MODELLING OF SOLAR COMBI PLUS SYSTEMS – FRAMEWORK AND HYDRAULIC SCHEME PROPOSALS

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1 Kurzfassung / Abstract

Im Herbst 2007 wurde das durch die EU unterstützte Projekt SolarCombi+ gestartet. Ziel des Projektes ist es den Markteintritt von Solar Kombi Plus Systeme (Systeme zur Warmwassererwärmung, Raumheizung und Raumkühlung kleiner Leistung) zu unterstützen. Hierzu werden zu Beginn Marktanalysen durchgeführt um die Marktnischen mit dem größten Potential zu identifizieren. Darauf aufbauend werden Modellierungen von Solar Kombi Plus Systemen durchgeführt und technisch und ökonomisch analysiert.
Im vorliegenden Dokument werden in der einer Einführung, Europäische Daten es Air Conditioning Marktes aufgezeigt und die Ergebnisse der Firmenbefragung vorgestellt. Es folgen Überlegungen zur Grundlage der Wahl von hydraulischen Schemen von standardisierten Anwendungen und eine Diskussion über die gewählten Gebäudetypologien und Klimata für die Modellierungen. Abschließend werden die beiden hydraulischen Grundschemen vorgestellt und ein Ausblick auf die zu erwartenden Modellierungsergebnisse gegeben.
Weitere Informationen befinden sich auf der Homepage www.solarcombiplus.eu

In autumn 2007 the European project SolarCombi+ has been started. Target of the project is to enhance the market penetration of solar combi plus systems (small scale solar systems which provide domestic hot water, space heating and space cooling) in Europe. Therefore market analyses are carried out in order to identify the most promising markets for such systems. Afterwards modeling of solar combi plus systems is carried out considering technical and economical aspects.
In the present paper are presented within the introduction actual numbers of the European air conditioning market and the results of the survey with industry partners. This is followed by discussions on the bases of the development of standardized hydraulic schemes and the presentation of the choices of building types and climatic areas for the following modeling activities. Finally the two chosen hydraulic schemes are presented and an outlook is given on the expected modeling results.
Further information can be found on the homepage www.solarcombiplus.eu

2 Framework

2.1 European air conditioning market

The European Air Conditioning (AC) market has grown rapidly during the last 5 years. The size of AC markets in the seven major European countries (France, Germany, Greece, Italy, Russia, Spain and the UK) expanded from some 2.4 million sold units in 2000 to 5 million sold units in 2004.
A further breakdown of the European AC market reveals that Italy and Spain are holding the largest market of about 1.4 to 1.7 million units per year (after 2004), followed by France, Greece and UK at 300,000 to 500,000 units each [Refrige.com].

Having a closer look at the France and the Italian markets can be stated that especially the monosplit units with small capacities are responsible for more than 50% of the overall sold units (see Figure 1 and Figure 2).

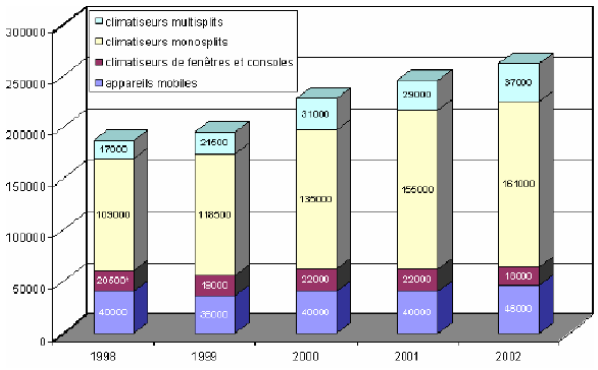

Figure 1 – Evolution of the air conditioning market of individual air conditioners with a capacity below 17,5 kW in France. Sold units in the years 1998 – 2003

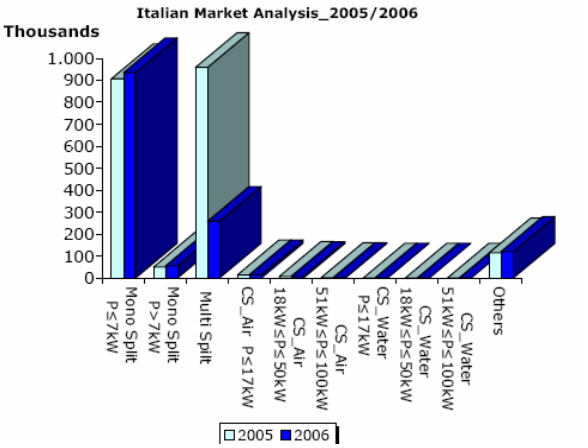

Figure 2 – Share of air conditioners with different capacities on the overall Italian market in the years 2005 and 2006 [CO.AER]

Solar combi plus systems with their capacity usually being between 5 and 15 kW can be classified in this market.

2.2 Market focus

In the SolarCombi+ project virtual case studies on the functioning of solar combi plus systems are being elaborated. In order to choose the most relevant cases, the industry partners of the project delivered information of their actual markets and their market interest – regarding building type and countries.

As methodology a questionnaire has been elaborated by CRES which was distributed to the industrial project partners. The whole questionnaire and results are included in the project report [Vougiouklakis Y. et al].

As can be seen in Figure 3 the most relevant building types for solar combi plus systems up to now are single family houses and small scale office buildings; As well for the future this are markets are regarded by most industry partners as the main ones (Figure 4).

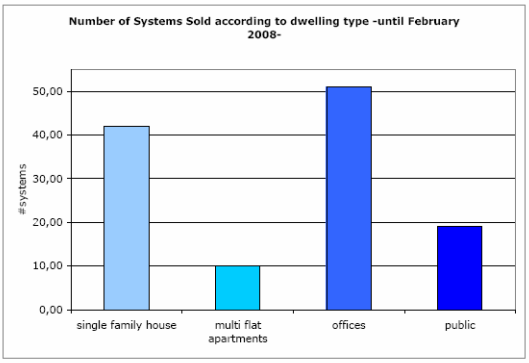

Figure 3 – Number of systems sold until February 2008, as reported by the industrial SolarCombi+ project partners

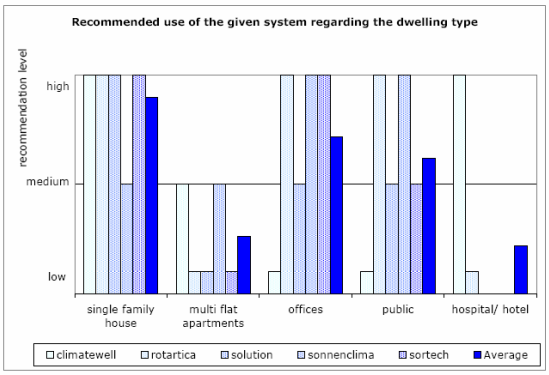

Figure 4 – Type of buildings which are considered most suitable for the utilization of solar combi plus systems by the industry partners

Regarding geographical aspects, Italy and Spain are considered as the most promising markets by the industry partners (see Figure 5).

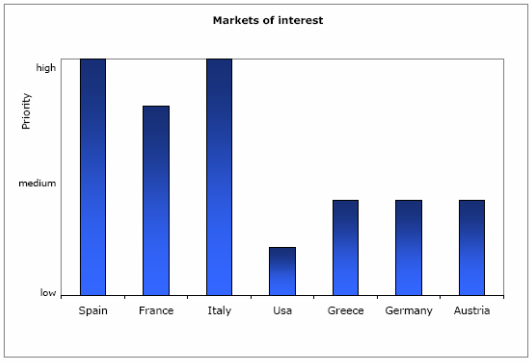

Figure 5 – Markets which are considered of high priority by the SolarCombi+ industry partners

3 Modelling of Solar Combi+ decks

3.1 Starting point – limits

Based on the information given by the market reports the elaboration of models was implemented.

The target is the modelling of a reduced number of hydraulic system schemes with the goal to provide to installing companies one system scheme which can be applied in many different cases. Here through the planning time, the probability to implement non optimised solutions in the design phase and to make mistakes in installation phase shall be reduced leading to more stable and more cost competitive systems.

- From the technical point of view the system scheme should be able to be used with radiant ceilings as well as with air ventilation systems. As well it has to be possible to integrate different kind of chillers and heat rejection circuits.
- From the legal point of view the system scheme should be able to be implemented in all relevant European countries. This aspect is critical especially regarding the Spanish law where a direct delivery of heat through the solar thermal collectors and the back up heater in one single heat storage is not allowed as the storage has to be kept constantly above 60°C for legionella reasons [ITE02, ITE10].

In general a compromise is searched for allowing an optimal use of the solar energy, a detailed control scheme, but at the same time a simple design scheme and a limited number of components (especially pumps and three way valves) in order to reduce costs and arbitrary energy consumption during operation. In fact in several realised solar cooling installations the system performance remained in operation behind the design values [Troi A. et al, Selke T.]

The modelling activities are based on already elaborated models and simulations especially on the ones of the IEA SHC Task 25 [H.M. Henning] based on the SACE method.

3.2 Climate and Type of application

In order to identify the optimised solutions for different climatic conditions, three locations have been chosen which represent certain areas of heating and cooling necessities. In order to identify these, the results from EcoHeatCool project where used. In Figure 6 and Figure 7 the European Cooling Index respectively heating index is schown for Europe [Werner S. et al]. The cooling and heating index is normalised to average European conditions (e.g. Strassbourg), humidity control is not considered in this indexes.

For modelling reasons the following three index pairs (EHI / ECI) have been chosen, leading for example to the following three locations:

- 100/100 (Strasbourg - France)
- 85/115 (Toulouse - France)
- 70/140 (Naples – Italy)

In order to choose the location itself, starting from the index pairs, the latent load played a relevant role. In fact Naples has been chosen instead of Madrid because it shows a higher humidity (yearly average dew point temperature is 8,1°C and 4,6°C respectively [EnergyPlus]).

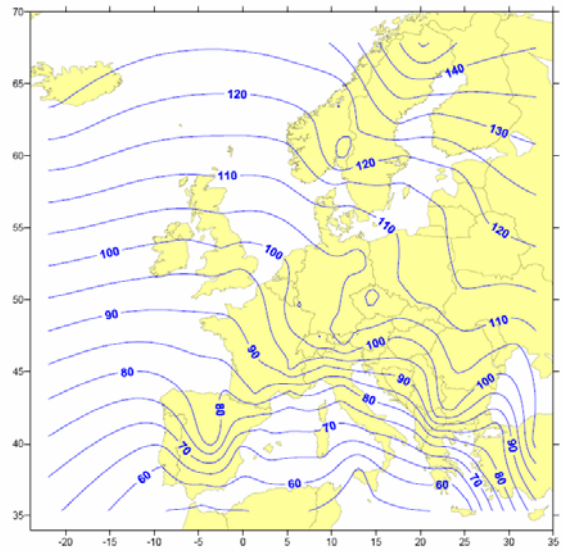

Figure 6 – European map showing the different European Cooling Index (ECI) levels [Werner S. et al]]

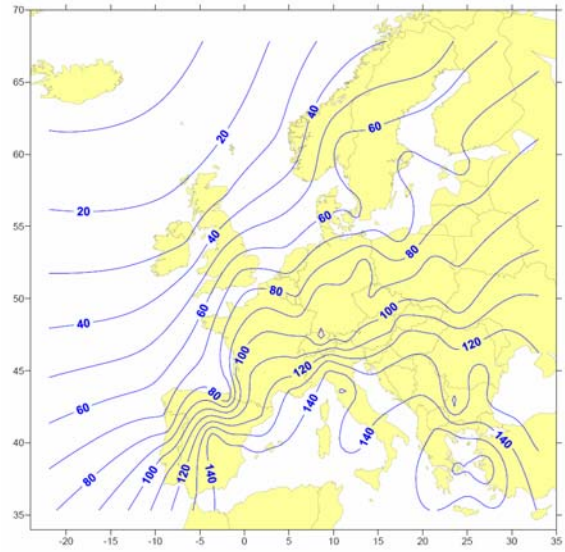

Figure 7 – European map showing the different European Heating Index (EHI) levels [Werner S. et al]

Within these 3 climates as well three different applications have been chosen. Following the market study results these are:

- A small office building with demand on chilled water at low temperatures (e.g., 7/12°C), foreseen for the operation with fan coils or for supply air cooling;
- A residential building with demand on chilled water at low temperatures (e.g., 7/12°C), foreseen for the operation with fan coils;
- A residential building with demand on chilled water at high temperatures (e.g., 15/20°C), foreseen for the operation with chilled ceilings or equivalent cooling techniques without dehumidification.

3.3 Scheme proposals

As a base for the modelling of the solar cooling systems, the following two schemes have been chosen.

The first scheme (Figure 8) is characterised by a clear separation between the solar heat storage and the back up boiler as requested by Spanish law. A direct connection between the solar system and the chiller is possible, avoiding heat losses or long heat up times. On the other hand this can lead to difficulties on the control of the chiller due to the immediate reaction on solar system. Varying irradiation may lead to clocking of chiller or boiler operation.

The second scheme (Figure 9) is characterised by a direct coupling of solar heat storage and back up boiler, not matching Spanish law. In order to allow a fast reaching of the set temperature the three way valve 3VS1 is included in the solar loop, a direct connection between the solar system and the chiller is not included. The overall system design is relatively simple.

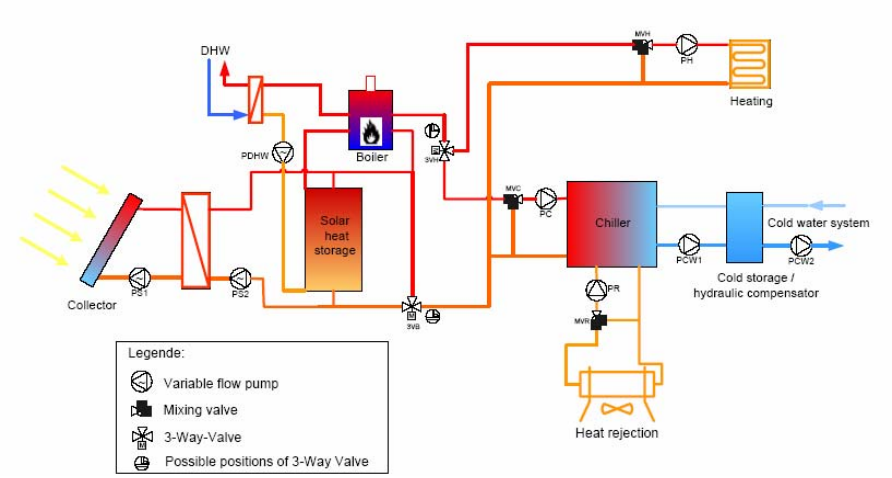

Figure 8: System scheme with boiler separated from the thermal heat storage and direct supply of the chiller from the solar system (bypassing the storage)

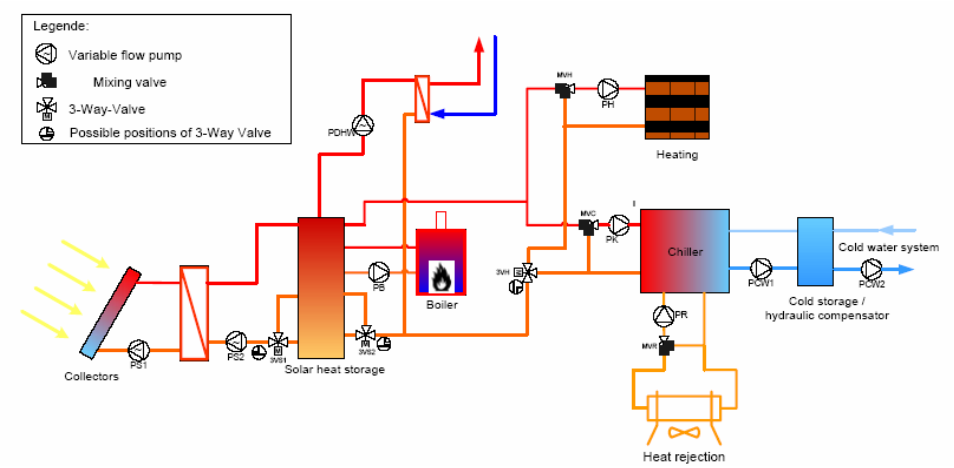

Figure 9: System scheme with boiler in direct connection to the solar heat storage

3.4 Results and available information

After the modeling phase the main results will be available on the solar combi plus homepage. This includes:

- The presentation of the system configuration which have shown up the highest energetic and economical efficiency for a broad range of applications
- The presentation of the most promising markets – e.g. climatic regions were mentioned systems have particular high economical efficiency, due to possibly high workload of each component, leading to low specific costs.
- An online tool, which helps assess the best configuration in the users specific case

4 Conclusions and Outlook

- The European air conditioning market has grown rapidly in the last years, especially in the small capacity range.

- By industry actors at present the most interesting markets for solar combi plus systems are considered to be Italy, Spain and France from the geographical point of view and single family houses and small scale office buildings from the building type.
- Considering technical and legal aspects two schemes have been proposed as unified hydraulic schemes for solar combi plus systems in Europe.
- The results of the modelling activities based on the presented schemes, building types and climatic areas will be available on the solar combi plus homepage including dimensioning proposals for the main components.
- The modelling activities in the SolarCombi+ project and especially the experience with an increased number of installations will show the efficiency of the proposed schemes and dimensioning.

5 Acknowledgments / Disclaimer

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