IEA Committee on Energy Research and Technology

EXPERTS' GROUP ON R&D PRIORITY-SETTING AND EVALUATION

Workshop on Space Cooling

International Energy Agency
Paris, France

17-18 May 2016

SPACE COOLING

17-18 May 2016

Hosted by the International Energy Agency, Paris

Rationale

The demand for space cooling in the built environment is growing rapidly worldwide, especially in emerging markets of equatorial hot and hot, humid climates. Even in many cooler climates, space cooling energy use in buildings is increasing, as demand for improved (and adjustable) thermal comfort grows. For instance, district cooling in Sweden increased from roughly 350 gigawatt-hours (GWh) of delivered thermal energy in 2000 to nearly 1,000 GWh in 2013 (IEA CHP/DHC Country Scorecard: Sweden, forthcoming 2016).

Space cooling currently accounts for an estimated 5% of total final energy consumption in the buildings sector (ETP 2016, forthcoming 2016), but it is the fastest growing end use in buildings (ETP modelling estimates). Cooling demand is dependent on numerous factors, some of which are more easily quantifiable than others, including climate, internal heat loads (from occupancy and equipment), occupant behavior (including occupant comfort levels), level of system controllability, architectural and material choice, and the size and design of a building (where natural cooling many not be possible because of building depth or inoperability of windows).

Global urbanisation will also have an impact on cooling demand. Urban environments with large, multi-story buildings typically have higher space cooling demand. Urban heat island effects can also significantly raise temperatures – and cooling demand – in cities.

The IEA Secretariat is currently looking at space cooling demand as part of its energy demand scenarios to 2050 under both the *World Energy Outlook* and *Energy Technology Perspectives* publications. Current IEA estimates show space cooling demand growing as much as tenfold in some regions, while global cooling demand increases by 2.5 fold by 2050. Other (external) energy forecasts predict even higher space cooling demand growth. The IEA, therefore, seeks to improve its assessment of space cooling demand in 2016 as part of its continued work stream on thermal energy loads in buildings. Work under the Energy Efficiency in Emerging Economies (E4) programme – with strong links to energy demand technology and policy in Mexico, Indonesia, India and South Africa – is also supporting this effort**.**

At the same time, research and development is pursuing technology options to reduce the energy demand associated with space cooling, or mitigate the growth in such demand. Many existing technologies have been optimized for temperate climates, but not so for high temperature and/or humid climates, where much of the rising demand is sourced. Further, there is international desire to eliminate or reduce the use of high global warming potential (GWP) HFCs as working fluids in space cooling equipment. HFCs are now prevalent as substitutes for CFCs, which are ozone depleting substances. This has led to a resurgence of innovation in technical options in this area.

In order to better estimate space cooling demand, and assess the barriers to various modalities of solutions, several critical issues need to be assessed.

- First, within the IEA modelling outlooks, population **weighted cooling degree-days (CDDs)** are needed to estimate how much cooling would be demanded across different regions relative to different comfort levels. E4 work in Mexico, using population forecasts by city in Mexico to 2050, recently looked at cooling demand relative to different thermal comfort levels (e.g. a Mediterranean level of comfort relative to US level of comfort) per population weighted CDD. Whereas previous ETP analysis had estimated a threefold growth in building cooling demand in Mexico to 2050, this new assessment found that even under a more conservative approach, cooling demand in Mexico could increase by fivefold or more. Improved assessment – using regional CDD values – is therefore a critical area of action in improving modelling scenarios to 2050. Further, the question of occupant behavior (preferred temperature; tendency to open windows) is one of the most significant sources of uncertainty in building energy use and is the subject of work on improving modelling of behavior.
- **Building envelope efficiency** is another critical factor in assessing building cooling demand more accurately. The Secretariat has spent the last year working with partners to improve assessment of thermal loads (in terms of final (input) and useful (output) energy demand) and building envelope technology potential. Large potential energy savings can be achieved through building design (either passive – e.g. building shading – or active – e.g. electrochromic glazing for windows), but additional work is needed to better assess to what point building envelope measures are cost effective relative to other energy saving measures (e.g. high efficiency cooling equipment or district energy supply).
- A third area of cooling assessment is technical potential (in terms of cooling equipment) relative to various environmental conditions. Presently, large portions of building cooling demand are in regions with relatively low latent (e.g. humidity) loads. Beyond core technical developments (e.g. improvements in heat pump technology performance), **treatment of both latent and sensible cooling loads** in many hot, humid regions will be an issue – especially as passive building design alone may not be able to address comfort with high latent loads.
- **Expected technical performance** (e.g. heat pump co-efficient of performance [COP]) should also be addressed. If fundamentally the world is shifting to a mechanical cooling environment, then much more effort will be needed to ensure very high cooling equipment efficiencies. Achieving expected technical performance also requires training, including both design (proper equipment sizing calculations have safety factors built in, plus engineers add their own safety factors which leads to the installation of a very conservative or oversized HVAC equipment), commissioning, and operation.
- Last, other **technically related issues, such as refrigerant choice** in cooling equipment, are of interest, as these issues may have energy and environmental impacts. There is currently work underway to use CO_2 as a refrigerant in heat pumping equipment, and district cooling – especially using natural cooling and variable renewables input – has made noticeable progress in some regions. In addition to CO_2, there is work on developing other low-GWP replacement refrigerants, particularly HFOs.

Natural refrigerants, e.g., propane, are also being examined. Another avenue for inquiry would be variable refrigerant flow (VRF) systems. Additional research in these areas – especially with respect to technical efficiency potential and environmental impact – would be valuable.

Current Activities

There are many activities addressing this topic ongoing throughout the world, including in the United States, Japan, Mexico and Europe. Some excellent work across these various areas is already taking place in the IEA Energy Technology Network through its Technology Collaboration Programmes (TCPs) including, in particular, Heat Pumping Technologies (HPT TCP), Buildings and Communities (EBC TCP), and District Heating and Cooling (DHC TCP).

Meeting Scope

The IEA's Experts Group on Energy R&D and Priority Setting will hold a workshop on 17-18 May 2016 in Paris, France. This workshop will focus on space cooling and address the reason for the increase in energy demand for space cooling as well as available and future technologies and policies to meet the demand in various countries. With input from speakers representing public authorities, research and the private sector the participants will discuss technologies, the demand for innovation, target oriented R&D programs and reasonable incentives to reduce the energy demand responsible for CO_2-emissions from space cooling.

The workshop will result in a summary report, posted publicly, that identifies challenges concerning space cooling, highlights best practice examples in various countries and technology sectors, identifies priorities and gaps in current programs for RD&D planners, and gives recommendations.

Questions

Questions to be addressed by the participating technology experts include:

- *What do scenarios forecast for future energy demand for space cooling?*
- *What are the main drivers for increasing demand for space cooling?*
- *Which measures can be taken to stabilize the energy demand for space cooling?*
- *How is space cooling handled in different countries?*
- *How does occupant behavior relate to energy demand for space cooling?*
- *To what extent does the age of the population influence the demand?*
- *Do regulation and/or higher comfort standards influence the demand for space cooling?*
- *Does the greenhouse effect influence the demand for space cooling?*
- *Does the increase in energy efficient devices reduce the demand for space heating in offices and private households?*

- *Is there a correlation between indoor climate and labor productivity?*
- *Can the problem of growing energy demand for space cooling be solved through energy efficient construction?*
- *How can demand side management help to minimize the need for space cooling?*
- *Which technologies for space cooling are currently used?*
- *What is the current status of technology for space cooling?*
- *To what extent can the energy demand be reduced by energy efficient devices?*
- *To what extent can new refrigerants contribute to reducing the problem?*
- *Can or to what extent can solar energy solve the problem?*
- *What progress can be expected in the foreseeable future?*
- *To what extent can geothermal cooling contribute to solving the problem?*
- *How can thermal energy storage systems (phase change material, ice storage) assist in shifting the cooling load for building owners and lowering the peak demand for utilities?*
- *After all energy load reducing measures are implemented, what technologies are there to assist buildings in approaching zero energy?*
- *How is thermal energy storage accommodated in heavily urban environments?*
- *Does the regulatory framework need adjustment to lower energy demand for space cooling?*
- *How can standards and labels for buildings and cooling devices be implemented effectively?*
- *How can R&D contribute to minimization of CO_2-emissions related to space cooling?*
- *Can replacement refrigerants contribute to reducing refrigerant Global Warming Potential?*

Target Audience

In addition to EGRD national experts, we are seeking input from RD&D decision-makers, strategic planners, and program managers from industry concerned with space cooling technologies and technologies to avoid the demand for space cooling. Participation is by invitation only.

DAY 1 – Tuesday, 17 May 2016

Introduction: Setting the Scene

The session provides background and context for the Workshop. It reminds participants of the purposed, interactive nature of presentations, dialogue and social interactions, and the expected outcomes, and post-meeting activities and communications.

- *Previous work of the group*
- *Rationale of the workshop*
- *Expected outcome of the workshop*
- *Expected demand for space cooling*
- *Activities with the IEA on space cooling*

Introduction			
Chair: Rob Kool			
08:30	*Registration*		
9.00 - 10:00	Welcome		Jean-François Gagné, Head, IEA Energy Technology Policy Division
	Introduction		Rob Kool, Chair EGRD, Netherlands Enterprise Agency
	1	Global energy demand for space cooling in 2050	John Dulac, IEA

Session 1: Future Demand for Space Cooling

This session analyses the current and projected demand for space cooling globally, as well as for selected regions of interest.

- *What do scenarios forecast for future energy demand for space cooling?*
- *What are the main drivers for increasing demand for space cooling?*
- *Which measures can be taken to stabilize the energy demand for space cooling?*
- *How is space cooling handled in different countries?*
- *How does occupant behavior relate to energy demand for space cooling?*

Future Demand for Space Cooling			
Chair: Birte Holst Jørgensen			
10:00	2	Energy demand for space cooling in the context of SE4All objectives	Ksenia Petrichenko, Researcher, Copenhagen Center on Energy Efficiency, UNEP DTU Partnership
10.30	3	UK cold energy needs in an integrated system	Dr. Gavin Harper, Birmingham Energy Institute

11:00	4	Energy demand for space cooling in Germany	Ms. Doreen Kalz, Fraunhofer ISE Institute
11:30	5	Energy demand for space cooling in a non-OECD country	Mr. Nihar Shah, Lawrence Berkeley National Laboratory
12:00	6	Energy demand for space cooling, best practices in Italy	Giovanni Puglisi, ENEA/Solar Heating and Cooling TCP
12:30	Discussion		
13:00	*Lunch*		

Session 2: Technological Options to Reduce Energy Demand for Space Cooling

This session discusses technological options to reduce or mitigate rising energy demand for space cooling in different countries. It focusses on construction methods, the building envelope, as well as energy efficient cooling technology and devices.

- *Can the problem of growing energy demand for space cooling be solved through building design and energy efficient construction?*
- *How can demand side management help to minimize the need for space cooling?*
- *Which technologies for space cooling are currently used?*
- *What is the current status of technology for space cooling?*
- *To what extent can the energy demand be reduced by energy efficient devices?*
- *To what extent can new refrigerants contribute to reducing the problem?*
- *Can or to what extent can solar energy solve the problem?*
- *What progress can be expected in the foreseeable future?*
- *To what extent can geothermal cooling contribute to solving the problem?*
- *How can thermal energy storage systems (phase change material, ice storage) assist in shifting the cooling load for building owners and lowering the peak demand for utilities?*
- *After all energy load reducing measures are implemented, what technologies are there to assist buildings in approaching zero energy?*
- *How is thermal energy storage accommodated in heavily urban environments?*

Technological Options to Reduce Energy Demand for Space Cooling			
Chair: Herbert Greisberger			
14:00	7	Current and Future Technologies for Space Cooling	Van D. Baxter, Building Equipment Research Group, Oak Ridge National Laboratory
14:30	8	How to use cooling to avoid peak-load	Tommie Månsson, PhD Candidate, Chalmers Univ. of Technology, Sweden

15:00	9	Ventilative Cooling	Prof. Per Heiselberg, Aalborg University, Denmark
15.30	*Coffee break*		
16:00	10	Cooling and Urban Energy projects.	Henk de Beijer, Director Solabcool
16:30	11	World's Largest Solar Cooling Systems – experiences from 12 years of commercial solar cooling in Europe, Asia and the USA	Harald Blazek, Strategic Business Development, SOLID
17:00	Discussion		
17:30	Close Day 1		

DAY 2 - Wednesday, 18 May 2016

Session 3: Barriers to and Supporting Factors for Low Energy Demand for Space Cooling

During this session relevant factors will be discussed that can influence the demand for space cooling and how these factors, themselves, can be shaped. The role of innovation, socio-economic factors as well as public awareness, standards and labels will be discussed and highlight how these factors can contribute to keep the demand for energy low.

- *To what extent does the age of the population influence the demand?*
- *Do regulation and/or higher comfort standards influence the demand for space cooling?*
- *Does the greenhouse effect influence the demand for space cooling?*
- *Does the increase in energy efficient devices reduce the demand for space heating in offices and private households?*
- *Is there a correlation between indoor climate and labor productivity?*

Barriers and Supporting Factors for Low Energy Demand for Space Cooling			
Chair: Robert Marlay			
09:00	12	Integration of cooling from a planning and urban development perspective	Djaheezah Subratty, Head, Policy Unit, UNEP
09:30	13	Standards Institute, Paris	Speaker tbc
10:00	14	Cooling energy: demand, technology and institution	Atsushi Kurosawa, Institute of Applied Energy
10:30	*Coffee break*		
11:00	15	LiBr Absorption Chillers and Heat Pumps – technology introduction and sample cases around the globe	Mr. HU Haidong, Senior Engineer, BROAD
11:30	16	Best practice technology – High Temperature Cooling	Prof. JIANG Yi,

			Tsinghua University, Beijing
12:00	Discussion		
12:30	*Lunch*		

Session 4: Public Policies Toward Space Cooling

This session discusses how public authorities can contribute to reduce the demand for space cooling.

- *Does the regulatory framework need adjustment to lower energy demand for space cooling?*
- *How can standards and labels for buildings and cooling devices be implemented to become effective?*
- *How can R&D contribute to minimization of CO_2-emissions related to space cooling?*
- *Can replacement refrigerants contribute to reducing refrigerant Global Warming Potential?*

Public Policies Toward Space Cooling			
Chair: Atsushi Kurosawa			
13:30	17	Heating & Cooling strategy for the EU	Timothée Noël, Policy Officer, DG Energy, European Commission
14:00	18	IEA global policies (E4)	Brian Dean, IEA
14.30	*Coffee Break*		
15:00	19	Mission Innovation & Cooling	Robert Marlay, DOE
15:30	Discussion		
16:00	Wrap Up of the Workshop, Panel Discussion, and Participants Round Table		
17:00	Close Day 2		

Meeting Location:

The workshop will be hosted by and located at the:

International Energy Agency
9, rue de la Fédération
75015 Paris, France