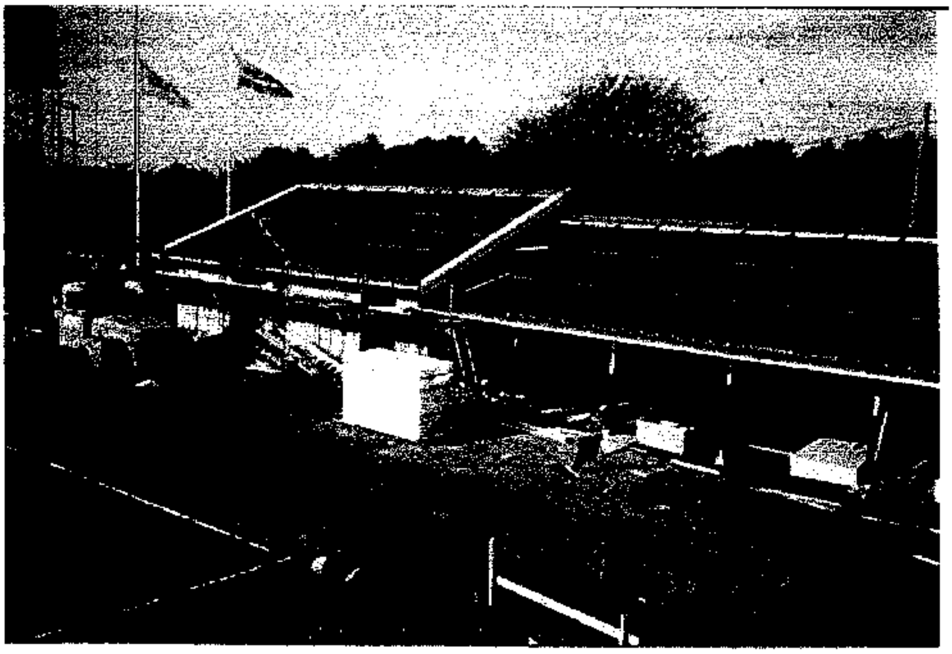
Design Process

Installation of a new central domestic hot water system, only for the reason of introducing a central solar domestic hot water system was not cost-effective.

There were only a few technical reasons to install glazed balconies (i.e., thermal bridges of the balcony slabs). Window frames and concrete were of good quality. Glazed balconies in this project could only be cost-effective if decisions were made on changing a block of apartments into special housing for the elderly.

At this point, no proposals could be created in which solar renovation could enhance the other renovation or maintenance needs.

Onsala



Introduction In order to improve the opportunities for applying solar collectors to existing multi-family buildings with flat roofs, a new prefabricated roof module with an integrated solar collector has been developed. The roof module is to be mounted directly on traditional roof trusses and so is also suitable for applying to new buildings. The first roof modules were applied in a new building project, which is described below.

Initiator Ivar Franzén and Jan-Olof Dalenbäck

Project manager Ivar Franzén and Lars Tirén, EKSTA Bostads AB

Participants Liljewall Arkitekter AB (site plan, buildings)
- Byggadministratör Peter Sörenson AB (administration)
- Andersson & Hultmark Projektering AB (heating plant including solar system design)
- Frank Andersson (heat distribution and floor heating design)
- PEAB Entreprenad Väst AB (main building contractor), A-Hus AB (sub-contractor roof trusses and roof modules), Johanson & Gunvert (sub-contractor heating plant and heat distribution)
- Chalmers University of Technology (solar system design, monitoring, evaluation)

Financing Ordinary building loans and governmental investment subsidy (35%) for the solar system

Building owner EKSTA Bostads AB (municipal housing company), phone: +46-30014060
fax: +46 30 077 708

Contact person Jan-Olof Dalenbäck
Building Services Engineering
Chalmers University of Technology
Phone: +46 31 772 1153, fax: +46 31 772 1152, e-mail: jod@vsect.chalmers.se

Building type New small residential building area

Location Onsala, a village situated 25 km south of Göteborg

Climatic data Latitude: 57°, Elevation: Close to sea level
Heating degree days: 3,800. (18/18°C)
Heating season: Sept. 15 to May 15
Av. annual outdoor temperature + 8 °C
Av. annual sunshine hours: approx. 1,700
Av. annual solar rad. (hor.): 940 kWh/m^2
For more detailed climate description see Annex A.4

Basic data 36 apartments in 9 blocks with approximately 2,500 m^2 heated floor area. Central heating plant with 220 m^2 of roof-integrated solar collectors, a 20 m^3 storage tank and 2x85 kW Pulsonex high efficiency oil burners.

Energy demand Well insulated buildings. Total energy demand was expected to be less than 100 kWh/m^2 occupied floor area per year.

Renovation reasons Not applicable here as it is a new building.

Why solar EKSTA Bostads AB had already used a combination of wood (70%), solar (20%) and oil or electricity (10%) in all new building areas for several years.

Major goals A special goal in this case was to demonstrate a new pre-fabricated roof module that could be applied to existing roofs, as well as new, multifamily buildings. Other goals included increasing building industry involvement (improved implementation) and investment cost reduction (at least 20%) compared to previous roof-integrated solar collectors on multifamily houses.

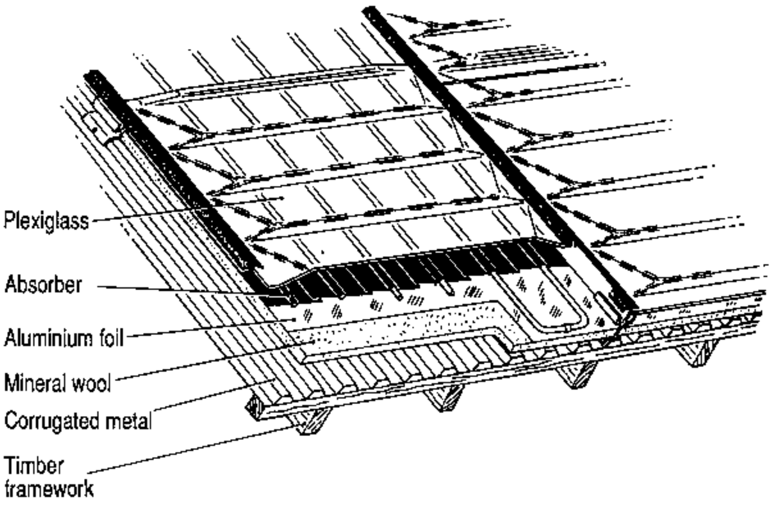
Proposed design The building area was designed with roof-integrated collectors before it became a demonstration project. The only redesign was the application of the new roof module instead of the traditional wooden roof.

The buildings were site-built out of wood, well insulated, heated by hydronic water based floor heating, and have mechanical ventilation. The buildings were heated and supplied with domestic hot water from a central heating plant via pipes in the ground. The solar system was designed to cover approximately 30% of the total energy demand for space heating and domestic hot water (i.e. to give net energy savings on the order of 30 kWh/m^2 occupied floor area per year).

A newly developed prefabricated roof module with an integrated collector was applied to the south roof of the heating plant and an adjacent carport. Together, the total roof areas were 220 m^2 (200 m^2 aperture area). In order to increase the available roof area, both the heating plant and the carport were designed with an asymmetric roof (longer slope to south).

This new design was superior to the previous type of roof-integrated collectors (i.e. TeknoTerm IT), in several aspects. First, marketing and manufacturing was transferred to a building contractor who could build the roof as well as the building. Second, the roof module was pre-fabricated using traditional building materials to a large extent which, in turn, resulted in better quality as well as lower costs.

TeknoTerm IT is designed for application on typical Swedish multifamily buildings and it eliminates the necessity of making any changes to the building or the roof construction. It simply replaces the outer roof cover, i.e., normally the roof tiles.

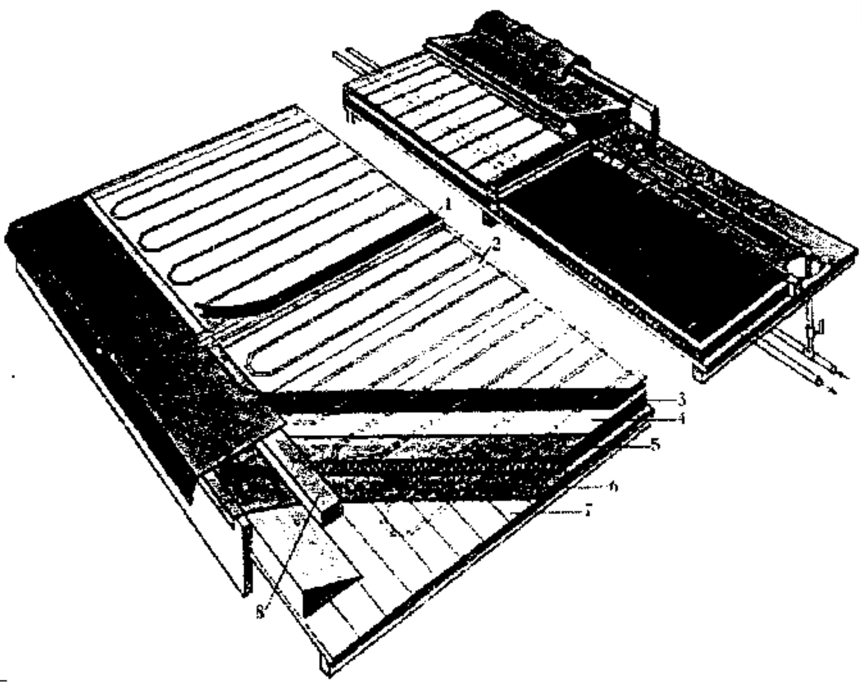


Principle design of the existing site-built roof-integrated collector - TeknoTerm IT

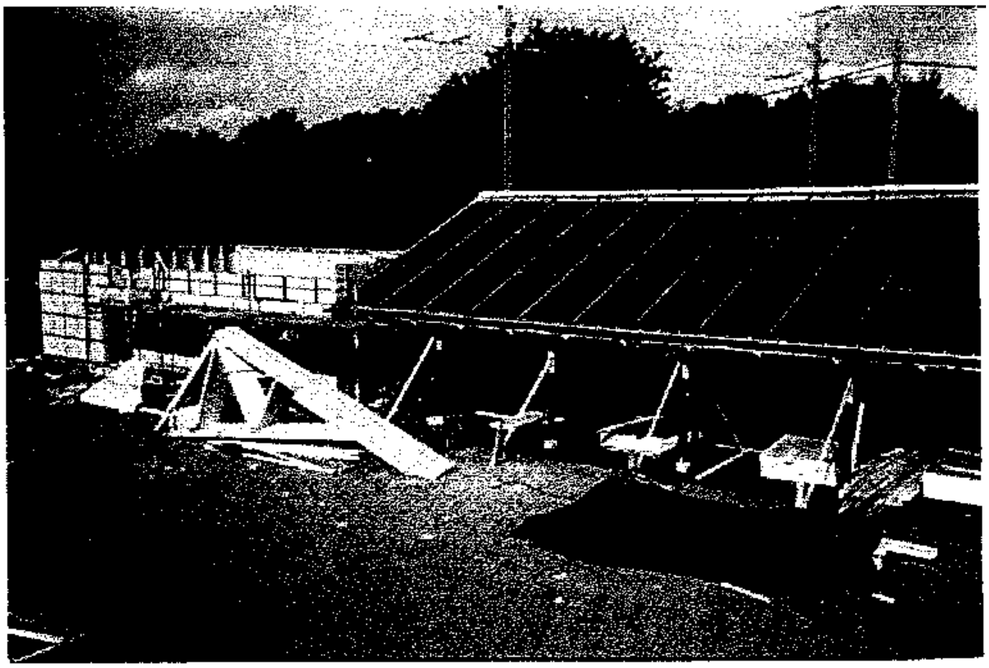
TeknoTerm IT is mounted on the roofing felt on site in sections of 1 m. The steps are 1) aluminium ribbons are mounted at 1 m intervals. 2) insulation and absorber (prefabricated) are placed between the ribbons. 3) the transparent covers (lm x lm, corrugated acrylic plates) are mounted between two rubber strips mounted on the aluminium ribbons. 4) the absorber is soldered to connecting pipes on the roof ridge. 5) top, sides and bottom of the collector roof are covered with ordinary cover plates of metal.

The building company Derome AB has now developed this application into a new roof module collector (i.e. a roof module with an integrated solar collector). See Figures below. The design is based on a common prefabricated roof module supplemented by the basic components in a solar collector (i.e. insulation, absorber and a transparent cover). The roof module is 2,400 mm wide and is designed to be mounted directly on the roof trusses (c/c 1,200 mm). The additional work on site includes joining up connecting pipes and cover plates only.

The development was carried out in co-operation with TeknoTerm and the collector part is, in principle, based on TeknoTerm IT. However, the new collector contains less aluminium and the corrugated acrylic cover was been replaced by hardened glass. Another major difference from the previous design is that the absorber is equipped with header pipes, i.e. there are only two pipe connections per module (2.4 m roof length).



Roof Module from A-Hus AB *(Derome* AB). *1. EPDM sealing, 2. Hardened low iron glass, 3. TeknoTerm Sunstrip absorber, 4. Aluminium foil, 5. High temperature thermal insulation, 6. Roofing felt, 7. Wooden roof module, and 8. Wooden frame-work*



Mounting of roof trusses and roof module collectors on heating plant and carport in the Onsala project

The new roof module collector was tested at the Swedish National testing facility in 1994 (test results No. 94E20539). The size of the tested collector module was on the order of 10 m^2. The roof module collector is normally mounted on roofs with an area of not less than 50 m^2, which results in a slightly improved performance (reduced edge losses).

The efficiency of the new roof module collector can be expressed as:

$$\eta = \eta_0 - U_0/G_T (T_f - T_a) - U_1/G_T (T_f - T_a)^2$$

where

G_T = Global solar radiation on collector (800 W/m^2);
η_0
U_0 = 3.04 W/m^2.K;
U_1 = 0.0203 W/m^2.K^2;
T_f = Average fluid temperature;
T_a = Ambient temperature

The thermal efficiency of the new roof module collector is characterised by a slightly higher zero loss efficiency compared to TeknoTerm IT since the transmittance of high quality solar glass (low iron content) is higher than for plastic (acrylic). The thermal losses are comparable to most flat plate collectors, although the amount of insulation is moderate.

Costs

The following costs are based on real contracts (Nov. 95).

Solar heating system	**SEK**	**SEK/m²**	**ECU/m²**
Roof module collectors	1) 185,300	838	-, 100
Connecting pipes	2) 47,000	213	— 24
Tank 20 m3	3) 60,000		
Heating plant, equipment	98,500		
Sub-total	390,800	1,768	— 210
VAT (25%)	97,700		
TOTAL 1	488,500	2,210	— 260
Subsidy (35%)	-170,975		
TOTAL 2	317,525	1,437	— 170

1) Extra cost, i.e. roof modules, 280,300 - roof with tiles, 95,000.
2) Total tank cost 120,000, replaces part of domestic hot water system, will be used in connection with a future wood pellet boiler.
3) Total heating plant cost, 395,000, the "solar cost" is estimated to be 25% of the amount.

Evaluation

The evaluation will focus on: 1) implementation, 2) investment cost reductions compared to earlier similar designs, and 3) thermal performance, in order to enable a successful full-scale project. The thermal performance of the collector roof will be documented according to a new test procedure proposed as CEN-standard.

Time schedule

Building and system design: Spring 1994 - Autumn 1994
Building construction: August 1995 - May 1996
Roof module installation: August 1995
Monitoring and Evaluation: Spring and Summer 1996

Result

The installation of the roof modules was less time-consuming than expected. Previous similar projects (i.e. with similar roof integrated collectors) have shown extra costs (i.e. difference between roof with and without collectors) between 1,200 and 1,500 SEK/m^2 depending on size. The extra cost here is 840 SEK/m^2 and the new development shows a cost reduction of about 40% in this first small pilot project.

The new module has 5-10% higher efficiency than the previously used collector type (TeknoTerm IT). The expected thermal output of the system is around 300 kWh/a/m^2 collector area as the solar system is designed for a rather large solar fraction. The thermal output of a system designed to cover about 40% of the heating requirements for only domestic hot water (e.g. in a renovation project) is expected to be around 400 kWh/a/m^2.

Similar projects Several, for example, see Särö and Hammarkullen in Subtask A.

Rannebergen

Initiator Dick Eriksson and Lars Almén, Göteborg Stads Bostads AB
Christer Nordström, Christer Nordström Arkitektkontor A

Project manager -

Participants Dick Eriksson, Göteborg Stads Bostads AB
Christer Nordström, Christer Nordström Arkitektkontor AB
J-O Dalenbäck, Chalmers University of Technology

Financing Building owner + about 50 % investment subsidy (EU and/or Boverket/NUTEK) for the "solar renovation"

Building owner Göteborg Stads Bostads AB (municipal housing company), Göteborg

Contact person Christer Nordström, Christer Nordström Arkitektkontor AB
Åsstigen 14, S-436 45 ASKIM, phone: +46 31 282 864, fax: +46 31 681 088

Building type Typical (concrete element) multifamily buildings from the 70's

Location Rannebergen, situated 20 km north of Göteborg

Climatic data

Latitude: 58°, Elevation:	approx. 200 m
Heating degree days (18 °C):	approx. 3,840
Heating season:	Sept. 15 to May 15
Average annual outdoor temperature:	+ 8 °C
Average annual sunshine hours:	approx. 1,700 h
Av. annual solar rad. (hor.):	940 kWh/m^2

For detailed climate description see Annex A.4

Basic data General: About 1,600 apartments in total. Solar renovation comprises 188 apartments (approximately 11,000 m^2 heated floor area) in one large building with nine staircases. Energy: District heating (radiators). Mechanical exhaust ventilation (fresh air slots in window frames). Individual electricity monitoring.

Energy demand Total net energy demand for space heating and domestic hot water was estimated to be respectively 200 kWh/m^2 and 50 kWh/m^2 occupied floor area per year. Household and operational electricity is estimated to be approx. 50 kWh/m^2 occupied floor area per year.

Renovation reasons The whole building needed to be refurbished and made more attractive; Rain water penetration between concrete elements; poor thermal comfort (cold bridges); high heating energy demand.

Why solar General interest in renewable energy. Possible to change the character of the whole building area in order to make it more attractive. Good experiences from earlier projects, i.e. the Solar House in Järnbrott (reported in subtask A).

Major goals The major aims were to make the building area more attractive, solve the problems with the facade elements, improve thermal comfort, social and ecological standards, and reduce the heating energy requirements.

Proposed design Solar renovation:

1) Solar heated air, from approximately 600 m^2 roof-mounted air collectors, circulated in approx. 2,000 m^2 prefabricated insulated facade elements (double air channels) mounted on parts of the north facade in order to reduce air leakage from the building and reduce thermal bridges (possibly combined with heat recovery from the exhaust ventilation).
2) Simple solar walls mounted on parts of the south facade in order to avoid rain water penetration and reduce thermal bridges.
3) Solar heated air from Solarwall® collectors or glazed transparent collectors mounted on the south wall of the staircases for preheating of ventilation air.

Traditional renovation: Refurbished apartments. Concrete facade element renovation.

The thermal savings in all (solar + partly traditional) were estimated to be 50%.

Costs Solar renovation: Approximately 9 million SEK, or 800 SEK/m^2 occupied floor area (95 ECU/m^2).

Evaluation The evaluation will be focused on: 1) architecture, 2) implementation, 3) thermal comfort, 4) thermal performance and 5) social and ecological aspects.

Time schedule

Building and system design:	Autumn 96 - Spring 97 (Preliminary)
Construction:	Summer - Winter 1997 (Preliminary)
Evaluation:	Spring 98 - Spring 99 (Preliminary)

Similar projects For example, see Solar House Järnbrott, S, reported in Subtask A.

Initiator J-O. Dalenbäck, Chalmers University of Technology

Project manager -

Participants G. Johansson, Bostads AB Poseidon
J-O. Dalenbäck, Chalmers University of Technology
K. Jonasson, EFEM (Architects). A. Bernestål, Andersson & Hultmark Projektering AB (Engineering consultants)

Financing Building owner + about 50 % investment subsidy (NUTEK and/or Boverket) for the "solar renovation"

Building owner Bostads AB Poseidon (municipal housing company), Goteborg

Contact person J-O Dalenbäck, Building Services Engineering
Chalmers University of Technology, S-41296 Göteborg
Phone +46 31 772 1153, fax +46 31 772 1152

Building type Typical (concrete element) multifamily buildings from the 70's

Location Gårdsten, situated 20 km north of Göteborg

Climatic data

Latitude: 58^0, Elevation:	approximately 200 m
Heating degree days (18 °C):	approximately 3,840
Heating season:	Sept. 15 to May 15
Average annual outdoor temperature:	+ 8 °C
Average annual sunshine hours:	approximately 1,700
Average annual solar rad. (hor.):	940 kWh/m^2

For detailed climate description see Annex A.4

Basic data General: About 1,000 apartments in total. Solar renovation comprises 60 apartments (approx. 5,000 m^2 heated floor area) in two buildings. Energy: District heating (radiators). Mechanical supply- and exhaust ventilation, where the supply fans have been shut off. No individual electricity metering.

Energy demand Total net energy demand for space heating and domestic hot water was estimated to be respectively approximately 200 kWh/m^2 and 50 kWh/m^2 occupied floor area per year. Household and operational electricity was expected to be approximately 50 kWh/m^2 occupied floor area per year.

Renovation reasons The whole building needed to be refurbished and made more attractive. Flat roofs needed to be renovated/rebuilt to inclined roofs. High heating energy demand.

Why solar General interest in renewable energy. Possible to change the character of the whole building area in order to make it more attractive. Good experiences from earlier projects, i.e. Hammarkullen.

Major goals The major aims were to make the building area more attractive, to solve the problems with the roofs, and to reduce the heating energy requirements.

Proposed design Solar renovation: Roof modules with integrated collectors (approximately 200 m^2) on the south-facing roof of the high rise building for preheating of domestic hot water.

Traditional renovation: New inclined roofs, using prefabricated roof trusses and modules. Heat recovery from ventilation air.

The thermal energy savings by using roof module collectors for preheating domestic hot water was estimated to be 20 kWh/m^2 occupied floor area per year.

The traditional renovation was estimated to reduce the net energy demand for space heating by 40 kWh/m^2 occupied floor area.

Costs Solar renovation: Estimated at approximately 500,000 SEK, or 100 SEK/m^2 occupied floor area (12 ECU/m^2).

Evaluation The evaluation will focus on 1) architecture, 2) implementation and 3) thermal performance.

Time schedule

Time schedule	Building and system design:	Autumn 96 - Spring 97 (Preliminary)
	Construction:	Summer - Winter 1997 (Preliminary)
	Evaluation:	Spring 98 - Spring 99 (Preliminary)

Similar projects See Hammarkullen, S, reported in Subtask A for an example

Thomas Stone High School

Initiator Charles County Board of Education

Project manager Mr. Ed Scott
Charles County Board of Education

Participants State of Maryland Interagency Committee on School Construction
Charles County Board of Education
Samaha Associates, Architect
Johnson Engineering, Engineers
U.S. Department of Energy, Science Applications International Corporation (SAIC), National Renewable Energy Laboratory (NREL), Lawrence Berkeley National Laboratory (LBNL)

Financing State of Maryland - 65% of 15,000 m^2 (160,830 ft^2) renovation and maximum 5,576m^2 (60,000 ft^2) addition
Charles County - remainder

Building owner Charles County Board of Education

Contact person Robert T. Lorand
Science Applications International Corporation (SAIC)
1710 Goodridge Dr. MS T2-2-5
McLean, Virginia, USA
Phone: (703) 821-4439
Fax: (703) 356-4056

Building type High School

Location USA, Waldorf, Maryland. Small village, school on major highway about one kilometer from center of village.

Climatic data

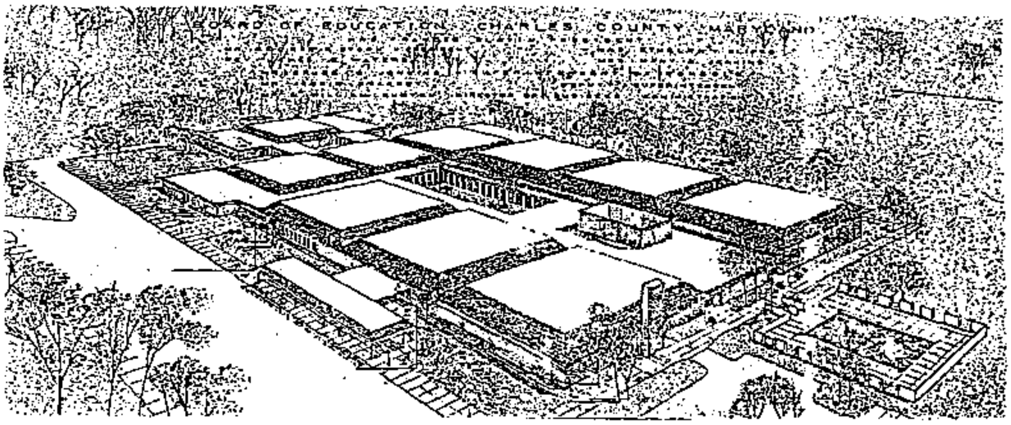
Latitude: 38°40'
Heating degree days: 2347
Length of heating season: October - May

Outdoor temperatures in °C are shown in the Table below

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Minimum	-18.9	-13.9	-8.3	-0.6	4.4	8.9	12.8	9.4	7.8	-5.0	-8.3	-6.7	-18.9
Maximum	16.1	16.7	24.4	30.0	33.6	34.4	32.8	36.1	33.3	29.4	24.4	15.0	36.1
Mean	-0.7	0.6	6.3	12.8	17.5	21.1	24.4	23.6	20.7	13.8	8.1	2.7	12.6

Outdoor temperatures

Basic data Existing floor area: 15,000 m². One floor above grade, with an underground classroom area under a small portion of the building. Masonry construction, built up flat roof with shingled sloped edges. Single-glazed windows. Open courtyard near center of building. Front of building (long side) faces northwest. Back side has no windows. Swimming pool located west of building. Flat roof area is clear except for cooling tower at one end. There are no trees, adjacent buildings or other sources of external shading. Twenty temporary classrooms located south of the building are to be removed as a part of the renovation. The school population is 1,250.



Thomas Stone High School - existing building

Energy demand Includes energy demand for 1,862 m² of temporary classrooms.

Period	Units	Electricity	Oil	Propane	Total
July 1, '89 Jun 30, '90	kWh MBtu kWh/m² Btu/SF	2,609,320 8,903 155 49,234	1,715,123 5,852 102 32,362	8,792 30 0.5 166	4,333,235 14,785 258 81,762
July 1, '90 Jun 30, '91	kWh MBtu kWh/m² Btu/SF	2,047,479 6,986 121 38,633	1,182,884 4,036 70 22,319	9,965 34 0.6 188	3,240,328 11,056 192 61,140
July 1, '91 Jun 30, '92	kWh MBtu kWh/m² Btu/SF	2,063,013 7,039 122 38,926	935,522 3,192 55 17,652	8,499 29 0.5 160	3,007,034 10,260 178 56,738
July 1, '92 Jun 30, '93	kWh MBtu kWh/m² Btu/SF	2,367,819 8,079 140 44,677	885,991 3,023 53 16,717	16,706 57 1 315	3,270,516 11,159 194 61,709

Monitored energy demands

Renovation reasons	Need for additional classroom space and upgrade to conform to existing codes (handicap accessibility, fire ratings, etc.). The addition is needed to increase school capacity to 1,600 students, and to provide new science laboratory facilities.
Why solar	To reduce utility bills and to enhance utilization of daylight.
Major goals	Develop an "exemplary" building that creates an excellent learning environment with low energy costs and an enhanced indoor environment.

Proposed design

Options considered included:

- Unglazed transpired air collectors for ventilation air preheat
- Increased daylighting using roof monitors and skylights
- Photovoltaic panels
- Solar pool heating
- Solar water heating
- High efficiency chillers/boilers
- Conversion to Variable Air Volume (VAV) ventilation system
- Variable speed pumps
- New energy management and control system (ems)
- Efficient lamps and fixtures.

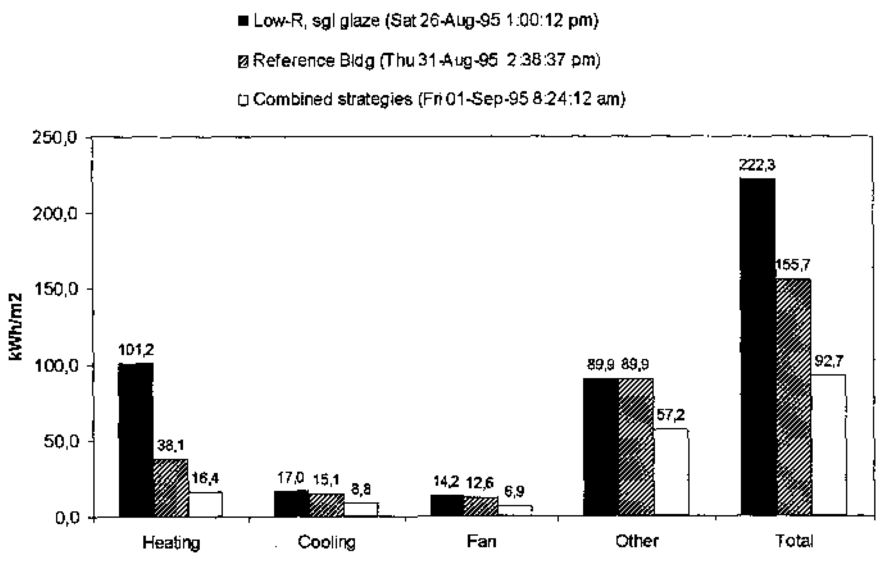
Options selected included the high efficiency chillers and boilers, VAV system, variable speed pumps, EMCS, and efficient lamps and fixtures. Some roof monitors were also incorporated. However, they were not tied into an automated dimming system for the electric lights so no energy benefits are anticipated. The final design did not incorporate enough of the solar and energy saving features to meet the goal of the Department of Energy's Exemplary Buildings Program. The principal reason cited for not including these features was lack of funding. Instead, major items such as a new auxiliary gymnasium and upgrades to equipment and facilities were decided upon.

Similar projects	One other school of identical design exists in the State of Maryland. Effective design concepts can be easily applied to other school construction projects in the state and the country.
Costs	The accepted bid, including selected design alternates, was 12.5 million ECU ($15.47 million), which is about 1.7 million ECU ($2.1 million) above the base budget.
Time schedule	Schematics completed - September, 1995 Construction Documents - June 1996 State of Maryland Approval - July, 1996 Contract Award - August, 1996 Construction Complete - February 1999 Monitoring - None planned Case Study - None planned

Design Process

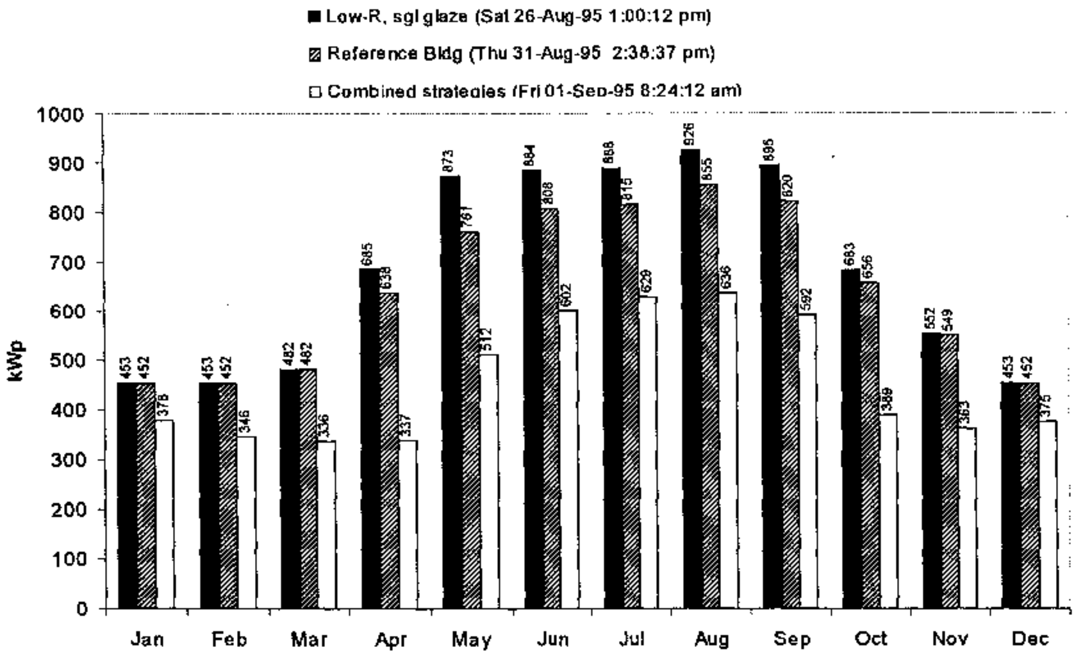
The initial plans for the school (1994) called for a major renovation and a 2,328 m^2 addition. SAIC became involved with the design at this point, based on discussions between the Maryland Interagency Committee on School Construction and the U.S. Department of Energy. There was considerable interest on the part of the Charles County Board of Education officials and the school officials. However, no additional funding had been provided to the architect/engineers to look at solar measures. Initial review of the school layout and energy usage indicated the greatest opportunity in the area of reducing electricity consumption rather than heating energy (fuel oil). This was due to the relatively high price of electricity as compared to fuel oil. In 1995, the Charles County Board of Education decided that a larger addition would be worthwhile, to accommodate 1600 students. This would postpone the need for a new high school by several years. This significant change required a major re-work of the basic layout (floor plan). SAIC prepared analyses of a number of design options using the Energy-10 software. The key solar features included solar ventilation pre-heating and daylighting (side lighting and top lighting using roof apertures). Energy efficiency features analyzed included upgrading windows from single glazed to double-glazed low-e, adding more insulation to the walls and roof, replacing the existing chillers and boilers with more efficient units, and upgrading the building energy management and control system (EMCS).

The preliminary analyses using the Energy-10 energy analysis/design software indicated overall savings of as much as 40% relative to a conventional renovation/addition (reference case), if all the energy efficiency measures and solar measures were implemented. This is illustrated in Figure 2, which compares three different designs: 1) Low R, single glazed, which corresponds to a building of the same size as the new, enlarged building, but with the same construction characteristics assumed for the existing building), 2) Reference Bldg, which corresponds to a renovation/addition done in a conventional fashion, with standard energy efficiency upgrades, and 3) Combined strategies, which corresponds to a renovation/addition with the solar features and more aggressive energy efficiency strategies.



Annual energy use comparison

Significant reductions in building peak electric demand (maximum power requirements) were projected in addition to the energy savings (see Figure 3). This is of particular significance due to the cost savings associated with reduced demand. The daylighting was expected to reduce the need for electric lighting up to 50%, saving about 15 kWh/m^2 occupied floor area annually per classroom. More detailed analyzes conducted by National Renewable Energy Laboratory (NREL) using the DOE-2 model corroborated this daylighting potential.



Monthly peak electric demand comparison

Specifications for these measures (high-performance skylights, daylighting controls, unglazed transpired collectors) were provided to the architect/engineer. However, they were not incorporated in the design due to concerns about total project costs, rather than energy operating costs. The budget was estimated to be about 10%-20% too low for renovating a building of this complexity. In addition, since no additional funding had been provided to the architect for design work related to the solar features, he did not have the necessary incentive to deal with the new/advanced features. As a result the final design, while having some worthwhile energy efficiency elements, will not be implemented as a solar renovation project.

CONCLUSIONS

Design Review Process within Task 20

The demonstration projects were based on ongoing or planned building renovation projects in Belgium, Denmark, Germany, the Netherlands, Sweden, Switzerland and the United States. Each of the IEA SHC Task 20 participants proposed projects to be included in the Task 20 activities, and in most cases, the national IEA Task 20 participants were involved in the design and development of the solar renovation project either acting as consultants or advisers to the clients. The projects were selected based on their suitability as national solar renovation projects for this Task.

Several designs were discussed and recommendations made. The new designs were developed and proposed to the design teams of the different demonstration projects. As the IEA SHC Task 20 participants as a group served in an advisory capacity only, and because of intentions or wishes of other members of the individual design teams (clients, architects, consultants, local authorities, etc.), it was in some cases somewhat complicated to influence the implementation of the most suitable solar designs developed at the IEA SHC Task 20 experts design reviews. However, a number of suggestions by the group were investigated and several of these suggestions were implemented in the demonstration projects.

Project Findings

From the different solar renovation demonstration projects, it is possible to derive a number of conclusions on the reasons for renovation, energy use, thermal and visual comfort, and economic aspects.

Reasons for renovation

Apart from technical reasons, such as energy, or comfort related problems or building physical problems, such as building degradation, more general reasons also influenced the design of the projects. Such reasons were: political decisions, special requests from building owners, projects aiming at investigating/examining specific non-solar technical solutions, marketing of new solar based renovation techniques, site specifics.

Several technical solutions were used in the different renovation projects. The most significant reasons for using each of these techniques are listed below.

Solar collectors

- Degradation of roof covering material
- Converting a flat roof into an inclined roof
- High energy demand for domestic hot water
- Maintenance of existing domestic hot water system was too expensive
- Need to replace existing open instantaneous boilers (geyser) because of too low capacity and to improve the indoor air quality (bad air quality from cooking)

Glazed balconies

- High energy demand for space heating
- Degradation of facades and reduction/elimination of thermal bridges and moisture damages
- Extend living area even during the heating season
- Added value to the apartments, make them more attractive to the rental market
- Noise protection

TI walls and second skin facades

- Existing facades need to be renovated (moisture and/or mould problems)
- High heat loss through the facade
- Thermal discomfort from cold interior surface temperatures of external walls
- Reduce maintenance costs
- Architecturally unappealing facades

Daylighting elements

- Lack of daylight due to shading from neighbouring buildings, trees, etc.
- Very low daylight contribution from deteriorated existing windows
- High energy use for lighting
- Improve indoor visual comfort while maintaining or improving thermal comfort

Energy savings

Significant reductions (more than 75%) in the energy use for space heating, ventilation and domestic hot water were expected to be, or have been achieved in most of the demonstration projects. In addition, reductions in electricity use for lighting using daylighting (up to 50%), were expected in some of the projects. The net energy demands for space heating (including ventilation), domestic hot water and lighting per square metre of occupied area for the demonstration projects are shown in Figures 1-4 on the following pages. The net energy demand as defined in this Task, is defined on page 9.

The majority of the solar renovation projects combined solar and conventional renovation measures, therefore, the energy savings resulted from solar and non-solar renovation applications. The non-solar renovations included insulating north facing walls with opaque insulation and replacing existing, but very old, heating and ventilation systems with more efficient systems. For most of the projects, energy saving measures other than solar-based measures (conventional renovation) make up a considerable portion of the savings. However, a significant percentage of the energy savings were expected from the solar renovations.

Solar renovation measures shortened the required heating period by 1 - 2 months in several projects by providing heating energy in late spring and early autumn.

For some of the projects, the net energy demand for the conventional renovation is not included. The reason for this is either that the numbers are not available or that they were neither considered nor estimated by the design teams.

Energy savings in percent

Figure 1 shows the expected percentage reduction in the net energy demand for the demonstration projects using conventional as well as solar renovation measures. For each project, the base energy demand is the net energy demand before renovation. Only savings from the types of energy demand that are investigated in each project are presented in Figure 1. That is, if one project only addresses space heating, only the relative savings for space heating are presented (likewise for projects focussed on either domestic hot water or electricity for lighting). The solar measures that are used in each project are described in Table 1 on page 11.

Figure 1 gives an idea of the possible energy percentage savings for the different types of conventional and solar renovation projects and may serve as an "appetizer" in the project definition phase when defining which solar measures might be attractive in future building renovations. More specific information on the energy savings in the pre-design phase for specific renovation measures are presented on the following pages. For the detailed design phase in future renovation projects, the designers must carry out their own calculations for the selected design.

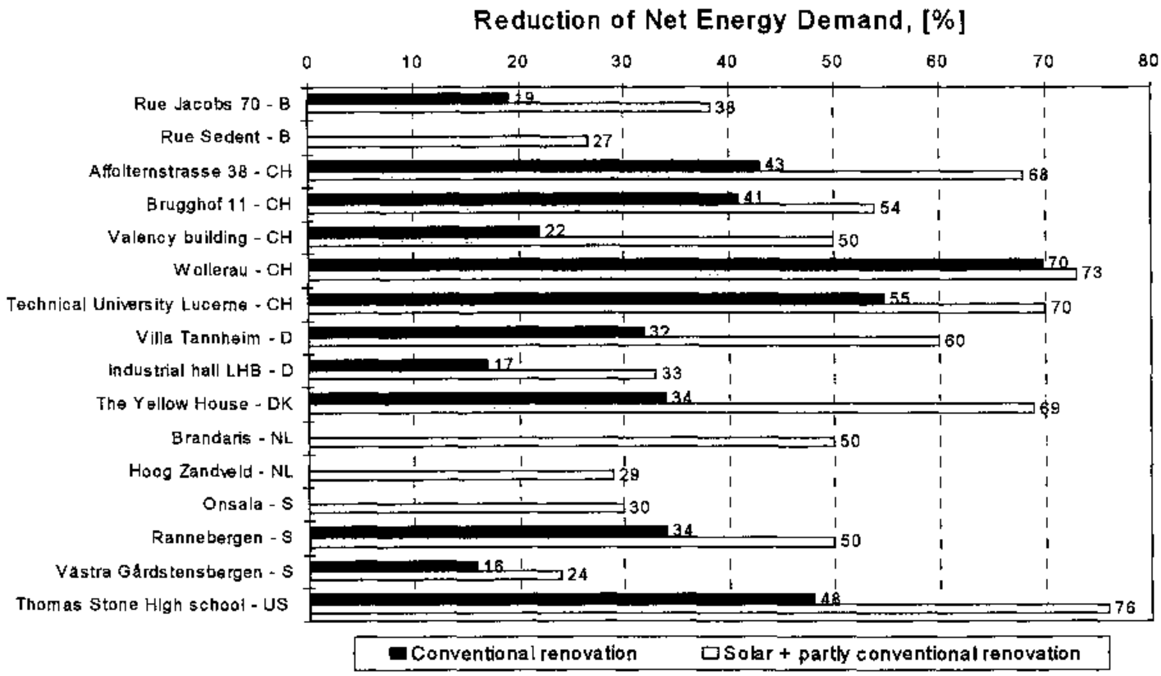


Figure 1. Expected percentage reduction in the net energy demand for the solar renovation projects - Design figures.

As mentioned above, several projects included both conventional and solar renovation measures, therefore, the yellow bar in Figure 1 includes the expected savings from the solar renovation as well as the expected savings from the conventional renovation. However, the effect of the solar renovation in these cases is larger than the difference between the yellow and the red bar as the solar renovation is replacing parts of the conventional renovation (e.g., TI walls replacing exterior insulation on parts of the facade).

The expected relative reduction of the net energy demand for the different solar renovation projects varied between 24% and 76% compared to the situation before the renovation. This illustrates the sensitivity of solar renovation measures to climate, building type and building use. It also underlines the importance of individual modelling during the design phase as solar-based building integrated components are much more dynamic than conventional measures such as conventional opaque insulation.

The expected energy demand reductions were above 35% for most of the solar renovation demonstration projects. It is worth noting, that the conventional renovation features in these projects often accounted for more than 50% of the reduction gained with solar renovation, underscoring the importance of an integrated design strategy.

Net Energy Demand for Space Heating

Most of the projects focussed on means to reduce the space heating energy demand. Furthermore, the thermal envelope typically is where renovation is mostly needed. The results /expected results for the different renovation projects are shown in Figure 2.

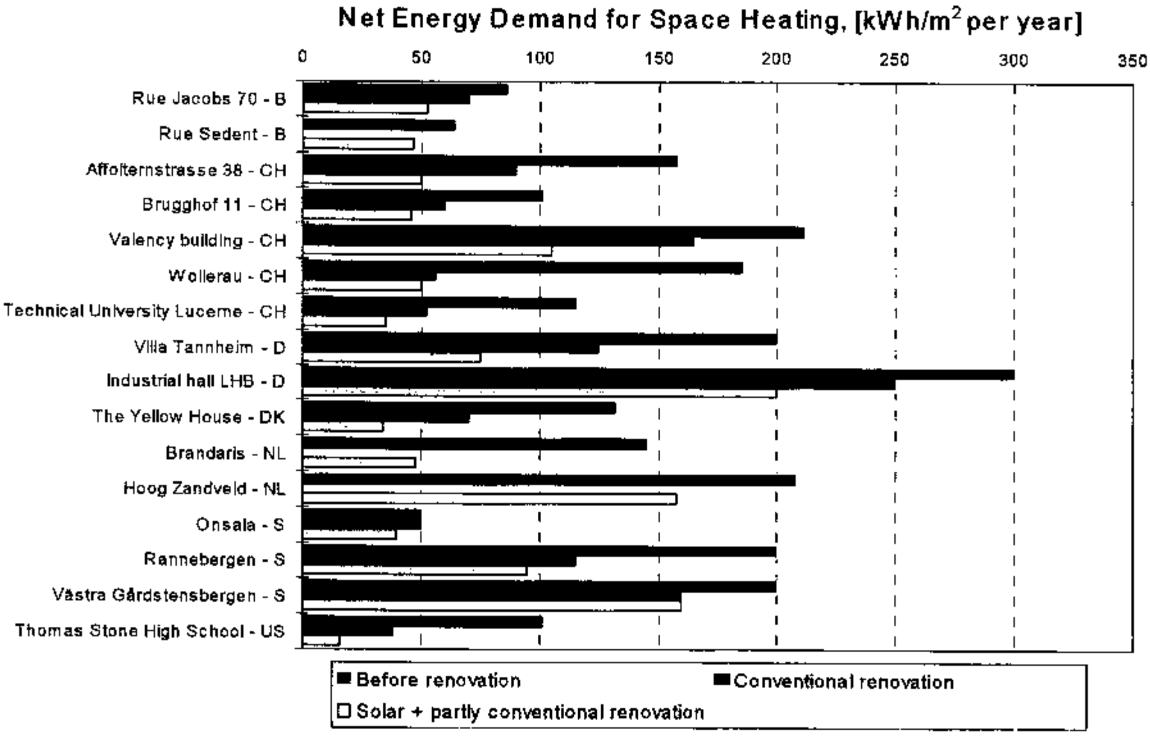


Figure 2. Expected annual net energy demand for space heating, (kWh/m² occupied floor area per year) - Design figures).

Figure 2 shows the annual net energy demand for space heating for those projects which were renovated in order to reduce the space heating demand. For most of these projects, the net energy demand was estimated to be reduced by more than 50% with renovation including solar systems compared to the energy demand before renovation. The following solar techniques were used: glazed balconies, TI-walls, second skin facades, ventilated solar walls, unglazed transpired collectors and roof-integrated solar air collectors. One very visible result was that for most projects, the net energy demands for the solar renovations were significantly lower than for the conventional renovations.

One important result was that the net energy demand for the projects that only used glazed balconies was expected to be reduced by about 25% (25 - 40 kWh/m^2 occupied floor area per year) compared to the situation before renovation. Thus, glazed balconies proved to be a very useful solar renovation measure.

In addition, solar preheating of ventilation air (savings of 15 - 45 kWh/m^2 occupied floor area per year) and the use of transparent insulation on the facades (savings of approximately 50 kWh/m^2 occupied floor area per year) were expected to significantly reduce the net energy demand for space heating.

In general, it is important to consider a country's climate, especially regarding space heating, when comparing different solar renovation proposals. Climate data for each of the countries participating in Subtask C are provided in Annex 4.

Net Energy Demand for Domestic Hot Water

About half of the solar renovation demonstration projects included proposals for reducing the net energy demand for domestic hot water by using roof-integrated solar collectors. The expected net energy demand for domestic hot water (DHW) for the projects is shown in Figure 3.

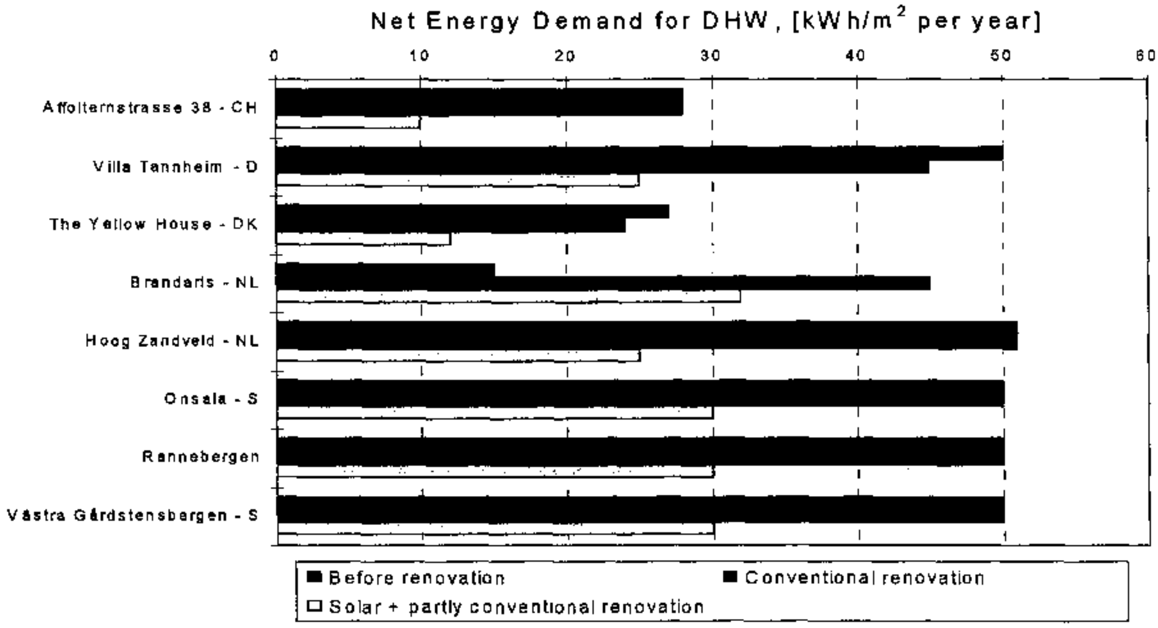


Figure 3. Expected annual net energy demand for domestic hot water, (kWh/m^2 occupied floor area per year) - Design figures.

Figure 3 shows that significant energy savings were expected. The simulated net energy savings on average, were approximately 50% compared to the situation before renovation. All of these projects used roof-integrated solar collectors for preheating domestic hot water. For a number of the projects studies on the possible savings from a conventional renovation were not conducted. For that reason, the net energy demand for domestic hot water before the renovation and for the conventional renovation for these projects is identical.

The project "Brandaris" had a higher energy demand for DHW using conventional and solar renovation measures compared to the situation before the renovation. This was due to the fact that the amount of hot water available before the renovation was very low compared to the normal Dutch requirements. A conventional renovation would increase the DHW consumption to the level of the normal standard and result in a higher net energy demand. By applying solar renovation measures, the net energy demand for DHW would be lower than the estimated value for the conventional renovation because of preheating of DHW with solar collectors, but still higher than before the renovation. Solar collectors would double the amount of hot water available, but only increase the net energy demand by about 50%.

Net Energy Demand for Lighting

Only two projects focussed on means to reduce the electricity demand for lighting by increasing the use of daylight. These are "The Yellow House" in Denmark and "The Thomas Stone High School" in the US. The expected net energy demands are shown in Figure 4:

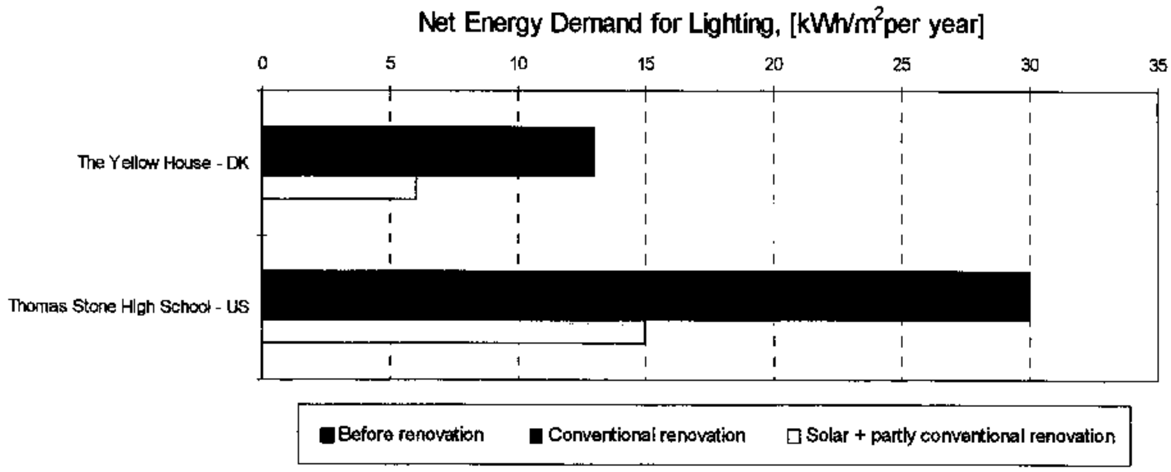


Figure 4. Expected annual net energy demand for lighting, (kWh/m² occupied floor area per year) - Design figures.

Expected reductions in the net energy demand for lighting were 55% (savings of 7 kWh/m² occupied floor area) and 50% (savings of 15 kWh/m² occupied floor area) for these two projects. Note, that the figures only include electricity savings for lighting and not any impacts on the energy requirements for heating or cooling, which could also be affected by daylighting strategies. Energy demand was reduced primarily due to the use of advanced lighting controls, and partly due to the increased amount of useful daylight. Regarding the daylight improvements, their main and most valued contribution was the improved visual comfort conditions, and the potential for improved occupant performance.

Many of the other 14 projects improved the daylight conditions in the buildings, but did not have a reduction in the lighting energy demand as a primary objective (e.g., no automatic lighting controls were installed to reduce/eliminate electric lighting when sufficient daylight is available).

For all of the above described energy demands (space heating, domestic hot water and lighting) the achievement of the expected energy savings are to be documented when the ongoing monitoring is completed. This monitored data will be evaluated and the results will be presented as part of Subtask E "Evaluation of Demonstration Projects."

Thermal and visual comfort

Large improvements in the thermal and visual comfort are expected in the majority of the demonstration projects.

The improved thermal comfort is achieved by avoiding draught from cold surfaces (e.g., uninsulated exterior walls, large single/double glazings), by using TI walls and glazed balconies, and by preheating ventilation air via solar based elements such as glazed balconies, ventilated solar mass walls and unglazed transpired collectors.

The visual comfort is improved by increasing the light level, avoiding glare, and providing a more uniform light distribution to the indoor areas. This is achieved by using TI glazings, increasing the glazing areas using well insulated, low-e, gas filled double or triple glazings, and by using light cores.

The improvement of the thermal and the visual comfort will be evaluated and the results will be presented in Subtask E "Evaluation of Demonstration Projects."

Economics

The expected or actual total costs for the solar renovation demonstration projects are shown in Figure 5. The type of costs are very different from one project to another as some only include design costs and others do not include VAT.

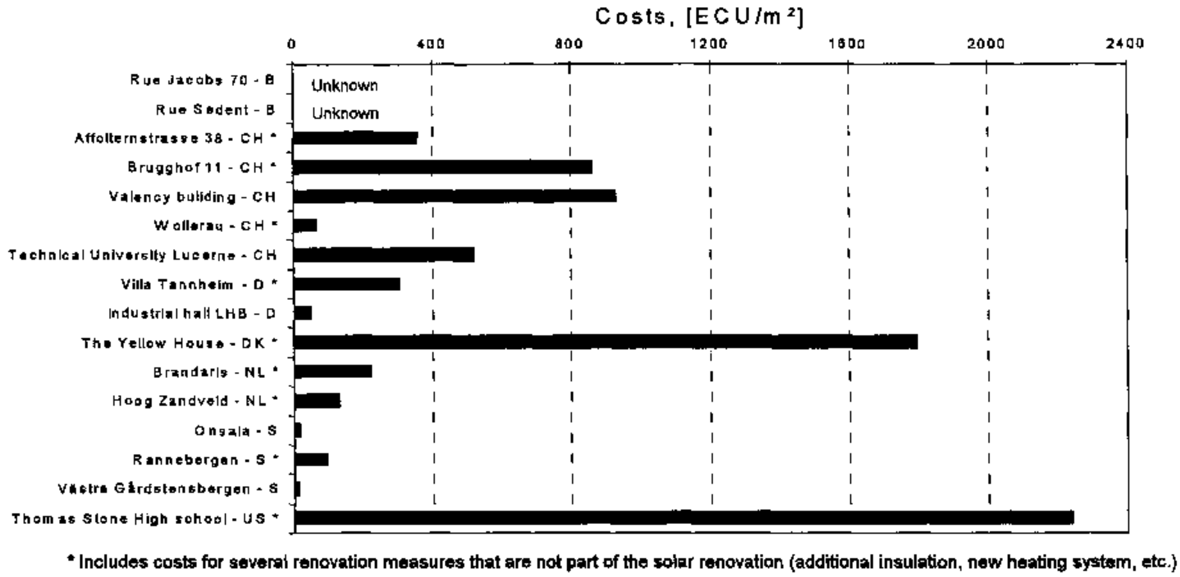


Figure 5. Expected/actual costs for the demonstration projects, [ECU/m^2 occupied floor area].

For the Belgium projects the costs were unknown, as these are only theoretical projects focussing on technical and architectural concepts.

For the different types of solar renovation measures included in the demonstration projects in Subtask C, the range of expected or actual costs per m^2 occupied floor area and per m^2 system area were as shown in Table 2:

Solar Renovation Measures	Costs per m² occupied floor area	Costs per m² system area
	[ECU/m²]	[ECU/m²]
TI walls	50 - 930	210 - 1,160
Second skin facades	~ 520	1,080 - 1,250
Glazed balconies	130 - 220	350 - 550
Roof integrated solar collectors	10 - 670	~ 210
Combinations of different technologies	300 - 3,010	-

Table 2: Expected or actual costs per m^2 occupied floor area and per m^2 system area for the solar renovation measures.

Several of the demonstration projects are expected to be more cost effective than conventional renovation projects as they serve multiple purposes:

- The demonstration projects are typically saving the same amount of energy (or even more)
- Technical problems (e.g. leaky roofs, thermal bridges, etc.) are solved
- Thermal and visual comfort is improved
- In several cases, the living space is extended (glazed balconies)

Some of the projects though, were too expensive to be considered economically beneficial today. However, governmental subsidies to some of the technologies (e.g. solar collectors) could increase the economic benefits for the house owners.

Even though some of the solar techniques used were not cost-effective, successful projects still incorporated them to achieve other benefits: added aesthetic value, noise protection, attractive apartments for the renting market, the projects visualise a concern for sustainability by the building owner.

Therefore, it is important to be aware that these more or less expensive projects can be characterized as examples of future building renovation, showing what is technically possible today and what, with respect to energy savings, may become cost effective tomorrow!

Detailed analyses of the cost-effectiveness of the demonstration projects will be carried out and presented as a part of Subtask E "Evaluation of Demonstration Projects."

Lessons learned

Below are listed the most important lessons learned from the projects' design and construction, based on the experiences of the design teams. The listing also includes valuable recommendations and obstacles encountered.

Energy savings

- Advanced solar renovation concepts require an overall energy conservation concept for the building.
- Building aesthetics are mostly given a higher priority than optimized energy designs when deciding on a building's architectural aspects.
- The interest in solar renovation is great, but the expected effect from solar renovation measures (e.g. energy savings) are often overestimated.
- Energy related aspects again have proven only to be a marginal element in the building renovation decision phase and "the saving of energy" apparently is too week a topic for deciding the overall design of the buildings compared to more traditional elements.

Architecture and Integrated design

- Improving the image of the building area is one of the main design aspects.
- Buildings must be "engineered" as single entities whose systems interact with each other.
- Detailed planning to ensure proper integration of solar features and conventional building elements is important for cost effectiveness, function, and appearance.
- Architects should be involved in renovation of facade systems because of the architectural impact.
- The project using windows with high performance glazing demonstrated that only an integrated approach in the window design may lead to significant energy demand reductions. The glazing type, size of window, frame construction, utilization of solar gains and solar gain control system must be carefully studied as one concept in order to avoid high heat losses in cold and dark periods and to avoid significant overheating in hot and sunny periods.
- Non-energy benefits (such as increased living space, noise reduction, improved visual comfort, added aesthetical value) must be stressed to convince architects of the value of solar renovation.
- Education of architects and their understanding of solar energy is crucial. Most important are demonstration projects to build confidence.

Design methods

- Detailed simulations in the design phase of new and more advanced technologies can give valuable advice on how to improve a building's performance, especially regarding thermal and visual comfort.
- It may be very useful to build models or mock-ups of the most crucial elements.
- Large complex renovation projects often require specialists for design concepts (simulation) and architectural solutions.

Technological developments

- Experiences from previous projects often lead to improvements of the solar systems allowing increased tolerances in the installation of the solar systems.
- The use of several new design solutions and products may cause serious delays as many - unforeseen technical as well as financial problems may arise.
- Knowledge of recent solar technology development is limited among building owners and many practising architects and consultants. Preconceived notions are based on 1980s designs and technologies, and are not necessarily positive.

Construction

- In larger projects, the use of prefabricated elements helps to reduce installation time as craftsmen are then able to install the new solar elements without specific and detailed knowledge of the working principles.
- In smaller projects with complex designs, it is beneficial to select builders who are interested and motivated in innovative projects, and who are familiar with the building techniques used.
- The use of standard dimensions improves building integration and installation time at the building site.
- Information must be provided that makes it easy to incorporate the solar features in the design and construction documents.

Economics

- It is important to propose several different designs and qualify these with comparable key figures and by taking the total costs into consideration so the optimum project design can be defined.
- Because of the major changes in the appearance of the building, it is necessary to provide a selection of architectural solutions to the building owner. For every proposal, the differences in energy gain and construction costs must be evaluated and comparisons of the variants on equivalent energy cost levels must be made.
- The use of standard components reduces component and manufacturing costs.
- New industrialized solar renovation elements (e.g., TI elements based on existing industrial U-shaped glazing) have been found to be cost-effective as well as energy effective.
- The design process must include a thorough investigation of the combined measures, (i.e., additional wall insulation in connection with necessary facade renovation, roof-integrated collectors with necessary roof renovation, etc.) including saved construction costs as it is difficult to get an acceptable pay-back figure based on operational costs only.
- It is often necessary to get additional funding, such as governmental subsidies, to use innovative elements in a project.
- Many sites make use of central district heating networks, that have low energy prices outside the heating seasons. This makes it difficult to find energy saving measures (especially for active solar) that are cost effective from the real estate owners point of view.
- Capital cost remains a major barrier. Even when life-cycle cost figures are used to show the significant benefits of the solar features.
- It can be concluded that the best way to influence a project is either through direct participation in a project (by an expert on solar renovation) or by having a client who is convinced of the benefits of an integrated solar renovation.

Clients and authorities

- Building owners must be committed to better building performance.
- It is important that the client is willing to take part in the responsibility for the project together with the consultants.
- Discussions with the local authorities are often needed to explain the innovative ideas.
- It is beneficial that the architects, engineers and local authorities work closely together from the start of the project.
- Specific information must be given to the tenants to ensure a smooth commissioning.

Summary of lessons learned

The most important lessons learned when implementing solar energy features into building renovation are:

- Some of the solar technologies investigated have made significant steps towards cost-effective applications, such as prefabricated, industrialized solar DHW systems. Equivalent energy costs are expected to be competitive to long-term energy prices in the future. However, because of high investment costs some technologies (like TI) will profit mainly from other kinds of added value. Steps to reduce the costs of these solar components and systems are necessary. And such steps are under investigation within the IEA SHC Task 20 (Subtask F, "Improvements of Solar Renovation Concepts and Systems").

- Solar concepts should be considered as an integrated component of every building renovation energy analysis and as part of the whole buildings' design. An energy study is a main element of the integrated energy design process. By achieving investment savings on conventional building elements, solar components and systems can be implemented within the limited budget of the client.

- It is important that the applied solar concepts in building renovation serve multiple purposes beyond providing energy savings (e.g., TI walls for concrete renovation and improved thermal comfort; glazed balconies for window frame repairs and increased living area during longer periods of the year; roof-integrated solar collectors for roof renovation, etc.). Furthermore, other added benefits should be introduced: added aesthetic value, noise protection, attractive apartments for the renting market, the projects visualise a concern for sustain ability by the building owner.

- The design and construction of solar renovations need advice from educated planners.

- Further education of architects and engineers about the functionality of building-integrated solar energy is a prerequisite for a broad implementation of solar energy systems in building renovation.

- Building-integrated solar designs often include new and special (and sometimes complex) items. Therefore, education and training on construction methods for building-integrated solar measures is required for the craftsmen involved in building renovation.

- More good examples of building-integrated solar energy systems need to be designed, constructed and reported. Such projects will help to build confidence in solar energy for building renovation.

In conclusion, a goal for the future should be to develop efficient, inexpensive, intelligent building-integrated solar systems that are cost effective on a short time basis (3 - 15 years), as the extended lifetime of a building is typically 30 years or more.

ANNEX A.1

Framework for Proposals for Solar Renovation Demonstration Projects

Framework for Proposals for Solar Renovation Demonstration Projects

Objective: To create a structured framework for proposing Solar Renovation Demonstration Projects in order to ensure a uniform way of presenting and reviewing the different solar renovation projects in Subtask C.

By using a structured framework, it will be possible to compare the project proposals from the different participating countries. The contents in the proposals have to be very clear and concise and not very comprehensive. The proposals shall focus on essential key points and key figures.

The framework itself consists only of the listed subjects shown in italics. The remarks to each *subject* are keywords to each of the different subjects, while the comments below is a description of how to fill in the framework.

Comments

It is important to point out, that proposals for projects that might not be built, at this stage are as attractive as projects that are more likely to be built. At least for the work in Task 20, the discussion of different solar renovation *concepts is* as important as the discussion of actual demonstration projects. Furthermore, it is not crucial that the participants in Task 20 take part in the design of the actual proposals. In stead the Task 20 participants might act as contact persons between Subtask C and the national design team.

The contents in the framework shall serve as *a short but informative* description of a project which will be discussed in detail at the following review meetings. Wherever possible, descriptions shall be accompanied by simple and complete drawings (e.g. *schematic site* plans, elevations and sections, etc.). Complete drawings are essential, even if the solar solutions concern only a part of the building: A description and presentation of the whole building and its surroundings, including the main space partitioning of the building, will contribute to a good evaluation and understanding of the solar design and its function in relation with the whole building.

In the phase of review and critique we must focus on the essential parts of the solar designs (i.e. the basic principles of the proposals) and make use of this opportunity to exchange ideas on a group based interaction. Therefore Subtask C participants shall be involved in an early stage of the design phase and at least before detailed drawings are completed. It is important that we avoid wasting our time discussing details that, at least for our work, are less important, such as simple cold bridges, load bearing problems, etc., since the project designers (all of us, or colleagues of ours) are supposed to be aware of such basic problems.

At the review meetings more detailed technical information about the proposals shall be presented. *The level of detail* of this material will depend on the different comments from participants reacting to the proposals. Therefore, if the proposer wants the maximum benefit from the phase of review and critique, the filled in frameworks shall be distributed to the participants well in advance of the next expert meeting.

Projects may be proposed at any time throughout Subtask C, but of course the response from the participants will depend on how late in the progress of Subtask C, the project is proposed. Depending on the relevance of a proposal and in order not to have too many similar project proposals, the participants may decide that a proposal shall not be included in the work carried out in Subtask C.

Regarding the time schedule and the semi-annual expert meetings in Task 20, it might be beneficial if the participants in Subtask C could have smaller review meetings in between the expert meetings. However, for economic reasons such meetings should only take place if the review and critique discussions are not possible via telephone meetings, telefax or e-mail.

In order to gel: the maximum benefit from the reviews, it would be useful to document the process by which different design strategies were evaluated and rejected or selected, even from before the project was presented to Task 20. Each presenter should provide the logic for the steps in the design process and summarize key aspects in the narrative. The associated drawings (as necessary), should also be included.

In describing the design strategies, information on the conventional renovation solution should be presented. This would serve as a benchmark to gauge the level of improvement in the key attributes, as the solar design progressed. Ultimately, we would like to be able to compare the solar renovation of an existing building with a similar conventional renovation. This is important to demonstrate the added benefits of solar renovation.

The framework will also be used for presenting the final proposals after the phase of review and critique. This means, that the proposer shall include the changes resulting from the reviews in a final project proposal. In this way, the final project proposal will also serve as a report of the design process for the proposed project. The report will document the design strategies of the builder and the project designer from before the project was presented to Task 20 as well as the contributions to the final design of the solar renovation demonstration project from the Task 20 participants, which is an agreed-upon Subtask C output.

Procedure for review and critique

A) The proposer shall send out project proposals well in advance of the expert meetings.

B) Any comments to a proposal shall be returned from the participants to the proposer before the expert meeting. In this way, the proposer, if needed, will be able to provide more detailed information to describe the proposed project and give quick answers to the questions raised by to the "reviewers" as well as react on the comments and perhaps redesign the proposal before the expert meeting.

C) Expert meetings at which the essential parts of the proposals will be discussed.

D) After the review and critique at the expert meeting, the proposer can send out a revised proposal and receive reactions from the other participants. In this way, a project might be reviewed several times before the final design is decided.

Project Title:	"NNNNNNNN NN NNNNNNN", SHC Task 20 STC Nxx
Initiator:	
Project manager	
Participants	Profession and role
Financing	Governmental, private, etc.
Building owner	The ownership might be changed as a consequence of the renovation
Contact person	Regarding IEA Task 20 activities.
Building type	Residential - E.g. SF, DU, RW, LR, HR, ORES (as described in Subtask A). Non-residential - E.g. LOFF, SOFF, COLL, SECN, ELEM, DEPT, SHOP, RETL, CLIN, ARPT, LIBR, WARE, INDU, OTHR (as described in Subtask A).
Location	Country as well as location (city-center, suburb, village, countryside)
Climatic data	Latitude, heating degree days (ref. temp. = 18°C), length of heating season, outdoor temperatures (annual or monthly minimum, mean and maximum values), number of sunshine hours during the heating season and the whole year.
Basic data	Building size and shape, building orientation, skyline profile (shadows from other buildings, trees, etc.), basic floor plans including the adjoining buildings, etc. The description should, wherever possible, contain *simple and informative* drawings, figures and diagrams of the building and its surroundings.
Energy demand	To evaluate the efficiency of the solar renovation projects, it is important to know the energy consumption of the buildings before the renovation is carried out. Essential key values are: • The energy consumption for: space heating, cooling, lighting, ventilation, DHW, etc. • Peak loads. • Level of insulation (U-values for the thermal envelope), glazing percentages on the facades, etc. • Details of the constructions and systems, regarding heating, ventilation, cooling and lighting. • Occupancy and schedule of occupancy.
Renovation reasons:	To end degradation (moisture, frost, erosion, use of "wrong" materials), to reduce the energy demand or the peak load (which might also be very promising), to improve the indoor air quality, to a public wish of preserving the building (architecturally, historically), etc.

Why solar Energy, thermal comfort, financing, architecture, individual, political, other.

Major goals Expected energy savings (kWh/m^2 floor area as well as the percentage of the present level), improve thermal and visual comfort (no draught from cold surfaces, no glare), ending degradation (e.g. reduction of the moisture content in the building construction, protection against erosion from the outdoor environment such as rain and wind), payback period, etc.

Proposed design This is the more extensive part of the framework and relates the methods to fulfil the major goals and objectives of the solar renovation projects. In this part, a description of the different technical elements of the proposed solar renovation demonstration projects shall be given: Glazed balconies, roof-integrated solar collectors, solar walls, high performance windows, transparent insulation materials, etc., and hopefully, several of the new and attractive concepts defined in Subtask B. The description should, wherever possible, contain *simple and informative* drawings, figures and diagrams of the most important parts of the project regarding solar energy.

This part of the proposal shall also give a description of the design process, including evaluations of different alternatives and other considerations from the early stage of the project, such as: "Why is a solar based solution chosen instead of extra insulation? Is it cheaper? More cost-effective?, etc. Please note the comments about the design process on page 2.

Similar projects For comparison and references, other projects, that have been built, could be described shortly, using photo's and showing the key figures regarding energy savings, thermal and visual comfort, user reactions, payback period, etc. This comparison could also refer to relevant case studies from Subtask A.

Costs Total costs (e.g. showing the costs for designing and building the traditional parts of the project as well as the costs for developing and building the different innovative parts of the projects). This could also include any extra costs from involving experts from IEA SHC Task 20. The costs should be shown in the national currency as well as in ECU's.

Time schedule If a proposer wants the experts in IEA SHC Task 20 to be able to comment and influence proposals for projects, that are likely to be built, it is very important to know the time schedule of the project, since the experts in Task 20 only meet every six months. Ideally, the time schedule shall be presented in a diagram and include four different phases. Listed in a preferred priority, these are: Design, construction, commissioning and monitoring.

ANNEX A.2

Performance Monitoring Reporting Formats

Objective: To provide a common format for compiling performance information in Subtask C.

Energy Performance Information Requirements:

At a minimum, one-year's worth of energy operating information should be collected. This information should include:

- **Monthly Energy Use by Fuel Type --** Fuel types include gas, oil, propane, coal, wood, steam, hot water, electricity, etc. Energy use should be reported in volumetric units (e.g., cubic metres or litres) for liquid and gaseous fuels and by weight (e.g., kg or metric tonnes) for solid fuels . Volumetric and weight units should be converted into energy units (e.g., kWh/month) consumed at the site. Energy units should be normalized by building floor area (kWh/m^2).

- **Monthly Fuel Use by End-Use --** If possible, the quantities of fuel cited above should be categorized according to heating, cooling, lighting, water heating, ventilation, and other (e.g., cooking) as appropriate.

- **Loads by End-Use --** Fuel use quantities should also be converted to "load" values, the amount of energy required to meet the heat loss, heat gain, illuminance levels, etc. without regard to the efficiency of the energy conversion equipment (Load Value = Fuel Use * Energy Conversion Efficiency). This information would help isolate the specific impacts of the solar renovation and energy efficiency improvements.

- **Monthly Peak Electric Demand --** The hourly rate of electricity use during the hour of the month at which electricity use is at a maximum. This rate would be useful in calculating electricity expenditures where the peak demand, in addition to energy use, factor into the utility bill.

- **Monthly Peak Electric Demand by End-Use --** The hourly rate of electricity use for each of the major end-use loads, during the hour of the month at which electricity use is at a maximum.

- **Monthly Climatic Conditions --** Includes outdoor and indoor climate conditions. For outdoor conditions, information on average insolation, average, maximum and minimum outdoor air temperatures, average humidity levels, and wind speed should be obtained. Degree days (heating and cooling) should also be calculated based on the average temperature data. Average indoor air temperature and humidity in selected spaces should be obtained to reflect the indoor thermal comfort situation. As appropriate, data on illuminance levels in selected areas should be collected for daylighting projects.

- **Solar System Performance --** Performance is measured in terms of "solar fraction," the percent of a given load (e.g., heating, cooling, ventilation, water heating, lighting) that is provided by the solar system. The remainder of the load is met by non-solar high efficiency or conventional energy conversion systems. The effects of solar building envelope measures (e.g., insulation) are captured in the load figures.

Ideally, this information would be obtained prior to the renovation from the existing building to serve as a basis for comparison. In most cases, such information will not be readily available; at best, only monthly fuel use data from utility bills will be available. Therefore, the "before-and-after" comparison can only be made on a monthly, rather than hourly, basis. However, comparisons with respect to simulated performance will be used to get a more in-depth understanding of the energy impacts of the solar renovation. Simulated performance covers information on end-use loads, as well as fuel consumption. The existing building will be modeled, along with the solar renovation building and a comparable (hypothetical) building with a more conventional (non-solar) renovation treatment. The performance data will be useful in fine-tuning the model(s) to enable more detailed evaluations.

The instrumentation specifications, data recording intervals, and data processing equipment will be left to the discretion of each participant. However, basic information on the actual building from as-built drawings or site evaluations will need to be completed. This information will follow the guidelines in Subtasks A and C.

Energy Use by Fuel Type

Project Title:	
Location:	
Country:	

YEAR ___________

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL[1]
Electricity													
kWh													
kWh/m²													
Gas													
m³													
kWh													
kWh/m²													
Oil													
liters													
kWh													
kWh/m²													
Coal													
kg or tonne													
kWh													
kWh/m²													
Steam													
kg or tonne													
kWh													
kWh/m²													
Other ___________													
kWh													
kWh/m²													
TOTAL													
kWh													
kWh/m²													

1 kWh/m² are annual average values. Other values are annual totals.

Fuel Use for ________________(End-Use Type[1])

Project Title:	
Location:	
Country:	

YEAR ______

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL[2]
Electricity													
kWh													
kWh/m²													
Gas													
m³													
kWh													
kWh/m²													
Oil													
liters													
kWh													
kWh/m²													
Coal													
kg or tonne													
kWh													
kWh/m²													
Steam													
kg or tonne													
kWh													
kWh/m²													
Other ______													
kWh													
kWh/m²													
TOTAL													
kWh													
kWh/m²													

1 e.g., heating, cooling, ventilation, lighting, water heating.

2 kWh/m^2 are annual average values. Other values are annual totals.

Fuel Use by End-Use

Project Title:	
Location:	
Country:	

YEAR ______

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Heating													
- electricity													
- gas													
- oil													
- coal													
- steam													
- other													
Cooling													
- electricity													
- gas													
- oil													
- coal													
- steam													
- other													
Ventilation													
- electricity													
Water Heating													
- electricity													
- gas													
- oil													
- coal													
- steam													
- other													
Lighting													
- electricity													
Other ______													
TOTAL													

Loads by End-Use

Project Title:	
Location:	
Country:	
YEAR ____	

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL[1]
Heating													
kWh													
kWh/m²													
Cooling													
kWh													
kWh/m²													
Ventilation													
kWh													
kWh/m²													
Water Heating													
kWh													
kWh/m²													
Lighting													
kWh													
kWh/m²													
Other													
kWh													
kWh/m²													
TOTAL													
kWh													
kWh/m²													

1 kWh/m^2 are annual average values. Other values are annual totals.

Climate Data

Project Title:													
Location:													
Country:													
							YEAR ______						
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**ANNUAL[1]**
OUTDOOR													
Insolation													
- Average Horiz. (kWh/m²)													
- Average on Solar Aperture (kWh/m²)													
Temperature													
- Average (°C)													
- Maximum (°C)													
- Minimum (°C)													
Humidity													
- Average Relative Humidity (%)													
Wind Speed													
- Average (m/s)													
Degree Days Heating (°C)													
Degree Days Cooling (°C)													
INDOOR													
Temperature													
- Average (°C)													
- Maximum (°C)													
- Minimum (°C)													
Humidity													
- Average Relative Humidity (%)													

1 Annual total for Degree Days. Maximum and minimum month for Temperature. Annual Average for Average Temperature and for all other values.

Peak Electric Demand, by End-Use

Project Title:	
Location:	
Country:	

YEAR ____

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Heating												
kW												
kW/m²												
Cooling												
kW												
kW/m²												
Ventilation												
kW												
kW/m²												
Water Heating												
kW												
kW/m²												
Lighting												
kW												
kW/m²												
Other ____												
kW												
kW/m²												
TOTAL ELECTRIC												
kW												
kW/m²												

Solar System Performance

Project Title:	
Location:	
Country:	

YEAR ____

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL[1]
Solar System Type													
System ____													
Solar Fraction													
- Heating													
- Cooling													
- Ventilation													
- Water Heating													
- Lighting													
- Other													
System ____													
Solar Fraction													
- Heating													
- Cooling													
- Ventilation													
- Water Heating													
- Lighting													
- Other													
System ____													
Solar Fraction													
- Heating													
- Cooling													
- Ventilation													
- Water Heating													
- Lighting													
- Other													
TOTAL SOLAR FRACTION													
- Heating													
- Cooling													
- Ventilation													
- Water Heating													
- Lighting													
- Other													

1 Annual Average Solar Fraction

ANNEX A.3

SOLAR RENOVATION PROJECT OCCUPANT/OWNER ATTITUDINAL QUESTIONNAIRE

OBJECTIVE: Evaluate owner and occupant satisfaction with solar renovation project(s).

SURVEY INSTRUCTIONS

- Give the survey to the respondent with Section 1 already completed.
- Use only the questionnaire sections that are related to the solar energy project(s) implemented.
- Sections 3-6 are to be used when there is no pre-construction survey. It is administered after the project is implemented to building occupants or owner/occupants.
- Sections 3A-6A are to be used when there is a pre-construction survey. It is administered both before and after the project is implemented to building occupants or owner/occupants.
- Sections 2 and 7 are to be completed whether or not there is a pre-construction survey. They are to be administered after the project is implemented. Section 2 is to be administered to building occupants, owners, or owner/occupants. Section 7 is to be administered to building occupants or owner/occupants only.

SECTION 1: PROJECT INFORMATION (TO BE COMPLETED BY SURVEYOR)

Building Address: ____________________________

____

____

Date Survey Completed: _______________

Surveyor's Name: _______________

Please circle the appropriate response for each survey question. In some cases, the response you circle requires a description.

1. Respondent Classification (circle all those that apply):

    1 Building Occupant
    2 Building Owner

2. In what type of building was the project(s) implemented?

    1 Residential-Single Family Detached
    2 Residential-Large Apartment Building (more than 4 floors)
    3 Residential-Small Apartment Building (4 floors or less)
    4 Residential-Garden Apartment/Row House
    5 Commercial-Large Office Building (more than 5000 m^2)
    6 Commercial-Small Office Building (5000 m^2 or less)
    7 Commercial-Other (please describe):

    ____
    ____
    ____

3. Describe the type(s) of solar renovation feature(s) that was implemented (e.g., active or passive solar, residential roof-mounted photovoltaic system).

____
____
____
____
____
____

4. What is the primary heating source?

1 Warm air from ventilation registers
2 Radiator or baseboard heat
3 Spot heating (radiant or space heating infrared lamps)
4 Other (please specify)________________________

5. What is the primary cooling source?

1 Chilled air from ventilation registers (central air)
2 Room air conditioners
3 Fans
4 Windows
5 Other (please specify)________________________

6. What is the primary type of artificial light in the working/living area?

1 Fluorescent
2 Incandescent
3 Other (please specify)___________________________

SECTION 2: OVERALL SATISFACTION WITH PROJECT

Please circle the appropriate response for each survey question. In some cases, the response you circle requires a description.

1. How has the renovation affected your working/living area quality and comfort?

   1 Positively
   2 Negatively
   3 No change noticed

   If "Positively" or "Negatively," please explain.

   ____
   ____
   ____

2. As part of the renovation project, a [name type(s) of systems implemented -- from Section 1, Question 3] was installed in your building. Do you understand how this system will benefit your building?

   1 Yes
   2 No

3. Were you briefed regarding any of the following topics related to the solar system installed in your building (circle those that apply)?

   1 Was not briefed
   2 Benefits relative to a conventional system
   3 Operation
   4 Maintenance
   5 Warranties
   6 Other (please describe)________________________

4. Do you find the solar features architecturally appealing?

   1 Yes
   2 No

   If "No," please use the following space to describe the aspects of the design you find unappealing.

   ____
   ____
   ____

5. Have you experienced problems with operation of the [name type(s) of systems implemented -- from Section 1, Question 3]?

1 Yes
2 No

If "Yes," please use the following space to describe the operating problem(s).

____
____
____

6. Have you experienced problems with getting prompt servicing to repair problems with the system(s) mentioned in response to the preceding question (Question 5)?

1 Yes
2 No

If "Yes," please use the following space to comment on the servicing problem.

____
____
____

7. How satisfied are you with this solar renovation project?

Not Satisfied		Somewhat		Very
1	2	3	4	5

If you circled a response that was "3" or lower, please explain your response.

____
____
____

8. Which feature(s) of the solar renovation do you like best and why?

____
____
____

9. Given your experience with the solar energy project that was implemented, would you be willing to participate in other solar energy projects?

Not Willing		Neutral		Very Willing
1	2	3	4	5

If you circled a response that was "3" or lower, please explain your response.

____
____
____

10. Did savings in energy costs (e.g., lower utility bills) attributable to the solar renovation project live up to your expectations?

1 Yes
2 No

If "No," please explain.

____
____
____

11. Would you buy and install solar energy technology in your building on your own (not as part of a participatory project)?

1 Yes
2 No
3 Maybe

Please explain.

____
____
____

SECTIONS 3 THROUGH 6 QUESTIONS

VERSION TO BE USED IF ONLY AN "AFTER RENOVATION" OCCUPANT ATTITUDE SURVEY IS CONDUCTED (NO PRE-CONSTRUCTION SURVEY CONDUCTED). IT IS TO BE ADMINISTERED TO OCCUPANTS AND OWNER/OCCUPANTS.

Use the following questions if only a post-renovation survey of building occupant attitudes is conducted. Questions in this version of Sections 3 through 6 ask the respondent to think about how conditions in the working/living environment have changed since the renovation; therefore, the responses offer a direct measure of the impact of the renovation on working/living environment quality.

SECTION 3: HEATING/COOLING

Please circle the appropriate response for each question. In some cases, the response you circle requires a description.

1. How often are you satisfied with the temperature in your working/living area, during the following seasons? (If you have not occupied this building during one of these seasons or do not occupy the building during one of the time periods (i.e., evening) listed, please circle N/A.)

	Never		Usually		Always	N/A
Summer						
Morning	1	2	3	4	5	6
Midday	1	2	3	4	5	6
Afternoon	1	2	3	4	5	6
Evening	1	2	3	4	5	6
Winter						
Morning	1	2	3	4	5	6
Midday	1	2	3	4	5	6
Afternoon	1	2	3	4	5	6
Evening	1	2	3	4	5	6

Are you "more satisfied" or "less satisfied" with the temperature in your working/living area than before the renovation?

	Less		No Change		More	N/A
Summer						
Morning	1	2	3	4	5	6
Midday	1	2	3	4	5	6
Afternoon	1	2	3	4	5	6
Evening	1	2	3	4	5	6
Winter						
Morning	1	2	3	4	5	6
Midday	1	2	3	4	5	6
Afternoon	1	2	3	4	5	6
Evening	1	2	3	4	5	6

2. Do you do anything to change the working/living area temperature so that you are more comfortable?

Summer

1 No need to regulate temperature; working/living area temperature is comfortable
2 Can not do anything
3 Turn down the thermostat temperature if too hot
4 Open window(s)
5 Open window(s) and turn on room fan
6 Other (please describe)____________________________

Winter

1 No need to regulate temperature; working/living area temperature is comfortable
2 Can not do anything
3 Turn up the thermostat temperature if too cold
4 Use a spot or area heater
5 Other (please describe)____________________________

How frequently do you take this action?

	Never	Once a week	Once daily	Several times a day
Summer	1	2	3	4
Winter	1	2	3	4

3. At what temperature is your thermostat set normally during the following seasons?

Summer Cooling Temperature Setting _________°C

Winter Heating Temperature Setting _________°C

4. Can you regulate the temperature in your working/living area?

1 Yes
2 No

If "Yes," please indicate how frequently you find it necessary to readjust the temperature?

Prior to Renovation

	Never	Once a week	Once daily	Several times a day
Summer	1	2	3	4
Winter	1	2	3	4

After Renovation

	Never	Once a week	Once daily	Several times a day
Summer	1	2	3	4
Winter	1	2	3	4

5. Does the sun have any impact on the comfort level of your working/living area?

1 Yes
2 No

If "Yes," please explain the impact (e.g., sun makes building too hot or building would be too cold without solar heat).

____
____
____

Since the renovation, has the sun had "more impact" or "less impact" on your working/living area?

Less		No Change		More
1	2	3	4	5

SECTION 4: VENTILATION

Please circle the appropriate response for each question. In some cases, the response you circle requires an explanation.

1. How would you describe the air circulation in your working/living area?

Poor		Fair		Excellent
1	2	3	4	5

Since the renovation, has the air circulation in your working/living area "improved;" or is it "poorer" than before the renovation?

Poorer		No Change		Improved
1	2	3	4	5

2. How would you describe the air quality in your working/living area?

<u>Prior to Renovation</u>

Poor		Fair		Excellent
1	2	3	4	5

If "Poor," please explain.

____

____

____

<u>After Renovation</u>

Poor		Fair		Excellent
1	2	3	4	5

If "Poor," please explain.

____

____

____

3. Are you able to control the air quality in your working/living area?

1 Yes
2 No

If "Yes," how?

4. How important is it to you to be able to control the air quality in your working/living area?

Prior to Renovation

Not Important		Neutral		Very Important
1	2	3	4	5

After Renovation

Not Important		Neutral		Very Important
1	2	3	4	5

SECTION 5: LIGHTING

Please circle the appropriate response for each question. In some cases, the response you circle requires an explanation.

1. Are you satisfied with the quality of the artificial lighting in the working/living area?

Never		Sometimes		Always
1	2	3	4	5

If you circled response numbers "1," "2," or "3," please explain.

____
____
____

Since the renovation, has the quality of the artificial lighting in your working/living area "improved;" or is it "poorer" than before the renovation?

Poorer		No Change		Improved
1	2	3	4	5

2. Are you satisfied with the balance of natural light and artificial light available in your working/living area?

Never		Sometimes		Always
1	2	3	4	5

If you circled response numbers "1," "2," or "3," please explain.

____
____
____

Since the renovation, has the balance of natural light and artificial light available in your working/living area "improved;" or is it "poorer" than before the renovation?

Poorer		No Change		Improved
1	2	3	4	5

If you circled response numbers "1" or "2," please explain.

____
____
____

3. Are you satisfied with the quality of daylighting in your working/living area?

Never		Sometimes		Always
1	**2**	**3**	**4**	**5**

If you circled response numbers "1," "2," or "3," please explain.

____

____

____

Since the renovation, has the quality of daylighting in your working/living area "improved;" or is it "poorer" than before the renovation?

Poorer		No Change		Improved
1	2	3	4	5

____

____

4. Which of the following do you prefer most when performing tasks during daylight hours (circle one)?

1 Natural light (daylighting)
2 Combination of natural light (daylighting) and artificial light
3 Artificial light
4 Other (please describe)____________________

SECTION 6: OTHER

1. Are there any other changes in the indoor environment -- good or bad -- that have occurred as a result of the renovation (e.g., decreased noise due to better windows, insulation, etc., increased noise due to fans or air movement, etc.)? Please list and describe below.

SECTIONS 3A THROUGH 6A QUESTIONS

VERSION TO BE USED IF BOTH BEFORE AND AFTER RENOVATION ATTITUDE SURVEYS ARE CONDUCTED. IT IS TO BE ADMINISTERED TO OCCUPANTS AND OWNER/OCCUPANTS.

Use the following questions if a baseline survey of attitudes is conducted prior to the building renovation followed by a post-renovation survey. When administering the post-renovation survey, the interviewer would ask the respondent to answer each question based on how they thought the renovation had changed aspects of the working/living environment. The before and after renovation responses would be compared to determine how respondent attitudes about the working/living environment shifted as a result of the renovation.

All questions in Sections 3A through 6A are asked when conducting the baseline survey. For the post renovation survey, ask only the following questions:

Section 3A: Questions 1, 3 (ask only the second part of Question 3 after project implementation), and 4

Section 4A: Questions 1, 2, and 4

Section 5A: Questions 1, 2, and 3.

Section 6A: Question 1

SECTION 3A: HEATING/COOLING

Please circle the appropriate response for each question. In some cases, the response you circle requires a description.

1. How often are you satisfied with the temperature in your working/living area, during the following seasons? (If you have not occupied this building during one of these seasons or do not occupy the building during one of the time periods (i.e., evening) listed, please circle N/A.)

	Never		Usually		Always	N/A
<u>Summer</u>						
Morning	1	2	3	4	5	6
Midday	1	2	3	4	5	6
Afternoon	1	2	3	4	5	6
Evening	1	2	3	4	5	6
<u>Winter</u>						
Morning	1	2	3	4	5	6
Midday	1	2	3	4	5	6
Afternoon	1	2	3	4	5	6
Evening	1	2	3	4	5	6

2. If you circled response numbers "1" or "2" above, do you do anything to change the working/living area temperature so that you are more comfortable?

<u>Summer</u>
1 No need to regulate temperature; working/living area temperature is comfortable
2 Can not do anything
3 Turn down the thermostat temperature if too hot
4 Open window(s)
5 Open window(s) and turn on room fan
6 Other (please describe)______________________________

<u>Winter</u>
1 No need to regulate temperature; working/living area temperature is comfortable
2 Can not do anything
3 Turn up the thermostat temperature if too cold
4 Use a spot or area heater
5 Other (please describe)______________________________

How frequently do you take this action?

	Never	Once a week	Once daily	Several times a day
Summer	1	2	3	4
Winter	1	2	3	4

3. At what temperature is your thermostat set normally during the following seasons?

Summer Cooling Temperature Setting________°C

Winter Heating Temperature Setting ________°C

4. Can you regulate the temperature in your working/living area?

1 Yes
2 No

If "Yes," please indicate how frequently you find it necessary to readjust the temperature?

	Never	Once a week	Once daily	Several times a day
Summer	1	2	3	4
Winter	1	2	3	4

5. Does the sun have any impact on the comfort level of your working/living area?

1 Yes
2 No

If "Yes," please explain the impact (e.g., sun makes building too hot or building would be too cold without solar heat).

____

____

____

SECTION 4A: VENTILATION

Please circle the appropriate response for each question. In some cases, the response you circle requires an explanation.

1. How would you describe the air circulation in your working/living area?

Poor		Fair		Excellent
1	2	3	4	5

2. How would you describe the air quality in your working/living area?

Poor		Fair		Excellent
1	2	3	4	5

If "Poor," please explain.

____

____

____

3. Are you able to control the air quality in your working/living area?

   1 Yes
   2 No

   If "Yes," how?____

4. How important is it to you to be able to control the air quality in your working/living area?

Not Important		Neutral		Very Important
1	2	3	4	5

SECTION 5A: LIGHTING

Please circle the appropriate response for each question. In some cases, the response you circle requires an explanation.

1. Are you satisfied with the quality of the artificial lighting in the working/living area?

Never		Sometimes		Always
1	2	3	4	5

If you circled response numbers "1," "2," or "3," please explain.

2. Are you satisfied with the balance of natural light and artificial light available in your working/living area?

Never		Sometimes		Always
1	2	3	4	5

If you circled response numbers "1," "2," or "3," please explain.

3. Are you satisfied with the quality of daylighting in your working/living area?

Never		Sometimes		Always
1	2	3	4	5

If you circled response numbers "1," "2," or "3," please explain.

4. Which of the following do you prefer most when performing tasks during daylight hours (circle one)?

1 Natural light (daylighting)
2 Combination of natural light (daylighting) and artificial light
3 Artificial light
4 Other (please describe)

SECTION 6A: OTHER

1. Are there any other indoor environment conditions that you would consider a problem, or that you would like to see improved. For example, noise due to poorly constructed or insulated walls or windows, etc. Please list and describe below.

____

____

____

NOTE: Ask Section 7 questions the first time the survey is administered.

SECTION 7: ABOUT YOURSELF

The following information will help us to understand how different types of people feel about their working/living environment.

How long have you worked/lived in the building/residence?	______years	______months
What is your sex?	______Male	______Female
What is your age?	______ years	

ANNEX A.4

Detailed Climate Descriptions

C L I M A T E   D A T A - S W E D E N

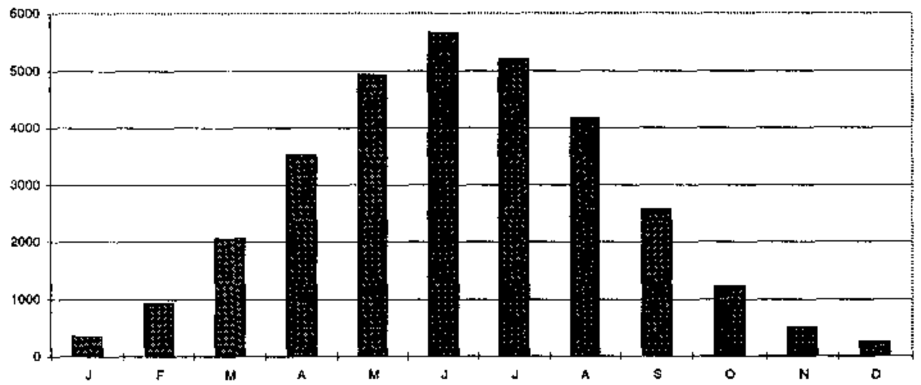
Climate data: Average Swedish West-coast climate
Location: Goteborg (Save), 30 years average (1961-1990)
Latitude: 57° north   Elevation: 20 m

The climate in Goteborg is Atlantic with relative mild temperatures and abundant, well distributed rainfall (very similar to the Danish climate).
Sweden is part of the northern temperate zone (winters with lasting frost and remaining snow, average temp. warmest month above 10 °C). North of Sweden belongs to the coniferous woodland (short summers), while south-west of Sweden belongs to the deciduous woodland (minimum 4.5 months above 10 °C, deciduous forests naked during the winter). Major climatic data for Sweden are shown below:

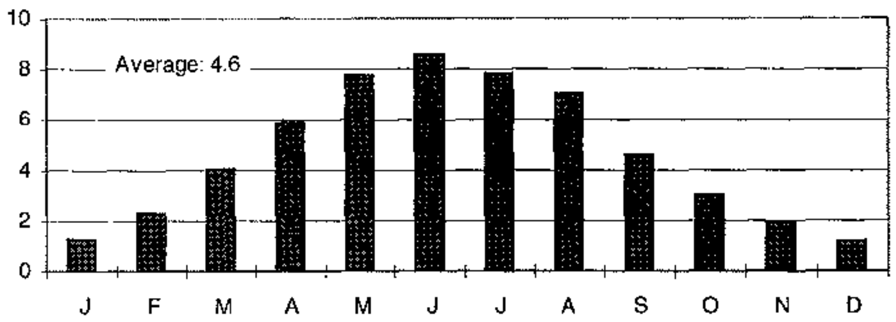
	Lat.	Year [°C]	Jan. [°C]	July [°C]	Glob.hor [kWh/a.m²]	Sunshine [hours/a]
Kiruna	67	-1.6	-13.8	12.1	817	1484
Luleå	65	1.5	-11.5	15.5	876	1956
Uppsala	59	5.3	-4.5	15.9	943	1698
Stockholm	59	6.0	-3.7	16.7	970	1821
Göteborg	57	7.1	-1.6	16.2	958	1722
Lund	55	7.9	-0.6	16.8	973	1592

80 % of the population lives south of Uppsala and about 40 % lives in the South-West parts of Sweden. Local variations in temperature, solar radiation and sunshine hours are of the same order as the differences between Uppsala and Lund.
Buildings are normally heated to 20-21 °C. The heating season typically lasts from September 15 to May 15.

Daily solar radiation [Wh/m²]



Daily sunshine hours

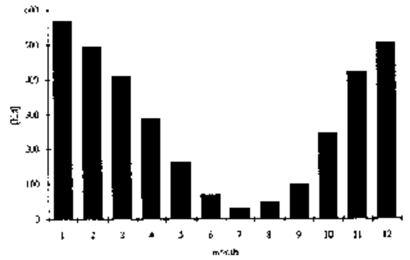


CLIMATE DATA - SWITZERLAND

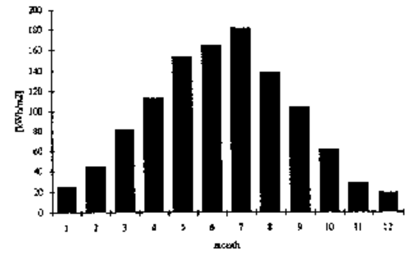
Climate Data: Swiss Design Reference Years
Because of the mountains (e.g. the Alps) Switzerland has typically three different climates with different basic design reference years needed:

Northern midland climate
Location: Zurich Airport, Switzerland
Latitude: 47.48° Elevation: 436 m Heating degree days (18/18): 335 Kd
Sunshine hours: 1377 h Mean air temp.: 10.6 °C Heating season: October 1st to May 15th (217 days)
Dominant wind direction is west and north west for all months and responsible for rainfall. Although periods of several cool and clear days with wind from north east may occur all over the year. Southern winds may reach the east of the Swiss midlands and is responsible for warm and relatively clear days. Relatively dry and cool winters with lots of fog or high clouds. Completely covered skies up the two weeks in a row are not uncommon. The main raining season is spring and November/December. Temperature during summer day may rise above 30°C. High humidity in summer leads very frequently to (local) thunderstorms.

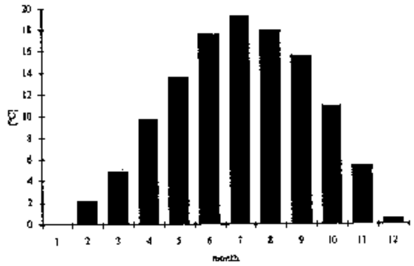
Degree Days



Solar Radiation

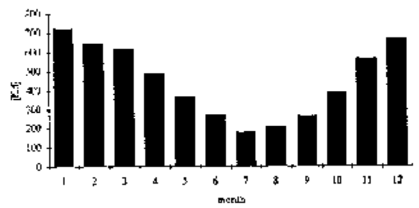


Mean Temperature

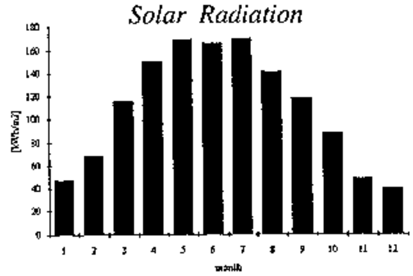


Alpine climate
Location: Davos, Switzerland
Latitude: 46.82° Elevation: 1590 m Heating degree days (18/18): 5372 Kd
Sunshine hours: 1603 h Mean air temp.: 4.6 °C Heating season: September 1st to June 30 th (300 days)
Wind directions are given by the orientation of the mountain valleys, usually changing direction once a day. This local winds may be very strong when dominated by a high pressure systems south of the Alps ("Föhn").
Winter are usually very long and cold with snow from the beginning of the year until March (in the valleys). However, as there is no fog and very often the influence of southern winds alpine climates get much more sunshine hours than the Swiss midland.

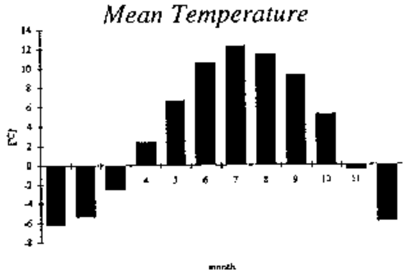
Degree Days



Solar Radiation

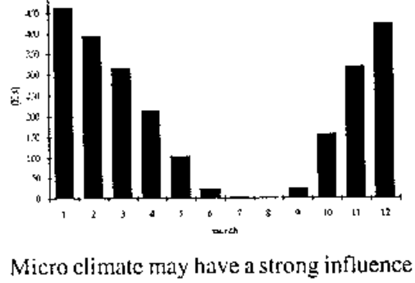


Mean Temperature

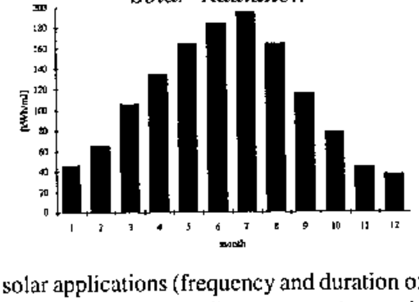


Southern climate
Location: Lugano, Switzerland
Latitude: 46.05° Elevation: 273 m Heating degree days (18/18): 2445 Kd
Sunshine hours: 1947 h Mean air temp.: 13.1 °C Heating season: October 15th to April 30th (173 days)
Main wind directions are along the north-south oriented valleys, changing direction depending on the interacting weather systems north and south of the Alps. After a relatively warm and nice early spring May and June are the months with heavy rainfalls. From July to September nice warm weather with thunderstorms in the evening is common. Winter may be very moderate along the lake sides and more alpine in the northern valleys.

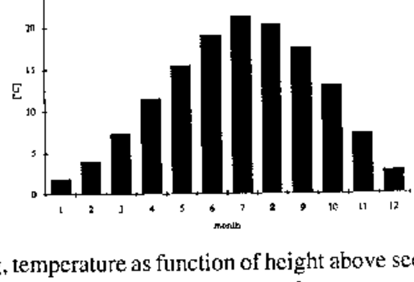
Degree Days



Solar Radiation



Mean Temperature



Micro climate may have a strong influence for solar applications (frequency and duration of fog, temperature as function of height above see level, reduced horizon due to mountains). For detailed analysis local influences must be considered for simulations in the design reference years. Houses in Switzerland are normally heated to 20°C.

References: [1] Norm SIA 381/3 [2] SIA-Dokumentation 64

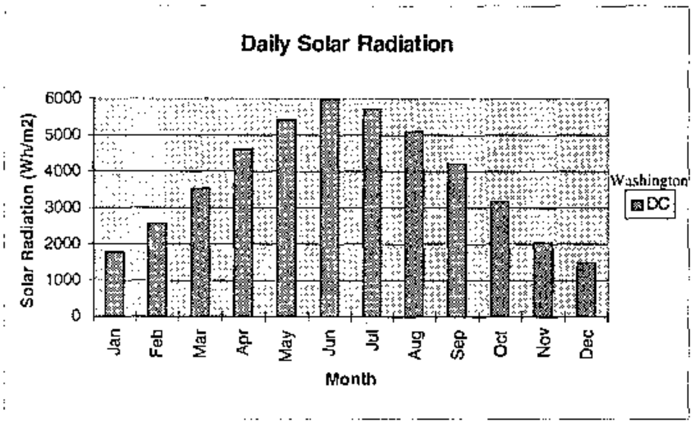
CLIMATE DATA - UNITED STATES

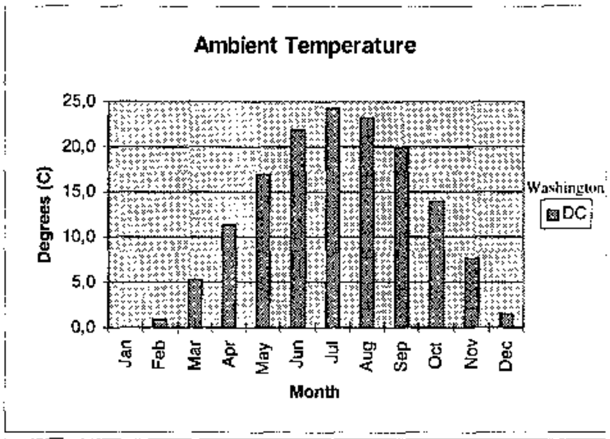
Climate Data: Test Meteorological Year (TMY) Data
The United States has wide climatic variations. For simulation purposes, the following sites were used :

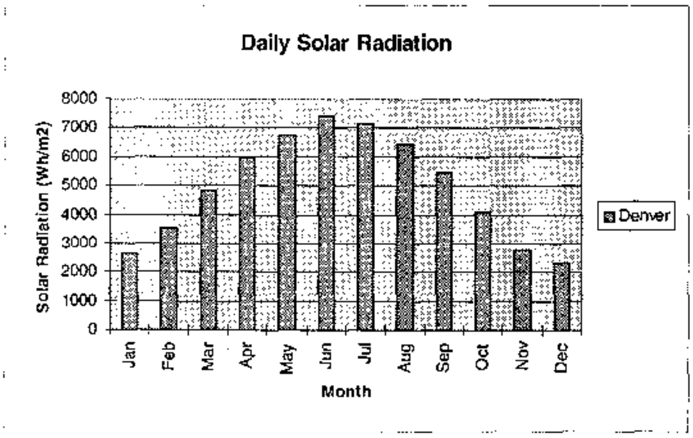
Location: Washington, DC - Denver, Colorado - Syracuse, NY
Latitude: 38 - 39 - 43
Elevation: 1.3 m - 491 m - 39.4 m
Heating DD: 2347 - 3490 - 3753

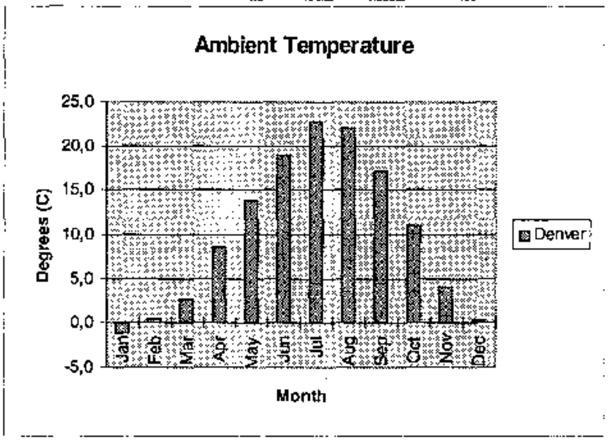
Washington, DC is a representative U.S. climate, with substantial heating and cooling requirements. Denver, Colorado has cold, sunny winters and mild summers. Syracuse, New York has cold, cloudy winters and mild summers.

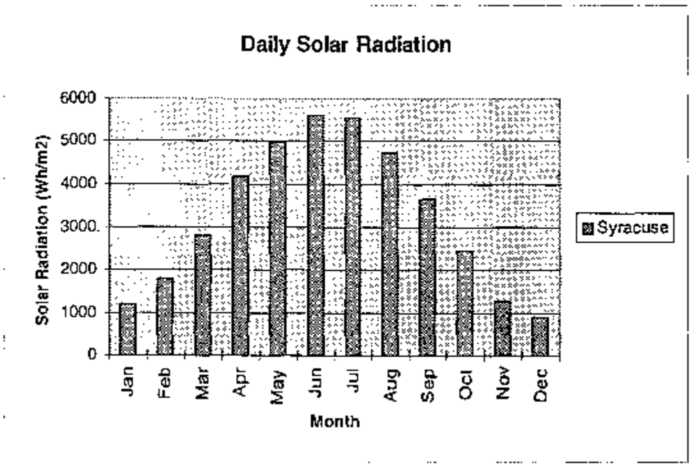
Monthly temperature and solar radiation distributions are illustrated below :

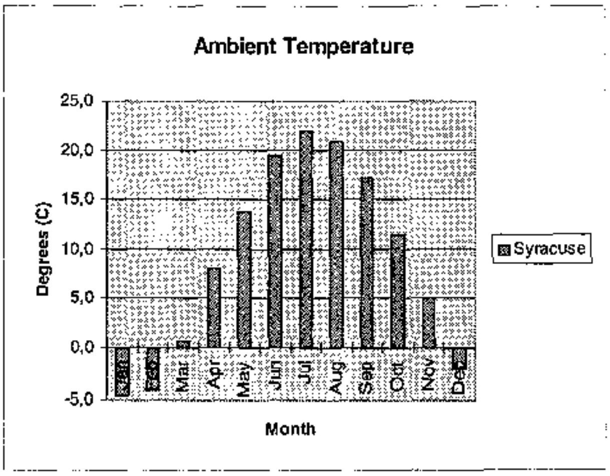










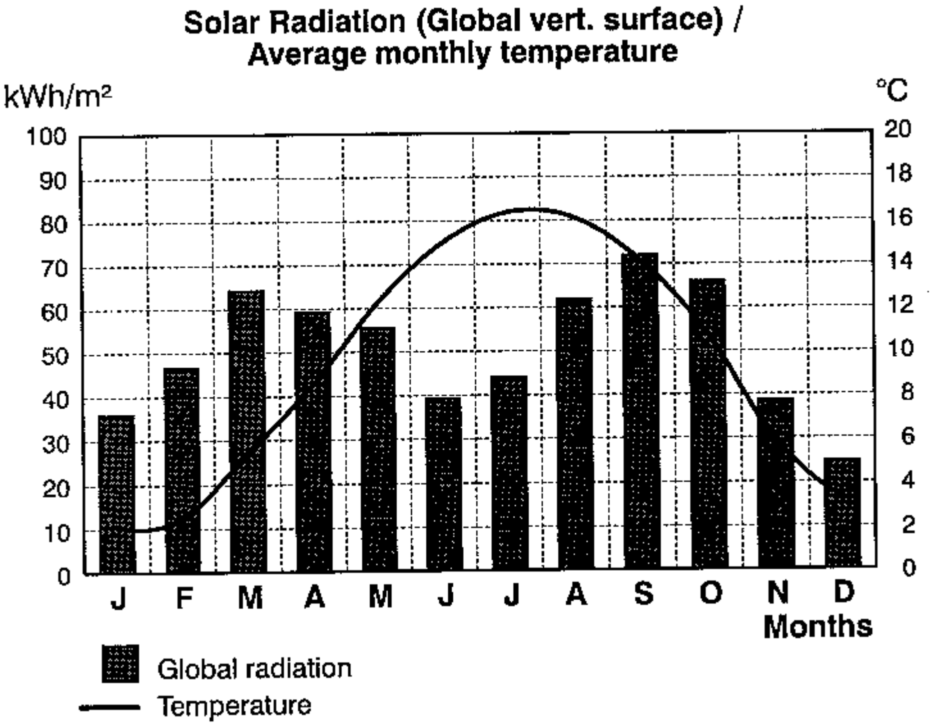


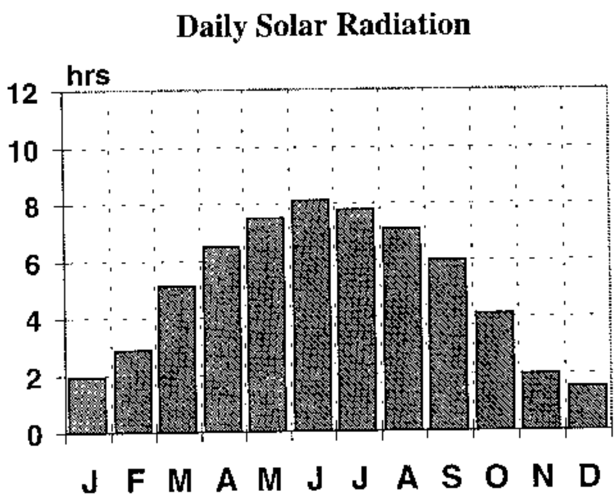
C L I M A T E   D A T A - B E L G I U M

Climate data : Belgian Reference Year - Royal Belgian Meteorological Institute

Location : Uccle, Belgium
Latitude : 50.8° - Longitude : -4.4° - Elevation : 100 m
Heating degree days (18/18) : 3004

Belgium has a maritime climate.
The climate of Brussels is best represented by Uccle Test Reference Year. The monthly nocturnal average outdoor temperature is near 2°C in winter and near 14°C in summer and the monthly diurnal average outdoor temperature is near 3°C in winter and 18°C in summer. Average daily sunshine amounts range from about 2 hours a day in January to between 7 and 8 hours in June.





C L I M A T E   D A T A - D E N M A R K

Climate data : Danish Design Reference Year

Location : Copenhagen, Denmark
Latitude : 55.6°, Elevation : 30 m, Heating Degree Days (18°C) : 3102

Denmark is, apart from Greenland, part of the northern temperate zone. The climate is maritime with relatively mild temperatures and abundant, well distributed rainfall. About 5 months are over 10°.

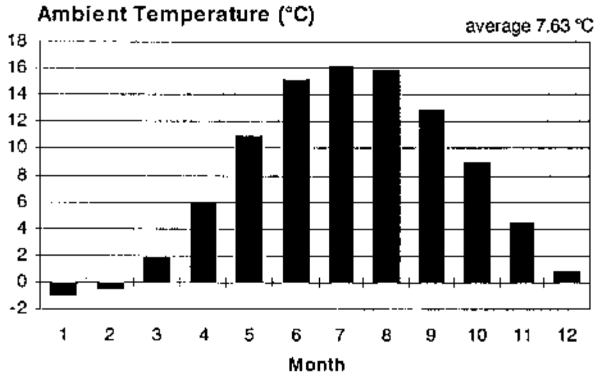
Air masses of maritime origin are most common, however, in approximately 2.000 hours per year dry continental air masses appear. Both situations are possible in all months, with easterly winds most often, relatively, in the first half of the year. Furthermore, as the temperature is rising in the first half of the year, humidity and precipitation is low during the spring.

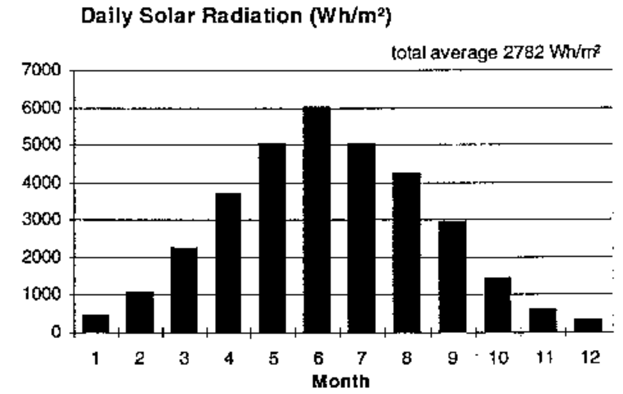
The dominant wind direction is for all months W or SW, although all months, and especially February through May and October-November show a large number of E or SE winds. This wind is most seldom from north.

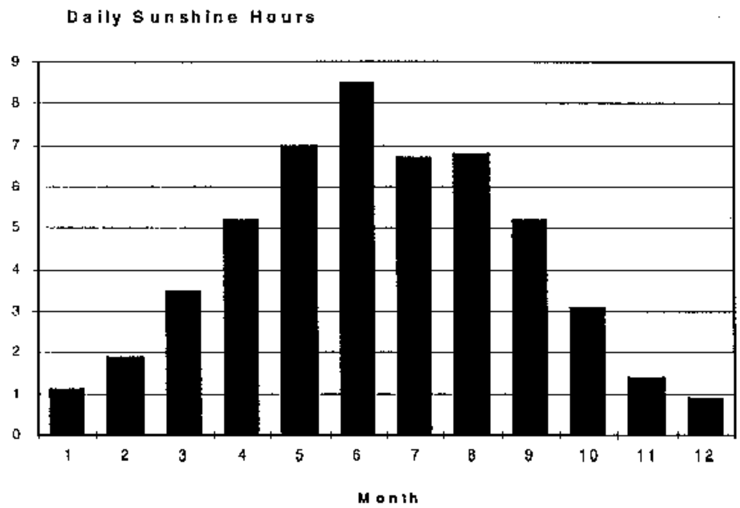
Sunshine hours show small variations over the area of Denmark. This variation is smaller than the variation from year to year.

Houses in Denmark are normally heated to 20°C. The heating season typically lasts from September 15th to May 15th.

Generally. Denmark, apart from the Farao Islands and Greenland, can be considered as a single zone, with only one reference year needed.







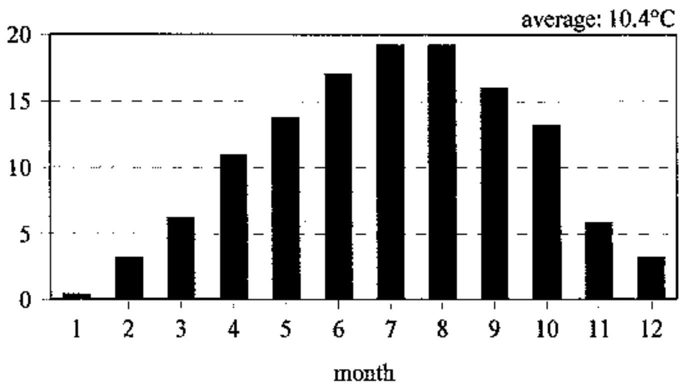
C L I M A T E D A T A - G E R M A N Y

Climate data: German Test Reference Years (TRY)

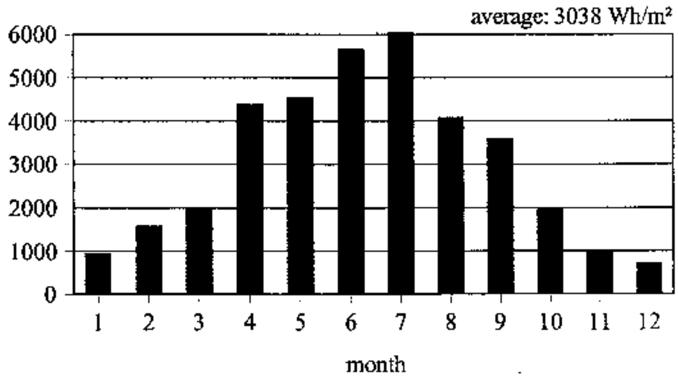
Location: Freiburg
Latitude: 48.0°N, Longitude: 7.9°E, Elevation: 269 m, Heating degree days: 3334 DD

The climate in Germany varies from a sea climate in the northern part to a continental climate in the eastern and southern parts. Houses build according to the current building code have a typical heating season of 280 days with approximately 3800 heating degree days. The reference temperatures are 15°C and 20°C for the outdoor and indoor air temperatures respectively. Depending on the location the heating degree days can range between 3300 and 5000 DD.
The annual total solar radiation available on a horizontal plane is 1000 kWh/m^2 on average, with a variation of 850 kWh/m^2 up north to 1150 kWh/m^2 in the southern part.
The dominant wind direction in Germany is west.
Hourly weather data are available as Test Reference Years (TRY) representing 12 regions in the former West-Germany. An extension to the former East-Germany is under development. Average monthly data for radiation and outdoor temperature data are given with the DIN 4108/6.
The building simulations were carried out with the TRY 7, representing the region Freiburg. Freiburg has a relatively mild winter.

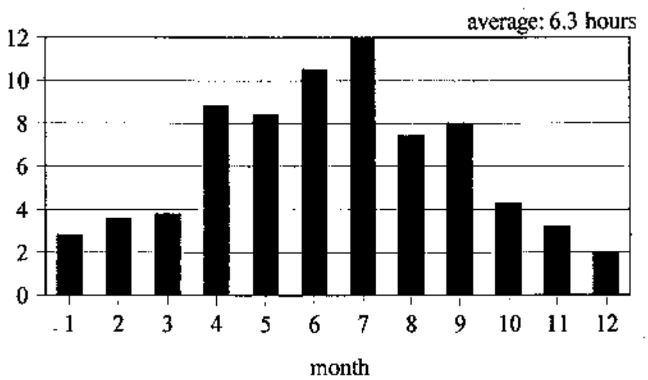
Ambient Temperature (°C)



Daily Solar Radiation (Wh/m²)



Daily Sunshine Hours



month	ambient temperature	daily solar radiation	daily sunshine hours
	°C	Wh/m²	hours
1	0,4	951	2,8
2	3,2	1579	3,6
3	6,2	1974	3,8
4	10,9	4387	8,8
5	13,8	4555	8,4
6	17,1	5653	10,5
7	19,2	6042	12,0
8	19,2	4074	7,4
9	16,0	3583	8,0
10	10,3	1945	4,3
11	5,8	940	3,2
12	2,3	713	2,0
average	10,4	3038	6,3

References: Blümel , K. et al: Entwicklung von Testreferenzjahren für Klimaregionen der Bundesrepublik Deutschland, BMBF FB-T86-051
DIN 4108/6, Berechnung des Jahresheizwärmebedarfs von Gebäuden (draft)

CLIMATE DATA - NETHERLANDS

Climate Data : Average Climate 1961 - 1990, Royal Dutch Meteorological Institute

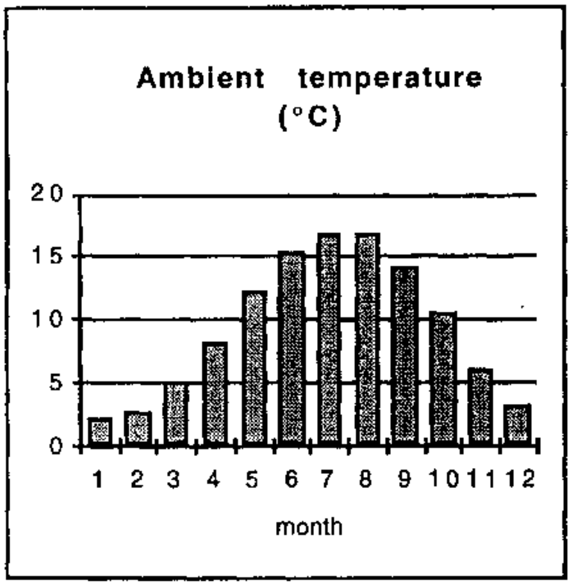
Location : De Bilt, The Netherlands
Latitude : 52.1 °, Elevation 5 m, Heating Degree Days (18°C) : 2804

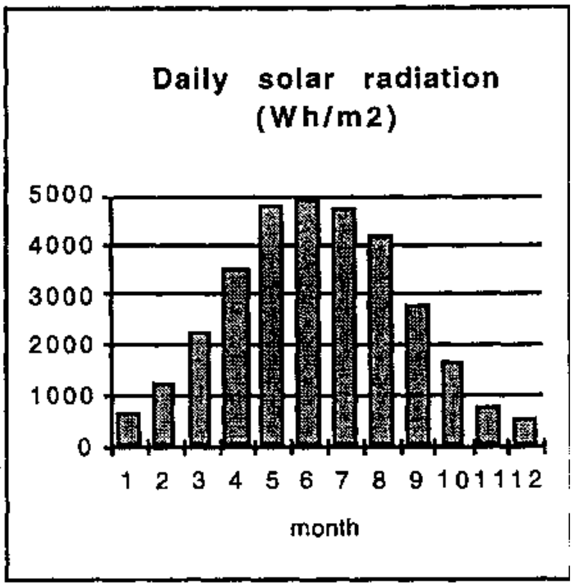
The Netherlands has a maritime climate.
Six months are above 10°C.

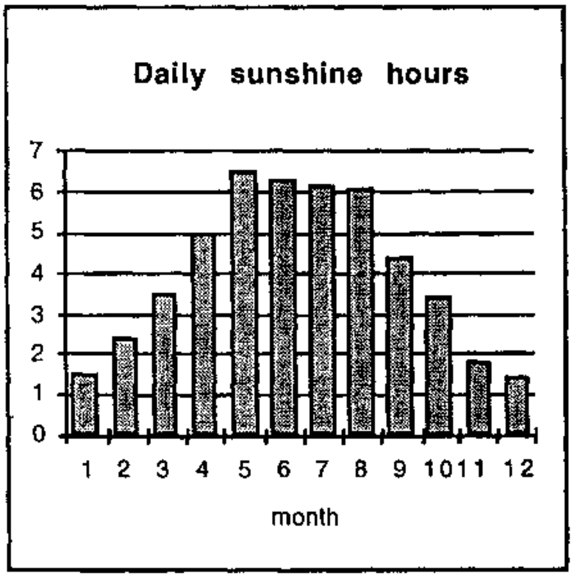
Predominant wind direction is South-West. Highest wind speeds occur near the coast.

Solar irradiation distribution can be considered even over the country; with the maximum irradiation near the coast being some 10 % above the irradiation inland.

The Netherlands can be considered one climatic zone, with only one reference year needed. For this reference year, data from De Bilt, in the center of the country, is used.







Weather data de Bilt, 1961-1990

month	ambient temperature °C	daily solar radiation Wh/m2	daily sunshine hours hours
1	2,2	635	1,5
2	2,5	1227	2,4
3	5,0	2244	3,5
4	8,0	3529	5,0
5	12,3	4753	6,5
6	15,2	4881	6,3
7	16,8	4706	6,1
8	16,7	4151	6,1
9	14,0	2802	4,4
10	10,5	1715	3,4
11	5,9	772	1,8
12	3,2	499	1,4
average	9,4	2660	4,0

ANNEX A.5

General Information about the IEA

GENERAL INFORMATION ABOUT THE IEA

INTERNATIONAL ENERGY AGENCY

The international Energy Agency was formed in 1974 within the framework of the Organisation for Economic Cooperation and Development (OECD) to implement a program of international energy cooperation among its member countries, including collaborative research, development and demonstration projects in new energy technologies. The European Commission also participates in the work of the Agency.

The policy goals of the IEA include diversity, efficiency and flexibility within the energy sector, the ability to respond promptly and flexibly to energy emergencies, the environmentally sustainable provision and use of energy, more environmentally acceptable energy sources, improved energy efficiency, research, development and market deployment of new and improved energy technologies, and cooperation among all energy market participants.

These goals are addressed in part through a program of international collaboration in the research, development and demonstration of new energy technologies under the framework of over 40 Implementing Agreements. The IEA's R&D activities are headed by the Committee on Energy Research and Technology (CERT) which is supported by a small Secretariat staff in Paris. In addition, four Working Parties (in Conservation, Fossil Fuels, Renewable Energy and Fusion) are charged with monitoring the various collaborative agreements, identifying new areas for cooperation and advising the CERT on policy matters.

IEA SOLAR HEATING AND COOLING PROGRAM

The Solar Heating and Cooling Program was one of the first collaborative R&D agreements to be established within the IEA, and, since 1977, its Participants have been conducting a variety of joint projects in active solar, passive solar and photovoltaic technologies, primarily for building applications. The 19 members are:

Australia	France	Spain
Austria	Germany	Sweden
Belgium	Italy	Switzerland
Canada	Japan	United Kingdom
Denmark	Netherlands	United States
European Commission	New Zealand	
Finland	Norway	

The 19 members of the IEA Solar Heating and Cooling Agreement have initiated a total of 24 R & D projects (known as Tasks) to advance solar technologies for buildings. The overall program is managed by an Executive Committee while the individual Tasks are led by Operating Agents. These Tasks and their respective Operating Agents are:

Task 1* Investigation of the Performance of Solar Heating and Cooling Systems - Denmark
Task 2* Coordination of Research and Development on Solar Heating and Cooling - Japan
Task 3* Performance Testing of Solar Collectors - Germany/United Kingdom
Task 4* Development of an Insulation Handbook and Instrument Package - United States
Task 5* Use of Existing Meterological Information for Solar Energy Application - Sweden
Task 6* Solar Systems Using Evacuated Collectors - United States
Task 7* Central Solar Heating Plants with Seasonal Storage - Sweden
Task 8* Passive and Hybrid Solar Low Energy Buildings - United States
Task 9* Solar Radiation and Pyranometry Studies - Canada/Germany
Task 10* Solar Material Research and Testing - Japan
Task 11* Passive and Hybrid Solar Commercial Buildings - Switzerland
Task 12* Building Energy Analysis and Design Tools for Soar Applications - United States
Task 13* Advanced Solar Low Energy Buildings - Norway
Task 14* Advanced Active Solar Systems - Canada
Task 15 Not initiated
Task 16* Photovoltaic in Buildings - Germany
Task 17* Measuring and Modelling Spectral radiation - Germany
Task 18* Advanced Glazing Materials - United Kingdom
Task 19 Solar Air Systems - Switzerland
Task 20 Solar Energy in Building Renovation - Sweden
Task 21 Daylighting in Building - Denmark
Task 22 Solar Building Energy Analysis Tools - United States
Task 23 Optimization of Solar Energy Use in Large Buildings - Norway
Task 24 Active Solar Procurement - Sweden
Task 26 Solar Combisystems - Austria

* Completed

TASK 20 : Solar energy in building renovation

The scope of Task 20 is the application of solar energy technologies for space and domestic hot water heating, cooling and lighting in existing residential and non-residential buildings. A number of the most promising concepts will be explored from the perspective of their impact on building thermal performance, visual comfort , environmental impact, and economic performance. It is also necessary to understand how decisions are made by building owners and others involved in the renovation process, how solar strategies will be valued in different markets, and how to obtain the support of building contractors and other key players.

Experts from participating countries have been improving/developing strategies/concepts for effectively and economically integrating solar designs in the renovation process. This includes compiling guidelines needed by designers and remodellers, and developing information needed to reach the key-decision in the renovation process.

Subtask A : Evaluation of existing building applications

Subtask A comprises evaluation of 15 existing solar renovation projects in six countries. The majority of these projects involve the multi-family building applications. Experiences concerning the different aspects of renovation, such as various solar features employed, the renovation process itself, and occupant reactions have been summarised in a working document.

The 15 case studies represent principally three major solar renovation concepts: glazed balconies and galleries, solar walls, and solar collectors. The primary reasons for undertaking the renovations were: need to repair or improve the building envelope and need to replace or improve the heating, ventilation, and air conditioning system.

Most of the case studies were judged to be successful as demonstration projects. However, most of the case studies included mixed renovation activities like traditional wall insulation and replacement of window in combination with one or two solar renovation concepts. Therefore it was hard to evaluate the energy savings, as well as the cost effectiveness and other improvements, related to the solar renovation concepts. This emphasises the importance of further efforts in this field.

Subtask B : Development of Improved/Advanced Renovation Concepts

The main work in Subtask B is concentrated on the development of improved renovation concepts for different applications and on investigating the potential for energy savings and replication. The work is divided into two project areas: improved solar renovation concepts/systems and conclusions for market conditions.

Under Subtask B, the experts have proposed, developed, and investigated improved solar renovation system concepts, and analysed the performance of the system concepts for defined climate conditions, building layout and construction characteristics.

Subtask C : Design of Solar Renovation Projects

The objective of Subtask C is to demonstrate the application of promising solar renovation system concepts in different buildings in different climates. The design process has been carefully examined by the experts in a specific review process, and lead to the construction of several demonstration projects. The design process is then documented to enable a wider audience to benefit from the lessons-learned under this Subtask.

To be able to make an informative comparison of the results from the demonstration projects, a well defined format for the monitoring of the demonstration projects has been developed. Furthermore, whenever possible within the time schedule, short-term monitoring has been performed. The evaluation of the solar renovation demonstration designs are based on the review and critique by the Subtask participants. The energy benefits as well as other benefits of using solar concepts have been analysed.

The work in Subtask C is divided into two parts: Design of solar renovation projects and Evaluation of solar renovation designs. Thus, Subtask C will result in documented designs for several solar renovation projects and a common framework for reporting and evaluating the projects.

Subtask D : Documentation and dissemination

The objective of this Subtask is to synthesize and document information obtained from Subtasks A, B and C. The Subtask will provide a source of generalized information on solar strategies suitable for a variety of building types and renovation situations,
including information on all aspects of the design process. The calculate, and to the extent possible, measured results of energy saving by the solar concept will be included in the information. Specially this Subtask consists of the following elements: Document solar renovation strategies ad lessons-learned, Arrange and participate in international symposia, Compile illustrative source material and National dissemination.

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