WP1.E5 / THEORETICAL EVALUATION OF PROMISING SYSTEM: Combisystem Unit with Integrated Pellets Auxiliary Heater (REBUS-Pellet)

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New Generation of Solar Thermal Systems

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This solar combisystem concept was developed based on the experiences of IEA-SHC Task26 /Weiss, 2003/, the ALTENER project "Solar Combisystems" /Ellehauge, 2003/ and investigations on the Swedish market for solar heating systems. The evaluated system is not yet on the market, although it has been tested in the lab and is currently being undergoing field trials. It should be considered as still under development. There are plans to make it simpler, based on the results of the field and lab trials. Certain features have not been described in detail due to constraints from industry. The reference system that it is compared to is a standard Swedish combisystem with external boiler and single buffer store containing three finned tubed heat exchangers, one for the solar circuit and two for preparation of hot water.

The system is characterised by the following features:

- Fully prefabricated "Technical Unit" comprising all active components in the system as well as controller and expansion vessels. It includes a compact pellet boiler and 80 l auxiliary buffer store.
- Modular construction in 60 x 60 cm units, the same size as standard cabinets for washing machines, cupboards etc.
- Designed for a new market niche in Scandinavia – pellet and solar heating in houses without a cellar.
- Designed to compete with ground coupled heat pump systems, the predominant heating system sold in Sweden.
- Flexible system size with solar preheat store that can either be one (or more) 60 x 60 cm cabinet(s) of 300 l volume if placed in living area, or one store of any suitable size if placed in cellar.
- High level of integration and prefabrication for minimised installation time and costs.
- All-in-one controller for all system control aspects.
- Optimised for high system efficiency and low emissions.
- The technical unit can be sold as a solar prepared boiler, and the collector and solar preheat store can be bought later.
- A water mantled pellet stove can be used instead of the integrated boiler without changing the hydraulic layout or controller.

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Reference system

Choice and use of the reference system

In this report, the system evaluation is based on a comparison with a reference system. The reference system matches the state of the art of system technology used for combined solar water heating and space heating in Sweden.

All statements in the *evaluation* section below are relative to (or in comparison with) the properties of the reference system.

Description of the reference system

Application: Mainly retrofit applications, but occasionally also in new houses.
Primary purpose: Solar hot water preparation and space heating (solar combisystem)
Secondary purpose: -
Collector loop: Pumped system.
Description: This system is a very flexible system that is used with a wide variety of sizes and auxiliary heat sources. The majority of the systems have a store of 500 – 1000 litres with a collector area of 7.5 – 15 m^2. The store is the centre of the system with all heat energy being transferred from the heat sources via the store to the end use. The system is nearly always installed in a cellar or other area not designated as a living space. There are several manufacturers of the system.
Cost (retail sales price of the reference system without installation):
4.000 – 5.000 € for the solar part of the system including electrical backup heater of 6 kW. The price depends on the supplier and depends largely on the quality of the collector and to a lesser extent the other components. For a system comparable to the evaluated system, a pellet boiler is required, costing 4.500 – 9.000 € depending on the degree of automisation. Costs are to the customer excluding VAT (25%).
Collector area and store volume of the reference system: 10 m^2, 750 l

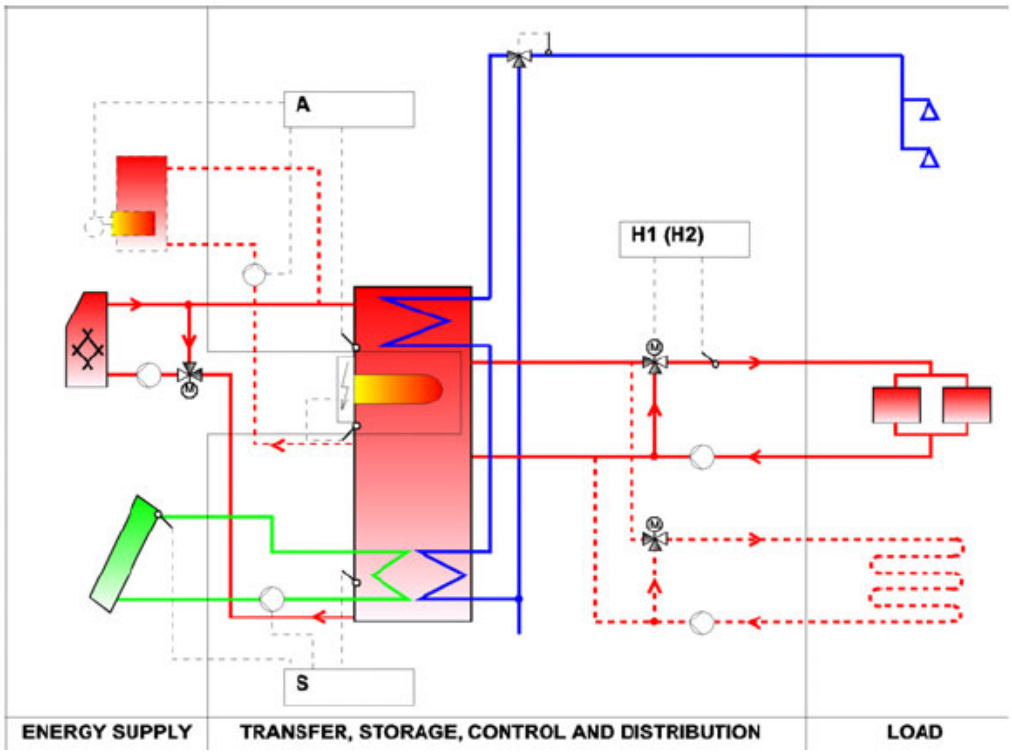


Figure 1: Reference system

Country: The system represents the state of the technology in Sweden
Reference: The reference system is described in more detail in NEGST WP1.D1 / SURVEY ON THE STATE OF THE TECHNOLOGY OF SOLAR THERMAL SYSTEMS, Appendix (Sweden).

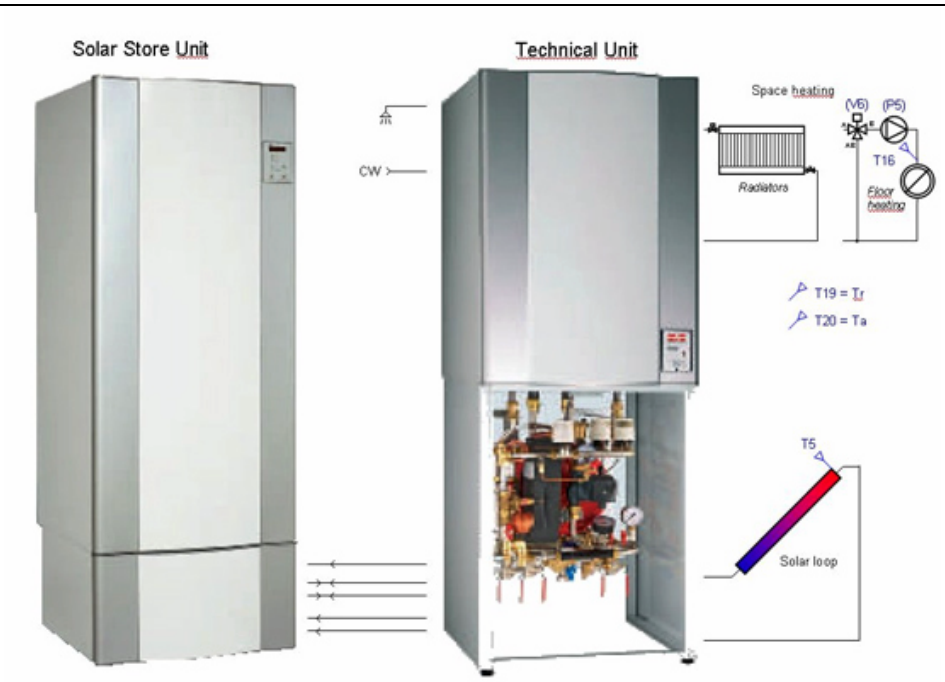
Evaluation

Description of the evaluated system

Application:
This is a combisystem that can be installed even in the laundry or utility room, as well as in the cellar. It is suitable for both existing and new houses.

Collector loop: pumped system.

Description:
This is a flexible system based on units with a footprint of 60 x 60 cm, the same as standard electrical appliances and cupboards. The system concept is based on a “Solar Store Unit” as one separate part in combination with a fully prefabricated “Technical Unit” which contains all the components, like a flat plate heat exchanger for domestic hot water preparation, a compact pellet boiler, a space heating pump and flow temperature regulator, solar collector loop components including the expansion vessels and the central controller as well. A newly developed central controller with some advanced new features is responsible for an optimised coordination of all components. The technical unit is complete and can be used as a boiler with all functions necessary for DHW preparation and space heat supply. The separate buffer store is solely for solar preheating and can be chosen in a number of sizes, or if 60 x 60 modules of 300 l volume are desired, with several store units. There is also a small standby store in the technical unit to ensure sufficiently long running time for the boiler and therefore good efficiency and low emissions.



Simple design study how the system could look like

Figure 2: Solar thermal system evaluated

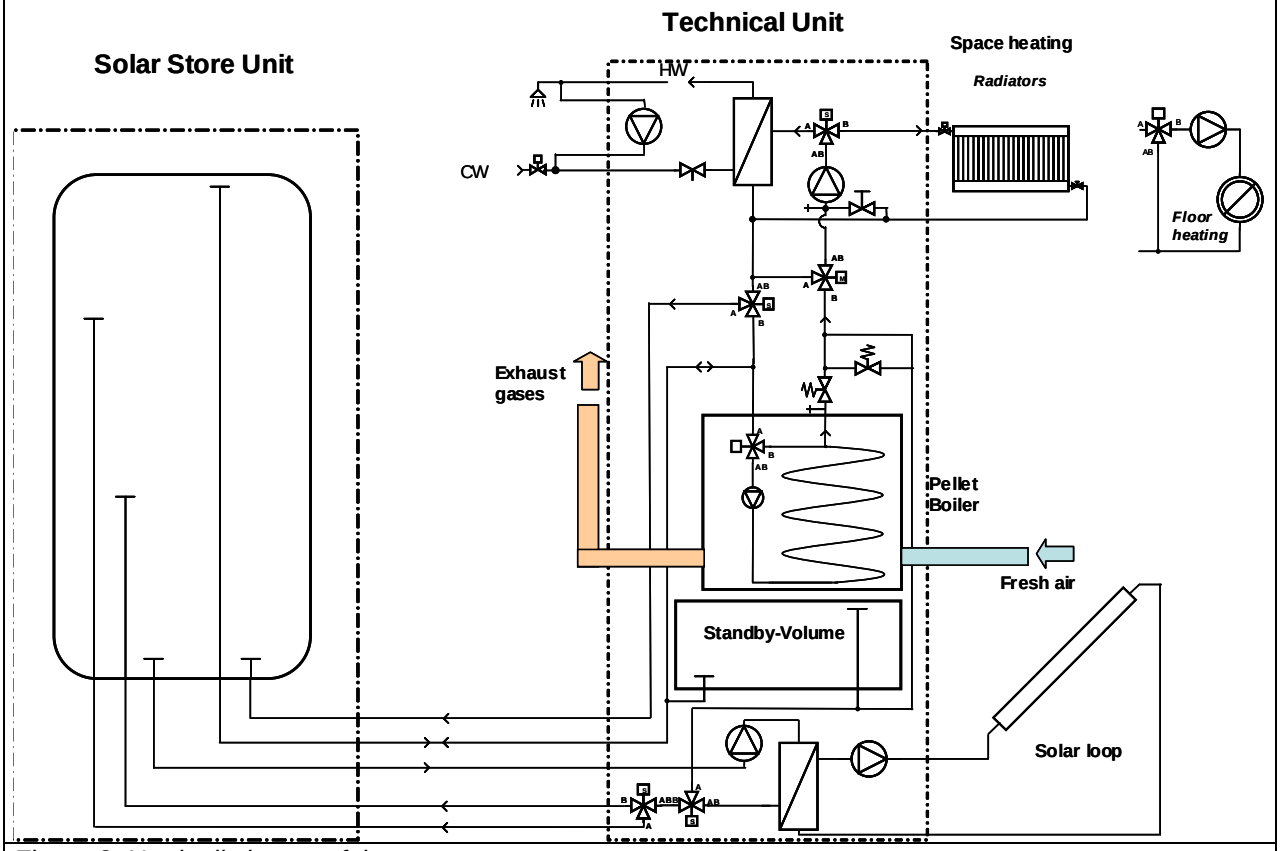


Figure 3: Hyrdaulic layout of the system.

Cost and savings

Material and manufacturing:
Reduction of components is realized as the space heating pump and the space heating mixing valve is also used for domestic hot water preparation. This means that for hot water preparation only, the flat plate heat exchanger and a switching valve are used as main components. Caused by this high grade of system integration it is also expected that a reduction of pipe length in the whole system can be realized. Nearly the whole system is preassembled in the manufacturing facility, allowing a more rational assembly with potential for reduced costs and risk for wrong installation. Compared to the reference system, it is possible that the cost of the evaluated system is higher as it is a more advanced system as well as having more preassembled. However, this results in significantly lower installation costs, which are expected to more than balance the potentially greater cost of the unit.

Installation:
This solar heating system consists of two units, where the “Solar Store Unit” only is the heat storage and the “Technical Unit” has integrated all hydraulic parts in a fully prefabricated way. This means the advanced pellet boiler, 80 l auxiliary-volume, all pumps, valves, heat exchangers, the controller and the expansion vessels (for small systems), which are necessary to supply the building with space heating and domestic hot water, are pre-installed in this “Technical unit”.
Installation work (beside collector on the roof and piping to the technical room) is to put the two units on their places side by side, connect the two units with 5 flexible pipes, connect the pipes of the collector, the domestic hot water, the space heating, the pellet feeding, and the exhaust gas pipe. As electrical work, only the collector sensor has to be fixed to the controller, and the pre connected tank temperature sensors have to be placed in the right sensor sockets. After filling the system with water and the solar liquid, the system can be switched on.
The number of work items during installation is significantly less than for the reference system. The evaluated system thus has a large potential for reduced installation costs and reduced installation errors.

Maintenance:
This is expected to be the same as for the reference system. The pellet boiler requires removal of the ashes once every couple of months and cleaning of the heat exchanger tubes once per month during winter. This is comparable to the better boilers in Sweden, but a greater requirement than the fully automated boilers from Austria, that are significantly more expensive.

Combined cost:
The cost of materials, manufacturing, installation and maintenance is expected to be similar toor marginally more expensive than that of the reference system, even though the new system has the potential for higher energy savings due to optimal heat management.

Performance and energy savings, including embodied energy:
For the same system size, an increase in energy savings compared to the reference is expected, due to the better interplay between the pellet boiler, thermal storage and the collectors. In addition reduced emissions are expected for the same reasons.

Cost performance ratio:
The cost/performance ratio is expected to be similar or better than the cost/performance ratio of the reference system. Further, the potential of fuel reduction of the proposed system in absolute numbers is higher due to the optimal heat management.

Additional benefits

Safety and health:
Domestic hot water is produced directly during tapping via flat plate heat exchanger, which avoids legionella problems.

Range of application, extra service, extra comfort, extra function:
Based on the possibilities of using the integrated central controller, it is planned to develop a new strategy for hot water circulation that will lead to reduced heat losses in the circulation loop. Based on the special hydraulic design of the system including the central controller, an advanced protection mode to avoid scalding will be available in this system.

Environmental friendliness:
As this system uses only renewable energy sources, it is very environmentally friendly during operation. This is also true of the reference system (with pellet boiler), but due to the better energy savings, the evaluated system is expected to use less pellets.

Aesthetics, building integration and space requirement:
The design of the system is based on the 60 x 60 cm concept, like all household appliances, and looking similar to a freezer or a refrigerator. Since the design is attractive, the system can with advantage be installed in used rooms (compared to basements) like entrance room, store room, kitchen, bath room, etc. If the system is installed in the living area, the “losses” from the cabinets will actually be useful heat gains to the building. During summer it will be possible to have an electrical backup to reduce heat gains and thus risk for overheating. Two cabinets together require less than 1 m^2 floor area.

As the system is based on a modular 60 x 60 cm concept, with aesthetically pleasing units, it will be possible to place it in laundries and utility rooms as well as in the cellar. This gives a much greater potential market than the reference system that is only suitable for the cellar.

Technical integration:
Integration into a conventional heating system is easy, since the controller takes care of all control tasks (no coordination problems between new and old controller or between more controllers) and due to an advanced control strategy for the space heating. The modular design allows for flexibility in system size, with one or more modules possible for storage if placed in the living area, or if placed in the cellar any other suitable store size could be used.

Markets and marketing considerations
Opening-up of new and niche markets:
Based on the design of the "Technical Unit", it is easy to realize a two step marketing concept because the Technical Unit itself can supply the house with space heating and hot water also without a solar tank. It is possible later on to add a solar tank and a collector without any changes in the Technical Unit, just connecting the pipes of the solar collector loop and the pipes between the Technical Unit and the tank.

There is no pellet and solar heating system in Sweden that has the same potential to be used in laundry or utility room. The evaluated system will thus make it possible for a pellet and solar heating system to compete with the dominating alternative of ground coupled heat pump for houses without a cellar.

Expansion of existing market:
Because of the high grade of prefabrication, it is possible to convince installers who are not experienced in solar heating technology to enter the solar heating market. The effort in teaching the employees is reduced to a minimum of time.

Special considerations and limitations
Since this new concept is under development and at the moment (September 2005) the first prototype is still being tested, no reliable facts can be stated. The first test results are however, promising. It is planned to install a second generation prototype at the end of 2005 in a one family demonstration house in order to test the system under real operating conditions.

Acknowledgements

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