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Solar integration: Five easy ways to incorporate solar thermal into conventional heating systems

Space heating and domestic hot water systems vary significantly all over the world and also across Europe. When existing buildings are retrofitted with solar thermal systems, the integration of solar thermal components into existing systems must be made as easy as possible. ***Dagmar Jaehnig*** *and* ***Charlotta Isaksson*** *have gathered together some examples of good solutions that are available.*

A large variety of conventional space heating and domestic hot water systems are being used in Europe. The type of system already installed in a building often dictates how the solar thermal system can be integrated and which kind of solar thermal system is used, giving a range of different solutions suitable for single-family and multi-family houses.

When integrating solar thermal into conventional heating systems it is important that the integration ensures good conditions for the performance of solar systems - priority should always be given to the sun!

Use collector as a second 'boiler'

Single-family houses that have an existing vertical domestic hot water tank with a single heat exchanger inside can retrofit a solar thermal system simply by connecting the solar thermal collectors in parallel to the existing conventional boiler.

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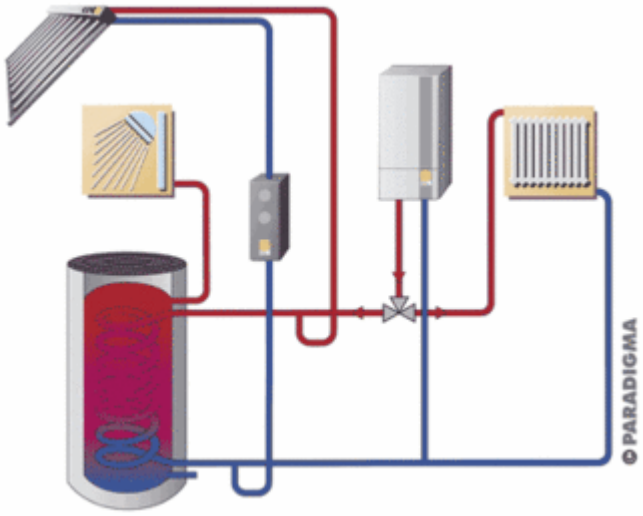

In this case, the collector loop can be connected directly to the conventional system like a second boiler (see Figure 1). Water from the space heating loop is used as heat transfer medium in the collector loop. This means that both energy sources (conventional boiler and solar) use the same heat exchanger in the domestic hot water tank. Therefore, the collector has to be operated at the same (or higher) temperature level as that provided by the boiler. The control strategy of the collector loop pump ensures that the flow temperature from the collector loop is always high enough to meet the required domestic hot water temperature.

This method only works with evacuated tube collectors, which are generally more efficient at high operating temperatures than flat plate collectors and - probably even more importantly - are resistant to freezing in winter time due to the vacuum insulation around the collector pipes. The exterior piping of the collector loop should be kept as short as possible, as freezing in the pipes and collector is prevented by occasionally circulating a small amount of heat from the store.

This type of system can also provide solar assistance to space heating. In this case, a few extra connections are necessary to allow the collector to deliver heat directly into the space heating loop. However, the small size of typical conventional domestic hot water storage tanks does not allow for high solar fractions.

When the conventional boiler has to be replaced

Another common situation is that the entire conventional boiler in a single-family house - which heats water as well as providing space heating - has to be replaced because of its age or low efficiency. In this case it makes sense to install a compact solar combisystem. These systems combine a storage tank for both space heating and domestic hot water, a hydraulic unit for the collector loop, a domestic hot water preparation unit inside or outside the tank, the auxiliary heat source and a control unit which takes care of the entire system in one single unit.

For the installer, it is easy to place the pre-fabricated compact unit into the heating room or possibly an attic and connect the existing space heating loop, the collector loop and the mains and domestic hot water pipes to it. There are systems on the market that use different kinds of auxiliary energy source such as natural gas, fuel oil or wood pellets. This means the existing fuel source can in most cases stay the same and the connection is the same as for a new conventional boiler.

A number of companies in European countries offer such compact solar combisystems (e.g. SOLVIS and Rotex in Germany, Solarfocus in Austria, CLIPSOL in France, Daalderop in The Netherlands, Agena in Switzerland, Solentek AB in Sweden).

The advantage of these systems is not only that they are compact and easy to install but also that they are pre-engineered. The installer does not have to dimension heat exchangers, collector areas, pipe diameters etc. Manufacturers offer compact solar combisystems in different sizes. The installer only needs to choose the package that best fits the domestic hot water consumption and space heating load for the specific case.[2]

Separate domestic hot water system

In many parts of Europe and North America, domestic hot water production and space heating are not typically delivered by a combined system but by separate units. Space heating can be by point sources, air or other heating systems. (See box A.)

Central system with two-pipe network

A common heating system in multi-family buildings uses a central conventional boiler or district heating station to supply both domestic hot water and space heating. A two-pipe heat distribution network is used to deliver the heat to the apartments.

The heat distribution system can stay exactly the same as in the conventional system. In each apartment, so-called ‘apartment heat transfer units’ are used that control the space heating loop flow and return temperature and supply heat for domestic hot water using a heat exchanger. The apartment heat transfer units are an essential part of the system because they ensure that the return temperatures from each apartment are as low as possible. Typically the return temperatures of well adjusted two-pipe networks are around 30°C. The space requirements for the heat transfer unit are very small. They can even be flush-mounted in the wall (see box B above).

The idea of the apartment units originated in Scandinavia. Properly equipped apartment units contain all the components required to provide decentralized heating of domestic hot water, to provide a hydraulic equalization of the space heating circuit, and for long-term operation and maintenance. In many cases, they also contain a heat metering unit that allows the allocation of heat costs for each user. Moreover, they are not only compact and industrially manufactured to the highest quality, but also feature components that do not require an external power supply. Although decentralized apartment units were originally used in the field of district heating, there are now several suppliers in Europe (e.g. Redan/Danfoss in Denmark, Logotherm in Germany) who supply units specially developed for use in multi-storey residential buildings.[1]

For applications with longer distances between users - such as in terraced houses - small domestic hot water stores can be installed in each apartment. These stores are charged in specified time windows once or twice a day. This way, the heat distribution network has to be operated at domestic hot water temperature (55°-60°C) only during these time windows. For the rest of the time, the temperature in the network can be decreased to the temperature necessary for space heating. Thereby, heat losses from the network are reduced.

Central space heating system with domestic hot water preparation in each apartment

Retrofitting in these instances is very similar to that in single family houses with separate hot water stores. However, in multifamily houses the distance to the roof is often significantly larger than for single family houses and it can be advantageous to mount the collectors on the facade (see box C) or mounted on the balustrade of a balcony (see box D).

This means that pipe connections from the collector into the apartment are very short. A simple controller could allow the electrical heating element to heat the store only after sunset, if there was not enough solar radiation to bring the store to the desired temperature.

Minimum effort

The best time to retrofit an existing building with a solar thermal system is always when the building is being renovated or when the heating system needs to be replaced. A number of simple solutions have been shown here, demonstrating that in many cases an existing system can be retrofitted with minimum effort.

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NEGST is a project funded by the European commission involving 18 institutions from 12 countries. The acronym stands for ‘New generation of solar thermal systems’. The overall objective of this project is to provide a framework for research in order to bring more cost-effective solar thermal systems, particularly for domestic hot water preparation and / or space heating on the market. This is necessary in order to contribute to the European Union’s Action Plans with regard to the reduction of CO2 emissions and the cost effective supply of renewable energy sources.

Project homepage with project deliverables for download: http://www.swt-technologie.de/html/negst.html

References

1. Fink C., Riva R., 2004, Solar-supported heating networks in multi-storey residential buildings - A planning handbook with a holistic approach, published in German by Arbeitsgemeinschaft ERNEUERBARE ENERGIE GmbH, Gleisdorf, Austria. An English version is available electronically from AEE INTEC, Gleisdorf, Austria.
2. Weiss W. (ed.), 2003, Solar heating systems for houses - A design handbook for solar combisystems, James & James (Science Publishers) Ltd, London, Great Britain. Box: NEGST Project

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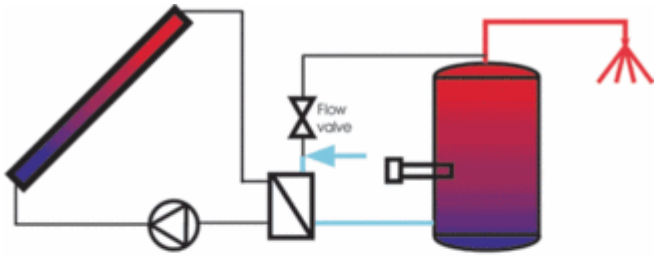
BOX A - DOMESTIC HOT WATER SYSTEM

A storage tank for domestic hot water is often heated by electricity via a heating element (immersion heater). For these tanks there are only two connections, one for the mains inlet and one for the hot water outlet. The solar thermal system connects to these two ports and supplies heat through them, normally via an external heat exchanger. For DHW discharge and higher flow, the flow valve is closed, the water back-flushes the heat exchanger and enters the store at the bottom (top figure). For charging of the tank, the flow valve is open and water can enter the heat exchanger by natural convection through the bottom connection and the hot water enters the store at the top (bottom figure).



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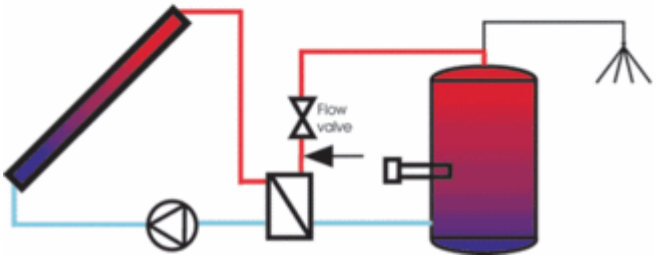

Box B - Central solar thermal system for buildings with two-pipe network

In a standard conventional heating system, a central boiler delivers heat into the heat distribution network. For retrofitting a solar thermal system, the system needs an additional buffer store that both the collectors and the conventional boiler can deliver heat into. The two-pipe network is fed from the top of the buffer store. The low return temperature from the network goes into the bottom of the store and ensures low return temperatures to the collectors and therefore high solar yields.

Box C - Facade-integrated collectors are connected to storage tanks in each apartment

Another typical scenario for multi-family houses is that the domestic hot water is provided by decentralized domestic hot water stores in each apartment. The auxiliary energy of the decentralized hot water stores is often electricity. The space heating system can be a central boiler or district heating system, or decentralized boilers in each apartment. A solar thermal system would in both cases be integrated into the individual domestic hot water stores and not supply any heat for space heating.

Box D - Collectors integrated in south-facing balconies are connected to storage tanks in each apartment

A sketch of the collector and storage tank configuration is shown in the figures. The solar thermal collectors can be installed integrated into the facade itself or, for example, into the balustrade of south-facing balconies. This solution is especially easy to realize if the facade has to be renovated anyway.

The advantage of this system concept over a central solar thermal collector field is that the collector loop piping does not have to be run though the entire building but only from the wall or balcony outside the apartment to the storage tank inside.

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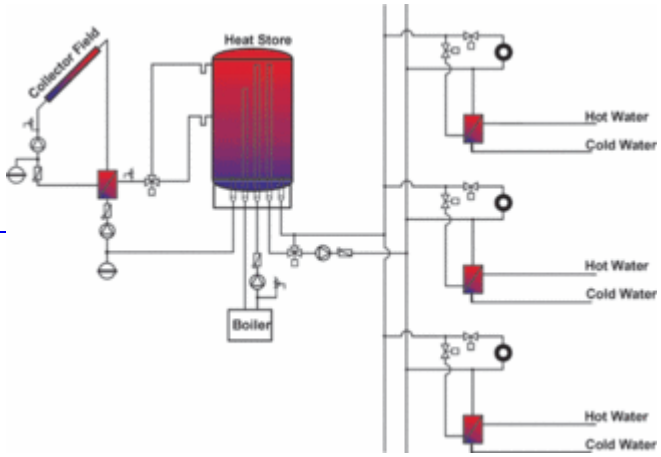

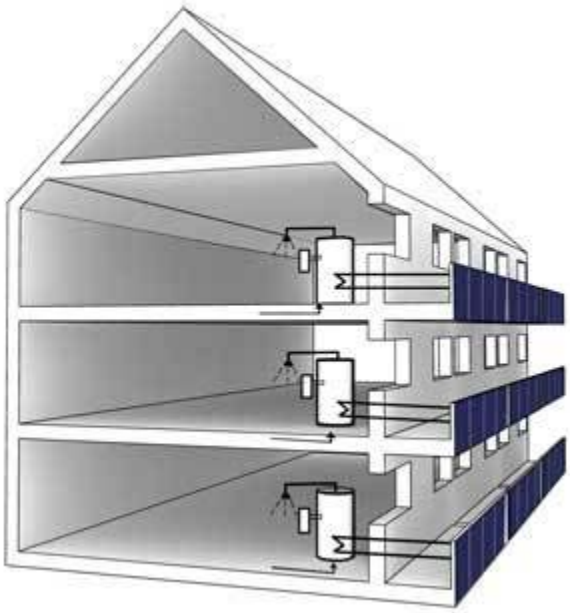

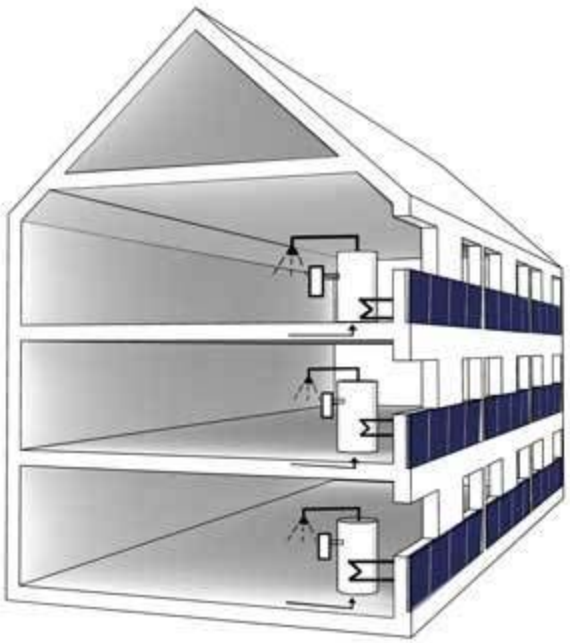

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