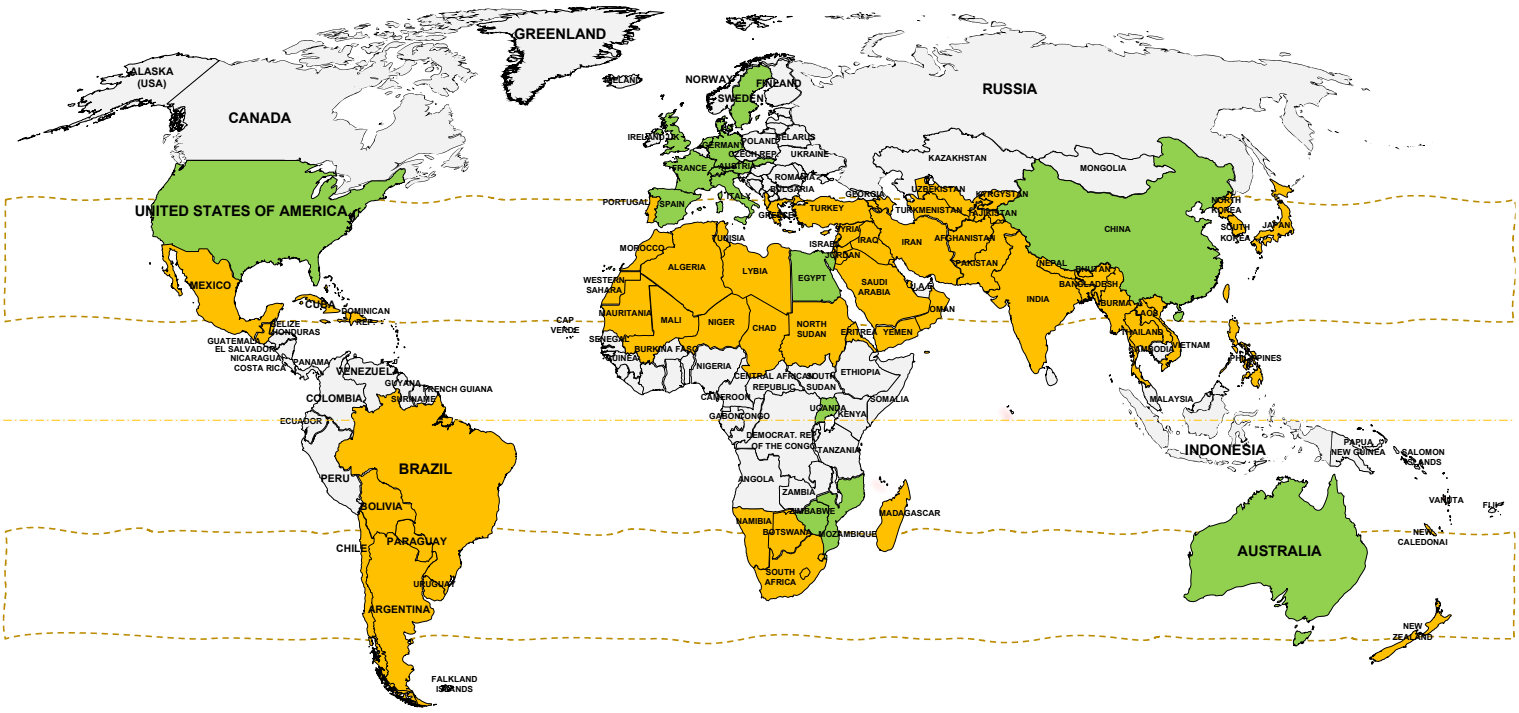
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Lessons Learned (Technical and Non-technical)



IEA SHC TASK 65 | SOLAR COOLING FOR THE SUNBELT REGIONS

Technology Collaboration Programme
by IEA

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Lessons Learned (Technical and Non-technical)

This is a report from SHC Task 65: Solar Cooling for the Sunbelt Regions and work performed in Subtask B: Demonstration

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Cover photo credit: World map with Sunbelt regions (marked yellow) and the 18 countries of the participating Task 65 experts (marked green), source: Neyer Brainworks & JER

Solar Heating & Cooling Technology Collaboration Programme (IEA SHC)

The Solar Heating and Cooling Technology Collaboration Programme was founded in 1977 as one of the first multilateral technology initiatives ("Implementing Agreements") of the International Energy Agency.

Our mission is *"Through multi-disciplinary international collaborative research and knowledge exchange, as well as market and policy recommendations, the IEA SHC will work to increase the deployment rate of solar heating and cooling systems by breaking down the technical and non-technical barriers."*

IEA SHC members carry out cooperative research, development, demonstrations, and exchanges of information through Tasks (projects) on solar heating and cooling components and systems and their application to advance the deployment and research and development activities in the field of solar heating and cooling.

Our focus areas, with the associated Tasks in parenthesis, include:

- Solar Space Heating and Water Heating (Tasks 14, 19, 26, 44, 54, 69)
- Solar Cooling (Tasks 25, 38, 48, 53, 65)
- Solar Heat for Industrial and Agricultural Processes (Tasks 29, 33, 49, 62, 64, 72)
- Solar District Heating (Tasks 7, 45, 55, 68)
- Solar Buildings/Architecture/Urban Planning (Tasks 8, 11, 12, 13, 20, 22, 23, 28, 37, 40, 41, 47, 51, 52, 56, 59, 63, 66)
- Solar Thermal & PV (Tasks 16, 35, 60)
- Daylighting/Lighting (Tasks 21, 31, 50, 61, 70)
- Materials/Components for Solar Heating and Cooling (Tasks 2, 3, 6, 10, 18, 27, 39)
- Standards, Certification, and Test Methods (Tasks 14, 24, 34, 43, 57)
- Resource Assessment (Tasks 1, 4, 5, 9, 17, 36, 46, 71)
- Storage of Solar Heat (Tasks 7, 32, 42, 58, 67)

In addition to our Task work, other activities of the IEA SHC include our:

- SHC Solar Academy
- *Solar Heat Worldwide*, annual statistics report
- SHC International Conference

Our members

Australia	European Commission	SACREEE
Austria	France	SICREEE
Belgium	Germany	Slovakia
Canada	International Solar Energy Society	South Africa
CCREEE	Italy	Spain
China	Netherlands	Sweden
Denmark	Norway	Switzerland
EACREEE	Portugal	Türkiye
ECREEE	REEECH	United Kingdom

Contents

1 Executive Summary

The goal of the IEA SHC Task 65 “Solar Cooling for the Sunbelt regions” is to focus on innovations for affordable, safe, and reliable Solar Cooling systems for the Sunbelt regions worldwide. Countries located between the 20th and 40th degree latitudes in the Northern and Southern Hemispheres face increasing cooling needs on the one hand and higher solar irradiation on the other, making the use of our planet’s most abundant resource – the sun - a compelling solution.

This document is the final report on activity B5 “Lessons learned (technical and non-technical).” Within Subtask B, Activity B5 involved identifying and documenting lessons learned, both technical and non-technical, to create a summary for dissemination in Subtask D. The primary objective was to collect trustworthy data and gain valuable insights from various stakeholders. A survey was conducted to gather information on stakeholder’s requirements, expectations, and specific circumstances that may prompt the utilization of solar cooling. The survey's primary objective was to identify crucial factors influencing the adoption of solar cooling technologies across different applications and regions. The gathered information was then analyzed to better comprehend the challenges, needs, and desires of the stakeholders involved.

The results obtained from the questionnaire showed that solar cooling technologies are highly valued and important, but their market transformation requires collaboration across various sectors. Engaging with stakeholders, including government agencies, industry players, research institutions, and consumers, is crucial for creating a supportive ecosystem for solar cooling. GIS software aids in effective planning and deployment, while technical training programs build capacity and expertise in the industry. Demonstrating the technical and economic viability of solar cooling and reducing reliance on the electrical grid can promote adoption. A multi-faceted strategy involving awareness-raising, market acceptance, and accelerated penetration can make solar cooling a sustainable solution for cooling needs. This approach contributes to climate change mitigation, economic growth, and energy security.

2 Scope of Activity B5 and Methodology

The activity aimed to identify and document lessons learned (technical & non-technical) and prepare a summary for the dissemination activities in Subtask D. The main focus in this activity was to gather reliable data; gain insights from research, experience, and observations; analyze the information to understand the stakeholder's challenges, needs, and desires; and integrating input from previous IEA SHC Task 48 and Task 53.

2.1 Differentiating Between Technical and Non-technical Issues

To conduct the survey, the differences between technical and non-technical issues were defined as follows:

1. Project Phases: Development – Implementation – Operation
2. Awareness for Solar Cooling: Training - Workshops - Presentations
3. Financial / Political Considerations: Access to Capital – Incentives – Tax Benefits – Policies
4. Social Equity: Long-term Economic Growth – Workforce – Infrastructure – Healthy Environment
5. Other:
    - Local Circumstances: energy infrastructure limitations, climate and climate change impacts
    - Motivations: Industry Champions, Green Corporate Image,...
    - Interactions: Technical System – Conditions and Use – Engagement - Expectations

2.2 Survey

For the survey, a questionnaire was designed to get more details on stakeholder's needs, expectations, and specific situations that could trigger the use of the product / service / process / strategy they want to or have to solve. The expected goal of the investigation was to identify key determinants to the adoption of solar cooling technologies for various applications.

The questions (see Annex) were presented to Task 65 members and prospective members (Subtask D dissemination activities) between April 8, 2022 and May 31, 2022.

3 Survey Results

Responses to the questionnaire were received from public and commercial stakeholders, including Universities (3), Energy Solution Providers (1), Renewable Energy Research and Promotion Centers (1), and Manufacturers (2). Countries covered include South & East Africa, West India, and Europe.

1. Stakeholder	University, South Africa	University, East Africa	Energy Solution Provider, East Africa	Renewable Energy Research and Promotion Center, EU	University, Western India; Business perspective
2. Challenges with SC	•Awareness •Not widely used •Lack of skilled personnel •No regulatory Framework / policies to ensure quality	•Struggle with sustainable provisions of essential basic services •Lack of understanding SC concept •Lack of human capital and/or network, research facilities, proof-of-concept pilots	•High costs for SC design / Product •Lack of flexible payment terms for SC solutions •Poor workmanship at cooling facilities •Lack of automated equipment in facilities •Unreliable grid power with poor power quality	•Limited market penetration •Prolonged payback period •Customer's requirements are difficult to achieve (< 8 years) without incentives •Lack of financial incentives •Lack of funding large scale SC installations •Small scale SC systems not financially attractive	•Viability •ROI is too low compared to other technologies •Only demonstration projects and no business •Lack of tech awareness to end users •Value proposition of SC not as dominant than payback period •Economy of scale leads to lower equipment cost
3. Goals and motivations for SC	•Deployment across sectors •AC in buildings •Refrigeration in food / health sector •Research in design, analysis, optimization for SC systems	•Transforming knowledge into useable products •Nurturing professionals for technology transfer to industry •Create a platform where researchers can interact with a physical infrastructure that works and can be replicated in the field	•High demand for reliable cooling solutions	•Raise public awareness for SC systems •Provide technical guidance to designers and installers •Provide consultation to Government and key stakeholders	•Get ROI while providing value to customer for product and services •Provide SC and thermal storage to global market for plug & play cooling and AC systems
4. Needs, pain points, limitations for SC	•Cooling of fresh produce to avoid spoilage •Off-grid refrigeration for abattoir and health centers	•Lack of adequate research facilities •Capacity and knowledge gaps •Lack of Proof-of-concepts	•Most milk cooling facilities are remote and off grid •Main power supply oftentimes diesel	•Presence of financial incentives to accelerate SC installations •EU Directives and national legislation should	•Viability with regard to other competitive technologies like compression cooling •Lack of

	•High costs of SC systems •Lack of funding	and economics of outshining the rather stable conventional technologies •Refrigeration of agricultural products to extend useful life as to effectively combat hunger •Environmentally friendly AC of buildings •Higher energy bills	generators •Lack of qualified personnel and spare parts •Fluctuating fuel prices •Need for robust, reliable, low maintenance power supply for cooling	promote the heating demand to be covered by renewable heat and not by electricity •Integration with smart energy and hybrid systems	awareness by end users of tangible SC benefits
5. Past/current product or project	•Looking into cooling of fresh products and cold chain solutions	•AC with direct solar evaporative cooling •Solar thermal pasteurization (heating) of water •Performance of direct solar powered evaporative cooling for improved indoor thermal comfort in hot /dry regions – potential for integration in place of high energy consuming vapor compression refrigeration systems •Development and optimization of solar water pasteurization system for use in rural areas	•Solar PV system designs	•About 10 SC installations, not all under operation •Involvement in design, monitoring, performance assessment in most of them •A system installed 24 years ago, still in operation •Mobilizing new areas of investment and increasing quality of life for all •SC cooling system for office building coupled with existing central cooled water system	•Mostly demonstration projects •Early market entry with modularized systems
6. Purpose for SC consideration	•Off-grid solution for fresh produce preservation	•Local solution To lack of indoor conditioning in most parts of the country •Adoption by individual consumers or by clustered settlements •Wide range of farm products require preservation to extend shelf-life	•Powering milk coolers •Electricity for dairy cooperative office	•Electricity reduction for space cooling •Increasing renewable energy source for building services	•Industrial and comfort cooling •Same purpose as other cooling technologies •Retrofit solar thermal systems from heating only to heating & cooling •Cooling and AC

7. Situation for SC to user	•University, commercial and industrial site	•Space at domestic, commercial, industrial sectors •Largest income sector is agriculture •Second largest is tourism	•Dairy cooperatives	•Customer site in Western Asia	•Substitute conventional cooling system •Retail, residential, hospitality sector, healthcare, public sector, industry
8. Values of SC to user	•Avoid spoilage •Food security •Increase profitability •Using clean energy •Awareness raising •Accelerating adaptation	•Energy is major enabler to health & economic liberation •Solar resource available & accessible for everyone •Significance beyond direct services	•Minimizing post-harvest losses •Increase profitability with clean energy sources	•Energetic indicators •Financial indicators •Environmental indicators	•Company brand image "Deliver what is promised" •Customers with focus on green portfolio investments •High electricity reduction •High GHG emission reduction •Natural refrigerants
9. Reasons for SC implementation	•Rural areas, no access to electricity •No cold rooms	•Off-grid power generation •Lack of grid reliability •High costs for electricity •Rural areas	•Reliable power •Enhanced power quality •OPEX cost reductions	•N/A	•Meeting green portfolio objectives •Corporate social responsibility
10. Key message to SC user	•SC is solution for unresolved cooling problems	•SC offers one of the best and direct routes for the transition to renewable energy •Opportunity to produce power at the point of consumption, cutting high transmission losses	•Maximize profitability •Lowering carbon footprint	•CO2 emission reduction •Electricity & peak load reduction •Energy security •Independence from fossil fuels	•Green portfolio •Corporate social responsibility •Electricity reduction for cooling and AC •GHG reduction •Natural refrigerants •Product lifetime •Circular product design
11. Additional thoughts		•SC should be equally competitive in the market •Synergies based on broad perspective •Technology relatively unknown •Limited specialists •Challenges: complexities, space requirements, costs			•Lowering SC Costs •Focus on development •Develop market through legislation / policy •Sector specific financial instruments and its acceptance by financial institutions, leasing/cooling -as-a-service

4 Discussion

While there is consensus on the importance and value proposition of solar cooling technologies, it has long been recognized that numerous “challenges” inhibit the adoption of solar cooling technologies, such as lack of information, shortage of experienced personnel, high initial costs, minimal supporting policy options, and limited access to capital. There is a considerable need for the solar cooling industry to communicate the value proposition to various stakeholders. However, the most effective approach for raising awareness, increasing market acceptance, and accelerating market penetration of solar cooling technologies needs to be identified.

The responses to the questionnaire revealed very meaningful and constructive aspects that should be considered for future work. The following recommendations are provided for further discussion:

- It might be beneficial for the solar cooling market transformation to develop a “Conversation Guide” to engage with a stakeholder on this topic where questions are asked and answered to assess the potential for solar cooling integration:
    - *Frequently Asked Questions*: It can be designed to increase the stakeholder’s awareness and understanding of solar thermal technologies and their potential.
    - *Questions to be Asked*: It can be designed to understand the stakeholder’s needs, situation, application potential, and contextual factors. It could include graphics showing different technical pathways depending on various circumstances.
- Use of GIS (Geographic Information System Software) to analyze general boundary conditions for different cooling systems and to analyze cooling system specific potentials by choosing and defining appropriate filters, e.g., climate zones, solar irradiances, industrial areas, water availability, market risks, purchasing power parity/gross domestic product, etc.
- Technical training and measures for the spreading of sorption cooling systems – experiences from the project “SorptionTakeOff” could be leveraged. This project is a collaboration between providers of sorption cooling chillers (EAW, SolarNext), research institutes (ILK Dresden, ZAE Bayern), and the Green Chiller Association for Sorption Cooling. To better market the overall development of the sorption systems with the developed controls, a demonstrator trailer is built and implemented in the project. The trailer will be used for training at refrigeration colleges and for passing on knowledge to planners, engineering offices, and energy consultants. For this purpose, documents are being prepared, and webinars and e-learning strategies are being developed. It is planned to widen the project results to a more international focus.

5 Conclusion

While there is consensus on the importance and value proposition of solar cooling technologies, the market transformation of solar cooling is a multidimensional process that requires collaboration in various contexts. Engagement with stakeholders, such as government agencies, industry players, research institutions, and consumers, addressing their concerns and providing guidance for solar cooling integration is essential to foster a supportive ecosystem. The utilization of GIS software enables effective planning and deployment of solar cooling systems, and technical training programs play a vital role in building capacity and expertise within the solar cooling industry. Establishing technical and economic viability aspects and reducing the burden and demand on the larger electrical grid operation and maintenance could encourage the adoption. A multi-faceted strategy can raise awareness, increase market acceptance, and accelerate market penetration so that solar cooling can become a viable and sustainable solution for meeting cooling demands. This will not only contribute to mitigating climate change but also foster economic growth and enhance energy security in the years to come.

6 Annex

Questionnaire for various stakeholders

IEA-SHC Task 65, "Solar Cooling for the Sunbelt Regions" –

Activity B5: Lessons Learned - Questionnaire

Dear Stakeholder,

To ensure we can provide you with optimal assistance, we kindly request your cooperation in answering the following questions. This will enable us to understand and address the challenges you, as a stakeholder, encounter in implementing solar cooling in your country/field of business.

1. Could you please share information about yourself in relation to your role as a stakeholder?
2. Clearly define your problem/challenges with solar cooling.
3. What are your goals, motivations, values, desires, interests, expectations for solar cooling in your field of business?
4. What are the needs, pain points, limitations of solar cooling in your field of business?
5. Do you have a solar cooling product/project yet? If so, please give details.
6. What does a prospective solar cooling user want to do with your product/project?
7. Where would your product/project be used?
8. What are the values of your product/project to a prospective solar cooling user?
9. Why would a prospective solar cooling user utilize/prefer your product to achieve their goals?
10. What would be your key message(s) to a prospective solar cooling user?
11. What is missing? Any additional thoughts?