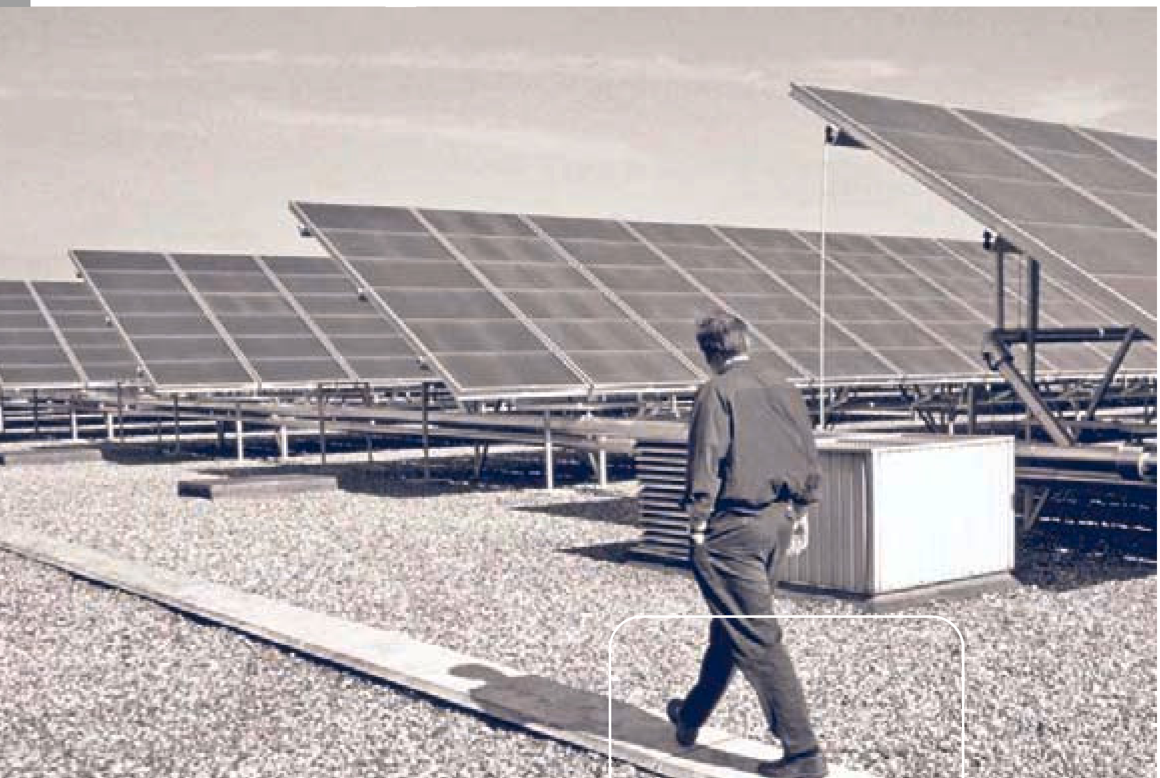
Solar Heat for Large Buildings



Guidelines and Practical Examples for Apartment Buildings, Hotels and Business

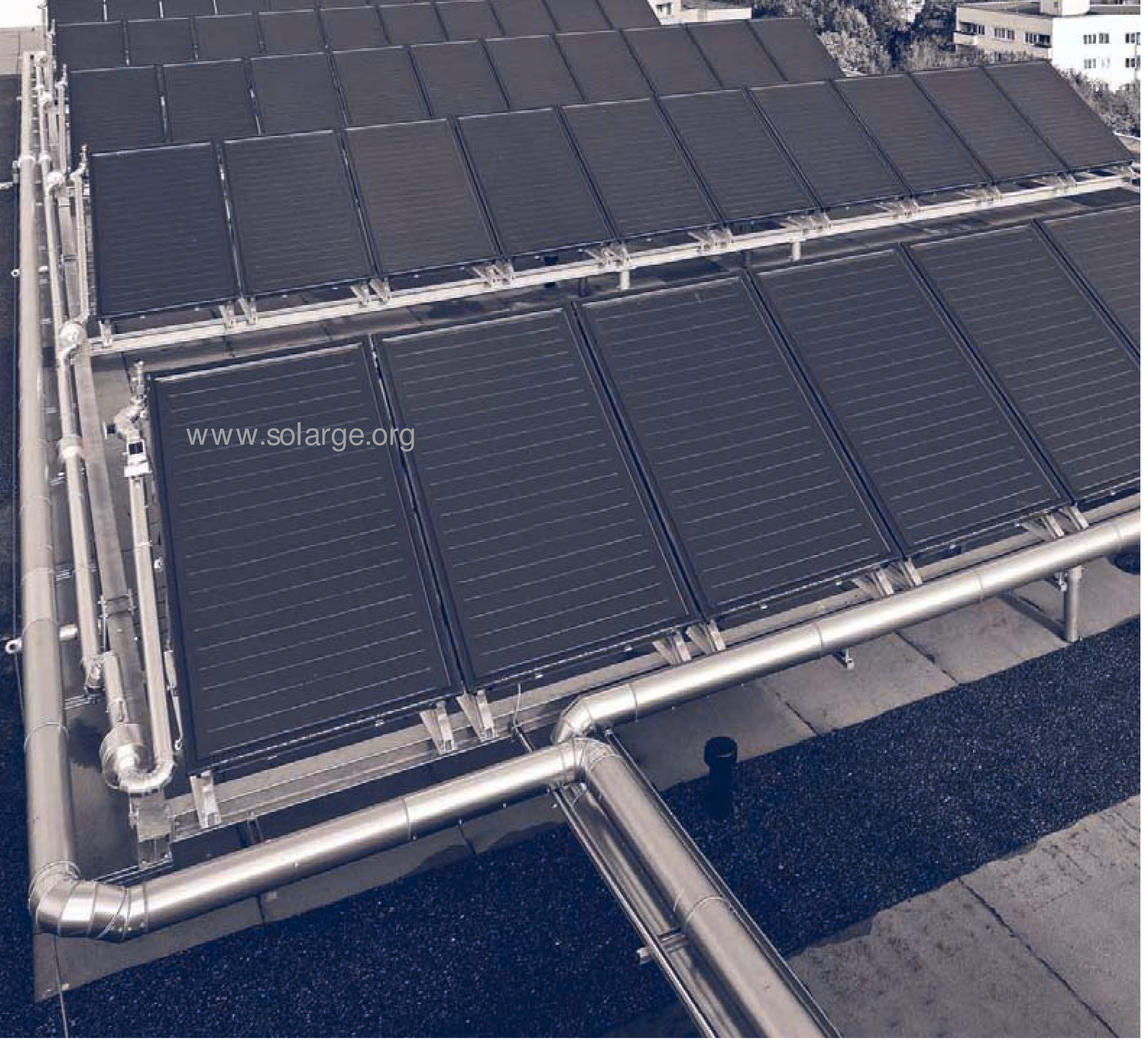
This publication was compiled
as part of the EU SOLARGE project

Intelligent Energy Europe

Foreword

Rising oil and gas prices, climate change and growing energy import dependency place our current energy supply arrangements under increasing threat. A major challenge for the future is to cut fossil fuel use to a minimum. About a third of Europe's final energy consumption is accounted for by space and water heating in buildings. Conserving energy and using renewables in this sector can reap massive cost savings and are an efficient way to help slow climate change.
This brochure is intended for building planners in the residential building, hotel and local government sector who aim to make buildings ready for the solar age. It presents examples of large solar thermal systems across Europe together with experience gathered in operating them.
The brochure has been produced as part of the European SOLARGE project, in which eleven organisations from eight countries around Europe use a wide range of measures to promote solar thermal systems in apartment buildings, hotels and municipal facilities. The examples are intended to encourage similar projects and invite replication.

The SOLARGE Team


www.solarge.org

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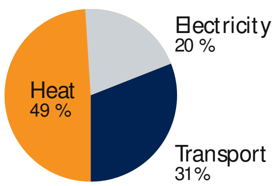
Large Solar Thermal Systems

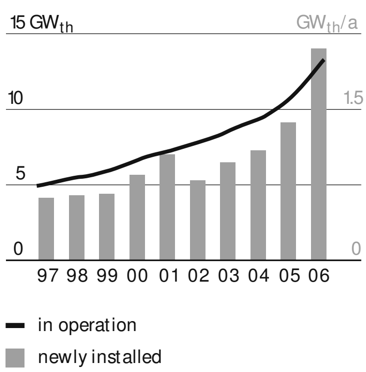
The great majority of solar thermal systems now in use belongs to detached or semi-detached houses.
But solar thermal systems are increasingly being used in larger buildings: apartment blocks, hotels and catering establishments, and public buildings.
Many large systems are already installed in Europe. The experience gained with these systems is so positive that many operators are planning more systems.
One important lesson learnt is that the design of large solar systems cannot be standardised. Each system must be individually designed, taking into account the circumstances and user needs. A task and a challenge for all architects and engineers involved.

Solar thermal: market development

The use of solar thermal heating has spread rapidly in recent years. Solar systems with a total collector area of some 19 million square metres are now installed across Europe. This impressive figure shows the technology has long matured and is established in the market. The European Solar Thermal Industry Federation (ESTIF) forecasts that total installed collector area will increase by 30 % a year over the long term. However, market penetration varies greatly between different EU states.



About half of final energy consumption is used in generating heat, most of it for buildings.



Growth of solar thermal energy in Europe
Solar thermal energy is booming. Over 19 million square metres (13.5 GW$_{th}$) of solar collectors were in operation across Europe by 2006.
Source: ESTIF

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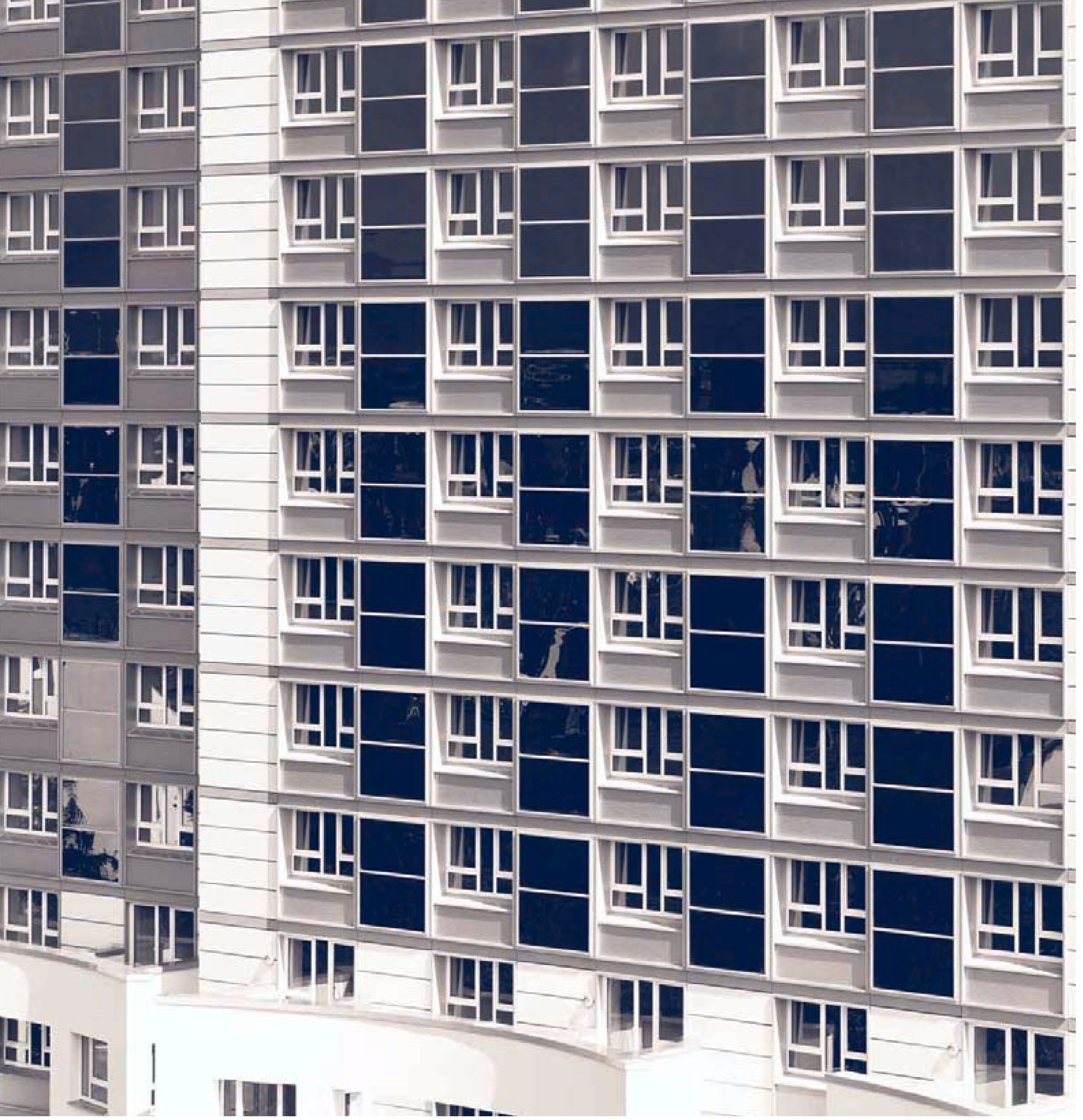
Flat plate collectors
Photo: Conergy



Fields of Application

Solar thermal energy can be used wherever low-grade heat is needed: For hot water, to supplement space heating, and to generate process heat for thermally driven air conditioning systems.
Solar thermal systems can supplement the supply of heat to buildings in summer, late spring and early autumn.

Apartment buildings

Large solar thermal systems on apartment buildings in Europe are mostly used to provide hot water. In central and northern regions of Europe there is also a trend towards 'combi-systems' that supplement space heating.

Public buildings

Sports facilities, old people's homes and swimming pools are generally well suited to solar thermal energy because they need hot water in large quantities. As administrative buildings mostly only need space heating, solar thermal systems are not suitable for such buildings unless air conditioning is required.

Hotels and restaurants

Hotels are very well suited to the use of solar thermal energy because they tend to be busiest in the summer months and in late spring and early autumn.
Solar energy is also useful to hotels and restaurants as a marketing instrument to attract environment-conscious tourists.

Apartment building, Salzburg, Austria
Photo: S.O.L.I.D./Austria Solar

Hotel du Golf de Valescure, France

Car wash Center in
Oberursel, Germany

Photo: Wagner-Solar.com

Swimming pools

Solar water heating in hotels combines excellently with water heating for swimming pools. Surplus heat is easily transferred to pool water, improving user comfort at no extra energy cost.

Solar air conditioning

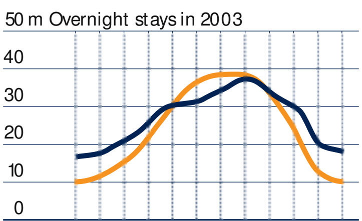
Hotels and restaurants often have large air conditioning needs, as do as hospitals and public buildings. Solar thermal energy can be used here in existing thermally driven air conditioning systems.

Car washes

Solar thermal systems provide a simple way of heating water for car washes. Heating the water also saves on detergent. It may make sense to connect repair shops and showrooms into the solar system to smooth heat demand over time.

Solar thermal energy for contractors

Solar thermal energy is also attractive as a product for energy suppliers and contractors. They can install collectors on factory, warehouse and residential roofs or on spare land and sell the generated heat to consumers or a district heating network. This makes for predictable energy prices and stable heat generation costs for district heat, in both cases for the long term.



Bed occupancy
Solar power

Bed occupancy and solar power
In many hotels (chart: Germany) hot water consumption tracks solar energy availability over the year.

Source: Federal Statistical Office 2005

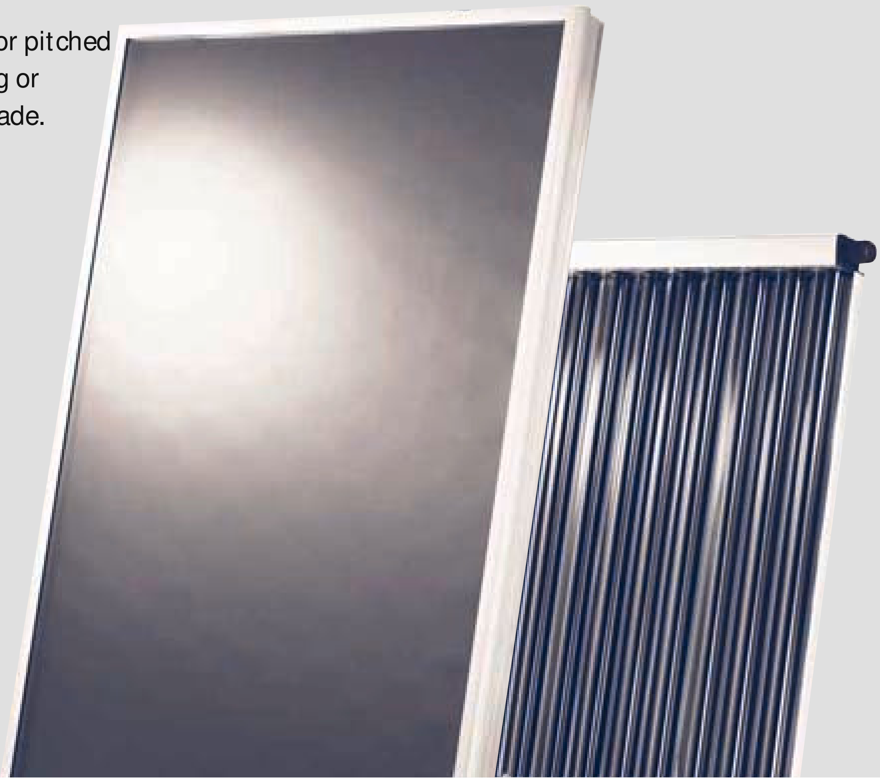
UPC Arena Graz, Austria:
Local heat management contracted to nahwaerme.at

Photo: S.O.L.I.D./ESTIF

Components
Collectors and Storage tanks

Collectors

A roof-mounted solar collector captures sunlight and converts it into heat. The unit's absorber has what is called a selective surface coating, allowing it to convert even diffuse or winter day solar radiation into heat energy with high efficiency. The collector is protected by tempered glass which can withstand even hailstones.
Collectors can be mounted on a flat or pitched roof, integrated into the roof cladding or installed as part of the building's facade.



Most modern solar thermal systems use flat plate or vacuum tube collectors. The required system temperatures as well as the mounting mode determine the type of collector.

Collector types overview

Collector Type	Heat Transfer Medium	Applications
Air collector	Air	Preheating for factory shed air-drying systems, 'open' air conditioning systems, and solar drying
Glazed flat-plate collector	Water or water-glycol mixture	Hot tap water, space heating, so-called 'open' and 'closed' single-stage air conditioning/chiller systems and preheating of industrial processes
Vacuum tube collector (direct flow)	Water or water-glycol mixture	Hot tap water, space heating, single-stage and two-stage air conditioning/ chiller systems and preheating of industrial processes
Vacuum tube collector (heat pipe)	Indirect heating of the heat transfer medium (Water or water-glycol mixture)	Hot tap water, space heating, single-stage and two-stage air conditioning/ chiller systems and preheating of industrial processes

Heat storage

Short-term storage

Short-term storage units store captured solar heat for several days to make up for rainy weather. Good temperature stratification is an important factor in such units. They are therefore made tall and slender so stable strata spanning a large temperature range can be built up over their height. Collector return flow temperatures should be as low as possible. This is a precondition for high system efficiency. Solar thermal energy can be made to cover up to 30 % of total heat demand.

Seasonal storage

Seasonal thermal storage is mostly used in district heating networks and can retain heat for several weeks. There are hot water, gravel/water, borehole and aquifer systems.
Hot water tanks used in seasonal heat storage are several thousand cubic metres in volume. Seasonal storage is mostly used in residential areas with hundreds of individual apartment buildings, but latterly as well as in separate apartment buildings. Seasonal storage allows solar energy to meet up to 100 % of total heat demand.

Solar thermal storage tanks

100 % solar-heated apartment building (under construction), by Jenni Energietechnik – completed in August 2007
Photo: Jenni Energietechnik AG, Switzerland

Seasonal thermal storage technologies

Borehole heat storage

Solar heat is transferred to the ground via boreholes 20–100 metres deep and is drawn upon as needed. Due to the lower thermal capacity of soil, the stores are generally three to five times larger than hot water units. However they are less complicated to build and can be extended as needed. No direct contact with groundwater is an advantage.

Gravel/water heat storage

Pits lined with special sheeting are filled with a gravel/water mixture. The heat is transported to the store by the water itself or through coiled pipes. Gravel/water storage has a lower heat capacity than straight hot water storage units and needs a bigger volume (about one and a half times).

Aquifer heat storage

This form of storage uses groundwater to store thermal energy. Groundwater raised from a borehole is warmed by a heat exchanger and then returned to the aquifer via a second borehole. The heat is recovered by reversing the flow. The cost per unit heat generated is relatively low, but such systems require specific hydrogeological conditions which do not exist everywhere.

Components
Additional elements

Heat exchanger

The solar heat captured by the collector is transferred to the heating circuit by a heat exchanger. On large solar thermal systems this is usually an external unit.
The heat exchanger hydraulically separates the different circuits so each one can be optimally run.
Heat exchangers are also used in what are known as fresh water stations. These heat mains water separately in each apartment, using the heating circuit as heat source. This is a cost-effective system because there is no need for protection against legionella or for additional pipework to distribute hot water.

Control

Obtaining the maximum energy yield from a solar thermal system critically depends on the efficient interaction of all system components. The control system is highly important in this regard.
A closed-loop control system controls both the heating and collector circuit. This means that both the solar thermal system and the supplementary heating system are run at optimum resource levels. Modern closed-loop control systems have a heat meter and in some cases remote diagnostics. These allow subsequent adjustment of the solar system and considerably simplify troubleshooting and billing for heating costs.
Freely programmable controllers are also available. These allow the operation of the solar system to be adapted to the individual load profile on the fly .

A well coordinated control of solar and auxiliary heating system is essential for a proper functioning.

Centralised heat control station for solar and conventional heat
Photo: Upmann, Berlin

Auxiliary heating

The supplementary heat supply can be arranged within the building centrally or on a decentralised basis. It can be integrated in series or in parallel.
The supplementary heat supply can be integrated in various ways depending on the situation in the building and the design of the heating and/or hot water system. Technical solutions are available to meet a wide range of needs.

A solar thermal system with decentralised heat storage tanks and auxiliary heating in Spain – El Llimonet
Photo: Qualitat Promocions

System Approaches

Reflecting differences in culture and climate, solar thermal systems are utilised in widely differing ways across Europe. Most systems in Southern Europe are used for supplying hot water. Those in Northern Europe often have a central heat storage unit and additionally provide supplementary heating, but there is also a trend towards district heating networks in which conventional heat sources are boosted by solar thermal energy in late spring and early autumn.
The greatest system differences can be found in heat distribution in apartment buildings. This can be done via the collector circuit, using heat transfer units in individual apartments, or centrally via circulating pipes.

Frostproofing and overheating protection

Collectors are generally prevented from freezing in winter by adding antifreeze. Where the heat transportation medium is pure water (mandatory in the Netherlands), frost protection is provided by a drain-back system.
Control and safety features protect systems from overheating when there is no demand/ no flow through the system, as in summer.

Solar hot water supply

When used to supply hot water, solar thermal systems generally meet up to 60 % of the respective heat demand. Hot water supply is either centralised via a circulating pipe or decentralised with a hot water unit in each apartment.
There are also systems (mostly in Spain) with decentralised storage tanks and supplementary heating units. Supplementary heating takes the form of the boiler station in each apartment supplied by a central collector field.
In centralised systems, protection against legionella is ensured by heating the standby tank once a day to 60 °C. There is no need to protect decentralised systems in this way due to the short distance from heat exchanger to tapes."

Space heating/combisystems

Solar supported space heating can be implemented in centralised and decentralised heating systems. Approx. 10-30 % (in some cases even more) of the entire heat demand will be covered by solar combisystems. How the solar system is integrated depends on solar system design and the building's heating system.

Photo: Pracatinat, Fenestrelle, Italy

Photo: Neuhof-Canonniers, Strasbourg, France

Overheating protection during the summer and frostproofing in winter is essential for safe and steady operation. Reliable and approved features from experienced planners and system providers ensure a well-protected CSTS for both extremes.

Solar systems in new buildings

In a new building, solar thermal technology can be planned as an integral part of the heating system to optimise overall energy supply. Planners have a free hand in deciding how collectors are integrated into the building (for example by making them part of the roof cladding or the building's facade) and the spatial arrangement of heat storage and control units. Boiler, solar thermal and heat storage capacity can also be matched to actual needs. Centralised supply systems are usually chosen for new buildings as the capital cost per unit is lower than decentralised systems.
However, hot water consumption – a key system design parameter – is relatively hard to estimate for a new building. Standardised consumption figures usually overestimate actual consumption. Exact knowledge of future heat loads is essential.

Refurbishment

Exact design and dimensioning is also important for solar thermal systems fitted during building modernisation. It is helpful to collect data on hot water consumption beforehand. Installing solar thermal systems during refurbishment usually means integrating them into existing heating and hot water systems. It often makes sense to replace any auxiliary heating at the same time, and to dimension both the boiler and the storage to match the system as a whole.

Backup for conventional heating

Boilers or heat pumps are available to meet any supply demand when collector output is too low. Solar thermal systems can be combined with generally available conventional heating systems.
Many manufacturers of conventional heating systems offer complete control units to run their systems in combination with solar thermal technology.
Storage for solar heat can be centralised or decentralised according to the heating and hot water system. When retrofitting, existing storage tanks can be kept and supplemented with the solar heat storage unit.

Estimate hot water needs as accurately as possible

Economic operation of a solar thermal system depends on accurate dimensioning to supply the required amount of hot water. If actual consumption is below estimate, the system is overdimensioned. If the storage unit is full but no hot water is used, no more heat can be taken from the solar collector even though the sun continues to shine. Harvested solar energy then goes unused. One solution here is to connect more heat-utilising units to the solar circuit.

382 dwellings provided with solar heat - see example on page 52 for further information.
Photo: Schalkwijk, Haarlem, Netherlands

Heating Circuits

Central heating systems

Solar thermal systems can be integrated particularly easily into central heating and hot water systems. A conventional two or four-pipe system may be used. Storage, control and supplementary heating are centralised.

Decentralised systems

In a decentralised system, the hot water is preheated by a common collector field. Supplementary heating and solar heat storage are provided by decentralised boiler units.

Fresh water units/ semi-decentralised systems

Fresh water units are a third option for integrating solar thermal energy. Heat transfer stations provide heat for hot water in each apartment. The heat source is usually the heating circuit. However, this requires high temperatures in the heat circuit. Fresh water units are therefore only suitable in buildings heated by radiators with an appropriate temperature range.

Boiler room with solar heat storage tanks and control unit

Photo: Sonnenkraft, Munich, Germany

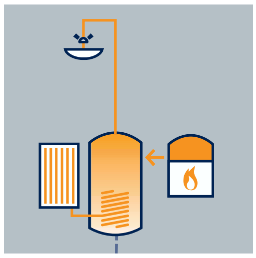
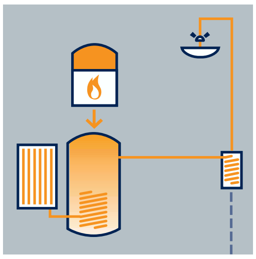
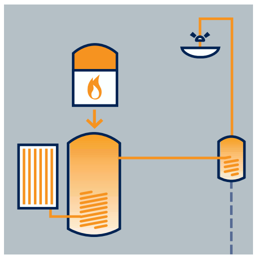
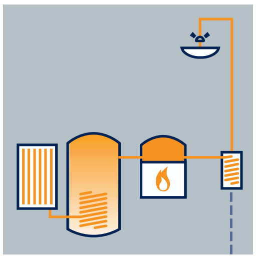
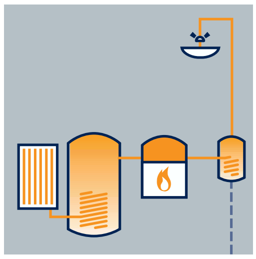
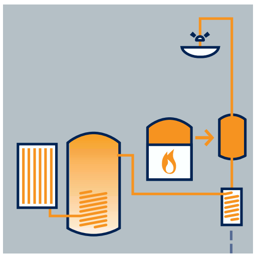
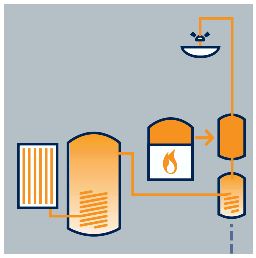
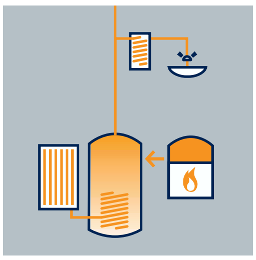
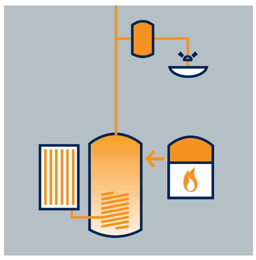
Fresh water unit in a building's two-pipe heating network. Apartment building in Salzburg.

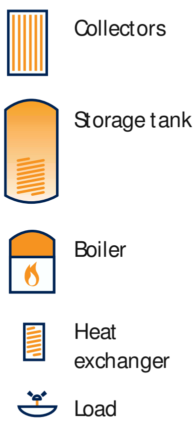
Photo: gswb Salzburg

Solar heat storage, auxiliary heating unit and control unit in each flat in an apartment building in Spain.

Photo: Vertix

Schematic diagram
Integration of a solar thermal system

	Serially connected tap water		Parallel-connected tap water and buffer charging system
Bivalent hot tap water heat storage			
Backup heated buffer storage		 also as tank-in-tank system	
Serial backup heating			
Backup heated tap-water storage * also as fully decentralised system		* 	
Hot water units			



Costs of Solar Thermal Systems

A solar thermal system (including pipework, storage unit, control system and system design) currently costs between EUR 700 - 1,200 per m^2 of collector area. The costs vary according to the collector type, the situation of the building, and the design philosophy used to optimise the system. The following list shows some typical planning scenarios:

Planing scenario 1:
Maximum energy saving
This planning objective can be attained with a solar fraction (solar energy as a fraction of total energy) equalling 30–100 % of the energy needed for hot water and space heating. Heating costs and greenhouse gas emissions are reduced for the long term.

Planning scenario 2:
Reduced heat generation costs
With a solar fraction of 10–20 % (including hot water and space heating), the solar system can operate at maximum output. This minimises the costs of solar heat generation and the payback period. The solar fraction may be higher for some apartment buildings and can reach 50 % for some district heating networks.

Planning scenario 3:
Compliance with legal requirements
Another planning objective can be to reduce a building's primary energy factor and hence its system input/output ratio to comply with legislation like Germany's Energy Saving Ordinance (EnEV) or Spanish Building Codes.

Cost-effectiveness
The cost-effectiveness of a solar thermal system is mostly determined by three factors: capital cost, energy output and oil price trends. Furthermore, considering synergies raises the economics of solar thermal systems. Example: Additional savings can be achieved by making flat plate part of a facade or roof. Due to their construction, flat plate collectors can serve a dual purpose as a heat source and a replacement for thermal insulation.

Dynamically rising prices for oil and gas tend to improve the cost-effectiveness of solar heat.

The profitability of a system is enhanced by further options, e. g. combining civil works, allocations etc. Experienced planners take all this into account.

Dimensioning solar thermal systems

Hot water only

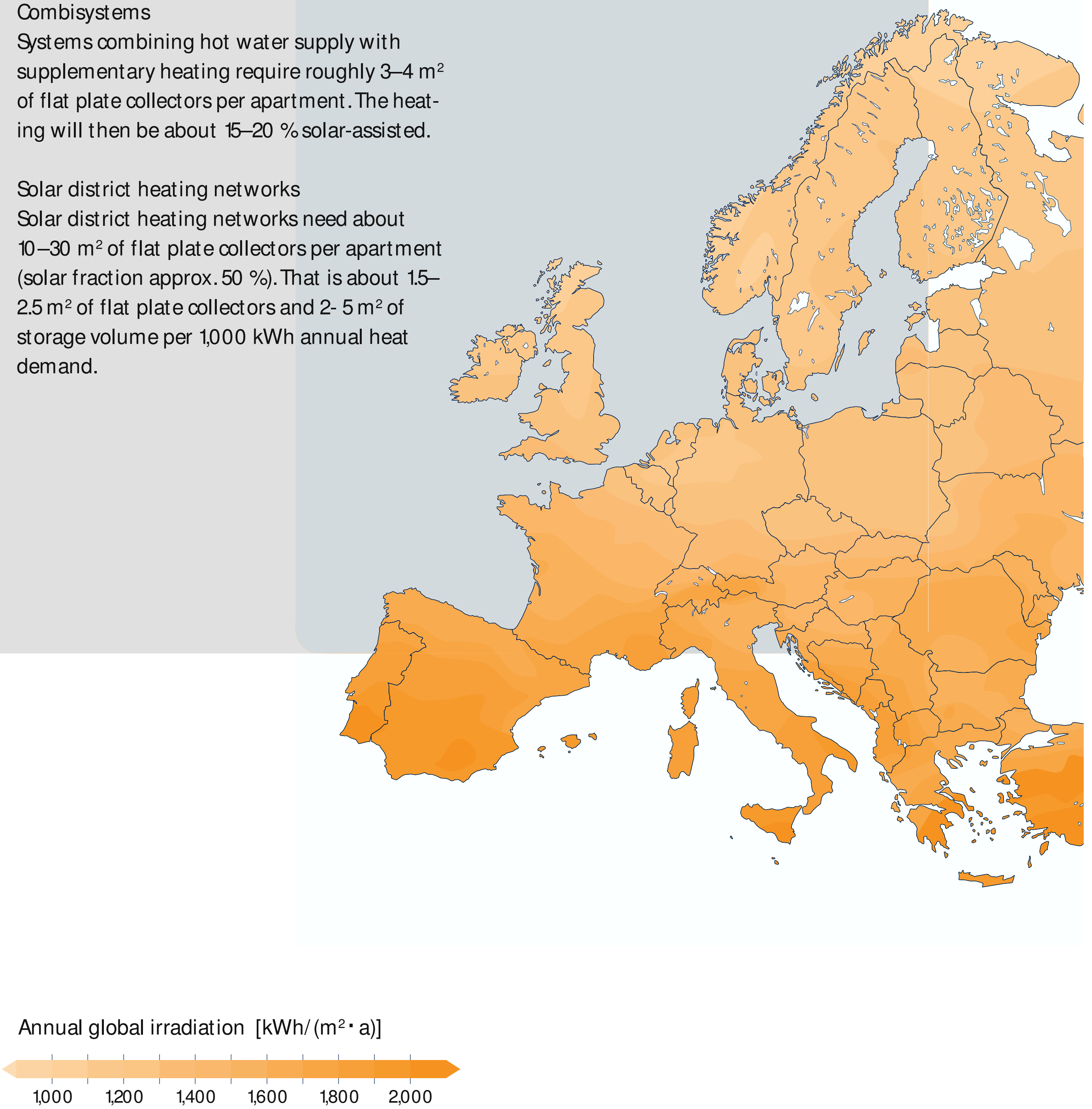
Meeting 50 % of the annual energy needs for hot water requires a collector area of 1–1.5 m² per apartment and about 50–60 l of solar heat storage per m² of collector surface.

Combisystems

Systems combining hot water supply with supplementary heating require roughly 3–4 m² of flat plate collectors per apartment. The heating will then be about 15–20 % solar-assisted.

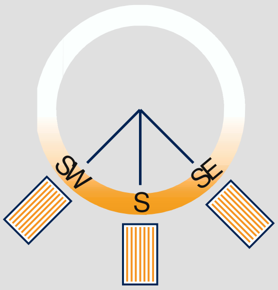
Solar district heating networks

Solar district heating networks need about 10–30 m² of flat plate collectors per apartment (solar fraction approx. 50 %). That is about 1.5–2.5 m² of flat plate collectors and 2- 5 m² of storage volume per 1,000 kWh annual heat demand.



Planning Procedure

Solar thermal systems for large buildings are always tailor-made. This means they need careful, individual planning.
Architects and system designers have to work closely together from the outset. This ensures that the finished system will work optimally. Contractually guaranteed savings make systems an even safer investment for owners.



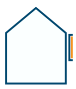
Preliminary planning checklist

1. Does installation of the solar thermal system fit in with the timing of planned modernisation work? The time of the next roof/facade renewal should match the lifetime of the collectors. The same applies for renewal of the heating system.
2. Location: Can the collectors be oriented between SE and SW? Are there any shading objects?
3. Collector mounting: Can collectors be fitted to the roof or integrated into the roof/facade? Is it possible to install entire collector fields?
4. Is there enough space for the solar heat storage tank and is it accessible for installation? What structural changes are needed for the storage tank to be installed?
5. Have all structural and energy system changes to the building been taken into account? Is the solar thermal system aligned to them? Is there further scope for energy improvements?
6. Choice of planning objective between substituting primary energy, minimising heat generation costs and legal compliance (building system input/output ratio or solar ordinances).

Horizontally mounted vacuum tube collectors on flat roof
Photo: Die Fabrik, Berlin (Germany)

40° installation on flat roof

Facade integration
Photo: Wagner-Solar.com



Installation planning checklist

1. Can architect and solar system designer work together from the outset to develop an integrated system?
2. Does the quoted price cover both designing the solar thermal system and matching it to the heating and/or hot water system? Do the solar system installers have experience with large systems? Are the expected energy savings subject to g uarantee?
3. Does the installation planning take into account that new trades will have to be brought into the building work and the heating system must first be optimised from an energy standpoint? Is it ensured that only suitable components and insulation materials for standing temperatures up to 200 °C will be used for the solar thermal system ?
4. Can the system be optimised when operating, i. e. when the building is occupied? When is the timeframe for fine-tuning the system?

Acceptance checklist

Following installation, it is essential to fine-tune the solar thermal system in operation. This optimisation should take place over a pre-set timeframe (e. g. three months). The system is tested at the same time to see if the guaranteed energy savings are achieved. The installers may be required to make adjustments.

Initial acceptance

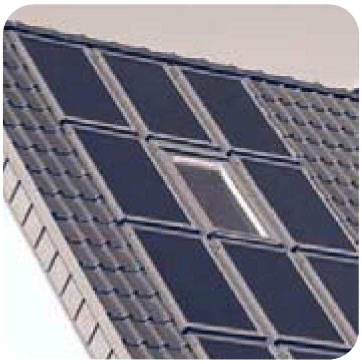
1. Are all system components properly fitted and connected? Have all circuits been tested under pressure?
2. Are all valves and pipes fully labelled?
3. Is the system fully insulated, without gaps in the insulation where pipework passes through walls and ceilings?
4. Are all parameter settings documented?

Final acceptance
(after stipulated period in operation)

5. Are all guaranteed parameters (energy savings) achieved?
6. Are all system components matched (suitably dimensioned heat exchanger, heat meter, temperature sensor, expansion vessel) and properly positioned?
7. Are all parameter settings and modifications to the system documented?

40° installation

Photo: Soli fer Solardach GmbH - Altenpfleheim St. Michael, Dresden (Germany)



Integrated collectors

Photo: Velux

Solar Air Conditioning in a Nutshell

Solar air conditioning systems are offered by several firms in Europe for offices and public buildings. Solar thermal energy is very well suited for running air conditioning systems, as cooling demand tends to correlate very well with the amount of sunshine.

Cooling demand heavily depends on building use, building type, the condition of the building (thermal insulation) and the interior heat load. In Central Europe, residential buildings are expected to need air conditioning for 50 to 200 hours a year. This increases to 1,000 hours for office and industrial buildings. The figure in Southern Europe is far higher, especially for hotels and office buildings.

The output of solar-powered chillers ranges from 10 kW to 5 MW. Such units are used to provide cold water and for air conditioning systems.

The 50–400 kW range is generally served by adsorption chillers operating with a solid adsorbent. The input temperature of about 60–90 °C is provided by flat plate or vacuum tube collectors (coefficient of performance $COP_{thermal}$: 0.5–0.7).

Absorption chillers with a liquid absorbent cover the 15 kw to 5 MW range. Input temperatures on these systems range from 80–110 °C. $COP_{thermal}$: 0.6–0.8 for a single-stage chiller and up to 1.2 for a two-stage system.

Absorption chillers need about 3–3.5 m^2 of collector surface per kW of cooling capacity.

Another system type, known as a sorption-assisted air conditioning system, uses desiccant and evaporative cooling (DEC). After cooling, the refrigerant (water) is expelled from the system. Desiccant and evaporative cooling systems achieve a cooling capacity in the 20-350 kW range. Such systems can be expanded on a modular basis. The operating temperature is only around 45–95 °C. This means the heat can be provided by simple flat plate collectors and in some cases even by air collectors ($COP_{thermal}$: 0.5–1.0). Systems using a liquid absorbent are currently being developed.

As a rule of thumb for open systems, about 8–10 m^2 of collector area can be assumed necessary per 1,000 m^3/hr installed capacity.

Typical performance figures ($COP_{thermal}$) for thermally driven chillers range from 0.5–1.2 depending on the system. However, the $COP_{thermal}$ performance figure differs from the figure used for electrically driven chillers. The coefficient for a thermally driven chiller is defined as the ratio of the heat given off by the cold water circuit and the heat needed to drive the process ($COP_{thermal} = Q_{cold} / Q_{hot}$). On electrically driven chillers, COP_{conv} is the ratio of the heat given off by the cold water circuit and the electrical energy used ($COP_{conv} = Q_{cold} / E_{elec}$).

Factory building with solar cooling, Audi, Ingolstadt, Germany
Photo: Solahart / ESTIF

Solar air conditioning – absorption chiller
Photo: Schüco

Solar air conditioning – adsorption chiller in the university hospital, Freiburg
Photo: Universitätsklinikum Freiburg/Fraunhofer ISE

Best Practice Catalogue

The systems presented by way of example in the following pages are selected from a large, nine-country project database which can be viewed in full at www.solarge.org.

The catalogue is divided into seven applications:

Applications for hot water
A Hot water for apartment buildings
B Hot water for hotels
C Hot water for public and social buildings

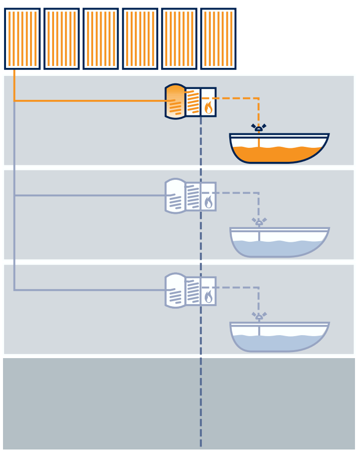
Applications for hot water and space heating
D Hot water and space heating for apartment buildings
E Hot water and space heating for hotels
F Hot water and space heating for public and social buildings

G Other applications

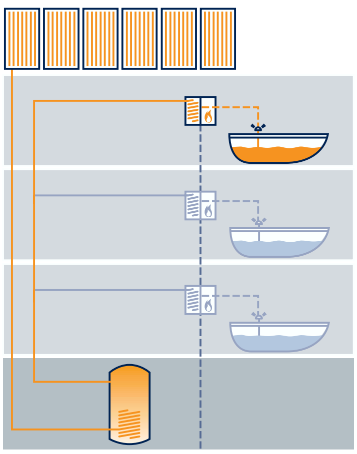
Besides hot water and space heating, some of the systems also provide heat for swimming pools and other purposes.

Survey
In a questionnaire-based survey, data and statements have been collected from system operators, owners and planners. The questionnaires covered over 120 items. In addition to technical and economic variables, survey respondents were asked for general remarks and recommendations for future projects. The facts and experience collected from survey respondents provide a comprehensive insight into the subject. Planners will find relevant technical details together with general requirements for planning and implementation.

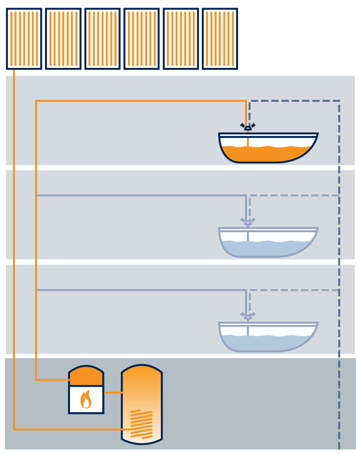
Scheme 1: Direct piping for hot tap water with decentralised solar storage and backup heaters (common in Spain)



Scheme 2: Two-pipe installation for hot tap water with centralised solar storage and decentralised backup heaters



Scheme 3: Two-pipe installation for hot tap water with centralised backup heater and solar storage (common in D, F, I, DK, NL)



Additional note: All systems depend on the situation of the building and local and national laws. In some cases, for example boilers, solar storage tanks etc. are located directly under the roof. The schemes shown provide only a simplified representation of the options for integrating a solar thermal system into a building.

How to use the Best Practice Catalogue

The examples presented in the pages that follow provide an overview of the different types of system. This allows comparison with readers' own plans. The examples are also a source of ideas for improvements to such plans.

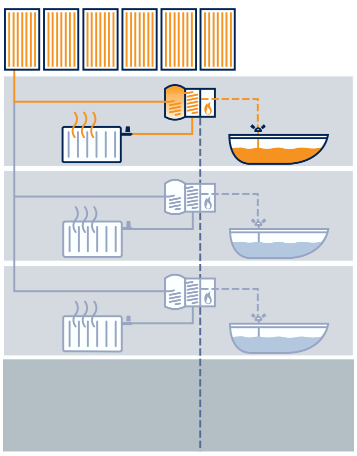
The examples show where solar thermal systems can be usefully integrated into heating systems. A wide range of system approaches is covered so that a suitable system type for every application can be founded.

The number of systems selected bears no relation to the number of systems of each type in operation today. Nor does the selection imply anything about where solar thermal systems are best deployed.

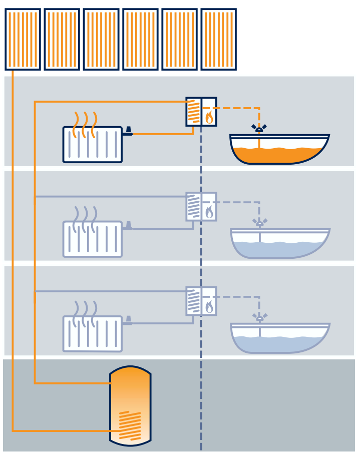
As mentioned elsewhere, the size of a planned solar thermal system always depends on the individual situation (consumption profiles, available installation options, integration into an overall system concept) and cannot be directly inferred from apparently similar systems.

It is therefore always important to obtain advice from professionals with experience in planning large solar thermal systems.

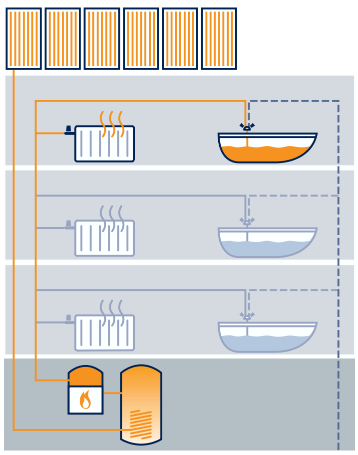
Scheme 4: Direct piping for space heating and hot tap water with decentralised solar storage and backup heaters (common in Spain)



Scheme 5: Two-pipe installation for space heating and hot tap water with centralised solar storage and decentralised backup heaters



Scheme 6: Two and four-pipe installation for space heating and hot tap water with centralised backup heater and solar buffer (common in D, A, I, DK, NL)



Vèrtix - San Cugat des Vallès Multi-Family House

Motivation

The main reason to install the CSTS was the San Cugat des Vallès Solar Ordinance. This municipal ordinance mandates the installation of solar thermal systems for hot water generation in new buildings with a minimum solar proportion of 60 %. This building was the first Vèrtix building where a solar thermal system was installed for hot water generation.

Profile

- Real estate company
- New multi-family house, 39 dwellings
- 61 m² flat-plate collector (gross area), on flat roof
- 60 % reduction of final energy consumption for hot water generation (calculated)

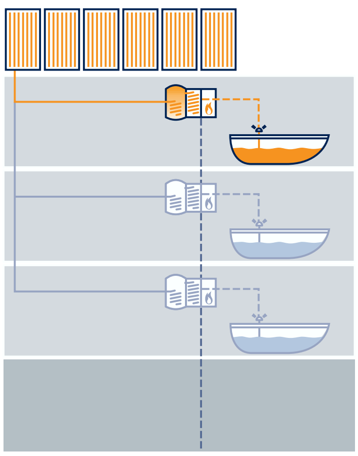
Facts in brief

Year of construction of CSTS	2004/2005
Aperture area of collectors	60 m²
Thermal output	42 kW_{th}
Collector yield	796 kWh/(m²·a)
Total costs of solar hot water system*	89,133 €
Subsidies	0 %
CO_2-emissions avoided	14.13 t CO_2 per year
Reduction of final energy	59,765 kWh/a
Replaced energy source	Natural gas

*costs without conventional heating system

Collector area per apartment:	1.5 m²
Investment costs per apartment:*	2,285 €
Solar fraction of global heat demand:**	60 %

* without consideration of subsidies
** measured



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Technical Description

The solar storage devices are distributed in a decentralised manner and are connected in series to a modulated combination boiler (for space heating and hot water generation).

- operation mode: low-flow
- type of hot water heating: decentralised
- type of space heating: decentralised
- solar buffer storage: 39 x 150 l

Financing

The project developer, Vèrtix, financed the CSTS installation themselves without applying for a subsidy or special loans.

Comments

- "The CSTS installation on San Cugat Vallès was the first one completed by Vèrtix. However, the implementation of the system was mandated by the municipality's Solar Ordinance. It was also taken on as a challenge by the project developer to comply with this obligation. The favourable results of the installation and the lack of major problems gave Vèrtix the confidence to invest in solar thermal systems in future buildings."

"The CSTS is running well. At the beginning there were some complaints because of the noise from one pump. The pump was changed and no more problems have been reported. In the beginning there were also some problems reported with the collector fluid. There were some small leaks in the circuit which caused pressure drops within the circuit. The leaks were detected and repaired and the circuit was filled again."

Decentralised heating system. Solar heat storages and backup heaters are located in each apartment. The building is composed of 39 apartments on 5 floors.

Best Practice No. 2

Tablis Wonen - Sperwerflat I Multi-Family House

Motivation

The project took place as part of an overall renovation of the hot water installation. Small individual gas-fired kitchen tap water heaters that emitted exhaust gases into the dwellings have been replaced by a central solar hot water system. There are several benefits for the tenants:

- hot water facility has been improved;
- indoor air quality has been improved (no more exhaust gases, less humidity);
- problems with mould on the kitchen walls have been solved due to lower humidity in the flats.

Profile

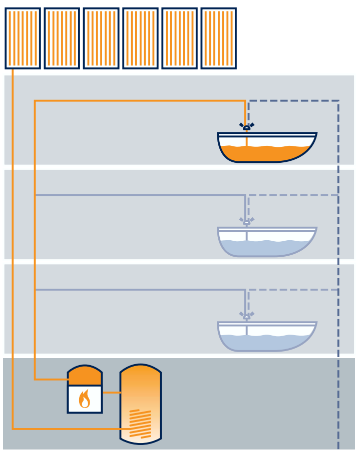
- Social Housing Association
- Multi-Family House (1968), 80 dwellings
- 90 m² flat-plate collector (gross area), on flat roof
- 57,000 kWh/a reduction of final energy consumption (measured)

Facts in brief

Year of construction of CSTS	2003
Aperture area of collectors	89 m²
Thermal output	62.3 kW_{th}
Collector yield	448 kWh/(m²·a)
Total costs of solar hot water system	50,211 €
Subsidies	31 %
CO_2-emissions avoided	10.5 t CO_2 per year
Reduction of final energy	57,000 kWh/a
Replaced energy source	Natural gas

collector area per apartment:	1.1 m²
investment costs per apartment:*	628 €
Solar fraction of global heat demand:	n/a

* without consideration of subsidies



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Technical Description

The solar hot water system consists of a 90 m^2 collector surface and a buffer storage with a storage volume of 3,000 litres. The solar collectors and buffer storage tank are connected by a plate heat exchanger. Solar heat is stored in the tap water. Drain-back protects against freezing and overheating.

- operation mode: high flow
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 3 m^3

Financing

The turn-key system cost amounted to EUR 564/m^2 (total EUR 50,000) paid for by the owner/investor, Tablis Wonen. Subsidies were granted from three sources for a total of 31% of the cost.

Comments

- "The complete retrofitting of the Sperwer building with a central solar hot water system resulted in a lot of 'wins' for the tenants: Better comfort, better indoor air quality, lowered indoor humidity, savings in energy bills and a contribution to climate change mitigation. Since this project, 8 other buildings have been equipped with a similar central solar hot water system."

"Installing solar thermal systems fits in with the social responsibility policy goals of Tablis. This is one such example where the hot water system for the flats has been modernised to improve living conditions (no exhaust gases in the flats, less humidity and mould) and comfort (improved hot water facilities). In order to compensate for the related increase in energy consumption (due to central hot water circulation losses and better facilities) the solar systems were added."

Flatplate collectors and solar heat storage of the Sperwer building

ATC Torino – Multi-Family House

Motivation

ATC Torino, a social housing public agency in the province of Turin, has dealt with environmental and energetic matters since 1996. Whenever possible, new technologies (especially renewable energy sources) have been integrated into ATC's buildings in order to reduce their environmental impact.

Profile

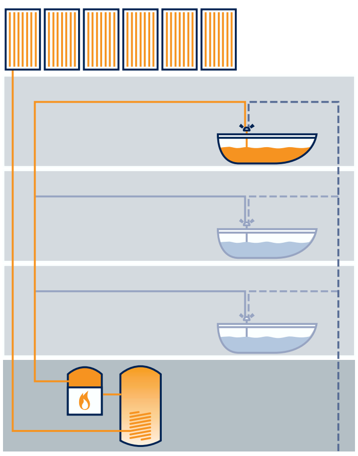
- Social housing association
- Multi-Family House, 42 dwellings
- 96m² flat-plate collectors (gross area), solar roof
- 69 % reduction of final energy consumption for hot tap water (estimated)

Facts in brief

Year of construction of CSTS	2005
Aperture area of collectors	90 m²
Thermal output	63 kW_{th}
Collector yield	633 kWh/ (m²·a)
Total costs of solar hot water system	76,287 €
Subsidies	43 %
CO_2-emissions avoided	20.7 t CO_2 per year
Reduction of final energy	76,000 kWh/a
Replaced energy source	Natural gas

collector area per apartment:	2.1 m²
investment costs per apartment:*	1,816 €
Solar fraction of hot water demand:**	46 %

* without consideration of subsidies
** heat demand for hot tap water generation (value: estimated)



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Technical Description

The solar system heats the buffer storage tank via an external heat exchanger. The buffer storage tank then loads one of three hot tap water tanks through a second external heat exchanger. The other two hot water storage tanks are heated by both the first buffer storage tank and the boiler. In order to assure the sanitary quality of the hot water, the solar hot water tank can also be heated up by the boiler.

- operation mode: low flow
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 4.0 m³

Financing

The province of Turin subsidised a part of the total investment costs through a demonstration programme (publications and presentations from various newspapers, newsletters and exhibitions on the Province's web site).

Comments

- “The building located in Moncalieri near Juglaris, illustrates the appeal of solar thermal technology. Due to the integration of the collectors into a solar roof, which is a cost effective and innovative solution in Italy, our solar thermal system is very attractive from an architectural point of view as well.

Roof integrated flat-plate collectors and solar heat storage in Moncalieri

Best Practice No. 4

WG Karl Marx e.G.– Multi-Family House

Motivation

Within the scope of the refurbishment of the building, a complete modernisation of the heating system including central hot water generation was necessary. For that reason, among others, the possibilities for solar energy integration were analysed. Although hot water provision with a solar thermal system seemed to be a favourable option, the implementation proved to be a great task for the planners and manufacturers involved as well as for us as the building owner. It should be mentioned then that, as of the time of the planning in 1998,

Profile

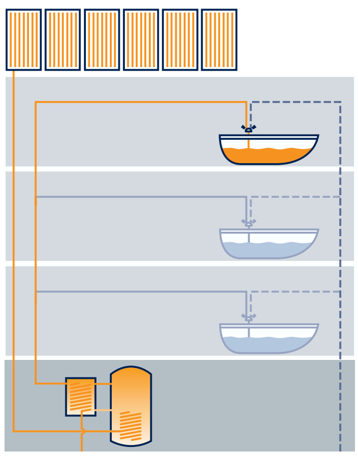
- Co-operative housing society
- Multi-Family House, 258 dwellings
- 222 m² flat-plate collectors (aperture area), on flat roof
- 88,270 kWh/a reduction of final energy consumption

Facts in brief

Year of construction of CSTS	2000
Aperture area of collectors	222 m²
Thermal output	n/a
Collector yield	approx. 300 kWh/(m²·a)
Total costs of solar hot water system	200,000 €
Subsidies	85 %
CO_2-emissions avoided	n/a
Reduction of final energy	88,270 kWh/a
Replaced energy source	District Heating

collector area per apartment:	0.9 m²
investment costs per apartment:*	775 €
Solar fraction of global heat demand:	n/a

* without consideration of subsidies



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For further information, please refer to www.solarge.org

large solar thermal systems for residential buildings were rarely installed so there was limited background experience for the project. In hindsight, the result was very favourable: The end technical and economic performance levels met all the predicted benchmarks.

Technical Description

The solar thermal system consists of a 222m² collector field connected to a separated control unit and storage devices. The solar thermal energy is used only for the generation of hot water.

- operation mode: Low flow
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 9.75 m^3

Financing

The purchase of the system was predominantly financed by soft loans, but 15% was financed by the housing society. The total costs of all implemented renovations (including CSTS) are shared by the tenants within the legal ranges.

Comments

- "The experience gained through this project underline the fact that solar thermal systems are suitable for implementation on large residential buildings. It was shown that technical and economic target values can be achieved. A key factor in the implementation was a good working knowledge of the consumption profiles before the installation of the CSTS. Remote monitoring will ensure the long-term functionality of the system.

WG Karl-Marx e.G.
- collector field

Best Practice No. 5

Municipality of Giurgiu – Policlinica Area Multi-Family House

Motivation

During the summer, the combined heat and power (CHP) plant in Giurgiu does not produce electricity and therefore the hot water supply is turned off completely between April and November. The installation of 300 m² of solar panels on two housing blocks was necessary to supply hot water for 80 flats during the summer months.

Profile

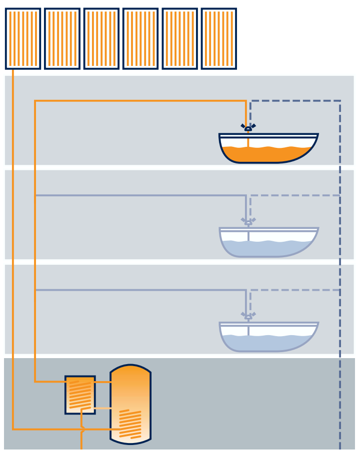
- Municipal housing administration
- 2 Multi-Family Houses, 2 x 40 dwellings
- 300 m² flat-plate collectors (aperture area), on flat roofs
- 58,000 kWh/a of solar heat

Facts in brief

Year of construction of CSTS	2001
Aperture area of collectors	300 m²
Thermal output	210 kW_{th}
Collector yield	193 kWh/(m²·a)
Total costs of solar hot water system	93,666 €
Subsidies	0 %
CO_2-emissions avoided	n/a
Reduction of final energy	n/a
Replaced energy source	District Heating (CHP)

collector area per apartment:	3.8 m²
investment costs per apartment:*	1,171 €
Solar fraction of global heat demand:**	100 %

* without consideration of subsidies
** this solar thermal system supplies 100% of the hot water demand of this both buildings during the summer periode



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Technical Description

It was decided to use a solar thermal system for the provision of domestic hot water during the summer months. A joint system with a large coverage area was built to supply the two housing blocks. Heat is stored directly in the domestic hot water or in existing hot water tanks; 2 x 5 m^3 for each block.

- operation mode: low flow
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 4 x 5 m^3

Financing

The solar project was part of Romania's District Heating Rehabilitation Project for Giurgiu which was financed by the Danish Environmental Agency (DEPA) through the Danish Cooperation for Environment in Eastern Europe programme (DANCEE). The Romanian counterpart contributed using its own financing measures.

Comments

- “The installation of 300 m^2 solar panels on two housing blocks in Giurgiu enables 80 dwellings to be supplied with hot water during the summer months. These flats are the only flats in Giurgiu with hot water supply in the summer and are therefore now very attractive to buy.

Collector field and solar heat tanks in Policlinica Area

Best Practice No. 6

Sundparken – Multi-Family House

Motivation

The Chairman of the housing society motivated the tenants to support the installation of the system despite the rent increase that would be incurred over a limited period of time. Rent rates would then return to lower levels.

Profile

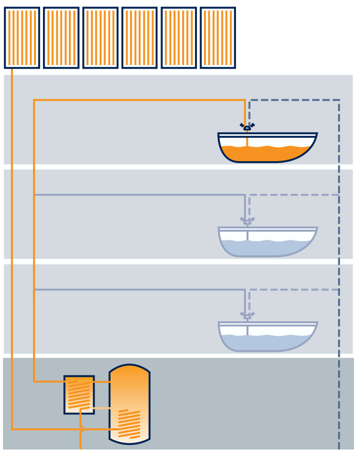
- Co-operative housing society
- Multi-Family Houses, 425 dwellings
- 336 m² flat-plate collectors (aperture area), on roof
- 123,000 kWh/a of solar heat

Facts in brief

Year of construction of CSTS	2000
Aperture area of collectors	336 m²
Thermal output	235 kW_{th}
Collector yield	approx. 366 kWh/(m²·a)
Total costs of solar hot water system	240,000 €
Subsidies	13 %
CO_2-emissions avoided	n/a
Reduction of final energy	123,000 kWh/a
Replaced energy source	District heating

collector area per apartment:	0.8 m²
investment costs per apartment:*	565 €
Solar fraction of global heat demand:**	3.1 %

* without consideration of subsidies
** measured



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Technical Description

The solar heating system is a low flow system with a 10,000 l hot water tank. Due to the orientation of the buildings the CSTS was designed as two separate systems with a common storage tank. Half of the solar collectors (168 m^2) face east, the other half of the solar collectors (168 m^2) face west.
The collector tilt is 15° from the horizontal for all the collectors. Both the east-facing and the west-facing collectors have their own solar collector loop, circulation pump, external heat exchanger and control system.

- operation mode: low flow
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 10 m^3

Financing

The project was financed mainly through reserves from the housing association's own revolving funds as well as a small loan, national subsidies and a tax break.

Comments

- “There is great potential for the expansion of the solar collector area for space heating, but, at the moment, the return temperature from the radiator system is considered to be too high.

Flat plate collectors and the central control system

Best Practice No. 7

ZUP Les Salines – 12 Multi-Family Houses

Motivation

„We would carry on with the approach followed by the city of La Rochelle since 1970. With the district heat development, the restoration of the former solar installation of the Salines would prove to be a necessary thing to do.“

Profile

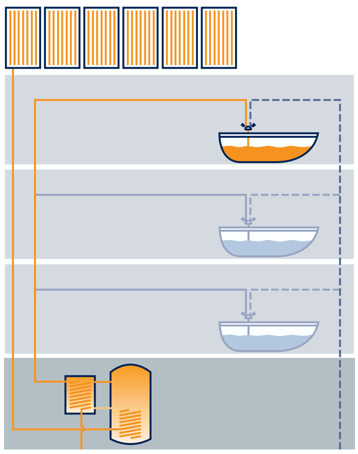
- Mairie de La Rochelle
- 12 Multi-Family Houses, 941 dwellings
- 1,164 m^2 flat-plate collectors (gross area), on flat roof
- 43 % reduction of final energy consumption (estimated)

Facts in brief

Year of construction of CSTS	2005
Gross area of collectors	1,164 m^2
Thermal output	750 kW_{th}
Collector yield	690 kWh/(m^2·a)
Total costs of solar hot water system	1,446,000 €
Subsidies	80 %
CO_2-emissions avoided	210 t CO_2 per year
Reduction of final energy	894,000 kWh/a
Replaced energy source	Diverse (District heating)

collector area per apartment:	1.2 m^2
investment costs per apartment:*	1,537 €
Solar fraction of global heat demand:	n/a*

* without consideration of subsidies



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Technical Description

The CSTS was restored in 2005 and is composed of 1,164 m^2 flat plate collectors installed on flat roofs of the twelve buildings. They are placed in a south/south-western orientation of 25° and with an inclination of 30°. Total solar storage is 58 m^3 shared between the twelve buildings.

- operation mode: variable
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 19 m^3

Financing

The total cost of this project was EUR 1,371,000 excluding VAT and EUR 1,446,000 including VAT (VAT at 5.5%). It was subsidised at 80% by Europe (FEDER funds: EUR 411,494) and by the ADEME / Regional Council of Poitou-Charentes (EUR 685,824).

Comments

- "A former solar installation already existed on this site and La Rochelle City Hall chose to carry on with this approach initiated in the Seventies with a restoration. La Rochelle City Hall arranged an agreement between the public utility company and the Elvo Ocean Company, the installation's operator. This operation was split into three parts, carried out by three different installers. For a project like this, it is important to work with an engineering company with lots of good references.

Boiler room with solar heat tanks, auxiliary heating and control unit

Best Practice No. 8

Fortuna Hotel

Motivation

During a regular pub meeting in the year 2000, hotel owner Manfred Meder and Otto Wehrle, collective solar thermal systems installer and producer of solar storage tanks, discussed the apparent high consumption of hot water in the FORTUNA Hotel. A special topic was the high consumption of oil for the heating of hot water during the warm months. Since the consumption of hot water is a given in hotels, operating costs were able to be reduced through the installation of a well-planned solar thermal system.

Profile

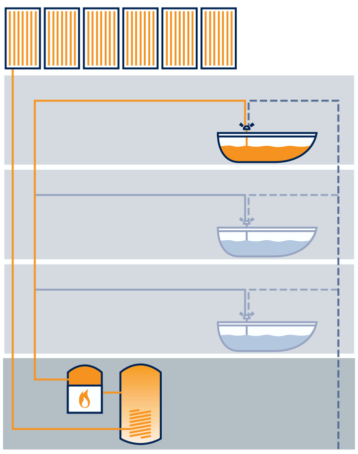
- Private ownership
- Hotel, 70 beds
- 53 m² flat-plate collectors (gross area), roof integrated
- 34,000 kWh/a reduction of final energy consumption

Facts in brief

Year of construction of CSTS	2004
Aperture area of collectors	46.7 m²
Thermal output	33 kW_{th}
Collector yield	546 kWh/(m²·a)
Total cost of solar hot water system	55,000 €
Subsidies	10.8 %
CO_2-emissions avoided	7.5 t CO_2 per year
Reduction of final energy	34,000 kWh/a
Replaced energy source	Heating Oil

collector area per room:	1.3 m²
investment costs per apartment:*	1,571 €
Solar fraction of global heat demand:**	7.7 %

* without consideration of subsidies
** estimated



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Technical Description

The solar storage tanks were built within one insulation jacket in order to cover the connecting pipes. This avoids heat losses between the solar storage tanks.

- operation mode: high flow
- type of hot water heating: central
- type of space heating: central
- tap water storage: 4.1 m³

Financing

The owner is also the investor. Nearly 90 % of the personal invested resources have a calculated return of investment period of approximately seven years. This is due to the planner's many years of experience. About 10.8 % of the project costs were subsidised by the Federal Office of Economics and Export Control (BAFA).

Comments

- "The structural condition of the building, a demand analysis, visiting reference systems, the experienced company that carried out the installation work and proven systems were all part of the successful integration of a solar thermal system into the existing building services. When awarding the contract only companies should be considered which can produce an installation schedule as early as in the preliminary stages. This way unnecessary surprises during assembly can be avoided."

„Finally the operating costs can be reduced with the help of a well-planned and well-installed solar thermal system because hot water consumption is guaranteed in hotels."

Roof integrated flatplate collectors of Hotel Fortuna and piping located in the gable

ACCOR Group – Hôtel Novotel Sophia Antipolis

Motivation

The solar installation was carried out with the help of the ACCOR Group's commitment to be involved with sustainable policy and to improve the brand image of the hotel.

Profile

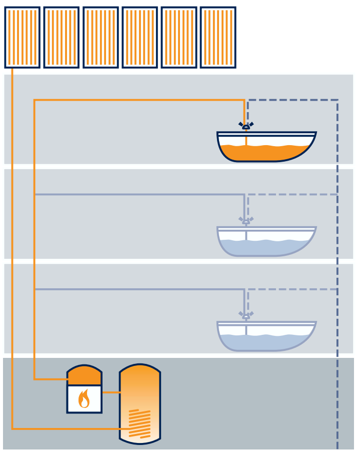
- Hotel chain
- Hotel, 97 rooms
- 113 m² flat-plate collectors (gross area), on a flat roof
- 48% reduction of final energy consumption for hot tap water heating

Facts in brief

Year of construction of CSTS	1999
Aperture area of collectors	108 m²
Thermal output	76 kW_{th}
Collector yield	832 kWh/(m²·a)
Total cost of solar hot water system	84,500 €
Subsidies	73 %
CO_2-emissions avoided	11 t CO_2 per year
Reduction of final energy	94,650 kWh/a
Replaced energy source	Electricity

collector area per room:	1.2 m²
investment costs per apartment:*	871 €
Solar fraction of global heat demand:	n/a

* without consideration of subsidies



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Technical Description

The CSTS was designed to cover 49 % of the energetic needs for hot tap water provision. 113 m^2 collector surfaces were installed on the flat roof facing south and with an inclination of 30 %. The collectors are connected to two 3,000-litre solar tanks. Back-up storage consists of five 3,000-litre electric storage tanks.

- operation mode: variable
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 6 m^3

Financing

The total cost of this operation was EUR 84,505 excluding VAT, subsidised at 73 % by the ADEME and the PACA Regional Council with EUR 61,742.

Comments

- "Aware of the importance of sustainability for the tourism industry, the ACCOR Group, of which this hotel is a member, has implemented a coherent environmental policy since 1993. In 1999, a contract to develop renewable energy sources was signed with the ADEME. Each year the measured solar output has exceeded the guaranteed energy outlined in the solar performance guarantee."

Flatplate collectors of the Hotel in Valbonne

Best Practice No. 10

Woonveste –
House for elderly persons

Motivation

The installation of this system was in accordance with the association's environmental mission. As part of their environmental policies Woonveste actively aims to reduce energy and water consumption and promotes the use of renewable energy systems in its building stock.

Profile

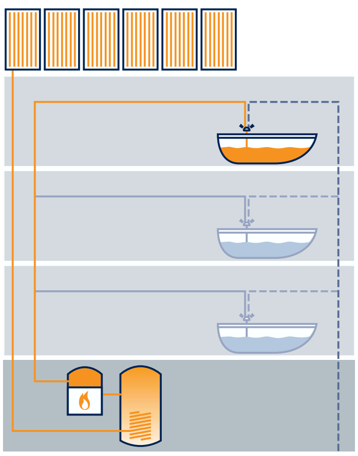
- Social Housing Association, Woonveste
- Multi-family House for elderly persons, 105 dwellings
- 100 m² flat-plate collectors (gross area), on a flat roof
- 38,900 kWh/a of solar heat

Facts in brief

Year of construction of CSTS	2003
Aperture area of collectors	96 m²
Thermal output	67 kW_{th}
Collector yield	approx. 405 kWh/(m²·a)
Total cost of solar hot water system	47,900 €
Subsidies	33 %
CO_2-emissions avoided	11.7 t/a
Reduction of final energy	55,500 kWh/a
Replaced energy source	Natural gas

collector area per apartment:	0.9 m²
investment costs per apartment:*	456 €
Solar fraction of global heat demand:	n/a

* without consideration of subsidies



Contact

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For further information, please refer to www.solarge.org

Technical Description

- operation mode: n/a
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 3 m³

Financing

For the realisation of this project, Woonveste was supported by the project "Space for Solar", which provided feasibility studies, an interesting turn-key offer based on a call for tender and an investment subsidy.

Comments

- "When the decision was made to install a solar water heater not all tenants were happy because of the corresponding increase in rent. But now the solar water heater is in service and the overall energy costs have been lowered by twice the amount of the rent increase. Needless to say, all the tenants are satisfied. Woonveste will continue its mission to install renewable energy systems in its building stock."

Flat plate collectors

Best Practice No. 11

TEZNO – Retirement Home

Motivation

The system, as well as the building, was financed by the Ministry of Labour, Family and Social Affairs and community of the town of Maribor. The complete building was taken over by the current users. The supplier of the solar system manages and maintains the system free of charge.

Profile

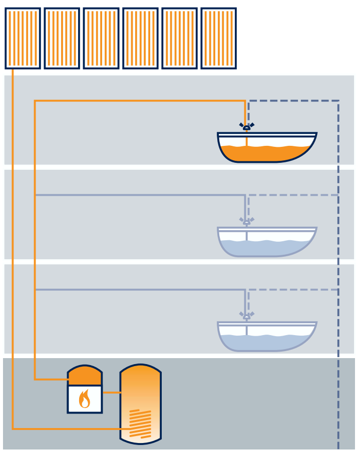
- Social Association
- Retirement home (2003), 200 residents + 80 Employees
- 110 m² flat-plate collector (gross area), on flat roof
- 29,390 kWh/a reduction of final energy consumption

Facts in brief

Year of construction of CSTS	2003
Aperture area of collectors	100 m²
Thermal output	70 kW_{th}
Collector yield	294 kWh/(m²·a)
Total costs of solar hot water system	50,000 €
Subsidies	50 %
CO_2-emissions avoided	5.9 t CO_2 per year
Reduction of final energy	29,390 kWh/a
Replaced energy source	Natural gas

collector area per apartment:	1.0 m²
investment costs per apartment:*	505 €
Solar fraction of global heat demand:**	2.3 %

* without consideration of subsidies
** estimated



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For further information, please refer to www.solarge.org

Technical Description

The solar system, which is used to heat hot tap water, is composed of two fields of flat selective solar collectors with a total area of 100 m². There are four heat storage tanks, each with a volume of 900 litres, which serve as buffer storage. Two of them are connected parallel forming the battery. Two batteries are connected in series. This way, better temperature distribution in the storage tanks is achieved. Heat from the buffer solar heat storage is transferred over a plate heat exchanger into two additional storage tanks where the tap water is heated. Each of them has a volume of 1,000 litres. Cold tap water flows through the first to the second storage tank and is additionally heated with a spiral exchanger integrated into the last storage tank and gas boiler.

- operation mode: low flow
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 3.6 m³

Financing

Due to the present owners having just taken over the building, accurate costs are not known. The investment cost was approximately EUR 500 per m² solar collector. Half of the investment was paid for by the local community as part of the programme to help the elderly.

Comments

- "During the process of discussion, planning, construction and operation of the large solar system a lot of experience was gained. The first two years of operation showed that the system is accurately designed and well constructed. There were no significant costs with system maintenance.
The experience has been successfully used in new projects."

Flatplate collectors
and hydraulics

Best Practice No. 12

Pracatinat – Educational Centre

Motivation

„The educational centre, Consorzio Pracatinat, specialises in environmental education activities, sustainable tourism and accompanying local sustainable development projects. Therefore, it has a natural affinity towards renewable technologies. This is clearly testified by the decision to install a solar thermal pilot plant, which contributes to create an environmentalist image for the centre. Furthermore, a display is mounted in the hall of the building to show the performance of the solar system.“

Profile

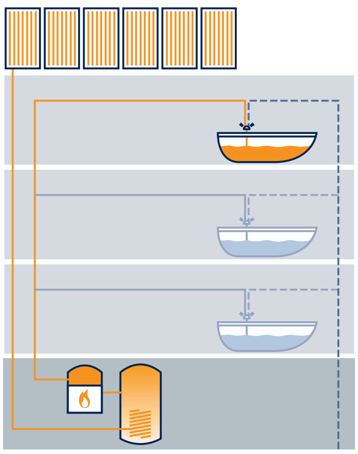
- Consorzio Pracatinat
- Hotel, 200 rooms
- 150 m² flat-plate collectors (gross area), on flat roof
- 180,000 kWh/a reduction of final energy consumption

Facts in brief

Year of construction of CSTS	2004
Aperture area of collectors	142 m²
Thermal output	100 kWth
Collector yield	697 kWh/(m²·a)
Total cost of solar hot water system	90,000 €
Subsidies	40 %
CO_2-emissions avoided	41.4 t CO_2 per year
Reduction of final energy	180,000 kWh/a
Replaced energy source	Natural Gas

collector area per apartment:	0.7 m²
investment costs per room:*	450 €
Solar fraction of hot water demand:**	55 %

* without consideration of subsidies
** heat demand for hot tap water generation (value: estimated)



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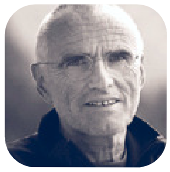


Technical Description

The collectors are connected to a 5 m³ buffer storage tank, which heats up a hot tap water tank via a heat exchanger. Two further tanks are connected in parallel and are heated up by both the solar tank and the auxiliary heating boiler. The recirculation circuit can be diverted either to the solar tank (in the summer) or to the other two tanks (in the winter) in order to optimise the efficiency of the system.

- operation mode: low flow
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 5 m³

Financing

The plant was partly financed by the province of Turin as part of a demonstration programme.

Comments

- “Due to the intermediate low efficiency of the system, the investment is not yet profitable. Small modifications to the plant, however, should be enough to improve the energetic and economic efficiency. Our application was evaluated and finally our hotel was chosen for the installation of a pilot plant. The technical staff were supported by experts in the planning and in the choice of suppliers. Recommendation for the realisation of future projects: before the decision to install a pilot plant is made, it should be ensured that all the players involved are informed and share the same opinion. Otherwise it will be difficult to coordinate all the people involved, such as the owner, the planner and those responsible for monitoring the project.

Flatplate collectors and panel display in Pracatinat

Best Practice No. 13

DEGEWO – Multi-Family House

Motivation

The project was carried out in the context of the solar reorganisation strategy of the DEGEWO.
Due to positive experiences in co-operation with the project partners and the total energy savings, every renovation or remodelling plan takes the use of solar thermal into consideration from the very beginning. The project must be profitable for the property company.

Profile

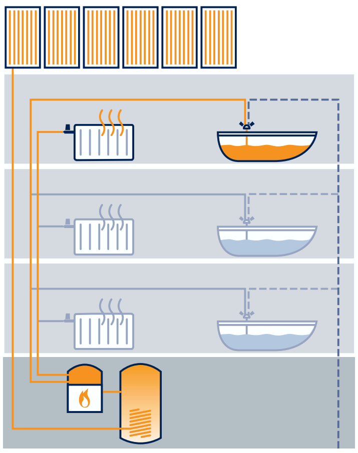
- Housing group
- Multi-Family Houses, 53 dwellings
- 59 m² flat-plate collectors (gross area), on a flat roof
- 29,050 kWh/a of solar heat

Facts in brief

Year of construction of CSTS	2004
Aperture area of collectors	54 m²
Thermal power	37.9 kW_{th}
Collector yield	approx. 538 kWh/(m²·a)
Total cost of solar heating/ hot water system	69,944 €
Subsidies	16.4 %
CO2-emissions avoided	7.38 t/a
Reduction of final energy	n/a
Replaced energy source	Natural gas

collector area per apartment:	1.0 m²
investment costs per apartment:*	1,320 €
Solar fraction of global heat demand:**	2.9 %

* without consideration of subsidies
** measured (this plant concept focuses on the boiler optimisation whereby fossil energy savings are considerably higher than shown by the solar fraction here)



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For further information, please refer to www.solarge.org

Technical Description

The solar thermal system has a collector area of 59 m² and a central regulation and control unit. The obtained solar energy is used for water heating, heater support and for the thermal solar Legionella-circuit by the solar compact station. Water and space heating is supplemented by fossil-generated heat only when necessary.

The solar collector system, water heating, space heating and the boilers are operated by a central, automatic controller, so that, apart from the energy savings by the solar collector system, this combined system will result in further energy savings compared to the conventional use of the boiler as it taps synergy effects. As part of maintenance procedures, the water heating system was renovated.

The boiler was replaced by a smaller, modern, fuel-efficient boiler that generates approx. 60-70% of the annual heating required by the housing complex. A remaining second boiler received a new modulating gas burner. The heat supply was retrofitted for natural gas and therefore emits fewer pollutants. The piping and armatures in the heating plant room, which were not replaced, received lagging in accordance with the EnEV for water heating and heater support.

- operation mode: low flow
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 1.3 m³

Financing

The costs of the installation and renovation were financed by subsidies (EUR 11,500) from the Market Stimulation Programme from the Federal Government, the Retrofit Premium from GASAG and equity capital (EUR 58,500) from the owners' association.

Comments

- “Large thermal solar systems can be operated efficiently and gains and costs can be calculable if the systems are considered in planning and implemented with competent partners from the beginning. Personal commitment and persistence are absolutely necessary for the realisation of such projects.

Combined solar energy and boiler control station “SEZ” in Berlin

Schalkwijk – Multi-Family House

Motivation

The housing corporation originally planned to install individual combined gas-fired boilers for space heating and hot water. This would, however, have consumed scarce living space. A sustainable, central heating system therefore appeared to be a good alternative. Both the housing corporation and the local government supported this solution and initiated a co-operative venture with the utility company.

Profile

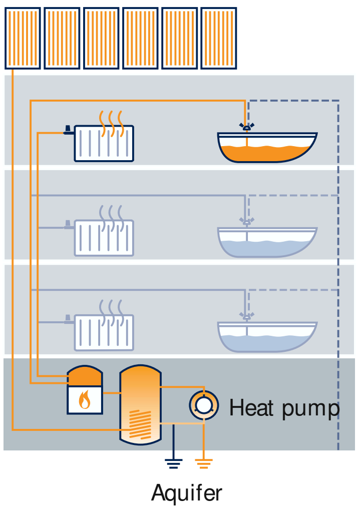
- Energy service company
- 9 Multi-Family Houses, 382 dwellings
- 2,925 m² flat-plate collectors (gross area), on roof
- 1,433,000 kWh/a of solar heat

Facts in brief

Year of construction of CSTS	2002
Aperture area of collectors	2,850 m²
Thermal output	1,995 kW_{th}
Collector yield	approx. 502 kWh/(m²·a)
Total cost of solar heating/ hot water system	1,825,000 €
Subsidies	35 %
CO_2-emissions avoided	n/a
Reduction of final energy	4,989,000 kWh/a
Replaced energy source	District Heating (Natural Gas)

collector area per apartment:	7.5 m²
investment costs per apartment:*	4,777 €
Solar fraction of global heat demand:**	67 %

* without consideration of subsidies
** estimated (due to the seasonal aquifer storage this solar plant supply that high solar fraction)



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For further information, please refer to www.solarge.org

Technical Description

Nine 40-year old blocks with 382 apartments were retrofitted and equipped with solar energy. The system consists of 2,850 m^2 glass-covered solar flat collectors, short-term heat storage, aquifer seasonal heat storage, heat pumps and boilers for peak demand. The energy savings, according to the design, amount to 70 %.

- operation mode: low flow
- type of hot water heating: central
- type of space heating: central per block
- solar buffer storage: 9 x 9.5 m^3

Financing

Eneco Energie is the investor and CSTS system owner. Eneco Energie sells the heat and hot water to the apartment owners. Grants cover 35 % of the overall investment. The net present value of the avoided exploitation of a conventional installation, totalling EUR 182,000 was paid by the housing association to Eneco Energie.

Comments

"In the long term, the future of an energy supplier will depend on its innovative power choices: Innovation meets our goals of social responsibility and enables the long-term continuity of our business. These are the drivers for developing the renewable energy market. In the past 10 years, Eneco Energie has carried out more than 50 large-scale solar thermal systems in the housing sector. An efficient organisation that can initiate, implement and operate large-scale solar thermal systems has been built. The 2 MW project is part of the continuous innovation process that we aim for. We intend to remain a market leader for the implementation of large-scale solar thermal systems in the housing sector."

Installation of pre-assembled flatplate collector structures for 382 dwellings in Haarlem

Die Fabrik – Hotel

Motivation

The hotel, "Die Fabrik", is located in a former industrial building, where telephones were once produced. In 1994, when the building was remodelled as a hotel, rooms, bathrooms, a large lobby and a restaurant were created. The 50-year-old, out-of-date steam heating system was not sufficient to maintain an acceptable level of comfort for the guests. Therefore, in 1999, the whole building was energetically modernised, including the boilers (switched to natural gas) and the heating system (pipes, radiators). The installation of a

Profile

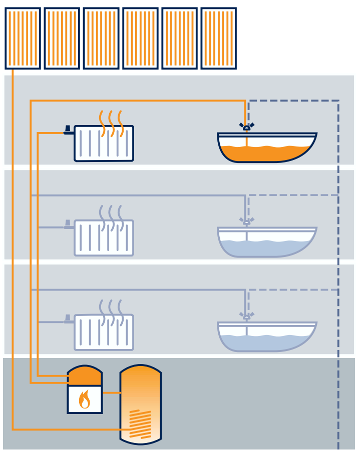
- Private ownership
- Hotel, 120 beds
- 27 m² vacuum tube collectors (gross area), on a flat roof
- 16,000 kWh/a of solar heat

Facts in brief

Year of construction of CSTS	1999
Aperture area of collectors	23 m²
Thermal output	16 kW_{th}
Collector yield	approx. 695 kWh/(m²·a)
Total cost of solar heating/ hot water system	40,000 €
Subsidies	33 %
CO2-emissions avoided	4.8 t/a
Reduction of final energy	35,000 kWh/a
Replaced energy source	Natural gas

collector area per bed:	0.2 m²
investment costs per bed:*	333 €
Solar fraction of global heat demand:**	7.1 %

* without consideration of subsidies
** calculated



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www.diefabrik.com

solar thermal collector for hot-water generation and heating support was planned. The entire renovation was substantially funded by the UFP Environmental Funding Program of Berlin.

Technical Description

27 m² vacuum tube collectors were installed flush to the flat roof of the hotel's rear building - without a mounting system. This solution was chosen because of static reasons. The high-performance collectors are connected with an efficient buffer storage system, measuring 2.25 m³, in the heating centre. Integrated into the heating system, with a shared control unit, the system covers 8 % of the energy needs for heating and 43 % of the energy needs for hot water generation (simulation result).

- operation mode: low flow
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 2.25 m³

Financing

The solar thermal system was installed as a key element in the energetic modernisation of the hotel. The subsidies granted from the UFP Program amounted to one third of the total costs (planning and installation). Thanks to the resulting high level of energy savings, particularly through the reduction of system losses and assistance from solar thermal energy, as well as the grants, the entire project was favourably profitable. As early as 1999 the overall measure was almost profitable.

Comments

"Within the scope of the changed utilisation of the building from industrial to hotel use, the solar thermal system was, and is, a highly valued part of the building's concept. The energy created by the solar thermal system provides economic relief from the energy costs which is becoming even more important due to the current increase in energy prices. In addition, the image of "Die Fabrik" is enhanced by the innovative energy concept - a factor that is well received by the guests."

Vacuum-tube collectors and display panel of the hotel "Die Fabrik"

Best Practice No. 16

Dom Paraplegikov – Hotel

Motivation

The health resort is designed for the physically handicapped and offers them an option for healthy and relaxing vacations. Disabled sportsmen can use the resort for preparing for sports competitions. This health resort is meant to become an incubator of ideas for all areas of life of a physically disabled person. The solar system was completed in 2007. One of the first results of the SOLARGE project was the fact that we have installed calorimeters in the solar system pipeline and connected to the BMS (Building Management System).

Profile

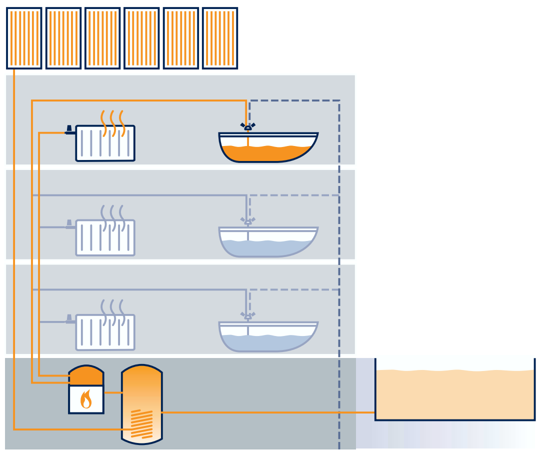
- Private ownership
- Hotel, Sports building Hospital, 120 beds
- 78 m² flat plate collectors (gross area), on roof

Facts in brief

Year of construction of CSTS	2006
Aperture area of collectors	72 m²
Thermal output	50 kW_{th}
Collector yield	n/a
Total cost of solar heating/ hot water system	34,317 €
Subsidies	90 %
CO2-emissions avoided	n/a
Reduction of final energy	n/a
Replaced energy source	Liquid gas

collector area per user:	0.6 m²
investment costs per user:*	286 €
Solar fraction of global heat demand:	n/a

* i without consideration of subsidies



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For further information, please refer to www.solarge.org

Technical Description

Two liquid-gas, high-temperature boilers were installed for space and tap water heating. Rooms are heated by radiators with thermostatic valves. Some parts of the building – therapy, congress room, and restaurant – have air-conditioning systems. Hot tap water as well as sea water is pumped into the pool and preheated by the solar system. The system consists of two sections of solar collectors with a total area of 72 m^2. Water heated by the solar collectors flows through a tube heat exchanger, integrated in the heat storage tank (2 m^3) for hot tap water generation and heating support or through a plate heat exchanger for the preheating of sea water for the pool.

- operation mode: high flow
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 4 m^3

Financing

The Health Resort Centre in Pacug was planned in such a way that quality was given first priority. The decision for a solar system was made a few years ago. This was a very good decision in hindsight, because the price of liquid-gas has increased. The institution, which financed the construction of the health resort, supported the decision. In the end, the price per square metre of solar collectors was a little higher than expected.

Comments

- „We are aware of the growing importance of energy conservation and therefore the decision to use as many renewable energy sources as possible was easy. With regard to the fact that our building lies in the sunniest area of Slovenia – 2,292 hours of sunshine per year – the solar system was a logical choice. One of the first results of the SOLARGE project will be the installation of calorimeters in the solar system and their connection to the building's management system.“

Flatplate collectors on roof and Solar heat tanks

Best Practice No. 17

Hotel du Golf de Valescure – Hotel

Profile

- Private ownership
- Hotel, 40 rooms
- 90 m² flat-plate collectors (aperture area), roof integration
- 58,000 kWh/a of solar heat

Motivation

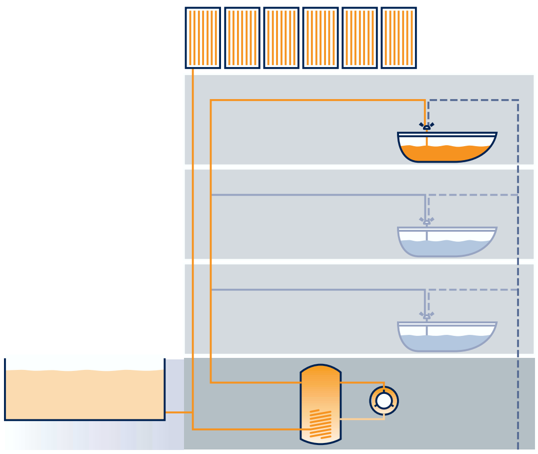
The hotel owner made the choice to respond to the environmental concerns of his hotel clientele, especially those from Northern-Europe. Tour operators are becoming more and more sensitive to these concerns as well. This hotel has had a CSTS since its opening in 1981.
In a sustainable development approach, the owner decided to totally restore the CSTS for tap water and swimming pool heating. The restoration enabled the total collector surface area to be reduced due to the significant deve-

Facts in brief

Year of construction of CSTS	2003
Aperture area of collectors	90 m²
Thermal output	63 kW_{th}
Collector yield	approx. 659 kWh/(m²·a)
Total cost of solar heating/ hot water system	101,000 €
Subsidies	48 %
CO2-emissions avoided	19 t/a
Reduction of final energy	68,000 kWh/a
Replaced energy source	Electricity

collector area per room:	2.3 m²
investment costs per room:*	2,525 €
Solar fraction of global heat demand:	n/a

* without consideration of subsidies



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For further information, please refer to www.solarge.org

lopment in collector efficiency over the past 20 years.

Technical Description

The CSTS was installed in 2003 and is composed of 90 m² flat-plate collectors integrated into the roof with a south-eastern orientation of 20° and an inclination of 30°. Hot tap water is stored in two solar tanks measuring 2500 l and 2000 l, and a back-up storage tank measuring 1500 l. The CSTS was designed to supply hot water for use in the hotel and the swimming pool.

- operation mode: variable
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 4.5 m^3

Financing

The CSTS cost totalled EUR 101,000 including VAT with EUR 40,000 for the collector system, 38,000 EUR for solar installation and EUR 8,400 for planning and development. The project was subsidised at 48 % with EUR 48,174 provided by the ADEME and the regional council of PACA.

Comments

- „I have wanted to involve the hotel in a globally oriented, environmental approach that integrates water, energy and waste management. To follow through with such an approach is to take the lead over other hotels and thus to secure a competitive advantage."

Roof integrated flate plate collectors of the Hotel du Golf de Valescure

Best Practice No. 18

Saignon Elderly House – Retirement home

Motivation

This specialised retirement centre in Saignon, intended for physically handicapped persons, is an example of a high-quality, environmentally oriented design process. This building was designed according to bioclimatic structure, with special regard to solar design, and has a one-floor construction to accommodate the needs of handicapped persons.

Profile

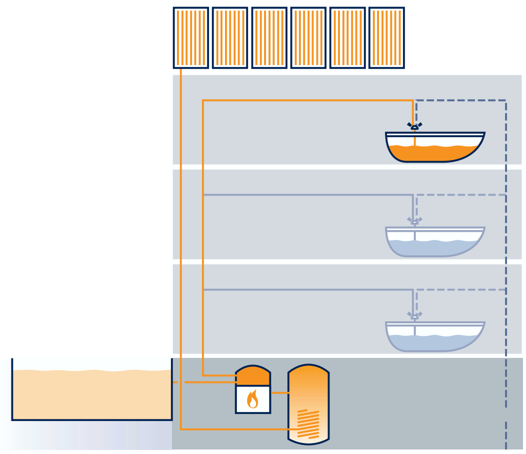
- Social Association
- Retirement home, 21 beds
- 56 m² flat plate collectors (gross area), on the ground
- 33,000 kWh/a of solar heat

Facts in brief

Year of construction of CSTS	2002
Aperture area of collectors	50 m²
Thermal output	35 kW_{th}
Collector yield	approx. 660 kWh/(m²·a)
Total cost of solar heating/ hot water system	57,600 €
Subsidies	82 %
CO_2-emissions avoided	10.5 t/a
Reduction of final energy	49,700 kWh/a
Replaced energy source	Heating oil and electricity

collector area per room:	5 m²
investment costs per room:*	5,750 €
Solar fraction of global heat demand:	n/a

* without consideration of subsidies



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For further information, please refer to www.solarge.org

Technical Description

The installation has been in service since 2002 and is composed of 50 m² flat-plate collectors located on an embankment near the building facing south and with an inclination of 30°. The hot water is stored in a solar tank measuring 3,000 litres and has two back-up tanks measuring 1,500 and 1,000 litres.

- operation mode: n/a
- type of hot water heating: central
- type of space heating: central
- buffer storage: 3 m³

Financing

The 50 m² solar installation of the retirement centre in Saignon cost EUR 57,600 including engineering and VAT and was subsidised with EUR 45,000 from free financing (state regional council and ADEME).

Comments

- This building was designed with an environmental and bioclimatic approach and, logically, a CSTS was integrated for hot tap water production.
An all-round project was carried out using an architectural contest and a commission was created to finalise project details and to draft a contract to choose the contracting companies.
The CSTS runs perfectly and provides 60 % of the hot tap water needs of the building, as determined by the feasibility study.

Rear side of the building and flat plate collectors located near the building on an embankment

Asilo dei Vecchi – Retirement home

Motivation

The building's managers started the project and were encouraged by a promotion program from the province of Turin which provided expert technical assistance and economic subsidies.

"Our local promotion programs for renewable energy sources are based on a complete support structure for the investors. It is essential to create subsidy schemes and inform the parties involved of their existence. Furthermore, technicians must be trained and supported,

Profile

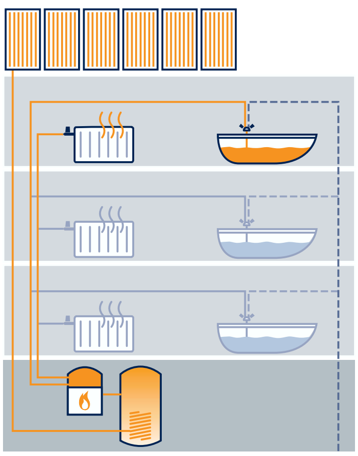
- Waldensian Church
- Retirement home, 98 inhabitants
- 78 m² vacuum tube collectors (gross area), on roof
- 54,000 kWh/a of solar heat

Facts in brief

Year of construction of CSTS	2004
Aperture area of collectors	70 m²
Thermal output	49 kW_{th}
Collector yield	623 kWh/(m²·a)
Total cost of solar thermal system	72,850 €
Subsidies	40 %
CO_2-emissions avoided	19.5 t CO_2 per year
Reduction of final energy	94,290 kWh/a
Replaced energy source	Natural gas

collector area per apartment:	0.7 m²
investment costs per apartment:*	743 €
Solar fraction of global heat demand:**	10.8 %

* without consideration of subsidies
** calculated



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For further information, please refer to www.solarge.org

especially during system design and the installation. Finally, an adequate monitoring plan should track the operation of each system."

Technical Description

The central heating system provides heat for hot tap water and space heating.
Together with the solar system, a new gas condensing boiler was installed. The existing boiler is used to cover the peak loads.

- operation mode: low flow
- type of hot water heating: central
- type of space heating: central
- solar buffer storage: 3 m^3

Financing

The solar thermal system in San Germano is one of three systems financed by the province of Turin as part of a demonstration program. The province of Turin subsidised 40 % of the system costs.

Comments

- The collector was designed for hot water preparation but also supports the heating system because of the existing hydraulic scheme. The system is running properly and is monitored monthly. Performance data for the system is available on the province government's website.

Vacuum-tube collectors on the roof of the retirement home in San Germano Chisone

Marstal District Heating

Motivation

The plant is part of the national strategy to develop large-scale solar heating systems for district heating and for seasonal heat storage.

Profile

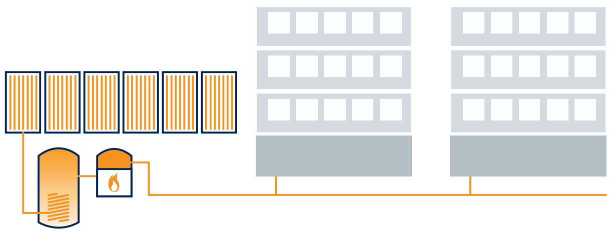
- Private company
- various, 1,420 users
- 19,000 m² various types of collectors (gross area), ground mounted
- 8,824,000 kWh/a output of solar heat

Facts in brief

Year of construction of CSTS	1996 – 2003
Gross area of collectors	19,000 m²
Thermal output	12,850 kW_{th}
Collector yield	approx. 464 kWh/(m²·a)
Total cost of solar heating/ hot water system	7,333,000 €
Financing	40 % self-financing 23 % loans, 37 % subsidies
CO_2-emissions avoided	2,500 t/a
Reduction of final energy	7,792,000 kWh/a
Replaced energy source	Natural gas

collector area per apartment:	26.4 m²
investment costs per apartment:*	10,476 €
Solar fraction of global heat demand:**	46.4 %

* without consideration of subsidies
** monitored



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Technical Description

- operation mode: variable
- type of hot water heating: decentralised
- type of space heating: central
- seasonal storage: 14,000 m^3

Financing

The entire system was built in a number of phases. In general, 30% of the grants came from the Danish Energy Agency. The latest addition was partly subsidised by the EU.

Comments

- „The project in Marstal has, together with other projects on Aeroe, provided a basis for a new industry on the small island of Aeroe. Main activities include the production of large solar collectors and heat exchanger units."

Aerial photo of Marstal and a part of the collector field

Techcentre ŠPAN – Car Centre

Motivation

„Špan Company has been constantly growing for 25 years now, and has always been concerned about protecting the environment. Our experiences have been so positive that we suggest everyone, especially large consumers of hot tap water and service water, to install a solar system. Unfortunately, in 2005, there were no governmental subsidies available, as had been the case before, so we had to build the system exclusively with our own financing."

Profile

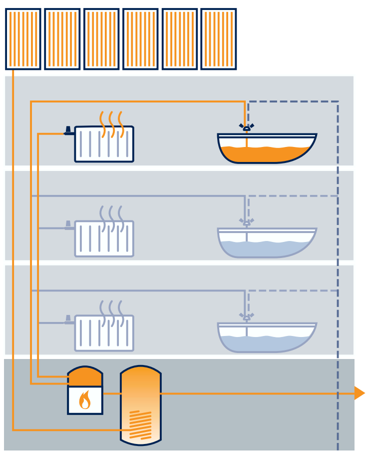
- Family company
- Car Centre
- 43 m² vacuum tube collectors (gross area), on a flat roof
- 18,890 kWh/a of solar heat

Facts in brief

Year of construction of CSTS	2005
Aperture area of collectors	28 m²
Thermal output	20 kW_{th}
Collector output	approx. 669 kWh/(m²·a)
Total cost of solar heating/ hot water system	45,800 €
Subsidies	0 %
CO_2-emissions avoided	5.4 t/a
Reduction of final energy	28,730 kWh/a
Replaced energy source	Liquid gas

collector area per 100 m² heated area:	0.9 m²
investment costs per 100 m² heated area:*	1,526 €
Solar fraction of global heat demand:	n/a

* without consideration of subsidies



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Technical Description

The solar system that is used for hot water preparation, the heating of a coffeehouse and heating the service water in the carwash, consists of ten units of vacuum solar collectors with heat pipes (30 pipes to one unit). The units are connected in series; the flow of heat transfer fluid is variable and depends on the temperature of the collectors' output.

- operation mode: variable
- type of hot water heating: central
- type of space heating: central
- buffer storage: 1.5 m^3

Financing

The system was paid for by the owner. The final price of the system was EUR 1,053 per m^2 of solar collector area. Only one third of this price was the cost of the solar collectors due to the high quality of installed elements and rather complex configuration of the system. Unfortunately, in the year 2005, subsidies for the financing of solar systems were not available, as was the case in the previous year.

Comments

- According to observations of system performance made since the system went into operation in October 2005, the system is very reliable due to the combination of antifreeze, drain-back technology and overheating protection. The prioritising of heat storage and variable flow operation contributes to the high solar collector yield.

Vacuum-tube collectors and solar storage tank of the car centre Špan

Outlook

The best practice examples from the SOLARGE project provide a compelling demonstration of the advanced state of technology in large solar thermal systems.

Research and development continue, however, as do market trends, and will further accelerate the adoption of solar thermal energy in Europe.

For example, industry and researchers are working on the development of storage units with greater storage densities and more compact dimensions. By 2030, buildings supplied 100% by solar energy could be standard in Europe.

Architecturally attractive integration of collectors into the building envelope will also become increasingly widespread. No longer just heat generators, collectors will become part of the roof cladding and a functional design element in facades.

Driven by the climate change debate and rising oil prices, it will become far more common to design buildings from a total energy consumption standpoint. Solar thermal energy will play a major role here.

People will expect higher standards of well-being in both residential buildings and work-place environments, increasing the need for air conditioning and hence cooling, especially in Southern Europe. Solar thermal energy will be increasingly important here, too, not least because collectors provide shade for the building's envelope and so reduce the need for cooling.

Besides their use in residential buildings, hotels and public facilities, solar thermal systems will become increasingly widespread in industrial applications. In the none-too-distant future, solar collectors will be able to supply process heat at temperatures of more than 250 °C. Laundries, electroplating operations and drying plants (for example in the coatings industry) will increasingly be operated with the aid of solar thermal energy.

Window integrated collector
Photo: Robin Sun

Fresnel collector for a solar cooling system in Bergamo, Italy
Photo: PSE

Facade integrated collectors

Photo: GREENoneTEC / ESTIF

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