IEA SOLAR HEATING AND COOLING (SHC) PROGRAMME, TASK 20:
SOLAR ENERGY IN BUILDING RENOVATION

Solar Energy in Building Renovation

JAMES X JAMES

IEA
INTERNATIONAL ENERGY AGENCY
Solar Heating & Cooling Programme

Contents

International Energy Agency (IEA) Solar Heating and Cooling (SHC) Programme, Task 20: Solar Energy in Building Renovation

If the use of solar energy is to mean that significantly less fossil fuel will be consumed, solar systems must be readily adaptable to existing buildings as well as new buildings. Under IEA SHC Programme Task 20: 'Solar Energy in Building Renovation', a number of the most promising solar concepts and systems for building renovation have been explored.

The first activity of Task 20 was the analysis of the performance of existing solar renovation projects that appear to be based on broadly applicable design concepts. Then on the basis of the information gained from these case studies, the participants investigated improved and advanced solar renovation system concepts with high potential for both energy savings and replication. Strategies for incorporating these concepts into the renovation process were developed for a number of specific projects.

The countries participating in Task 20 are: Belgium, Denmark, Germany, The Netherlands, Sweden, Switzerland and the USA.

Acknowledgements

The support of Novem (The Netherlands Organization for Energy and Environment), which has funded the leadership of the subtask on Dissemination and the work related to this brochure, is gratefully acknowledged. My thanks to all who contributed to the production of this brochure: all national experts, Videm Communicatie and my colleagues at W/E Consultants. The contents of this brochure are based on the research work of experts funded by the participating countries.

Chiel Boonstra,
Gouda, The Netherlands
September 1997

Authors: Chiel Boonstra, Irma Thijssen, W/E Consultants Sustainable Building, Gouda, The Netherlands

Photography: Amstelland Stadsherstel, Amersfoort; Joost Brouwers, Rotterdam; Rob Sol, Eindhoven; Woningstichting Patrimonium, Amsterdam; De Jong Luchtfotografie, Zeist; Jacob Blegvad Arkitektkontor, Copenhagen; Swedish Council for Building Research; IEA SHC Programme Task 20 experts

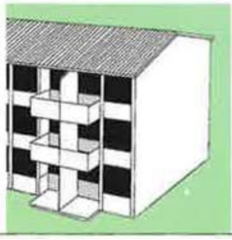
Graphics: Laus vd Bliek, W/E Consultants Sustainable Building, Gouda, The Netherlands

Illustrations: Ad Oskam, Rotterdam, The Netherlands

Design and production: James & James (Science Publishers) Ltd, London, UK

Printed in Hong Kong by CTPS

Solar Energy in Building Renovation



Some decades after they have been built, all residential and non-residential buildings have to be renovated. The motivation for this renovation can be any number of things: a desire to repair or replace a leaking roof, deteriorated concrete balconies or poor window frames; the need to:

- increase living or work-space area;
- upgrade the appearance of the building;
- improve indoor comfort levels;
- reduce utility expenses;
- replace heating, ventilation and hot water systems; or
- accommodate changes in building use.

Solar renovation challenges

Regardless of the reason for it, renovation presents both special challenges and the opportunity to apply different solar energy options. Solar energy is a clean and sustainable energy source and, therefore, has economic as well as environmental and social value. Among the most promising options for the renovation of buildings are:

- building integrated solar collectors;
- glazed balconies;
- transparent insulation (TI).

These options can help to improve the construction of the building, occupant comfort and thermal performance.

Air-based solar collectors preheat ventilation air, thus reducing the energy demand for space heating. The same effect can be achieved with glazed balconies, which also save energy by reducing ventilation, infiltration and transmission losses and solve problems with thermal bridges.

Water-based solar collectors preheat domestic hot water (DHW) and may also contribute to space heating. Transparent insulation is most suitable for use on poorly insulated solid walls or as a daylighting element in windows and facades. Transparent insulation combines excellent insulation properties with a high transmittance of light and solar energy.

All these options, in one way or another, add a new architectural element to a building, integrated in the roof (solar collectors), in the balcony (complete glazing) or in the facade (TI).

REITSE HOEVE, TILBURG (NETHERLANDS) – BEFORE RENOVATION, AFTER STANDARD RENOVATION AND AFTER SOLAR RENOVATION WITH GLAZED BALCONIES

Advantages of solar renovation

Solar renovation can be beneficial for building owners and occupants because:

- energy is saved;
- thermal and visual comfort are improved;
- maintenance problems are solved;
- the architectural image is enhanced;
- the utility of the space is enhanced.

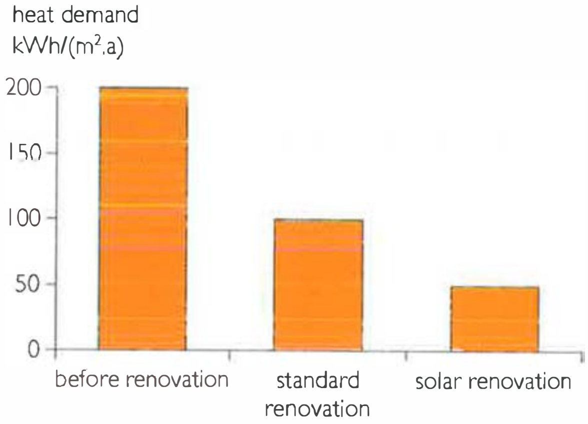
These conclusions are based on a large number of case studies and design reports of projects in Belgium, Denmark, Germany, The Netherlands, Sweden, Switzerland and the USA. These projects have been evaluated within the framework of the IEA SHC Programme Task 20: 'Solar Energy in Building Renovation'.

In the participating countries, the average annual thermal energy requirement for space heating and DHW before renovation of a building was approximately 150–250 kWh/m² of heated floor area. Typically, after standard renovation, the annual energy demand was 100 kWh/m², while additional annual savings resulting from solar applications ranged from 10 to 50 kWh/m². Occupants were generally satisfied with the results of renovation .

Costs of solar renovation

The case studies and design reports show a wide range of specific investment costs. Most relevant, however, are the net renovation costs, resulting from the application of solar technologies. Glazed balconies, for example, may replace major concrete or facade renovation and building integrated solar collectors can replace roof renovation. In many cases the inclusion of solar features increases the value of the building.

Heat demand and energy savings



HYBRID SOLAR HOUSE, JÄRNBROTT, GÖTEBORG (SWEDEN) – SOLAR RENOVATION WITH ROOF COLLECTORS AND A SOLAR-HEATED AIR GAP; BEFORE RENOVATION

AFTER RENOVATION

Conditions for solar renovation

A major prerequisite for the inclusion of solar features when existing buildings are renovated is that a large part of the building facades or the roof faces south, although if the orientation is south-east or south-west the performance will not be significantly affected. A further aspect that must be considered is whether the building envelope is shaded during the heating season. Roof-sited solar systems are generally less affected by shading from surrounding buildings.

In order to reduce thermal energy as well as power requirements, a solar renovation design is preferably applied in combination with traditional energy conservation measures, such as additional insulation and improved windows. The design should start from the renovation requirements, not with the technologies.

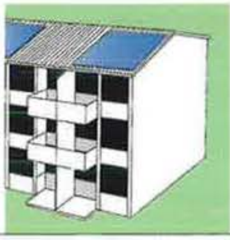
The design must be produced within the context of a whole building, rather than on a component-by-component basis. For example, integrated solar collectors can be included when roof renovation is needed. However, whether this is necessary is strongly related to the state of the current or the new DHW and space heating systems. Therefore, discussion of the renovation should involve collaboration between the architect, the building designer and the engineering consultant. Furthermore, the thermal energy performance should be calculated with a tool that enables understanding of the effects of both solar concepts and traditional concepts. Building simulations should preferably be carried out in cooperation with an experienced individual or firm.

AFFOLTERNSTRASSE, HEDINGEN (SWITZERLAND) – BEFORE RENOVATION AND WITH SOLAR RENOVATION: A TI WALL IS USED FOR HEATING AND ROOF-INTEGRATED SOLAR COLLECTORS FOR DHW

Renovation needs and solar opportunities

	Building-integrated collectors	Glazed balconies	Transparent Insulation	Unglazed transpired collectors	Integrated PV systems	Roof windows	Double glazing with low-E	Second-skin facade
Building performance								
Architectural image	●	●	●	●	●	●		●
Energy performance	●	●	●	●	●	●	●	●
Improved daylighting			●			●		●
Increased need for space		●				●		
Indoor comfort levels		●	●	●			●	●
Building renovation needs								
Facade	●	●	●	●	●		●	●
Window frames		●	●				●	●
Roof	●				●	●		
System renovation needs								
Space heating	●	●	●	●				●
Ventilation	●	●		●	●			●
DHW	●							

Integrated Solar Collectors



The use of solar collectors integrated into the building envelope is one of the most interesting solar energy applications that can be used in connection with renovation of buildings, particularly when there is a need to replace the DHW system. When flat roofs need to be rebuilt or when roofing material needs to be replaced, integrated solar collectors can act as a new waterproofing roof cover. This means that the cost of the solar collector can be partly covered by the cost of repairing a leaky roof.

Water-based collectors can contribute significantly to meeting the DHW and space heating loads, while air-based collectors can improve heating and ventilation systems. Most existing residential buildings are ventilated naturally. However, if energy conservation measures are applied, it may be necessary for a mechanical ventilation system to be added because the building envelope has been made more airtight, which reduces air infiltration. Air-based collectors, combined with a mechanical exhaust system, can provide preheated air. Exhaust ventilation with solar preheating of the air can be an economical alternative to using supply and exhaust ventilation systems with heat recovery.

HAMMARKULLEN IN GÖTEBORG (SWEDEN) – ROOF COLLECTORS FOR DHW

Solar collectors in building renovation

Solar collectors are installed with the main purpose of:

- **preheating DHW and/or space heating**
- **preheating ventilation air**

Building-integrated solar collector can be used to create synergy between energy-efficiency and architecture:

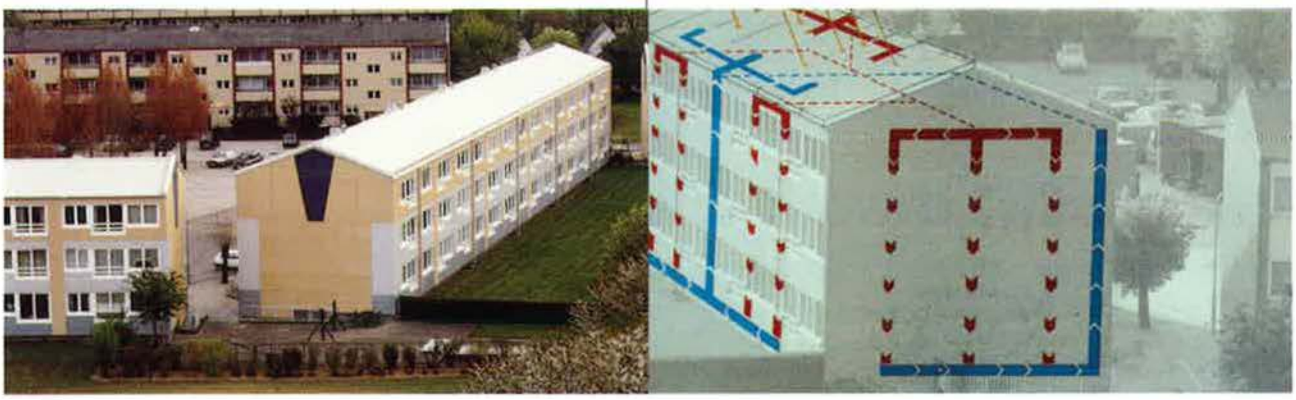
- **converting sunlight into useful heat**
- **replacing roof and facade materials and**
- **being designed to give the building a new identity and character**

Opportunities

Solar collectors can be built on site or mounted using prefabricated modules of roof elements. Solar collectors can also be integrated in south-oriented facades, especially when the cladding has to be replaced.

Design principles

Integrated solar collectors are a new architectural element and can give a building a new identity and character. Solar collectors are visible, even on roofs, and can have different forms, sizes, patterns and surfaces. When solar collectors are integrated into facades, the design needs to be considered in more detail than when they are added on roofs. In facades, shading is also an important aspect. Other design aspects that have to be considered are the shedding of snow and rain, mounting, connections and piping. Building integrated solar collectors are typically associated with collective DHW systems. There are, however, developments where large collector arrays supply individual DHW systems.



HYBRID SOLAR HOUSE, COPENHAGEN (DENMARK) – ROOF COLLECTORS FOR HEATING THE CAVITY WALL

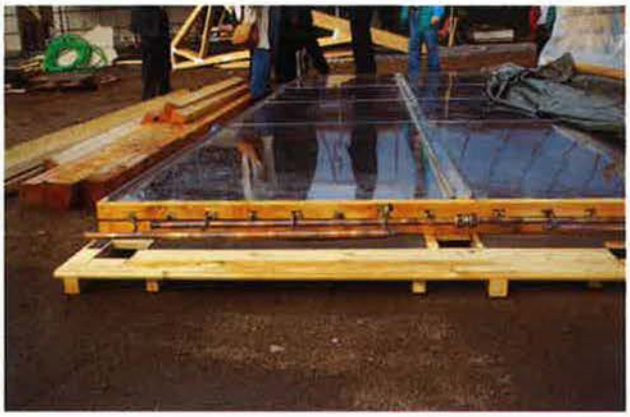
Costs and benefits
Normally solar collectors cover 40–50% of the annual heat requirements for DHW in multifamily building applications. Key figures are about 3–5 m² of collector area and 200 litres of water storage per apartment. To cover 10–20% of the annual heat demand for space heating and ventilation, a collector area of about 10 m² per apartment is required.

Typical costs for collectors are 100–450 ECU/m² per collector, depending on the collector type. Roof-module collectors for multifamily buildings and do-it-yourself collectors for single-family buildings are the cheapest.

Total systems range from 200 to 800 ECU/m² per collector with systems for multifamily buildings being the cheapest.

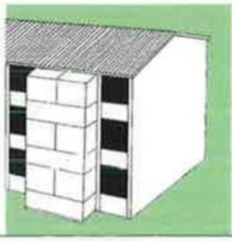
Working principles
Solar collectors can be either water-based or air-based. Solar collectors for preheating DHW typically use water in storage tanks for heat storage. An air-based collector system is usually designed to make use of the building structure for heat storage.

KLOPVAART, UTRECHT (THE NETHERLANDS) - SOLAR COLLECTORS FOR DHW



ONSALA IN GÖTEBORG (SWEDEN) – PREFABRICATED ROOF MODULE WITH INTEGRATED SOLAR COLLECTORS

Future options
- **Prefabricated roof modules with integrated water-based collectors are under development in a number of countries.**
- **In the framework of IEA SHC Programme Task 19 prefabricated air-based collectors are being developed.**



Glazed Balconies

The use of glazed balconies is an important strategy in the application of solar-energy designs in building renovation. Glazed balconies also help to solve major problems with the building envelope, such as poor insulation, damaged or deteriorated concrete, thermal bridges and window frame maintenance. Glazed balconies can protect existing facades and balconies and can improve the living quality of apartments. Their main benefits are adding a space to an apartment for use during parts of the year, improving thermal comfort and resolving moisture problems in adjacent rooms. Glazed balconies enhance the architectural image of a building and its apartments.

The most suitable buildings for glazed balconies are existing apartment buildings with aligned (integral, walled-in on three sides) or partly aligned balconies. The glazed balcony itself can be used approximately 100 days more per year than an unglazed balcony, without supplementary heat.
Well designed glazed balconies can realize major energy savings, provided that the glazed balcony is not heated by conventional means. Basic energy savings are achieved by solar heat capture and as a result of reduced ventilation, infiltration and transmission losses. Major savings will be achieved if ventilation air is preheated in the balcony. Solar preheating of ventilation air as it passes through the glazed balcony requires facade elements and systems to be specially designed, so that most of the ventilation and infiltration air is forced to enter through the glazed balcony.

Glazed balconies in building renovation

Advantages of glazed balconies:

- **Energy is saved**
- **Ventilation air can be preheated**
- **The indoor climate is improved**
- **Maintenance problems are solved**
- **The architectural image is enhanced**
- **The utility of the space is enhanced**
- **The lettability is enhanced**

GLAZED BALCONIES IN GLAUBTENSTRASSE (SWITZERLAND)

Opportunities

Glazed balconies offer a wide range of opportunities for creative design and can give apartment buildings a completely new image. For energy savings, the orientation is relatively important, with south-facing orientations providing the most benefit. The wider the balcony, the larger the savings. Glazing an aligned balcony also saves more energy than glazing an outside (fully exposed) balcony.

Design principles

Solar preheating of ventilation air as it passes through the glazed balcony can be accomplished by using the apartment's exhaust ventilation system. All other facade elements have to be more airtight than the glazed balcony and the distribution of vents should cause the ventilation air to enter through the glazed balcony.

Either the balcony facade or the facade of the building itself can be well insulated by applying double glazing with a low-E coating.

To control solar gains in summer, a glazed balcony must have operable glazed elements, e.g. opening or sliding glass elements. For comfort reasons shading is also necessary, as with an unglazed balcony.

HØJE GLADSAXE, COPENHAGEN (DENMARK) – GLAZED BALCONIES

Costs and benefits

Major energy savings can be achieved if the thermal, glazing and ventilation parameters are optimized. The orientation has somewhat less effect. Adding a glazed balcony, without preheating ventilation air, can save 10–20 kWh/m² of apartment floor area per annum. If the glazed-balcony concept is part of a total envelope renovation that includes double-glazed windows with heat-reflecting (low-E) glass, the annual heat demand for space heating can be reduced to 35–55 kWh/m². Savings of 30–40 kWh/m² per annum can be achieved by using low-E glazing. Glazed balconies with preheating of ventilation air save up to 30 kWh/m² per annum for an average apartment of 70 m² in climates that are typical of northern and central Europe and similar US climates.

The figures of 35–55 kWh/m² may be compared with up to 200 kWh/m² per annum before renovation and about 100 kWh/m² per annum for a standard renovation with double-glazed (non-low-E) windows.

Another benefit is a 5–8°C increase in the average temperature during the heating season, allowing the glazed balcony to be used for about 100 days more each year than an unglazed space.

A significant increase in energy use for space heating may be caused by unintended use of the glazed balcony (for example, by leaving the doors between the heated apartment and the glazed balcony open at all times). Adequate user information must therefore be provided to the occupants so that they understand how to get the greatest energy benefits from the balcony.

The cost of glazed balconies varies from country to country. The typical range of investment costs is 2000–7000 ECU per apartment. A reasonable part of this may be shared with renovation costs, e.g. for concrete renovation, removing thermal bridges and window frame maintenance.

Working principles

Glazed balconies basically reduce both transmission losses and ventilation losses. Part of the heat loss is recovered by the incoming ventilation air. In the glazed balcony, ventilation air from outside is preheated by the sun and then distributed in the dwelling. For optimum performance, the airtightness of the rest of the apartment must be very high.

Future options

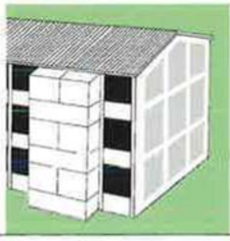
- **Prefabricated systems with simpler framing options and integrated ventilation possibilities are being developed.**
- **A glazed balcony could integrate active solar elements, such as a solar collector or PV cells, in its parapet.**

VAASA (FINLAND) – GLAZED BALCONY PROJECT WITH FRAMELESS WINDOWS

KILDEPARKEN, COPENHAGEN (DENMARK) – GLAZED BALCONIES AND TRANSPARENT INSULATION IN PARAPETS

ELVIRA IN AMSTENRADE (THE NETHERLANDS) – GLAZED BALCONIES IN SENIOR CITIZENS' APARTMENTS

THE YELLOW HOUSE IN AALBORG (DENMARK) – DESIGN FOR GLAZED BALCONIES. RENOVATION COMPLETED IN 1997



Transparent Insulation

Heat transmission and air infiltration through the building envelope are the major causes of heat loss in old buildings that need to be renovated. These losses can be reduced by using improved windows and additional opaque insulation and by making the building envelope more airtight. While these traditional measures only reduce the heat losses, the use of transparent insulation (TI) materials makes it possible both to reduce transmission losses, and to capture solar heat in uninsulated massive walls, i.e. walls with a significant thermal mass. The heat is absorbed, stored and transferred to the interior by the massive wall. As a result of the heat storage capabilities of the walls, the solar heat captured during the daytime is slowly released during the evening. While applying additional insulation to the outside wall will result in improved comfort, because the inside wall temperature will increase, applying TI will improve the comfort even more because the temperature on the inside of the wall will be even higher.

TI is applied, together with a transparent cover, so that it acts as a new wall facing and can thus be used to renovate facades that have deteriorated .

WOLLERAU (SWITZERLAND) – FIXED LAMELLAS USED AS A SUNSHADE IN SUMMER

Transparent insulation in building renovation

Basic applications of TI:

- Solar wall heating
- Highly insulating glazings with light guiding properties

Benefits of solar wall heating with TI:

- Walls with heat energy gains instead of transmission losses
- Improved comfort and lower heating requirements because of warm walls
- Simple, passive and self regulating heating system

Benefits of TI glazing:

- Improved light intensity distribution in rooms, reduces electricity demand
- Increased daylight usage and heat conservation at the same time

Opportunities

The existing facade should preferably be constructed of masonry materials and be uninsulated, with no openings or only a few small ones. The ideal orientation is south, south-west or south-east. TI is most applicable in locations with high solar radiation and/or low temperatures, for example climates typical of central northern Europe, the north-east USA and mountain areas.

Design principles

Transparent insulation is most effective on massive uninsulated walls, constructed of concrete, limestone or brick, with a density of 1200 kg/m³ or more. When TI is used on solid walls, glass is used in most cases to protect it from the elements. Consequently, condensation and glare must be addressed early in the design phase. As TI has significant implications for the architectural and mechanical systems of a building, using TI should be considered early in the design process. Solar-gain control, e.g. shading, must also be addressed in the design strategy.

Traditionally, TI has been applied using glass facade systems as curtain walls. Nowadays, however, prefabricated facade elements with integrated absorbers are available. Recently, a composite TI/plaster system has come onto the market. This provides traditional opaque insulation embedded in a plaster matrix. The results are similar in appearance to traditional stucco-like exterior insulating facade systems.

VILLA TANNHEIM IN FREIBURG (GERMANY) – COMPOSITE TI/PLASTER SYSTEM

Costs and benefits

A high-performance TI wall system that is properly designed and installed reduces annual heat energy demand by about 65–100 kWh/m² of TI facade, for a south facade, compared to traditional insulation (U=0.3 W/m²K). High-efficiency systems, however, require solar gain control, which increases the complexity and the cost of the system. The composite TI/plaster insulation system contributes 50 to 75 kWh/m² of TI facade. Solar gain control is not required if only parts of the facade are covered. The costs of systems with TI panels and shading systems vary from 500 to 900 ECU/m² of wall area. Prefabricated facade elements vary from 450 to 650 ECU/m². Composite TI/plaster systems range from 200 to 250 ECU/m².

Working principles

When TI is placed in front of an external wall, it allows solar radiation to pass through. By means of an absorber the radiation is transformed to heat, which is stored in the wall. From there, it is passively distributed into the building.

LABORATORY PSI (SWITZERLAND) – TI AS DAYLIGHTING ELEMENT

Future options

- **New systems and companies are entering the TI market and this will enhance competition in both price and number of alternative solutions.**
- **The application of smart windows, such as switchable glazing, may be an adequate solar gain control for TI elements in the future**

INDUSTRIAL HALL LHB IN SALZGITTER (GERMANY) – DAYLIGHTING WITH TI

TI as a daylighting element

- **TI as a daylighting material can increase lighting comfort by diffusing daylight.**
- **Transparent insulation can be used to replace glazed parts of the building envelope.**
- **TI glazing is particularly suitable for situations without direct solar radiation and in locations that will not lead to glare problems, such as top sections of windows, parapets and north-oriented clerestories or roof monitors.**
- **TI can be applied in translucent walls or industrial halls, glazed entrance halls of commercial and office buildings, glazed staircases, glazed walls of indoor swimming pools, windows in buildings such as libraries and art galleries and windows of office buildings.**
- **TI glazing can replace regular glazing. TI glazing reduces (outgoing) transmission losses, disperses (incoming) daylight and slightly attenuates light transmission. One cannot see clearly through TI glazing. Therefore, it is not a good choice for view glazing.**

More Solar Concepts

Unglazed transpired collectors

An unglazed transpired collector (UTC) is a dark-coloured perforated plate, through which air is drawn for delivery into a space or a supply air stream. The plate absorbs solar energy, which raises its temperature above that of the surrounding environment. The ventilation air is heated as it passes through the plate. UTCs serve as protective cladding which can be used in place of conventional cladding materials. UTCs are most suitable for buildings with high-ventilation airflow requirements. Typical UTC materials are 0.80 mm thick metals with the size and spacing of the perforations based on the requirements of the application. Unglazed transpired collectors cost 40–160 ECU/m² of collector area, when installed in large-scale applications.

UTCs reduce the energy requirements for heating of ventilation air and can recover heat loss through outside walls.

Integrated photovoltaic systems

Photovoltaic (PV) modules basically convert sunlight directly into electricity. As a result of inefficiencies in modules' ability to capture and convert the sunlight, they also generate heat, which can be put to good use for heating ventilation air. Therefore, combining PV with preheating of ventilation air can be beneficial. PV modules can be integrated as architectural components in facades, in roofs or in glazed elements, such as atrium roofs. At present, investment costs are 1050–1350 ECU/m² of area of PV module. New developments are facade, roof and glass integrated systems in a large variety of forms.

Reference: IEA SHC Programme Task 16: Photovoltaics in Buildings

Roof windows

Roof windows reduce the energy requirements for lighting and heating by admitting daylight and solar radiation into occupied areas. Standardized products, including skylights and roof monitors, are very common in new buildings and building renovations. Glazing materials include glass (low E, multiple-pane, gas-filled etc.) and plastics. In order to save energy, roof apertures and daylight distribution systems must be designed with both heating and cooling load impacts taken into account and must be integrated with the electrical lighting system through the use of daylighting controls.

Double glazing with low-E coating

Replacement of existing windows with new ones that have an improved insulation value is known as a common and effective way to improve the building envelope. Low-E glazing improves the balance between transmission losses and solar gain, without significant extra costs.

Reference: IEA SHC Programme Task 18: Advanced Glazing Materials

Second-skin facade

A second-skin facade is an additional building envelope installed at a distance from the existing facade. The new internal space that is created provides additional insulation and will be heated by solar radiation. Second-skin facades may be used for all building types, although offices, schools and industrial buildings seem to be most suitable.

The buffer zone may have a function in the HVAC system, by providing preheated ventilation air or by extracting air.

Design Integration

Design integration is of critical importance in achieving maximum benefits from a solar renovation project. This means close cooperation among building owners, architects or designers, engineers and solar-energy consultants throughout the design, construction and initial post-renovation building operation phases.

The renovation process and its participants (those given in bold are always involved, while the involvement of others depends on the local situation)

Decision making	Ministries Municipality **Building owner** Occupants
Design	**Building owner (technical services dept)** Municipality (city planning, public works) Architect Engineering consultant Energy consultant Occupants
Approval	**Municipality (local authority dept)**
Construction	**Building owner** Contractor Installer Municipality Utilities, inspection
Occupancy and use	**Building owner (maintenance dept, tenancy services dept)** Occupants Municipality Utilities

What can a building owner do?

A building owner can make inventories of her/his building stock, develop short- and mid-term planning of renovation activities and look for opportunities to integrate solar energy. The most important step for the building owner is selecting a design team that has experience of solar strategies. This experience is important in identifying the opportunities, in evaluating design alternatives and in developing the design details and specifications.

How should the design team work ?

The renovation goals should be established at the outset, with each team member given a clear understanding of the major problems to be solved and the benefits hoped for. The solar concepts should be introduced and evaluated early in the design process, and be dealt with as an integral part of the design development.

All team members should be involved throughout the process. Modular products, such as prefabricated roof module collectors, glazed balcony facades and TI facade elements, make construction on site easy and quick.

What should local authorities know ?

Planning and building regulatory bodies should be able to evaluate the solar designs against current building codes. In some cases local authorities will need experts' assistance in evaluating the solar renovation designs, as they may not yet be referenced in national or local building codes.

What is the role of the occupants ?

Depending on the design elements and the specific solar features selected, occupant behaviour can have varying degrees of influence on the success of a renovation project. For certain measures, such as preheating ventilation air or using glazed balconies, occupant behaviour is critical in achieving energy savings. For others, such as roof-integrated collectors, it is of much less importance. In any case, it is desirable to have occupant input into the process, in order to increase the likelihood of acceptance and satisfaction.

IEA Solar Heating and Cooling Programme Task 20 Projects

Several examples from renovation practice demonstrate the possibilities of Solar Energy in Building Renovation. Within the framework of IEA Solar Heating and Cooling Programme Task 20, feasibility studies have been undertaken for a number of projects, some of which are already under renovation.

Feasibility studies in the framework of IEA SHC Programme Task 20

Thomas Stone High School, Waldorf, Maryland, USA

- Solar energy measures: Unglazed transpired air collectors for ventilation preheat, daylight using skylights, light ducts
- Building type: High school with original floor area of 15,000 m²
- Building year: 1968
- Building owner: Charles County Board of Education
- Status: Construction from 1996 to 1999, although solar energy measures are not likely to be implemented
- Other renovation measures: The renovation will also include 5600 m² of additional new space, upgrade to conform to existing codes (accessibility for handicapped people, fire ratings etc.), high-efficiency chillers/boilers, conversion to VAV system and variable speed pumps
- Total investment: 11 MECU (US $13.5 million)
- Investment in solar renovation: 81,500 ECU (US $100,000)
- Energy savings: 100 MWh/year (solar applications)

Hoog Zandveld, Nieuwegein, The Netherlands

- Solar energy measures: Collective solar hot water boiler (DHW), glazed balconies
- Building type: Apartment blocks and single-family houses
- Building year: 1975
- Building owner: Woningbouwvereniging Onze Woning
- Status: Feasibility study
- Other renovation measures: Insulation of thermal bridges, double glazing in bedrooms, roof insulation
- Investment in solar renovation: 7300 ECU/apartment
- Energy savings: Solar DHW system 15 kWh/m² per annum, glazed balcony 39 kWh/m² per annum of heated floor area

Technical University, Lucerne, Switzerland

- Solar energy measures: Remove part of suspended ceiling to activate storage mass for solar energy, plus version 1: single glazing as second skin in front of the existing facade, or version 2: double glazing with IR-reflective coating as second skin in front of the existing facade
- Building type: School with 2–5 storeys and a heated floor space of 27,500 m², of which examined 5390 m²
- Building year: 1972 and 1977
- Building owner: Canton Lucerne
- Status: Feasibility study
- Other renovation measures: Insulation of the parapet, new windows and replacement of the lighting system (version a) or version with extra insulation of window frames and removing a part of the suspended ceiling (version b)
- Investment in solar renovation: 160–250 ECU/m² of heated floor area per annum
- Energy savings: 40–60 kWh/m² per annum

Rue Sedent, Jambes, Belgium

- Solar energy measures: Glazed galleries along the eastern facade
- Building type: 66 apartments in a residential building with 8 storeys
- Building year: 1976
- Building owner: Not known
- Status: This project will not be realized
- Other renovation measures: Increasing natural lighting by constructing light cores for the garages and staircases, balconies on the west facade
- Investment in solar renovation: n.a.
- Energy savings: About 25%, from 64–47 kWh/m² per annum

Rannebergen, Göteborg, Sweden

- Solar energy measures: solar heated air from roof mounted air collectors, circulated in prefabricated insulated facade elements on the north facade, simple solar walls on the south facade
- Building type: 188 apartments in one multifamily building
- Building year: Approximately 1975
- Building owner: Göteborg Stads Bostads
- Status: Proposed as a Thermie project
- Other renovation measures: Refurnished apartments, concrete facade element renovation
- Investment in solar renovation: 95 ECU/m² of heated floor area
- Energy savings: Roughly 40% compared to the existing situation

Rue Jacobs 70, Perwez, Belgium

- Solar energy measures: Addition of a two-level greenhouse on the south-east facade
- Building type: Single family row (terrace) house with two living floors, a cellar and an unoccupied attic
- Building year: End of 19th century
- Building owner: Owner-occupied
- Status: This project will not be realized
- Other renovation measures: Enlarging the living space by redistribution of the inner rooms, raising the natural daylight contribution by a new design for the staircases (including a light core) and lowering the garden level, insulation of the attic and adding the roof windows
- Investment in solar renovation: n.a.
- Energy savings: Nearly 40%

Renovation projects in the framework of IEA SHC Programme Task 20

1 Brandaris, Zaandam, The Netherlands

- Solar energy measures: Collective solar hot water boiler (DHW), glazed balconies, TI walls
- Building type: 384 apartments in a multifamily residential high-rise building of 14 storeys
- Building year: 1968
- Building owner: Woningstichting Patrimonium, Amsterdam
- Status: Realized in 1997, Thermie (SHINE)
- Other renovation measures: Insulating cavities, ceiling, low-E glazing, improved airtightness, three-speed individual mechanical exhaust ventilation, individual heat metering, connections for hot-fill equipment
- Investment in solar renovation: 4700 ECU per apartment, 59 ECU/m²
- Energy savings: 57%, energy demand for space heating will be 48 kWh/m² per annum and for DHW 32 kWh/m² per annum

2 Onsala, Göteborg, Sweden

- Solar energy measures: New prefabricated roof module with an integrated solar collector, that can be applied on both existing and new multifamily buildings
- Building type: 36 apartments in nine blocks
- Building year: 1996
- Building owner: EKSTA Bostads, Kungsbacka

1 2 3 4 5

- Status: Realized in 1996
- Other renovation measures: Well insulated buildings
- Investment in solar renovation: 20 ECU/m² of floor area per annum; 260 ECU/m² of collector area per annum
- Energy savings: Total heating demand, including DHW, less than 100 kWh/m² per annum, of which approximately 25% is covered by solar energy

3 The Yellow House, Aalborg, Denmark

- Solar energy measures: Glazed balconies, preheating of ventilation air in ventilated solar walls with integrated PV-modules, integrated lamellas in south-facing windows and roof integrated solar collectors (DHW)
- Building type: Eight apartments in a four-storey residential building
- Building year: Approximately 1900
- Building owner: The Municipality of Aalborg
- Status: Renovation in 1996
- Other renovation measures: Larger windows in a new facade with highly insulating low-E glazings, facade insulation, demand-controlled ventilation system, energy-efficient appliances
- Investment in solar renovation: 156,000 ECU per apartment, 2,780 ECU/m²
- Energy savings: 60% for space heating and ventilation (to less than 50 kWh/m² per annum) and 50% for DHW

4 Affolternstrasse 38, Hedingen, Switzerland

- Solar energy measures: TI system on south facade with lamella blind, solar preheating of DHW
- Building type: 11 apartments in a residential building of three storeys
- Building year: 1969
- Building owner: Pension fund of Ernst Schweizer AG
- Status: Renovation started in 1995
- Other renovation measures: Thermostatically controlled radiator valves, insulation of heat pipes, attic floor and cellar ceiling, new heating system and separation of DHW from space heating system, new windows
- Investment in solar renovation: 5500 ECU per apartment, 86 ECU/m² of heated floor area
- Energy savings: 30%

5 Brugghof 11, Niederurnen, Switzerland

- Solar energy measures TI elements on south-west facade with external lamella blinds, 1 kW roof installation with PV tile system
- Building type: 12 apartments in a four-storey residential building
- Building year: 1971
- Building owner: Stiftung Wohnkolonie Eternit, Niederurnen
- Status: Renovation in 1996
- Other renovation measures: This building had previously been renovated some years ago; extra measures now are insulation of roof, cellar ceiling and facade, new windows, balconies, kitchen and bathroom installations
- Investment in solar renovation: 6300 ECU per apartment, 79 ECU/m²
- Energy savings: 46%, 54 kWh/m² per annum

6 Valency building, Lausanne, Switzerland

- Solar energy measures TI on all facades (130 m²), with venetian blinds to prevent summer overheating and radiative losses during the night in the heating season. Outside single glazing protects the system from the weather
- Building type: Small one-family residential house
- Building year: 1957
- Building owner: Lausanne Public Utilities
- Status: Renovation carried out in 1995
- Other renovation measures: Glazed balconies
- Investment in solar renovation: 1200 ECU/m² for the TI walls
- Energy savings: 60%

7 Wollerau, Switzerland

- Solar energy measures: TI wall heating with prefabricated TI facade elements
- Building type: Multifamily building
- Building year: 1965
- Building owner: Gebrüder Frey AG
- Status: Renovated in 1996
- Other renovation measures: Roof renovation and insulation, window replacement, low-E glazing, facade insulation with 100 mm mineral wool, new shading systems
- Investment in solar renovation: 610 ECU/m² TI facade area
- Energy savings: 70 kWh/m² of TI facade area per annum. Calculated energy demand after renovation 50 kWh/m² per annum

8 Villa Tannheim, Freiburg, Germany

- Solar energy measures: Prefabricated TI elements on the west facade and a 7.5 m² flat-plate solar collector for pre-heating DHW and space heating
- Building type: Multifamily building, now mainly used as an office building, with three storeys and a heated area of approximately 540 m²
- Building year: 1900
- Building owner: Municipality of Freiburg
- Status: Renovated in 1995
- Other renovation measures: New glazing and frames, facade insulation and new heating device
- Investment in solar renovation: 11,000 ECU for the TI facade (50 m²) and 8900 ECU for the collector system
- Energy savings: 70% of 250 kWh/m² per annum for heating; 50% savings on DHW

9 Industrial hall LHB, Salzgitter, Germany

- Solar energy measures: TI inside the glazed area of the building
- Building type: Industrial assembly hall of 40,000 m²
- Building year: 1940
- Building owner: Linke-Hofmann-Busch (LHB)
- Status: Renovation from 1995 to 1997, started with the west facade
- Other renovation measures: The reconstruction of the glazed facades is the first step in a bundle of measures to improve the whole energy supply to the hall, which also has to be reconstructed afterwards
- Investment in solar renovation: 2 MECU for the whole project with a facade area of 7440 m², TI construction 145 ECU/m²
- Energy savings: Approximately 15% of former 350 kWh/m² per annum + reduced electricity for lighting

10 Västra Gardstensbergen, Göteborg, Sweden

- Solar energy measures: Roof-integrated collectors for preheating DHW, glazed balconies and TI
- Building type: multifamily buildings
- Building year: Approximately 1975
- Building owner: Bostads AB Gårdsten, Göteborg
- Status: Thermie (SHINE)
- Other renovation measures: New inclined roofs, additional loft insulation, new windows, heat recovery
- Investment in solar renovation: 60 ECU/m² of heated floor area
- Energy savings: Roughly 40% of present 270 KWh/m² per annum heated floor area for heating and ventilation

6 7 8 9 10

Literature and Addresses

IEA SHC Programme Task 20 publications

IEA SHC Programme 20 Brochures

- Solar Energy in Building Renovation
- Solar Collectors in Building Renovation
- Glazed Balconies in Building Renovation
- Transparent Insulation in Building Renovation

Developed under the Subtask on Dissemination, led by Chiel Boonstra, W/E Consultants Sustainable Building, The Netherlands.

Published by and available from:
James & James (Science Publishers) Ltd, 35-37 William Road, London NW1 3ER, UK, 1997
Email: james@jxj.com

IEA SHC Programme Task 20 Technical Reports

Subtask A: Evaluation of Existing Building Applications. 'Solar Energy in Building Renovation', Jan-Olof Dalenbäck, Building Services Engineering, Chalmers University of Technology, Göteborg, Sweden. Summary article published in Energy and Buildings 24 (1996) 39–50.

Subtask B: Improved Solar Renovation Concepts. Improved Solar Renovation Concepts, edited by André de Herde, Architecture et Climat, Louvain-la-Neuve, Belgium, 1997

Subtask C: Solar Renovation Demonstration Projects. Solar Renovation Demonstration Projects. Design of Solar Renovation Projects, edited by Olaf Bruun Jørgensen, Esbensen Consulting Engineers, Copenhagen, Denmark, 1997

IEA SHC Programme Task 20 organization

Operating agent (OA) and operating agent assistant

SWEDEN: **Arne Elmroth (OA)**
Elisabeth Kjellsson
(OA assistant)
Dept. of Building Physics
Lund University
PO Box 118
S-221 00 Lund
Email: Arne.Elmroth@byggtek.lth.se
Elisabeth.Kjellsson@byggtek.lth.se

Experts from the participating countries

BELGIUM
André de Herde
Centre de Recherche en Architecture
Université Catholique de Louvain
Place de Levant 1
B-1348 Louvain-la-Neuve
Email: deherde@arch.ucl.ac.be

DENMARK
Olaf Bruun Jørgensen
Esbensen Consulting Engineers
Teknikerbyen 38
DK-2830 Virum
Email: o.b.joergensen@esbensen.dk

GERMANY
Karsten Voss
Fraunhofer Institute for Solar Energy Systems
Oltmannstrasse 5
D-79100 Freiburg
Email: karsten.voss@ise.fhg.de

THE NETHERLANDS
Chiel Boonstra
W/E Consultants Sustainable Building
Crabethstraat 38j
PO Box 733
NL-2800 AS Gouda
Email: boonstra@w-e.nl

SWEDEN
Jan-Olof Dalenbäck
Building Services Engineering
Chalmers University of Technology
S-41296 Göteborg
Email: jod@vsect.chalmers.se

SWITZERLAND
Andreas Haller
Ernst Schweizer AG
Metallbau
CH-8908 Hedingen
Email: ahaller@access.ch

USA
Robert T. Lorand
Science Applications Int. Corp.
1710 Goodridge Drive, McLean
Virginia 22102
Email: lorandr@tcplink.nrel.gov