SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task 53
New Generation Solar Cooling & Heating Systems (PV or solar thermally driven systems)

Solar Heating and Cooling & Solar Air-Conditioning

Position Paper

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Solar Cooling – Position Paper

The purpose of this paper is to provide relevant information to energy policymakers so that they can understand why and how solar cooling and air-conditioning (SAC) systems should be supported and promoted. It presents state of the art solar thermal and photovoltaic supported solar heating and cooling systems. In addition, it provides a comprehensive summary of the main findings as provided by the IEA SHC Task 53 work.

Introduction and Relevance

Space cooling is and will continue to be one of the most critical issues in energy systems[1]. Increasing demand for refrigeration and air conditioning has led to a dramatic increase in peak electricity demand in many countries. In addition to increasing electricity costs, brownouts in summer months have been attributed to a large number of conventional air conditioning systems powered by electrical energy. The increasing usage of vapor compression cooling machines (more than 100 million units of room air-conditioners were sold in 2016 worldwide) also leads to increased greenhouse gas emissions from indirect emissions related to fossil fuel derived electricity consumption.

An opportunity to reverse this trend is to use the solar source, that produces the cooling demand in buildings. The distinct advantage of the cold production based on solar energy is the high contemporaneity of solar irradiation and cooling demand (i.e., the use of air conditioning is highest when sunlight is abundantly available), which reduces the need for energy storage.

Status of the Technology/Industry

Solar cooling consists of two main solutions (i) photovoltaic systems in combination with vapor compression cooling machines, and (ii) solar thermal systems in combination with thermally driven sorption chillers, both solutions are market-ready technologies. The IEA Solar Heating and Cooling Program (IEA SHC) provides an overview of the state-of-the-art technologies and markets. Market barriers and innovation challenges are identified as well as suggestions to overcome them.

Significantly hot summer periods in Europe, as well as the use of natural refrigerants, has increased the awareness of solar cooling technologies in the industry. More than 1,500 solar cooling systems have been commissioned in recent years, mainly based on solar thermal collectors and thermally driven chiller[2] utilization. Interest in these products continues to increase.

As costs related to generation and distribution of electricity during peak periods remain high and more frequent electricity blackouts occur, the attractiveness of solar cooling systems will continue to grow.

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[1] OECD/IEA (2018): The Future of Cooling. Opportunities for energy efficient air conditioning. Edited by IEA Publications, International Energy Agency.
[2] Mugnier, Daniel; Jakob, Uli (2015): Status of solar cooling in the World. Markets and available products. In WIREs Energy Environ 4 (3), pp. 229–234. DOI: 10.1002/wene.132

Current Barriers

Currently, the main technical challenges of Solar Air Conditioning (SAC) lie in system level integration. Many systems fail to achieve planned energy savings because of mistakes in proper design and energy management of systems that result in a high overall electricity consumption of auxiliary components. A particular area where errors occur is the heat rejection subsystem - an area that has often has not received sufficient attention in the past. Other oversights led the development of many systems that were far too complex, and as a result, created non-optimal control resulting in significant maintenance effort.

The main problem areas, observed from practical experience of realized installations, are:

- Heat rejection: cooling towers often need too much electricity and are not properly controlled at part load conditions. Small capacity wet cooling towers are relatively expensive and need an inappropriate high effort for maintenance. Dry cooling towers require significantly less maintenance effort but demand more electricity, and often the heat rejection temperatures are high, which affects system efficiency or disable the use of certain technologies.
- Highly efficient auxiliary components and careful hydraulic design are essential. This is particularly important as solar cooling systems need more hydraulic loops than standard solutions.
- The overall system design requires various professional skills for the different subsystems: solar energy at medium temperature (higher than that used for standard domestic hot water application), hydraulics with pressurized and medium temperature water, and air-conditioning or industrial cooling.

The second main shortcoming of SAC already identified in this paper is the economics. The initial investment costs of realized SAC installations remains at 1.5 to 2.5 times higher than conventional state-of-the-art systems. The two major possibilities to overcome that barrier are; (i) to focus on medium to large system sizes which lead to economies of scale, and; (ii) to standardize as much as possible the systems to reduce on-site effort and risks. An important focus should also be on policy strategies that enable a cost reflective means of internalizing electricity system costs into the upfront purchase price of solar cooling systems.

Currently, the achieved non-renewable primary energy savings or reduction in greenhouse gas emission are not reflected in the economics. Regulations and policies that include the environmental quality could improve economic viability.

Potential and Actions Needed

The technological development of solar thermally driven cooling has significantly advanced in recent years. As a result, the focus of research has shifted towards addressing the challenges that pertain to the system level in proper design and operational control of fully integrated systems. The same occurs with respect to the PV driven solutions which often use market available, reliable components that are assembled and complemented with low-priced PV modules.

Integrated systems that maximize the share of consumed solar energy is the only way to significantly decrease pressure on the electricity grid.

Both, public and private R&D efforts are needed to further improve solar cooling at the system level. Research and development should focus on pre-engineered systems for the medium capacity range, which minimizes design and planning effort, and the risk of installation errors.

Simplification of the systems is key to reach a wide range of applications.

Specific focus should be made on quality procedures for design, commissioning, continuous measurement, verification and maintenance of systems.

Unfortunately, solar cooling has not yet been sufficiently developed to effectively reduce costs. To fulfill its environmental and cost reduction potential - widely based on innovations and market sales increase - solar cooling will likely require some form of government policy support in the short term. Policy mechanisms should include both thermal and compression driven systems so that solar heating and cooling can share support policy targets accordingly.

Regardless of the support scheme (e.g., direct grants, tax incentives, minimum building renewable energy content), it is most important to avoid stop-and-go support, which usually harms the market more than it helps.

Develop specific tax credit, tax-free or even funding schemes opportunities for SAC projects (in countries where electricity is highly subsidized, e.g., in some countries of the MENA region). At a national public budget level, electricity savings from related to solar cooling can lead to a reduction in taxation revenue. Measures to support a sustainable market development are most important. This includes establishment of large-scale demonstration programs with both; (i) incentives and; (ii) quality assurance requirements that combine to encourage adoption and lower the risk.

These actions should be organized at regional and national levels. They should first be promoted in regions of the World where cooling is an important issue (e.g., the Middle East, South East of Asia, Sun Belt in the USA, Australia) and where environmental issues are a major concern (such as the impact of pollution due to greenhouse gas emissions).