

1 Introduction

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1.1 The scope

This book is about a hybrid technology called “solar and heat pump.” It is basically the combination of a solar system with a heat pump delivering heat to a building.

When the sun is shining, the collectors will be the primary source of energy for the domestic hot water preparation and for the space heating. Furthermore, the daily solar production can be stored for future use during a few days. When the sun is less abundant or when the solar storage is empty, the heat pump will take over the duty. The source of the primary low-energy “heat” for the heat pump to operate can be air, ground, or water from a river or an aquifer. A nice feature of the hybrid combination is that the solar collectors can also be used as the provider of the primary heat for the heat pump. The two components will then operate in the so-called serial mode.

This book will analyze the behavior of the main combinations of solar and heat pump, derive facts from practical projects, provide results from simulations and laboratory tests, and draw conclusions based on 4 years of activity of a collaborative project developed under the auspice of the International Energy Agency.

1.2 Who should read this book?

This book is recommended to the HVAC (heating, ventilation, and air conditioning) industry, the HVAC engineers and students, energy systems designers and planners, architects, energy politicians, manufacturers of solar energy components, manufacturers of heat pumps, standardization bodies, heating equipment distributors, and researchers in HVAC and building systems.

1.3 Why this book?

Producing heat from solar energy is an established technology since the 1990s.

The heat pump technology known since 1930 is becoming a standard solution to heat buildings and prepare domestic hot water in many countries. Both markets have shown growth since 2000, especially the heat pump market noticeably in countries with a high share of hydroelectricity in their energy supply.

For some years, systems that combine solar thermal technology and heat pumps have been marketed to provide space heating and to produce domestic hot water. The energy prices, the need to reduce the overall electricity demand or the strategy to move to more efficient solutions for heating than the current ones, the European Union legislation, and future scenarios calling for more renewable energies have driven the change.

A strong initial development of combination of solar and heat pump started some years ago with the help of early work from industry and research bodies in a few European

countries. Innovative companies have shown success stories in this early period and continue to promote the advantages of solar and heat pump combinations based on real experience.

The IEA Solar Heating and Cooling Program (SHC) launched in 2010 a 4-year project called Task 44, “solar and heat pump systems.” This was a joint effort with the IEA Heat Pump Program (HPP) under the name “Annex 38” to contribute to a better understanding of SHP (for “solar and heat pump”) systems.

This book presents the state of the art of the combined technology of solar collectors and electrical heat pumps based on the work undertaken within the Task 44 and Annex 38 project called T44A38 throughout this book. More than 50 participants from 13 countries have contributed to the collaborative effort over the 4 years of this international project.

It is anticipated that the electricity cost will increase on the planet in the future, due to CO₂ cost considerations and scarcity of energy resources. Solar photovoltaics might change the picture if the technology is massively adopted. But still, highly efficient heat pumps reducing the electricity demand will be needed to substitute the fossil heating solutions that dominate the world energy market in the 2010s. Combinations with solar collectors can increase the overall performance of a heat pump and will therefore also be an elegant solution of choice.

There are scientific and technological issues in integrating solar collectors and heat pump machines. The complexity lies in having two variable sources that should work together optimally. Heat storage management and control strategies are also of prime importance for optimal design. This book will present the challenges and some solutions on all aspects.

T44A38 has concentrated its efforts on electrically driven heat pumps, not because other techniques such as sorption machines are not possible but because no participants in this international activity presented a project with a thermally driven machine.

1.4 What you will learn reading this book?

This book deals with

- heating systems;
- heat distribution by water-based systems (e.g., radiators and floor heating systems);
- small-scale systems, one-family house to small dwellings (5–100 kW);
- electrically driven heat pumps;
- residential houses; and
- new buildings and buildings to be renovated.

1. You will understand that SHP systems are complex systems that need careful design and optimal integration.

2. You will learn that good combinations of solar and heat pump can be achieved when the application is correctly done in adapted conditions. Examples are shown and discussed.
3. You will discover which definitions for the seasonal performance factor (SPF) of an installation are recommended for a comparison of heating solutions, for the assessment of technologies, for an environmental analysis, or for some economical considerations.
4. You will be able to classify all kinds of SHP systems in a new systematic way using the T44A38 “energy flow chart” diagram that you can use further to represent any kind of energy system.
5. You will see the advantages of different combinations of SHP found on the market and be able to challenge the vendor on the system design and performance.
6. You will learn that detailed simulation tools exist and a special framework to simulate SHP systems is available on the T44A38 web site.
7. You will understand which energy flows you should monitor in a project or in the laboratory and what SPF you can reasonably expect.
8. You will have the tools to assess the energy and economical benefits and other qualitative benefits that you can get out of a combination of SHP.
9. You will have a tool to evaluate the cost of the delivered heat of an SHP and what CO₂ reduction can be expected if you succeed to increase the SHP performance.

The logical organization of this book is the following:

– *Part One: Theoretical considerations.*

Chapter 2 will tell you how the SHP systems found on the market in 2010–2012 can be classified in a systematic way thanks to the collaboration of more than 80 SHP companies.

Chapter 3 explains the theory behind the main components that you will find in an SHP system: the collector, the storage tank, the borehole, and the heat pump.

Chapter 4 presents all definitions of the performances of a complex system such as the coefficient of performance (COP) and all kinds of the SPF depending on the boundaries considered, and explains which should be used for which purpose.

Chapter 5 reviews the methods to test SHP systems in a laboratory so that prototypes or commercial products can be characterized and even further optimized.

– *Part Two: Practical considerations.*

Chapter 6 presents the basics of monitoring SHP systems and recommends the best practice in data acquisition of SHP systems. Results of relevant systems monitored *in situ* are presented.

Chapter 7 shows how to simulate SHP systems with the T44A38 framework. It also presents important results on SHP combinations and sensitivity analyses. The benefit of a solar system in SHP is also quantitatively assessed through simulations.

Chapter 8 provides an interesting approach to evaluate the cost of an SHP system that can be compared with a classical or non-solar system. What brings solar system to a

heat pump is quantitatively evaluated and qualitative criteria are listed according to the numerous experts in T44A38 along the 4-year work.

Complementing this book, the web site of T44A38 provides all appendices. The simulation framework is, for example, downloadable as well as all other documents produced during the course of T44A38 and papers or contributions from T44A38 experts at scientific conferences.

Enjoy!

Internet sources

task44.iea-shc.org/publications

<http://www.heatpumpcentre.org/en/projects/ongoingprojects/annex38>

www.iea-shc.org/

www.heatpumpcentre.org/

www.ehpa.org/

www.estif.org/

www.rhc-platform.org