MEDISCO
MEDITERRANEAN SOLAR COOLING

Project no. **032559**

Project acronym **MEDISCO**

Project title **MEDiterranean food and agro Industry applications of Solar COoling technologies**

Instrument **Specific Targeted Project**

Thematic Priority **INCO**

Final Activity Report

Period covered: *1/10/06 (month 0) – 31/03/2010 (month 42)* Date of preparation*: 15/04/2010*

Start date of project: 1/10/2006 Duration: 42 months

Project coordinator name: Dr. Mario Motta

Project coordinator organisation name:
Dipartimento di Energia, Politecnico di Milano (POLIMI)

1. Project summary

MEDISCO project was aiming to test and optimize solar thermally driven cooling concepts for the food and agro industry in the Mediterranean region, which under local conditions can result economically and socially sustainable. The objective is to asses which systems could better suite the actual and future demand of the food and conservation industry sectors in the south edge of the basin and estimate in technical and economical terms the most appropriate approach for the application of solar thermally driven systems. The partners carried out a survey of the energy requirement of the industrial sector analyzed in Egypt, Morocco and Tunisia. Further the project was devoted to the development of novel high performing solar driven cooling and refrigeration concept, aiming at the best compromise towards innovative technologies use, primary energy savings and economic issues. The concepts developed have be implemented through the collaborative work of the research institutions and the technology providers involved, resulting in theoretical and simulation activities. Therefore the optimized system was constructed and installed in two experimental setups the first was in Tunisia and the second in Morocco, allowing on site monitoring activities of the system performance. The experiences gained through the experimental activities, was used to create guidelines for best practice applications. The project results participated in increasing the knowledge and strengthen the awareness among the major stakeholders on the penetration potential of solar technologies in the food industry in the region. They will contribute to future Community RTD activities related to these systems. Transfer of experiences within the MEDISCO project, at a regional level, has been amplified thanks to the Mediterranean Renewable Energy Centre (MEDREC), based in Tunis within the Mediterranean Renewable Energy Programme (MEDREP). Further dissemination towards the international scientific community has been carried out (IEA- SHC Tasks 38 and 33).

2. Project objectives

In line with the target Area B.1.5: “Renewable energies for Mediterranean specific needs” of the INCO specific measures and more specifically with the priority research area B.1.5.1 “Cost-effective renewable energies for SMEs and production plants” and B.1.5.3 “Co-generation, solar-assisted engines to produce electricity and heating, cooling and hot water” indicated in the 2004 INCO work programme, the research project contributed to the application of environmentally sustainable an economically viable cooling (and heating) systems for the food and agro industries of the south Mediterranean countries. The main objective of the project achieved was to develop two cost effective economically sustainable and environmental friendly food refrigeration concepts.

A clear specific object of this project was to develop and experimentally test two novel solar cooling concept which have the following characteristics: robust, reliable, less as possible water consuming: In order to reach this ambitious goal, the thermal driven cold technology components have been selected among the few small scale (below 25 kW) industrially produced systems. The size of the machines allows modularity, for large capacity users, as well as small scale applications. ROBUR, which has twenty-five years experience in the industrial production of these systems, commercialized already hundreds of gas-fired machines for humid hot climates (i.e., which can condense at temperatures higher than 50°C) and it developed and tested solar driven systems. The machines (i.e., heat pump/chiller, depending on the chosen configuration) are based on liquid absorption ammonia-water technology. The two big advantages of this machine are the capability to condense with air (i.e., not water consumption for the wet cooling tower) and the possibility to reach cold production temperatures up to -20°C, which make the system flexible for many applications in the food conservation industry.

During the project the partners carried out a survey on the medium temperature collector technologies currently available. The aim was to select the collectors that are: technically compatible with the thermal driven refrigeration machine, closer to a commercial application (in order to maximise the reliability of the system) and that minimise the investment costs (particular attention was paid at the forecasted price once market available). Moreover the research activities focused on system level in order to overcome the possible problems often faced with previous experimental activities on solar cooling.

In particular the partners focused: on the system and hydraulics configuration (e.g., heat/cold storage), on control and operation parameters. The effort were devoted both at theoretical and experimental activities, which are strongly interconnected.

3. Contractors involved

Consortium				
Partic. Role	**Part. no.**	**Participant organisation name**	**Part. short name**	**Country**
CO	1	POLITECNICO DI MILANO, DIPARTIMENTO DI ENERGIA	POLIMI	Italy
CR	2	FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS	ISE	Germany
CR	3	ROBUR S.p.a.	ROBUR	Italy
CR	4	TECSOL SA	TECSOL	France
CR	5	AGENCE DE L'ENVIRONNEMENT ET DE LA MAITRISE DE L' ENERGIE	ADEME	France
CR	6	AGENCE NATIONALE POUR LA MAITRISE DE L'ENERGIE	ANME	Tunisia
CR	7	MOROCCAN CENTRE FOR DEVELOPMENT OF RENEWABLE ENERGIES	CDER	Morocco
CR	8	EGYPTIAN ENVIRONMENTAL AFFAIRS AGENCY	EEAA	Egypt
CR	9	DOMAINE NEFERIS	CCG	Tunisia
CR	10	INTERNACIONAL DE METODES NUMERICS A L'ENGINYERIA	CIMNE	Spain
CR	11	PHOTOTHERME SARL	PHOTOTHERME	Morocco

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4. Work performed and end results

WP1 – Sector characterization and technology classification
The main objectives of this work package was to review the actual situation of the food industry in the Mediterranean region and to analyze the state of the art of the cooling and refrigeration technologies in order to define the characteristics of thermal driven cooling and solar technologies suitable for future solar cooling application in the food and agro industries sector of the third countries

To achieve this object, project partners carried out a deep study aiming at the characterization of the industrial sector energy consumption. A survey was created in two languages (Arabic and French) and circulated to the main AFI in Egypt, Morocco and Tunisia and a picture of the present situation of the agro-food industry was drawn.

Moreover the assessment of potential energy savings that could be obtained in the period 2010-2030 through the introduction of the solar cooling technologies for the main Agro-food industrial processes in three different scenarios.

WP2 MEDISCO solar cooling concepts development and systems design.
Two main objectives in this phase of the project were achieved; the first was to define the end-users requirements, and to develop the two different MEDISCO solar cooling system's concepts for typical end-use patterns and to design the two experimental facilities. And the second objective was to select the medium temperature collector technology which better suites the solar cooling planned application.

To achieve the first objective, the partners defined the end users both in Tunisia and Morocco and made several site visits to define the end users requirements as described D2.1, and developed the solar cooling concept to ensure the best integration with the existing cooling system [Fig. 1], and the final system concepts were developed and system sizing were done and the detailed design of the experimental facilitates were done.

To achieve the second objective a technological and economical survey and analyses of the medium temperature solar technologies market available (or at pre-commercial stage) which could better fit the highly innovative solar cooling concept aiming at: technological performance, low cost, cost effectiveness and as far as it is possible local production in the third countries. the solar concentrating collectors survey report was used for the selection of collectors that have been acquired for the installation on the experimental sites.

WP3 – Engineering tools
The first objectives of this work package was to develop mathematical models suitable for parametric analysis of the system components selected for the experimental activities , and the implementation and creation of a calculation tool for parametric analysis while validation of these models was done through the monitoring data.

Component models of the two systems concepts worked out in WP2 were developed, these models are for the collectors (Fresnel and Parabolic trough collectors), the

absorption chillers and the PCM storage. After running the two installations, the experimental data acquired were used and the devolved models were validated.

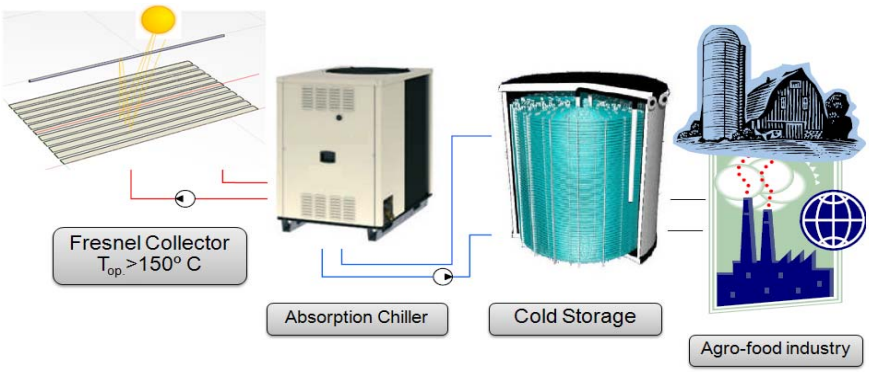

Figure 1. General System concept

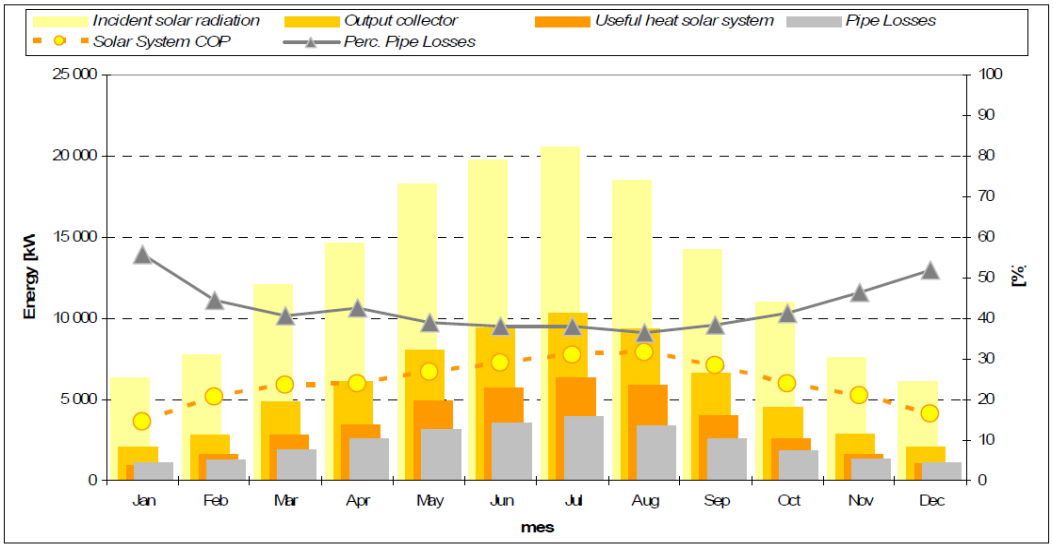

Figure 2 Sample of the SimChip simulation tool results

The second objective of this workpackage was to development of a user-friendly simplified design software tool for planners and technical professionals

The second objective was achieved as a software tool has been developed for the quick assessment of possible MEDISCO system applications. This assessment requires a complete analysis procedure from technical considerations and optimisation to financial issues. This tool is simple and user-friendly interface for the user has been developed, even though the software elaborates complex aspects, and implements the mathematical models that were developed. Users of the software are mainly planners and technical professionals.

The simulation tool (Fig.3) was released on the project website as well as other professional open source software websites such as www.sourceforge.net to be downloaded for free accompanied with user guide and manual.

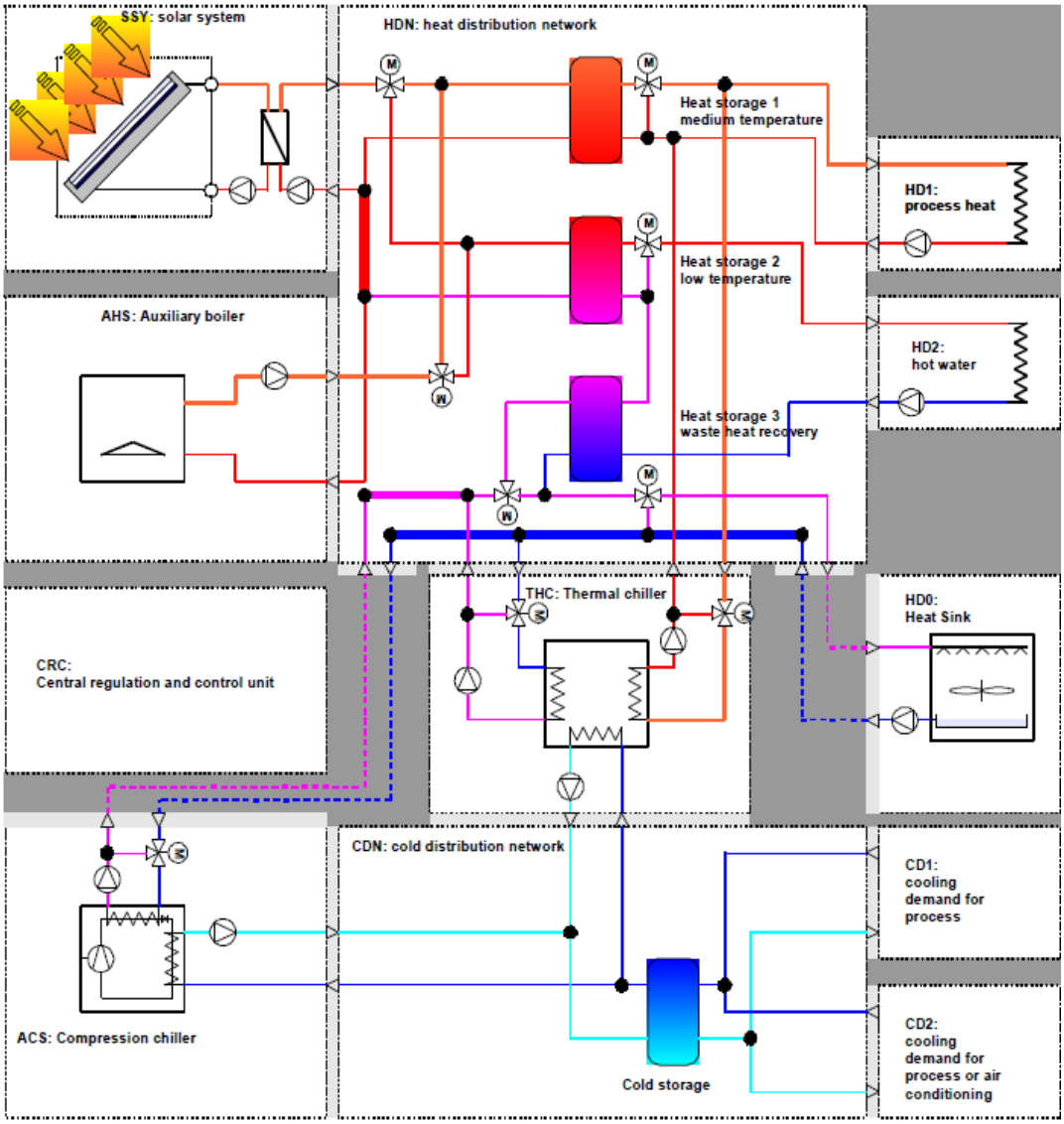

Figure 3 Snapshot of the simplified simulation tool.

WP4 – Experimental tests

The objectives of this workpackage are:

- Design of measurement system and creation of a scientific monitoring protocol
- Installation and commissioning of the two solar driven heating and cooling systems designed
- Carry out experimental activities which enables the performance assessment of the two systems
- Tuning of systems operation parameters and control under real conditions
- Creation of a database of monitoring data suitable for models validation

Project partners developed the monitoring protocol in accordance with the most up to date unified monitoring procedure developed in Task 38 SHC of the IEA, and the two systems designs in Tunisia “Domaine Neferis” [Fig.4 and Fig.5] and Morocco “Best Milk” [Fig.6 Fig.7] were installed and the experimental activities were carried out and the operating parameters of both systems were investigated to tune the system operation and control strategy to ensure optimum system performance.

Regarding the experimental activities of the two installation, partners carried out continuous monitoring of the plant for the optimization and performance assessment of the system, as well as tuning of systems operating parameters and control strategy under real conditions.
And a data base of the monitoring data suitable for the simulation models validation has been created based on the operation of the single components of the systems as well as the overall performance of the system.

Figure4. Installation in Tunisia

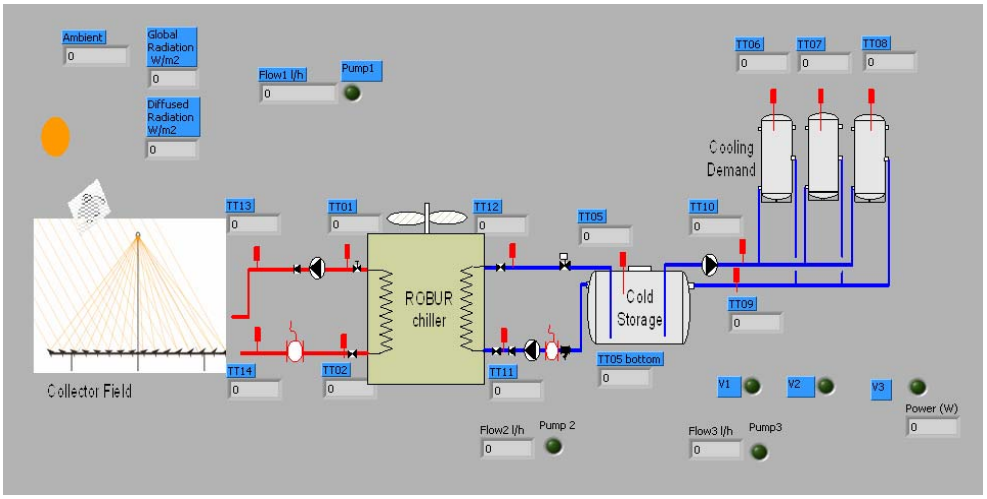

Figure 5. Snapshot from the graphical interface of the monitoring software for the system in Tunisia.

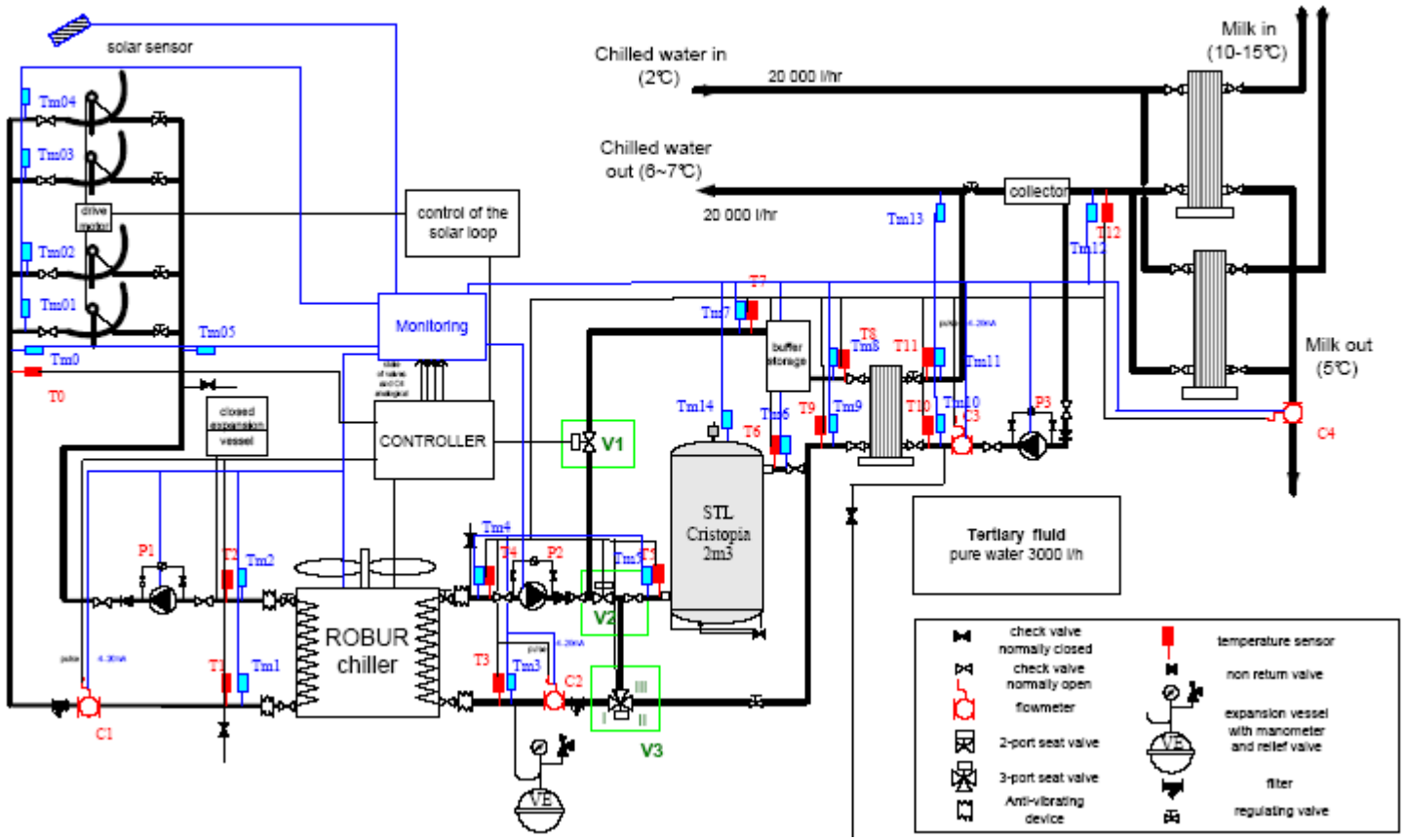

Figure 7. Moroccan system scheme

Figure 6. Installation in Morocco

WP5 - Technology assessment & design guidelines

The main objectives of this workpackage were:

- Definition of the evaluation procedures
- Experimental data analysis
- Performance evaluation of the two systems in energetic terms and their optimisation through computer simulations
- Creation of design guidelines

Defining the performance figures established the base of Monitoring activates and is of high importance to decide what monitoring procedure to be followed and which data are supposed to be collected, as well as which types of sensors to be selected.

In order to allow a clear comparison between the two MEDISCO systems as well as with other solar assisted cooling systems, and as well between measured and simulated values, a comprehensive and unified monitoring procedure is required.

A unified monitoring procedure has been developed within the frame of the international perennial years project – Task 38 – under the umbrella of the International Energy Agency (IEA) Solar Heating and Cooling Program. Within Task 38 in the years 2008 and 2009 14 small scale (< 20 kW cooling capacity) and 12 large scale systems were planned to be monitored.

In this unified monitoring procedure, and in order to have a common starting point for the single monitoring levels a basic scheme and a reference system had to be defined. In the following Figure 8 the proposed reference solar assisted heating and cooling (SHC) system including the detailed energy fluxes for full monitoring and the conventional reference system is shown:

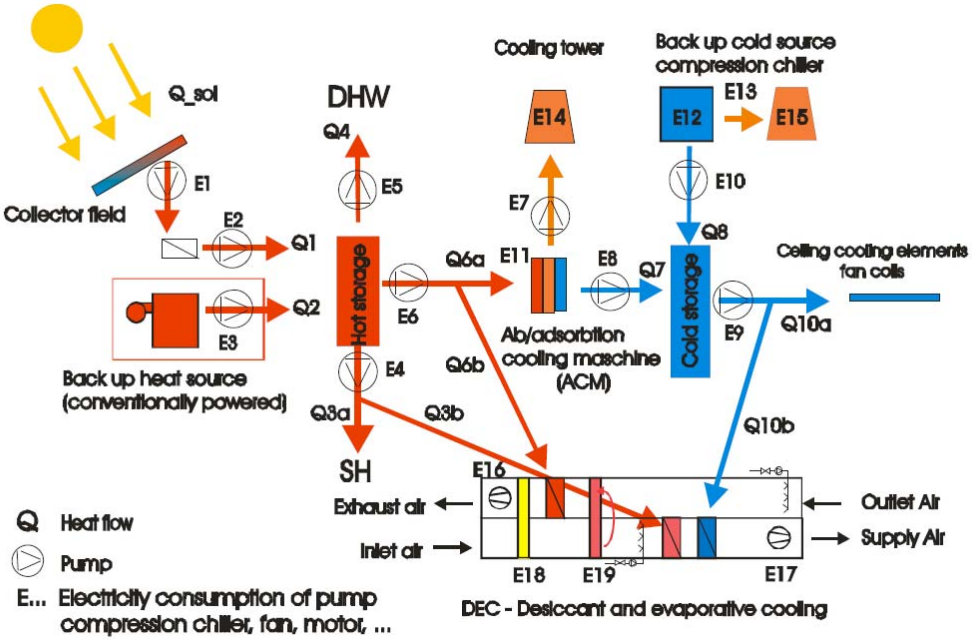

Figure 8. Proposed reference solar heating and cooling system including the single energy fluxes.

The application of the nomenclature used for the Task 38 IEA-SHC reference system to the energy fluxes of the MEDISCO system is presented in Figures 8.

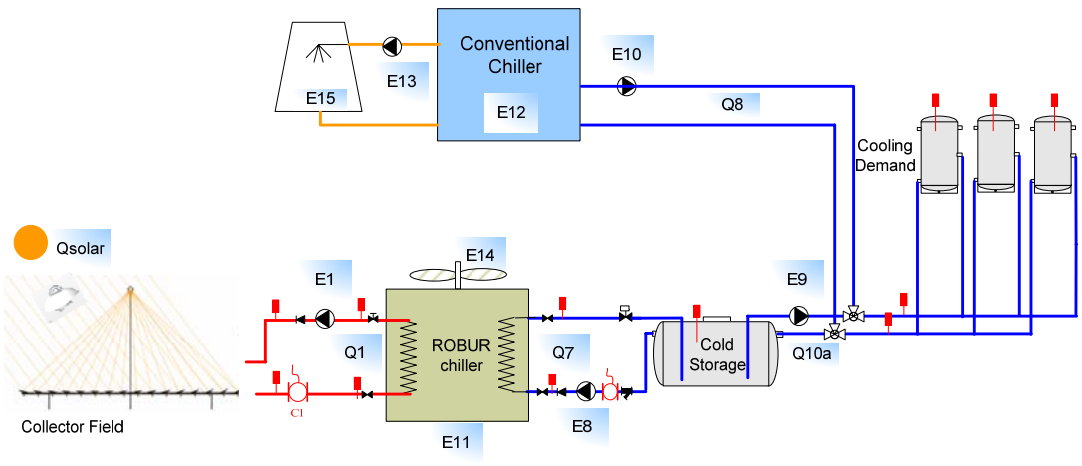

Figure 9. The scheme of MEDISCO according to the nomenclature of the unified monitoring scheme.

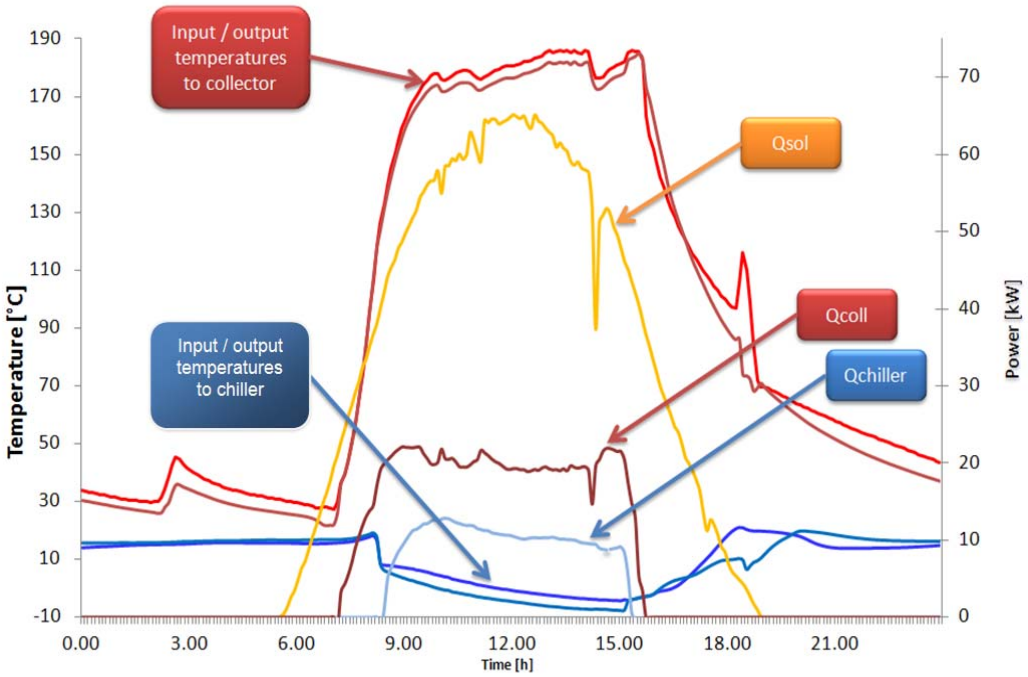

Figure 10. Powers and inlet outlet temperatures of the collector and chiller.

- The system's performance was evaluated in order to optimize their performance, and single days monitoring data of the period March 2008 to April 2010 were analysed in detail in order to understand and optimize the operation of the system. These parameters include: the time required to reach set operation temperature of the chiller, efficiency of collector, coefficient of performance of chiller and electric consumption [Fig. 10 and Fig.11].
- Analysis of the systems performance resulted in optimization measures carried out and resulted in improvement of the system performance. As well as used to validate the simulation models for simplified simulation tool for WP3.

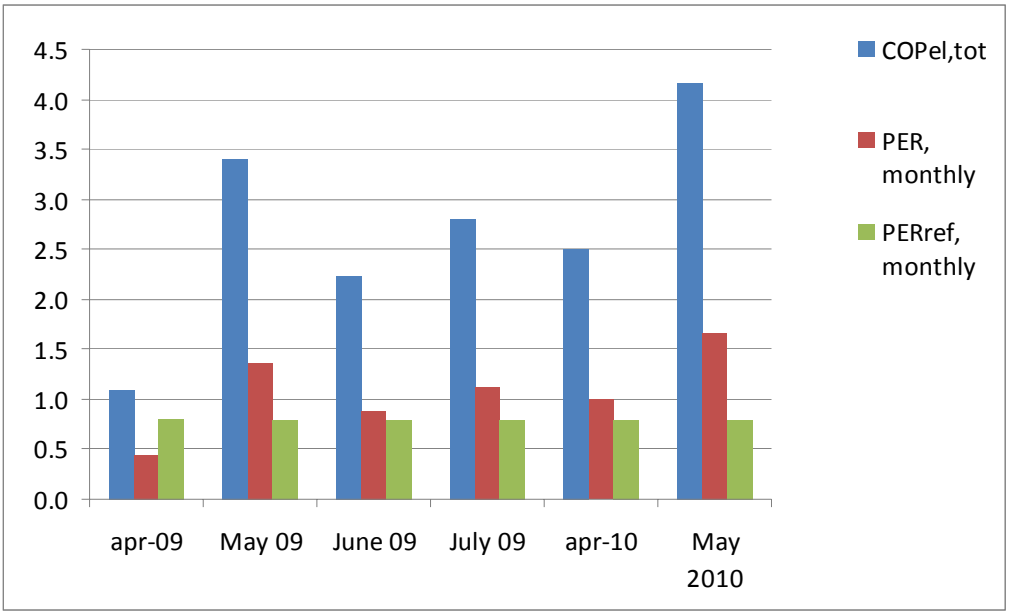

Figure 11. Sample of the performance figures calculated for the Tunisian system.

During the project, two experimental sets up, with novel high performing solar driven cooling and refrigeration concepts, have been constructed and installed allowing on site monitoring activities of the system performance.
The experiences gained through the experimental activities have been used to create the MEDISCO design guidelines in order to disseminate the best practice applications for next solar-cooling concept installations in this area.

The design guidelines were published and uploaded on the project website to be downloadable for interested designers and engineers.

For what the technology assessment of the Best Milk plant concerns, a first set of monitoring data is presented in deliverable 5.1.

WP6 – Potentials & Markets analysis

The main objectives of this workpackage are:

- Identification of technical and economic potential of the most convenient applications for the MEDISCO systems.
- Definition of the opportunities for market penetration
- Identification of the main market barriers
- Characterization of the socio-political impacts.

In order to identify the technical and economic potential as well as to define the opportunities for market penetration:
The simulation tools output of WP3 has been extensively used with two main objectives:

1. In a first simulation campaign an optimization study of operation parameters and a selection of optimum system configurations were carried out.

2. In a second simulation campaign the behaviour of the system in different climatic zones and under varying loads and operation conditions is analyzed

The deliverables 5.2 and 6.1 summarize the results of the simulation campaigns and, furthermore, gives a general idea of the potential of solar cooling technologies in the different fields of agro- and food industry (AFI) of Mediterranean countries. This potential study is based on national production amounts, energy-economic figures and reasonable assumptions. Since the range of products and the way they are produced are very manifold, the potential of solar cooling technologies for an explicit process or company can't be determined from this general approach. For this explicit task, the freely available simulation tool should be used by everyone interested in the topic.

In the methodology followed, the starting points for the analysis carried out are the two demonstration plants realized within the MEDISCO project. Based on the real plants, a typical reference case (base case) has been created that represents a typical installation in AFI industry, with a typical system size and typical load conditions.
For this base case, an optimisation of system and operation parameters has been carried out, in order to detect the potential for improvement with respect to the demonstration plants' configuration.

The optimised reference case then has been used as a base for calculating the system performance and energy savings potential in other climatic areas and under other operating conditions. [Fig. 12]

The results for the typical industries then have been used in order to estimate the overall potential in the AFI industry of the Southern Mediterranean countries under study.

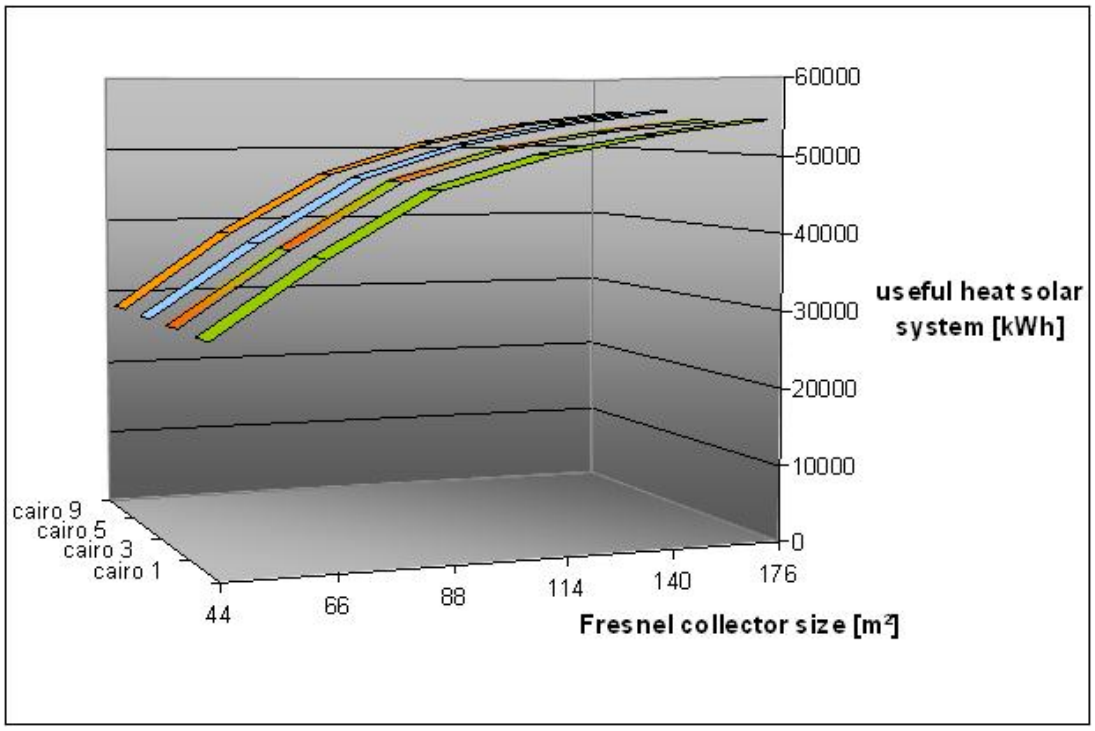

Figure 12 Simulation results – useful heat solar system as a function of the Fresnel collector size

WP7 – Dissemination

Dissemination activities carried out during the project were very successful toward the objectives planned

- Dissemination towards local authorities, decision makers and industrial players of the potentials and market analysis results through information campaign, organization of workshops, articles published in non-specialized journals.
- Dissemination to industry and scientific community of non-confidential scientific and technical aspects of the MEDISCO concepts
- Dissemination towards technical actors and professionals of the technical outcomes of the project. Trough (i.e. IEA-SHC meetings)
- Dissemination targeted to best practice transfer to MPCs partners;

The dissemination of the results of this project, with special regard to the state of the art of energy consumptions for cooling needs in the food and agro industry, and opportunities for the deployment of solar cooling systems, was carried out toward stakeholders, designers and engineers, academic community and public. A detailed description of the activities carried out in the dissemination workpackage is presented in the appendix 1.

- Dissemination activities of the project's concept and potential have been carried out towards the scientific community. In particular presentations of the project contents and preliminary results have been given at the relevant expert meetings within the International Energy Agency, Solar Heating and Cooling Programme: TASK 38– Solar Air-conditioning and Refrigeration as well as toward the scientific community participating in conferences such as, OTTI 2009 and ISES 2009, EUROSUN 2010.
- Public awareness was the target of several dissemination activities as well as technical visits to the MEDISCO plant for national press was organized.
- The development of the project website to cope with the progress and the updates of the projects as well as to afford the public outcomes of the project as the design guidelines and the simulation tool.
- National workshops was held in Egypt with participation of several project partners and the EU delegation in Cairo and focused to the local scientific community (researchers, high level institutions and scientific societies…).
- The MEDISCO final event was organised by CCG, ANME and POLIMI in Tunisia with the participation of all the project partners, the Italian ministry of environment, MEDREC "Mediterranean Renewable Energy Centre", and was attended by relevant stakeholders in the region.
- A guided tour to the experimental setup in Tunisia was arranged for the relevant stakeholders participated in the MEDISCO final event.
- Short movie describing the MEDISCO project, aims, installations, energetic and environmental advantages has been produced by professionals and presented in several occasions as well uploaded on the internet to ensure a wide spread.

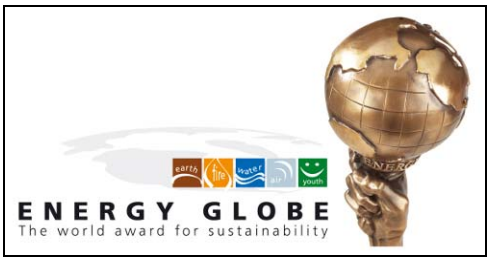

Figure 12 Energy globe award logo received by Medisco in 2009

Medisco project website www.medisco.org