

1 Introduction

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There has been a tremendous increase in the market for air-conditioning worldwide, especially in developing countries. Global sales of room air-conditioners has increased dramatically, from about 44 million units per annum worldwide in 2002 to more than 100 million units per annum in 2013 [1]. In order to limit the negative impact on energy consumption, greenhouse gas emissions and electricity network infrastructure, solar air-conditioning is proposed as a new environmentally sound alternative to conventional fossil-fuel-based air-conditioning.

Solar air-conditioning is intuitively a good combination, because the demand for air-conditioning correlates quite well with the availability of the sun. The hotter and sunnier the day, the more air-conditioning is required. Key benefits include:

- It saves electricity and thus conventional primary energy sources and greenhouse gas emissions.
- It reduces peak electricity demand. This could help to reduce the size and cost of electricity network infrastructure if applied on a broad scale.

Interest in solar air-conditioning has grown steadily over the last ten years. A recent survey has estimated the number of worldwide installations at nearly 1200 systems in 2014 (Figure 1.1).

Solar air-conditioning can be achieved by either driving a vapor compression air-conditioner with electricity produced by solar photovoltaic cells, or by driving a thermal chiller with solar thermal heat. The vast majority of existing solar air-conditioning systems (Figure 1.1) are driven by solar thermal heat. While the idea of cooling from heat seems counterintuitive, solar thermal air-conditioning has many benefits and synergies, which are listed below.

- Solar thermal cooling technologies use environmentally sound materials that have no or very little ozone depletion potential (ODP) and global warming potential (GWP).
- Integrated systems can be designed to satisfy the need for multiple thermal products in a building cost-effectively, for example, domestic hot water, space heating (solar combi-systems) as well as solar cooling.
- Solar thermal collectors are generally more efficient (>40%) than photovoltaic (electricity) panels (<20%). This is particularly significant for integrated systems, where heating (and domestic hot water) is a significant portion of the total building thermal demand. But it is less significant for solar cooling-only applications where low photovoltaic (PV) efficiency is compensated by the higher efficiency of electricity-driven chillers compared with thermal chillers.
- Thermally driven cooling can be used to reduce the risk of high temperature stagnation situations in solar thermal collector systems designed predominantly for heating applications.

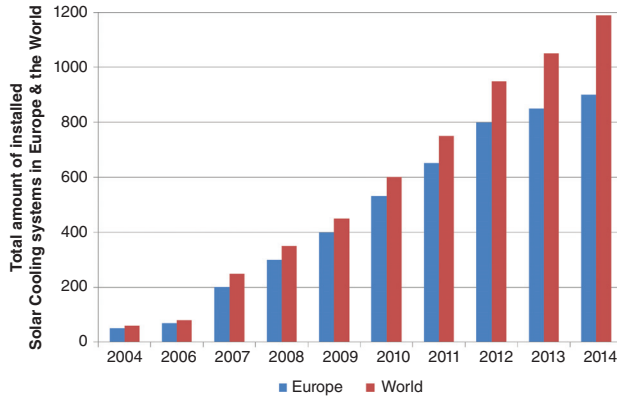


Fig. 1.1 Estimation of the global number of solar cooling systems [2]

- Thermally driven cooling systems, compared with electrical chillers, are low-noise and vibration-free.
- Thermally driven cooling systems can use other waste heat sources to supplement the solar heat source.

1.1 About the IEA SHC Task 48

IEA SHC Task 48 “Quality Assurance and Support Measures for Solar Cooling” was a project conducted by a group of researchers and practitioners from nine countries (Australia, Austria, Canada, China, France, Germany, Italy, Singapore and USA). Its aims were to find solutions to enable industry to deliver solar thermal driven heating and cooling systems that are (a) efficient, (b) reliable and (c) cost-competitive. These three major targets were to be achieved through activities grouped into four subtasks (Figure 1.2):

1. Development of tools and procedures that characterize the performance of the main components of solar air-conditioning (SAC) systems (Subtask A).

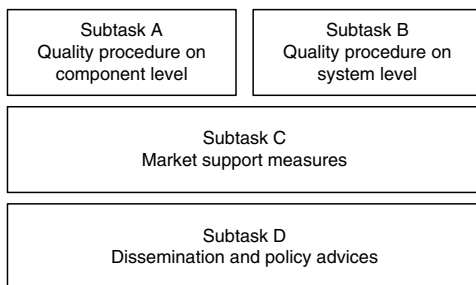


Fig. 1.2 Schematic of the main activities in IEA SHC Task 48

2. Creating practical and unified procedures for specifying the best technical configurations for complete integrated SAC systems (Subtask B).
3. Development of standards and procedures to identify and validate the quality of SAC systems under three scenarios (Subtask C):
 - a. Measured performance of large systems, post-construction.
 - b. Design quality of large systems, prior to construction.
 - c. Deemed performance of small “plug-and-play” solar cooling products, at point of sale.
4. Production and dissemination of information to promote solar thermal-driven cooling and heating systems (Subtask D).

The scope of the Task includes the technologies for production of cold water or conditioned air by means of solar thermal heat. It starts with the solar radiation reaching the collector and ends with the chilled water and/or conditioned air transferred to the application. While the cold distribution system in the building, and the interaction of the building with the technical equipment, is not the main topic of the Task, this interaction is discussed in specific cases, where necessary.

The IEA SHC Task 48 was completed in summer 2015. Full details and outcomes can be found at www.task48.iea-shc.org.

1.2 Ambition and philosophy of the book

The Solar Cooling Design Guide (the *Guide*) is intended as a companion to the *IEA Solar Cooling Handbook* [3]. The content and function of the two companion books are as follows

- The *IEA Solar Cooling Handbook* (the *Handbook*) provides a comprehensive but general overview of the various technologies and equipment components that convert solar heat into useful cold. It aims to provide comprehensive information and advice on all aspects of solar cooling, in order to enable engineers to design their own solar cooling system from first principles. In this way, it focuses on the broader principles involved, and it leaves full design flexibility for engineers to respond to the wide range of possible applications that may be encountered. While it contains examples, it does not provide prescriptive designs for specific applications.
- This *Guide* aims to provide more detailed and specific engineering design information than in the *Handbook*. By focusing on a limited number of specific case study examples, the *Guide* aims to provide additional useful information relevant to specific embodiments of solar cooling, which are not necessarily general to all forms of solar cooling. In this way it aims to provide a limited number of more prescriptive design solutions, which reduces the number of decisions required by the engineer, and more clearly codifies the art of solar cooling design in the light of specific application experience.

The *Handbook* aims to give comprehensive foundational design understanding across the breadth of alternative solar cooling solutions, while the *Guide* aims to supplement this information with more detailed advice for a limited number of specific applications.

The form of the *Guide* follows an engineering design description for three specific designs, with the rationale for each key design decision explained. The system flow sheet is described, and the application conditions under which the system selection is appropriate are discussed. Where appropriate, numerical constraints are suggested for the selection and sizing of parameters of key equipment items.

It should be noted that there are many other attractive solar cooling technology solutions. The absence of a given solar cooling technology from the *Guide* does not mean that it is not appropriate or less attractive than the solutions provided in the *Guide*. The *Guide* is merely a positive statement on a small number of solutions rather than a negative statement on other solutions.

While the *Guide* aims to more completely elucidate a set of specific solutions, it is not intended as a substitute for good design by a qualified engineer based on full understanding of the principles of solar cooling, as described in the *Handbook*.

References

- [1] Japan Air Conditioning, Heating & Refrigeration News, Ltd. (2015) *Heating and Refrigeration News*. World Air Conditioner Market. JARN, Tokyo, Japan, 05/2015.
- [2] Mugnier, D. and Solem Consulting/TECSOL (2014) Market development of solar thermal cooling. *SHC 2014 Conference, Beijing, China*, October 2014.
- [3] Henning, H.M., Motta, M., and Mugnier, D. (2013) *Solar Cooling Handbook: A Guide to Solar Assisted Cooling and Dehumidification Processes*, Walter de Gruyter & Co.