SOLAR THERMAL APPLICATIONS IN EU AND CEE COUNTRIES

Main Facts

An Inexhaustible Source of Energy

Measured by human dimensions the sun is an inexhaustible source of energy. The total solar irradiation on the earth's surface exceeds the world energy demand 2900 times. Although, countries in Northern and Central Europe obtain less power of irradiation per m² than countries in Southern Europe, they receive much more solar energy than their primary energy demand. Northern and Central Europe receive approx. 360 x 10^{12} kWh solar energy which corresponds to 90 times the amount of primary energy consumed.

Energy Saving Potential and Environmental Benefits

In Northern and Central Europe on average three quarters of supplied energy in households are used for heating and additionally up to 12% - for hot water generation. This indicates that nearly 90% of the energy demand in households is for heating and hot water supply. Considerable energy savings are possible by solar energy: with diurnal hot water storage tanks, 15-25% of the heating and hot water demand can be covered by solar energy while with seasonal hot water storage systems, 50-70% of the energy demand for heating and hot water can be met.

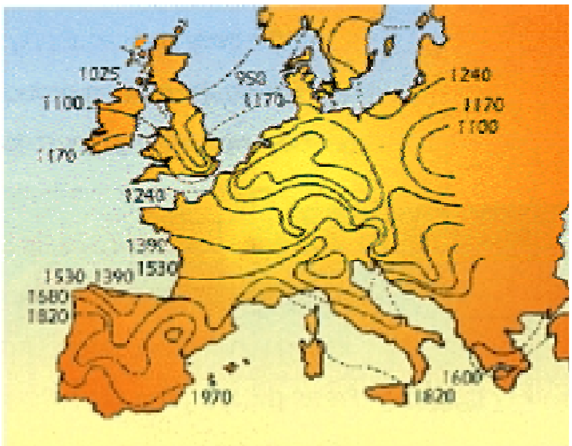
Worldwide public concern about environmental pollution and the need to conserve our limited resources of fossil fuels have lead to a wider use of renewable energy sources incl. solar technologies, as they are clean and inexhaustible. The application of solar thermal system will decrease the use of fossil fuels and will lead to 50% of CO2 emissions reduction. This implies an annual reduction of more than half a ton of CO2 per household.

The policy: Solar energy uses for space heating and hot water production are well recognised within the European Union. The European Commission in its White Paper set out the objective to supply 12 % of the gross domestic energy consumption of the EU states from renewable energy sources. Solar thermal systems will have to contribute to it with 100 millions m² installed by 2010 with an intermediate objective of 15 millions m² by 2003 while in 1999 the total installed area was 8,8 millions m².

The market: In response to the above policy objectives, the European market for solar thermal technologies is constantly increasing. Thus the annual sales of flat solar collectors increased by 18 % annually from 1994 to 1999. In 1994 there are 480 000 m² sold while in 1999 the sold quantities are almost double – 890 000 m².

Key factors:

1. **Annual Solar Radiation (kWh/m²)**



For comparison, Bulgaria enjoys average solar radiation of 1450 to 1600 kWh/m² per year depending on the region.

2. Annual Space Heat Demand

Austria	100-150	kWh/m²
Denmark	100	kWh/ m²
Germany	100-150	kWh/ m²
Sweden	60-100	kWh/ m²

3. **Annual Hot Water (45°C) Demand**

Austria	650-950	kWh/person
Denmark	860	kWh/person
Germany	740-1,040	kWh/person
Sweden	700-950	kWh/person

4. Annual Collector Output depending on type, design and operation of the system varies from 350 to 450 kWh/m² .

ENERGIE

It is quite common to combine solar with biomass heating. A combined biomass and solar heating system is an ideal application since during summer the biomass furnace need not to be operated for the hot water production.

Following are some examples of solar use for space heating and hot water production in multifamily houses and in district heating in Austria, Denmark, Germany, Sweden, Greece, Bulgaria and Romania.

Here It Works

Austria—Graz

In 1996 a solar heated student hostel was built in Graz - the capital of the Austrian state of Styria. On 3 050 m², 151 students can be accommodated in 33 apartments.

The design was developed in co-operation with the Technical University of Graz and contains an extensive energy savings package: insulation of the outer building walls and room temperature control.

Operation

100 m² large - surface collectors by Sonnenkraft Co. were installed, inclined at 35° south to supply a 5 m³ hot water buffer tank in the cellar. Approximately 80% of energy saving are achieved by the extensive insulation.

This project has gained an innovative character due to the contracting model which was developed by the Graz utilities. Here the utility pre-finances the additionally required conventional heating systems for domestic hot water.

Performance

With this plant it is possible to save 52 000 kWh of district heating per year, which amounts to about 33% of the total demand.

Economical Aspects

About 110 000 Euro are additional expenses for the plant (approx. 2% of the total construction costs). This investment enables annual energy savings of about 11 000 Euro (32% of the total energy costs per annum). Considering an annual 3% increase in energy prices the plant will be paid back in 12.5 years

Denmark—Skelhøjvej

A/B Skelhøjvej is building complex in Lyngby, Copenhagen, consisting of 3 apartment buildings with a total of 48 apartments, which are all supplied from a central heating station. In 1996 a solar heating plant was installed on the building. As the house ends are facing north-south, it was decided to install half the solar collectors facing east and the other half facing west.

Operation

The size of the solar heating plant is 105 m? divided over 8 modules of which four face east and the other four face west. The solar collector is an integral part of the roof. Because of this the amount of tiling required was reduced.

The East and West sides are controlled separately and have their own return pipe from the storage, but have a common feed pipe. This means that the collectors facing East start producing early in the morning, in the middle of the day all collectors produce heat, while the collectors facing west can produce into the late evening.

Performance

The solar energy plant is designed to deliver 29,700 kWh per year. In the boiler room the large old boiler was removed and 5 new gas boilers were installed. In the middle of the room a 6,300 litres storage tank was installed. CO2 was reduced by 11.9 t/year and NOx by 31 kg/year.

Economical Aspects

The total cost was about 30 000 Euro, but since the hot-water tank needed to be replaced anyhow, the additional price was only approx. 23 000 Euro.

Germany—Oederan

Reconstruction of prefabricated buildings with integration of a solar heating system has been carried out in the community of Oederan, 15 km east of Chemnitz in Saxon. The central heating system as well as all sanitary facilities were renewed in all 23 buildings, having four floors each. Heat is supplied via a small-scale district heating system and an internal heating sub-station. As owner, the Stadtbau und Wohnungs-verwaltungsgesellschaft Oederan GmbH placed a special emphasis on solar water heating as part of the reconstruction programme.

Operation

Seven of the buildings facing south were each equipped with 98.4 m² of collector surface (150 mm depth). These integrated collector systems, manufactured by Solvis, supply 6 hot water buffer tanks situated in the cellar of each house. Each buffer system has a capacity of 4.5 m³. On demand opposing flow heat exchangers will transfer the heat to the domestic water. Each plant supplies approx. 96 consumers.

Performance

The total solar yield amounts to 39,000 kWh/a. Compared to the total demand of 92,800 kWh/a this amounts to 42%. One of these plants is used as reference and is operated by the Technical University of Dresden.

Economical Aspects

Each plant costs 47 000 Euro, i.e. specific investment costs of 475 Euro/m² of collector surface.

Setting the specific yield of the collectors of 400 kWh/m²/a against an assumed annuity of 10 years the specific heat price will be about 0.12 Euro/kWh.

Here It Works

Sweden—Onsala, Göteborg

In Onsala a Swedish town south of Gothenburg, 9 multi-family houses with 36 apartments were built in 1995. These buildings have approx. 2 600 m^2 living area which are supplied with heat by a solar heating buffered heating plant, which is connected to a small-scale district heating grid. The houses are constructed out of wood and are well insulated, according to the Swedish standard. Climatizing is achieved by heated floors and a ventilation system with waste heat recovery. For the first time newly developed, prefabricated roof modules were used with integrated solar panels. These modules can also easily be set-up directly on roofs of already existing buildings.

Operation

A total of 220 m^2 collector surface were placed on the south-facing roofs of the heating plant and the adjoining service building. The prefabricated modules are mounted the same way as other prefabricated wooden roofs. The collected solar heat is stored in a 20 m^3 buffer tank from which the heating system is supplied. This plant meets 25% of the total heat demand.

Performance

The total solar yield amounts to 66,000 kWh/a. Compared to the total demand of 260,000 kWh/a this corresponds to 25%.

Economical Aspects

The total costs for the solar plant, including connection to the conventional heating system amount to 57 460 Euro. Government funding for the solar system reduced this amount to 37 570 Euro. The additional costs for the plant amount to 170 Euro per m^2 collector surface.

Setting the specific yield of the collectors of approx. 300 kWh/m^2/a against an assumed annuity of 10 years the specific heat price will be 0.06 Euro/kWh - including interest and pay-back.

In this case the relatively low price difference of approx. 100 Euro between conventional and solar roof modules led to low costs for solar heating. Similar projects showed additional investment costs of 135-170 Euro/ m^2.

Greece - Crete Island

ALDEMAR Group of Hotel & Tourism enterprises, giving emphasis in the construction and operation of hotel units with minimum environmental impacts has created an innovative energy saving project in the luxurious hotel complex Royal Mare in Hersonisos – Crete (total capacity 2 300 beds). The project comprises:

- installation of 2 800 m^2 solar collectors in a way that the aesthetics of the hotel complex is not affected
- installation of hot water storage tanks (boiler) with total capacity of 150 m^3
- upgrade of all hot water mechanical installations and designing interventions in order to maximise energy savings
- heating of the sea-water in the spa center
- maintaining of energy performance and protection of the mechanical equipment and networks from corrosion and
- complete graphic representation and control of the energy saving system from a central computer.

The system comprises installation of Chromagen high performance (B type) solar collectors and related systems for hot water production with total area of 2 800 m^2. The average annual performance of the solar system is equal to 580 kWh/m^2 and the produced thermal energy is 1 615 000 kWh. The average annual consumption was 430 000 lt LPG and 280 000 lt diesel. By using the solar collectors and similar interventions, a fuel saving of 85% is achieved.

Technical Description & Specifications

In this particular project the designing method of slow-flow hot water production was used.

Chromagen flat-plate solar collectors are used, with $\eta(30/800)=73\%$ and $F_R U_L=3.9$ W/m^2K.

The most important technical characteristics are:

- suitability for seaside environment with strong sea-winds
- metal cover of high mechanical resistance (St. Steel 316L)
- highly effective insulation at the back and round of the absorbing area
- crystal cover of high resistance at different temperatures and in UV radiation
- absorption =0.95, emissivity =0.12, wind-pressure resistance to 180 mph
- water proof age-resistant gasket material

The collectors are placed on special fixing bases at the roof of each building. The bases are made of galvanized metal corners (30X30 mm) and placed on H or L shaped beams. All metal parts are galvanized and the whole structure is integrated in such a way to meet the structural features of the buildings and to allow the normal outflow of rain water. The series of collectors are oriented to the south with a slope of 30° and are arranged in such a way as to avoid shading between the series of the collectors.

The budget of the project was 1 212 000 Euros and was supported by the Greek Operational Program for Energy. On the basis of the surface area of installed solar collectors, it is the biggest project in Greece and the biggest in the hotel sector in Europe.

How it works in Bulgaria

In 1998 a Phare demonstration project for installation of solar collectors for hot water production was implemented in **Dr. Chakmakov Hospital,** town of **Radnevo, Bulgaria**.

The site is a medium size regional hospital with approximately 250 beds with a total floor area of 6 818 m?. The hot water was produced on steam to water heat exchangers based on light fuel oil steam boilers. The hot water consumption amounts to 198 MWh/ year.

A system of 210 m^2 solar collectors with solar selective coating and an estimated production of 150 MWh/ year or 76 % of the hot water demands was installed including an accumulator tank of 5 m^3 volume and a stainless steel plate heat exchanger and all necessary auxiliary fittings and equipment..

The total projects costs are 62 190 Euro of which about 11 300 Euro are co-financing from the beneficiary and the rest is provided by Phare programme.

The expected benefits are 3 902 Euro annual cost savings (equivalent to more than 50 % annual fuel savings) and simple pay-back period of 15.9 years (at current energy prices).

It should be mentioned here that given the current increase of energy prices towards real market levels it can be assumed that the pay-back at present is shorter.

How it works in Romania

In 2001, two solar thermal systems were installed in the **mini-hotels Beta and Gamma in Costinesti resort - Constanta County**. The installations will be used only for the summer period for domestic hot water preparation.

Costinesti is a summer resort, situated in southeast extremity of Romania, in Constanta County, on the Black Sea coast, elevation 10 m. It has a seacoast climate with hot summers (July average temperature above 22°C) and mild winters (January average about 0°C), reduced nebulosity in summer and low precipitation (400 mm annually). In summertime the sun shines for 10-12 hours daily.

The equipment installed for these mini-hotels was Vitosol 300 produced by Viessmann Company. System components include:

- solar collector with 3 m^2 absorber surface area, 83% optical efficiency, 1.5 liters fluid capacity (heat transfer medium) and 6 bars max. working pressure;
- Solar Divicon pump station;
- expansion vessel (25 litres);
- air separator (automated de-aerator);
- Tyfocor antifreeze medium;
- Solartrol-E (electronic temperature difference control unit with digital temperature display, integrated diagnosis system and permanently retrievable output balancing);
- Vitocell-B 100 (domestic hot water cylinder for dual operation, 500 litres, with Ceratoprotect two-coat enamel finish);
- connecting system; mounting accessories; supports;

Thanks to the highly effective Sol-titanium coating, the vacuum tube collector Vitosol 300 can also utilize diffused solar radiation. So it is suitable not only for domestic hot water applications, but also as a backup for central heating purposes.

The total costs of each solar thermal system are 5106 Euro and the simple pay-back is about 6 years. The estimations show that about 2.3 t.o.e fossil fuel / year can be saved with this investment .

Some of the benefits of the installation are:

- High level of operational reliability and a long service life due to the use of high-grade, corrosion-resistant materials such as special solar glass, copper and stainless steel.
- High efficiency due to the Sol-titanium coated absorber and vacuum collector tubes.
- Energy-efficient Duotec double-pipe heat exchanger, which almost completely encloses the condensers for better heat transfer.
- The condenser is flexibly connected to the vacuum tube via a stainless steel corrugated pipe. The individual tubes can be rotated for optimum alignment to the sun.
- The dry connection of the collector tubes enables individual tubes to be mounted and disassembled without having to drain the solar heating system.

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