INFORMATION BROCHURE ON

LARGE-SCALE SOLAR HEATING

THERMIE B - Contract no DIS/1164/97

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Göteborg, November 1999
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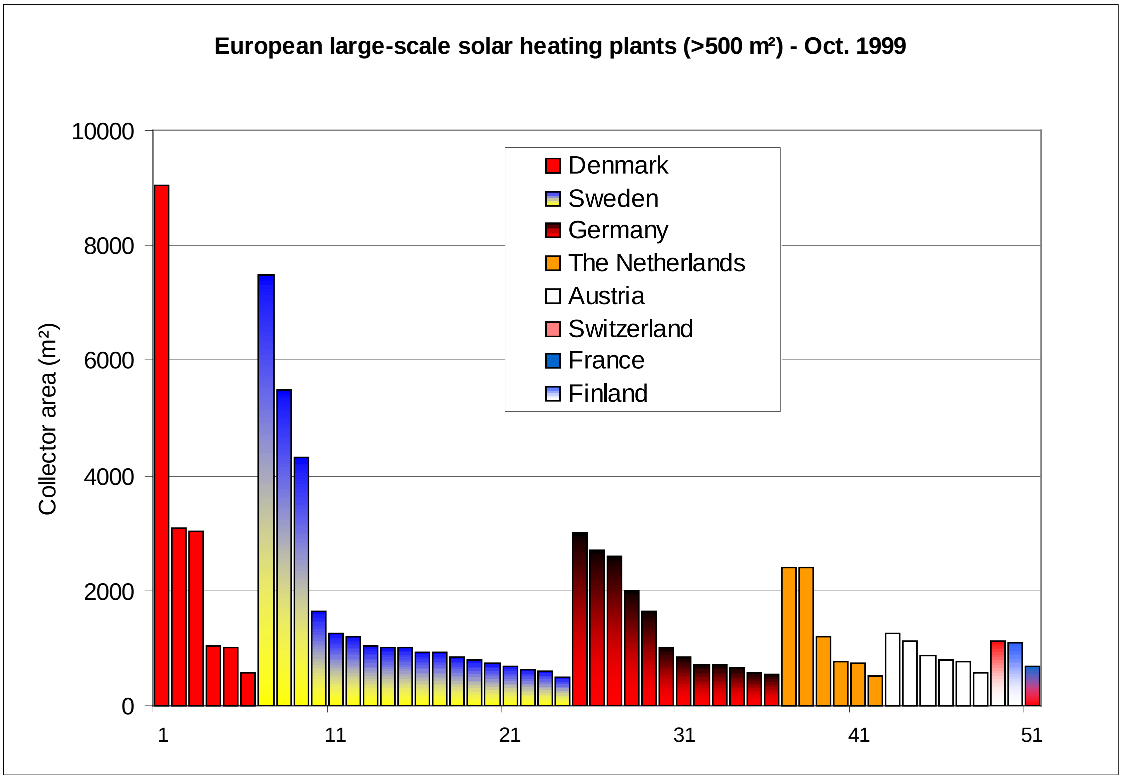
CONTENT

European Large-scale Solar Heating Plants

Interest in large-scale solar heating, especially in Germany and Austria, has increased during recent years and 25 new plants have been put into operation since the beginning of 1997. However, Sweden is still the leading country with a total of 18 out of 51 European plants with more than 500 m^2 of solar collectors.



Summary

In total, there are about 8 million m^2 of solar collectors in Europe, corresponding to about 4000 MW thermal power, which is of the same order of magnitude as for European wind power. However, unlike wind power, solar collectors are mainly installed in small systems. So far, only a minor part of the total market comprises large-scale applications. Enclosed table and diagram show all European large-scale solar heating plants having more than 500 m^2 (~250 kWth) of solar collectors, corresponding to about 40 MW thermal power altogether.

The largest plant was built in 1996 by Marstal Fjernvarme A/S on the island Ærø in Denmark. The collectors were supplied by ARCON Solvarme A/S and similar plants have earlier been built by Uppsala Energi AB, Telge Energi AB and Falkenberg Energi AB in Sweden, as well as by Saltum and Ry Fjernvarme in Denmark. The oldest plant still in operation dates from 1983. Sweden is the leading country, with more than 35% of European installed collector area.

Almost all the plants (43 out of 51) supply heat to residential buildings, in most cases via a central heating plant. Two thirds of these plants are connected to existing buildings, especially in Sweden, Denmark and Austria. About one third are built in connection to wood fuel fired heating plants: this is most common in Sweden and Austria. Non residential plants are e.g. connected to industries (Breda and Lisse, NL), hospitals (Nordhausen, DE and Heemstede, NL), commercial buildings (Neuchatel, CH, Chemnitz and Magdeburg, DE).

Most of the plants are designed to cover the summer load using short-term water storage, but 11 plants are equipped with seasonal storage that covers a larger part of the load. Out of these seven plants use water and three use the ground as storage medium.

Most of the plants have roof-integrated or roof-mounted collectors, while the largest plants in Sweden and Denmark have ground-mounted collector arrays. Common flat plate collector designs tend to dominate, and only two of the large-scale plants are equipped with evacuated tube collectors (Groningen, the Netherlands, Chemnitz, Germany).

The dominating contractor is ARCON (Denmark) which has installed close to 30,000 m^2 of large module collectors (pioneered by TeknoTerm). Examples of other contractors with more than one plant on the list are ZEN (Netherlands), TeknoTerm and Solsam (Sweden), Solvis and Wagner (Germany), SOLID, Sonnenkraft and Krautsack (Austria). Almost all plants have a pressurised collector systems with an anti-freeze mixture, usually glycol and water, while two plants (Breda and Brandaris, the Netherlands) have drain back collector systems.

In favourable cases, investment costs may be down below 250 EURO/m^2 of collector area, resulting in a solar heat cost of 0.06 EURO/kWh or less under typical conditions.

European Large-Scale Solar Heating Network

The 'European Large-Scale Solar Heating Network' is a non-profit-making network of European institutes and companies with long experience in development and implementation of solar heating systems for housing areas. The network is open to all countries in order to create a common forum for expert groups working with Central Solar Heating Plants (or CSHP), and forms the base for continued international co-operation.

The main objective of the 'European Large-Scale Solar Heating Network' is to enhance the development of large-scale solar heating technologies (i.e. residential heating, district heating, process heating at moderate temperatures) through knowledge transfer on both general and more specific issues between participating countries. The aim is to promote a wider utilisation of large-scale solar heating by encouraging knowledge transfer, as there is a need to reduce the gap between the actual status of existing technologies and present knowledge about these technologies by potential users. This is done by organising and/or promoting workshops and other co-operative efforts (e.g. Internet) aimed at facilitating knowledge transfer between consultants, architects, property owners, utilities and contractors. The aim is that workshops should be organised annually (at least) in connection to a demonstration project.

This will increase the experience from planning, design and implementation of large-scale solar heating plants among involved institutes and companies, which will improve the possibilities to make further improvements in future projects. Furthermore, working together in the network will improve the industrial competitiveness among the institutes and companies involved. There is potential for a considerable improved cost performance ratio compared to earlier solar heating plants. Furthermore, an increased market for solar heating applications, especially large-scale applications, will result in reduced investment costs for solar collectors in general.

The present co-operation relates to the THERMIE B project "European Large Scale Solar Heating Network" (Contract no DIS/1164/97, Duration 971001-990331) comprising two workshops. The first took place in Neckarsulm, Germany in May 1998, and the second in Amsterdam, The Netherlands in May 1999.

Information

*An Internet home page <**http://www.hvac.chalmers.se/cshp**> with a list of 'European Large-scale Solar Heating Plants" together with addresses and links to involved institutes, etc., is created. The intention is to keep the Internet page up-to-date and complement with plant descriptions and links to related sites.*

	Plant, Year in operation	Owner, Country	Area(m²)	CSHPxx
1	Marstal, 1996-	Marstal Fjernvarme A/S, **DK**	9040	DS
	Nykvarn, 1984-	Telge Energi AB, **SE**	7500	DS
	Falkenberg, 1989-	Falkenberg Energi AB, SE	5500	DS
	Lyckebo, 1983-	Uppsala Energi AB, SE	4320	SS
	Ærøskøping, 1998-	Ærøskøping Fjernvarme, DK	3090	DS
	Ry, 1988-	Ry Fjernvarme A/S, DK	3025	xS
	Hamburg; 1996-	Hamburger Gaswerke, **DE**	3000	SS
	Friedrichshafen, 1996-	Techn. Werke Friedrichsh., DE	2700	SS
	Neckarsulm, 1997-	Stadtwerke Neckarsulm, DE	2600	SS
	Groningen, 1985-	De Huismeester, **NL**	2400	SS
11	Breda, 1997-	Van Melle, NL	2400	DS
	Augsburg, 1998-	Bayerisches Staatsministerium, DE	2000	SS
	Fränsta, 1999-	Vattenfall Energimarknad, SE	1650	DS
	Stuttg.-Burgholzhof, 1998-	Neckarwerke Stuttgart AG, DE	1635	DS
	Säter, 1992-	Säter Energi AB, SE	1250	xS
	Eibiswald, 1997-	Nahwärmegen. Eibiswald, **AT**	1250	DS
	Älta, 1997-	SIFAB, SE	1200	DS
	Lisse, 1995-	Dames&Werkhoven, NL	1200	DS
	Bad Mitterndorf, 1997-	Genossensch.. Biosolar BM, AT	1120	DS
	Neuchatel, 1997-	Swiss Fed Office of Stat., **CH**	1120	SS
21	Kerava, 1985-	Private association, **FIN**	1100	SS
	Åsa, 1985-	EKSTA Bostads AB, SE	1030	DS
	Saltum, 1988-	Saltum Fjarnvarme A/S, DK	1025	xS
	Tubberupvænge, 1991-	Herlev kom. Boligselskab, DK	1000	SS
	Odensbacken, 1991-	Örebro Energi, SE	1000	xS
	Fjärås Vetevägen, 1991-	EKSTA Bostads AB, SE	1000	DS
	Stuttgart-Brenzstr., 1997-	Neckarwerke Stuttgart AG, DE	1000	DS
	Hågaby, 1998-	Uppsalahem AB, SE	930	DS
	Kullavik 4, 1987-	EKSTA Bostads AB, SE	920	DS
	Poysbrunn, 1997-	Genossensch.. B/SW Poysbrunn, AT	870	DS
31	Hammarkullen, 1985-	Gbg Bostads AB, SE	850	DS
	Göttingen, 1993-	Stadtwerke Göttingen, DE	850	xS
	Ekerö, 1997-	Ekeröbostäder AB, SE	800	DS
	Nikitsch, 1997-	FWG Nikitsch, AT	780	DS
	Brandaris, 1999-	Patrimonium WS Amsterdam, NL	760	DS
	Kroatisch-Minihof, 1997-	FWG Kroatisch-Minihof, AT	756	DS
	Särö, 1989-	EKSTA Bostads AB, SE	740	DS
	De Zwoer, 1990-	Stichting Zwembad Dr.-Rijsenburg, NL	740	DS
	Nordhausen, 1999-	SK GmbH Nordhausen, DE	717	DS
	Oederan, 1994-	SWG Oederan mbH, DE	700	DS
41	Echirolles, 1999-	OPAC 38, **FR**	690	DS
	Henån, 1997-	Orust kommun, SE	685	DS
	Magdeburg, 1996-	Universität Magdeburg, DE	657	DS
	Malung, 1987-	Malungsbostäder, SE	640	DS
	Älta, 1998-	HSB Brf Stensö, SE	600	DS
	Obermarkersdorf, 1995-	Fernw.genossench. Oberm., AT	567	DS
	Steinfurt-Borghorst, 1999-	W & T Bau GbR - DE	566	SS
	Ottrupgaard, 1995-	Ottrupgaards bofaellessk., DK	562	SS
	Chemnitz, 1998-	Solaris Verwaltungs GmbH, DE	540	SS
	Heemstede, 1998-	Stichting De Hartekamp, NL	520	DS
51	Torsåker, 1999-	Vattenfall Energimarknad, SE	500	DS

Market potential in Europe

In a study initiated by EU, the prospects of market development for solar thermal systems in Europe were investigated /1/. In a further study, the market potential for solar thermal residential heating in six European countries was investigated (Sweden, Denmark, Germany, Austria, Greece and Italy) /2/. These countries represent a spectrum of the residential situation and climatic conditions in Western Europe and in adjacent parts of Eastern Europe. They have a total population of about 180 million and represent a region with about 500 million inhabitants.

The market potential study was based on statistical information about the population, the state of the residential buildings, the energy usage for heating and domestic hot water and the climatic conditions in different regions. The market potential was determined for solar heating systems supplying domestic hot water and space heating in small houses and multifamily houses, as well as central block heating and district heating systems. For economical reasons, only systems with diurnal storage were taken into account. The techno-economical potential was determined taking into account commercial considerations, such as the costs of competing rational energy sources, including co-generation or other low cost energy sources, where applicable.

In general, the size of the available roof surface is not a limiting factor for the application of solar energy with diurnal storage. However, unfavourable orientation of roofs and partial shading by other buildings, as well as administrative hinders in cities, are believed to reduce the potential in many European countries to 30 - 40 % of the existing dwellings.

Co-generation plants with low heat generation costs and other low cost heat sources (waste heat, refuse, biofuels, etc.) are found to make it difficult for solar plants to compete in many of the larger district heating systems. Solar plants in smaller block heating stations have a better prospect of competing for a large part of the heating plants. Heat generated using fossil fuels, i.e. oil or natural gas, is the principal form of heat which solar heating systems has to and can compete with in larger systems.

Table 1: *Estimate of the potential solar collector market in sample countries.*

Coll area (Mm²)	SE	DK	DE	NL	IT	GR	Sum
Small houses							
DHW	1.86	0.54	22.14	8.08	10.44	3.45	46.51
DHWS	1.92	0.35	22.77		8.70		33.74
to 2015	0.48	0.21	9.31	3.52	1.37	0.68	15.57
Small systems	**4.26**	**1.10**	**54.22**	**11.60**	**20.51**	**4.13**	**95.82**
Multifamily buildings							
Existing	1.29	0.36	9.65	1.30	6.34	0.97	19.91
to 2015	0.12	0.15	4.20	0.43	1.03	0.20	6.13
Central systems							
Block centrals	0.90	2.76	6.56	0.09	3.18	0.04	13.53
District heating	0.81	1.50	2.94	0.05	0.04		5.34
to 2015	0.04	0.24	8.79	0.36	4.28	0.42	14.13
Large systems	**3.16**	**5.01**	**32.14**	**2.23**	**14.87**	**1.63**	**59.04**

The techno-economical potential is derived for an expected market growth of 20 – 25 % year accoding to /1/ and an assumed cost reduction due to this growth. The potential for solar collectors in the six countries was found to be about 100 Mm² for small systems and 60 Mm² for large systems (systems for multifamily houses and block- and district heating). The *corresponding solar heat (replacing mainly fossil fuel) is about 45 and 25 TWh/year respectively. The break-downs per country and system are shown in Tables 1 and 2.*

Table 2: *Estimate of the potential solar heat in sample countries.*

Solar (TWh/a)	SE	DK	DE	NL	IT	GR	Sum
Small houses							
DHW	0.65	0.21	9.30	3.31	6.26	2.17	21.90
DHWS	0.44	0.09	6.83		3.92		11.28
to 2015	0.15	0.08	3.69	1.36	0.79	0.42	6.49
Small systems	**1.24**	**0.38**	**19.82**	**4.67**	**10.97**	**2.59**	**39.67**
Multifamily buildings							
Existing	0.43	0.14	3.91	0.52	3.90	0.63	9.53
to 2015	0.04	0.06	1.87	0.19	0.70	0.14	3.00
Central systems							
Block centrals	0.32	1.10	2.89	0.04	2.00	0.02	6.37
District heating	0.29	0.60	1.29	0.02	0.02		2.22
to 2015	0.01	0.11	4.25	0.16	2.97	0.30	7.80
Large systems	**1.09**	**2.01**	**14.21**	**0.93**	**9.59**	**1.09**	**28.92**

In a very rough manner it can be stated that the net solar collector market potential for systems with diurnal storage is about 1 m² per inhabitant in Northern and Central Europe and 0,5 m² per inhabitant in Southern Europe. Based on this relation it is possible to estimate the market potential for the countries within EU to be about 250 to 400 Mm² solar collectors, of which about 10 Mm² are installed today. See Table 3. With this size of the market it is believed that the solar heating costs will decrease toward the cost goals of about 300 EURO/m² for small systems and 150 EURO/m² for large systems (systems costs including diurnal storage).

Table 3: *Estimate of the potential solar collector market for Europe*

	Population (Millions)	**Dwellings** (Mill.units)	**Collector market** (Mm²)
Northern region	31,4	12	25 - 35
Central region	181,3	75	150 -250
Southern region	176,2	55	75 -100
Europe	**390**	**142**	**250 - 385**

Systems for seasonal storage were not included in this analysis, but it is probable that such systems will increase the net market potential considerably by a factor 2 to 3 and hence about 5-fold the market of large systems. However, due to today's high costs of seasonal storages themself, this market must presume an appreciable increase of the competing costs for fossil fuels.

*/1/: European Solar Industry Federation – Sun in Action.
EU- Altener contract Nb. 4.1030/E/94-003 – Final Report.*

/2/: Heimo Zinko, et al: The market potential for solar heating plants in some European countries. APAS-RENA CT 94-0057, 1996.

Denmark

The Danish large-scale solar heating plants are used in district heating systems and all collectors are ground mounted. The development has taken place in two steps.

District heating without storage.

Based on Swedish experiences the first Danish plant, 1 000 m^2 large of groun-mounted collectors, was built in Saltum 1987.

1000 m^2 collector array in Saltum.

Later on the second plant with 3 025 m^2 of solar collectors was built in Ry. The Ry plant was put into operation in March 1990 with subsidy from EU and the Danish Energy Agency.

The district heating plant in Ry supplies annually about 32 GWh (1990) to the city of Ry, using wood chips boilers and solar heating. The annual solar gain is about 1.2 GWh and the solar plant is operated without any water storage tank, using only the district heating network as a buffer-storage.

The total investment for the solar heating plant amounted to 6,0 MDKR (January 1990).

District heating with short-term storage

Marstal District Heating, situated on the Island Ærø, decided in 1995 to establish 8064 m^2 solar collectors and a 2100 m^3 hot water storage tank to cover up to 15% of their heating load. The main fuel is waste oil and the annual load is 26 GWh. The solar plant was put in operation in November 1996 and the annual yield in a normal year is 3.4 GWh.

8064 m^2 collector array in Marstal.
Photo: Marstal Fjernvarme.

The total investment for the solar heating plant including building and connection to the existing network was 20,6 Mio. DKR (1996)

The operation of the solar plant has been uncomplicated despite the fact that the pumps run with variable flow allowing a constant output temperature from the solar collectors.

In 1999 the plant was extended to 9040 m^2 due to the connection of more district heating customers.

Future development

The next step in the development is expected to be solar heating combined with straw or wood heated district heating plants.

Ærøskøbing district heating company, also situated on Ærø, will establish the first plant of this type, 4900 m^2 solar collectors covering 17% of the heat load, during 1999 and 2000.

Calculations show that up to 25% of the production can be covered by solar heat at a heat price only 30% higher than the present heat price with straw and wood. During the next 3-5 years the heat price using solar collectors is expected to be reduced with 25-30% allowing solar heating plants to be competitive without support.

Sweden

The Swedish large-scale solar heating plants are used by district heating and housing companies, mainly for existing building areas, using both ground mounted collector arrays and roof-integrated or mounted collectors.

District heating

The early efforts were very much driven by a small number of pioneering utilities, e.g. Uppsala, Telge and Falkenberg Energi, within an experimental building program by the Council for Building Research.

5 500 m² collector array in Falkenberg 1989. Photo: Falkenberg Energi AB.

The district heating plant in Falkenberg supplies annually about 40 GWh to the central parts of the city using wood chips boilers and a solar heating plant together with natural gas boilers (used for back up in the summer and winter peak demand).

The annual gain is close to 2 GWh and the solar plant is operated using a 1 500 m³ water storage tank. The total investment for the solar heating plant amounted to 12.3 MSEK (March 1990). The solar heating plant was initially designed to cover the summer load, but is now covering a smaller part, as the district heating network has been extended over the years.

New housing areas

EKSTA Bostads AB pioneered the use of roof-integrated solar collectors in new building areas already in the 80's. EKSTA is a municipal property owner which has bought and built 100 000 m² of housing facilities and service premises in the urban districts of Kungsbacka. One marketing catch phrase is "Close to nature in solar heated houses".

At present EKSTA owns and operates ~6 000 m² of roof-integrated collectors (generating heat equivalent to ~250 m³ of oil per year). All plants are still in operation with very low operation and maintenance costs.

Initially EKSTA used site-built collectors, but the latest development, a roof module collector mounted directly on the roof trusses, has now been applied in a couple of recent projects. This development has resulted in even better integration in the building process, as well as further reduced investment cost and improved thermal performance.

In a new residential area in Onsala, 220 m² of prefabricated roof modules with integrated collectors, are mounted on the heating plant and a carport.

220 m² roof module collectors in Onsala. Photo: Jochen Dahm

The solar heating plant, designed to cover 20% of the annual heat demand in nine buildings with 36 residential units with 2 500 m² heated area, is operated together with a pellet and an oil boiler (summer back up and winter peak demand).

Based on real contracts (Nov. 1995) the investment cost for the solar system amounted to 194 SEK (~23 EURO) per m² heated floor area, or 2% of the total investment cost.

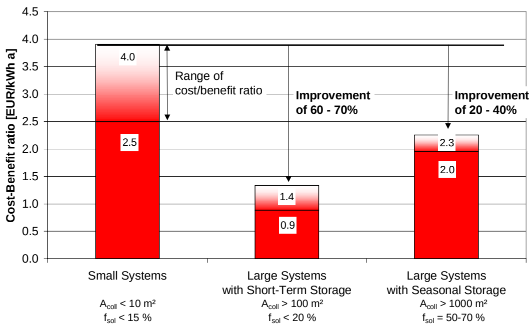
Future development

The main efforts focus on replacing the use of oil in combination with wood fuels in existing heating plants and most recent projects comprise roof-integrated collectors. However, Kungälv Energi has recently decided to build a 10 000 m² ground-mounted collector array, as a complement to wood chips boilers. The plant has got governmental, as well as EC support and is expected to generate 4 GWh/a. The total load is about 100 GWH/a.

Germany

The first steps towards large scale solar heating systems in Germany were taken in the late 80´s with pre-design studies. In 1992 the first pilot plants with 115 and 190 m² collector area and short term storage were realised in Ravensburg. One of the main aims was, to demonstrate the technology and show, that a great reduction in system cost per m² collector area and an increase in solar gain is possible compared to small systems.

In 1993 a program called "**Solarthermie 2000**" with a duration of 10 years was initiated by the German government. The program was intended to allow demonstration of large scale solar heating plants in real technical scale. Until 1999 five projects with seasonal storage (two more are under construction) and about 50 large-scale projects with short-term storage have been realised.



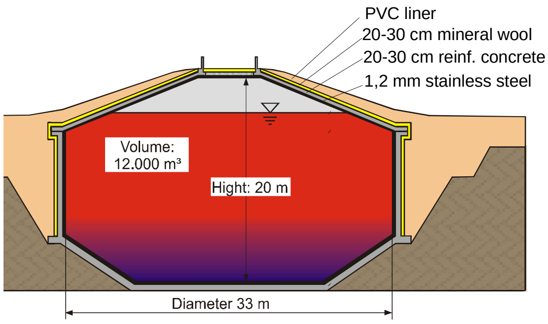
Improvement of the cost/benefit -ratio for large systems compared to small systems

The improvement of the cost-benefit ratio for systems with short-term storage compared to small systems is in the range of 60 to 70%. Even for systems with seasonal storage, where about half of the energy requirements for space heating and warm water is provided by solar energy, the cost-benefit ratio is 20 to 40% better than for small domestic hot water systems.

In **Friedrichshafen** a system with seasonal storage (12.000 m³ water volume) was put in operation in 1996. 380 flats in 10 blocks of multifamily houses and about 50 terraced houses are connected to the heating net by now. 4.250 m² of collector area, installed on the roofs of the buildings, provide almost half of the heat demand for space heating and warm water. After three years of operation it can be stated that involved researchers and utilities, as well as the inhabitants are satisfied with the results.

2 700 m² (+ 1 550 m² extention in progress) collector array in Friedrichshafen 1996. Photo: Boris Mahler.

The water storage is build out of reinforced concrete. To prevent water and moisture leakage a stainless steel liner covers the inside. The outer sides and the top are insulated with 20 to 30 cm of mineral wool.



12.000 m³ hot water pit storage. Cross section, main dimensions and components .

In the city of Stuttgart an old military barrack in **Brenzstrasse** was converted to a new housing area. 1.000 m² collectors provide 50% of the warm water demand. The collector arrays are spread over the settlement and only 15% of the (south oriented) roofs must be used. The cost/benefit ration in this project is less than 1 Euro/kWh and the solar price is about 90 Euro/MWh.

1.000 m² solar system with short term storage. Photo: Michael. Guigas

The Netherlands

The large-scale solar heating plants in the Netherlands are mainly used for providing hot water, in most cases for collective housing or houses for elderly people. One of the largest systems is however for an industrial application. Large-scale seasonal storage is limited to a few experimental situations but seasonal cold-storage's in aquifers are widely used.

Collective hot water systems

The most widely implemented application of large solar heating systems is collective housing, institutions and homes for the elderly. Most systems have a size of about 100 m^2. Some are larger, for example the flat "Brandaris" in Zaandam. This project is an example of solar renovation developed by the IEA Solar heating and Cooling programme and subsidised by the Thermie-programme. The system provides hot water and part of the space heating. The collectors are placed on top of the flat at 45 m height at a very windy side.

The Brandaris with 760 m^2 collectors on top

Another interesting project is the "Hartekamp" It is an institute for mentally handicapped with a central hot water system.

Collectors on the roof of the swimming-pool of the Hartekamp

The solar system provides hot water and also heating for an indoor swimming pool. This project is interesting, because the solar system is leased from the utility. The costs for the lease are equivalent with the savings on the energy costs. This construction is possible by the use of different fiscal and other financial measures. The solar leasing is now promoted throughout the country. In 1998 4300 m^2 of solar collectors was installed in large systems. The costs for this system were approximately 400 Euro per m^2 solar collector (this price includes storage, control unit, piping and installation).

Seasonal storage

For residential buildings, there is a project from 1985 in Groningen with duct storage for 90 houses. In Lisse, heat is stored in a concrete tank and used for bulb-drying.

Future developments

The aim is to get a lot of systems with collector areas in the range of 50 to 200 m^2. This should create enough volume to lower the price of the systems. Larger systems are planned when seasonal storage becomes more economic. For the storage the most interesting technology is aquifer storage. However, the high temperature that is needed is difficult to reach in an aquifer, therefor some projects that combine solar energy, aquifer storage and heat pumps are planned.

Industrial applications are only few, but the largest system in the Netherlands is the 2400 m^2 system for the sweet factory Van Melle in Breda. The system is the largest drain back system in the world. The hot water is used in the production and for cleaning.

Industrial use of solar heat in the Van Melle factory

Austria

At the end of 1996, 305 villages and towns in Austria were supplied with energy from central biomass-fired plants. By establishing local heating networks it is possible to convert the heat supply of entire towns to indigenous renewable energy sources in a short period of time, without having to perform a great deal of conversion work in the buildings to be supplied with energy.

For technical and economic reasons, most of these plants are operated only during the heating season. Therefore some local heating co-operatives have added a solar plant to their biomass plant to be able to offer all year round operation in an economic manner. The solar plant is designed to cover the entire heating requirement in the summer in order to prevent the starting up of the wood chip boiler in an extremely low power range.

The pioneer

The first local biomass-fired heating plant, which received solar support, was the plant in Deutsch-Tschantschendorf in Southern Burgenland. The solar system operation was started up in October 1994 and the plant now supplies 34 customers with heat all year round. The connected load is 930 kW and the plant consists of a 600 kW wood-chip boiler and 325 m² of roof-integrated solar collectors with a 34 m³ buffer storage tank for solar heat and peak load coverage.

Solar-biomass plant Deutsch Tschantschendorf

In the first summer of 1995 full coverage was reached in the months of June, July and August, in 1996 the solar coverage was over 90% in these three summer months. The specific collector yield, measured on the heat exchanger, has varied between 370 and 410 kWh/m²a in during 4 years of operation (1995 -98).

Bad Mitterndorf and Eibiswald

The results from Deutsch-Tschantschendorf were promising and two larger plants were put in operation in 1997. Main data are shown in the table. In extremely cold periods the solar storage tank makes it possible to cover peak loads even though the maximum power of the boiler is about 30% less than the maximum demand of the network.

	Eibiswald	**Bad Mitt.**
Net [m]	3 200	3 500
Boiler [kW]	2 000	4 000
Coll. [m²]	1 250	1 120
Storage [m³]	105	140

Solar-biomass plant Eibiswald

Solar-biomass plant Bad Mitterndorf

Solar yield and costs

The forecasted and already measured summer solar coverage are over 90% and the expected annual solar yields are around 400 kWh/m²a. In Eibiswald first measure-ments have already confirmed the simula-tions. The system costs of the solar plants are around 250 Euro/m² collector area, this means half cost compared to plants of medium size (50 – 200 m²), respectively 30% of the cost of small plants for detached family houses. Till 1999 about twenty solar-biomass plants were build and are running very successful.

Finland

The first large-scale solar heating system in Finland was built in the early 1980s in Kerava. This system consisted of 1,100 m^2 of solar collectors and of a seasonal storage in ground.

Kerava solar village

In early 1990s, a small collector field was connected to a district heating plant at Orivesi town.

The largest solar heating project is the Ekoviikki site in Helsinki (60 ^{o}N). Ekoviikki is a new housing area with 1,700 inhabitants where ecological and sustainable planning principles and their practical implementation into urban areas will be demonstrated. The construction of the buildings started in the summer of 1999 and will be finished in 2001.

The project comprises 9 individual building integrated solar heating systems with a total area of 1,250 m^2 and covers about half of the houses in Ekoviikki. The solar heating systems will provide about one half of the hot water demand of the apartments connected to solar. In some cases, solar will also provide low temperature heat for floor heating and thus increase the solar yield. In this case solar yields around 400 kWh/a.m^2 could be expected. The basic heating in Ekoviikki is provided by district heating.

The Ekoviikki solar project is a part of the EU Thermie A programme. The total project cost is about 0.8 million Euro. The project has 9 partners co-ordinated by Solpros from Finland. Helsinki City and its utility are strongly present. The main innovations relate to a large-size collector (a'10 m^2) especially designed for roof integration, low flow and low temperature operating strategy and heat storage stratification. Moreover, the integration of solar aspects is strongly present both on organisational and construction matters.

The construction of the first solar installations started in autumn 1999 and the monitoring will extend to the end of 2001.

Ekoviiki housing area

Within the new national renewable energy promotion programme of the Finnish Government in response to the Kyoto goals and starting 2000, concrete goals for solar heating utilization and public support are set. By the year 2010 when the programme ends, 100,000 m^2 of solar installations including large systems should have been built. The long-term vision is 1 million m^2 of solar thermal systems by 2025.

Switzerland

Italy

The Melegnano project is the first public initiative of this kind in Italy. Additionally, it is the first time in Italy that a simplified "Guaranty of Solar Results Contract" has been applied.

The main aim of the project is to demonstrate the technical and economical feasibility of the implementation of solar energy heating systems in a residential area. As a first step in this direction, a pilot solar plant in a public swimming pool centre is being realised and will be monitored and evaluated. The plant comprises 200 m^2 of flat plate solar collectors and 10 m^3 of tank volume. It is designed to provide hot water for the swimming pool facilities. Estimated total load: 145 MWh/a, solar plant contribution: 104 MWh/a and solar fraction: 72%.

Melegnano: View from pool side.

The aim of the plant is twofold: to provide energy and economic savings as well as to influence the public opinion, preparing the way for the introduction of a solar district heating system. Thus, in parallel with the plant construction, a feasibility study is being carried out for the implementation of a solar thermal space heating plant to a nearby large residential area using an interseasonal energy storage.

In the actual plant the "variable flow" principle is adopted. A complete remote control has been implemented and will offer the opportunity to optimise the control strategy. Moreover, telemonitoring will continuously provide data for the evaluation of the plant performance.

Greece

The Lykovrissi Solar Village is a housing area and it is the most important solar project in Greece until this date. The aim of the project was to test all existing thermal solar technologies for space heating and DHW existing at the time of its design (1984). Passive solar applications were also used. Among the active solar systems an interseasonal storage system was also tested.

This interseasonal system was designed to cover the needs for hot water and space heating of a multi-storey building, comprising 24 apartments. The total heated area is 1 700 m^2.

Lykovrissi: the interseasonal storage tank in front of the heated building.

This solar system consists of 162 m^2 solar collectors. Their tilt angle is 38°, facing due south. The 500 m^3 interseasonal storage tank is made of stainless steel. The total annual load to be covered by the system is of about 134 MWh.

Monitoring results covering a two and a half year period showed that the average contribution of solar energy for DHW was of about 69% for all solar systems and 82% for the interseasonal storage system. Regarding space heating, while the average contribution of all the solar systems was 19%, that of the interseasonal system climbed up to 51%, showing the good performance of system types even under the Mediterranean climate.

The interseasonal storage system is already operating normally for about 11 years.

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