Conference Proceedings

EuroSun 2014
Aix-les-Bains (France), 16 – 19 September 2014

New Generation Solar Cooling and Heating systems with IEA SHC Task 53: overview and first results

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Abstract

Solar cooling technology is currently facing a very exciting challenge. Air conditioning is a large and growing energy consumer, especially in sunny and developing countries. Worldwide efforts to develop renewable energy solutions must address this critical cooling application. A new Generation of Solar Cooling systems including the coupling between Photovoltaic modules and a reversible heat pump is very promising and able to represent a cost competitive solution both reliable and efficient. To address this new generation of solar cooling, a new IEA Solar Heating and Cooling Program Task, called Task 53 has just started for 3.5 years and will be described. This paper will first concentrate on the description of Task 53 with its objectives and work plan then it will show the first results such as the state of the art of the new generation solar cooling systems. Then, a virtual case study on the cost competitiveness of a PV reversible heat pump installed in Madrid for cooling and heating will be presented, underlining that such a solution already would present a payback time of less than 10 years in the Spanish economical today's conditions.).

1. Introduction

Most cooling and refrigeration systems are still worldwide powered by electricity and thermally driven cooling technologies are largely used in combination with waste heat, district heat or co-generation units but not yet widely with solar thermal technology. Over the last decade, about one thousand installations have been realized, mostly in the framework of research and demonstration programs.

Some years ago, the start of commercial market development has been observed in the residential sector in Mediterranean countries (e.g. Spain) and in the office building sector in Asia (India, Singapore, China). Solar cooling technology did not grow up as fast and as massively as expected but the technology is facing a very exciting challenge. Mature components are available and a significant number of reference installations have been realized worldwide. The technology has shown that significant energy savings are possible, and it has reached a level of early market deployment.

However, the financial risk for parties involved in solar cooling business is still not clear. Solar air conditioning being stricto sensu solar energy as the main energy driver to do air conditioning, a brand new topic is becoming very actual in the solar cooling World: PV driven solar air conditioning systems. This new and very promising topic is related to the direct coupling of photovoltaic and electrically driven chillers/air conditioners (*Meunier F. et al., 2013*).

Selection and/or peer review under responsibility of EuroSun2014 Scientific Committee
doi:10.18086/eurosun.2014.07.12 Available at http://proceedings.ises.org

2. IEA SHC Task 53 presentation

The main objective of this IEA Solar Heating and Cooling Task 53 is to assist a strong and sustainable market development of solar cooling systems. Planned from March 2104 until June 2017, this Task focuses on packaged solutions which will be pre-engineered systems with small capacities for the following building types: single family houses, small multi-family buildings, offices, shops, commercial centers, factories, hotels. All of these buildings can be grid connected or off grid in case of PV cooling and heating. The studied cooling and heating power range are from 1 $kW_{cooling/heating}$ to several tens of $kW_{cooling/heating}$. As for the association between photovoltaic and reversible heat pumps or air conditioners can be made indirectly with the presence of an electric grid, the main scope of the present Task is the direct coupling between solar and cold production machine. However, special configurations and control strategies are considered for certain countries, in Central Europe especially, to allow a maximized use of PV power direct for heating/cooling even without direct coupling.

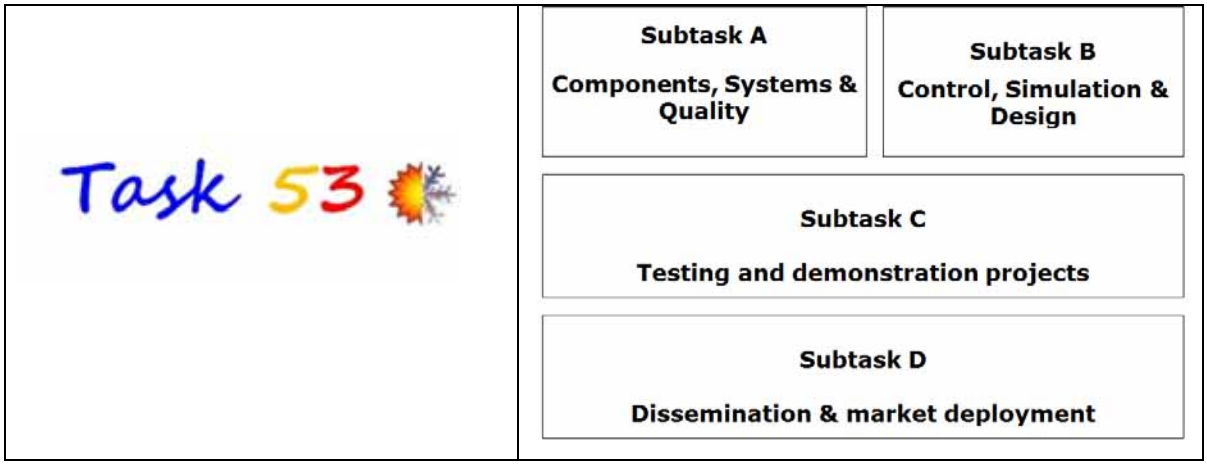

Fig 1. Principle scheme for a PV cooling concept

The Task is intended therefore to create a logical follow up of the IEA SHC work al-ready carried out by trying to find solutions to make the solar driven heating and cooling systems at the same time cost competitive. This major target should be reached thanks to five levels of activities:

1) Investigation on new small to medium size PV & solar thermal driven cooling and heating systems

2) Proof of cost effectiveness of the above mentioned solar cooling & heating systems

3) Investigation on life cycle performances on energy & environmental terms (LCA)

4) Assistance for market deployment of new solar cooling & heating systems for buildings worldwide

5) Increase of energy supply safety and influence the virtuous demand side management behaviors.

The Task 53 structure is divided into 4 subtasks and has already shown that more than 7 countries are contributing (China, Austria, Australia, Sweden, Spain, Italy, Switzerland).

3. State of the art of the New Generation Solar Cooling and Heating systems

The first results of the Task 53 Subtask A (Components, Systems & Quality) are presented in this section by showing the state of the art of the New Generation commercially available and close to the market systems.

Several manufacturers from Switzerland (Cosseco), France (Freecold), US (Lennox) and China (Midea) are commercializing systems directly coupling PV and heat pumps. Besides, Climatewell (Sweden) and Solarinvent (Italy) are close to introduce to the market very innovative solar thermal cooling systems with a clear ambition to go for cost competitiveness.

A complete chart presenting these products with their features, performances (PER savings, electrical efficiency) and costs will be presented, permitting to show a clear picture of this revolutionary young and raising market during the oral presentation. The basic principle scheme used in the new generation of systems using PV energy can be seen in Figure 2.

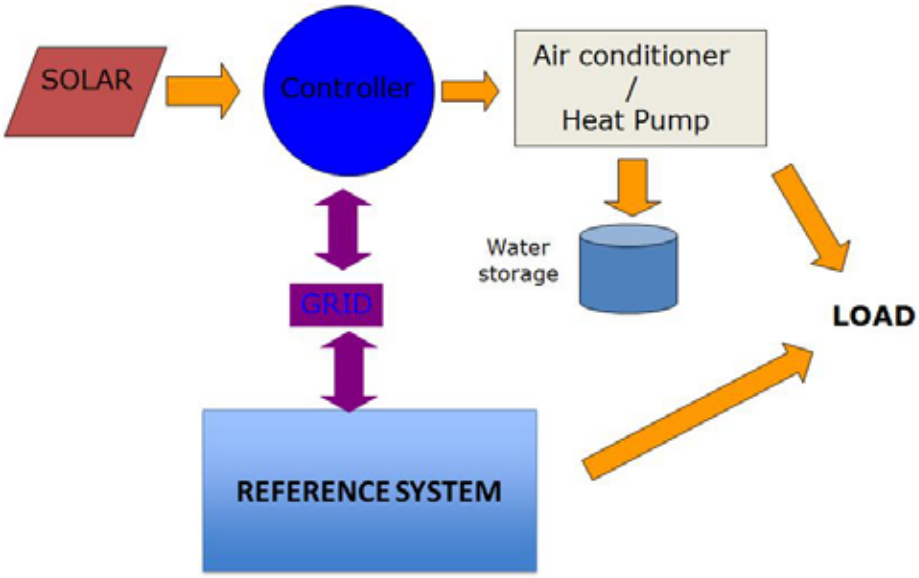

Fig 2. Principle scheme for a PV cooling concept

4. PV cooling and heating case study

4.1. Hypothesis

The last part of the communication is aimed at presenting a virtual case study for a multifamily building in Madrid (Spain) having a thermal load made of heating, cooling and domestic hot water load. It is made of 6 apartments with a total area of 540 m² to treat. This building is occupied by 18 residents (ECS consumption up to 540 liters / day). The heating demand is of 11 kWh / m².year and the cooling one of 40 kWh / m².year (25 kW cooling as peak load). The PV electricity is directly consumed on the production system heating / cooling (principle scheme in Fig.3). The surplus is intended primarily to supply the system with hot water. The remaining excess energy will be valued by self consumption inside the building. A PV + heat pump system is modeled including 20 kW_p PV modules and a reversible heat pump of 25 $kW_{cooling}$ capacity.

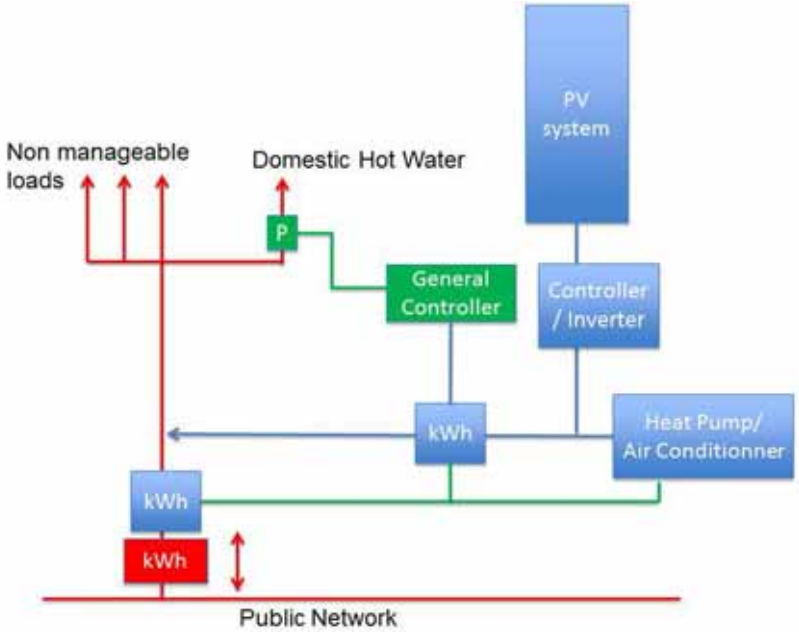

Fig 3. : PV + reversible heat pump coupling configuration and integration in the building

4.2. Results

Calculations show an overall yearly electrical efficiency of this boosted heat pump of 7,25 with a particular interesting value in summer period (June-September) of 10,2. This configuration, due to the Spanish electricity price, gives a payback time of nearly 10 years, especially if the PV system is not in a feed in tariff configuration and guarantees a full self consumption mode. This case is virtual and in particular conditions but shows a very promising way to make solar cooling cost competitive, especially if the system is strongly contributing to peak cooling load management (electricity capacity savings in summer peak period). A detailed presentation of the results will be shown in the oral presentation of the present conference.

5. Conclusion

The IEA SHC Task 53 on the New Generation Solar Cooling and Heating systems has just started but already shows that the solar cooling sector is benefitting from a new dynamics, mainly boosted by PV driven systems and brand new products. Especially, the coupling between Photovoltaic modules and a reversible heat pump is very promising and able to represent a cost competitive solution both reliable and efficient from the first studies. The next works of Task 53 (http://task53.iea-shc.org/) within June 2017 will be oriented to support the development of a strong and sustainable market for solar PV or new innovative thermal cooling systems (*Kohlenbach P. et al., 2014*).

6. References

Meunier F. et al., *La climatisation solaire : thermique et photovoltaïque*, Dunod, ISBN 2100582062, Paris (2013)

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