

Short Term Scientific Mission – Final Report

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1. STSM Information

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2. Overview of the scientific mission

This STSM was framed into the activities developed as part of the on-going PhD project “COOLFACADE: Architectural integration of solar driven cooling strategies into the curtain-wall”. The experience was evaluated as positive both in terms of the progress made in research content, and also in terms of exchange, considering networking and the possibility to discuss and get relevant feedback from peers and experts.

2.1. Objectives

The activities carried out during the STSM fell in line with one of the specific objectives of the PhD project: To report and compare available solar driven cooling technologies in terms of performance and feasibility for façade integration. Within this main objective, the following specific objectives were proposed for the STSM:

- 2.1.1. To describe and select the systems to be analysed.
- 2.1.2. To define the evaluation strategy and methods to be used.

2.2. Activities

Several activities were carried out in order to achieve the proposed objectives. Some of them were planned ahead while some others were included later in order to respond to new developments. The activities are explained below, categorised according to each objective (1 or 2).

Objective 1: To describe and select the systems to be analysed.

Activity 1.1: definition and description of different solar cooling technologies, considering principles involved and components required for integration.

Based on an earlier review, it was decided that the evaluation will focus on Sorption cooling (absorption & adsorption), Desiccant cooling (solid & liquid), and thermoelectric cooling, considering vapour compression heat pumps coupled with PV cells as reference of the more advanced and mature cooling technology related with the use of solar energy. Within this activity, descriptive schemes were developed for each cooling technology, considering energy inputs, functioning principles and required components, as minimum requirements to consider while evaluating integration possibilities (fig.1).

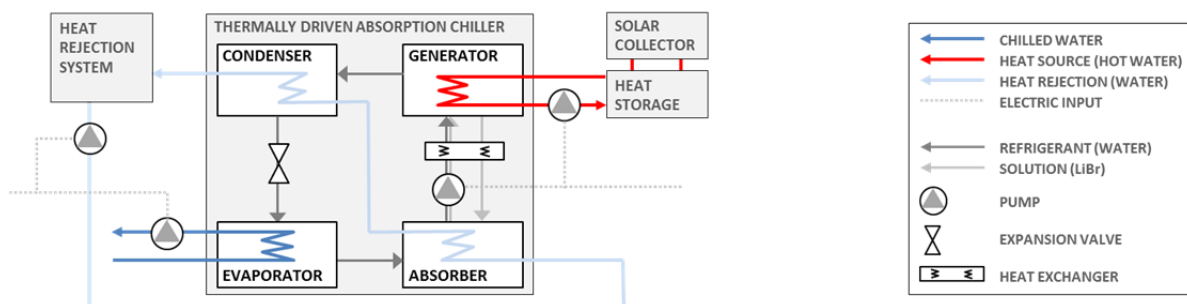


Fig.1: Scheme of working principle and components of an absorption heat pump

Activity 1.2: development of a database of experiences related with solar cooling technologies, considering prototypes, monitoring, simulations or models to gather relevant information about current technological possibilities.

These experiences come from State funded research projects, product development by companies and industries, PhD theses and scientific journal articles in general. The categorised information available for these technologies will serve as the main input of the following evaluation.

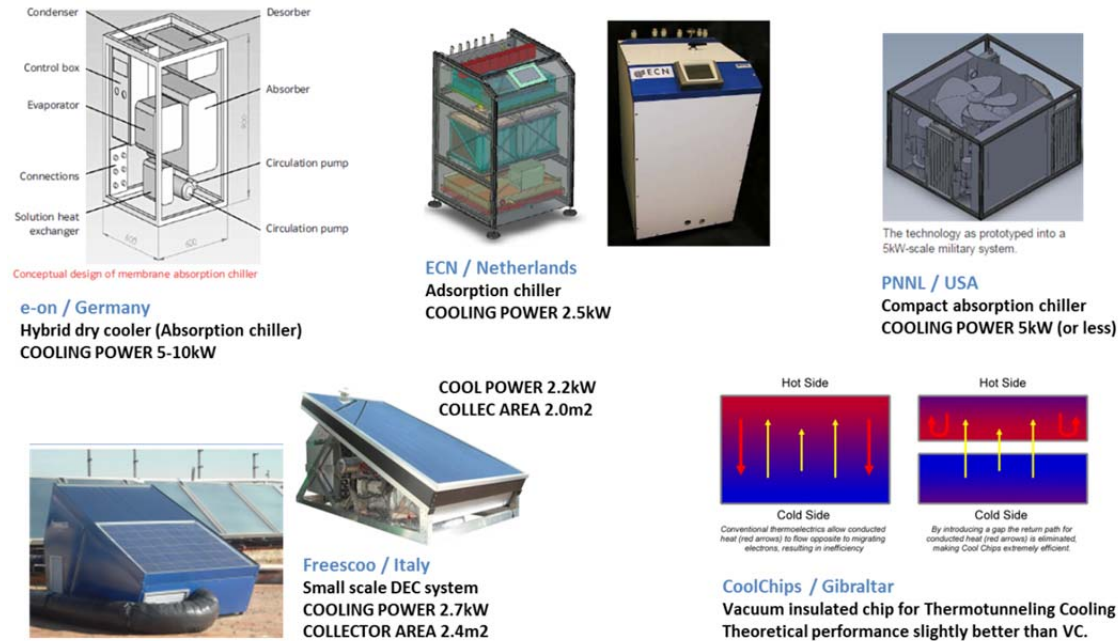


Fig.2: Examples of some prototypes and new developments using several solar cooling technologies

Objective 2: To define the evaluation strategy and methods to be used.

Activity 2.1: definition of a framework for the evaluation of solar cooling technologies.

A framework for the evaluation was proposed following an initial review of several experiences related with solar cooling technologies and their potential for integration in buildings. First of all, it was decided that the main input for the evaluation will be existing data to be obtained either by secondary sources (technical sheets, reference indexes and reviews), or primary sources (technical specifications of systems, research project reports and interviews with experts).

Furthermore, it was decided to focus on the evaluation of prototypes and latest developments of both solar cooling systems and integrated façade concepts, keeping built experiences of integrated facades (without solar cooling integration) and market ready solar cooling systems as reference to assess technical feasibility and achieved cost/performance (fig.3).

Activity 2.2: definition of parameters and variables for the evaluation. For the definition of the parameters, different sub-activities were carried out, assessing relevant parameters in terms of architectural integration and in terms of performance and technical operation of solar cooling technologies.

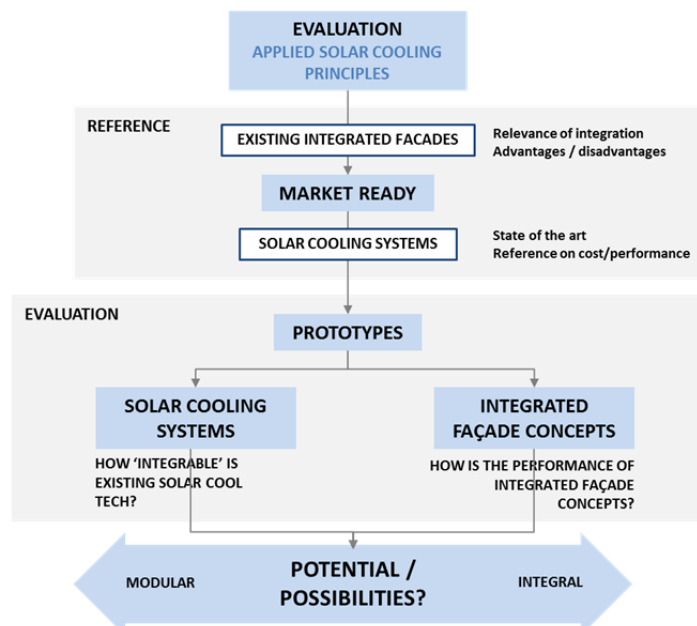


Fig.3: Framework for the evaluation of solar cooling integration possibilities

Activity 2.2.1: initial review of research projects and research experiences related with solar cooling development and/or façade integration of building services.

A review was carried out trying to establish relevant parameters from previous experiences. The review paid special attention to several reports from different Tasks developed by the Solar Heating and Cooling programme from the International Energy Agency, such as Task 38 (Solar Air-Conditioning and Refrigeration), Task 41 (Solar energy and architecture) and Task 48 (Quality Assurance and Support Measures for Solar Cooling).

Activity 2.2.2: data processing of results from façade integration survey.

A survey was developed as part of the research project in order to gather information about the main problems and barriers for the integration of building services in facades. The survey was addressed to façade experts and professionals with experience in building services integration and it was carried out during September and October both personally (during COST Action 1403 September meeting) and online (during the whole timeframe). Neither the survey itself nor the data processing were considered as part of the activities to be fulfilled within the STSM at the moment of the application, however it was judged as a relevant activity in order to get valuable information about parameters to evaluate architectural integration possibilities and validate theoretical knowledge and assumptions with data based on practical experience.

Activity 2.2.3: interviews with experts.

During the STSM, the opportunity arose to conduct some interviews to experts as a way to gather direct information and discuss findings and previous assumptions. Two interviews were carried out during the STSM. A first one with Philipp Molter, architect with experience in façade design and integration of solar thermal technologies, from TUM; and a second one with Eberhard Lavemann, researcher at ZAE Bayern and expert in solar thermal cooling systems and especially liquid desiccant technologies. Both interviews were regarded as a relevant input for the ongoing research project.

Objective 3: Exchange and networking

Even though this objective is not explicitly declared as such, the exchange of information and generation of further possibilities for cooperation is seen as an important part of any STSM. Besides informal discussion with peers, two activities are worth mentioning:

Activity 3.1: Presentation in a PhD colloquium between the Chair of Building Technology and Climate Responsive Design and the Associate Professorship of Architectural Design and Building Envelope from the Faculty of Architecture of TUM. This activity took place on October 27th and it worked as a discussion forum for PhD researchers from both academic units.

Activity 3.2: Lecture for Master Students about literature search and references management. By request of professors Tillmann Klein and Philipp Molter from the Associate Professorship of Architectural Design and Building Envelope, the author gave a lecture showing an approach to conduct a systematic literature search and data management, based on his own experience dealing with the information gathered for the ongoing PhD project.

2.3. Outcomes

As it was stated in the application form for the STSM, its main purpose was the evaluation of several solar cooling systems in terms of their potential for architectural integration in facades. However, given that the length of the STSM is not enough to carry out the entire evaluation, the STSM would serve to define the boundaries and set the evaluation method. This purpose was partially accomplished, because even though real progress was made in terms of gathering information for this definition, there is need for more information to set the final set of criterion. As tangible results from the STSM, there is a preliminary evaluation method that needs to be tested and validated (more interviews would help), and there is also an initial database of experiences that needs to be further completed to get the necessary information to perform the evaluation.

The following table shows the level of achievement for each activity mentioned before, considering related objectives and comments. It is difficult to estimate a definitive level of completeness but the author hopes that the comments help clarify the current stage of said activities within the overall objective.

OBJECTIVE	ACTIVITY	COMPLETED DURING STSM?	COMMENTS
1. To describe and select the systems to be analysed	1.1. Definition and description of solar cooling technologies	YES	The technologies to evaluate were selected and described with simplified schemes considering components and functioning principles for integration. It is important to point out that there is the possibility that selection of systems could change according to new findings related with less known systems.
	1.2. Development of a database of experiences	PARTIALLY	A database of 270 entries was generated with basic information after an initial review. However, the database must be completed by means of a more detailed review of the experiences, which was out of the time constraints of the STSM.
2. To define the evaluation strategy and methods to be used	2.1. Definition of a framework for the evaluation of solar cooling technologies.	YES	A preliminary framework was defined, considering the methods to gather information and the type of systems/experiences to be analysed.
	2.2. Definition of parameters and variables for the evaluation	NO	The parameters to consider in the evaluation have to be further validated and tested. Refer to sub-activities 2.2.1 - 2.2.3. to assess progress in this aspect.
	2.2.1. Initial review of research projects and research related with solar cooling development and/or façade integration of building services.	YES	An initial review was carried out, gathering information about relevant parameters to consider in the evaluation (main variables to assess integration potential in different areas). Also, a database of relevant research projects and a list of researchers was made in order to contact them if needed.
	2.2.2. Data processing of results from façade integration survey	PARTIALLY	The info was categorised and formatted by means of descriptive analysis. However, there is need for a deeper analysis of open questions that won't be done until the end of the year when the survey is closed, to avoid bias.
	2.2.3. Interviews with experts	PARTIALLY	Even though the scheduled interviews within the STSM were conducted without problems, there is need for more interviews with experts so it is an ongoing activity.

Table 1: Level of achievement of activities carried out within the STSM.

The results obtained from the evaluation will be shared in the form of a scientific journal paper. This also applies to the results obtained from the survey conducted during the Cost Action 1403 meeting held on September. That information will be used to write a separate scientific paper. Both papers will be sent for publication in peer review scientific journals during 2016.