WP1.E6 / THEORETICAL EVALUATION OF PROMISING SYSTEM: Combisystem Unit with Integrated Gas Auxiliary Heater

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New Generation of Solar Thermal Systems

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SUMMARY

This solar combisystem concept is developed based on the experiences of the IEA-SHC Task26 /Weiss, 2003/, the ALTENER project “Solar Combisystems” /Ellehauge, 2003/ and investigations on the needs of the Danish market of 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 Danish combisystem with external boiler and a hot water tank containing two heat exchanger spirals, one for the solar collector loop and one for the boiler loop. An external heat exchanger can transfer solar heat from the solar collector loop to the space heating system.

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 natural gas boiler.
- 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 – natural gas and solar heating in houses without a cellar.
- Designed to compete with systems based on natural gas boilers.
- Flexible system size with solar 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 store can be bought later.

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 Denmark.
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: Solar hot water preparation and space heating (solar combisystem)
Collector loop: Pumped system
Description: This system is mainly a solar domestic hot water system which is able to use remaining solar energy for supplying the space heating system directly without using a heat storage. This is a good solution for slightly oversized solar domestic hot water systems. But since no heat storage is used, the solar fraction is expected to be low.
Cost (retail sales price of the reference system without installation): Euro 5000 excluding VAT.
Collector area and store volume of the reference system: 8 m^2, 300 l

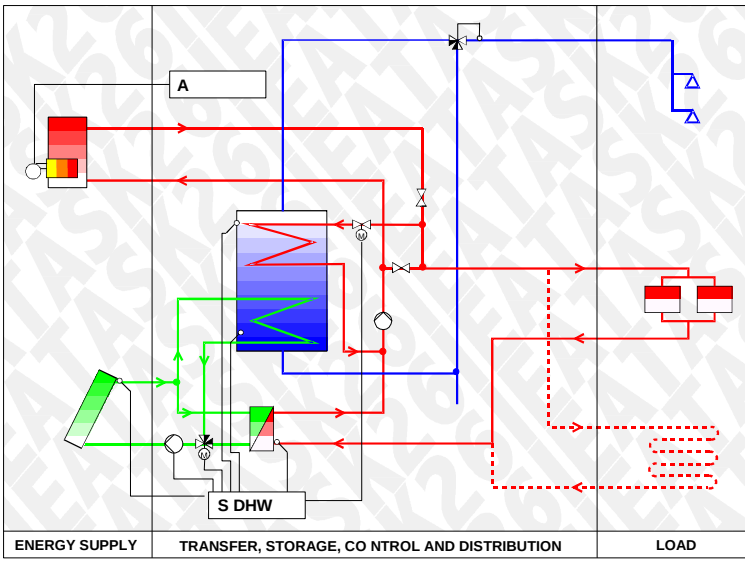


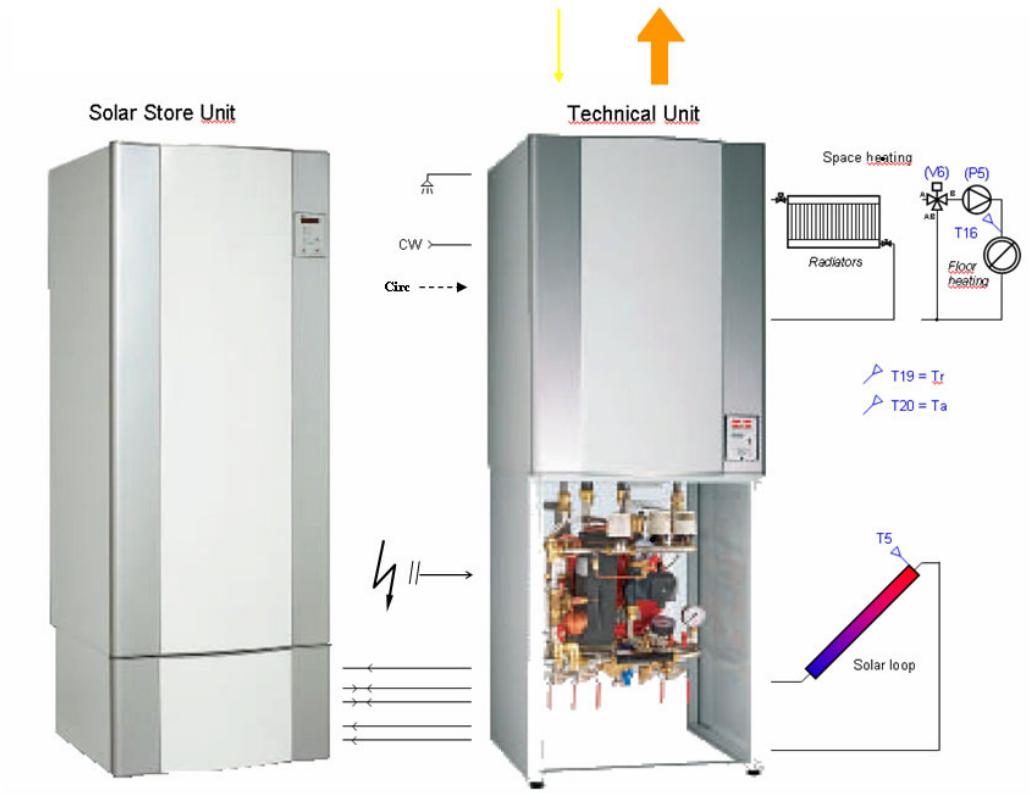
Figure 1: Reference system

Country: The system represents the state of the technology in Denmark . The reference system is described in more detail in NEGST WP1.D1 / SUMMARY REPORT ON TODAY'S SYSTEM TECHNOLOGY, Appendix (Denmark)

Evaluation

Description of the evaluated system

Application: Solar hot water preparation and space heating (solar combisystem).
Collector loop: Pumped system.
Description: The system concept is based on a “Solar Store Unit” as one separate part in combination with a fully prefabricated “Technical Unit” which contains peripheral components like a flat plate heat exchanger for domestic hot water preparation, a condensing natural gas boiler, a space heating pump and mixing group, 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.
Typical size of the storage tank: 300 l.



Simple design study how the system could look like

Figure 2: Solar thermal system evaluated

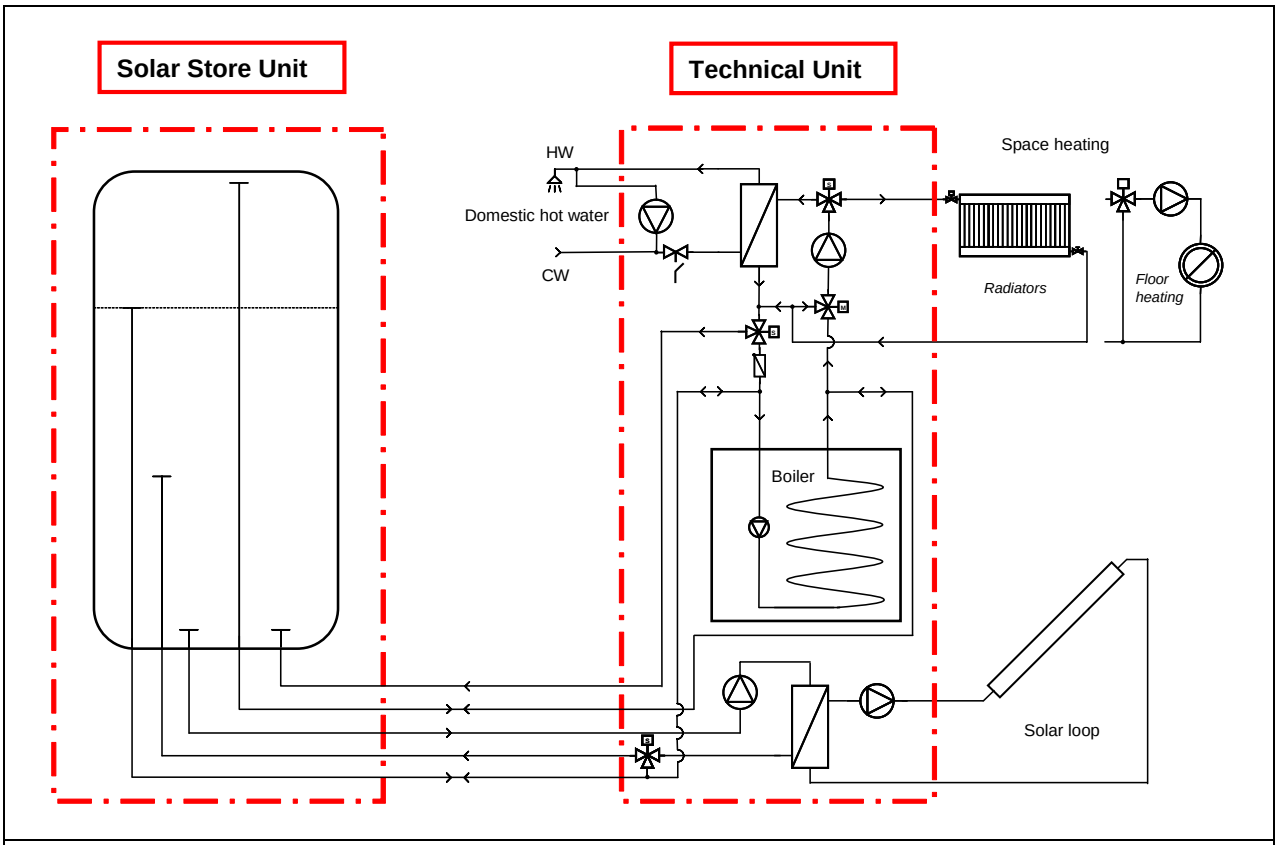


Figure 3: Hydraulic layout of the system

Cost and savings

Material and manufacturing:

Reduction of components is realized in that way that the space heating pump and the space heating mixing valve are 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.

Installation:

This solar heating system consists of two units, where the “Solar Store Unit” hosts the heat storage only and the “Technical Unit” has integrated all hydraulic parts in a fully prefabricated way. This means the condensing gas boiler, 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 mounting collectors on the roof and installing pipings to the technical room) is to arrange the two units, connect them with 5 flexible pipes, connect the pipes of the collector, the domestic hot water, the space heating, the natural gas, and the exhaust pipe. As electrical installation work, only the collector sensor and the pre connected tank temperature sensors have to be connected properly. After filling the system with water and the solar collector fluid, the system can be switched on.

Maintenance:

There is no relevant difference with respect to the reference system. The high integration grade of this solar combisystem can possible cause problems when exchanging damaged components.

Combined cost:

The cost of materials, manufacturing, installation and maintenance is expected to be similar to that of the reference system.

Performance and energy savings, including embodied energy:
An increase in energy savings compared to the reference is expected due to the better interplay between the natural gas boiler and the collectors.

Cost performance ratio:
The cost/performance ratio is expected to be 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.

Additional benefits

Safety and health:
Based on the special hydraulic design of the system including the central controller, an advanced protection mode to avoid burning due to hot water, will be available in this system. 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 expected that a newly developed strategy of hot water circulation will lead to shorter time until hot water reaches the tapping including less energy losses for circulation.

Environmental friendliness:
As this system is expected to have higher energy savings than other solar combisystems it is environmentally friendly.

Aesthetics, building integration and space requirement:
The design of the system is based on a concept of fitting all components on a floor area of 60 cm x 60 cm like standard household appliances, and looking similar to a freezer or a refrigerator. Since the design is aimed to be attractive, the system can with advantage be installed in housing space (compared to basements). An additional effect of this aesthetic advantage is that in such cases the energy losses are really directly used for heating rooms which are used in daily life.
Both cabinets together require less than 1 m^2 floor area.

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.

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 later possible 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.
This concept combines the advantage for the installer to use a fully prefabricated SCS, but it is also easy to use his favourite condensing gas boiler or solar tank since all “intelligence” is concentrated in the Technical Unit. For many installers this is an important point on accepting a new product.

Expansion of existing market:
Because of the high grade of prefabrication, it could be 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 in September 2005 the first prototype just started to be tested, no reliable facts can be stated. But the first test results are promising. It is planned to install a second generation prototype in spring 2006 in a one family demonstration house in order to test the system under real operating conditions.

Acknowledgements

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