

INTERNATIONAL ENERGY AGENCY  
(IEA)

ENERGY CONSERVATION THROUGH ENERGY STORAGE  
(ECES)



" Sustainable Cooling with Thermal Energy Storage "

Prepared by

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## 1. Introduction

Renewable and natural energy sources, main components of sustainable energy systems, can only be made continuously available to users through thermal energy storage (TES). In addition to heating, TES provides several flexible alternatives for cooling systems. Recent discussions on topics like global warming and heat waves have brought attention once again to energy efficient cooling systems utilizing renewable energy sources. Cooling demand has already been increasing due to the evolving comfort expectations and technological development around the world. Climate change has brought additional challenges for cooling systems designers.

New cooling systems must use less and less electricity generated mostly by fossil fuel based systems and still be able to meet the ever increasing and varying demand. Two important key points of efficient energy usage are demand leveling measures and finding the best mix of energy sources. Annual load factor for power generation, which is the ratio of annual average power supply to maximum power supply, is generally used to show the increasing demand on electricity. In countries where large cooling demand exists in summer, the load factor of electricity for power generation is decreasing. For example, load factor of 70% in the 1960's declined to 55% in 1994 for Japan. In European countries like Germany, England and France the load factor is kept more or less around 65% for the same period of time. However, load factor is expected to decline again not only in Japan but in other countries.

The short/long term load leveling and the peak shaving accomplish improvements in load factor. The electric load curve with strong peaks can be changed with diurnal (daily) thermal energy storage. Annual electric load curve shows large demand in summer and low demand in winter. If summer electric consumption can be shifted to winter, annual load profile can be smoothed even more. This can be achieved with Annual Cycle Energy System (ACES). The ACES utilizes renewable/natural and waste energy with TES for short and long term. ACES can be introduced to individual buildings and district heating/cooling systems.

Rapid growth of energy consumption is especially expected in Asian countries. Most of Asian countries have warm climate and increasing cooling demand. For example in China, the electric demand has increased immensely due to recent remarkable economic development and progress in living standards. Also number of air-conditioners sold has been increasing rapidly. In 2003 summer regional electric power failures were seen in China. It is a serious problem for Chinese economics and ventures that want to advance to China. Already China is the second country of the world in energy consumption and CO<sub>2</sub> emissions. In other Asian countries, same situation can occur in the near future. TES

can be one of the solutions for this problem and TES technology has to be transferred properly to these countries.

Recent “black-out” instances in North America in August 2003, once again showed the urgent need to find a way to use less electricity for cooling. Even the nuclear power plants of France were not adequate to meet the peak demand of electricity for cooling during the heat wave in summer of 2003, killing 15000 people.

## 2. Scope and Objectives

The new Annex will follow a project oriented approach for optimized integration of TES in cooling systems by demonstrating and evaluating the sustainability (energy saving and CO2 emission reduction) of cooling system with TES system.

Under the background described above, the objectives of the new Annex are:

- Advance the prospects of cooling with TES systems.
  - Technology development (short-term, long-term, alternative combinations of short-term with long-term TES utilizing renewable/natural energy).
  - Establishment of design method (evaluation of design tools)
  - Feasibility studies
  - Demonstration projects
- Information Dissemination and Technology Transfer within participating countries and to other countries (including non-Member countries).

## 3. Area of Activities

### Subtask A : Demonstration projects/System performance evaluation for an actual project

This Annex aims to demonstrate the prospects of sustainable cooling using **short-term, long-term and alternative combinations of short-term with long-term** thermal energy storage.

The thermal energy storage media that can be considered for short-term are water, ice, phase change materials (PCM), building structure etc., and for long term underground options including soil, aquifer, and cavities/pits are possible. Thermal storage systems can be applied to several sectors like commercial and institutional buildings, residential, district heating and cooling, etc.. In this subtask, demonstration projects for implementation of thermal energy storage in energy systems will be carried out in

participating countries. The systems will be evaluated based on data from a monitoring programme of the actual thermal energy storage.

### **Subtask B: Design Procedure and System Performance Evaluation Tools**

A good design is necessary to fully demonstrate energy-saving performance of a thermal storage system. For a good design, the manuals and design tools that were developed with the correct understanding of performance of a system are required. Another important issue is the proper operation of thermal storage system. For the optimal operation of thermal storage system, the appropriate operation tools and manuals are needed. So, in this subtask:

- Existing design manuals and tools for the short and long term thermal storage will be reviewed using inventory developed in Annex 14 or from other activities.
- Evaluation of design tools with respect to possibility of their use in various stages of design procedure will be examined.
- For a specific system, performance evaluation with two or more design tools will be performed, and the results will be compared.

Finally the comprehensive design/evaluation tool which leads to realization of the optimized integration of TES in cooling system is established.

### **Subtask C : Information Dissemination and Technology Transfer**

Information dissemination and technology transfer are conducted in the following two ways.

1. The knowledge acquired by Subtask A and B will be summarized into the booklet with the title of "Design, operation and evaluation of cold storage system", and this is distributed to the participating countries.
2. Workshops and international conferences

Workshop will be held in various countries including a non-Member countries. It will be possible for the non-Member countries (NMCs) to participate in this workshop. This is developed to technology transfer to Asian countries , the Mediterranean coast countries where air conditioning load will increase in the future. Moreover, it leads to realization of Sustainable Cooling in a true meaning.

## **4. Means**

The Participants shall share the coordinated work necessary to carry out this Task. The objectives shall be achieved by demonstration projects, review of design/operation/evaluation tools and the information and technology transfer. The result of the projects should be distributed to the participating member countries in the

Annex. If possible demonstration projects should be performed jointly between two or more of the participating member countries. Semi-annual meetings should be held for discussion of the results and for arrangement of workshops.

## 5. Results

The results of this Task shall be

- periodic documents and interim progress reports on the results achieved under the Programme of Work
- recommendations for future case studies shall be given by priority by the Participants.
- final report describing the work carried out under this Task. The final report should restate the scope and objectives of the Annex, its findings and documentation of case studies and demonstration projects
- Publication of the booklet: “Design, operation and evaluation of cold storage systems”.

## 6. Time schedule

This Annex shall commence 1st of January 2006 and remain in force until 31st of December 2007. It may be extended by agreement of two or more Participants, acting in the Executive Committee, and taking into account any recommendations of the Agency's Committee on Energy Research and Technology concerning the term of this Annex. Extensions shall apply only to those Participants who agree to the extension or who notify the IEA Secretariat of their decision to continue to participate.

Phase 1: January-Jun 2006

- Collecting information on the advanced and sustainable cooling system with thermal energy storage
- Pickup applications of which performance will be evaluated
- Discuss the method for evaluations and the performance indexes
- Workshop and Expert Meeting

Phase 2: July – December 2006

- Evaluation of actual projects in participating countries
- Collecting information on the design manuals/tools and operating manuals
- Workshop and Expert Meeting (at new country)

Phase 3: January – Jun 2007

- Evaluation of actual projects in participating countries (continuation)
- Collecting information on the design manuals/tools and operating manual (continuation)
- Define the application and condition for investigating the design manual and tools
- Workshop and Expert Meeting (at new country)

Phase 4: July – December 2007

- Execution of several design tools for the defined application
- Making the summary for competition
- Final report and dissemination of results
- Final Workshop and Expert Meeting

**7. Specific Obligations and Responsibilities of the Participants**

Each Participant shall

- provide the Operating Agent with detailed reports on the results of the work carried out
- collect, assess and report to the Operating Agent data on ongoing projects in the field of thermal energy storage
- participate in the editing and review of draft reports on the Task
- be prepared to host semi-annual experts meetings and arrange workshops
- participate in case studies or demonstration projects either nationally or in cooperation with other participating member countries
- cooperates positively on the technology transfer within participating and to non-participating countries
- participate in activities to enroll new members to the Annex by spreading information about the Annex and act in technology transfer to non-member countries where appropriate

**8. Specific Obligations and Responsibilities of the Operating Agent**

In addition to the obligations enumerated in Article 7 of this agreement the Operating Agent shall:

- Prepare and distribute the results mentioned in Article 5 above
- At the request of the Executive Committee organize workshops, seminars, conferences and other meetings
- Prepare the detailed program of work for the Task in consultation with the Participants and submit the programme of work for approval to the Executive Committee

- Propose and maintain a methodology and a format for the submission of information on data and results from case studies and demonstration projects and other on ongoing projects as described in Article 7
- Provide the semi-annually and other periodic reports to the Executive Committee on the progress and the results of the work performed under the programme of work
- Provide to the Executive Committee within six month after completion of all work under the Task a final report for its approval and transmittal to the Agency
- In coordination with the Participants use its best effort to avoid duplication with activities of other related programs and projects implemented by or under the auspices of the Agency or by other competent bodies
- Provide the Participants with the necessary guidelines for the work they carry out assuring minimum duplication effort
- Coordinate the efforts of all Participants and ensure the flow of information in the Task
- Perform such additional services and actions as may be decided by the Executive Committee acting by unanimity

## 9. Funding

(a) Semi-annual meetings. The Participants shall host the semi-annual meetings pursuant to Article 4 above in turn. The cost of organizing and hosting meetings shall be borne by the host Participant.

(b) Publications. The Operating Agent shall meet the cost of publishing the reports and summary assessments described in Article 5 above.

(c) Individual financial obligations. Each Participant shall bear all the costs it incurs in carrying out the Task activities, including reporting and travel expenses.

(d) Task-Sharing requirements. Apart from the participation in the demonstration projects, the review of tools and technology transfer which are anticipated to be financed outside of the Annex, the Operating Agent should devote 6 man-month per year to the work in the Annex. The Participants are expected to devote 3 man-month per year to the work in the Annex.

## 10. Operating Agent

Heat Pump&Thermal Storage Technology Center, Japan , acting through the Department of Environmental Engineering and Architecture , Graduate School of Environmental Studies at Nagoya University, Nagoya, Japan is designated as Operating Agent.

## 11. Information and Intellectual Property

### (a) Executive Committee's Powers.

The publication, distribution, handling, protection and ownership of information and intellectual property arising from this Annex shall be determined by the Executive Committee, acting by unanimity, in conformity with this Annex.

### (b) Right to publish.

Subject only to copyright restriction described in Article 11(i) below, the Participants shall have the right to publish all information arising from this Task, except proprietary information, as defined in Article 11(c) below.

### (c) Proprietary information.

The Participants and the Operating Agent shall take all necessary measures in accordance with this Article, the laws of their respective countries and international law to protect the proprietary information provided to, or arising from this Task. For the purpose of this Annex, proprietary information shall mean information of a confidential nature such as trade secrets and know-how which is appropriately marked provided that such information:

- (1) Is not generally known or publicly available from other sources;
- (2) Has not previously been made available by its owner(s) to others without obligation concerning its confidentiality;
- (3) Is not already in the possession of the recipient Participant(s) without obligation concerning its confidentiality;

It shall be the responsibility of each Participant supplying such proprietary information and of the Operating Agent for developing proprietary information to identify each information as proprietary and to ensure that it is appropriately marked.

### (d) Production of Relevant information by Governments.

The Operating Agent should encourage governments of all Agency Participating Countries to make available or identify to the Operating Agent all published or otherwise freely available information known to them that is relevant to the Task.

### (e) Production of relevant information by Participants.

Each Participant agrees to provide to the Operating Agent all previously available information and information developed independently of the Task which can assist or is needed by the Operating Agent to carry out its function in this Task, which is freely at the disposal of the Participant and the transmission of which is not subject to any contractual and/or legal limitations under the following conditions:

(1) If no substantial cost is incurred by the Participant in making such information available at no cost to the Task therefore;

(2) If substantial costs must be incurred by the Participant to make such information available at such charges to the Task as shall be agreed between the Operating Agent and the Participant with the approval of the Executive Committee;

### (f) Use of confidential information.

If a Participant has access to confidential information which would be useful to the Operating Agent in carrying out the studies, assessments, analyses or evaluations called for in this Task, such information may be communicated to the Operating Agent but shall not become part of any report or other form of documentation issued as part of this Task, nor shall it be communicated to the Participants except as may be agreed between the Operating Agent and The Participant who supplies such information.

(g) Acquisition of Information for the Task.

Each Participant shall inform the Operating Agent of the existence of information that can be of value to the Task but which is not freely available and each Participant shall endeavor to make such information available to the Task under reasonable conditions in which event the Executive Committee may, acting by unanimity, decide to acquire each information.

(h) Reports on work performed under the Task.

The Operating Agent shall provide reports on all work performed under the Task and the result thereof including studies, assessments, analyses, evaluations and other documentation but excluding proprietary information in accordance with Article 10(c) above.

(i) Copyright.

The Operating Agent, or each Participant for its own result, may take appropriate measures necessary to protect copyrightable material generated under this Task. Copyrights obtained shall be the property of the Operating Agent, for the benefit of the Participants provided, however, that Participants may reproduce and distribute material, but shall not publish it with a view of profit, except as otherwise provided by the Executive Committee.

(j) Authors.

Each Participant shall, without prejudice to any rights of authors under its national laws, take necessary steps to provide the co-operation from its authors required to carry out the provisions of this Article. Each Participant shall assume the responsibility to pay awards or compensation required to be paid to its employees according to the laws of the country.

## **12. Participants in this Task**

Participants in this task are