DELIVERABLE NO WP4.D2
DRAFT PROCEDURES AND RESOURCE DOCUMENTS
Subtask 5: Solar Cooling

Dissemination level: Public

August 2007

CONTENTS

In total this Deliverable consists of 18 pages.

The task of WP4.D2 “draft procedures and resource documents” was divided into the following 9 subtasks:

1. advanced collectors
2. advanced stores
3. advanced controllers
4. combisystems
5. solar cooling
6. solar desalination
7. fluids
8. LCA (Life Cycle Assessment)
9. m² -> power and energy

The resource documents of subtask 5 “solar cooling” (subtask leader: INETI) are included in this report.

New Generation of Solar Thermal Systems

WP 4.5: SOLAR COOLING
Contribution to a future development of CTSS method applicable to solar assisted air conditioning systems (or solar cooling systems)
Dissemination level: Public

May 2007

Prepared by: Maria João Carvalho
Revision by: Chris Bales

CONTENTS

SUMMARY

In this report we are focusing on **thermally driven cooling processes** and mainly in **heat transformation processes** as described in reference /1/. According to normative document prEN TS 12977 /2/, the systems can be:

- ***Small and large custom built solar heating systems*** *with liquid heat transfer medium in the collector loop for residential buildings and similar applications.*

and in both cases (small and large systems) cooling systems can be considered.

The performance testing for custom built systems is based on the CTSS (Component Testing and System Simulation) method, reason for which it is necessary to identify the possibility of application of such method to Solar Assisted Air Conditioning System or Cooling Systems.

A survey on Solar Assisted Air Conditioning projects, allowed the identification of diferent software tools which can be classified according to the objective of their development. They can be evaluation tools for pre-design of solar assisted air conditioning systems, detailed transient simulations of the system, which use as input load files – heating and cooling loads – obtained from other software programmes or transient simulations that simultaneously model the building and the HVAC systems used.

The main characteristics of each of the identified tools are listed and a first evaluation for use in CTSS method is made.

A search on available test methods for relevant HVAC components for Solar Assisted Air Conditioning systems was also performed.

- **Introduction**

In order to clarify to which systems this work is targeted, we reproduce here a schematic representation of the different possibilities of using solar radiation for cooling or air-conditioning as represented in reference /1/.

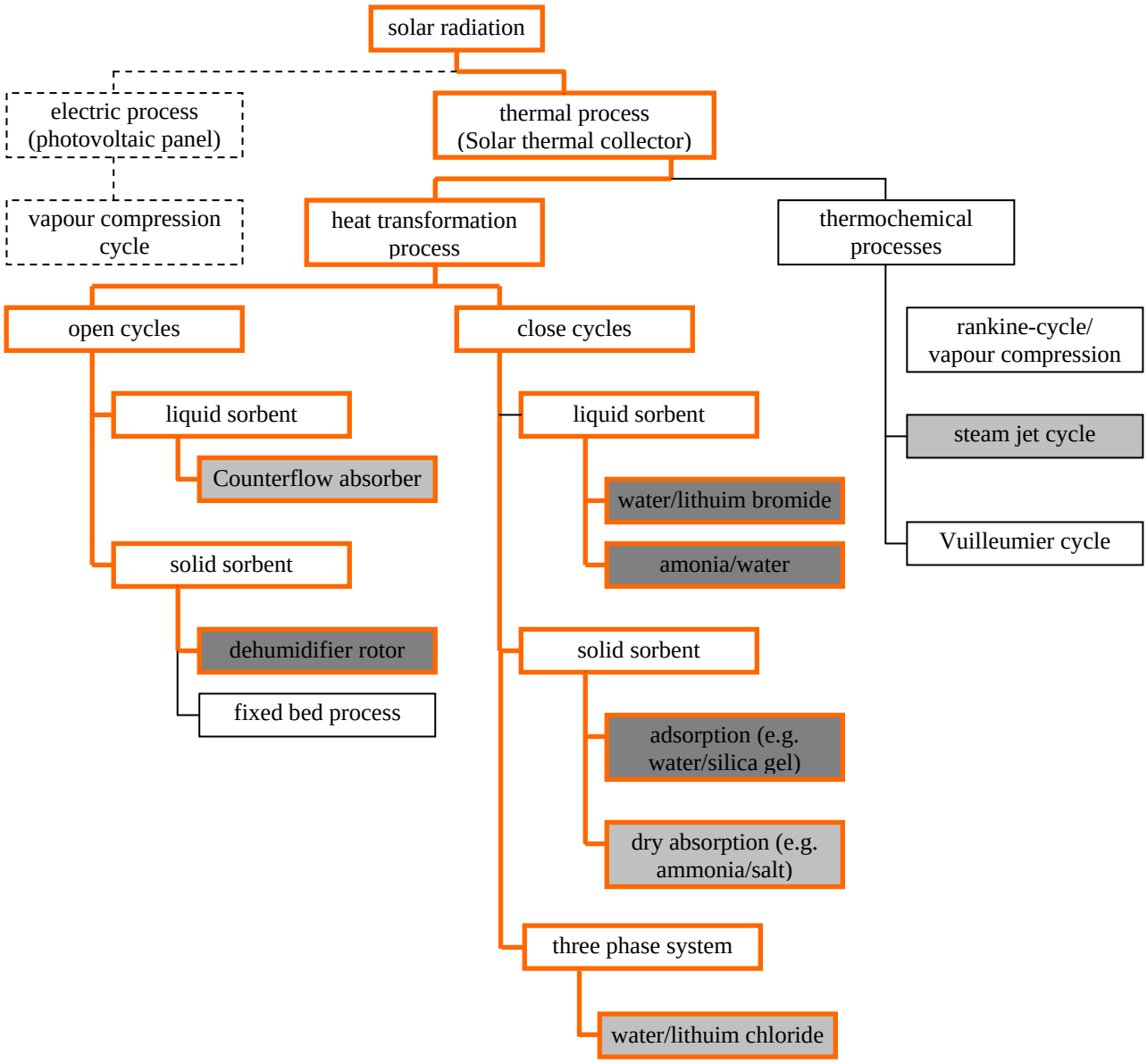

Fig. 1 – Overview on physical methods to use solar radiation for cooling and air-conditioning (adapted from reference /1/)

We are focusing in **thermally driven cooling processes** and mainly in **heat transformation processes** (lines and boxes marked in orange). According to reference /1/ the boxes in dark grey correspond to the commercially available technologies and boxes in light grey correspond to pilot projects or systems in test. The three phase closed system type has only recently been developed.

It is also important to refer that normative document prEN TS 12977 /2/, considers in its scope the following systems:

- ***Small and large custom built solar heating systems*** *with liquid heat transfer medium in the collector loop for residential buildings and similar applications.*

and that system classification in the referred document considers the categories listed in Table 1. In bold are signalled the type of systems that need the identification of the possibility of CTSS method.

Table 1) – System classification according to prEN TS 12977 /2/.

Small Custom Built Systems	***Large Systems***
A – domestic hot water preparation only	*A – **A system in which the store(s) and the collector array(s) are located in one building for which the heat/cool is provided.** No seasonal store and no heat/cool distribution network outside the building is included.*
B – space heating only	*B – **A system which consists of a central heating/cooling plant and one or more collector array(s). The heat/cool is transported via a heat/cool distribution network to the heating plant and/or to other buildings.** No seasonal store is included.*
C – domestic hot water and space heating	*C – a large custom built system which mainly consists of one or more large collector array(s) and in which the heat/cool is transferred to a seasonal store or directly into a heat/cool distribution network.*
D – others (e.g. including cooling)	*D – others*

Considering also a schematic representation of these systems given in Fig.2 (adapted from ref. /3/), we can think of the application of future prEN TS 12977 standard /2/, to the yellow box. In a more modest approach it is possible to consider only the application to green box.

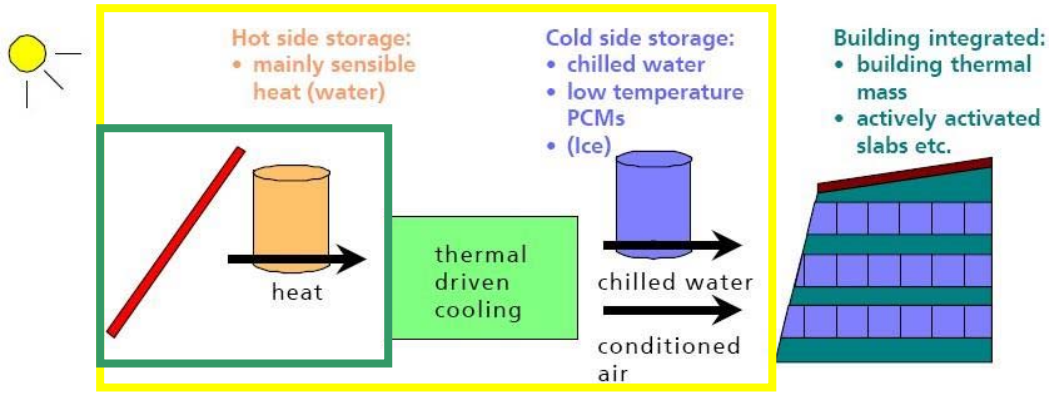

Fig. 2 – Schematic representation of Solar Assisted Air Conditioning Systems (adapted from reference /3/)

The yellow box includes small custom built systems of class D as well as large custom built systems of class B (and C), while the green box includes large custom built systems of class A. According to part1 of prEN 12977, only small custom built systems should be performance tested (according to prEN 12977-2). For large custom built systems no requirement for performance test is considered, but monitoring according to prEN 12977-2 is recommended.

The performance testing for custom built system is based on the CTSS (Component Testing and System Simulation) method. It is thus necessary to identify the possibility of application of this method to Solar Assisted Air Conditioning System or Cooling Systems.

- **Survey on existing software for simulations of solar assisted air conditioning systems**

As a result of the survey on Solar Assisted Air Conditioning projects, up to this moment, the following software was identified:

Table 2 - Software identification

Software	Source
SACE: Solar cooling evaluation light tool	Reference /3/ http://www.ocp.tudelft.nl/ev/res/sace.htm
EasySolarCooling	See reference /4/. Not available
SolAC – Solar Assisted Air Conditioning Software	Reference /5/ http://www.iea-shc-task25.org/english/hps6/index.html
TRNSYS	Reference /6/ www.sel.me.wisc.edu/trnsys/
ColSim	References /7,8/ www.colsim.de
EnergyPlus	Reference /9/ www.eere.energy.gov/buildings/energyplus/
INSEL	Reference /14/ http://www.inseldi.com/index.php?id=21&L=1
MathLab and Simulink:	
CARNOT	See reference /4/
SIMBAD	Reference /10/ http://kheops.champs.cstb.fr/Simbadhvac/
IBPT	Reference /11/ www.ibpt.org

The above software programmes can be classified according to the objective of their development. They can be evaluation tools for pre-design of solar assisted air conditioning systems, detailed transient simulations of the system, which use as input load files – heating and cooling loads – obtained from other software programmes or transient simulations that simultaneously model the building and the HVAC systems used.

The main characteristics are presented in the following text and are separated based on the available information and according to the above statement.

A) Evaluation tools for pre-design of solar assisted air conditioning systems

SACE: Solar cooling evaluation light tool (reference /3/)
This software was developed in the framework of European Project "SACE: Solar air conditioning in Europe". Project summary and deliverables can be found in http://www.ocp.tudelft.nl/ev/res/sace.htm. The software can be downloaded free, from the project site.
The objective of this software is to allow **a quick feasibility study of solar assisted air conditioning systems.**
The annual solar fraction for heating and cooling is calculated based on an hour-by-hour comparison of needed heat for a thermal driven cooling and available solar heat.

It performs parametric studies and allows the comparison of conventional AC systems with Solar Assisted AC systems. Figure 3, shows the main window of this tool.

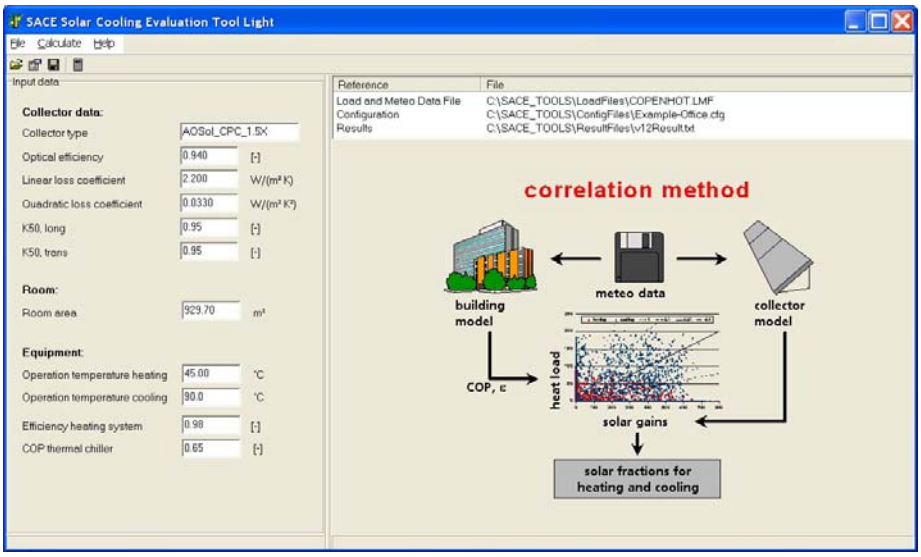

Fig. 3 – SACE main window

For calculations it needs a load file (heating and cooling load) and a weather file with hourly values. The solar system is mainly characterized by collector efficiency parameters. The building is represented by its area and the HVAC equipemnet by two operating temperatures (heating and cooling), efficiency of heating system and COP of thermal chiller.

EasySolarCooling is referred by Edo Wiemken et al. (see reference /4/) as a further development of SACE. This tool is not available to download or purchase. It is used internally by Fraunhoffer ISE.

SolAC – Solar Assisted Air Conditioning Software (reference /5/)

This software was developed by ILK Dresden in the frame work of Implementing Agreement "Solar Heating & Cooling" – Task 25 – Solar assisted air-conditioning systems.
The software is available for free download at:
http://www.iea-shc-task25.org/english/hps6/index.html
Documentation of the software is also available when downloading (reference /5/)
The input data for the programme are:

- weather data including solar radiation (hourly data)
- load files including heating and cooling loads (hourly data)

An example of the system different components can be seen in Fig. 4.

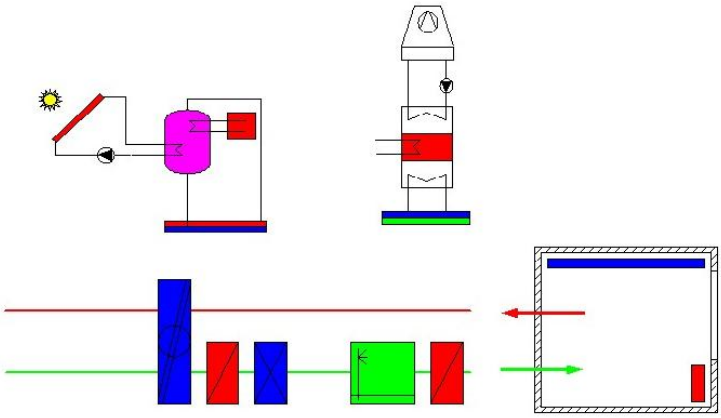

Fig. 4 – Example configuration for simulation with SolAC software.

Four different units are considered in this software:
- Solar system
- Cooling device
- Air handling unit
- Cooling and heating components in the room

These units can have different configurations chosen by the user (see Fig. 5).
The results of the simulation are available as hourly values. The models adopted for each component are described in detail in reference /5/, but the source code is not available. It is not possible to add other components.

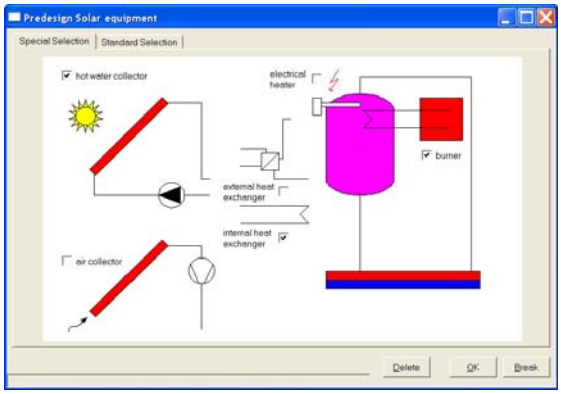

Fig.5a) Solar system options.

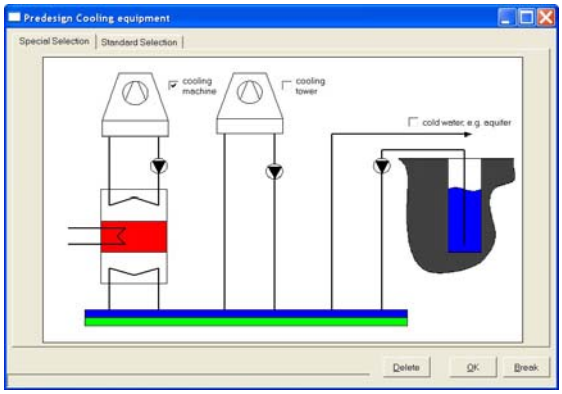

Fig.5b) Cooling device options.

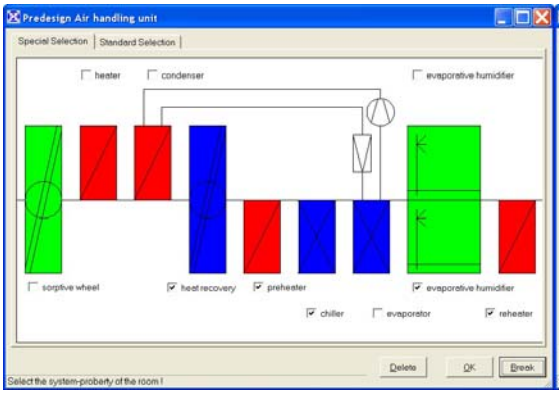

Fig.5c) Air handling unit options.

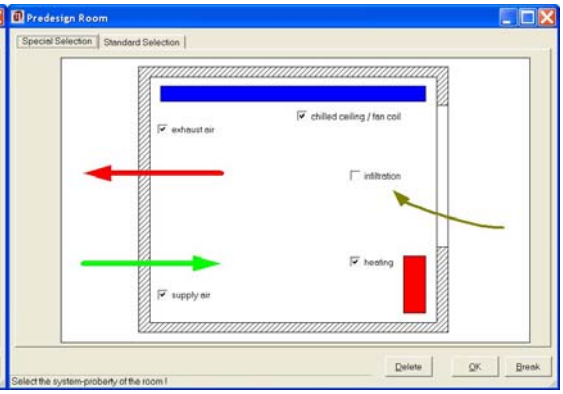

Fig.5d) Options for cooling and heating components in room.

B) Transient Simulation Tool
B1) System orientated

TRNSYS (reference /6/)
TRNSYS is a very well know tool among the solar energy community. It was developed in the seventies in University of Wisconsin.
Subroutines describing the components of solar systems, hydraulic components and HVAC are called Types. It already includes Types for many solar heating system components and also for HVAC system components. It is an open source software and it allows for the inclusion of new components.
It also has a special editor for definition of the Building characteristics which allows the calculation of heating and cooling loads.
It is not a free software. It involves some degree of complexity in its use.
Many examples of its use for design of solar assisted air conditioning systems are available. Some are referred in /4/.

ColSim (reference /7,8/)
The objective for the development of ColSim was the possibility to simulate and test complex control strategies in different HVAC and thermal solar systems coupled to a building model. The developers of this Software tool indicate as a reason to develop it the fact that *the simulation of controller strategies with the simulation code TRNSYS and other commercially available programs is not possible without modifying numeric algorithms of the programs' solvers in order to achieve convergence with small time steps*.
Detailed description of **ColSim** can be found in www.colsim.de and in the Programme Manual available for download (see reference /8/). A more synthetic description can be found in reference /7/. It is a public domain software and its current platform is LINUX although it can also be used in windows.
It allows the construction of new modules for different system components, but there is no clear knowledge of the present situation.
Several references can be downloaded in the internet page but most of them in German language.

INSEL® – Integrated Simulation Environment Language (reference /14/)
This software is described as “an integrated environment and a graphical language for the creation of simulation applications”. It uses graphical symbols that are interconnected by mouse operations and which can represent mathematical functions or real components of different systems , e.g., solar thermal collectors.
The present version of INSEL already has available a toolbox for Solar Thermal that includes collectors for liquid heating as flat plate and vacuum tubes, air collectors, storage tanks and also models for solar thermal cooling plants, like dessicant and evaporative cooling systems, as well as, absorption cycles.
This software also has an user-programable environment in which other component models can be built. Programming languages like FORTRAN and C/C++ are supported.
A learning edition is available for free download at http://www.inseldi.com/index.php?id=21&L=1 .

B2) Building Orientated

Energy Plus (reference /9/)
EnergyPlus is described as “an energy analysis and thermal load simulation program”.
It is based on a user’s description of a building from the perspective of the building’s physical make-up, associated mechanical systems, etc., EnergyPlus calculates the heating and cooling loads necessary to maintain thermal control setpoints

Some of the main characteristics of this software, selected from the detailed description in /9/, are:

- ***Integrated, simultaneous solution*** *where the building response and the primary and secondary systems are tightly coupled (iteration performed when necessary)*
- ***Sub-hourly, user-definable time steps*** *for the interaction between the thermal zones and the environment; variable time steps for interactions between the thermal zones and the HVAC systems (automatically varied to ensure solution stability)*
- ***ASCII text based weather, input, and output files*** *that include hourly or sub-hourly environmental conditions*
- ***Heat balance based solution*** *technique for building thermal loads that allows for simultaneous calculation of radiant and convective effects at both in the interior and exterior surface during each time step*
- ***Loop based configurable HVAC systems*** *(conventional and radiant) that allow users to model typical systems and slightly modified systems without recompiling the program source code*

EnergyPlus can be downloaded free from www.eere.energy.gov/buildings/energyplus/.
It has already incorporated several HVAC system components as well as solar thermal collectors. The physical models of the components are described in detail in reference /9/. It will be possible to include new models. Guidelines for this are given in reference /9/.

C) Tools based on MathLab and Simulink

MathLab and Simulink are commercially available simulation tools not specific for solar energy use, but are referred in /4/ as having modules that allow simulation of solar assisted air conditioning systems.

In reference /4/ a tool box **CARNOT**, developed by the Aachen University is given as example.
Another tool box of this type is **SIMBAD** (SIMulator of Building and Devices), developed by CSTB (see reference /10/).
This toolbox is presented as the first HVAC toolbox for the MATLAB/SIMULINK environment. It provides a large number of ready to use HVAC models and related utilities.

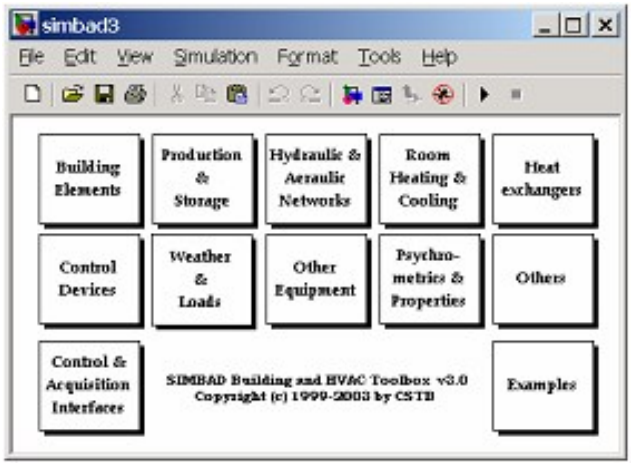

Fig. 6 – Main window of Simbad

The models have online documentation. The models are developed either completely in the SIMULINK block diagram language, in MATLAB code or in compiled C-code. The source codes of modules written in C-Language or MATLAB language are provided. The open structure of the models enables the users to modify them and personalise the models.

In the internet page of this software several examples of application of this software are referred. Among them we refer:

i) the test of controllers for the European Standards (CEN TC247),
ii) the development on Fault Detection and Diagnosis methods for HVAC systems (IEA Annex 34),
iii) the development of virtual test benches for manufacturers of HVAC control equipment (QUALISIM project)

A further investigation of these applications is recommended.

International Building Physics Tool (www.ibpt.org)
Another tool box, developed by a group of researchers from Sweden and Denmark (reference /11/), which uses as platform Simulink/Mathlab, is called International Building Physics Tool and its objective is the numerical modelling of heat, air and moisture flows in buildings.
The IBPT is an open source and it is publicly available. Downloads can be made from www.ibpt.org.
It is a transient simulation tool. It is building orientated but it can include HVAC components. At this moment the information available does not show that components like solar collectors are already developed and also there are almost no HVAC systems modules.

It is probably possible to combine this building physics tool box with the HVAC toolbox SIMBAD.

- **Potential of existing software for use with CTSS testing**

From the survey results it was possible to identify different calculation tools that range from simple tools to support first decisions for the choice of the most adequate technologies for air conditioning with solar system assistance, to detailed simulation tools, e.g., TRNSYS.
In reference /2/ it states that "the modelling of the system should be carried out using a detailed transient simulation programme in which it is possible to model the different system and store configurations involved, and in which all parameters determined in the component tests can be adjusted.", and thus the more detailed tools are recommended. According to /4/ this is also the case for the detailed planning of an installation.

In practice, the simulation tool needs to fulfil the following requirements:

- Sufficient of the parameters of the component models need to be variable to be in agreement with the information obtained from the separate component tests.

In addition the following features are beneficial:

- Capability to make long term (annual) simulations for predefined boundary conditions.
- Be possible to couple with an automatic parameter identification (optimisation) tool.
- Models can be changed or added relatively easily by the testing institute – this means open source code.

In Table 3 a first evaluation for the above tools is made. This evaluation is made based on the descriptions in the respective Manuals and Literature found up to this moment.

Table 3 – First evaluation of software identified

Software	**Solar Components**	**AC Components**	**New Components**	**Free downlaod**	**Open source code**
SACE	Yes	Yes	No	Yes	No
SolAC	Yes	Yes	No (*)	Yes	No
TRNSYS	Yes	Yes	Yes	No	Yes
ColSim	Yes	Yes, but no clear list was possible to obtain.	Yes	Not clear	Yes
Energy Plus	Yes	Yes	Yes	Yes	Not clear
INSEL	Yes	Yes	Yes	NO	NO (**)
SIMBAD	Yes	Yes	Yes	No(***)	Yes
IBPT	No	Yes (few available at this moment)	Yes	Yes (***)	Yes

(*) Only by developers of the software
(**) For already available modules
(***) These toolboxes require the user to already have purchased Matlab/Simulink

It is clear from the description made that both SACE and SolAC are not eligible for CTSS method as they cannot, e.g., simulate the store model separately.

Programmes like TRNSYS, ColSim and INSEL seem to be best candidates. Programmes like EnergyPlus, SIMBAD and IBPT, should be possible to use but are building orientated and are not known as well by the solar air conditioning community.
Further research is needed in order to determine:
- compatibility of software output with present performance indicators considered in /2/ and
- which HVAC components are available for each of the above listed software tools (only for those which are most interesting for CTSS), and whether the parameters in them are compatible with those available from the component tests.

The first aspect can only be evaluated with a further development of the standard /2/ and decision on which performance parameters will be used for Solar Assisted Air Conditioning System or Cooling Systems, i.e., further development of section 7. of prEN 12977-2:2006.

Preliminary results of the second aspect can be seen in Annex A of this document.

- **Testing standards for relevant HVAC systems**

A remaining aspect is the possibility to find the characterization of the different HVAC components in tests according to European or International Standards and in agreement to what is used in these tools.

A search was made of European and International standards focussing mainly on Chillers. In Annex B standards found are listed. It was not possible to analyse the references found in detail and probably many of them are not relevant for our subject. From this search we considered as most relevant the following reference, *ANSI/ARI Standard 560-2000, Absorption water chilling and water heating packages*, because it presents a form of characterization of this type of component that is in line with TESS Libraries approach.

From reference /13/ it was possible to identify also USA standards for testing and rating of desiccant dehumidification systems:
1.American Society of Heating, Refrigerating and Air-conditioning Engineers - Standard 139 - "Method of Testing for Rating Desiccant Dehumidifiers Utilizing Heat for the Regeneration Process", 1998R
2. Air-conditioning and Refrigeration Institute, Rating Standard 940-"Desiccant Dehumidification Components".

This search did not allow covering many of the components of systems listed in Fig.1, but is a first contribution to a future test methodology along the lines of CTSS.

Acknowledgements
The author acknowledges comments and contributions from Giorgos Panaras, Jan Schindl and Tim Selke.

References

/1/ Hans-Martin Henning (Ed.) (2004), *Solar-assisted air-conditioning in Buildings. A handbook for planners*, Springer Wien NewYork.
/2/ prEN TS 12977:2005- Thermal Solar Systems and Components – Custom built systems (presently proposed to CEN TC 312 for CEN Enquiry)
/3/ Hans-Martin Henning (2003), *SACE – Solar Cooling Computer Tool – Guidelines for use*, http://www.ocp.tudelft.nl/ev/res/sace.htm
/4/Wiemken, E et al (2004), *Design and planning support for solar assisted air-conditioning guidelines and tools*, Eurosun 2004
/5/ Franke, U. and Seifert, C. (2005), *Solar Assisted air conditioning of Buildings – IEA Task 25, Subtask B: Design tools and simulation programmes – documentation for SolAC programme, version 1.5*
/6/ *TRNSYS – Transient system simulation environment* developed at the Solar Energy Laboratory at Univ. of Winsconsin, Madison, USA, http://sel.me.wisc.edu/trnsys/
/6a/ *TRNSYS 16 – Transient system simulation environment. Standard Component Library. Overview, Volume 3*
/7/ Wittwer, C. et al. "ColSim – A new simulation environment for complex system analysis and controllers", in www.colsim.de
/8/ Kettner, Christiane *ColSim – Manual, University of Karlsruhe*, FBTA", in www.colsim.de
/9/ *Energy Plus Manual- version1.2.2 (2005),* US Department of Energy, Energy Efficiency and Renewable Energy, www.eere.energy.gov/buildings/energyplus/
/10/ Simbad - http://kheops.champs.cstb.fr/Simbadhvac/
/11/ Wietzmann, P. et al (2003), Presentation of the International Building Physics toolbox for simulink, 8th International IBPSA Conference, Eindhoven, Netherlands
/12/ TESS Library Documentation, Distributed upon purchase of the referred Libraries in CD Rom. http://www.tess-inc.com
/13/ S.J. Slayzak and J.P. Ryan, *Desiccant Dehumidification Wheel Test Guide, NREL/TP- 550-26131, December 2000, available at link:* http://www.pdhengineer.com/Course%20Files/Completed%20Course%20PDF%20Files/Mechanical/Desiccant%20Wheels%20Test%20Guide.pdf
/14/ Tutorial – INSEL ® - INtegrated Simulation Environment Language - 2003–2006 Doppelintegral GbR (www.inseldi.com)

Annex A – Analysis of HVAC available in TRNSYS and TESS Library

The Analysis on HVAC components was made for **TRNSYS 16**. The most relevant components are (see /6a/)

Type 107 – Absorption Chiller (hot water fired, single effect) – The data necessary to characterize the chiller is *normalized catalog data.* Any size of chiller can be modelled.

Type 51 – Coling Towers – "Overall performance data" must be introduced by the user in order that characteristic parameters of the cooling tower are determined and used further in the simulations.

A much larger and more interesting set of HVAC can be found in the **TESS Libraries** (see reference /12/). A Summary of the ones considered most relevant is presented here:

Type 680 – Single-effect hot water-fired absorption chiller (Equivalent to type 107 of TRNSYS 16)
Type 679 – Single-effect steam-fired absorption chiller
Type 677 – Double-effect hot water-fired absorption chiller
Type 676 – Double-effect steam-fired absorption chiller

All these types are indicated to be characterized by *normalized catalog data*, making it possible to model any size of chiller assuming the relevant data is available.

Type 683 – Rotary desiccant dehumidifier – models a rotary dessicant dehumidifier containing nominal silica gel.

Annex B – Search on standards for HVAC components

HEAT PUMPS - ISO Standards
http://www.iso.org/iso/en/

ISO 5151:1994	Non-ducted air conditioners and heat pumps - Testing and rating for performance
	Specifies the standard conditions on which the ratings of single-package and split-system non-ducted air conditioners employing air- and water-cooled condensers are based, and the test methods to be applied for determination of the various ratings. Is limited to systems utilizing a single refrigeration circuit and having one evaporator and one condenser. Also specifies the test conditions and the corresponding test procedures for determining various performance characteristics of these non-ducted air conditioners and heat pumps.
ISO 13253:1995	Ducted air-conditioners and air-to-air heat pumps - Testing and rating for performance
	Establishes performance testing and rating criteria for ducted air-conditioners using air- and water-cooled condensers and ducted air-to-air heat pumps. Is limited to systems which use a single refrigeration circuit and have one evaporator and one condenser.
ISO 13256-1:1998	Water-source heat pumps - Testing and rating for performance - Part 1: Water-to-air and brine-to-air heat pumps
	No abstract available
ISO 13256-2:1998	Water-source heat pumps - Testing and rating for performance - Part 2: Water-to-water and brine-to-water heat pumps
	No abstract available
ISO 13261-1:1998	Sound power rating of air-conditioning and air-source heat pump equipment - Part 1: Non-ducted outdoor equipment
	No abstract available
ISO 13261-2:1998	Sound power rating of air-conditioning and air-source heat pump equipment - Part 2: Non-ducted indoor equipment
	No abstract available

HEAT PUMPS and air conditioning units - CEN TC 113 – Published Standards

http://www.cenorm.be/CENORM/BusinessDomains/TechnicalCommitteesWorkshops/CENTechnicalCommittees/CENTechnicalCommittees.asp?param=6095&title=CEN%2FTC+113

CEN / TC 113- Published standards

Standard reference	Title	Citation in OJ	Directive
CEN/TS 14825:2003	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Testing and rating at part load conditions	No	92/75/EEC
EN 12900:2005	Refrigerant compressors - Rating conditions, tolerances and presentation of manufacturer's performance data	No	-
EN 13215:2000	Condensing units for refrigeration - Rating conditions, tolerances and presentation of manufacturer's performance data	No	-
EN 13771-1:2003	Compressors and condensing units for refrigeration - Performance testing and test methods - Part 1: Refrigerant compressors	No	-
EN 14511-1:2004	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 1: Terms and definitions	Cited in OJ C 115 (2004-04-30)	92/75/EEC, 2002/31/EC
EN 14511-2:2004	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 2: Test conditions	Cited in OJ C 115 (2004-04-30)	92/75/EEC, 2002/31/EC
EN 14511-3:2004	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 3: Test methods	Cited in OJ C 115 (2004-04-30)	92/75/EEC, 2002/31/EC
EN 14511-3:2004/AC:2004	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 3: Test methods	Expected	92/75/EEC, 2002/31/EC
EN 14511-4:2004	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 4: Requirements	Cited in OJ C 115 (2004-04-30)	92/75/EEC, 2002/31/EC
EN 15218:2006	Air conditioners and liquid chilling packages with evaporatively cooled condenser and with electrically driven compressors for space cooling - Terms, definitions, test conditions, test methods and requirements	No	2002/31/EC
EN 255-3:1997	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors - Heating mode - Part 3: Testing and requirements for marking for sanitary hot water units	No	92/75/EEC
EN 255-3:1997/AC:1997	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors - Heating mode - Part 3: Testing and requirements for marking for sanitary hot water units	No	92/75/EEC
EN 810:1997	Dehumidifiers with electrically driven compressors - Rating tests, marking, operational requirements and technical data sheet	No	-
ENV 12102:1996	Air conditioners, heat pumps and dehumidifiers with electrically driven compressors - Measurement of airborne noise - Determination of the sound power level	No	92/75/EEC

HEAT PUMPS and air conditioning units - CEN TC 113 –Standards Under development

CEN / TC 113- Standards under development

	Project reference	Title	Candidate Citation	Current status	DAV
00113025	prEN 12102	Air conditioners, liquid chilling packages, heat pumps and dehumidifiers with electrically driven compressors for space heating and cooling - Measurement of airborne noise - Determination of the sound power level	No (92/75/EEC)	Under Approval	2004-08
00113034	prEN 13771-2	Compressors and condensing units for refrigeration - Performance testing and test methods - Part 2: Condensing units	No	Under Approval	2005-01
00113041	prEN 14511-1 rev	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 1: Terms and definitions	No (92/75/EEC, 2002/31/EC)	Under Development	2008-10
00113042	prEN 14511-2 rev	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 2: Test conditions	No (92/75/EEC, 2002/31/EC)	Under Development	2008-10
00113043	prEN 14511-3 rev	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 3: Test methods	No (92/75/EEC, 2002/31/EC)	Under Development	2008-10
00113044	prEN 14511-4 rev	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 4: Requirements	No (92/75/EEC, 2002/31/EC)	Under Development	2008-10

Other standards

Canadian Standards Association

CAN/CSA-C743-02 – Performance Standard for rating packaged water chillers

From reference http://www.csa-intl.org/onlinestore/GetCatalogItemDetails.asp?mat=0000000000024156 21&scopescroll=false&parent=0

1 Scope

1.1 This Standard applies to factory-designed and prefabricated vapour-compression chillers, including one or more hermetic or external drive compressors. The compressor types include centrifugal, screw, scroll, reciprocating, or other types, and the condenser types include water-cooled and air-cooled/evaporatively cooled types, or the package can be supplied without a condenser. Also, air- or water-cooled heat reclaim condensers can be supplied.

1.2 This Standard applies to
a) factory-designed and prefabricated water-cooled absorption chiller/heater units;
b) single-effect indirect-fired by steam or hot water; and
c) double-effect, both indirect-fired by steam or hot water** and direct-fired by oil, natural gas, or LP gas; **water is the refrigerant and lithium bromide is the absorbent.
This Standard does not apply to absorption chiller/heater units with air- cooled condensers, nor does it apply to applications employing heat pumping or exhaust gas firing.

Air-Conditioning & Refrigeration Institute
Aproved American National Standard

ANSI/ARI Standard 560: 2000 - Absorption water chilling and water heating packages (21 pages)

The standard has:

As purpose:... to establish for absorption water chilling and water heating packages: definitions; test requirements for Published Ratings; markinh and nameplate data; and conformance conditions.

As scope: aplies to water-cooled single-effect steam and hot water operated water chilling units, water-cooled double-effect steam and hot water operated water chilling units, and double-effect Direct fired (natural gas, oil, LP gas) water chilling/heating units. Water is the refrigerant abd LiBr (lithium bromide) the absorbent.

New Generation of Solar Thermal Systems

WP 4.5: SOLAR COOLING
Contribution to a future development of CTSS method applicable to solar assisted air conditioning systems (or solar cooling systems)
Dissemination level: Public

May 2007

Prepared by: Maria João Carvalho
Revision by: Chris Bales

CONTENTS

SUMMARY

In this report we are focusing on **thermally driven cooling processes** and mainly in **heat transformation processes** as described in reference /1/. According to normative document prEN TS 12977 /2/, the systems can be:

- ***Small and large custom built solar heating systems*** *with liquid heat transfer medium in the collector loop for residential buildings and similar applications.*

and in both cases (small and large systems) cooling systems can be considered.

The performance testing for custom built systems is based on the CTSS (Component Testing and System Simulation) method, reason for which it is necessary to identify the possibility of application of such method to Solar Assisted Air Conditioning System or Cooling Systems.

A survey on Solar Assisted Air Conditioning projects, allowed the identification of diferent software tools which can be classified according to the objective of their development. They can be evaluation tools for pre-design of solar assisted air conditioning systems, detailed transient simulations of the system, which use as input load files – heating and cooling loads – obtained from other software programmes or transient simulations that simultaneously model the building and the HVAC systems used.

The main characteristics of each of the identified tools are listed and a first evaluation for use in CTSS method is made.

A search on available test methods for relevant HVAC components for Solar Assisted Air Conditioning systems was also performed.

- **Introduction**

In order to clarify to which systems this work is targeted, we reproduce here a schematic representation of the different possibilities of using solar radiation for cooling or air-conditioning as represented in reference /1/.

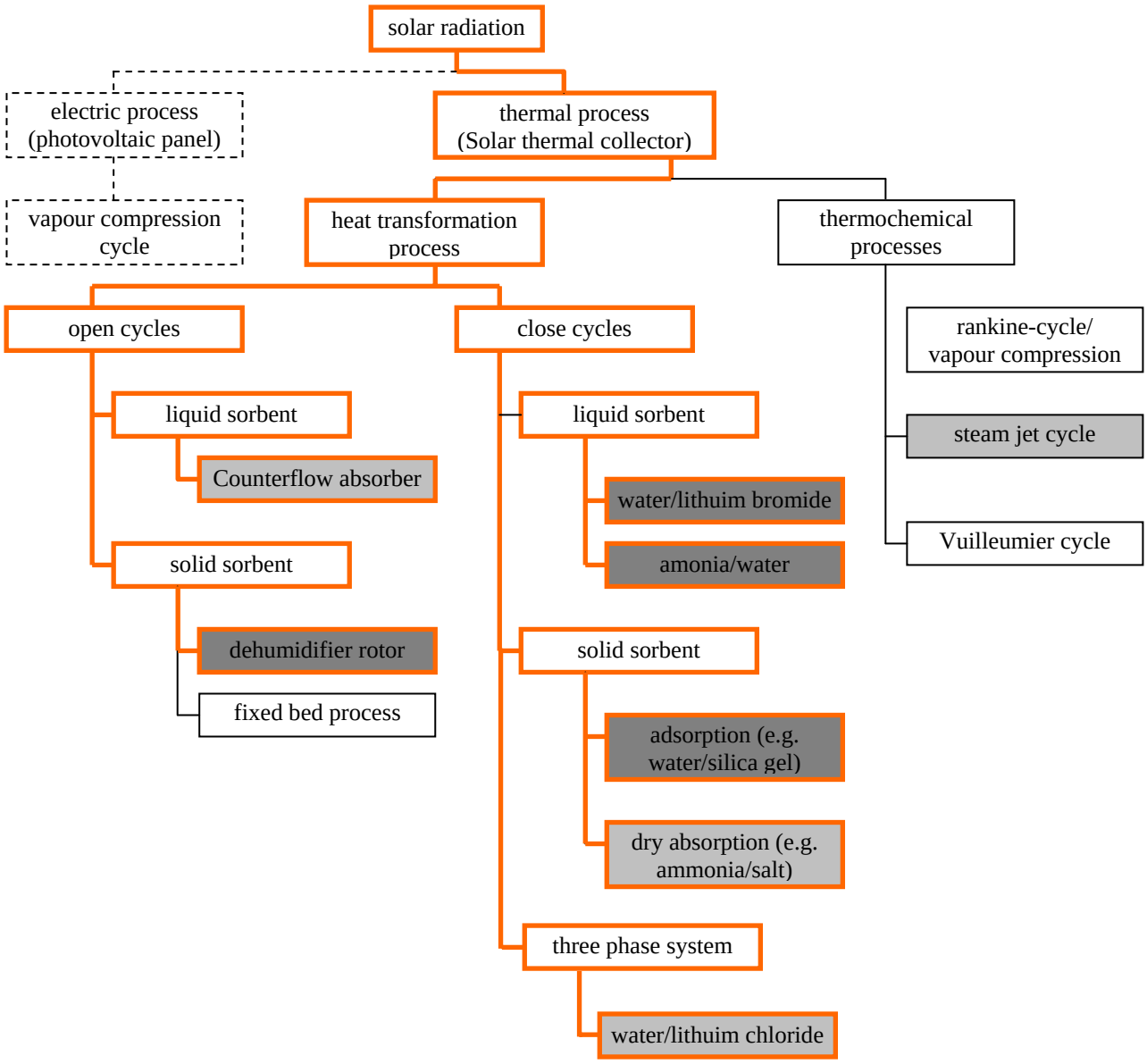

Fig. 1 – Overview on physical methods to use solar radiation for cooling and air-conditioning (adapted from reference /1/)

We are focusing in **thermally driven cooling processes** and mainly in **heat transformation processes** (lines and boxes marked in orange). According to reference /1/ the boxes in dark grey correspond to the commercially available technologies and boxes in light grey correspond to pilot projects or systems in test. The three phase closed system type has only recently been developed.

It is also important to refer that normative document prEN TS 12977 /2/, considers in its scope the following systems:

- ***Small and large custom built solar heating systems*** *with liquid heat transfer medium in the collector loop for residential buildings and similar applications.*

and that system classification in the referred document considers the categories listed in Table 1. In bold are signalled the type of systems that need the identification of the possibility of CTSS method.

Table 1) – System classification according to prEN TS 12977 /2/.

Small Custom Built Systems	***Large Systems***
A – domestic hot water preparation only	*A – **A system in which the store(s) and the collector array(s) are located in one building for which the heat/cool is provided.** No seasonal store and no heat/cool distribution network outside the building is included.*
B – space heating only	*B – **A system which consists of a central heating/cooling plant and one or more collector array(s). The heat/cool is transported via a heat/cool distribution network to the heating plant and/or to other buildings.** No seasonal store is included.*
C – domestic hot water and space heating	*C – a large custom built system which mainly consists of one or more large collector array(s) and in which the heat/cool is transferred to a seasonal store or directly into a heat/cool distribution network.*
D – others (e.g. including cooling)	*D – others*

Considering also a schematic representation of these systems given in Fig.2 (adapted from ref. /3/), we can think of the application of future prEN TS 12977 standard /2/, to the yellow box. In a more modest approach it is possible to consider only the application to green box.

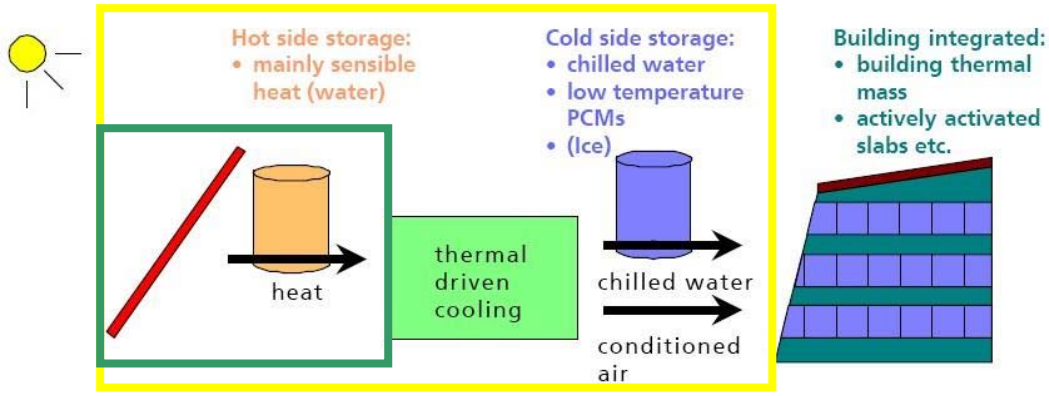

Fig. 2 – Schematic representation of Solar Assisted Air Conditioning Systems (adapted from reference /3/)

The yellow box includes small custom built systems of class D as well as large custom built systems of class B (and C), while the green box includes large custom built systems of class A. According to part1 of prEN 12977, only small custom built systems should be performance tested (according to prEN 12977-2). For large custom built systems no requirement for performance test is considered, but monitoring according to prEN 12977-2 is recommended.

The performance testing for custom built system is based on the CTSS (Component Testing and System Simulation) method. It is thus necessary to identify the possibility of application of this method to Solar Assisted Air Conditioning System or Cooling Systems.

- **Survey on existing software for simulations of solar assisted air conditioning systems**

As a result of the survey on Solar Assisted Air Conditioning projects, up to this moment, the following software was identified:

Table 2 - Software identification

Software	Source
SACE: Solar cooling evaluation light tool	Reference /3/ http://www.ocp.tudelft.nl/ev/res/sace.htm
EasySolarCooling	See reference /4/. Not available
SolAC – Solar Assisted Air Conditioning Software	Reference /5/ http://www.iea-shc-task25.org/english/hps6/index.html
TRNSYS	Reference /6/ www.sel.me.wisc.edu/trnsys/
ColSim	References /7,8/ www.colsim.de
EnergyPlus	Reference /9/ www.eere.energy.gov/buildings/energyplus/
INSEL	Reference /14/ http://www.inseldi.com/index.php?id=21&L=1
MathLab and Simulink:	
CARNOT	See reference /4/
SIMBAD	Reference /10/ http://kheops.champs.cstb.fr/Simbadhvac/
IBPT	Reference /11/ www.ibpt.org

The above software programmes can be classified according to the objective of their development. They can be evaluation tools for pre-design of solar assisted air conditioning systems, detailed transient simulations of the system, which use as input load files – heating and cooling loads – obtained from other software programmes or transient simulations that simultaneously model the building and the HVAC systems used.

The main characteristics are presented in the following text and are separated based on the available information and according to the above statement.

A) Evaluation tools for pre-design of solar assisted air conditioning systems

SACE: Solar cooling evaluation light tool (reference /3/)
This software was developed in the framework of European Project "SACE: Solar air conditioning in Europe". Project summary and deliverables can be found in http://www.ocp.tudelft.nl/ev/res/sace.htm. The software can be downloaded free, from the project site.
The objective of this software is to allow **a quick feasibility study of solar assisted air conditioning systems.**
The annual solar fraction for heating and cooling is calculated based on an hour-by-hour comparison of needed heat for a thermal driven cooling and available solar heat.

It performs parametric studies and allows the comparison of conventional AC systems with Solar Assisted AC systems. Figure 3, shows the main window of this tool.

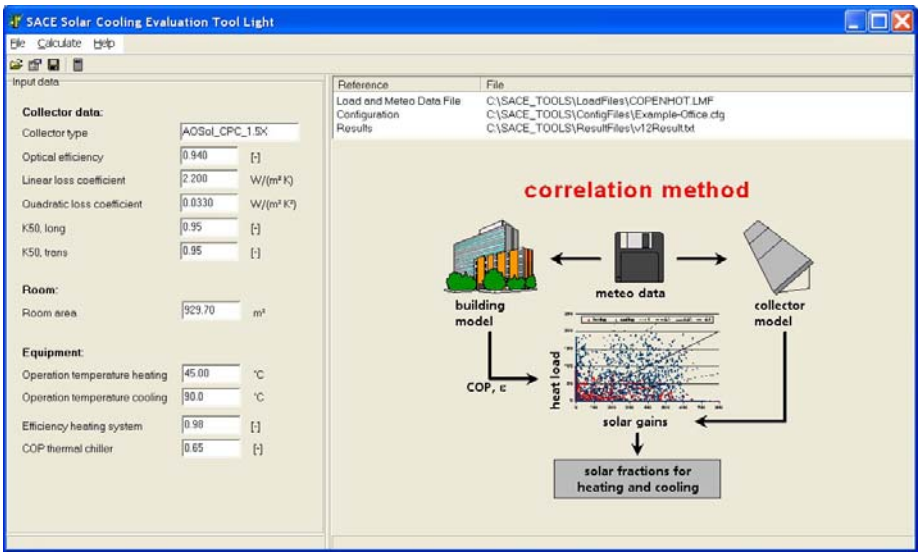

Fig. 3 – SACE main window

For calculations it needs a load file (heating and cooling load) and a weather file with hourly values. The solar system is mainly characterized by collector efficiency parameters. The building is represented by its area and the HVAC equipemnet by two operating temperatures (heating and cooling), efficiency of heating system and COP of thermal chiller.

EasySolarCooling is referred by Edo Wiemken et al. (see reference /4/) as a further development of SACE. This tool is not available to download or purchase. It is used internally by Fraunhoffer ISE.

SolAC – Solar Assisted Air Conditioning Software (reference /5/)

This software was developed by ILK Dresden in the frame work of Implementing Agreement "Solar Heating & Cooling" – Task 25 – Solar assisted air-conditioning systems.
The software is available for free download at:
http://www.iea-shc-task25.org/english/hps6/index.html
Documentation of the software is also available when downloading (reference /5/)
The input data for the programme are:

- weather data including solar radiation (hourly data)
- load files including heating and cooling loads (hourly data)

An example of the system different components can be seen in Fig. 4.

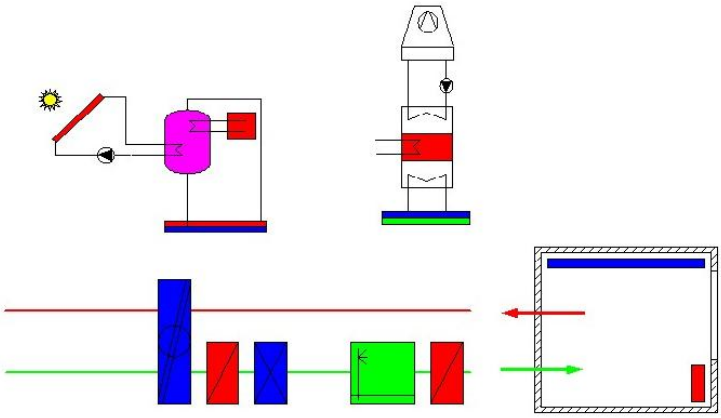

Fig. 4 – Example configuration for simulation with SolAC software.

Four different units are considered in this software:
- Solar system
- Cooling device
- Air handling unit
- Cooling and heating components in the room

These units can have different configurations chosen by the user (see Fig. 5).
The results of the simulation are available as hourly values. The models adopted for each component are described in detail in reference /5/, but the source code is not available. It is not possible to add other components.

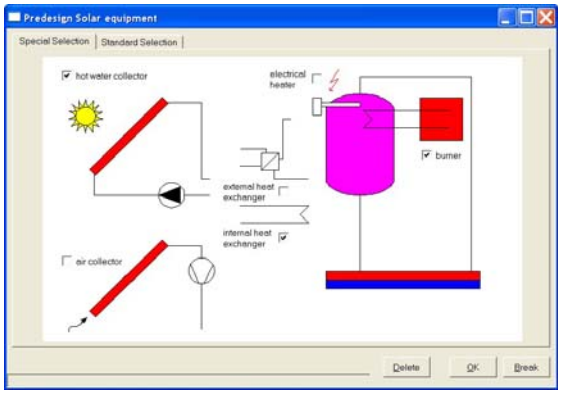

Fig.5a) Solar system options.

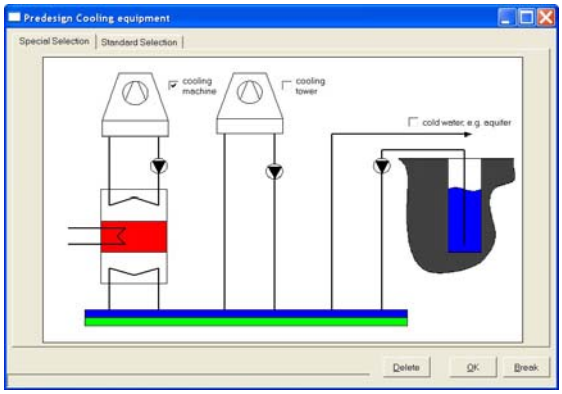

Fig.5b) Cooling device options.

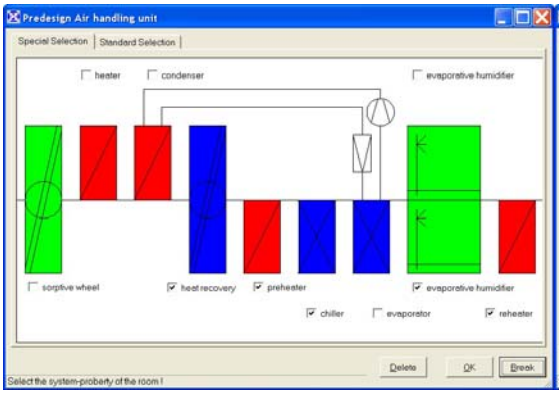

Fig.5c) Air handling unit options.

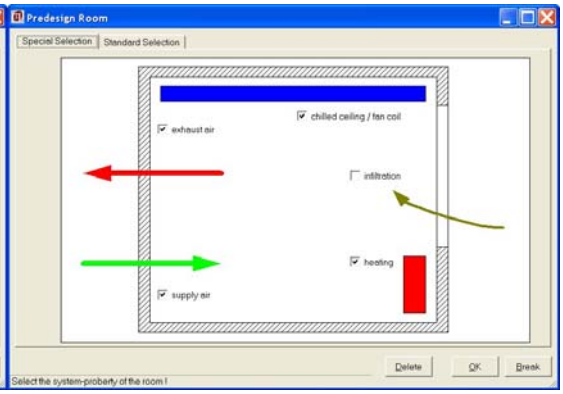

Fig.5d) Options for cooling and heating components in room.

B) Transient Simulation Tool
B1) System orientated

TRNSYS (reference /6/)
TRNSYS is a very well know tool among the solar energy community. It was developed in the seventies in University of Wisconsin.
Subroutines describing the components of solar systems, hydraulic components and HVAC are called Types. It already includes Types for many solar heating system components and also for HVAC system components. It is an open source software and it allows for the inclusion of new components.
It also has a special editor for definition of the Building characteristics which allows the calculation of heating and cooling loads.
It is not a free software. It involves some degree of complexity in its use.
Many examples of its use for design of solar assisted air conditioning systems are available. Some are referred in /4/.

ColSim (reference /7,8/)
The objective for the development of ColSim was the possibility to simulate and test complex control strategies in different HVAC and thermal solar systems coupled to a building model. The developers of this Software tool indicate as a reason to develop it the fact that *the simulation of controller strategies with the simulation code TRNSYS and other commercially available programs is not possible without modifying numeric algorithms of the programs' solvers in order to achieve convergence with small time steps*.
Detailed description of **ColSim** can be found in www.colsim.de and in the Programme Manual available for download (see reference /8/). A more synthetic description can be found in reference /7/. It is a public domain software and its current platform is LINUX although it can also be used in windows.
It allows the construction of new modules for different system components, but there is no clear knowledge of the present situation.
Several references can be downloaded in the internet page but most of them in German language.

INSEL® – Integrated Simulation Environment Language (reference /14/)
This software is described as “an integrated environment and a graphical language for the creation of simulation applications”. It uses graphical symbols that are interconnected by mouse operations and which can represent mathematical functions or real components of different systems , e.g., solar thermal collectors.
The present version of INSEL already has available a toolbox for Solar Thermal that includes collectors for liquid heating as flat plate and vacuum tubes, air collectors, storage tanks and also models for solar thermal cooling plants, like dessicant and evaporative cooling systems, as well as, absorption cycles.
This software also has an user-programable environment in which other component models can be built. Programming languages like FORTRAN and C/C++ are supported.
A learning edition is available for free download at http://www.inseldi.com/index.php?id=21&L=1 .

B2) Building Orientated

Energy Plus (reference /9/)
EnergyPlus is described as “an energy analysis and thermal load simulation program”.
It is based on a user’s description of a building from the perspective of the building’s physical make-up, associated mechanical systems, etc., EnergyPlus calculates the heating and cooling loads necessary to maintain thermal control setpoints

Some of the main characteristics of this software, selected from the detailed description in /9/, are:

- ***Integrated, simultaneous solution*** *where the building response and the primary and secondary systems are tightly coupled (iteration performed when necessary)*
- ***Sub-hourly, user-definable time steps*** *for the interaction between the thermal zones and the environment; variable time steps for interactions between the thermal zones and the HVAC systems (automatically varied to ensure solution stability)*
- ***ASCII text based weather, input, and output files*** *that include hourly or sub-hourly environmental conditions*
- ***Heat balance based solution*** *technique for building thermal loads that allows for simultaneous calculation of radiant and convective effects at both in the interior and exterior surface during each time step*
- ***Loop based configurable HVAC systems*** *(conventional and radiant) that allow users to model typical systems and slightly modified systems without recompiling the program source code*

EnergyPlus can be downloaded free from www.eere.energy.gov/buildings/energyplus/.
It has already incorporated several HVAC system components as well as solar thermal collectors. The physical models of the components are described in detail in reference /9/. It will be possible to include new models. Guidelines for this are given in reference /9/.

C) Tools based on MathLab and Simulink

MathLab and Simulink are commercially available simulation tools not specific for solar energy use, but are referred in /4/ as having modules that allow simulation of solar assisted air conditioning systems.

In reference /4/ a tool box **CARNOT**, developed by the Aachen University is given as example.
Another tool box of this type is **SIMBAD** (SIMulator of Building and Devices), developed by CSTB (see reference /10/).
This toolbox is presented as the first HVAC toolbox for the MATLAB/SIMULINK environment. It provides a large number of ready to use HVAC models and related utilities.

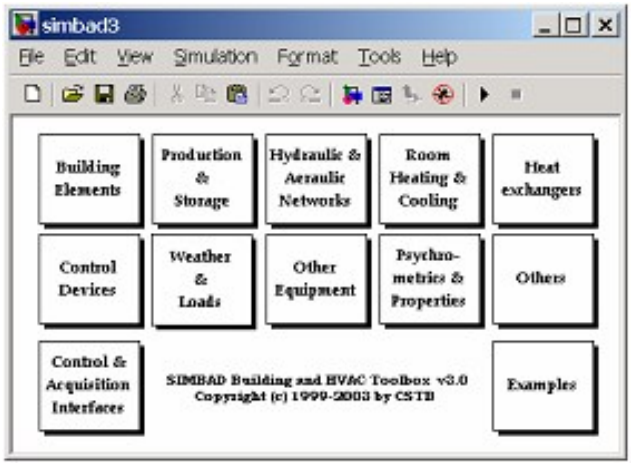

Fig. 6 – Main window of Simbad

The models have online documentation. The models are developed either completely in the SIMULINK block diagram language, in MATLAB code or in compiled C-code. The source codes of modules written in C-Language or MATLAB language are provided. The open structure of the models enables the users to modify them and personalise the models.

In the internet page of this software several examples of application of this software are referred. Among them we refer:

i) the test of controllers for the European Standards (CEN TC247),
ii) the development on Fault Detection and Diagnosis methods for HVAC systems (IEA Annex 34),
iii) the development of virtual test benches for manufacturers of HVAC control equipment (QUALISIM project)

A further investigation of these applications is recommended.

International Building Physics Tool (www.ibpt.org)
Another tool box, developed by a group of researchers from Sweden and Denmark (reference /11/), which uses as platform Simulink/Mathlab, is called International Building Physics Tool and its objective is the numerical modelling of heat, air and moisture flows in buildings.
The IBPT is an open source and it is publicly available. Downloads can be made from www.ibpt.org.
It is a transient simulation tool. It is building orientated but it can include HVAC components. At this moment the information available does not show that components like solar collectors are already developed and also there are almost no HVAC systems modules.

It is probably possible to combine this building physics tool box with the HVAC toolbox SIMBAD.

- **Potential of existing software for use with CTSS testing**

From the survey results it was possible to identify different calculation tools that range from simple tools to support first decisions for the choice of the most adequate technologies for air conditioning with solar system assistance, to detailed simulation tools, e.g., TRNSYS.
In reference /2/ it states that "the modelling of the system should be carried out using a detailed transient simulation programme in which it is possible to model the different system and store configurations involved, and in which all parameters determined in the component tests can be adjusted.", and thus the more detailed tools are recommended. According to /4/ this is also the case for the detailed planning of an installation.

In practice, the simulation tool needs to fulfil the following requirements:

- Sufficient of the parameters of the component models need to be variable to be in agreement with the information obtained from the separate component tests.

In addition the following features are beneficial:

- Capability to make long term (annual) simulations for predefined boundary conditions.
- Be possible to couple with an automatic parameter identification (optimisation) tool.
- Models can be changed or added relatively easily by the testing institute – this means open source code.

In Table 3 a first evaluation for the above tools is made. This evaluation is made based on the descriptions in the respective Manuals and Literature found up to this moment.

Table 3 – First evaluation of software identified

Software	**Solar Components**	**AC Components**	**New Components**	**Free downlaod**	**Open source code**
SACE	Yes	Yes	No	Yes	No
SolAC	Yes	Yes	No (*)	Yes	No
TRNSYS	Yes	Yes	Yes	No	Yes
ColSim	Yes	Yes, but no clear list was possible to obtain.	Yes	Not clear	Yes
Energy Plus	Yes	Yes	Yes	Yes	Not clear
INSEL	Yes	Yes	Yes	NO	NO (**)
SIMBAD	Yes	Yes	Yes	No(***)	Yes
IBPT	No	Yes (few available at this moment)	Yes	Yes (***)	Yes

(*) Only by developers of the software
(**) For already available modules
(***) These toolboxes require the user to already have purchased Matlab/Simulink

It is clear from the description made that both SACE and SolAC are not eligible for CTSS method as they cannot, e.g., simulate the store model separately.

Programmes like TRNSYS, ColSim and INSEL seem to be best candidates. Programmes like EnergyPlus, SIMBAD and IBPT, should be possible to use but are building orientated and are not known as well by the solar air conditioning community.
Further research is needed in order to determine:
- compatibility of software output with present performance indicators considered in /2/ and
- which HVAC components are available for each of the above listed software tools (only for those which are most interesting for CTSS), and whether the parameters in them are compatible with those available from the component tests.

The first aspect can only be evaluated with a further development of the standard /2/ and decision on which performance parameters will be used for Solar Assisted Air Conditioning System or Cooling Systems, i.e., further development of section 7. of prEN 12977-2:2006.

Preliminary results of the second aspect can be seen in Annex A of this document.

- **Testing standards for relevant HVAC systems**

A remaining aspect is the possibility to find the characterization of the different HVAC components in tests according to European or International Standards and in agreement to what is used in these tools.

A search was made of European and International standards focussing mainly on Chillers. In Annex B standards found are listed. It was not possible to analyse the references found in detail and probably many of them are not relevant for our subject. From this search we considered as most relevant the following reference, *ANSI/ARI Standard 560-2000, Absorption water chilling and water heating packages*, because it presents a form of characterization of this type of component that is in line with TESS Libraries approach.

From reference /13/ it was possible to identify also USA standards for testing and rating of desiccant dehumidification systems:
1.American Society of Heating, Refrigerating and Air-conditioning Engineers - Standard 139 - "Method of Testing for Rating Desiccant Dehumidifiers Utilizing Heat for the Regeneration Process", 1998R
2. Air-conditioning and Refrigeration Institute, Rating Standard 940-"Desiccant Dehumidification Components".

This search did not allow covering many of the components of systems listed in Fig.1, but is a first contribution to a future test methodology along the lines of CTSS.

Acknowledgements
The author acknowledges comments and contributions from Giorgos Panaras, Jan Schindl and Tim Selke.

References

/1/ Hans-Martin Henning (Ed.) (2004), *Solar-assisted air-conditioning in Buildings. A handbook for planners*, Springer Wien NewYork.
/2/ prEN TS 12977:2005- Thermal Solar Systems and Components – Custom built systems (presently proposed to CEN TC 312 for CEN Enquiry)
/3/ Hans-Martin Henning (2003), *SACE – Solar Cooling Computer Tool – Guidelines for use*, http://www.ocp.tudelft.nl/ev/res/sace.htm
/4/Wiemken, E et al (2004), *Design and planning support for solar assisted air-conditioning guidelines and tools*, Eurosun 2004
/5/ Franke, U. and Seifert, C. (2005), *Solar Assisted air conditioning of Buildings – IEA Task 25, Subtask B: Design tools and simulation programmes – documentation for SolAC programme, version 1.5*
/6/ *TRNSYS – Transient system simulation environment* developed at the Solar Energy Laboratory at Univ. of Winsconsin, Madison, USA, http://sel.me.wisc.edu/trnsys/
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/7/ Wittwer, C. et al. "ColSim – A new simulation environment for complex system analysis and controllers", in www.colsim.de
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/14/ Tutorial – INSEL ® - INtegrated Simulation Environment Language - 2003–2006 Doppelintegral GbR (www.inseldi.com)

Annex A – Analysis of HVAC available in TRNSYS and TESS Library

The Analysis on HVAC components was made for **TRNSYS 16**. The most relevant components are (see /6a/)

Type 107 – Absorption Chiller (hot water fired, single effect) – The data necessary to characterize the chiller is *normalized catalog data.* Any size of chiller can be modelled.

Type 51 – Coling Towers – "Overall performance data" must be introduced by the user in order that characteristic parameters of the cooling tower are determined and used further in the simulations.

A much larger and more interesting set of HVAC can be found in the **TESS Libraries** (see reference /12/). A Summary of the ones considered most relevant is presented here:

Type 680 – Single-effect hot water-fired absorption chiller (Equivalent to type 107 of TRNSYS 16)
Type 679 – Single-effect steam-fired absorption chiller
Type 677 – Double-effect hot water-fired absorption chiller
Type 676 – Double-effect steam-fired absorption chiller

All these types are indicated to be characterized by *normalized catalog data*, making it possible to model any size of chiller assuming the relevant data is available.

Type 683 – Rotary desiccant dehumidifier – models a rotary dessicant dehumidifier containing nominal silica gel.

Annex B – Search on standards for HVAC components

HEAT PUMPS - ISO Standards
http://www.iso.org/iso/en/

ISO 5151:1994	Non-ducted air conditioners and heat pumps - Testing and rating for performance
	Specifies the standard conditions on which the ratings of single-package and split-system non-ducted air conditioners employing air- and water-cooled condensers are based, and the test methods to be applied for determination of the various ratings. Is limited to systems utilizing a single refrigeration circuit and having one evaporator and one condenser. Also specifies the test conditions and the corresponding test procedures for determining various performance characteristics of these non-ducted air conditioners and heat pumps.
ISO 13253:1995	Ducted air-conditioners and air-to-air heat pumps - Testing and rating for performance
	Establishes performance testing and rating criteria for ducted air-conditioners using air- and water-cooled condensers and ducted air-to-air heat pumps. Is limited to systems which use a single refrigeration circuit and have one evaporator and one condenser.
ISO 13256-1:1998	Water-source heat pumps - Testing and rating for performance - Part 1: Water-to-air and brine-to-air heat pumps
	No abstract available
ISO 13256-2:1998	Water-source heat pumps - Testing and rating for performance - Part 2: Water-to-water and brine-to-water heat pumps
	No abstract available
ISO 13261-1:1998	Sound power rating of air-conditioning and air-source heat pump equipment - Part 1: Non-ducted outdoor equipment
	No abstract available
ISO 13261-2:1998	Sound power rating of air-conditioning and air-source heat pump equipment - Part 2: Non-ducted indoor equipment
	No abstract available

HEAT PUMPS and air conditioning units - CEN TC 113 – Published Standards

http://www.cenorm.be/CENORM/BusinessDomains/TechnicalCommitteesWorkshops/CENTechnicalCommittees/CENTechnicalCommittees.asp?param=6095&title=CEN%2FTC+113

CEN / TC 113- Published standards

Standard reference	Title	Citation in OJ	Directive
CEN/TS 14825:2003	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Testing and rating at part load conditions	No	92/75/EEC
EN 12900:2005	Refrigerant compressors - Rating conditions, tolerances and presentation of manufacturer's performance data	No	-
EN 13215:2000	Condensing units for refrigeration - Rating conditions, tolerances and presentation of manufacturer's performance data	No	-
EN 13771-1:2003	Compressors and condensing units for refrigeration - Performance testing and test methods - Part 1: Refrigerant compressors	No	-
EN 14511-1:2004	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 1: Terms and definitions	Cited in OJ C 115 (2004-04-30)	92/75/EEC, 2002/31/EC
EN 14511-2:2004	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 2: Test conditions	Cited in OJ C 115 (2004-04-30)	92/75/EEC, 2002/31/EC
EN 14511-3:2004	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 3: Test methods	Cited in OJ C 115 (2004-04-30)	92/75/EEC, 2002/31/EC
EN 14511-3:2004/AC:2004	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 3: Test methods	Expected	92/75/EEC, 2002/31/EC
EN 14511-4:2004	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 4: Requirements	Cited in OJ C 115 (2004-04-30)	92/75/EEC, 2002/31/EC
EN 15218:2006	Air conditioners and liquid chilling packages with evaporatively cooled condenser and with electrically driven compressors for space cooling - Terms, definitions, test conditions, test methods and requirements	No	2002/31/EC
EN 255-3:1997	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors - Heating mode - Part 3: Testing and requirements for marking for sanitary hot water units	No	92/75/EEC
EN 255-3:1997/AC:1997	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors - Heating mode - Part 3: Testing and requirements for marking for sanitary hot water units	No	92/75/EEC
EN 810:1997	Dehumidifiers with electrically driven compressors - Rating tests, marking, operational requirements and technical data sheet	No	-
ENV 12102:1996	Air conditioners, heat pumps and dehumidifiers with electrically driven compressors - Measurement of airborne noise - Determination of the sound power level	No	92/75/EEC

HEAT PUMPS and air conditioning units - CEN TC 113 –Standards Under development

CEN / TC 113- Standards under development

	Project reference	Title	Candidate Citation	Current status	DAV
00113025	prEN 12102	Air conditioners, liquid chilling packages, heat pumps and dehumidifiers with electrically driven compressors for space heating and cooling - Measurement of airborne noise - Determination of the sound power level	No (92/75/EEC)	Under Approval	2004-08
00113034	prEN 13771-2	Compressors and condensing units for refrigeration - Performance testing and test methods - Part 2: Condensing units	No	Under Approval	2005-01
00113041	prEN 14511-1 rev	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 1: Terms and definitions	No (92/75/EEC, 2002/31/EC)	Under Development	2008-10
00113042	prEN 14511-2 rev	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 2: Test conditions	No (92/75/EEC, 2002/31/EC)	Under Development	2008-10
00113043	prEN 14511-3 rev	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 3: Test methods	No (92/75/EEC, 2002/31/EC)	Under Development	2008-10
00113044	prEN 14511-4 rev	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 4: Requirements	No (92/75/EEC, 2002/31/EC)	Under Development	2008-10

Other standards

Canadian Standards Association

CAN/CSA-C743-02 – Performance Standard for rating packaged water chillers

From reference http://www.csa-intl.org/onlinestore/GetCatalogItemDetails.asp?mat=0000000000024156 21&scopescroll=false&parent=0

1 Scope

1.1 This Standard applies to factory-designed and prefabricated vapour-compression chillers, including one or more hermetic or external drive compressors. The compressor types include centrifugal, screw, scroll, reciprocating, or other types, and the condenser types include water-cooled and air-cooled/evaporatively cooled types, or the package can be supplied without a condenser. Also, air- or water-cooled heat reclaim condensers can be supplied.

1.2 This Standard applies to
a) factory-designed and prefabricated water-cooled absorption chiller/heater units;
b) single-effect indirect-fired by steam or hot water; and
c) double-effect, both indirect-fired by steam or hot water** and direct-fired by oil, natural gas, or LP gas; **water is the refrigerant and lithium bromide is the absorbent.
This Standard does not apply to absorption chiller/heater units with air- cooled condensers, nor does it apply to applications employing heat pumping or exhaust gas firing.

Air-Conditioning & Refrigeration Institute
Aproved American National Standard

ANSI/ARI Standard 560: 2000 - Absorption water chilling and water heating packages (21 pages)

The standard has:

As purpose:... to establish for absorption water chilling and water heating packages: definitions; test requirements for Published Ratings; markinh and nameplate data; and conformance conditions.

As scope: aplies to water-cooled single-effect steam and hot water operated water chilling units, water-cooled double-effect steam and hot water operated water chilling units, and double-effect Direct fired (natural gas, oil, LP gas) water chilling/heating units. Water is the refrigerant abd LiBr (lithium bromide) the absorbent.